Revision 2
March 27, 1984

# Control Room Design Review

## Criteria Report

The South Texas Project

HOUSTON LIGHTING & POWER COMPANY

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# CRITERIA REPORT

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**CONTROL ROOM DESIGN REVIEW**

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ACRONYMS AND ABBREVIATIONS

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

ACRONYMS AND ABBREVIATIONS (Cont.)

| | |
|---|---|
| LPSI | Low Pressure Safety Injection |
| LR01 | Licensed Reactor Operator #1 |
| LR02 | Licensed Reactor Operator #2 |
| M/M | Man/Machine |
| MCP | Main Control Panel |
| MON | Monitor |
| MSR | Moisture Separator Reheater |
| MT | Management Team |
| MW(e) | Megawatts (electric) |
| NOS | Numbers |
| NRC | Nuclear Regulatory Commission |
| OERT | Operating Experience Review Task Group |
| OSC | Operational Support Center |
| PORV | Power Operated Relief Valve |
| PRT | Project Review Team |
| PSAR | Preliminary Safety Analysis Report |
| RAS | Recirculation Actuation Signal |
| PZR | Pressurizer |
| RCB | Reactor Containment Building |
| RCP | Reactor Coolant Pump |
| RCS | Reactor Coolant System |
| RECIRC | Recirculating |
| REQ'D | Required |
| RG | Regulatory Guide |
| RHR | Residual Heat Removal |
| RO | Reactor Operator |
| RWST | Refueling Water Storage Tank |
| RX | Reactor |
| SBCS | Standby Cooling System |
| SFTA | System Function and Task Analysis |

ACRONYMS AND ABBREVIATIONS (Cont.)

| | |
|---|---|
| SG | Steam Generator |
| SIS | Safety Injection System |
| SOE | Selected Operational Event(s) |
| SPDS | Safety Parameter Display System |
| SRO | Senior Reactor Operator |
| SS | Subsystem |
| STAT | Systems Task Analysis Team |
| SUPVR | Supervisor |
| SW | Switch |
| SYS | System |
| TMI | Three-Mile Island |
| TSC | Technical Support Center |

## PREFACE

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

Prior to completion of the CRDR, a decision was made by HL&P to redesign six of the ten main control panels. This redesign effort 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. 2

The CRDR is described in the Program Plan document. It contains a detailed description of the plans for the major 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: 2

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 design revisions. 2

The following is a description of the documents covering this CRDR (See Figure P-1): 2

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. 2

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. 2

D. System Function and Task Analysis (SFTA) Report - Describes the methodology, results, conclusions and recommendations for the SFTA effort defined in the Program Plan. 2

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. 2

F. Annunciator Report - Describes the review process, results, conclusions and recommendations 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. 2

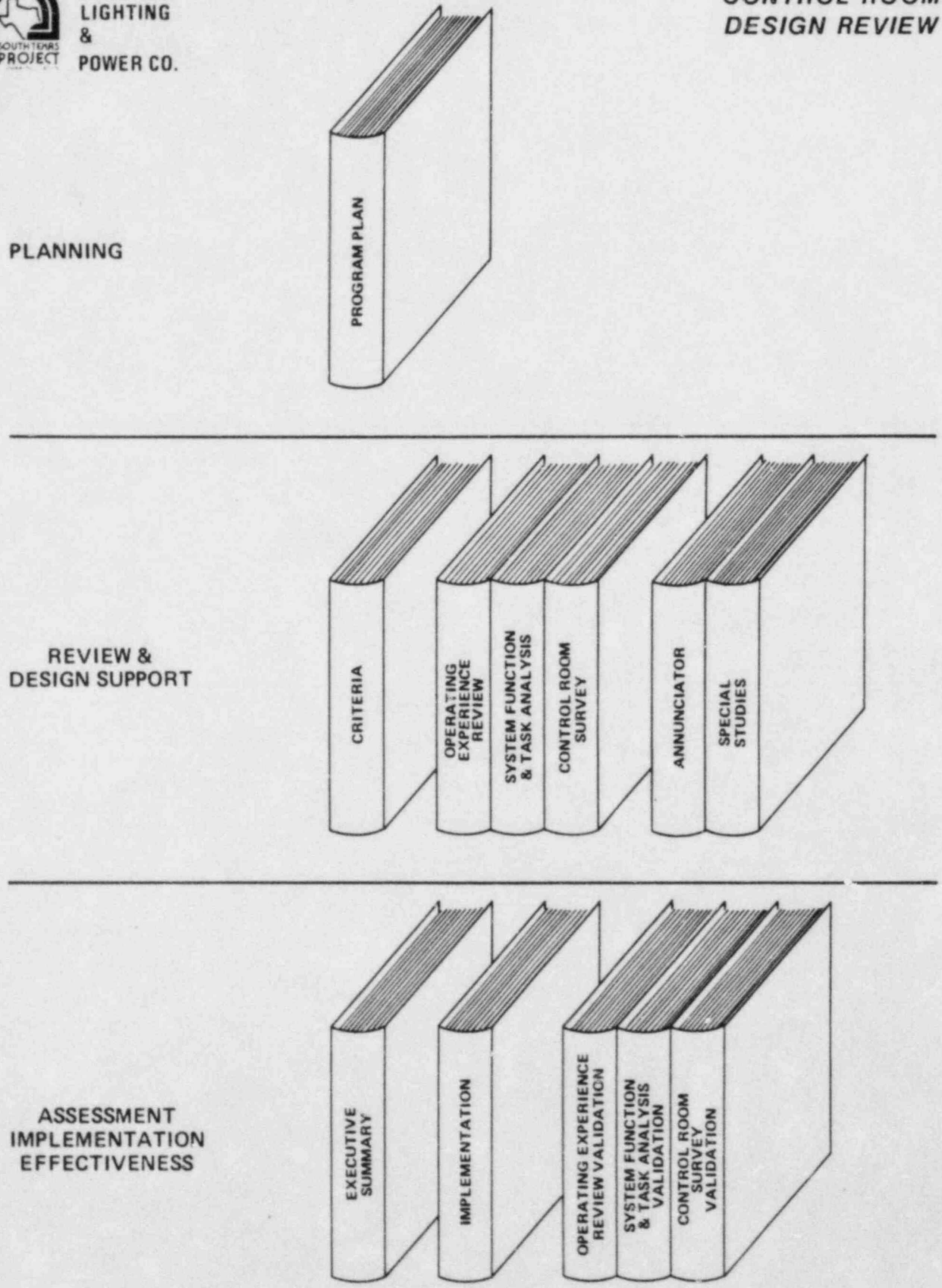
H. Implementation Plan Report - Summarizes the CRDR, the control room design changes, and the proposed methods of implementing the design changes. 2

I. SFTA Validation Report - Summarizes the second SFTA review based on re-layed 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. 2

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.




STP CRDR MAJOR REPORTS
Figure P-1

# 1.0 INTRODUCTION

## 1.1 PURPOSE

The Criteria Report has been established to fulfill two purposes:

- o Provide the Control Room Design Review (CRDR) teams with a basis for reviewing the control room.

- o Provide project personnel with a document that will tie together the plant systems and promote a unified and coordinated design with regards to the control room interface.

## 1.2 CONTENT

The criteria report consists of several sections. The purpose of each section is as follows:

A. General: To describe the systems controlled from the control room and describe the operations that are performed in it. To describe, in general, the interaction of the control room with other control stations in the plant.

B. Control Room Layout and Features: To describe the actual control room and the arrangement of the various pieces of equipment.

C. Main Control Room Layout and Features: To describe the main control panels and hardware. To give some general guidance to application and the interactions with other control stations.

D. Auxiliary Shutdown Panel: To describe the auxiliary shutdown panel and hardware mounted on it. Included will be specific parameters monitored and how they relate to the regulatory requirements.

E. Human Factors Guidelines: To define those human factors criteria from NUREG 0700 specifically applicable to STP. This section covers topics such as workspace, controls, visual displays, labels, process computers, panel layout and control-display integration criteria.

F. Communications Criteria: To describe the control room communications system and the types of equipment to be employed.

G. Control Room Annunciation Features: To describe the functional requirements for an integrated annunciation plan which includes the main plant annunciator, the plant computer, the bypass and inoperable status system, and the safety parameter display system.

H. Post-Accident Monitoring (PAM) Features: To describe the criteria for selecting the instruments comprising PAM and to define the specific parameters to be measured for STP.

I. Bypassed and Inoperable Status Features: To describe the criteria for selecting the parameters to be monitored for intentional bypassed or inoperable status. In addition, this section describes the feature whereby the parameter's status is monitored subsequent to ESF actuation.

J. SPDS Features: To describe the basic criteria for the SPDS and the types of equipment to be employed.

## 1.3 PROJECT DESIGN CRITERIA

Project design criteria documents govern the design of the STP nuclear plant and shall take precedence in case of any conflict with criteria contained herein. The applicable project design criteria documents are as follows:

| | | |
|---|---|---|
| A. | 7Z319ZQ1002 | Annunciator |
| B. | 5Z359ZQ1021 | Control Room Evacuation and Subsequent Safe Shutdown |
| C. | 5Z289ZQ1007 | HVAC Systems, Equipment, Control, and Monitoring |
| D. | 5Z539ZQ1010 | Post Accident Monitoring |
| E. | 5Z559ZQ1006 | Emergency Response Facilities Data Systems (Includes SPDS) |
| F. | 7Z269ZQ1005 | ESF Status Monitoring |
| G. | 5Z189ZQ1004 | Plant Computer |

## 2.0 GENERAL

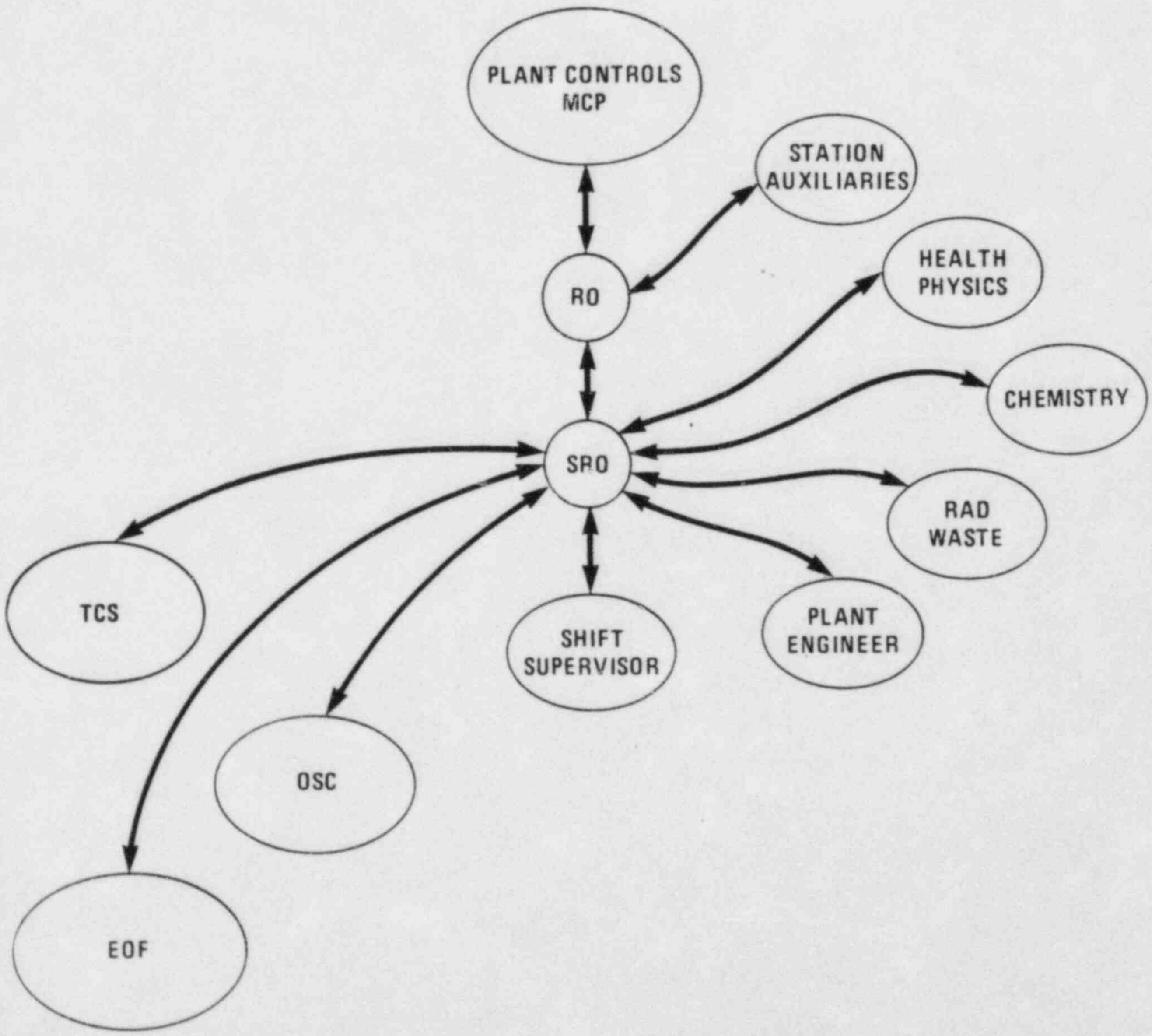
### 2.1 SCOPE

The control room provides the central location for performing the activities associated with operating the plant. 10 CFR 50 Appendix A, Criteria 19 states in part, "A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including LOCA."

In order to satisfy the intent of the above criterion, it is important that the control room operators have knowledge of the operability status for all significant systems and associated equipment necessary to operate the plant. This results in significant interaction between the control room operators and personnel not normally stationed in the control room. The major interactions are illustrated in Figure 2.1-1 and are described as follows:

A. Not all controls are located in the control room. Numerous subsystems and miscellaneous auxiliary systems necessary to enhance plant availability are operated or controlled at stations close to the equipment. Manual operations involving these local control panels are generally coordinated through the control room.

B. Maintenance and surveillance operations are ongoing activities both during power operation and during shutdown. These activities are performed only with the full knowledge of the control room personnel.




CONTROL ROOM OPERATOR INTERACTIONS
Figure 2.1-1

C. During the conduct of normal plant operations, the control room operators interact with other organizations such as:

1. Health Physics
2. Chemistry
3. Radwaste
4. Maintenance

D. During the conduct of emergency operations, the control room personnel interact with other emergency response facilities as described in Section 2.4.

## 2.2 PLANT OPERATIONS

Plant operations that are normally controlled from the control room consist of those actions required to operate the major systems and subsystems that result in the successful fulfillment of the plant operating mode, or the successful transfer from one operating mode to another. The operating modes are categorized as follows:

A. Normal power operation including steady-state, transient load changes, and anticipated plant upset transients

B. Normal plant startup and shutdown operation

C. Shutdown during maintenance

D. Shutdown during refueling

E. Emergency conditions

## 2.3 SYSTEMS CONTROLLED FROM THE CONTROL ROOM

The total plant is comprised of over 100 systems. Many of these systems are not normally active operating systems and, therefore, are not controlled from the control room. However, systems that are normally inactive, but are required for safe shutdown or post-accident monitoring, are controlled from the control room. Regulatory Guide 1.97 defines the minimum required instruments to be displayed in the control room for post-accident monitoring purposes.

Figure 2.3-1 shows the interaction of the major systems during normal power generation. The control panels in the control room, boards 4 through 10, provide for control and monitoring the major systems. Boards 1 through 3 are delegated to the safety systems.

The following paragraphs describe the basic systems which are controlled from the control room. In addition, information is presented on the functions of the systems and the interaction of its subsystems.

A. Reactor Control

The reactor is the heat generating source for the plant. Heat is produced by nuclear fission. The rate of heat generation is controlled from the control room, as well as the thermal hydraulic performance of the reactor core, by means of associated controls for the reactor coolant system and the secondary coolant system.

B. Reactor Coolant System (RCS)

The principal function of the reactor coolant system is to transport the heat produced in the reactor core to the steam generators where the heat energy is converted into steam. Figure 2.3-2 illustrates the interaction of the elements comprising the RCS. The system and its major components are controlled from the control room. The major components and their functions are as follows:

1. The reactor vessel, as principal component of the RCS, contains the heat-generating core and associated supports, controls, and coolant circulating channels. Outlet and inlet nozzles provide for the exit of the heated coolant and the return of the cooled coolant to the vessel for circulation through the core.

2. The reactor coolant pumps circulate the coolant to the reactor where it is heated, then to the steam generators where it transfers heat to the secondary system, and then back to the reactor coolant pumps' suction.

3. The pressurizer provides a point in the RCS where liquid and vapor can be maintained in equilibrium under saturated conditions for the purpose of pressure control. The pressure control equipment includes the pressurizer and its sprays, heaters, power-operated relief valves, safety valves and the surge line.

The pressurizer functions to maintain the RCS pressure during plant steady state operation and to limit pressure changes that would otherwise occur during plant transients. The pressurizer pressure controls are operated from the control room. The pressurizer and its associated pressure controls serve to maintain adequate DNB ratio in the reactor core during plant operations at power and during transients.

4. The pressurizer relief tank condenses and cools the discharges from the pressurizer safety and relief valves. Discharges from a number of relief valves located inside the containment are also piped to the relief tank.

The RCS serves as the second barrier for confining the reactor fission products (the fuel cladding is the first barrier). The reactor protection system (RPS) automatically activates those engineered safety features (ESF) necessary to maintain core cooling. Manual control capability is provided for long-term post accident recovery operations.

C. Chemical and Volume Control System (CVCS)

The CVCS serves as the water treatment system for the RCS. In addition, the system provides the capability to compensate for volume changes in the reactor coolant. Figure 2.3-3 shows a schematic of the system. It is comprised of several subsystems, all of which are controlled from the control room. The functions of the CVCS are:

1. Maintains a programmed water level in the pressurizer to maintain required water inventory in the RCS.

2. Maintains seal water injection to the reactor coolant pumps for sealing and cooling.

3. Controls reactor coolant water chemistry conditions, radioactivity level, boron concentration and provides controlled makeup.

4. Provides means for filling, draining, and pressure testing of the RCS.

5. Provides reactor coolant purification during cold shutdown.

The subsystems comprising the CVCS are:

1. Boron recycle system
2. Boron thermal regeneration system
3. Reactor makeup water system
4. Charging system

The CVCS is important to plant operation because of its role in processing primary coolant. However, its functions are not used for the purpose of mitigating the effects of accidents. Therefore, the CVCS is normally isolated upon an initiation of a containment isolation signal.

D. Steam Generator (S/G)

The S/Gs convert the heat energy in the reactor coolant (added by the reactor core) to steam. In order to perform this function, the S/G level control operates to match the rate of feedwater flow into the S/G to the rate of steam flow out of the S/G. The level controller is programmed to a fixed setpoint. Instruments are located in the control room to indicate the S/G performance variables, level and pressure, to the operators. A schematic diagram of the steam generator is shown in Figure 2.3-4.

The S/G serves as the principal barrier between the primary and secondary coolant systems.

E. Main Steam System

The main steam system is used to perform the following functions:

1. Supply steam to the following:
   - Turbine-Generator
   - S/G Feed Pump Turbines
   - Auxiliary Feedwater Pump Turbine
   - Gland Seals
   - Moisture Separator Reheater
2. Serves as the medium to transport excess heat generated in the reactor to the steam dump or to atmosphere.

The main steam system has the capability to automatically or manually vent steam to the condenser or to atmosphere as the means for rejecting heat produced in the reactor coolant system.

The controls for these operations are from the control room. Venting the system to the condenser is the preferred path. However, the condenser is not safety related. The path providing steam venting to the atmosphere through the relief valves is safety related. In addition to venting steam to the atmosphere, the relief valves provide automatic relief from system overpressurization. A schematic of the main steam system is shown in Figure 2.3-5.

F. Turbine-Generator

The turbine converts the heat energy in the main system to mechanical energy, i.e., rotation, and the generator then converts the mechanical energy to electrical energy. The turbine-generator incorporates controls for admitting steam into the high pressure and low pressure sections of the turbine and for varying turbine load. These controls are part of the overall turbine-generator control system, which is supplied by the turbine-generator manufacturer as a control panel insert located in the control room. The turbine generator is shown schematically on Figure 2.3-6.

The turbine generator is not safety related; it is automatically tripped in the event of a reactor trip.

G. Feedwater and Condensate Systems

The feedwater and condensate systems function to deliver quality water from the condenser to the steam generators. A schematic diagram of the systems is shown in Figure 2.3-7.

The systems are not safety related; however, they are important to plant availability and, as such, basic controls for operating the systems are in the control room. The controls in the control room are:

1. Condensate Pumps
2. Low pressure feedwater heaters, including controls for extraction steam, heater drains, and drain pumps
3. High pressure feedwater heaters, including controls for extraction steam, heater drains, and drain pumps
4. High pressure feedwater pumps. Note: The controls for the feedwater pump drive turbine are integrated with the control logic for the feedwater flow control valve.

H. Auxiliary Systems

Several non-safety auxiliary systems have instruments and controls located in the control room. These are:

1. Auxiliary cooling water systems
2. Gland seal steam
3. HVAC equipment
4. Hydrogen system

I. Electrical System

The Electrical System has the following functions:

1. To provide power to the emergency buses from offsite or onsite power sources.

2. To provide power to the nonsafety-related plant systems from either offsite or onsite power sources.

3. To distribute the electric energy produced by the turbine-generator to the utility's grid system.

The portion of the system associated with distributing power to the emergency buses is safety related, while the remainder of the system is not safety related. The controls located in the control room consist of those breakers associated with distributing power according to the three functions noted above, plus the controls associated with synchronizing one bus to another.

J. Residual Heat Removal System (RHR)

The primary function of the RHR system is to remove decay heat from the RCS during plant shutdown and refueling operations. Additionally, the RHR heat exchangers are used in conjunction with the low head safety injection pumps for emergency core cooling. A schematic diagram of the system is shown in Figure 2.3-8.

The RHR system is used only during shutdown and refueling operations. The system consists of three identical safety-related trains. The system is operated via manual control from the control room.

K. Auxiliary Feedwater System (AFW)

The AFW system is used to perform the following functions:

1. Provide feedwater flow to the steam generators during normal startup and shutdown.

2. Provide feedwater flow to the steam generator during accident conditions following isolation of normal feedwater flow.

The system is safety-related and consists of four independent process loops, one to each steam generator. Three of the AFW pump drives are electric motors, powered by three redundant Class 1E power trains, and one drive is a steam turbine. The system is automatically activated by the ESF control logic. Manual controls are available in the control room to perform all system functions. The system is shown schematically in Figure 2.3-9.

L. Component Cooling Water and Essential Cooling Water (CCW)

The function of the CCW system is to provide cooling water to safety-related heat exchangers and operating equipment upon ESF activation. The CCW is a closed loop system and transfers heat to the essential cooling water (ECW) system which transports the heat to the ultimate heat sink - the evaporating cooling pond. These systems are automatically activated by the ESF logic. Manual controls are also available in the control room to control all system functions.

M. Engineering Safeguard Functions (ESF)

The ESF include several systems that are designed to mitigate the consequences of accidents. Each system is safety class and comprised of three trains. In addition, each system is automatically activated by the ESF activation logic. Manual controls for each system are provided in the control room.

A list of the systems that comprise the ESF, and their respective functions, is given below.

1. Safety Injection. To provide emergency core cooling in those design basis events involving real or potential loss of coolant from the RCS.

2. Containment Spray. (1) To remove heat from the containment atmosphere and thereby limit the excursion in reactor building pressure/temperature subsequent to a large break LOCA or a main steamline break; and (2) to limit the quantity of airborne iodine in containment following a LOCA.

3. Reactor Containment Fan Coolers. To remove heat from the containment atmosphere following an energy release inside containment of moderate magnitude.

4. Containment Isolation. To isolate those process systems penetrating the containment building in order to confine fission producer releases to the inside containment boundary.

5. Combustible Gas Control. To assure that the containment integrity is not endangered due to the accumulation of combustible hydrogen following a loss of coolant accident.

N. Other Safety Systems

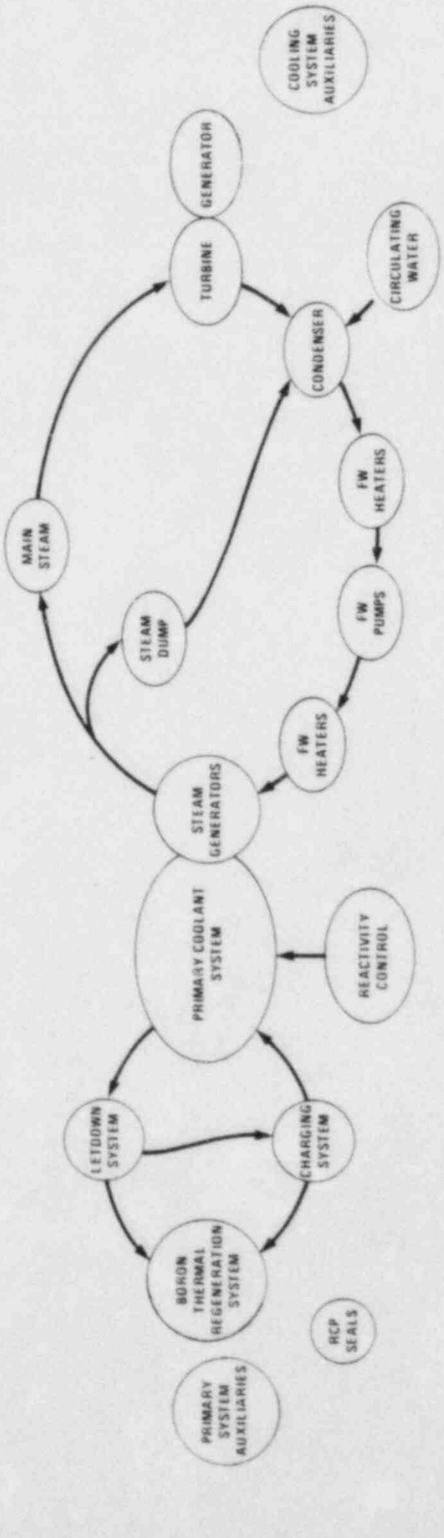
There are several other safety systems for which controls are provided in the control room. Generally, these systems are activiated automatically by ESF logic, but monitoring and/or manual operation is available to assure that an accident condition is not aggravated by failures in the automatic system.

Examples are:

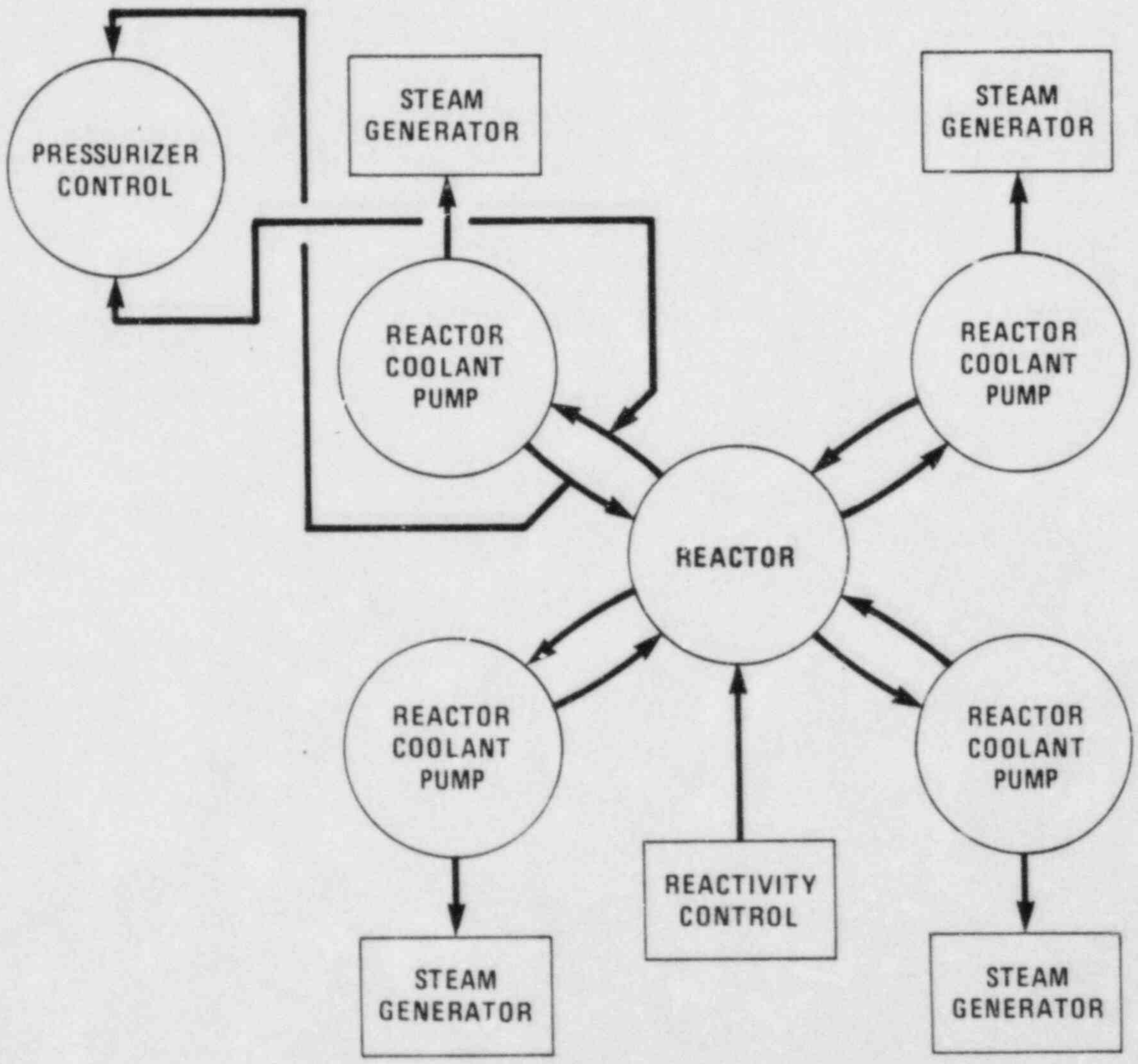
1. Diesel generator
2. Control room air handling
3. EAB HVAC
4. FHB HVAC
5. MSIV above seat drain isolation valves

HOUSTON
LIGHTING
&
POWER CO.

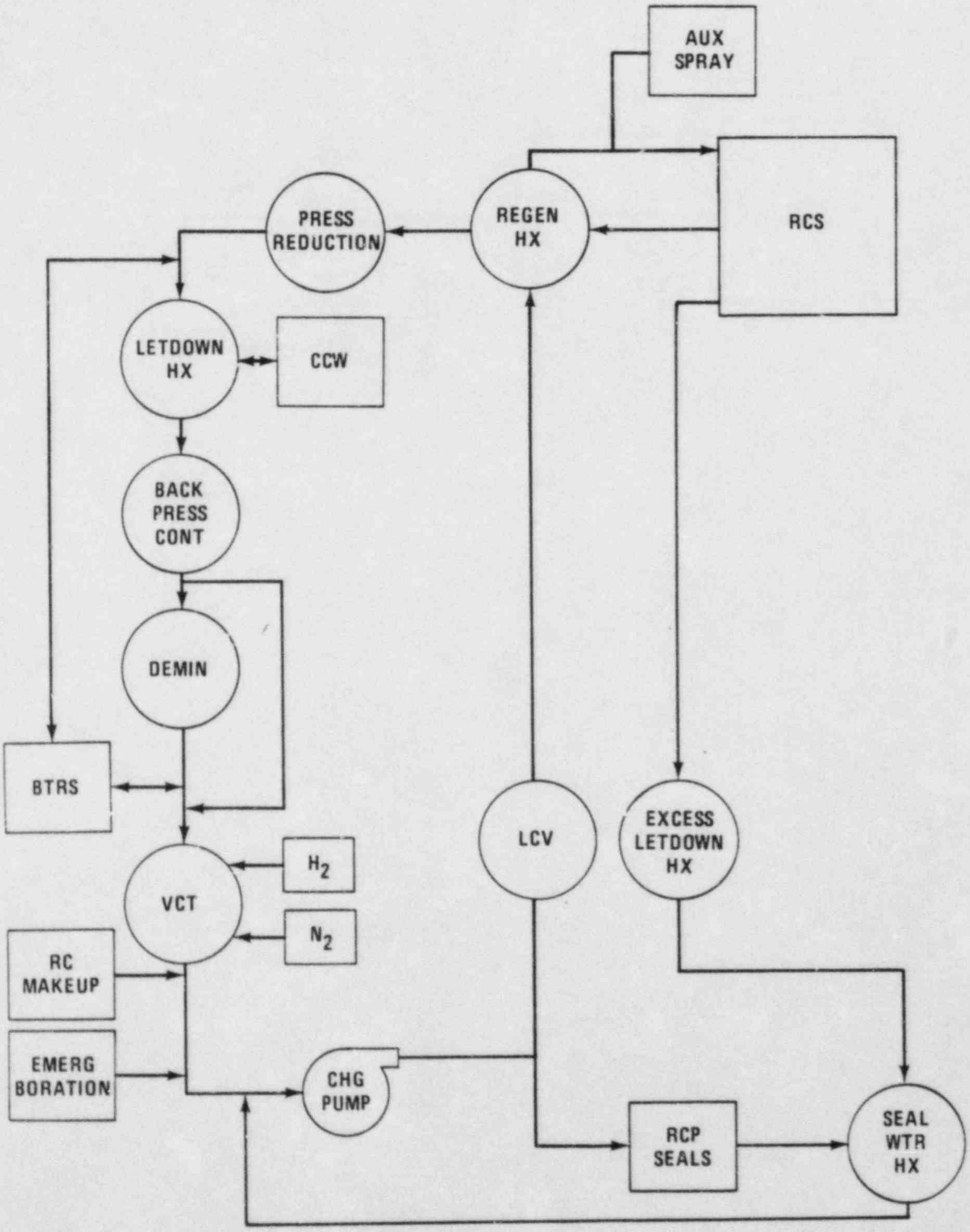
**CONTROL ROOM DESIGN REVIEW**



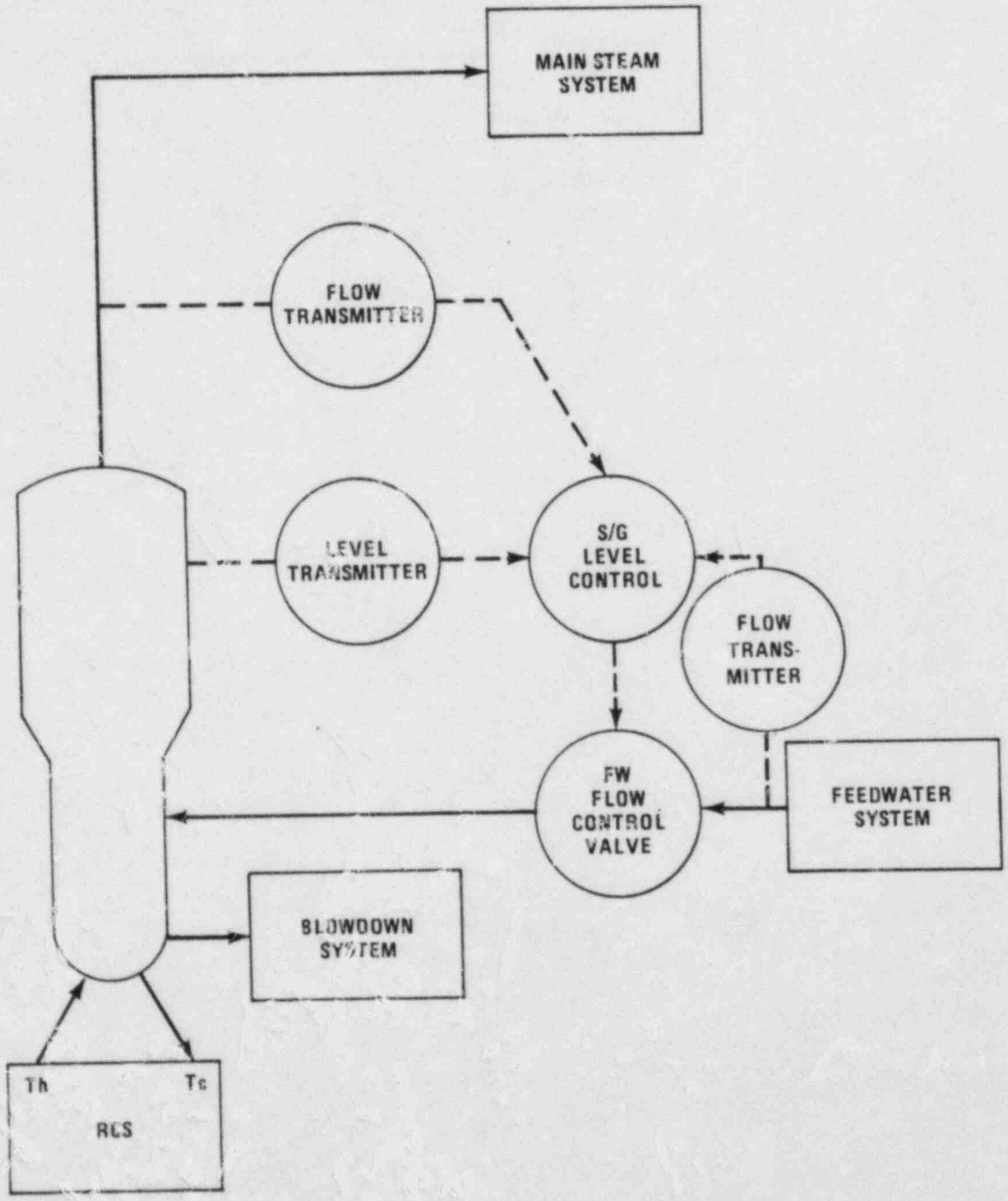

**INTERACTION OF MAJOR SYSTEMS DURING NORMAL POWER GENERATION**
**Figure 2.3-1**



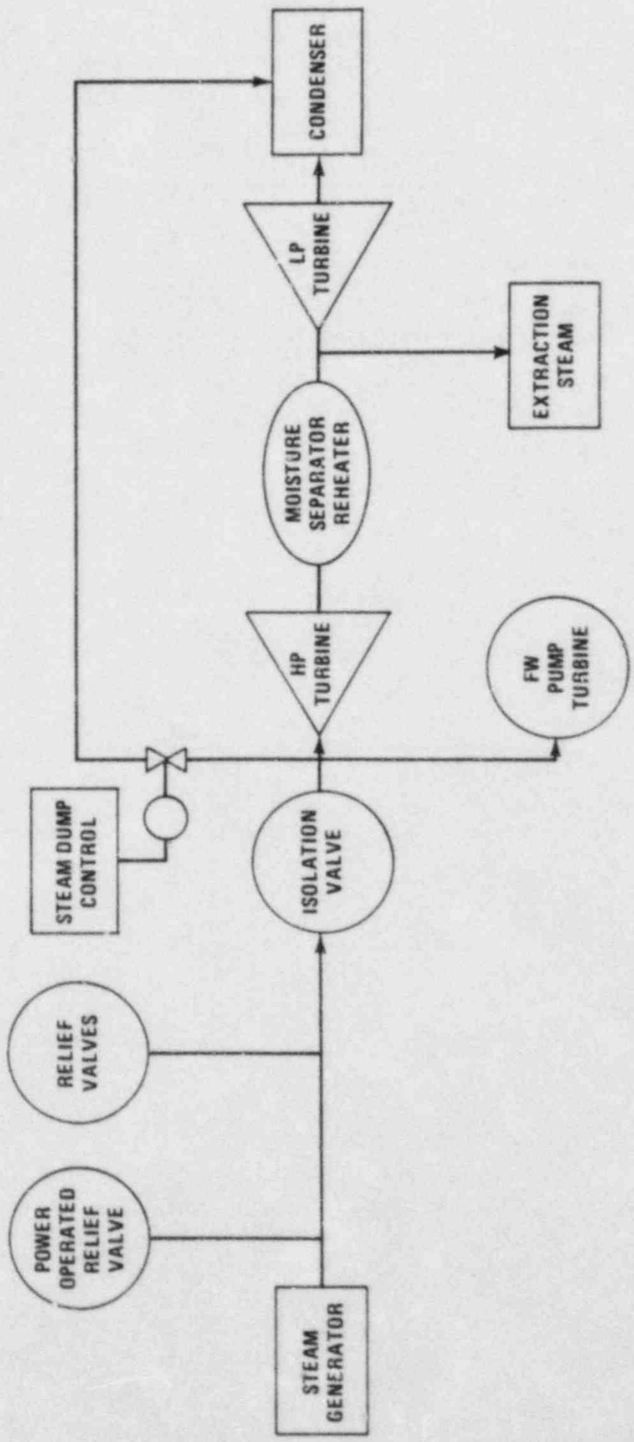

REACTOR COOLANT SYSTEM
FLOW DIAGRAM
Figure 2.3-2



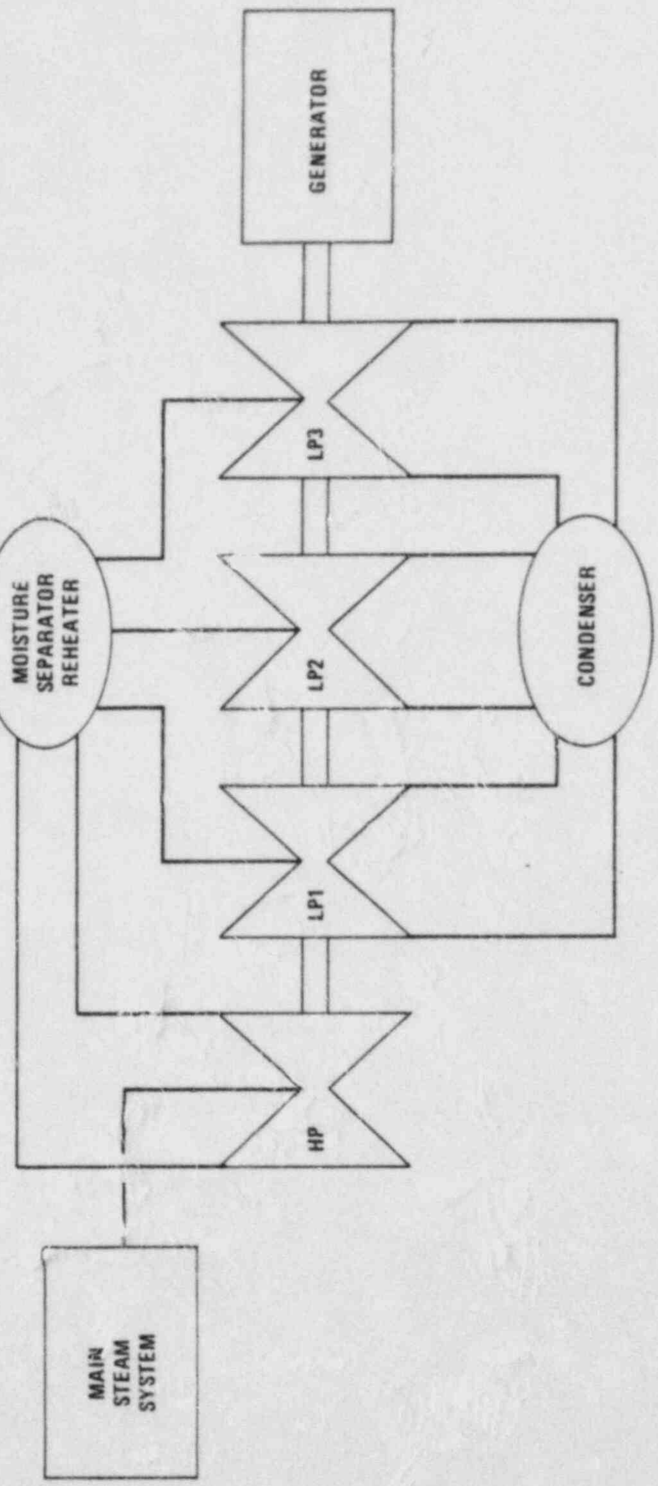

SCHEMATIC DIAGRAM
CHEMICAL VOLUME CONTROL SYSTEM
Figure 2.3-3



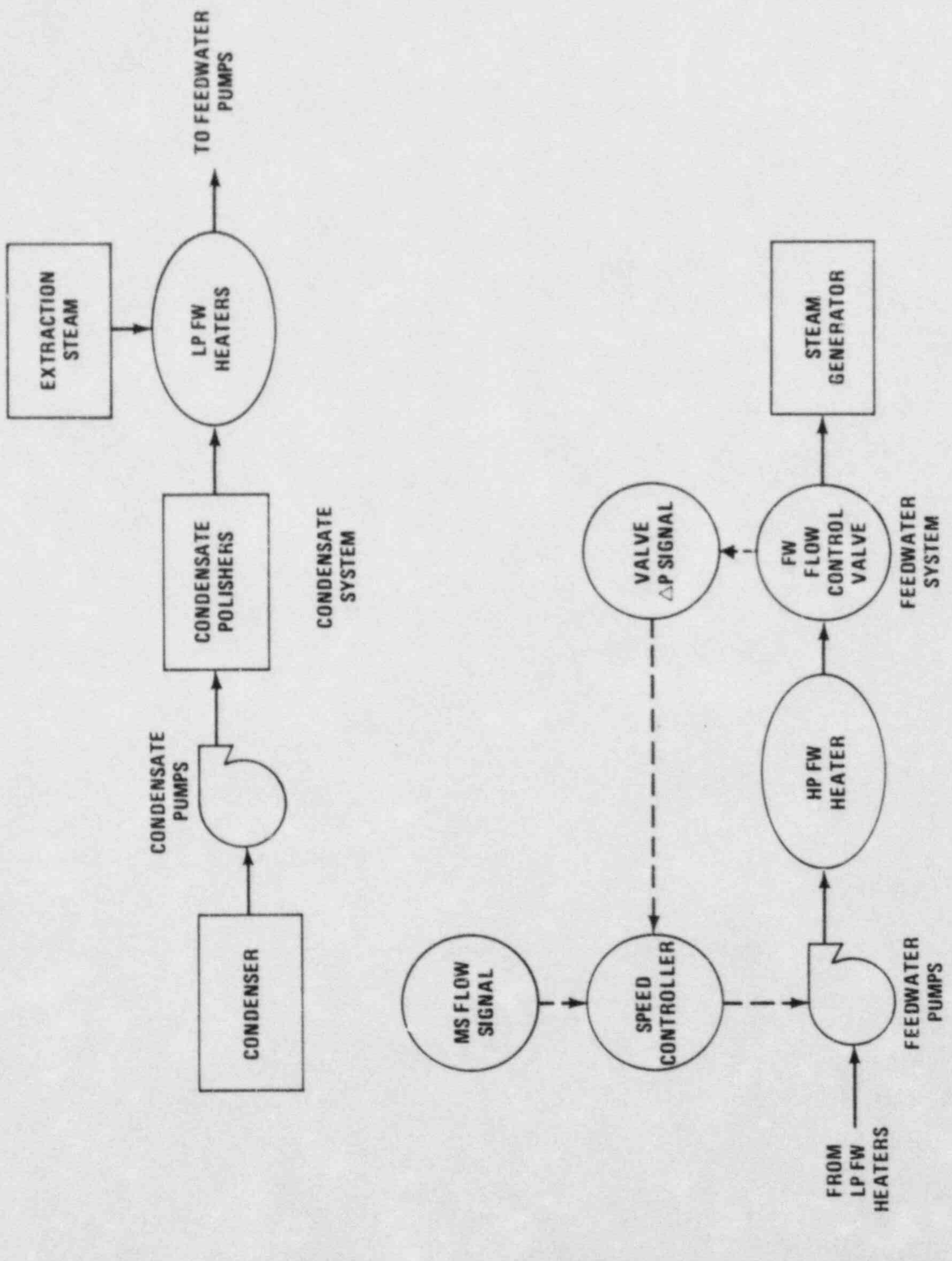

STEAM GENERATOR FLOW
DIAGRAM
Figure 2.3-4



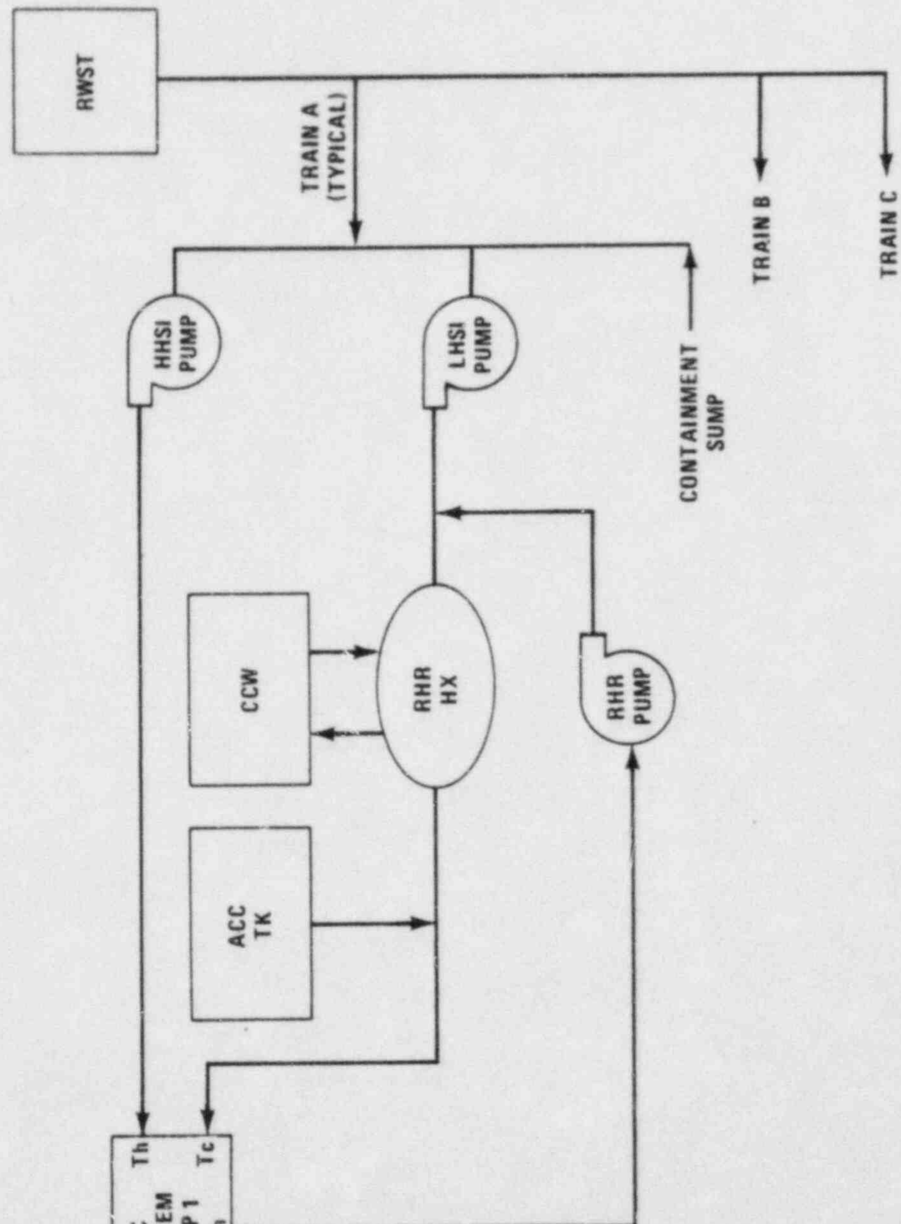

MAIN STEAM SYSTEM
Figure 2.3-5



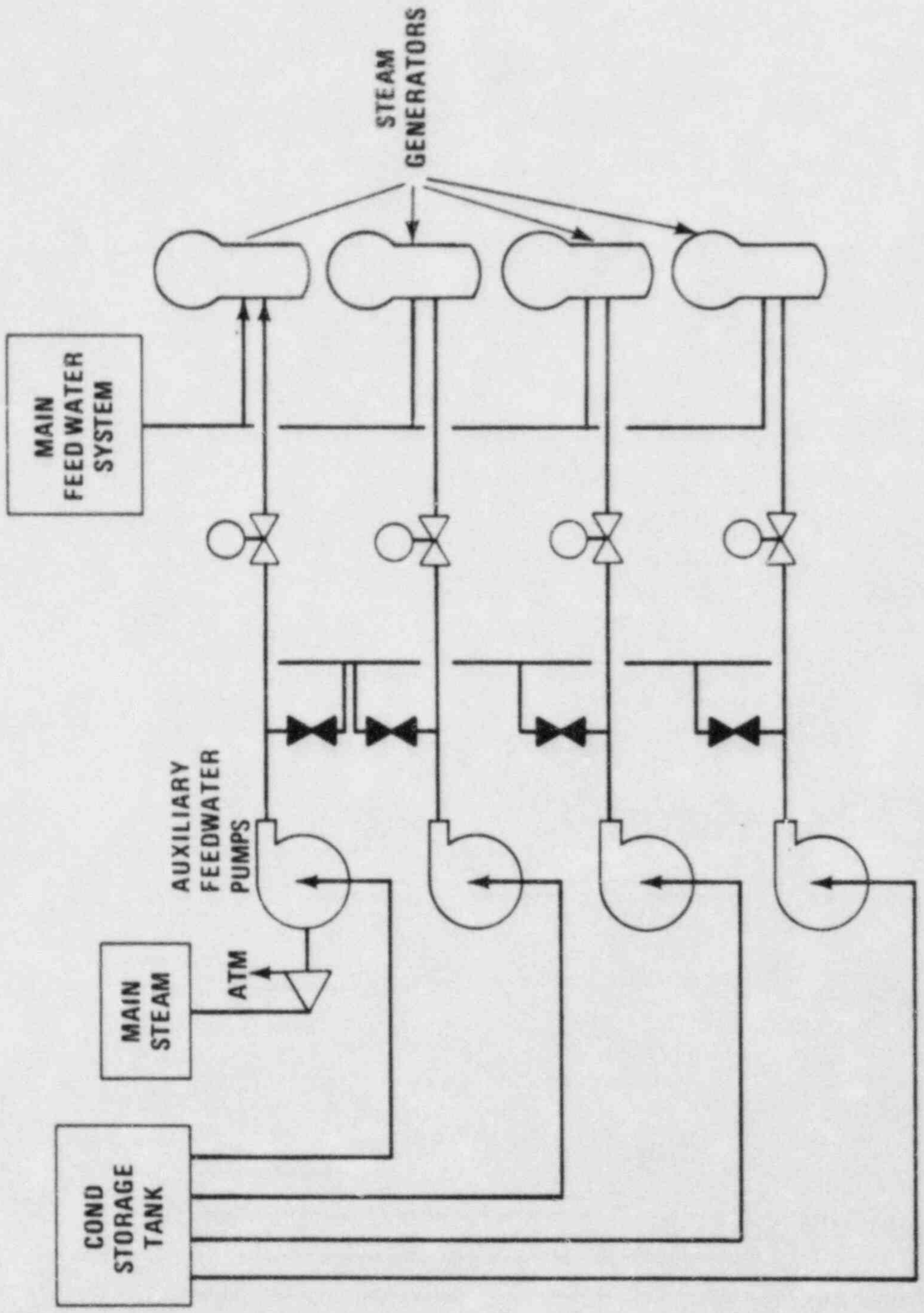

TURBINE GENERATOR
SCHEMATIC DIAGRAM
Figure 2.3-6




CONDENSATE AND FEEDWATER SYSTEMS
Figure 2.3-7




SAFETY INJECTION AND
RESIDUAL HEAT REMOVAL SYSTEMS
Figure 2.3-8




AUXILIARY FEEDWATER SYSTEM
Figure 2.3-9

## 2.4 EMERGENCY RESPONSE FACILITIES

As a result of TMI, the NRC has instituted NUREG-0696, NUREG-0737 Supplement 1, and NUREG-0814 which contain criteria for emergency response facilities. The control room serves as one element in the facilities complex. The following paragraphs describe the role of each facility in an emergency situtation.

The emergency response facilities consist of the following:

A. Technical Support Center (TSC)

The TSC provides plant management and technical support to plant operations personnel during emergency conditions. In this way, the reactor operators are relieved of peripheral duties and communications not directly related to reactor system manipulations. The TSC is located in the same building as the control room.

B. Control Room

The control room is the location from which actual plant operations are performed. It contains the controls, displays and instrumentation to enable the operators to make control actions and to observe subsequent system response.

C. Operations Support Center (OSC)

The OSC provides a location where plant logistic support can be coordinated during an emergency. Operations personnel are assembled here and may be called to assist the control room operators in performing actions outside of the control room. The OSC is located in the maintenance area in the administration building.

D. Emergency Operations Facility (EOF)

The EOF is located approximately one mile from the plant site and provides the following functions:

1. Management of overall plant emergency response

2. Coordination of radiological and environmental assessment

3. Determination of recommended public protective actions

4. Coordination of emergency response activities with Federal, State, and local agencies

5. Dissemination of information to the public

## 3.0 CONTROL ROOM LAYOUT AND FEATURES

### 3.1 CONTROL ROOM ARRANGEMENT

The Control room layout for STP is illustrated in Figure 3.1-1. The control room envelope is defined as an enclosed area which contains those controls, instrument displays and alarms necessary to operate the plant, plus life support systems to house the operators on a continuous 24-hour basis.

#### 3.1.1 Primary Control Panels

Within the control room envelope is an area designated as the Primary Operating Area. This area is shown as the shaded area in Figure 3.1.1. As shown in the figure, the primary operating area contains ten control panels, which in turn contain the controls, instrumentation and displays associated with operating the plant during the modes of operation defined in Section 2.2.

Overall plant operation is reflected by the performance of its constituent systems and their respective subsystems and components. The constituent systems controlled within the primary operating area are the following:

A. Panels CP 001, 002, and 003 contain the Engineered Safety Features (ESF) systems, Trains A, B, and C. These systems are safety related Class 1E systems, i.e., electrically independent and physically separated from each other and from nonsafety related equipment in accordance with Regulatory Guide 1.75. The ESF systems include the following subsystems:

   1. Residual Heat Removal System
   2. Safety Injection
   3. Containment Spray
   4. Emergency Diesel Generator

5. Component Cooling Water System
6. Essential Cooling Water System
7. Reactor Containment Fan Coolers

B. Panel CP 004 contains the Chemical and Volume Control system and the Reactor Coolant Pump system.

C. Panel CP 005 contains the Reactor Coolant system plus the Reactor system. The Reactor system includes the control rod drives and the nuclear instrumentation.

D. Panel CP 006 contains the Steam Generator (S/G) level controls, the auxiliary feedwater system controls, the S/G blowdown controls, controls for the 3 turbine driven feedpumps, Main Steamline Isolation and the Main Steam PORVs.

E. Panel CP 007 contains the controls for the main Turbine-Generator and the Moisture Separator Reheater.

F. Panel CP 008 contains the Feedwater and Condensate systems including controls for the low pressure and high pressure heater drip pumps.

G. Panel CP 009 contains the Circulating Water system.

H. Panel CP 010 contains the Electrical Power distribution controls and controls for placing the main generator on line.

3.1.2 Secondary Control Panels

In addition to the control panels in the primary operating envelope, several control panels are located in the control room envelope for convenience. These are as follows:

A. CP 011 - Nuclear Instrumentation

B. CP 012 - Flux Mapping

C. CP 013 - Motion Seismic Monitoring

D. CP 014 - Vibration Monitoring

E. CP 015 - Loose Parts Monitoring

F. CP 022 - HVAC Controls

G. CP 018 - General Purpose Recorders

H. CP 019 - Fire Protection

3.1.3 Display Systems

Several display systems are specifically located in the control room in order to facilitate the control room operators' response to abnormal or emergency situations. These are:

A. Bypass/inoperable status system per Regulatory Guide 1.47

B. Post-accident monitoring system per Regulatory Guide 1.97

C. Safety parameter display system

D. Overall plant annunciator system

In addition to the above, the control room houses a computer to perform annunciation, data logging, and other functions to enable the control room operators to make assessments of plant conditions and radiological releases.

## 3.2 CONTROL ROOM FEATURES

The following features are relevant to the control room design:

A. The control room shall be arranged to facilitate plant operations during normal and abnormal conditions as the prime objective.

B. The operational controls and associated instrumentation shall be laid out in a functional manner, i.e., system to system as related to normal sequence of operation, and within each system as related to the flow path or sequence of operation.

C. The control room shall be esthetically pleasing since it is the only area in the plant that will be occupied for 24 hours per day for the design life of the plant.

D. The control room layout shall be designed so that nonoperating personnel such as technicians may gain access to the relay room and computer areas without passing near the main operating consoles.

E. A communications and log desk separate from the main control panels shall be provided to enable the operator to communicate with any area in the plant as well as off site.

F. A storage area shall be provided for the storage of emergency equipment such as first aid, anti-C clothing, emergency radiation monitoring equipment, and self-contained breathing apparatus.

G. The control room shall be designed for control by two operators and one supervising operator.

H. The supervising operator's office shall be designed and located so as to provide him with a view into the operator control area.

I. The control panels shall be designed for stand-up operation.

J. The control room shall be a secured area with controlled access. Each entrance to the control room shall be protected so that unauthorized personnel are prevented from entering the control room. All unprotected entrances shall be maintained in a secured closed position with adequate provision for safe emergency fire exit.

K. Equipment and space shall be provided for the operators' personal convenience. The convenience features shall include:

1. Restroom facilities
2. Kitchen or eating facilities, e.g., microwave oven and refrigerator
3. torage for garments and personal gear
4. Desks, tables, chairs, bookcases, etc.

## 3.3 CONTROL ROOM ENVIRONMENTAL CRITERIA

The main control room environment shall be maintained by automatic heating and air-conditioning units which control the temperature and humidity within the comfort zone for the operating personnel. For the extreme outside conditions defined in the FSAR, the control room environment shall be capable of being maintained within the following limits:

A. Temperature, 65-80°F

B. Relative Humidity, 30-80%

Attention shall also be given to protection from vapors, dust, and radiological sources. Carpets consistent with fire requirements are desirable to minimize dust movement and to enhance acoustics.

The control room envelope shall be sufficiently leak tight, and the ventilation system shall have sufficient capacity, so that the control room can be maintained at a slight positive pressure above atmosphere. The objective of this feature is to prevent the diffusion of smoke or contaminants from outside to inside the control room.

Adequate space shall be provided to store and use the documents while the operator pursues his duties during normal and abnormal conditions.

## 3.4 COMMUNICATIONS

Communication links capable of allowing continuous information exchange to onsite and offsite locations shall be provided. The communications shall be as described in Section 7.0, and will generally consist of:

A. Commercial telephone

B. Dedicated telephone

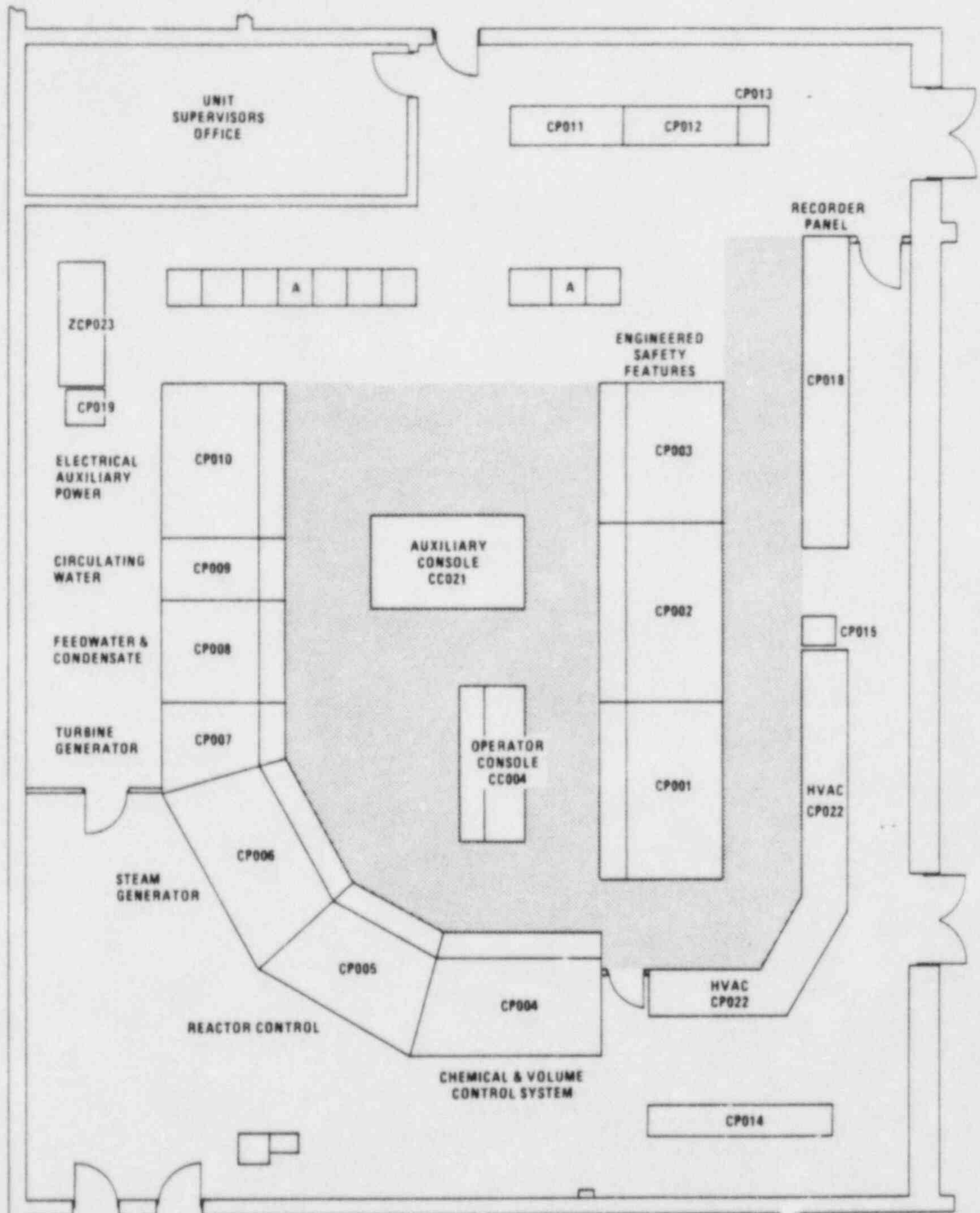
C. Radio transceiver

D. Plant paging system

E. Sound powered phones

## 3.5 AUXILIARY SHUTDOWN STATION

Sufficient manual controls shall be provided outside the control room to bring the plant to a safe shutdown condition should evacuation of the main control room become necessary. Criteria for the Auxiliary Shutdown Station are described in Section 5.0.




CP011 – NUCLEAR INSTR. PANEL
CP012 – FLUX MAPPING
CP013 – MOTION SEISMIC MONITORING
CP014 – VIBRATION MONITORING

– CRDR EVALUATION AREA
CP015 – LOOSE PARTS MONITORING
CP019 – FIRE PROTECTION PANEL
A – COMPUTER TYPERS
ZCP023 RADIATION MONITORING

CONTROL ROOM LAYOUT
**Figure 3.1-1**

# 4.0 MAIN CONTROL PANELS

## 4.1 GENERAL CRITERIA

Process Systems and equipment monitoring is required to provide the control room operators with sufficient information to establish operating conditions of plant systems, subsystems and components controlled from the control room.

Overall Plant performance is reflected by the performance of its constituent systems and their respective components. Selective monitoring of system and equipment parameters provides representative data of operating conditions.

Primary considerations in selecting which system and equipment parameters to monitor, where to display this information and how to display this information are:

A. Frequency of usage of the controls.

B. Consequences of the operator not being able to take necessary action.

C. The urgency of corrective action required by the operator.

D. The importance of the system or equipment to plant safety and overall performance.

E. Vendor recommendations for monitoring vendor supplied packages.

F. The reduction of personnel radiation exposure.

## 4.2 DISPLAY EQUIPMENT

Selected process system parameters shall be monitored to provide representative data of plant operating conditions and to enable operating personnel to attain an optimum level of plant performance and safety. The type and location of display shall be as follows:

### 4.2.1 Indicators

Considerable use of hardwired indicators shall be made to provide a continuous display of pertinent process parameters which shall enable operating personnel to rapidly assess the performance of systems during transient and steady state operation. Indicators shall be provided and located according to system operating requirements.

### 4.2.2 Recorders

2 Use of hardwired recorders shall be made to augment or replace an indicator when the following information is required of the analog variable:

A. When a hard copy of the variable versus time is required for historical purposes.

B. When required by licensing commitments.

C. When relatively short time base trending information on a continuous basis is required for operator assessment.

### 4.2.3 Computers

2 The computer systems are the Plant Computer, Emergency Response Facilities Computer (ERF-DADS), Qualified Display Processing System (QDPS), Radiation Monitoring Computer (RMS) and the Fire Protection computers.

The computer systems shall compliment and/or duplicate panel-mounted hardwired displays of Process System parameters in order to increase the amount ofinformation available to the operator. The computer systems shall be utilized for supervisory monitoring of the following: 2

A. All Process System parameters which are required for performance calculations.

B. Major Process System parameters which do not require continuous display.

C. Major process parameters which enable the operator to determine the conditions of Process System operation.

D. All Process System parameters which are required for periodic logging.

E. All Process System parameters which are required to analyze the causes for inadvertent or unplanned plant shutdowns.

Additional criteria applicable to the plant computer is contained in Section 12.0.

4.2.4 Annunciators

Annunciator windows alert the operator to abnormal equipment operating conditions. Undesirable equipment operating conditions which require prompt operator attention are displayed by annunciator windows. The control room annunciators are part of an integrated annunciation plan described in Section 8.0.

## 4.3 CONTROL ROOM SWITCHES

### 4.3.1 General

To provide a consistent approach to the operation of various types of equipment and to minimize operator error, control switches in the main control room shall be in accordance with Table 4.3-1.

The type of equipment being controlled and the required modes of operation shall determine the type of switch, switch action and nameplate engraving.

Control switches shall be provided with an auto position, and the word "auto" engraved on the nameplate, if the equipment satisfies the following criteria:

A. Pump or fan subject to automatic starting.

B. Motor operated or solenoid operated device subject to automatic opening and/or closing.

If a pump or fan is designed to automatically stop due to any type of protective action, it shall not be considered an auto function.

### 4.3.2 Pumps and Fans

All pumps and fans shall be controlled by General Electric type SBM switches with pistol grip handles. The switches shall be provided with a pull to lock position and shall be either Type 1 or 2 as indicated in Table 4.3-1.

Control circuits designed for automatic operation shall incorporate the following features:

A. The equipment can be started by the operator at any time and shall remain running when the switch returns to the auto position.

B. The equipment can be stopped by the operator at any time but will restart if the auto start signal is still on.

C. If the equipment started automatically and the auto start signal has been removed, the equipment shall remain running until stopped by the operator.

If start permissives are required, they shall be incorporated into the start circuit for all starting conditions. Protective trip devices shall be incorporated into the stop circuit and shall remain active at all times unless bypassed during ESFAS operation.

If the equipment is automatically started by the ESFAS, the logic shall preclude the operator from tripping until the ESFAS signal is reset.

#### 4.3.3 Motor Operated Valves and Dampers

All motor operated valves and dampers shall be controlled by General Electric type CR 2940 spring return selector switch units with standard operators or micro switch type PTS spring return selector switch units with knob type operators. The switch shall be either Type 3 or 4 as indicated in Table 4.3-1. 2

Control circuits designed for fully automatic operation shall incorporate the following feature:

A. The equipment can be opened or closed by the operator but shall return to the position determined by the auto signal.

TABLE 4.3-1

MAIN CONTROL ROOM CONTROL SWITCH TYPES

| Switch Type | Controlled Device | Automatic Operation | Switch Mfg/Type | Nameplate | Switch Action |
|---|---|---|---|---|---|
| 1 | Pump or Fan | No | G.E./SBM | PTL-Stop-xx-Start | Maintained in PTL. S.R. to xx from Start & Stop. |
| 2 | Pump or Fan | Yes | G.E./SBM | PTL-Stop-Auto-Start | Maintained in PTL. S.R. to Auto from Start & Stop. |
| 3 | MOV or Damper | No | G.E./CR 2940 or Micro Switch PTS (3) | Close-xx-Open | S.R. to xx from Open and Close |
| 4 | MOV or Damper | Yes | G.E./CR 2940 Micro Switch PTS (3) | Close-Auto-Open | S.R. to Auto from Open and Close |
| 5 | Solenoid Operated | No | G.E./CR 2940 Micro Switch PTS (3) | Close-Open | Maintained in both positions |
| 6a | Solenoid Operated | Yes | G.E./CR 2940 Micro Switch PTS (3) | Close-Auto-Open | Maintained in both positions |
| 6b | Solenoid Operated | Yes | G.E./CR 2940 Micro Switch PTS (3) | Auto-Open Close-Auto | Maintained in both positions |
| 7 | Solenoid Operated (ESF Components) | Yes | Micro Switch PTS (3) | Close-Auto-Open | S.R. to Auto from Open and Close(1) |
| 8 | Solenoid Operated (Non-ESF Components) | Yes | G.E./CR 2940 | Close-Auto-Open | Maintained in all positions(2) |

2

| Abbreviation | Denotes |
|---|---|
| PTL | Pull to lock switch position |
| S.R. | Spring return switch action |
| xx | Denotes normal switch position |

NOTE

1. On ESF Components, a maintained switch position (open or close) shall be provided for the safe or failure position of the device.
2. On non-ESF components, override capability shall be provided if it will not cause potential damage to equipment or danger to operating personnel.
3. Class 1E switches are micro switch type PTS. Non 1E switches are GE type CR 2940. 2

Control circuits designed for automatic operation in one direction only shall incorporate the following design features:

A. The equipment can be driven in the direction commanded by the auto signal and shall remain in that position until commanded to the opposite direction.

B. The equipment cannot be driven in the direction opposite to that commanded by the auto signal if the auto signal is on.

C. The equipment can be driven in the direction opposite to that commanded by the auto signal if the auto signal is off and shall remain in that position until the auto signal is on or until commanded by the operator.

4.3.4 Solenoid Operated Devices

All solenoid operated devices shall be controlled by General Electric type CR-2940 selector switch units with standard operators or micro switch type PTS spring return selector switch units with knob type operators. The switch action shall be determined by the safety class and mode of operation and shall be either type 5, 6, 7 or 8 as indicated in Table 4.3-1. 2

Control circuits designed for ON-OFF operation shall be controlled by switch Type 5.

If the equipment is subject to automatic operation with manual control for one direction only, it shall be controlled by switch Type 6a or 6b.

When it is required to manually operate the device to both the open and close positions, switch Type 7 or 8 shall be used. Refer to Notes 1 and 2 following Table 4.3-1 to determine the correct switch action.

## 4.4 PROCESS SYSTEMS - CONTROL ROOM MONITORING

### 4.4.1 Water/Oil Storage and Transfer

Water/oil storage and transfer systems consist of the following:

A. Condensate storage and transfer

B. Reactor makeup water

C. Fire protection

2 The process monitoring criteria are the following:

A. Major system parameters shall be monitored by the computer. These points include:

1. Pump discharge pressure or header pressure
2. Flows important to system operation
3. Tank levels important to system operation

B. Critical tanks shall have continuous indication and high and/or low level alarms.

C. Controlled variables imperative to plant operation shall be provided with Control Room indication and/or alarm to warn of conditions exceeding normal control limits. Depending on the significance of the variable, hardwired or computer alarms can be used. Hardwired alarms should be used for the more significant functions.

D. The discharge pressure of all major pumps or header pressure shall be displayed to allow the operator to assess the operation of the pump(s).

4.4.2 Cooling Water Systems And Support Systems

Cooling water systems consist of the following:

A. Essential Cooling Water System

B. Component Cooling Water System

C. Circulating Water

D. Auxiliary Cooling Water - Open and Closed Loop 2

E. Chilled Water

F. Screen Wash

The process monitoring criteria are the following:

A. Major system parameters shall be monitored by computer. These points include:

1. Pump discharge pressure or header pressure

2. All major system flows

3. Tank levels important to system operation

4. Temperature

5. Radiation.

B. Major tanks shall have Control Room indication and high and/or low-level alarms.

C. Process variables which support equipment operation but do not require immediate tripping action shall be alarmed.

D. The discharge pressure of major pumps or header pressure shall be displayed to allow the operator to assess the operation of the pump(s).

E. Permanent filters and strainers whose differential pressure is critical to system operation shall have annunciator alarms.

F. If an on-off control has override capability from the Control Room, indication of the affected process variable shall be provided.

G. Instrumentation shall be provided to determine heat exchanger performance. Outlet pressure and/or temperature, depending upon system configuration, shall be monitored locally or by computer.

H. Where filters are provided in pump discharges or common headers, auto start pressure interlocks and alarms shall be monitored downstream of the filter.

I. As a minimum, computer monitoring of supply and return header temperature shall be provided for all cooling water systems. Principal heat loads within a system shall have outlet temperatures monitored by the computer.

J. Radioactivity monitoring shall be provided on selected process streams to indicate possible process system malfunctions and to prevent the contamination of clean or non-radioactive process liquids.

### 4.4.3 Secondary Coolant

The secondary coolant system consists of the following:

A. Main Steam System

B. Condensate System

C. Feedwater System

D. Steam Generator Blowdown System

E. Extraction Steam System

F. Heater Drips and Drains System

G. Turbine Vents and Drains

H. Condenser Gas Removal System.

The process monitoring criteria are the following:

A. Variables which provide input for automatic analog control systems shall be displayed.

B. Controlled variables imperative to plant operation shall be provided with indication and/or alarms to warn of conditions exceeding normal control limits. Depending on the significance of the variable, hardwired or computer alarms can be used. Hardwired alarms shall be used for the more significant functions.

C. Major system parameters shall be monitored by computer. These points include:

1. Pump discharge pressure or header pressure.

2. System temperature as required at points before and after equipment which could affect fluid temperature. For equipment which is in parallel service or which has divided compartments, each section shall be monitored separately.

3. Temperature, pressure and flow points required for performance calculations.

4. Flows important to system operation.

5. Tank levels important to system operation.

D. Radioactivity monitors shall be provided on selected processes to indicate possible process system malfunction.

E. Major tanks shall have Control Room indication and level alarms.

4.4.4 Water Treatment Systems

The water treatment systems shall not be controlled from the Control Room. The condensate polishing systems shall have bypass control in the Control Room only. 2

The process monitoring criteria are the following:

A. Filters and strainers imperative to system operation shall have high differential pressure alarms.

B. Major tanks shall have a level indication and/or alarm.

C. Indicators/recorders shall be provided to monitor parameters essential to the system operation like ph of feedwater to the reverse osmosis modules, conductivity of reverse osmosis module effluent, conductivity of demineralizer effluent, conductivity of system effluent.

D. Alarms shall be provided to annunciate system trouble for the makeup demineralizer system.

4.4.5 Air Systems

Air Systems include the following:

A. Instrument Air System

B. Station Air System

The process monitoring criteria are the following:

A. If an on-off control has override capability from the Control Room, indication of the affected process variable shall be provided.

B. Controlled variables important to plant operation, shall be provided with indication and/or alarms to warn of conditions exceeding normal control limits. Depending on the significance of the variable, hardwired or computer alarms can be used. Hardwired alarms should be used for the more significant functions.

C. All major system parameters shall be monitored by the computer. These points include each system header pressure.

4.4.6 Vent And Drain Systems

Vent and drain systems consist of both radioactive and non-radioactive vents and drains.

The process monitoring criteria are the following:

A. Drain sump level switches shall be utilized for sump pump controls and annunciator alarms.

2 B. Filters and strainers imperative to system operation shall have high differential pressure alarms.

4.4.7 Cooling Reservoir Systems

Cooling reservoir systems consist of the following:

A. Reservoir Makeup Pumping

B. Reservoir Blowdown

C. Reservoir Spillway

The process monitoring criteria are the following:

A. Alarm and process information on the operation of the reservoir facilities shall be displayed in the main Control Room. 2

4.5 EQUIPMENT MONITORING

4.5.1 Computer Monitored Equipment Status

A. The computer shall monitor the operating status of the following equipment:

1. Each ESF diesel

2. Each ESF pump of any rating

3. The BOP diesel generator

4. Each emergency pump driven by a DC motor 2

5. Each HVAC chiller

6. Each safety-related and selective non-safety related fan motors

7. Selected pumps rated less than 250 HP such as lube oil pumps, cooling water pumps, EH fluid pumps or instrument air compressors whose tripping could cause damage to equipment or cause unit trip

8. Each ESF offsite supply breaker

2

9. Each 13.8 kV auxiliary bus distribution breaker

10. Each 4.16 kV auxiliary bus distribution breaker

11. Each 480 V electrical operated distribution breaker

B. The computer shall monitor the trip status of the following equipment:

1. Each ESF pump and fan breaker of any rating

2. Each ESF diesel

3. Each turbine driven pump

4. Each emergency pump driven by a DC motor

2

5. Selected nonsafety pumps rated less than 250 HP such as lube o pumps, cooling water pumps, EH fluid pumps or instrument air compressors whose tripping could cause damage to equipment or cause unit trip

6. The BOP diesel generator

7. Each switchyard circuit breaker

8. Each ESF offsite supply breaker

9. Each 13.8 kV auxiliary bus distribution breaker 2

10. Each 4.16 kV auxiliary bus distribution breaker

11. Each 480 v Electrical operated distribution breaker.

4.5.2 Valves

The following criteria apply to motor operated valves, air operated valves and solenoid operated valves directly connected to the process.

A. Position indication shall be provided for all valves controlled from the Control Room. 2

4.5.3 HVAC Equipment

The following criteria apply to HVAC equipment.

A. HVAC dampers that are safety related and non-modulating shall be provided with status lights at the control switch location.

B. The operation status of both safety and non-safety related chillers shall be provided by indicating lights at each control switch location. 2

# 5.0 AUXILIARY SHUTDOWN PANEL

## 5.1 FUNCTION

The Auxiliary Shutdown Panel (ASP) provides an alternate control station where the plant can be brought and maintained to safe shutdown conditions in the event that the main 2
Control Room becomes uninhabitable.

## 5.2 GENERAL CRITERIA

Sufficient manual controls and instrumentation shall be provided outside the Control 2
Room to maintain a safe shutdown condition should evacuation of the Control Room become necessary. The controls provided shall be located on the auxiliary shutdown panel for those system components which are not accessible for local control. Other system components may be located on the auxiliary shutdown panel for convenience.

All controls required for safe shutdown outside the Control Room shall be designed to comply with applicable regulatory requirements. All these controls shall be located in areas which are environmentally controlled separately from the Control Room, i.e., a condition necessitating evacuation of the Control Room due to Control Room internal environmental upset, shall not prevent access to these controls. 2

## 5.3 INTEGRATION OF CONTROLS

The capability to bring the plant to a safe shutdown outside the control room shall be a 2
combination of locally operated equipment and equipment operated from the ASP.

The systems that do not have full system local control but will have controls on the ASP are:

Residual Heat Removal

Accumulator Isolation

Boric Acid Transfer

Letdown

Charging

2 Pressurizer Pressure Control

Pressurizer Pressure Relief

Reactor Head Vent

Auxiliary Feedwater

They will have the associated control switches, meters and controllers. Annunciation and additional indication will be provided by two QDPS plasma displays.

Control shall be shifted to the ASP by the use of transfer switch panels located in the appropriate switchgear rooms. Transfer swithces for train D components shall, however, be located on the ASP.

Access to the ASP area shall be controlled and alarmed in the main control room.

## 5.4 GUIDELINES

The ASP shall meet the requirements for the Main Control Panel. Additional requirements are contained in the following sections and their related appendices:

6.0 Human Factors Guidelines 2

7.0 Communication Criteria

12.0 Plant Computer Features

# 6.0 HUMAN FACTORS GUIDELINES

## 6.1 CONTROL ROOM WORKSPACE

### 6.1.1 General Layout

The purpose of the control room is to provide a central point for plant operation. All information needed for safe operation shall be within the control room area. Systems shall be operable or monitored from the control panels and these panels shall conform to the normal physical limitations of the operator.

#### 6.1.1.1 Accessibility of Instrumentation and Equipment (Ref: NUREG-0700, Sec. 6.1.1.1)

Main control panel instrumentation and equipment shall include those controls and displays that are essential to detect abnormal conditions and to bring the plant to a safe shutdown.

During operational sequences when continuous monitoring or the timing of control actuation is essential, operators shall not be required to attend to instrumentation located beyond the primary operating area.

#### 6.1.1.2 Staffing and Equipment Layout Consistency (Ref: NUREG-0700, Sec. 6.1.1.2)

Control room staff and individual task assignments shall ensure total and responsive coverage of controls, displays and other equipment required during all phases or modes of plant operations.

6.1.1.3 Furniture and Equipment Layout
(Ref NUREG-0700, Sec. 6.1.1.3)

Equipment spacing and placement is dependent upon control room configuration, staffing, and other relevant design features. Furniture and equipment layout shall conform to the following criteria:

A. Desks and consoles placed in the primary operating area shall permit operators at those desks or consoles full view of all control and display panels, including annunciator panels in the primary operating area.

B. Desk and console placement shall allow voice communications with other staff personnel within the primary operating area.

C. Operators shall have access to any work station without impediments such as poorly located cabinets, desks, and other similar obstacles or tripping hazards such as loose cords and equipment.

D. Convenient positioning for performing any task at any work station is essential.

E. Space allowances for an operator seated at a console or desk shall allow unrestricted individual mobility in leaving or entering the chair/console work station. A minimum of 36 inches from operator's edge of the console or desk or any opposing surface is required. Lateral space required shall be no less than 30 inches. Greater space allowances are preferred.

F. A minimum separation of 50 inches is required between a single row of stand-up vertical panels/equipment and adjacent panels or other obstructions.

G. A minimum of 50 inches shall separate two rows of facing stand-up vertical panels that must be operated by one operator.

H. A minimum of eight feet shall separate facing stand-up vertical panels that must be operated by more than one person.

I. Panels and equipment enclosures shall be designed and maintained so that no unguarded openings exist through which unwanted objects can be introduced.

6.1.1.4 Document Organization and Storage
(Ref: NUREG-0700, Sec. 6.1.1.4)

It is essential that a good system of document storage and retrieval be implemented for quick and easy access. Types of documents include, for example, plant schematics, procedures, check-off sheets, emergency plans, technical manuals, and station and general administrative orders. The following criteria shall be met for control room documents:

A. All procedures and other necessary documents that are needed for reference shall be maintained within the control room envelope in an area where they can be easily located and used.

B. Clearly visible labels identifying the documents are required.

C. Search and identification time will be reduced by separating operational documentation from other documentation or coding documents with coding techniques such as color coded binding, etc.

D. Documents shall be portable, not constrained in racks and shall be bound so that they will remain open when in use.

E. Protection and maintenance of documents is necessary to keep them from becoming dog-eared, torn, dirty, and difficult to read.

6.1.1.5 Spare Parts, Operating Expendables, and Tools
(Ref: NUREG-0700, Sec. 6.1.1.5)

Spare parts, such as indicator lamps, and any tools needed by the operating staff shall be stored in suitable designated spaces within the control room envelope. The following criteria shall be met for the control room expendables:

A. An adequate supply of expendables, such as fuses, bulbs, ink, ink pens, recorder charts, printer paper, etc., shall be stored for ready access.

B. All necessary or special tools required to replace expendables shall be readily available.

C. Adequate storage for the required spares and expendables shall be provided.

D. Different types, sizes or styles of expendables or spares shall be clearly and distinctively marked to avoid misapplication.

E. An inventory record of status and use of spares and expendables should be established.

6.1.1.6 Supervisor and Non-Essential Personnel Access
(Ref: NUREG-0700, Sec. 6.1.1.6)

The shift supervisor shall be located within the confines of the control room envelope and in an area that allows for prompt access to the primary operating area. Visual and voice

contact with operators in the primary operating area shall be provided. Provisions to limit access and movement of non-essential, but authorized, personnel to prescribed areas within the control room envelope shall be made.

6.1.2 Multi-Unit Control Rooms
(Ref: NUREG - 0700, Sec. 6.1.3.2)

Each of the control rooms for Units 1 and 2 of the South Texas Project shall be essentially identical, but separate and independent with no sharing of contents or personnel. The two control boards shall not be mirror imaged.

6.1.3 Work Station Design

Anthropometric Basis for Equipment Dimensions
(Ref: NUREG-0700, Sec. 6.1.2.1)

A design goal shall be established for equipment dimensions to accommodate the 5th through the 95th percentile of the user population. See Table A.1-1 of Appendix A for anthropometric data used to set limits for equipment dimensions.

Refer to Appendix A for work station design criteria specific to stand-up consoles, sit-down consoles, sit-stand work stations and vertical panels.

Refer to Appendix B for guidelines specific to desk dimensions and chairs.

Refer to Appendix C for guidelines specific to emergency equipment.

Refer to Appendix D for guidelines specific to control room environment.

## 6.2 CONTROLS CRITERIA

### 6.2.1 General

#### 6.2.1.1 Selection of Controls
(Ref: NUREG-0700, Sec. 6.4.1)

All controls shall ensure ease of operation and shall be suitable for operator use in the control room. Each control shall be the appropriate type for the function it performs.

A. Multi-rotation controls shall be used when precision is required over a wide range of adjustments.

B. Detent controls shall be used when the operational mode requires control operation in discrete steps.

#### 6.2.1.2 Adequacy
(Ref: NUREG-0700 Sec. 6.4.1.1)

All types shall be easily adjusted with the required level of precision. The precision and range of a control shall not exceed the need, reliability or safety margin.

#### 6.2.1.3 Human Suitability
(Ref: NUREG-0700 Sec. 6.4.1.1)

Each control shall be recognizable in terms of its function and shall conform to operator expectations, such as:

2 A. Rotary selector switch, CR-2940 or PTS - valve or damper operation.

B. Pistol grip, SBM - pump operation
Pistol grip, SBM - fan operation
2 Pistol grip, SBM - circuit breakers

C. Lever type handle, SBM & SB-1 - selector switch, ammeter and voltmeter selector switches
Oval type handle, electroswitch - selector switch *
Knob type handle, micro switch - selector switch * 2

D. Oval shaped handles, SBM - synchronizing switch

E. Oval shaped handle, W-2 - electrical voltage adjuster

F. Pushbuttons, CR-2940 - trips, reset functions, ESF status monitoring or annunciator lamp test and control functions
Pushbuttons, micro switch - reset and block functions *

2

G. Continuous Adjustment Rotary - process controllers, etc

* Denotes switch types when used for interface with low voltage process control or solid state protection system.

6.2.1.4 Compatibility with Emergency Gear
(Ref: NUREG-0700 Sec. 6.4.1.1)

All controls shall be compatible with emergency gear. While wearing protective equipment (e.g., oxygen masks, protective gloves), controls shall be easy to identify and easy to activate.

6.2.1.5 Durability
(Ref: NUREG-0700 Sec. 6.4.1.1)

Controls shall be sufficiently rugged to withstand normal use. Each control shall retain its appearance, "feel", and functional characteristics during its service life. Controls shall not develop internal looseness, binding or backlash.

6.2.1.6 Prevention of Accidental Activation
(Ref: NUREG-0700 Sec. 6.4.1.2)

Controls shall be located and oriented so that the operator is not likely to strike or move them accidently in any sequence of control movements. The method used shall depend (in part) on the need for rapid operator access and the seriousness of consequences following an accidental activation. Accidental activation of controls shall be minimized by one or more of the following methods:

A. Controls may be recessed, shielded, or otherwise surrounded by physical barriers. The control shall be entirely contained within the barrier.

B. Controls may be covered or guarded with movable (e.g., hinged) barriers. When the guard is in the open position, it shall not interfere with the operation of the guarded control or other adjacent controls. Safety or lock wires shall not be used.

C. Controls may be provided with interlocks which require an extra movement (e.g, pull-to-lock) or prior operation of a related or locking control.

D. When a strict sequential activation is necessary, controls shall be provided with locks to prevent the controls from passing through a position. Further movement shall require a new control action.

6.2.1.7 Resistance to Movement
(Ref: NUREG-0700 Sec. 6.4.1.2)

All controls shall be provided with resistance (e.g., friction or spring-loading), so that distinct or sustained effort is required for activation.

6.2.1.8 Direction of Movement
(Ref: NUREG-0700 Sec. 6.4.2.1)

To minimize operator error, control movements shall conform to the following population stereotypes:

| | Component | Function | Control Action |
|---|---|---|---|
| A. | Pumps & Fans | Start | Right, Clockwise |
| | | Auto, Normal | Center |
| | | Stop | Left, Counterclockwise, |
| | | Pull to lock | Extreme left counterclockwise and pull out |
| B. | Valves & Dampers | Open | Right, Clockwise |
| | | Normal | Center |
| | | Auto | Center |
| | | Close | Left, Counterclockwise |
| C. | Circuit Breakers | Close | Right, Clockwise |
| | | Auto, Normal | Center |
| | | Trip | Left, Counterclockwise |
| | | Pull to lock | Extreme left counterclockwise and pull out |
| D. | Synchroscope | Off | Center |
| | | On | Right, Clockwise |

2

| | Component | Function | Control Action |
|---|---|---|---|
| E. | Voltage Adjusters | Increase<br>Decrease | Right, Clockwise<br>Left, Counterwise |
| F. | Control Rod Drive/ Position | In<br>Out | Up<br>Down |

2

6.2.1.9 Coding of Controls
(Ref: NUREG-0700 Sec. 6.4.2.2)

The use of coding methods (e.g., color coding, size coding) shall be governed by the relative advantages and disadvantages of each type of coding. For example, size and location coding may improve visual identification, yet may also require extra board space. Where coding is used to differentiate among controls, application of the coding shall be uniform throughout the control room. Criteria listed below shall be met when the following coding methods are used:

A. Location Coding

Controls shall be located in functional groups. Controls with similar functions shall be in the same relative location within the group from panel to panel.

B. Size Coding

No more than three different sizes of controls shall be used for discrimination by absolute size. Controls used for performing the same function on different items of equipment shall be the same size.

1. When knob diameter is used as a coding parameter, differences between diameters shall be at least 0.5 inch.

2. When knob thickness is a coding parameter, differences between thicknesses shall be at least 0.4 inch.

C. Shape Coding

Controls shall be differentiated by shape. In particular, controls which may be manipulated in a "blind" fashion shall be shape coded. For example, where an operator must simultaneously observe a display and move a control which is outside his field of view, the controls shall be shape-coded and separated by distance. Control shapes shall be visually and tactually identified.

6.2.1.10 Color Coding
(Ref: NUREG-0700 Sec. 6.5.1.6)

The use of color as a coding medium in control rooms offers a valuable means of providing unambiguous, easily discriminable information to the operator. Among other applications, color coding can aid in the perception of warning signals, the identification of functional relationships, and the association of displays with related controls. When used in a coding system, color shall always be redundant with some other cue. The information provided by a particular color shall also be indicated in some other form, e.g., location, orientation. Color can be particularly useful as a means for organizing information and is especially effective as a means for coding low probability or very important events.

The benefits of color coding can be realized only if color is not used indiscriminately. Excessive use may provide interference to effective control room operation. The same qualities which make color useful for coding can, if overused or inconsistently applied,

result in unintended confusion and distraction. As colors are used more frequently and as the number of different colors used for coding increases, the attention-getting value of each color diminishes. Similarly, when a particular color has multiple meanings it both loses its attention-getting quality and may lead to confusion or operator error.

All coding schemes must be learned. Learning of a color code can be facilitated by keeping the code simple and by taking advantage of common usage in everyday life. Complex or poorly designed coding systems will detract from, rather than enhance, operator performance.

Criteria listed below shall be met when color coding is used:

A. Redundancy

In all applications of color coding, color shall provide redundant information.

B. Number of Colors

The number of colors used for coding shall be kept to the minimum needed for providing sufficient information and shall not exceed 11.

C. Meaning of Colors

The meaning attached to a particular color shall be narrowly defined and shall be consistent across all applications within the control room. The meaning of a particular color shall remain the same whether applied to panel surfaces or projected in signal lights or on CRTs. It shall also remain the same both within and among the various systems to which it is applied.

1. The primary principle which shall be applied in selecting colors for coding purposes, which do not have the immediate hazard implications of red, green and amber, is to ensure that each color is recognized as different from any other. All colors selected shall have maximum contrast with each other. The following colors yield satisfactory contrast for red-green-deficient and color-normal individuals:

   a. white
   b. black
   c. yellow
   d. purple
   e. orange
   f. light blue
   g. red
   h. buff
   i. gray

2. The following colors can be used only for color-normal individuals (NUREG-0700 citing Kelly, 1965):

   a. green
   b. purplish pink
   c. blue
   d. yellowish pink
   e. violet
   f. orange yellow
   g. purplish red
   h. greenish yellow
   i. reddish brown
   j. yellow green

k. yellowish brown
l. reddish orange
m. olive green

3. The color of the control shall contrast with panel background. Also, when color coding is used to relate a control to its corresponding display, the same color shall be used for both the control and the display.

2 Reference Appendix S for use of color in the control room.

## 6.3 VISUAL DISPLAY CRITERIA

### 6.3.1 General

#### 6.3.1.1 Introduction

Visual displays as defined in this document and NUREG-0700 include vertical, horizontal, and circular meters, indicator lights, legend lights, graphic recorders, drum-type counters and electronic counters. Cathode ray tubes (CRTs) are included in Section 6.5, Process Computers.

#### 6.3.1.2 Information to be Displayed (Ref: NUREG-0700, Sec. 6.5.1.1)

Visual displays shall give the operators all the information about system status and parameter values that is needed to meet task requirements in normal, abnormal, and emergency situations. Efficient performance requires not only display of all needed information but also avoiding the display of extraneous information in the prime operating area. Redundancy in the presentation of information items shall be limited to cases where needed for backup or to avoid excessive operator movement.

6.3.1.3 Demand Information versus Status Information
(Ref: NUREG-0700, Sec. 6.5.1.1)

To prevent operator confusion, it is essential that displays be identified as to whether they reflect actual or demand status. Visual display of actual system/equipment status shall be displayed for all important parameters. Status information displays the state or level actually in effect. Demand information displays equipment that has been commanded (by control settings or otherwise) to a particular state or level. It displays only what is demanded - not what is actually being realized.

6.3.1.4 Display Failure
(Ref: NUREG-0700, Sec. 6.5.1.1)

When panel instruments, such as meters, fail or become inoperative, the failure shall be apparent to the operator (e.g., through off-scale indication).

Refer to Appendix F for additional guidelines related to visual displays.

Refer to Appendix G for guidelines specific to meter displays.

Refer to Appendix H for guidelines specific to indicator light displays.

Refer to Appendix I for guidelines specific to graphic recorders.

Refer to Appendix J for guidelines specific to drum-type counters.

Refer to Appendix K for guidelines specific to electronic counter displays.

## 6.4 LABELS AND LOCATION AIDS

### 6.4.1 Labeling Principles

#### 6.4.1.1 Introduction

A great deal of information concerning the function and operation of controls and displays is provided to the operator by labeling. Labels are generally used to:

A. Identify a specific control or display
B. Describe the function of a control or display
C. Describe the operations of a control
D. Describe relationship among controls and displays
E. Provide information on hazards or special conditions.

#### 6.4.1.2 Need for Labeling
(Ref: NUREG-0700, Sec. 6.6.1.1)

Since labeling provides the information which allows operator discrimination of required controls or displays, and the assurance that the correct control action or display reading is being made, readable and comprehensible labels are essential. Controls, displays, and any other items of equipment which must be located, identified, read or manipulated shall be appropriately and clearly labeled to permit rapid and accurate human performance.

#### 6.4.1.3 Hierarchical Scheme
(Ref: NUREG-0700, Sec. 6.6.1.2)

To reduce confusion, operator search time, and redundancy, a hierarchical labeling scheme shall be used. Ranking of labels shall conform to the following:

A. Major labels shall be used to identify major systems or operator work stations.

B. Subordinate labels shall be used to identify subsystems or functional groups.

C. Component labels shall be used to identify each discrete panel or console element.

D. Labels shall not repeat information contained in higher-level labels.

E. Labels shall be graduated in letter size such that system/major labels are approximately 25 percent larger than subsystem/subordinate labels.

F. Subsystem/subordinate (functional labels) shall be approximately 25 percent larger than component labels.

G. Component labels shall be approximately 25 percent larger than control position identifiers.

6.4.2 Label Placement And Orientation
(Ref: NUREG-0700, Sec. 6.6.2.1)

Labels should be normally placed above the panel element(s) they describe. When the panel is above eye level, labels may be placed below components to enhance visibility. Placement of labels on the control panels shall conform to recommendations in Figure 6.4-1.

The following criteria shall also be met for placement of labels:

A. Labels shall be placed very near the items which they identify and shall not appear on the control itself when an adjustment or manipulation is required that causes the operator's hand to obscure the label for an extended time period.

B. Adjacent labels shall be separated by sufficient space so that they are not read as one continuous label.

C. Label location throughout a system and within panel groupings shall be uniform.

D. Labels shall be mounted in a way that will preclude accidental removal and shall be mounted on a flat surface.

6.4.3 <u>Label Orientation</u>
(Ref: NUREG-0700, Sec. 6.6.2.3)

Improperly oriented labels can lead to confusion and cause delays in location and identification of important controls and/or displays. Labels shall be oriented horizontally so that they may be read quickly and easily from left-to-right.

Vertical orientation shall be used only where space is limited. Curved patterns of labeling shall be avoided.

6.4.4 <u>Label Visibility</u>
(Ref: NUREG-0700, Sec. 6.6.2.4)

The following criteria shall be followed for label visibility:

A. Labels shall not obscure any other information source.

B. Labels shall not detract from or obscure figures or scales which must be read by the operator and shall not be covered or obscured by other components in the equipment assembly.

C. Labels shall be visible to the operator during control actuation.

D. Administrative procedures should be in place for the periodic cleaning of labels.

6.4.5 Label Content
(Ref: NUREG-0700, Sec. 6.6.3.2)

The primary function for labels is to describe the function of equipment items. If needed for clarity, engineering characteristics or nomenclature shall also be described. The following criteria shall be considered for the selection of words within labels:

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

B. Unusual technical terms should be avoided.

C. Instructions shall be clear and direct.

D. Words shall be spelled correctly.

E. Brevity shall not be used if the results will be unfamiliar to operating personnel.

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, acronyms, abbreviations, and part/system numbers.

H. Words and abbreviations of similar appearance shall be avoided where an error in interpretation could result. When labels containing similar words, abbreviations or acronyms are located in close proximity to each other, different words shall be selected or means of coding shall be used to reduce the probability of selecting the wrong control or reading the wrong display. (See Figure 6-4.2)

I. Functional labels shall be used to identify functionally grouped controls or displays and shall be located above the functional groups they identify.

J. Control positions shall be labeled at all discrete functional positions.

K. Direction of motion (increase, decrease) shall be identified for continuous motion rotary controls.

L. Each control position shall be visible to the operator during operation of the control.

M. Access openings used by operators shall be labeled to identify the function of items accessible through it. All danger, warning, and safety instruction labels shall be in accordance with appropriate safety standards.

N. Abstract symbols shall be used only if they have a commonly accepted meaning for all intended users (e.g. %). Symbols shall be distinguishable from each other and shall be consistently used within and across panels.

O. Roman numerals shall be avoided.

6.4.6 Abbreviations, Acronyms and Terms for Labeling
(Ref: NUREG-0700, Sec. 6.6.3.3)

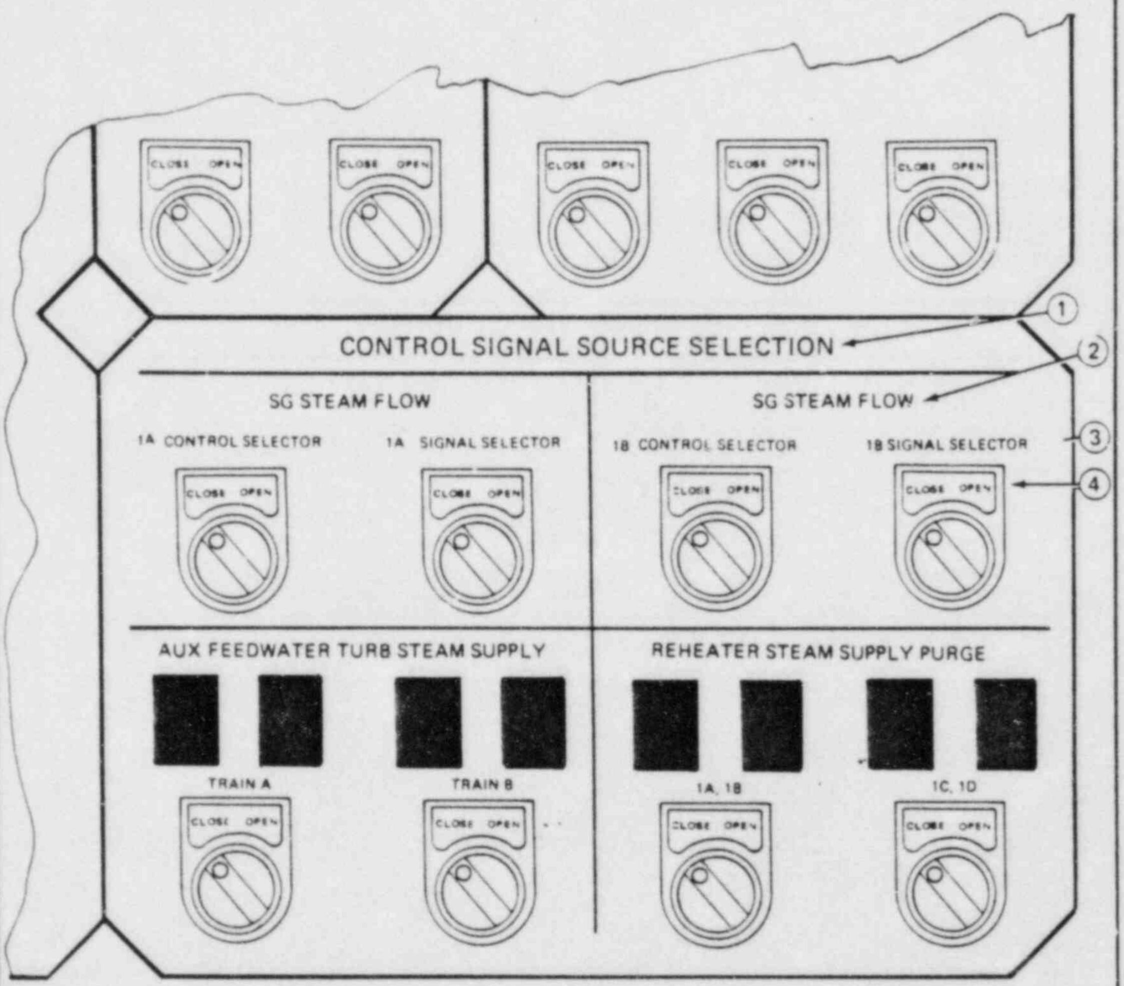
When it is necessary to abbreviate, only standard abbreviations shall be used. A list of standard abbreviations and acronyms for STP is shown in Appendix L. This list is intended to aid the developer/designer in the selection of terms, abbreviations, and acronyms for label content. This list was developed from labels present in numerous nuclear power plants. Such a list cannot be considered complete and all inclusive of the requirements for all applications. Additional operational experience, personal preferences, and an ever-expanding technology create constant expansion of this type of list. This list may also contain terms which have little or no application to the South Texas Project. This is not to say such terms will never be used for some requirement at sometime.

When a standard list of terms, abbreviations, acronyms, and part/system numbers has been approved, it shall be put under administrative control. There shall also be no mismatch between nomenclature used in procedures and that printed on the labels.

Refer to Appendix L for standard abbreviations that shall be used for all labeling at STP.

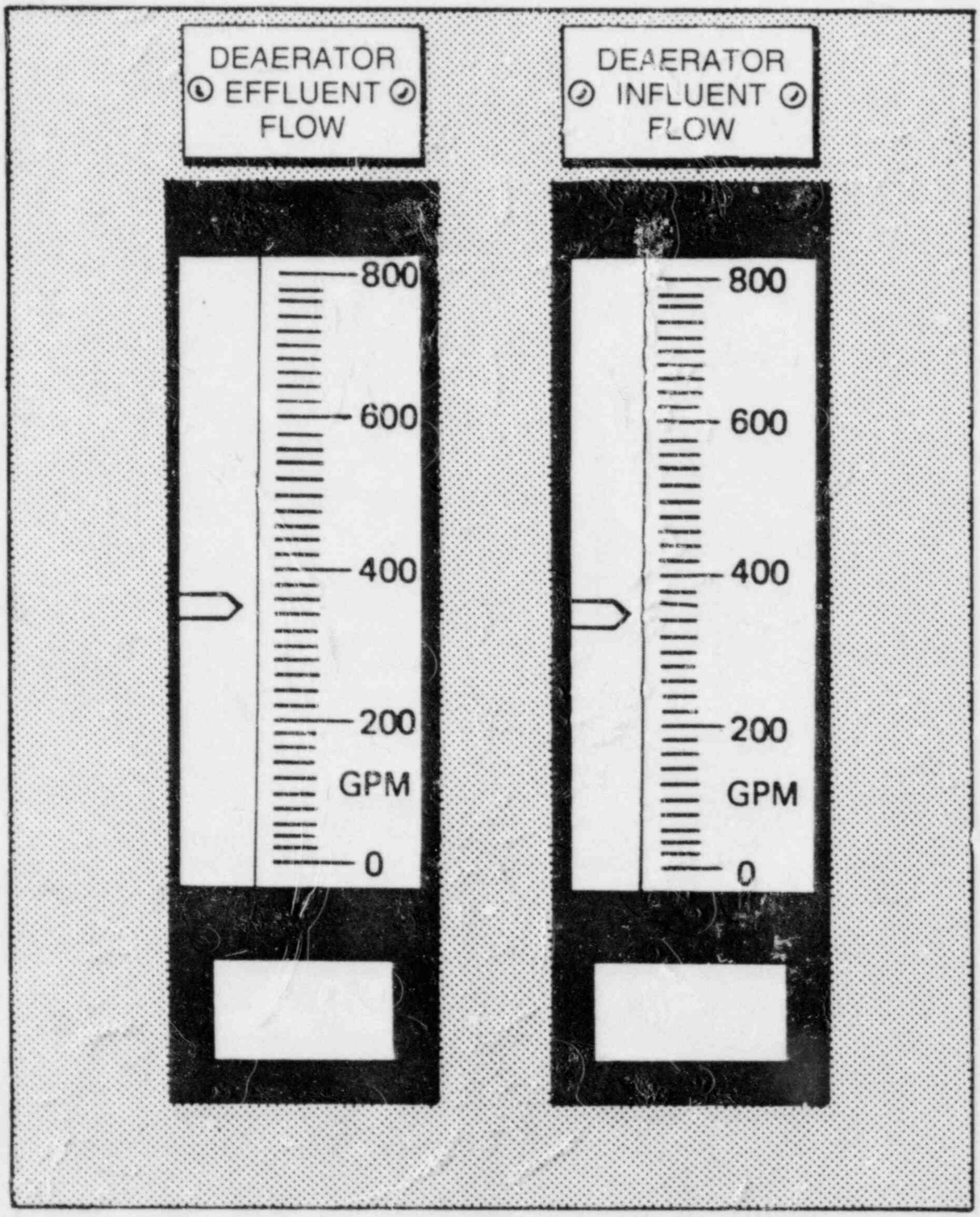
Refer to Appendix M for guidelines specific to label lettering.

Refer to Appendix N for guidelines specific to location aids.




| Label Designation | Location |
|---|---|
| 1. System/workstation label | Centered near top edge of panel |
| 2. Subsystem/functional label | Centered near top of subsection |
| 3. Component label | Above component display or control |
| 4. Control position indicator | Near control |

**EXAMPLE OF GOOD PANEL LABELINC**
**Figure 6.4-1**




EXAMPLE OF LABELS THAT ARE TOO SIMILAR
Figure 6.4-2

## 6.5 PANEL LAYOUT CRITERIA

### 6.5.1 General

#### 6.5.1.1 Assigning Panel Contents
(Ref: NUREG-0700, Sec. 6.8.8.1)

All controls and displays shall be located such that safety and efficiency of plant operations are promoted. Displayed information shall maximize the operator's awareness of plant systems status. Methods to ensure that this latter criterion is met are to group controls and displays by (a) task sequence, (b) system function, and (c) importance and frequency of use.

A. Grouping by Task Sequence (First priority) - Control and display locations shall be selected to minimize operator movement. Both normal and abnormal procedures shall be considered in this selection process. Priority shall be given to locating controls and displays to optimize frequently occurring routine tasks and time-critical emergency tasks with a minimum of operator movement among panels when operating a given train.

B. Grouping by System Function (Second priority) - Controls and displays shall be assigned to panels according to system function and train. This assignment will enhance the operator's understanding of the relationship of controls to corresponding systems for a given train.

C. Grouping by Importance and Frequency of Use (Third priority) - Where possible, controls and displays shall be assigned to panels according to their criticality to systems operations. Controls or displays that are neither safety related nor frequently used shall be installed in secondary panel areas.

6.5.1.2 Effective Panel Layout
(Ref: NUREG-0700, Sec. 6.8.1.2)

Locations of control and displays within a single panel shall be selected to provide effective viewing and manual control. First priority shall be given to the allocation of panel positions to ensure the integrity of grouping by system function, train and task sequence. Second priority control/display location factors include: (a) frequency of use; (b) significance of use during emergencies; (c) criticality to overall system performance; and (d) special use requirements such as accuracy, speed, force, and movement.

6.5.1.3 Recognition and Identification Enhancement
(Ref: NUREG-0700, Sec. 6.8.13)

Three primary techniques shall be used to set apart groups of controls and displays. These techniques are spacing, demarcation, and color shading.

A. Spacing - Consists of physical separation of groups of components with more space between groups of components than among components within any single group. Spacing between groups shall be at least the width of a control or display in the groups.

B. Demarcation - Consists of circumscribing functional or selected groups of controls and displays with a contrasting line. The application of demarcation techniques shall conform to the three criteria described in Section 6.4 (Labels and Location Aids). These criteria are use, contrast, and permanence.

C. Color Shading - Functional groupings of controls and displays can be enhanced by color shading of the panels. When color shading is used, colors shall provide contrast and shall be consistent with other color coding in the control room.

The identification of emergency controls shall be enhanced via one or more of the above techniques.

6.5.2 Layout Arrangement Factors

6.5.2.1 Sequence, Frequency of Use, and Functional Considerations
(Ref: NUREG-0700, Sec. 6.8.2.1)

Due consideration shall be given to tradeoffs among human factors principles relative to other design requirements. Of primary significance in these considerations will be the sequence by which controls and displays are used, the frequency of their use, and their function.

A. Sequence - Controls and displays shall be grouped according to their sequence of use. Controls that are operated and displays that are observed in a specified sequence shall be grouped in a left-to-right or top-to-bottom pattern. When there is a set of related controls and displays, their layout shall be symmetrical.

B. Frequency of Use - Frequently used controls and displays shall be easily identifiable and shall be located within areas of the panel that are optimal for operator control and monitoring.

C. Functional Considerations - Functionally related controls and displays shall be grouped together when they are used together to perform tasks of the same specific function.

6.5.2.2 Logical Arrangement and Layout
(Ref: NUREG-0700, Sec. 6.8.2.2)

The control/display arrangement shall be logical in the sense that operator expectations are generally met. Components shall be arranged left-to-right and top-to-bottom, and shall be identified in alphabetic or numeric sequence.

In general, except where functional integrity is sacrificed, operator expectations shall be accommodated in the panel layout.

6.5.2.3 Layout Consistency
(Ref: NUREG-0700, Sec. 6.8.2.3)

The layout of identical control/display groups shall be consistent both among and within panels. Repeated functions shall not be mirror-imaged.

6.5.2.4 Standardization
(Ref: NUREG-0700, Sec. 6.8.2.4)

Precedents and standard practices for arrangement and location of controls/displays shall be followed unless other critical factors dictate otherwise. Standardization shall be maintained from panel to panel where similar functions are located at several work stations that must be used by the same operators.

6.5.3 <u>Specific Panel Layout Design</u>

6.5.3.1 Separation of Controls
(Ref: NUREG-0700, Sec. 6.8.3.1)

Controls shall be separated in accordance with the minimum separation distances specified in Table 6.5-1. Criteria for determining separation requirements shall be access, inadvertant actuation, and simultaneous actuation.

A. Access - Control access shall not be impeded by any position of an adjacent control.

B. Inadvertent Actuation - Control actuation shall not result in inadvertent actuation of an adjacent control.

C. Simultaneous Actuation - Simultaneous actuation of adjacent controls (as required) shall be possible.

TABLE 6.5-1

MINIMUM SEPARATION (INCHES)*

| CONTROL | KEY OPERATED CONTROLS | PUSH-BUTTON NOT IN AN ARRAY | PUSH-BUTTON ARRAYS | LEGEND SWITCHES, LEGEND SWITCH ARRAY | ROTARY SELECTOR SWITCHES | CONTINUOUS ROTARY CONTROLS | J-HANDLES (LARGE) | J-HANDLES (SMALL) | JOY STIC |
|---|---|---|---|---|---|---|---|---|---|
| Key-Operated Controls | 1.0 | 0.5 | 1.5 | 1.0 | 0.75 | 0.75 | 5.0 | 2.0 | 0.7 |
| Pushbuttons Not in an Array | 0.5 | 0.5 | 2.0 | 2.0 | 0.5 | 0.5 | 6.0 | 3.0 | 0.5 |
| Pushbutton Arrays[1] | 1.5 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 6.0 | 3.0 | 1.5 |
| Legend Switches, Legend Switch Arrays[2] | 1.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 6.0 | 3.0 | 1.5 |
| Rotary Selector Switches | 0.75 | 0.5 | 2.0 | 2.0 | 1.0 | 1.0 | 5.0 | 2.0 | 0.7 |
| Continuous Rotary Controls | 0.75 | 0.5 | 2.0 | 2.0 | 1.0 | 1.0 | 5.0 | 2.0 | 0.7 |
| J-Handles (Large) | 5.0 | 6.0 | 6.0 | 6.0 | 5.0 | 5.0 | 3.0 | 5.0 | 6.0 |
| J-Handles (Small) | 2.0 | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 | 5.0 | 1.0 | 3.0 |
| Joy Sticks | 0.75 | 0.5 | 1.5 | 1.5 | 0.75 | 0.75 | 6.0 | 3.0 | 0.7 |

1 Pushbuttons within an array, 0.75 inches center-to-center.

2 Legend switches within an array, no minimum distance, but should be separated by a barrier. Barrier should be at least 0.125 inches wide, 0.183 inches high, with rounded edges. Legend switches manufactured as elements of a module or modular array may be mounted as closely as engineering considerations permit.

*Distances are measured from edge-to-edge of the control rotation envelopes. Distances shown are industry-wide minimums, and are less than the desirable minimum separation for nuclear power plant control rooms.

6.5.3.2 Strings or Clusters of Similar Components
(Ref: NUREG-0700, Sec. 6.8.3.2)

Factors such as search time, discriminability of components, and avoidance of selection errors shall be considered in the design of component strings, matrices, and other cluster arrangements. The following criteria shall apply to the assessment of clusters:

A. Orientation - Displays shall be configured in horizontal rows rather than vertical columns.

B. String Length - Strings of small displays shall not exceed 20 inches on the control board.

C. Number of Components - No more than five similar components should be laid out in an unbroken row or column. If this must be done, the string or cluster shall be broken up by techniques such as physical spacing or demarcation.

D. Large Matrices - Large matrices of similar components shall have the coordinate axes labeled for identification of any single component within the grid. The left and top sides of the matrix shall be used for labeling. Large matrices shall be subdivided by appropriate demarcation.

6.5.3.3 Mirror Imaging
(Ref: NUREG-0700, Sec. 6.8.3.3)

Mirror imaging shall not be used, and any recurring functional groups shall be replicated.

## 6.6 CONTROL - DISPLAY INTEGRATION CRITERIA

### 6.6.1 Basic Control - Display Relationships

#### 6.6.1.1 Single Control and Display Pairs
(Ref: NUREG - 0700, Sec. 6.9.1.1)

Controls and displays that are normally used together shall be located in close proximity to each other. They shall be positioned such that the control does not obstruct the display.

A. Proximity - Visual displays to be monitored during control manipulation shall be sufficiently close to the operator so that they can be read clearly and without parallax from a normal operating posture.

B. Obscuration - Controls and displays shall be located such that displays are not obscured during normal operation of a control.

C. Association - Related controls and displays shall be easily identified as being associated. This association can be established (or enhanced) by 1) location, 2) labeling, 3) coding, 4) demarcation, and 5) consistency with operator expectations. The operator shall immediately be able to detect:

1. Association of controls with displays

2. The relationship between the direction of movement of a control and that of a display.

3. The rate and limits of movement of the control and display

6.6.1.2 Multiple Controls or Displays
(Ref: NUREG-0700, Sec. 6.9.1.2)

Multiple arrays of controls and displays shall be apparent to the operator and consistent with human expectations.

A. Multiple Controls, Single Display - When several interacting controls are associated with a single display, the array shall conform to the following:

1. Controls shall be mounted below the display

2. Controls shall be centered relative to the display

3. Controls shall be grouped in a line or matrix

4. If not feasible to mount controls directly below the display, controls should be mounted to the right of the display.

5. Where there is a normal order of use, controls shall be arranged for left-to-right or top-to-bottom use.

6. Layout enhancement techniques (e.g. spacing, demarcation) shall be used where the above practices cannot be applied.

B. Single Control, Multiple Displays - When more than one display is affected by a single control, the array shall conform to the following:

1. Displays shall be located above or to the left of the control.

2. The control shall be placed as near as possible to the display.

3. Displays shall be arranged horizontally or in a matrix.

4. Displays shall read from left-to-right or top-to-bottom.

5. Displays shall not be obscured during control manipulation.

6. Layout enhancement techniques (e.g. spacing, demarcation) shall be used where the above practices cannot be applied.

C. Display Selectors - Where displays are selected for viewing via a rotary selector switch, the following shall apply:

1. The control shall move clockwise from off through settings 1, 2, 3...n.

2. The control position and display sequences shall be the same.

3. Control position indications shall correspond with display labels.

4. Displays shall read off-scale, not zero, when not selected.

6.6.2 <u>Groups of Controls and Displays</u>

6.6.2.1 Location and Arrangement of Control - Display Groups (Ref: NUREG - 0700, Sec. 6.9.2.1)

A. Functional Integrity - Multiple controls or displays related to the same function shall be grouped together.

B. Sequence of Use - Sequence of use shall be left-to-right and top-to-bottom.

6.6.2.2 Single Panel Arrangements
(Ref: NUREG - 0700, Sec. 6.9.2.2)

Appropriate arrangement for control-display relationships are, in their order of priority, (a) display over each control, (b) displays and controls in matched rows, and (c) multi-row displays with a single row of controls. Practice shall be consistent so that operator expectations are not confused.

A. Display Above Each Control - This preferred configuration (Figure 6.6-1) will include displays directly above their associated controls. The display/control pairs shall be arranged in rows.

B. Controls and Displays in Rows - Displays may be arrayed in rows matched to controls arrayed in similar rows below. Each control shall occupy the same relative position as the display to which it is associated (Figure 6.6-2). Controls and displays shall have corresponding labels.

C. Multi-row Displays With Single - Row Controls - A less desirable arrangement consists of two or more rows of displays arrayed above a single row of controls. If this arrangement is used, displays shall be ordered left-to-right and top-to-bottom, and matched to controls ordered left-to-right. Controls and displays shall have corresponding labels.

D. Consistent Practice - Arrangements of functionally similar controls and displays shall be the same throughout the control room.

E. Control/Display Packages - Where controls and related displays are assembled in modular units, their design shall ensure that the above principles are met.

6.6.3 Dynamic Control - Display Relationships

6.6.3.1 General Movement Relationships
(Ref: NUREG - 0700, Sec. 6.9.3.1)

Display responses to control movements shall be consistent and compatible with the operator's expectations. The following principles shall be applied to general movement relationships.

A. Rotary Controls - Rotary controls shall turn clockwise to cause an increase in parameter value. Associated display movements shall be as follows:

1. Linear scales, up or to the right

2. Digital displays, increasing in value

3. Strings of indicator lights, bottom-to-top or left-to-right

4. Circular meter pointers, clockwise

B. Linear Controls - Linear controls shall move up or to the right to cause an increase in parameter value. The associated display relationships shall be:

1. Linear scales, up or to the right

2. Digital displays, increasing in value

3. Strings of indicator lights, bottom-to-top or left-to-right

C. Display Response Time Lag - Where there is a time lag between actuation of a control and the resulting system condition, that condition shall be reflected by displays in real time.

1. No time lag shall exist between system condition change and display indication.

2. When there is a time lag between control actuation and ultimate system state, there shall be an immediate feedback indication of the process and direction of parameter change.

6.6.3.2 Control - Display Ratio
(Ref: NUREG - 0700, Sec. 6.9.3.2)

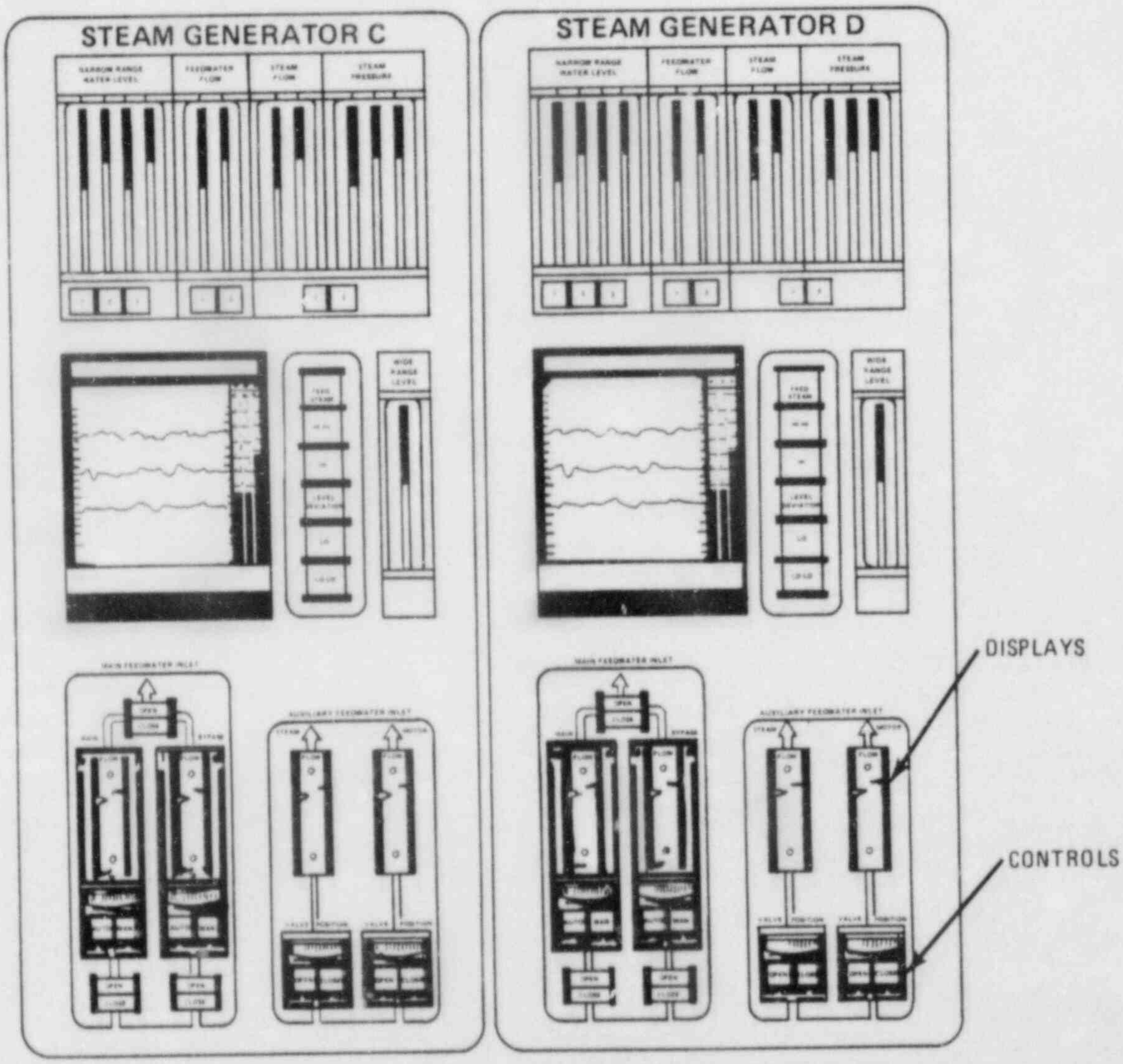
Control - display ratio will be determined by the separate requirements for precision of controls and displays.

A. Controls - Controls shall provide the capability to easily and precisely affect the parameter controlled. Controls shall be effective in sufficient time, under expected dynamic conditions, and within the limits of manual dexterity, coordination, and reaction time of the operators.

B. Displays - Displays shall provide the capability to distinguish among significant levels of the system parameter controlled.

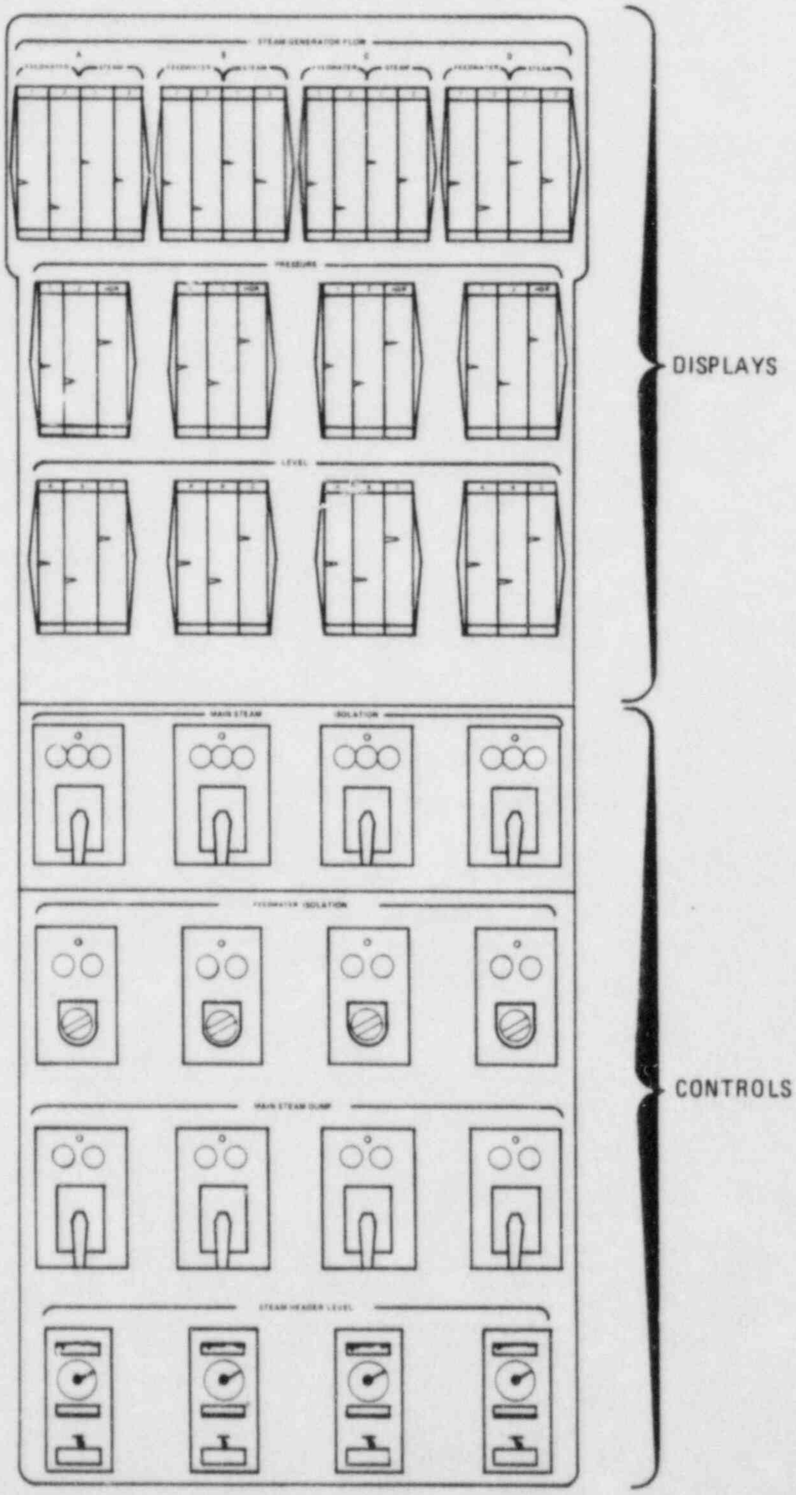
C. Excess Precision - Displays and controls shall not have significantly greater precision than that necessary to maintain the required system states.

D. Feedback - Feedback from a display shall be detectable and apparent for any deliberate control movement.




CONTROL-DISPLAY PAIRS ARRANGED IN A MATRIX.
DISPLAYS ABOVE CONTROLS (ARROWS) IS THE
PREFERRED ARRANGEMENT.

Figure 6.6-1




ROWS OF DISPLAYS LOCATED IN THE SAME RELATIVE POSITIONS AS THEIR ASSOCIATED CONTROLS ON THE LOWER PANEL. (FROM SEMINARA ET AL., 1979)

**Figure 6.6-2**

# 7.0 COMMUNICATION CRITERIA

## 7.1 GENERAL

### 7.1.1 Information Exchange

Control room communication system shall provide a reliable means of information exchange between:

A. Control room personnel and auxiliary operators at local control stations

B. Control room and field assessment and maintenance personnel

C. Control room and key management personnel

D. Control room and Emergency Operations Facility

E. Control room and Technical Support Center

F. Control room and Operational Support Center

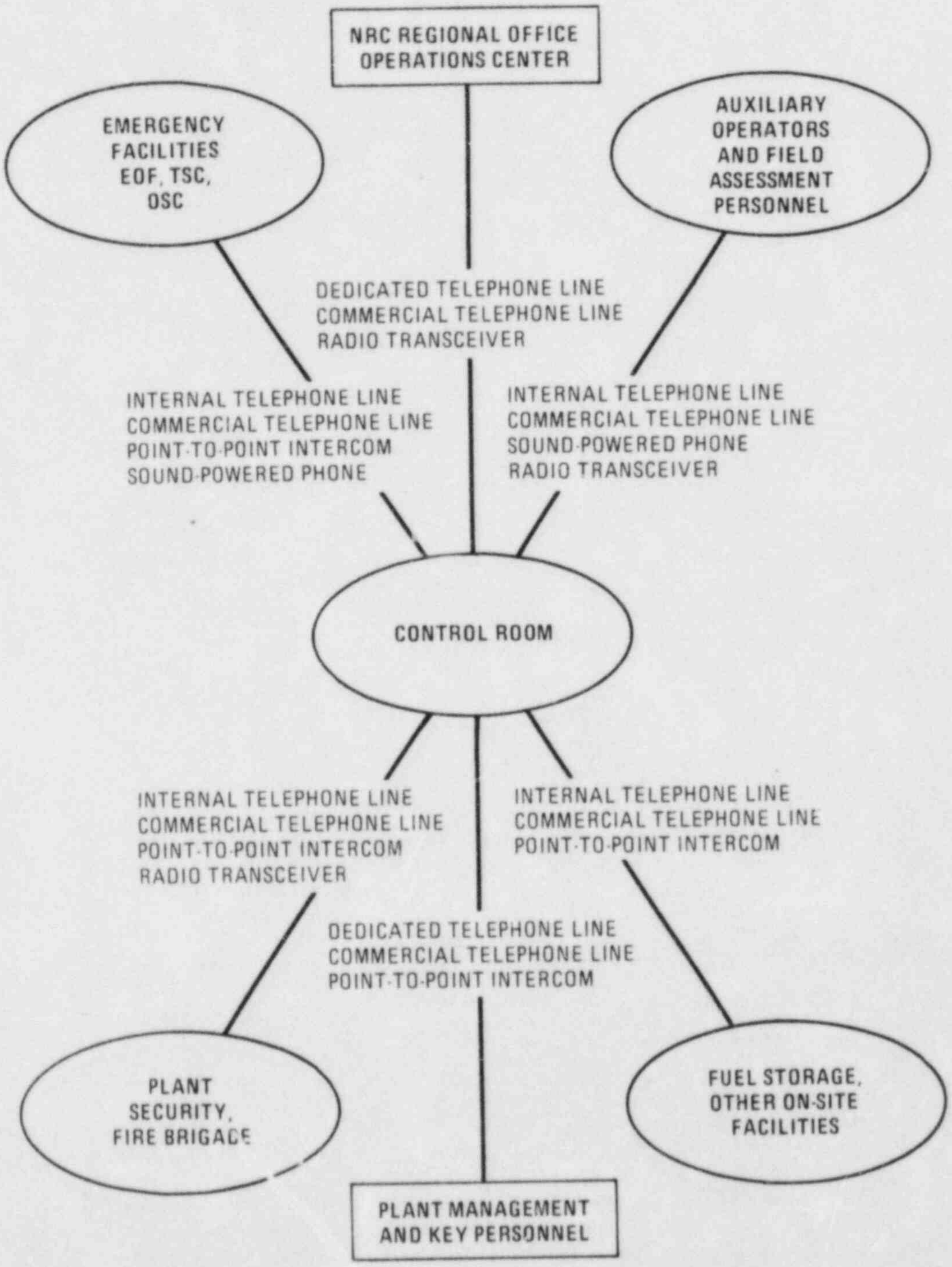
G. Control rocm and NRC Regional Office Operations Center

H. Control room and fuel handling and other onsite facilities

I. Control room and Plant Security (CAS and SAS operators)

J. Control room and fire brigade

A sample of control room communications is presented in Figure 7.1-1.




A SAMPLE SCHEMATIC OF CONTROL ROOM COMMUNICATIONS
Figure 7.1-1

7.1.2 Basic Criteria

The basic human factors criteria for the control room communications system shall address the following aspects of the system design:

A. Convenience of use

B. Reliability

C. Noninterference with other plant systems

D. Rational allocation of specific functions to the system elements and their integration into a general communications network to assure complete communication capability under normal and emergency conditions.

Convenience of the system use requires that proper anthropometric, psychological and environmental considerations be taken into account in the system design so that probability of operator error and discomfort are minimized.

Reliability of the system requires that a redundant power supply be provided along with an alternative means of communication to be used when the system becomes inoperable. It also requires that a special procedure for testing system operability be established.

Noninterference with other plant systems implies that use of communications equipment does not affect control room operations and conditions.

Rational allocation of functions requires, in particular, that under emergency conditions the control room personnel relinquish those communications which are not directly related to reactor system manipulations. At this time plant management

communications and communications with offsite authorities will be conducted through the Technical Support Center and Emergency Operations Facility.

### 7.1.3 VOICE COMMUNICATION LINKS

The following voice communication links shall be included:

A. Conventional-powered telephone (Commercial)

B. Conventional-powered telephone (Internal)

C. Sound-powered telephone

D. Radio transceivers

E. Paging system

F. Electrically powered headset/handset system

G. Special

Instructions shall be provided and conspicuously posted for use of each communication system, including suggested alternatives if a system becomes inoperable.

Procedures shall be established for the transmission of emergency messages from the control room and for processing incoming information during an emergency.

7.2 CONVENTIONAL-POWERED TELEPHONE SYSTEM
(Ref: NUREG-0700, Sec. 6.2.1.2

Conventional-powered telephone systems shall include internal telephone lines and commercial lines as primary and backup means of communication.

Telephones (preferably of built-in type) shall:

A. Provide sufficient speech intelligibility in the basic auditory frequency range.

B. Be of standard sizes and shapes to be compatible with expected anthropometric characteristics of the user population.

C. Be positioned to prevent accidental activation of controls in the process of telephone use or handsets being pulled out by passing traffic.

D. Be located in the positions of the expected most frequent functional use.

E. Have cords of nonkink or self-retracting type and of sufficient length to allow the operators to communicate simultaneously with reading the instruments or performing limited operating tasks.

F. Have adjustable ringing loudness.

G. Be positioned such that the operator can dial while facing the control panels.

Telephones positioned close together and intended for different functional use shall be properly labeled or color coded.

Internal telephone lines shall be connected to the paging system. Messages from the control room shall override all other messages on the paging system. Microphone input to the paging system shall be compatible with the rest of the system.

Control room telephone lines shall have executive override to access a busy telephone. Switching shall result in a minimum delay in making desired connections under both normal and emergency conditions.

## 7.3 SOUND-POWERED TELEPHONE SYSTEM (Ref. NUREG-0700, Sec. 6.2.1.3)

Sound-powered and electrically-powered phones are intended primarily to be used as a means of communication with remote plant areas outside the control room under both normal and emergency conditions.

The headsets shall have adequate frequency response characteristics to assure sufficient speech intelligibility. They shall have adjustable supporting structures and should cause minimal physical discomfort.

Plug-in jacks shall be located near control stations and panels as well as in instrument and local control cabinets to permit communication simultaneously with performing operating tasks or maintenance tasks. Plug-in jacks shall be conspicuously marked.

When not in use, the headsets shall be stored in a specially designated, easily accessible place.

Headsets available to the control room personnel shall include those of binaural type with noise cancelling microphones and sound insulating cushions on earphones to be used when the operator has to leave the control room for plant areas with high ambient noise.

There shall be a sectionalizing panel with switches to allow sectionalizing of the electrically-powered communication system. There shall be at least 40 switches with the capability of 12 channels by connection to independent power supplies. This circuitry shall be independent of the sound-powered circuitry and conveniently mounted near the Unit Supervisor's office.

A patch panel shall be provided to allow for the isolation of the three communication circuits associated with the emergency shutdown system. It shall be located adjacent to the sectionalizing panel.

## 7.4 RADIO TRANSCEIVERS
(Ref. NUREG-0700, Sec. 6.2.1.4, 6.2.1.5)

Radio transceivers present alternative means of communication to the conventionally-powered and sound-powered phones and can be used when it is necessary to provide for user mobility and to establish control room communications with locations beyond the range of installed telephone connections.

### 7.4.1 Walkie-Talkie Radio Transceivers

A. Walkie-talkie radio transceivers shall:

1. Have good frequency response in the auditory frequency range and adequate dynamic characteristics

2. Cause minimal inconvenience in transportation and operation

3. Allow one hand operation

B. Provisions shall be made:

1. To verify that the operation of radio tranceivers does not interfere with low-level analog or digital equipment operation, and to restrict the use in those areas identified where interference cannot be eliminated

2. To verify that the conditions of wave propagation for the selected operating frequency allow reliable communication with the control room from all the intended areas

3. To establish procedures for the speaker identification such that more than two parties can use the same radio channel from different locations

4. To have special conspicuously marked storage and to maintain sufficient supply of replacement batteries to ensure long periods of uninterrupted operation.

7.4.2 <u>Fixed-Base UHF Transceivers</u>

A. Fixed-base UHF transceivers shall:

1. Provide good signal intelligibility within standard telephone passband

2. Have sufficient dynamic range and adjustable gain with limited gain control so that audible signal is generated at the lowest control level.

B. Provisions shall be made:

1. To verify that UHF radio communications do not affect the operation of other equipment within or outside the control room, or restricted areas identified where interference cannot be eliminated.

2. To establish special procedures for the system use.

7.5 ANNOUNCING SYSTEM
(Ref. NUREG-0700, Sec. 6.2.1.6)

The announcing system shall:

A. Provide reliable means of one-way communications when a message has to be delivered from the control room to multiple distant areas.

B. Deliver intelligible audio message to all possible areas of the target personnel location.

C. Have an input from the internal telephone system and backup power supply so that the public address capability is not lost with the loss of major power supply. Microphones used in the announcing system should be of high sensitivity type and should permit at least 50 dB variations in signal input.

D. Have gain controls with limited control range so that at the lowest setting the signal is still above the level of audibility for the entire target area.

E. At each particular location, the paging system loudspeakers volume shall be adjusted so that the signal does not interfere with detection of auditory alarms.

The control room shall have privileged input into the public address paging system.

## 7.6 COMMUNICATION ENHANCEMENTS AND SPECIAL PROVISIONS

To provide a comfortable acoustical environment for the operators and to enhance their ability to communicate clearly, provisions shall be made such that the background noise for the control room does not exceed NCA-35, which corresponds to the normal voice range of approximately 6-12 ft.[1] To achieve this objective, as well as to minimize reverberation in the control room, sound-insulating and sound-absorbing materials shall be used whenever possible to cover sound-reflecting surfaces.

It is also important to ensure that the operators' communications capabilities are not impeded in emergency situations, when the operators have to use protection face masks. To this end, the emergency face masks shall be equipped with mechanical or electronic speech transmitters.

1) Beranek, L.L., Revised Criteria for Noise in Building, Noise Control, 1957. 3(1), 19.

# 8.0 CONTROL ROOM ANNUNCIATION FEATURES

## 8.1 FUNCTIONAL REQUIREMENTS

A. Alert the operator to the fact that a system or process deviation exists.

B. Inform the operators about the nature of the deviation and the urgency (or priority) of any needed action . 2

C. Guide the operator's initial response to the deviation.

D. Confirm whether the operator's response corrected the deviation.

## 8.2 GENERAL CRITERIA

The annunciator concept shall conform to the following general criteria:

A. Alert, but not startle the operators.

B. Intervene, but not disrupt control room activities.

C. Assist the operators in monitoring the plant, but shall not encourage undue reliance. Quantitative and status information shall be provided by other means. 2

D. Minimize nuisance alarms, but provide an adequate amount of valid alarms.

E. Provide adequate and timely information, but should not increase the workload of the operators.

## 8.3 INTEGRATION OF SUBSYSTEMS INTO A COORDINATED ANNUNCIATION PLAN

The components of an integrated annunciation plan shall consist of certain functions of the following subsystems.

2
A. Main plant annunciator

B. Computer systems

C. ESF bypass and inoperable status system

These systems shall be coordinated to provide a coherent means of notifying the operator of plant abnormalities, to assess the degree of abnormality, and provide an initial information structure upon which to base corrective action. They shall perform complementary rather than redundant functions.

Desirable features of an annunciation system are parallel presentation of information and a fixed mode of display. These features are available with conventional window box panels. Flexibility to accommodate changes and to examine a wide variety of relationships and trends is available in the computer.

## 8.4 ANNUNCIATION FUNCTIONS

The following are the specific functions and features required of the coordinated annunciation plan.

### 8.4.1 Auditory Alert

The operators shall be notified of the existence of an alarm by sound and have their attention directed to the appropriate panel or computer display device. Horns and chimes shall be located on the control panels so that the location of the alarm can be determined

by the direction of the sound. Auditory alert (alarm) signals may be initiated by any of the subsystems in the coordinated annunciation plan.

8.4.2 Visual Alarm

Visual alarm information shall be presented to the operator via annunciator windows and computer driven display devices. The information shall indicate the nature of the deviation and be color coded for priority.

8.4.3 Operator Response Capability

Controls for operator response to annunciation functions shall be conveniently located. The following control functions are required:

A. Silence Auditory Alert

Controls shall be provided to silence the auditory alert from any silence control in the primary area. Under control of administrative procedures it shall also be possible to adjust the intensity of the auditory alert. 2

Auditory annunciation shall be automatically reset when silenced.

B. Alarm Acknowledge

Controls shall be provided to acknowledge visual alarms. Acknowledgement shall turn off the flashing windows and cause them to continue with a steady display until reset. Acknowledgement shall be possible only from the work station where the alarm originated.

C. Alarm Reset

Controls shall be provided to reset alarms after they have been cleared. The reset control shall silence any audible signal and terminate the visual display, indicating clearance . The reset control shall be effective only at the work station where the alarm originated.

D. Alarm Test

Controls shall be provided to assure that the auditory alert signals and visual annunciation displays are still functional. Test capability shall be provided for both the conventional annuncator and the computer-based hardware.

When a "Test" pushbutton located on a control panel is depressed, the auditory alert shall sound and all the related annunciator windows shall
2 flash. "Reset" shall terminate the test, and all visual displays shall again perform their previous functions. Test of computer alarm functions shall
2 utilize the built-in test capabilities of the computer. The auditory test is a single beep and terminates automatically.

Groups of annunciation response controls shall have the same relative arrangement at each location. The controls shall be coded in some way for easy recognition. The design of the coordinated annunciation plan shall be such that the operators shall have little reason to attempt to defeat the controls. Control of both conventional and computer based alarms shall not require redundant actions or separate control hardware.

8.4.4 Prioritization

Alarm priority designations shall be used to help direct operator action to where it is most needed. There shall be three priority levels for computer displays and three priority levels for annunciator windows. All priority levels for the annunciator windows and computer-driven displays shall be the same.

The coding methods for visual displays shall be color and numeric.

On the annunciator tiles, colors shall indicate priority of alarms. On the computer-driven alarm displays, there shall be a designation of priority. These displays shall also have a special character used for flashing, and color coded the same as the applicable annunciator tile. Alarm priority designations to be used shall conform to those shown in Section 6.3.1.4 of NUREG 0700. The priority level criteria shall be:

Priority 1 - Red

Plant shutdown (Reactor trip, turbine trip) 2

Radiation release

Plant conditions which must be immediately corrected or will cause plant shutdown or radiation release. 2

Priority 2 - Yellow

Technical specification violations which, if not corrected, will require plant shutdown. 2

Plant conditions which, if not corrected, will lead to plant shutdown or radiation release.

Priority 3 - White

Plant conditions representing problems which affect plant operability but which should not lead to plant shutdown radiation release or violation of technical specifications.

8.4.5 First Out

Some method is required to determine which plant shutdown alarm occurred first. The capability to determine the initiating event and the sequence of events shall be available to the operator through the plant computer.

8.4.6 Hard Copy

Hard copy records of alarms and the sequence of events shall be available for immediate use and historical analysis.

8.4.7 Alarm Screening (Computer)

2 Alarm screening shall be used in the plant and ERF DADS computers to reduce the number of alarms necessary to be handled in any given situation.

8.4.8 Alarm Sort

The capability shall be provided to sort and display alarms by time of occurence, priority, system, and functional group.

8.4.9 Alarm Combination

Alarm conditions shall be combined into multiple input windows where the multi-input alarms summarize single input annunciators or where the operator response would be the same for all. Alarm combinations shall not be capable of being reset until all inputs to
2 the combined alarm have returned to normal. Input descriptions for multiple input alarms shall be available on the computer-driven alarm displays and on the alarm log.

8.4.10 Ring Back

When a previously abnormal condition returns to normal it shall be accompanied by a brief auditory signal and slow flashing of the visual indication to provide feedback on the corrective action. The flashing shall terminate after the alarm is reset.

8.4.11 Reflash

When two or more process deviations share the same annunciator window and the window is steadily lit, another point going into alarm state shall cause the window to begin flashing again (and to activate the auditory alert) even though a previous alarm may not have been cleared. The window shall not return to normal until all process deviations associated with it have been cleared.

8.4.12 Transient Alarm Detection

An alarm shall remain displayed until acknowledged and reset by the operator even if it has already returned to normal. This will allow deviations to be detected which are only momentarily in the alarm state. Further verification of transient alarms shall be available on the printed alarm log. 2

8.4.13 Alarm List Paging

Computer-based alarm lists shall have the capability to display sequential pages of the list by depression of no more than a single pushbutton. The capability to return to the latest page of alarms by a single depression of a pushbutton shall also exist.

8.4.14 Local Annunciation 2

Annunciation of applicable alarms shall be provided on the auxiliary shutdown panel when it has been activated. Annunciation of the activation of the auxiliary shutdown panel shall occur in the control room.

2 8.4.15 Data Movement Within the Annunciation System

2 Multiple input alarms within the main plant annunciator system shall be sent to the plant or ERF DADS computers. QDPS alarm information shall also be available in that area. A signal from the auxiliary shutdown panel shall be available at the main plant annunciator to indicate activation of the auxiliary panel.

## 8.5 OPERATOR INTERFACE REQUIREMENTS FOR THE COORDINATED ANNUNCIATION PLAN

### 8.5.1 Equipment Useage Criteria

#### 8.5.1.1 Main Plant Annunciators

Panels of annunciator windows arranged as matrices of visual alarm tiles shall be located
2 above the related controls and displays at a height where they can be easily observed and read by an operator. Individual tiles shall be organized in system and functional groups. The auditory annunciator sources shall be located near the appropriate panels to help direct the operator by the source of the sound.

#### 8.5.1.2 ESF Status Monitoring

Status indicator light panels shall be located on the control panels just below the annunciator windows. Lettering on these shall be large enough to be read by a person standing near the panel. They shall be organized by system or function.

8.5.1.3 Plant Computers 2

A. Display Devices

1. One display device shall be located on the operator console for alarm display. A second utility display device shall be available on that console for annunciation support information, alarm sorts, and as a backup device for the alarm display.

2. An adequate number of alarm display devices shall be distributed on the vertical boards around the control room. They shall be mounted recessed and have the face angle adjusted for optimum glare control under existing control room lighting conditions. They should be paired with other display devices for backup. The primary function of these devices is for alarm display related to the controls and other display devices to which they are near. These alarm display devices may also be used by the operator for other functions as desired.

B. Alarm Display Controls

1. A function control keyboard shall be available on the main control board near each of the alarm displays. These are to enable the operator to obtain desired alarm details quickly with minimum training required to understand the controls and little effort to utilize them. Function keys shall be available to select alarm or other data displays, to cause alarms to be ordered chronologically or by priority, and for paging control. 2

2 2. The operator console shall contain the same function control keyboard as is mounted on the main control panels to control the alarm presentation display. In addition, there shall be function keys to select "all alarms" and to select alarms applicable to any specified part of the main control panel. There shall also be the capability to select alarm presentation by system and functional groupings.

There shall also be keys for reassignment of alarm displays on the main control panels. A "QWERTY" type keyboard may be included in addition for other functions, but a carefully planned dedicated function keyboard is required for alarm presentation control.

C. Printers

2 1. One line printer shall be available in the control room to provide a log of all alarms and status changes. The printer shall have the capacity to keep up with incoming alarms.

2 2. A second printer shall serve as a utility printer and to back up the alarm printer. This will supply hard copy to the operator for alarm functions such as alarm sorts by priority or chronology and by system or functional groups. A list of points out of scan, all ESF equipment bypassed and/or inoperable, and all equipment not in safety position or state shall be available.

8.5.2 Functional Criteria for Equipment

8.5.2.1 Annunciator Tiles

The maximum number of tiles per annunciator window box shall be 50. The most important deviations shall have annunciator tiles dedicated to them. Other deviations shall be displayed on multiple input windows whenever this is feasible. These tiles shall be grouped in a logical manner (i.e., by system and function) and located above the appropriate control panel. The objective is to present an acceptable amount of information for the operator to deal with at any moment.

The principal means for reducing the number of alarm tiles are careful organization by system and function, elimination of tiles for status indication, use of carefully selected multiple input tiles, and utilization of the plant or ERF DADS computer alarm functions | 2
to a much greater extent for detailed alarm information.

When an alarm condition occurs, the appropriate tile shall flash until acknowledged by the operator. All flashing windows under control of a given acknowledge control shall cease flashing, but remain lit, when that acknowledge control is depressed. Highest priority alarms shall be lighted in red, both when flashing and when steady. A return to normal shall cause the window to flash slowly (one-half the low priorty alarm flash frequency). | 2
Reset shall turn off the lights in those windows which have returned to normal. However, a multiple input window shall not be able to be reset until all inputs to it have returned to normal.

8.5.2.2 Computer-Driven Display

Selected alarms generated within or going to the main plant annunciator system shall be available to the plant or ERF DADS computer for display purposes. Additional alarms | 2
may be generated within the plant computer and these shall also be available for display.

2 When a point goes into the alarm the CRT shall show a line for that point. The point shall be identified and the deviation type and/or numeric value, if applicable, together with the set point and the priority level shall be shown. One special character in the displayed line shall flash until the alarm is acknowledged. Color coding of the flashing character shall be used to supplement the indicated numeric priority. Each computer driven alarm display page shall show the current time, what page of alarms is being displayed, how many alarm pages apply to that display, and how many unacknowledged alarms exist.

8.5.2.3 Example of Annunciation Operation

The table below provides an example of the operation of a representative coordinated display and auditory alert plan which is intended by these criteria.

| Situation | Control | Horn | Annunciator Tile | CRT Display: Special Character | CRT Display: Parameter Value | |
|---|---|---|---|---|---|---|
| Normal | - | - | - - | - | - | |
| Deviation | - | On | Flashing Red<br>Flashing White<br>Flashing Yellow | Flash Red<br>Flash White | Yellow | |
| Deviation | Silence | Off | Flashing Red<br>Flashing White<br>Flashing Yellow | Flash Red<br>Flash White | Yellow | |
| Deviation | Acknow | Off | Steady Red<br>Steady White<br>Steady Yellow | Steady Red<br>Flash White | Yellow | |
| Return to Normal | - | Chime, Self Terminating | Slow Flash Red<br>Slow Flash White<br>Slow Flash Yellow | Slow Flash Green<br>Slow Flash White | Green | 2 |
| Normal | Reset | Off | Off | Blank | Blank | |
| Normal or Deviation | Test | On | Flashing Red<br>Flashing White<br>Flashing Yellow | Flashing Red "Test" | - | |
| Normal or Deviation | Reset after Test | Off Automatically | As Before | As Before | As Before | |

## 8.6 MISCELLANEOUS CRITERIA

### 8.6.1 Inapplicable Alarms

Alarms not related to Control Room operations shall be eliminated from the control room (e.g., security alarms should be sent to the security department on the security monitoring system). During plant operations where alarms are generated, but no true alarm condition exists, (such as low discharge pressure when the associated pump is not required to run), it 2 is desirable that the alarm be prevented.

8.6.2 Device Alternates

Key computer-driven display and printer devices shall have alternates and device failures shall cause the alternate to be used automatically, without loss of information.

8.6.3 Expansion Capability

Some expansion capability shall exist in both the plant annunciator system and in the plant
2 or ERF DADS computer to add additional alarm annunciation.

8.6.4 Response Time

2 The time from the input to the annunciator and/or plant or ERF DADS computer system of a plant deviation to the time of the annunciation and display of that deviation shall not be greater than one second.

8.6.5 Consistent Methods

Consistant application of identification techniques, use color and sound, and operator response shall be a requirement for all subsystems within the coordinated annunciation plan.

8.6.6 Parallel Inputs

Inputs to the main plant annunciation shall be isolated and directed in parallel to the plant
2 or ERF DADS computer.

8.6.7 Window Box Row/Column Labeling

All annunciator window boxes shall have row/column labeling so that each tile can be readily identified.

8.6.8 Replacement of Annunciator Lamps

The annunciator window design shall permit rapid replacement of lamps, present no shock hazard during maintenance activities, and include a means to ensure correct tile replacement.

8.6.9 Tile Lighting

There shall be good contrast between lit and unlit tiles. Good contrast is also required between flashing and no flash states. A normal tile shall be dark. Blank tiles shall never be lit except for testing. In case of flash failure, the tile shall still light up.

8.6.10 Tile Legend

Tile legend shall be unambiguous and address specific conditions (i.e., not HI-LO, or TEMP-PRESS). Abbreviations and acronyms shall be consistant with those used elsewhere in the control room. Use of abbreviations shall conform to the guidelines given in Appendix L.

8.6.11 Tiles Readability

Tile lettering should conform to the following criteria:

A. Character height should subtend a visual angle of 15 minutes as a minimum, or 0.004 x viewing distance.

B. Letter height should be identical for all tiles, based on maximum viewing distance.

C. Letters should be in Capital Letters, without serifs.

D. Character width-to-height should be between 1:1 and 3:5.

E. Stroke width-to-character height ratio should be between 1:6 and 1:8.

F. Minimum spacing between characters should be one stroke width.

G. Minimum spacing between words should be one character width.

H. Minimum spacing between lines should be one-half the character height.

2 J. Tiles should be sized to accommodate at least three lines of twelve characters each.

## 9.0 POST-ACCIDENT MONITORING FEATURES

### 9.1 FUNCTION

In order to enable the operators to monitor plant variables and systems during and following an accident, a post-accident monitoring (PAM) system shall be provided. The PAM system will have five basic functions:

A. Provide information required to permit the operator to take preplanned manual actions to accomplish safe plant shutdown

B. Determine whether the reactor trip, engineered safety-feature systems, manually initiated safety systems, and other safety related systems are performing their intended functions (i.e., reactivity control, core cooling, integrity of reactor coolant pressure boundary, radioactivity control, and containment integrity). 2

C. Provide information to the operators that will enable them to determine the potential for causing a gross breach of the barriers to radioactivity release (i.e, fuel cladding, reactor coolant pressure boundary, and containment) and to determine if a gross breach of a barrier has occurred.

D. Furnish data regarding the operation or status of plant systems so that the operator can make appropriate decisions as to their use.

E. Provide information regarding the release of radioactive materials to allow for early indication of the need to initiate action necessary to protect the public and for an estimate of the magnitude of any impending threat.

## 9.2 GENERAL CRITERIA

### 9.2.1 Variable Classifications (Types)

The design criteria for the PAM system are in general accordance with Reg. Guide 1.97, Rev. 2. In this regard, the variables to be measured are divided into five classifications defined as follows (Note that the classifications are not mutually exclusive in that a given variable or instrument may be applicable to one or more types of classification). The types are:

#### 9.2.1.1 Type A

Type A are those variables used in preplanned actions for design basis accident events. They are monitored and provide the primary information required to permit the control room operators to take the specified manually controlled actions for which no automatic control is provided and that are required for safety systems to accomplish their safety function for design basis accident events.

Primary information is that which is essential for the direct accomplishment of the specified safety functions. It does not include those variables that are associated with contingency actions that may also be identified in written procedures.

#### 9.2.1.2 Type B

Type B are those variables that provide information to indicate whether plant critical safety functions are being accomplished and/or maintained.

#### 9.2.1.3 Type C

Type C are those variables that provide information to indicate the potential for being breached or the actual breach of the barriers to fission product release, i. e., the fuel cladding, primary coolant pressure boundary, and containment. The sources of potential breach are limited to the energy sources within the barrier itself.

9.2.1.4 Type D

Type D are those variables that provide information to indicate the operation of individual safety systems and other systems related to safety. They are used for mitigating the consequences of an accident and for recovery of the plant to attain a safe shutdown condition.

9.2.1.5 Type E

Type E are those variables to be monitored as required for use in determining the magnitude of the release of radioactive materials and for continuously assessing such releases. They are used to monitor the habitability of the control room and plant areas where access may be required to service equipment necessary to mitigate an accident.

9.2.2 Qualification Categories

Reg. Guide 1.97 further defines three categories affecting the variables to be monitored to denote the relative importance to safety of the variable and likewise the severity of the qualification requirements for the instruments used to measure the variable. Category 1 is intended for key variables and provides the most stringent requirements. Categories 2 and 3 variables are of lesser importance in determining the state of the plant and therefore do not require the same level of operational assurance.

Category 1 requires immediately accessible display; however, recording is provided on recorder panel. 2

Category 2 requires a accessible-on-demand display. 2

Category 3 is intended to provide requirements that will insure that high quality off-the-shelf instrumentation is obtained and applies to backup and diagnostic instrumentation.

A key variable is that single variable (or minimum number of variables) that most directly indicates the accomplishment of a safety function (in the case of Types B and C) or radioactive material release (in the case of Type E). The design and qualification criteria category assigned to each variable indicates whether the variable is considered to be a key variable or for system status indication or for backup or diagnosis. That is, for Types B and C, the key variables are Category 1; backup variables are generally Category 3. For Types D and E, the key variables are generally Category 2; backup variables are Category 3.

## 9.3 DESIGN CRITERIA

The design criteria for the five variable types, A through E, and the three categories, 1 through 3, are summarized in Tables 9.3-1 and 9.3-2. The details of the design criteria are presented in the following paragraphs; however, details governing the qualification of the instrument channels are not included herein.

### 9.3.1 Selection Criteria - Category 1

The selection criteria for Category 1 variables are subdivided according to the variable type. Type A, those key variables used for diagnosis or providing information for necessary operator action, are defined as Category 1. (Preferred backup Type A variables are defined as Category 2). Type B, those key variables which are used for monitoring the process of accomplishing or maintaining critical safety functions, are defined as Category 1. Type C, those key variables which are used for monitoring the potential for breach of a fission product barrier, are defined as Category 1. Type D, those key variables that are used for monitoring the performance of safety systems which are essential to maintaining critical safety functions and which may lead the operator to take contingency actions that are not necessary and would be adverse to safety, are defined as Category 1.

## TABLE 9.3-1

## SUMMARY OF SELECTION CRITERIA

| TYPE | CATEGORY 1 | CATEGORY 2 | CATEGORY 3 |
|---|---|---|---|
| A | Key variables that are used for diagnosis or providing information for necessary operator action | Variables which provide preferred backup information and are subject to a High Energy Line Break (HELB) when required to perform their functions | Variables which provide preferred backup information and are not subject to a HELB when required to perform their functions |
| B | Key variables that are used for monitoring the process of accomplishing or maintaining critical safety functions | Variables which provide preferred backup information and are subject to a HELB when required to perform their functions | Variables which provide preferred backup information and are not subject to a HELB when required to perform their functions |
| C | Key variables that are used for monitoring the potential for breach of a fission product barrier | Variables which provide preferred information and are subject to a HELB when required to perform their functions | Variables which provide preferred backup information and are not subject to a HELB when required to perform their functions |
| D | Key variables that are used for monitoring the performance of safety systems which are essential to maintaining critical safety functions and which may lead the operator to take contingency actions that are not necessary and would be adverse to safety. | Key variables which have not been included under Category 1 which are used for monitoring the performance of plant systems | Variables which provide preferred backup information which are used for monitoring the performance of plant systems of plant systems |

TABLE 9.3-1 (CONT.)

SUMMARY OF SELECTION CRITERIA

| TYPE | CATEGORY 1 | CATEGORY 2 | CATEGORY 3 |
|---|---|---|---|
| E | None | Key variables to be monitored for use in determining the magnitude of the release of radioactive materials and for continuously assessing such releases | Variables to be monitored which provide preferred backup infor-tion for use in determining the magnitude of the release of radioactive materials and for continuously assessing such releases |

Table 9.3-2

SUMMARY OF DESIGN REQUIREMENTS

| Design | Category 1 | Category 2 | Category 3 |
|---|---|---|---|
| Single Failure | Yes | No | No |
| Power Supply | Emergency Standby | On Site | As Required |
| Channel out of Service | Technical Specifications | Technical Specifications | No |
| Testability | Yes | Yes | No |
| Indication | Immediately Accessible | Demand | Demand |
| Recording | Yes | As Required | As Required |

9.3.2 Design Criteria - Category 1

A. Where failure of one accident-monitoring channel results in information ambiguity (e.g., the redundant displays disagree), additional information shall be provided to allow the operator to deduce the actual conditions in the plant. This may be accomplished by providing additional independent channels of information of the same variable (addition of an identical channel), or by providing independent channels which monitor different variables which bear known relationships to the multiple channels (addition of a diverse channel(s)). Redundant or diverse channels shall be physically separated from each other to the extent practicable and from equipment not related to safety in accordance with 10 CFR 50 Appendix A, Criteria 22 and 24, and derived regulatory guides consistent with the STP licensing basis.

For situations such as isolation valves in series, the intent is generally to verify the isolation function. In such a situation, a single indication on each valve is sufficent to satisfy the single failure criteria if those indications are from different trains (i.e., unambiguous indication of isolation).

In the event that diversity is employed in lieu of redundancy , detailed procedures shall be established to detect and resolve any ambiguity that may exist. These procedures shall recognize such factors as electrical independency and physical separation of the channels employed.

If ambiguity does not result from failure of a channel, then an additional redundant or diverse channel is not required.

B. The monitoring instrumentation design shall minimize the development of conditions that would cause meters, annunciators, recorders, alarms, etc., to give anamolous indications potentially confusing to the operator.

C. The instrumentation shall be designed to facilitate the recognition, location, replacement, repair, or adjustment of malfunctioning components or modules.

D. To the extent practicable, monitoring instrumentation inputs shall be from sensors that directly measure the desired variables.

9.3.3 Information Processing and Display Interface Criteria - Category 1

A. The operator shall have immediate access to the information from redundant or diverse channels in engineering units familiar to the operator (e.g., for a temperature reading, degrees not voltage). Where two or more instruments are needed to cover a particular range, overlapping of instrument spans shall be provided as practicable.

B. A historical record of a minimum of one instrumentation channel for each process variable shall be maintained. A recorded pre-event history for these channels is required for a minimum of one hour and continuous recording of these channels is required following an accident until such time as continuous recording of such information is no longer deemed necessary. This recording should be available when required but need not be immediately accessible. One hour was selected based on a representative slow transient which bounds this time requirement. ( For example, for a one-half inch LOCA, trip occurs at approximately fifty minutes after initiation). Where direct and immediate trend or transient information is essential for operator information or action, the recording shall be immediately accessible.

C. The instruments designated as Types A, B, and C should be specifically identified on the control panels so that the operator can easily discern that they are intended for use under accident conditions.

9.3.4 Selection Criteria - Category 2

The selection criteria for Category 2 variables are subdivided according to the variable type. For Types A, B, and C, those variables which provide preferred backup information and are subject to a HELB environment when required to perform their function are defined as Category 2.

For Type D, those key variables (which have not been included under Category 1) that are used for monitoring the performance of safety system have been designated Category 2. Type E, those key parameters to be monitored for use in determining the magnitude of the release of radioactive materials and for continuously assessing such release, are defined as Category 2.

9.3.5 Design Criteria - Category 2

A. The monitoring instrumentation design shall minimize the development of conditions that would cause meters, annunciators, recorders, alarms, etc., to give anomalous indications potentially confusing to the operator.

B. The instrumentation shall be designed to facilitate the recognition, location, replacement, repair, or adjustment of malfunctioning components or modules.

C. To the extent practicable, monitoring instrumentation inputs shall be from sensors that directly measure the desired variables.

9.3.6 Information Processing and Display Interface Criteria - Category 2

A. The instrumentation signal shall be, as a minimum, processed for display on demand.

B. The instruments designated as Types A, B, and C should be specifically identified on the control panels so that the operator can easily discern that they are intended for use under accident conditions.

9.3.7 Selection Criteria - Category 3

The selection criteria for Category 3 variables are subdivided according to the variable type. Types A, B, and C, those variables which provide preferred backup information and are not subject to HELB environment when required to perform their functions, are designed as Category 3. Types D and E, those variables which provide preferred backup information, are defined as Category 3.

9.3.8 Design Criteria - Category 3

A. The monitoring instrumentation design shall minimize the development of conditions that would cause meters, annunciators, recorders, alarms, etc., to give anomalous indications potentially confusing to the operator.

B. The instrumentation shall be designed to facilitate the recognition, location, replacement, repair or adjustment of malfunctioning components or modules.

C. To the extent practicable, monitoring instrumentation inputs shall be from sensors that directly measure the desired variables.

9.3.9 Information Processing and Display Interface Criteria - Category 3

The instrumentation signal shall be, as a minimum, processed for display on demand.

## 9.4 VARIABLES TO BE MONITORED

### 9.4.1 Type A Variables

Key Type A Variables have been designated Category 1. These are the variables which provide the most direct measure of the information required. The Type A key variables are listed in Table 9.4-1.

The RCS Subcooling (Range 200°F Subcooling to 35°F Superheat) is designated as a preferred backup Type A variable, and therefore is designated as Category 2. No Type A variables are designated Category 3.

### 9.4.2 Type B Variables

Type B variables are those variables that provide the control room operators with information to assess the process of accomplishing or maintaining critical safety functions. The Type B key variables, the preferred backup variables and their respective categories are listed in Table 9.4-2.

### 9.4.3 TYPE C VARIABLES

Type C variables are those variables which provide the control room operators with information to monitor the potential breach, or actual breach, of any of the three fission product barriers: fuel cladding, reactor coolant system boundary, and the reactor containment boundary. Variables which indicate potential breach are considered as key variables, and variables which indicate an actual breach are considered as preferred backup information. The Type C key variables, the preferred backup variables and their respective categories are listed in Table 9.4-3.

Table 9.4-1

SUMMARY OF KEY TYPE A VARIABLES

| | Variable | Range | |
|---|---|---|---|
| 1. | RCS Pressure (Wide Range) | 0-3000 psig | |
| 2. | Hot Leg Reactor Coolant Temperature (Wide Range $T_{hot}$) | 0-700°F | |
| | Diverse Variable: Core Exit Temperature | 100-2200°F | |
| 3. | Cold Leg Reactor Coolant Temperature (Wide Range $T_{cold}$) | 0-700°F | |
| | Diverse Variable: Steamline Pressure | 0-1400 psig | |
| 4. | Wide Range Steam Generator Level | 0-100% | |
| | Diverse Variable: Auxiliary Feedwater Flow | 0-110% | |
| 5. | Narrow Range Steam Generator Level | 0-100% | |
| | Diverse Variable: Auxiliary Feedwater Flow | 0-110% | |
| 6. | Pressurizer Level | 0-100% | |
| 7. | Primary Reactor Containment Pressure | -5-60 psig | |
| 9. | Steamline Pressure | 0-1400 psig | |
| 9. | Refueling Water Storage Tank (RWST) Level | 0-100% | |
| 10. | Primary Reactor Containment Water Level | 0-609K Gal | 2 |

| | | Variable | Range |
|---|---|---|---|
| 2 | 11. | AFW Storage Tank Level | 0-100% |
| | 12. | Auxiliary Feedwater Flow | 0-110% |
| | | Diverse Variable: Wide Range Steam Generator Level | 0-100% |
| 2 | 13. | High Range Containment Radiation Level | 1.0 to $1 \times 10^{7}$ R/Hr |
| | 14. | Secondary System Radiation | |
| | | . Condenser Vacuum Pump Exhaust Radiation | $10^{-6} - 10^{5}$ uCi/cc |
| 2 | | . Steam Generator Blowdown | $10^{-6} - 10^{-1}$ uCi/cc |
| | | . Steamline Radiation | $10^{-3} - 10^{4}$ R/Hr |
| | 15. | Core Exit Temperature | 100 - 2200°F |
| | | Diverse Variable: Wide Range T Hot | 0-700°F |
| | 16. | RCS Subcooling | 200°F Subcooled- 35°F Superheat |

Table 9.4-2

SUMMARY OF TYPE B VARIABLES

| Critical Safety Function | | Variable | Range | Category |
|---|---|---|---|---|
| Reactivity Control | Key: | Neutron Flux | $10^{-8}$ to 100% Power | 1 |
| | Preferred Backup: | a. Wide Range $T_{Hot}$ | 0-700°F | 2 |
| | | b. Wide Range $T_{Cold}$ | 0-700°F | 2 |
| | | c. Control Rod Position | 0-100% Inserted | 3 |
| Reactor Coolant System Pressure Control | Key: | RCS Pressure (WR)[a] | 0-3000 psig | 1 |
| | | RCS Pressure (Extended Range) | 0-3500 psig | 1 |
| | Preferred Backup: | a. Containment Pressure | -5-60 psig | 2 |
| | | b. High Range Containment Radiation Level | 1.0 to $1x10^7$ R/Hr | 2 |
| | | c. Secondary System Radiation | $1x10^{-6}$ to $1x10^5$ uCi/cc | 2 |
| Reactor Coolant Inventory Control | Key: | Pressurizer Level | 0-100% | 1 |
| | Preferred Backup: | a. Reactor Vessel Water Level | 0-100% | 2 |
| | | b. Containment Water Level | 0-600K Gal | 2 |
| | | c. Wide Range Steam Generator Level | 0-100% | 2 |
| Reactor Core Cooling | Key: | Core Exit Temperature | 100 - 2200°F | 1 |
| | Preferred Backup: | a. Wide Range $T_{Hot}$ | 0-700°F | 2 |
| | | b. Wide Range $T_{Cold}$ | 0-700°F | 2 |
| | | c. RCS Pressure (WR)[a] | 0-3000 psig | 2 |
| | | d. RCS Subcooling | 200° Subcooling to 35°F Superheat | 2 |
| | | e. Reactor Vessel Water Level | 0-100% | 2 |

[a] Wide Range

| Critical Safety Function | | Variable | Range | Category |
|---|---|---|---|---|
| Heat Sink Maintenance | Key: | a. Narrow Range S/G Level | 0-100% | 1 |
| | | b. Wide Range S/G Level | 0-100% | 1 |
| | | c. Auxiliary Feedwater Flow | 0-110% | 1 |
| | | d. Steamline Pressure | 0-1400 psig | 1 |
| | | e. Core Exit Temperature | 100 - 2200°F | 1 |
| | | f. Wide Range $T_{Hot}$ | 0-700°F | 1 |
| | Preferred Backup: | a. Main Feedwater Flow | 0-110% | 2 |
| | | b. Main Steamline Isolation and Bypass Valve Status | open/closed | 2 |
| Primary Reactor Containment Environment | Key: | a. Containment Pressure | -5-60 psig | 1 |
| | | b. Containment Radiation Level | 1.0 to $1x10^7$ R/Hr | 1 |
| | | c. Containment Water Level | 0-600K Gal | 1 |
| | | d. Containment Hydrogen Concentration | 0-10% | 1 |
| | Preferred Backup: | None | | |

TABLE 9.4-3

SUMMARY OF TYPE C VARIABLES

| Barrier | | Variable | Range | Category | |
|---|---|---|---|---|---|
| In-Core | Key: | Core Exit Temp | 100-2200°F | 1 | |
| Fuel Clad | Preferred: | a. Reactor Vessel Water Level | 0-100% | 2 | |
| | Backup: | b. RCS Sampling | Various | 3 | |
| | | c. RCS Activity Level | 10 uCi/cc to 10 Ci/cc | 2 | |
| RCS | Key: | RCS Pressure (Extended Range) | 0-3500 psig | 1 | |
| Boundary | Preferred: | a. RCS Pressure (Wide Range) | 0-3000 psig | 2 | |
| | Backup: | b. Containment Pressure | -5-60 psig | 2 | |
| | | c. Containment Water Level | 0-609K Gal | 2 | 2 |
| Containment Boundary | Key: | a. Containment Pressure (Extended Range) | 0-180 psig | 1 | 2 |
| | | b. Hydrogen Concentration | 0-10% | 1 | |
| | Preferred: | a. Common Plant Vent Radiation | $1x10^{-6}$ to $1x10^{4}$ uCi/cc Noble Gases | 3 | |
| | Backup: | b. Adjacent Building Radiation | 0.1 to $1x10^{4}$ R/Hr | 3 | 2 |
| | | c. Containment Isolation Valve Status | open/closed | 2 | |
| | | d. Containment Pressure | -5-60 psig | 2 | |

### 9.4.4 Type D Variables

Type D variables are those variables that provide the control room operators with information to monitor the operation of plant safety systems and other systems that are safety related. These variables are to help the operator make appropriate decisions in using the individual systems important to safety in mitigating the consequences of an accident and subsequent recovery to attain a safe shutdown condition and verification of the automatic activation of safety systems. The Type D key variables, the preferred backup variables and their respective categories are listed in Table 9.4-4.

### 9.4.5 Type E Variables

Type E variables are those variables that provide the control room operators with information to determine the magnitude of the release of radioactive materials and for continuously assessing such releases. They also monitor the habitability of the control room, monitor plant areas where access may be required for servicing equipment necessary to monitor or mitigate the consequences of an accident, and estimate the magnitude of the radiation source available for potential release. These variables are listed in Table 9.4-5.

TABLE 9.4-4

SUMMARY OF TYPE D VARIABLES

| System | Variable | Range* | Category |
|---|---|---|---|
| RCS Pressure Control and Pressurizer Level | a. Pressurizer PORV Status | O-I-C | 2 |
| | b. Pressurizer PORV Block Valve Status | O-I-C | 2 |
| | c. Primary Safety Valve Status | O-I-C | 2 |
| | d. Pressurizer Heater Breaker Position | Open-Closed | 2 |
| | e. Pressurizer Level | 0-100% | 2 |
| | f. RCS Pressure (Wide Range) | 0-3000 psig | 2 |
| CVCS | a. Charging System Flow | 0-500 gpm | 2 |
| | b. Letdown Flow | 0-500 gpm | 2 |
| | c. Volume Control Tank Level | 0-100% | 2 |
| | d. CVCS Valve Status | O-I-C | 2 |
| | e. RCP Seal Injection Flow | 0-20 gpm each | 2 |
| Secondary Pressure and S/G Level Control | a. SG Atmospheric PORV Status | O-I-C | 2 |
| | b. SG Safety Valve Status | O-I-C | 2 |
| | c. Main Steam Isolation and Bypass Valve Status | O-I-C | 2 |
| | d. Main Steam Pressure | 0-1400 psig | 2 |
| | e. Main Feedwater Control Valve Status | O-I-C | 2 |
| | f. Main Feedwater Control Bypass Valve Status | O-I-C | 2 |
| | g. Main Feedwater Isolation Valve Status | O-I-C | 2 |
| | h. SG Blowdown Isolation Valve Status | O-I-C | 2 |
| | i. Main Feedwater Flow | 0-110% | 2 |
| | j. Auxilary Feedwater Flow | 0-110% | 2 |
| | k. Wide Range S/G Level | 0-100% | 2 |
| | l. Narrow Range S/G Level | 0-100% | 2 |

| 2

*O-I-C equal Open
Intermediate
Closed

TABLE 9.4-4 (cont'd)

SUMMARY OF TYPE D VARIABLES

| | System | Variable | Range* | Category |
|---|---|---|---|---|
| | ECCS | a. Total HHSI Flow | 0-2000 gpm | 2 |
| | | b. Total LHSI Flow | 0-5000 gpm | 2 |
| | | c. Accumulator Pressure | 0-700 psig | 2 |
| | | d. ECCS Valve Status | O-I-C | 2 |
| | | e. Safety Injection Pump Status | On-Off | 2 |
| | | f. RWST Level | 0-100% | 2 |
| | | g. Containment Water Level | 0-609K Gal | 2 |
| 2 | Containment Systems | a. RCB Fan Cooler P | 3-4 in. water | 2 |
| | | b. Containment Pressure | -5-60 psig | |
| | | c. Containment Water Level | 0-609K Gal | |
| | | d. Containment Spray Flow | 0-110% | 2 |
| | | e. Containment Spray Valve Status | 0-I-C | 2 |
| | | f. Containment Spray Pump Status | On-Off | 2 |
| | Component Cooling Water | a. CCW Header Pressure | 0-150 psig | 2 |
| 2 | | b. CCW Header Temperature | 0-250°F | 2 |
| | | c. CCW Surge Tank Level | 0-100% | 2 |
| | | d. CCW Flow to ESF Components | 0-110% | 2 |
| | | e. CCW Valve Status | O-I-C | 2 |
| | | f. CCW Pump Status | On-Off | 2 |
| | Essential Cooling Water | a. Essential Cooling Water System Flow | 0-110% | 2 |
| | | b. Essential Cooling Water System Valve Status | O-I-C | 2 |
| | | c. Essential Cooling Water Pump Status | On-Off | 2 |

*O-I-C equal Open
Intermediate
Closed

TABLE 9.4-4 (cont'd)

SUMMARY OF TYPE D VARIABLES

| Barrier | Variable | Range* | Category |
|---|---|---|---|
| Electric Power Systems | a. Standby Power and Emergency Source Status | Various | 2 |
| | b. Other Safety Related Energy Sources | Various | 2 |
| Auxiliary Feedwater System | a. Auxiliary Feedwater Flow | 0-110% | 2 |
| | b. Condensate Storage Tank Level | 0-100% | 2 |
| | c. Auxiliary Feedwater Valve Status | O-I-C | 2 |
| | d. Auxiliary Feedwater Pump Status | On-Off | 2 |
| Residual Heat Removal | a. RHR Heat Exchanger Discharge Temp | 50-400°F | 2 |
| | b. RHR Flow | 0-110% | 2 |
| | c. RHR Valve Status | O-I-C | 2 |
| | d. RCS Pressure (Wide Range) | 0-3000 psig | 2 |
| Reactor Protection System | Reactor Trip Breaker Position | Open/Closed | 2 |
| Turbine | a. Turbine Stop Valve Position | Open/Closed | 2 |
| | b. Turbine Throttle Valve Position | Open/Closed | 2 |
| HVAC | ESF Environment | Temp Above Setpoint, Stopped/Running | 2 |

*O-I-C equal Open
Intermediate
Closed

TABLE 9.4-5

SUMMARY OF TYPE E VARIABLES

| | Variable | Range | Category |
|---|---|---|---|
| | High Range Containment Radiation Level | 1.0 to $10^7$ R/HR | 2 |
| 2 | Secondary System Radiation | $10^{-6}$ to $10^5$ uCi/cc | 2 |
| | Unit Vent Radioactivity Level | $10^{-6}$ to $10^5$ uCi/cc Noble Gas<br>$10^{-11}$ to $10^2$ uCi/cc Particulate<br>$10^{-11}$ to $10^2$ uCi/cc Halogens | 2<br>2<br>2 |
| | Site Environmental Radiation Level | Various | 3 |
| | Control Room Radiation | 0.1 to $10^4$ R/hr<br>$10^{-6}$ to $10^{-1}$ uCi/cc | 3<br>2 |
| 2 | Adjacent Building Radiation Level | 0.1 to $10^4$ R/hr<br>$10^{-6}$ to $10^{-1}$ uCi/cc | 3<br>2 |
| | Access Area Radiation | 0.1 to $10^4$ R/hr | 3 |
| | Non-Headered Effluent Radiogas Concentration (condenser vacuum pump) | Activity:<br>$10^{-6}$ to $10^5$ uCi/cc | 2 |
| | Concentration From Liquid Pathways | Activity:<br>$10^{-6}$ to 0.1 uCi/cc | 2 |
| | FHB Vent Radiation | Activity:<br>$10^{-6}$ to 0.1 uCi/cc | 2 |

TABLE 9.4-5 (cont'd)

SUMMARY OF TYPE E VARIABLES

| Variable | Range | Category | |
|---|---|---|---|
| Effluent Path Flow Rate/Status: | 0-110% | 3 | |
| S/G Blowdown | | | |
| Cond. Polish | | | 2 |
| Liquid Radwaste | | | |
| Unit Vent | | | |
| Condenser Vacuum Pump TGB Drain | | | |
| Meteorological Parameters: | | | |
| Wind Speed | 0-50/0-100 mph | 3 | |
| Wind Direction | 0-180°-360° | 3 | 2 |
| Ambient Temperature | 0 to 120°F | 3 | |
| Atmospheric Stability ( T) | -6°F to +6°F | 3 | |
| Dew Point | 0-120°F | 3 | |
| Precipitation | 0-Infinity | 3 | |
| Solar | 0-2 Langley's/cm/cm | 3 | |

# 10.0 BYPASSED AND INOPERABLE STATUS FEATURES

## 10.1 FUNCTION

In order to enable the control room operators to assess the status of the engineered safety features (ESF), an ESF status monitoring system is provided. The ESF status monitoring system has two functions:

A. To provide control room indication when any portion of an ESF system or its support systems has been bypassed or deliberately rendered inoperable during normal plant operating modes.

B. To provide control room indication when any component of an ESF system or its support systems fails to achieve its designed safe operating position following the initiation of its ESF actuation signal. | 2

## 10.2 DESIGN CRITERIA

The bypassed and inoperable status monitoring subsystem of the ESF status monitoring system shall meet the guidelines presented in Reg. Guide 1.47, Rev. 0. The following specific criteria apply:

A. The ESF status monitoring system shall monitor:

1. Automatically actuated ESF systems
2. Manually actuated ESF systems
3. ESF support systems

B. The components for the ESF status monitoring system shall include those components:

1. Automatically actuated by ESFAS
2. Active and manually activated

2 Bypass indication for safe shutdown components shall also be provided. The safe shutdown components that also perform the ESF function shall be monitored within their ESF system. Those components required for safe shutdown but not monitored within a ESF system shall be monitored separately under one group each for each train A, B, C. The bypass/inoperable lights shall be arranged to provide ESF system level bypass/inoperable indication.

C. The selection of an ESF component and its associated system(s) for ESF and bypass/inoperable status indication shall be based upon the protective function the component performs within that ESF system. An ESF component performing its protective function in two or more ESF systems (e.g., changing plant modes) shall be monitored for its status in each of those ESF systems. Each ESF system shall include the support systems and components for its bypass/inoperable status indication so that when a support system becomes bypassed or inoperative all ESF systems that it supports shall also be indicated to have become inoperative.

D. The ESF status monitoring system shall consist of three independent trains (A, B, C) of logic and indication. Each train shall consist of two subsystems of logic and indication as follows:

1. Bypass or inoperable status indication
2. ESF actuated status indication

The bypass/inoperable status indication subsystem shall continuously monitor the status of field contacts and automatically indicate that a specific piece of ESF equipment has been bypassed or rendered inoperable. Such indication shall be accomplished by lighting up the component level window. The bypass/inoperable indication shall also

provide a system level audio-visual annunciation to alert the control room operator that an ESF system has been bypassed or rendered inoperable. The sequence of operation for the system level alarm will be the same as for the plant annunciator system. 2

The ESF-actuated status indication subsystem shall continuously monitor the status of field contacts and automatically indicate that a specific piece of ESF equipment is not in its safety position after the receipt of a safety actuation signal. Such indication shall be accomplished by lighting up a component level window. The ESF-actuated status indication system shall also provide a system level audio-visual annunciation to alert the control room operator that an ESF system is not aligned to its safety position after the receipt of its safety actuation signal. The sequence of operation for the system level alarm will be the same as for the main plant annunciator system. 2

The system level audio-visual annunciation for the bypass/inoperable and the ESF-actuated status indication subsystems shall be designed with multiple-input logic so that each newly arrived component level condition will initiate or reinitate the system level alarm. Separate Silence, Acknowledge, and Reset push buttons shall be used to process the alarms. 2

E. The capability for initiating a manual bypass indication and alarm shall be provided via a system level manual bypass switch used to indicate the bypass/inoperable condition to the operator for those components/conditions which are not automatically monitored.

F. The logic provided with the ESF status indication subsystem shall have the provision to "seal in" the incoming safety actuation signals. There shall
2 be one "seal-in" circuit per ESF system per train with a common reset for all three trains for each ESF system.

G. Criteria for the displays alarms and switch characteristics are defined in Section 6, "Human Factors Guidelines".

H. Bypass or inoperable status indication shall be provided for conditions which meet all three of the following:

1. The bypass or inoperable condition affects a system that is designed to automatically perform a function that is related to the safety of the public

2. The bypass will be utilized by plant personnel or the inoperable condition can reasonably be expected to occur more frequently than once per year and,

3. The bypass or inoperable condition is expected to occur when the affected system is normally required to be operable.

I. The ESF status monitoring system shall be designed and installed in a manner which precludes the possibility of adverse affects on the plant safety system. Any failures within the ESF status monitoring system shall not reduce the independence within the redundant safety systems.

J. The ESF status monitoring system shall be used to supplement administrative procedures by providing indications of safety systems availability or status.

2

The administrative procedures shall not require operator action based solely on the basis of the ESF status monitoring system.

K. The ESF and the bypass/inoperable status indication subsystems shall be equipped with lamp and logic test features for component as well as the system level alarm windows. Loss of power to a portion of the system will be annunciated in the Main Plant Annunciator system. 2

L. Deliberate manual actions which render ESF-actuated components and devices inoperable (once a year or more) shall be automatically displayed on a component level. Active components not directly actuated by ESF signal but rendered inoperative once a year or more frequently such that it compromises the safety functions of the ESF system shall also be automatically displayed on a component level to the control room operator.

Rendering a piece of ESF equipment inoperative through the use of features provided strictly for infrequent maintenance (less than once a year) is not automatically indicated. Such maintenance features may include manual valves provided for isolation of the equipment for repair and electrical cable connectors, screw terminals or manual disconnects. The bypass/inoperable indication of these conditions shall be manually initiated on an ESF system level.

Manual bypass/inoperable indication may be set up or removed under administrative control. The automatic indication feature of the ESF status monitoring system shall not be removed by operator action.

M. The source power to bypass/inoperable and the ESF-actuated indicator subsystems shall be uninterruptible and non-Class 1E. 2

## 11.0 SPDS FEATURES

### 11.1 FUNCTIONAL REQUIREMENTS

The basic function of the SPDS is to provide operating personnel in the control room the necessary information for making quick assessments of the plant safety status.

#### 11.1.1 SPDS Functions

A. Provide continuous indication of plant parameters and derived variables representative of safety status of the plant

B. Aid operator in the detection of abnormal operating conditions

C. Assist in analysis and diagnosis of cause of abnormalitites

D. Monitor plant response to corrective actions

E. Provide signal validation and functional comparison capability

F. Flag unvalidated data

G. Provide trending capabilities

H. Be responsive to all operating modes

I. Provide audio or visual cues for:

1. Existence of unsafe operating conditions in plant

2. SPDS system failures

3. Alerting operator to need for operator action

11.1.2 Equipment Required To Implement Functions

Equipment shall be provided for driving the required displays, accepting inputs and acknowledgements from the operator, and providing communication links with other systems.

Operator interface shall be included which provides display devices and pushbuttons or switches for implementing the operator/system interface requirements.

Sufficient redundancy shall be provided to satisfy all functional requirements and availability goals.

11.1.3 Criteria For Integration With The Control Room

11.1.3.1 Location

Displays shall be located in the control room at one or more specially designated stations.

A set of function keys, and/or full keyboard shall be installed at each display station to provide display status indication and operator interaction for that group of displays.

11.1.3.2 Rendundancy Requirements

To simplify the man-machine interfaces and minimize operator errors, a single display system shall be used for evaluating the safety status of the plant. Redundancy shall be provided as necessary to meet the availability requirements.

11.1.3.3 Operator Interface

The SPDS shall be integrated into the control room in such a manner that it will:

A. Not interfere with access to the operator interface of any other system

B. Be readily observable during normal operational activities

C. Impose little or no additional training requirements upon the operating staff (i.e. the displays, indicators, and controls should be very nearly self explanatory).

D. Easily recognizable and readable.

11.1.3.4 SPDS Status Verification and Failure Recognition Criteria

System status indication which can be manually reset by the operator shall be provided.

11.1.4 Displays

Critical safety functions to be monitored while the plant is operating shall include but not be limited to those listed in Section 9.4.

Provision shall be made for simultaneous display of brief messages applying to:

A. Plant conditions

B. SPDS status

C. Input conditions

D. Operator prompts

11.1.5 System Response Times, and Sampling Rates
(Ref. NUREG 0700, Sec. 6.7.1.7)

Positive feedback must be given to keyboard entry by the operator.

2 Considering the nature of the SPDS functions, response to display requests for the SPDS functions as listed in Section 11.1.1 (i.e., acknowledgement) must occur within one second.

11.1.6 Reinitialization

The time of automatic reinitialization of the system shall be displayed to the operator.

11.1.7 Data Filtering and Smoothing Criteria

Any smoothing prescription shall be applied to current values and shall use no data older than five seconds.

11.1.8 Bad Input Handling Criteria

Detectable input failures (measurement errors, bad instrumentation, etc.) shall be flagged in some way. Calculations based on manually replaced input values shall be indicated as such.

11.1.9 System Transient Response and Plant Operating Mode Detection Criteria

The basic SPDS displays shall be functioning and valid during all plant transients in accordance with the availability requirements. Without operator intervention, the system shall be able to display parameters for at least the following plant operating modes:

A. Power operation

B. Cold shutdown

C. Hot shutdown

D. Hot standby

E. Startup

F. Refueling

(Ref: STP FSAR, Sec. 15.0.1.1, Steady state and shutdown operations)

## 11.2 HUMAN FACTORS REQUIREMENTS

### 11.2.1 Display Criteria

#### 11.2.1.1 Display Concepts and Formats

There shall be a primary system level display which will indicate the overall status of each selected safety system. This display shall serve as the SPDS monitoring display. Other display formats shall be available for use as auxiliary displays to provide more detailed information when requested by the operator.

Special display formats shall be developed for the following:

A. Primary display

B. Auxiliary displays

C. Trending displays

D. SPDS status verification

11.2.1.2 Readability
(Ref. NUREG 0700, Sec 6.5.1.3, 6.7.2.1, 6.7.2.2)

The display shall be readable from the emergency station of the Senior Reactor Operator. However, display format shall be carefully evaluated to optimize readability. Large characters or special graphics may be used to emphasize the display or to allow reading data from further than normal reading distance.

11.2.1.3 Logging and Trending Criteria

2 Historical data shall be maintained for the last ___ hours. At least ___ time points shall be maintained for each variable. This data shall be available for variable trends displays and for logging on a printer upon operator request.

11.2.1.4 Other Display Criteria
(Ref. NUREG 0700, Sec. 6.7.2)

Other display criteria related to display mounting, lighting, presentation formats, trend plots, operator interaction, use of color and graphics, highlighting, and paging shall be as specified by NUREG 0700, Sec. 6.7.2.

11.2.2 DISPLAY, INDICATION, AND ALARMS CRITERIA

Status indication shall be used to indicate failures on the SPDS equipment. Audible annunciation may be used to attract operator attention or to signal a plant safety status change. Plant status information shall only be presented on the display devices.

11.2.3 Criteria For Operator Interaction

The following operator interaction capability shall exist at each display station:

A. Acknowledge

B. Verify status (of SPDS)

C. Change displays

D. Recall data

11.2.4 Data Compression 2

Data to be displayed may be compressed by using averages of a set of variables where appropriate. However, if the average contains bad, suspect or manual inputs the resulting average shall be flagged.

11.2.5 OPERATOR PERCEPTION CRITERIA

The display method used shall be self-explanatory and not dependant upon operator memory for interpretation.

# 12.0 PLANT COMPUTER FEATURES

## 12.1 FUNCTIONAL REQUIREMENTS

Basic plant computer functions which are required fall into five categories:

A. General analog and digital input monitoring

B. Logging of plant operating data, alarms and status changes

C. Performance and other special calculations

D. Historical data collection, storage and retrieval

E. Display of alarms and other plant operation data

The major advantages of computer assisted information processing in the control room are improved quality of information presentation as well as reduced number of indicators necessary for proper identification of the plant status. Potentially, the computer can perform the functions of preliminary analysis and integration of relevant data on the basis of a prespecified plant model implemented in the data base.

## 12.2 EQUIPMENT REQUIRED

Equipment shall be provided for driving the required displays, accepting inputs and acknowledgments from the operator and providing communication links with other systems.

An operator interface shall be included which provides display devices, display controls, and printers for implementing the operator/plant interface requirements.

Sufficient redundancy shall be provided to satisfy all functional and availability requirements.

## 12.3 CRITERION FOR INTEGRATION WITH CONTROL ROOM

### 12.3.1 Location

Displays shall be located in the control room on the main control panels and on a special operators console. Printers shall also be located in the control room. Dedicated function control keys shall be the primary means for requesting displays on the main control panels. Operator controls for computer displays shall also be located on the operator console. Programming and other controls which could cause system failure if inadvertently used shall be locked out or located outside the control room.

### 12.3.2 Redundancy Requirements

All display and printer devices shall have backups. An adequate number of display devices shall be mounted on the main control boards to supplement operator requirements for detailed alarm and other systems and performance information. At least two display devices shall be located on the operators console and at least two printers shall be located in the control room.

### 12.3.3 Operator Interface

The plant computer operator interface shall be integrated into the control room in such a manner that it will:

A. Not interfere with access to or operation of any other system;

B. Be readily observed during normal operational activities;

C. Impose little or no additional training requirements upon the operating staff (i.e. the displays, indicators and controls should be very nearly self explanatory).

12.3.4 Plant Computer System Status

Plant computer status indication shall be provided in the control room. Alarm annunciation shall be provided for plant computer failures.

12.3.5 Diagnostics, Testing, and Surveillance Criteria

Provisions shall be made for execution of periodic self diagnostics at least once per second without affecting the normal plant computer functions.

Other programs shall be available to be executed upon operator manual request to verify the system operation without removing the system from service.

A set of programs shall be available to support and expedite surveillance testing. These may require temporary removal of the system from service.

12.3.6 Guidelines

Refer to the following appendices for additional guidelines applicable to the plant computer.

A. Appendix O; Process computer Guidelines.

B. Appendix P; Guidelines Pertaining to Keyboards, Function Controls, Computer Response Times and Access Aids.

C. Appendix Q; Guidelines Specific to CRT Displays.

D. Appendix R; Printers Guidelines.

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10 CFR 50, Appendix A - General Design Criteria For Nuclear Power Plants.

# APPENDIX A

## ANTHROPOMETRIC AND WORK SPACE DESIGN GUIDELINES FOR STAND-UP CONSOLES, SIT-DOWN CONSOLES, SIT-STAND WORK STATIONS AND VERTICAL PANELS

## A.1 ANTHROPOMETRIC DATA

Equipment dimensions should be as defined in Table A.1-1.

TABLE A.1-1
ANTHROPOMETRIC DATA USED TO
SET LIMITS FOR EQUIPMENT DIMENSIONS

| | Bounding Measurements (inches) | |
|---|---|---|
| Standing (without shoes) | 5th Percentile Adult Female | 95th Percentile Adult Male [1] |
| Stature | 60.0 | 73.5 |
| Eye height from floor | 55.5 | 68.6 |
| Shoulder height | 48.4 | 60.8 |
| Elbow height | 37.4 | 46.8 |
| Fingertip height [2] | 24.2 | 28.8 |
| Functional reach [3] | 25.2 | 35.0 |
| Extended functional reach [4] | 28.9 | 39.0 |
| Distance from central axis of body to leading edge of console [5] | 5.0 | 5.3 |
| Eye distance forward of central axis of body [5] | 3.0 | 3.4 |
| **Seated** | | |
| Popliteal height (bend at back of knee) | 15.0 | 19.2 |
| Sitting height above seat surface, erect, | 31.1 | 38.5 |
| relaxed | 30.5 | 37.6 |
| Eyeheight above seat, sitting erect | 26.6 | 33.6 |
| Shoulder height above seat surface | 19.6 | 25.8 |
| Elbow height above seat surface | 6.4 | 11.3 |
| Functional reach | 25.2 | 35.0 |
| Extended functional reach | 28.9 | 39.0 |
| Thigh clearance height | 4.1 | 7.4 |
| Buttock-popliteal length | 17.1 | 21.5 |
| Knee height | 18.5 | 23.6 |

| Standing (without shoes) | Bounding Measurements (inches) 5th Percentile Adult Female | 95th Percentile Adult Male |
|---|---|---|
| Distance from central axis of body to leading edge of console[5] | 5.0 | 5.3 |
| Eye distance forward of central axis of body[5] | 3.0 | 3.4 |

Notes for Table A.1-1

[1] MIL-STD-1472B gives separate values for male ground troops and aviators. The two were averaged for presentation here.

[2] Data for male aviators only, 5th and 95th percentiles.

[3] Measured from wall to tip of right index finger, with right arm extended horizontal to floor, both shoulders against wall.

[4] Measured as stated in note 3, except right shoulder extended out from wall as far as possible with left shoulder against wall.

[5] These measurements are not given MIL-STD-1472B. Values provided in Seminara et al. (1980), an EPRI report, are presented although they are based on measures of a different population. Differences in other measurements between the MIL-STD population and the EPRI population are small enough that these EPRI values should provide reasonable approximations.

## A.2 STAND-UP CONSOLES

### A.2.1 Dimensions
(Ref: NUREG-0700, Sec. 6.1.2.2)

Stand-up console dimensions should be as defined in Figure A-1. This profile should accommodate the highest reach of the operator without stretching or using a stool or ladder to operate the highest control.

The profile is also to accommodate the lowest reach of the operator male without bending or stooping to reach the lowest control. The benchboard slope, in conjunction with its depth, should result in all controls being within the reach radius of the operator. The following criteria should be met for stand-up consoles to accommodate the maximum reach of the operator:

A. Controls should be set back a minimum of 3 inches from the front edge of the sloped panel to prevent accidental actuation.

B. No control should be placed more than 25 inches from the front edge of the control panel.

Extended functional reach is a more realistic measure of operator reach than functional reach because operators frequently bend and/or lean to manipulate controls during normal operation. Therefore, extended functional reach should be used as the reach measure for STP control board purposes.

### A.2.2 DISPLAY POSITIONING
(Ref: NUREG-0700, Sec. 6.1.2.2)

Readability of displays and annunciators is affected by: (a) display height and orientation with respect to the line-of-sight of the operator when standing directly in front of the display, (b) display distance and orientation

with respect to the straight-ahead line of sight of the operator when read from an off-side position, and (c) display marking size relative to the reading distance.

Displays and annunciators should be mounted so they are within 75° above the horizontal line-of-sight of the operator (Figure A-2). This is defined as the upper limit of the vertical visual field.

The optimum mounting of display faces is perpendicular to the actual line-of-sight of the operator. Displays and annuciators should be mounted so that a viewing angle not exceeding 45° above and below the operator's actual line-of-sight to the display is created (Figure A-2). This criterion applies to any display or any annunciator mounted in any attitude within the vertical visual field of the operator. The display edge that is the greatest distance from the eye reference point (i.e. the top of displays above the operator and the bottom of displays below the operator) should define the viewing angle to determine whether the above criterion is met.

A.2.3 HORIZONTAL PLACEMENT OF DISPLAYS
(Ref: NUREG-0700, Sec. 6.1.2.2)

Horizontal viewing angles from the straight-ahead line-of-sight to the face of the display should not exceed 45° to either side of the operator (Figure A-3). This includes annunciator tiles, which should readable from the the operator position within reach of acknowledge button location.

A.2.4 LATERAL SPREAD OF CONTROLS AND DISPLAYS
(Ref: NUREG-0700, Sec. 6.1.2.2)

The lateral spread of controls and displays should be such that the operator is able to perform the required task sequences at a given work station with minimum repositioning. The maximum lateral spread of controls and displays at

a single operator work station should be no greater than 72 inches. Foot room allowances of 4 inches both horizontally and vertically or greater should be incorporated in the stand-up control panel.

## A.3 SIT-DOWN CONSOLES
(Ref: NUREG-0700, Sec. 6.1.2.3)

### A.3.1 DIMENSIONS

If the seated operator must see over the sit-down console, the maximum height of the console backboard should be 27 inches above the seat. Recommended seat height should be 14 inches. Therefore, the maximum console height should be 41 inches above the floor. Console height greater than 41 inches may be acceptable where the seated operator need only monitor (not read) status lights and annunciators beyond the console, if they are placed at suitable height and distance.

### A.3.2 CONTROL HEIGHT
(Ref: NUREG-0700, Sec. 6.1.2.3)

Controls at a sit-down console should be within the reach radius of 25 inches (5th percentile female). Measurements should be made using seated shoulder height with the shoulder in line with the leading edge of the benchboard (Figure A-4).

### A.3.3 BENCHBOARD SLOPE
(Ref: NUREG-0700, Sec. 6.1.2.3)

The slope of the benchboard, in conjunction with its depth, should be such that all controls are within the functional reach radius of the opeator (Figure A-5) and all displays and markings can be read.

A.3.4 CONTROL PLACEMENT
(Ref: NUREG-0700, Sec. 6.1.2.3)

Controls should be set back a minimum of 3 inches from the front edge of the console to prevent accidental actuation. Other controls may be mounted as far back as 25 inches from the console edge. This distance accommodates the extended functional reach of the operator (Figure A-4).

A.3.5 DISPLAY POSITIONING
(Ref: NUREG-0700, Sec. 6.1.2.3)

The principal factors affecting readability of displays and annunciators are: (a) display height and orientation relative to the operator's line-of-sight when seated at the console; (b) display distance and orientation relative to the operator's straight-ahead line-of-sight when a display must be read from an off-side position; and (c) the size of display markings relative to the distance the display must be read. Unless specifically noted, measurements should be made with the eyepoint in line with the leading edge of the benchboard (Figure A-6). All displays should be located so they are within the upper limit of the visual field of 75° above the horizontal line of sight of the operator. Also, all displays should be mounted such that the angle from the line-of-sight to the display face plane is 45° or less.

A.3.6 LATERAL SPREAD OF CONTROLS AND DISPLAYS
(Ref: NUREG-0700, Sec. 6.1.2.3)

The lateral spread of controls and displays on sit-down consoles is dependent on the operator's reach, panel orientation, grouping of controls and displays, and seat position reference point for given task sequence (Figure A-6). For control and monitoring actions that must occur sequentially, all required controls and displays should be within the maximum extended reach and viewing

range of a seated operator from a single reference point. To achieve sustained or precise control action, the operator should not be required to stretch or bend significantly.

In order to effectively achieve the goals stated above, consideration should be given to use of wing-panels emanating from the sloped back-panel, thereby providing a "wrap around" effect at each work station. Back-panel and wing panel slopes should be such that all controls regardless of location are within the reach of the operator.

A.3.7 LEG AND FOOT ROOM
(Ref: NUREG-0700, Sec. 6.1.2.3)

Sufficient leg and foot room should be provided so operators can maintain comfortable positions while operating the controls (Figure A-7).

A.3.8 WRITING SPACE
(Ref: NUREG-0700, Sec. 6.1.2.3)

Writing space at sit-down consoles is required by the operators working there. A 16-inch deep by 24-inch wide space is recommended where these dimensions would fit operator reach capability within the total configuration of the console. Less space may be adequate commensurate with the frequency and duration of writing requirements. Any writing space provided should not interfere with operation of controls and viewing of displays. If space limits preclude a console writing space, a nearby desk or table should be provided.

A.4 <u>SIT-STAND WORK STATIONS</u>
(Ref: NUREG-0700, Sec. 6.1.2.4)

The STP control room utilizes both sit-down control consoles and stand-up panels. This provides needed mobility to monitor large panel areas. It also

provides the needed seated stability to perform precise task or tasks which may proceed for long periods requiring sustained attention, such as reactor startup.

A.4.1 CHAIR HEIGHT
(Ref: NUREG-0700, Sec. 6.1.2.4)

If seated operation at the stand-up panels is required, the chair provided should be high enough so that the seated eye level is approximately the same as the standing eye level.

A.4.2 CONTROL AND DISPLAY POSITIONING
(Ref: NUREG-0700, Sec. 6.1.2.4)

The locations of controls and displays for sit-stand work stations should conform to the requirements for stand-up consoles as defined in Section 6.1.3.3.

A.4.3 KNEE ROOM
(Ref: NUREG-0700, Sec. 6.1.2.4)

Adequate knee space and foot support should be provided for operator comfort.

A.5 VERTICAL PANEL CONTROL AND DISPLAY PLACEMENT
(Ref: NUREG-0700, Sec. 6.1.2.5)

In order to eliminate extreme reaching, stretching, or stooping at vertical panels, the following criteria should be met for placement of controls and displays:

A. Controls should be within a space of 34 inches to 70 inches off the floor.

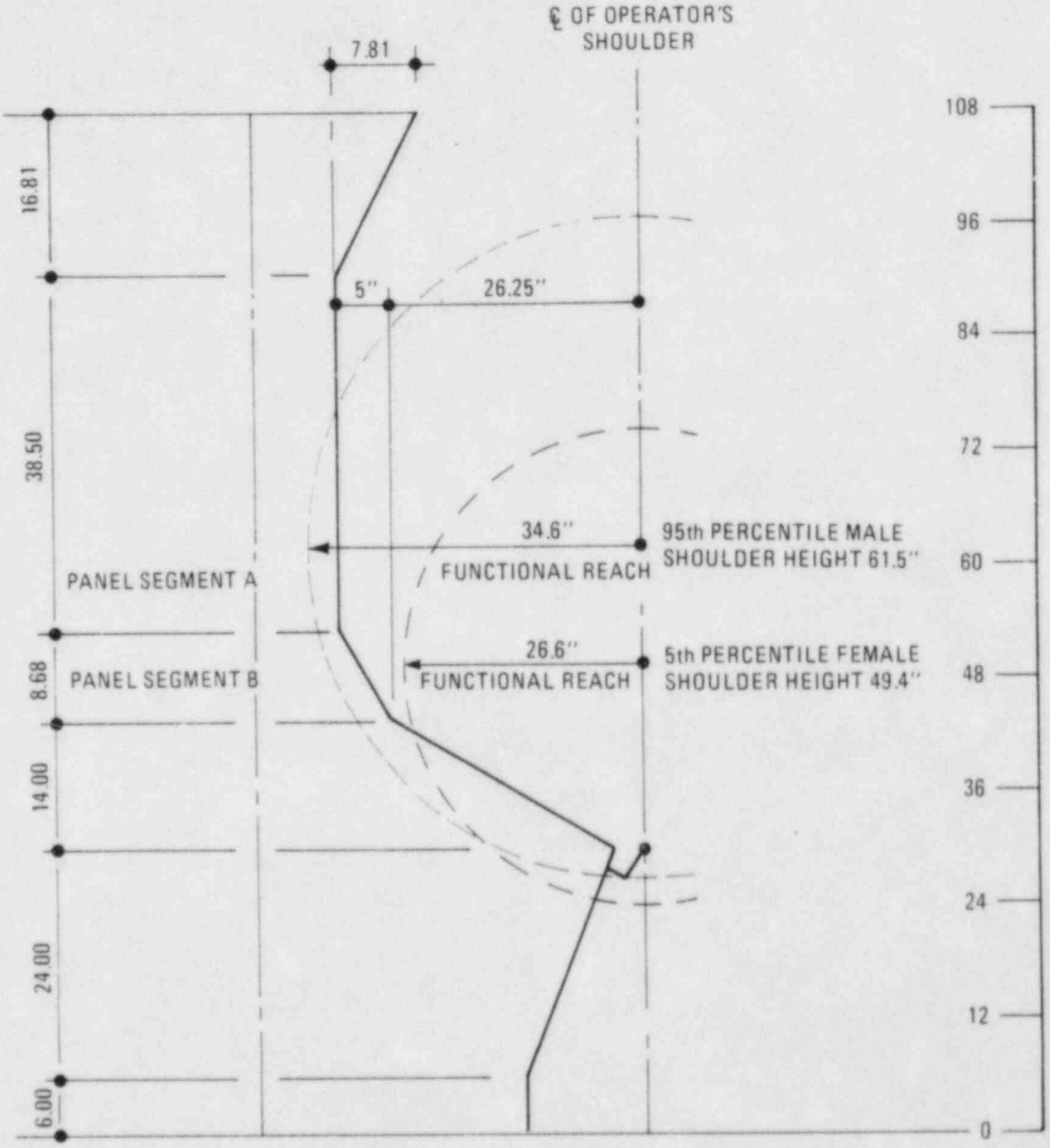
B. Controls that require precise or frequent operation, and those controls performing emergency or safety functions should be located within an area between 34 inches and 53 inches above the floor.

C. Displays should be placed between 41 inches and 70 inches above the floor.

D. Displays requiring frequent or precise reading should be located between 50 inches and 65 inches off the floor.

A.6 USE OF PROCEDURES AND REFERENCE MATERIALS AT CONSOLES AND STAND-UP PANELS
(Ref: NUREG-0700, Sec. 6.1.2.6)

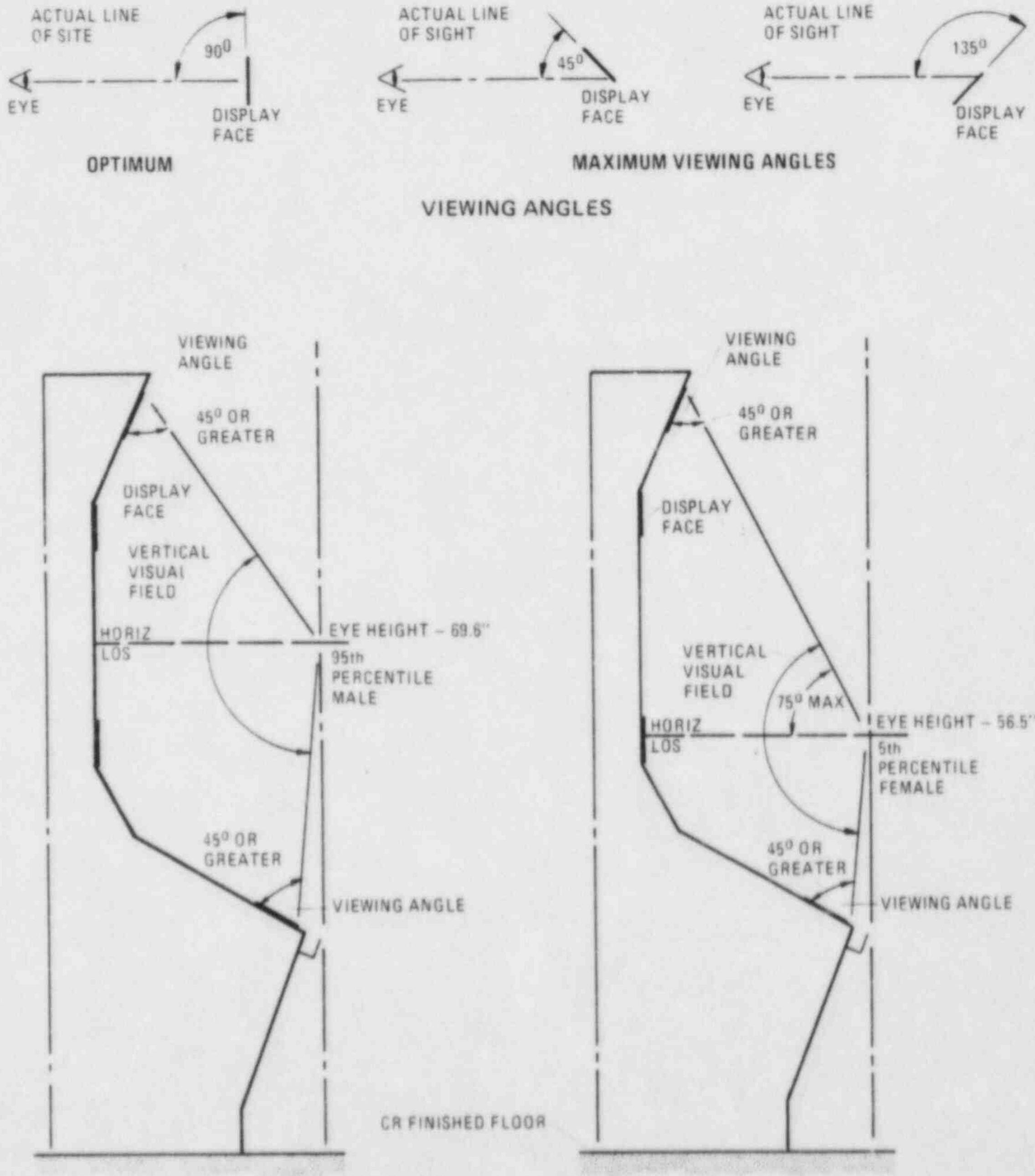
Provisions should be made to provide easy consultation of procedures manuals and other reference materials during task performance at the consoles and panels. Manuals should not be placed on benchboards or on slope-front panels. A roll-around bookcase-reference table is considered a viable solution to this situation. This method would lend itself well to specific out-of-the-way yet ready-access storage of the required reference documents.




NOTE: DIMENSIONS WERE OBTAINED FROM THE CRDR ANTHROPOMETRY REPORT AND ARE SPECIFIC FOR STP

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

Figure A-1



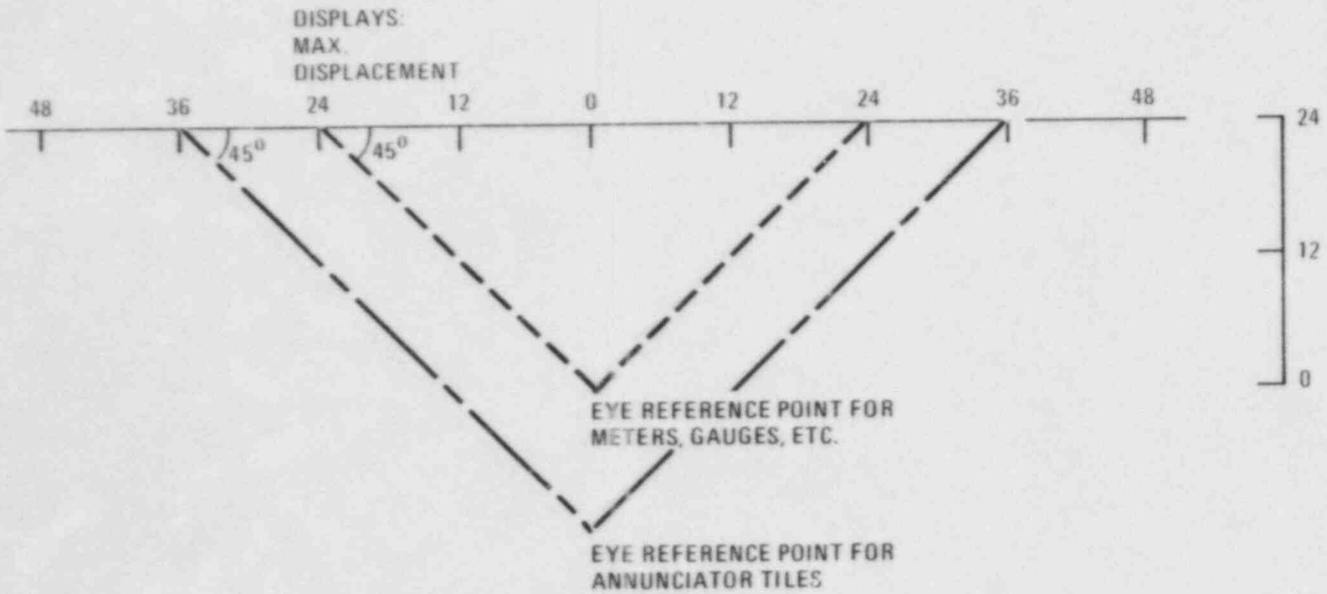

NOTE: ONE INCH ADDED FOR SHOE HEIGHT

**OPERATOR EYE HEIGHT LINE OF SIGHT (LOS) AND VISUAL ORIENTATION FOR SOUTH TEXAS PROJECT STAND-UP CONTROL PANELS**

**VIEWING ANGLES**
**Figure A-2**

HOUSTON LIGHTING & POWER CO.

CONTROL ROOM DESIGN REVIEW

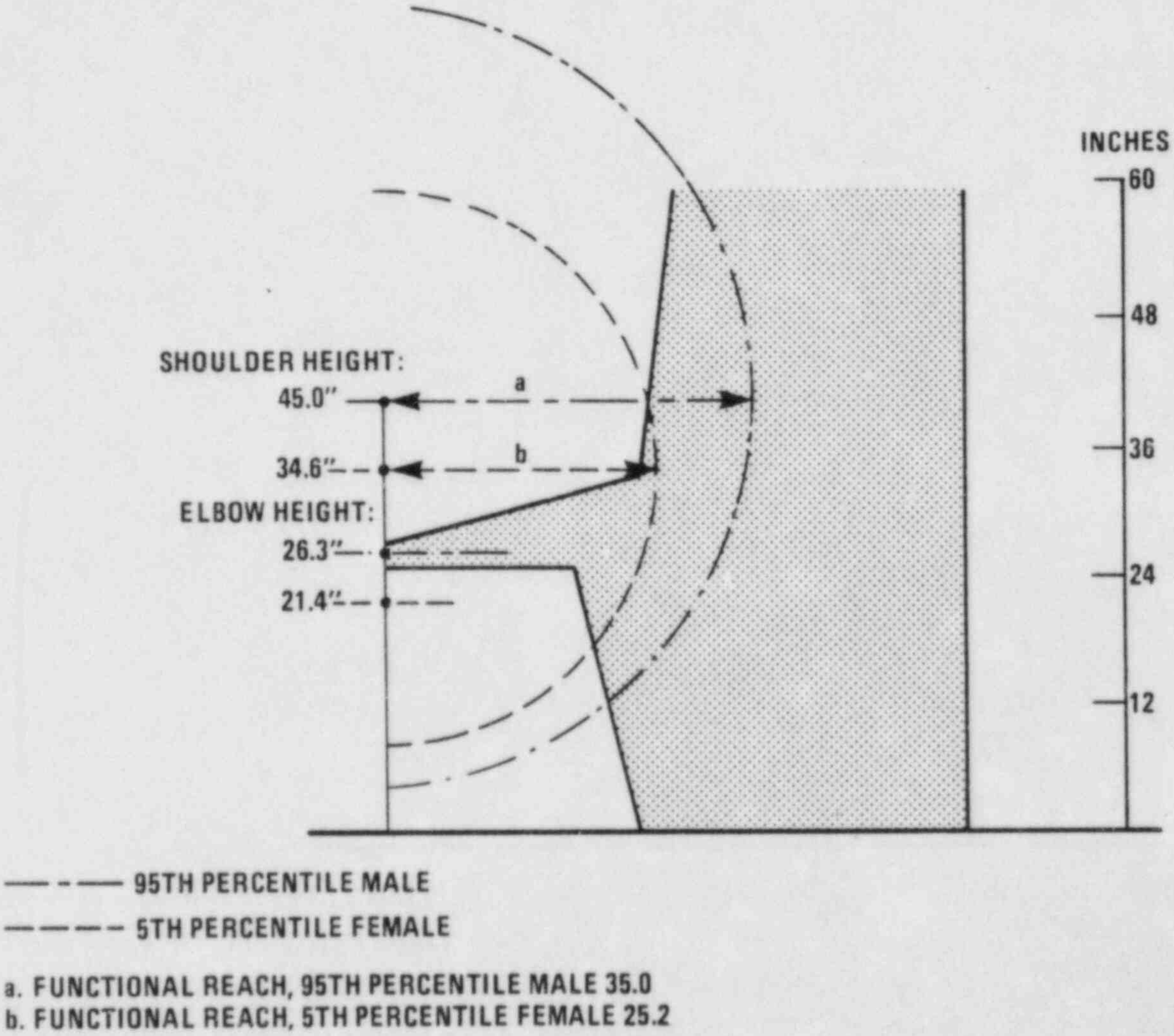



FOR METERS AND OTHER DISPLAYS WHICH MAY HAVE TO BE READ WHILE A CONTROL ANYWHERE ON THE BENCHBOARD IS OPERATED, MEASUREMENT SHOULD BE MADE WITH THE EYE REFERENCE POINT IN LINE WITH THE LEADING EDGE OF THE BENCHBOARD. FOR ANNUNCIATOR TILES, THE EYE REFERENCE POINT MAY BE BACK FROM THE BENCHBOARD EDGE. THE DISTANCE BACK SHOULD BE CONSISTENT WITH THE ABILITY OF THE OPERATOR TO REACH THE ANNUNCIATOR RESPONSE PUSHBUTTONS. TWELVE INCHES IS A SUITABLE NOMINAL DISTANCE BACK FOR MOST CONSOLES.

NOTES: A WRAP-AROUND PANEL WOULD ALLOW GREATER DISPLACEMENT

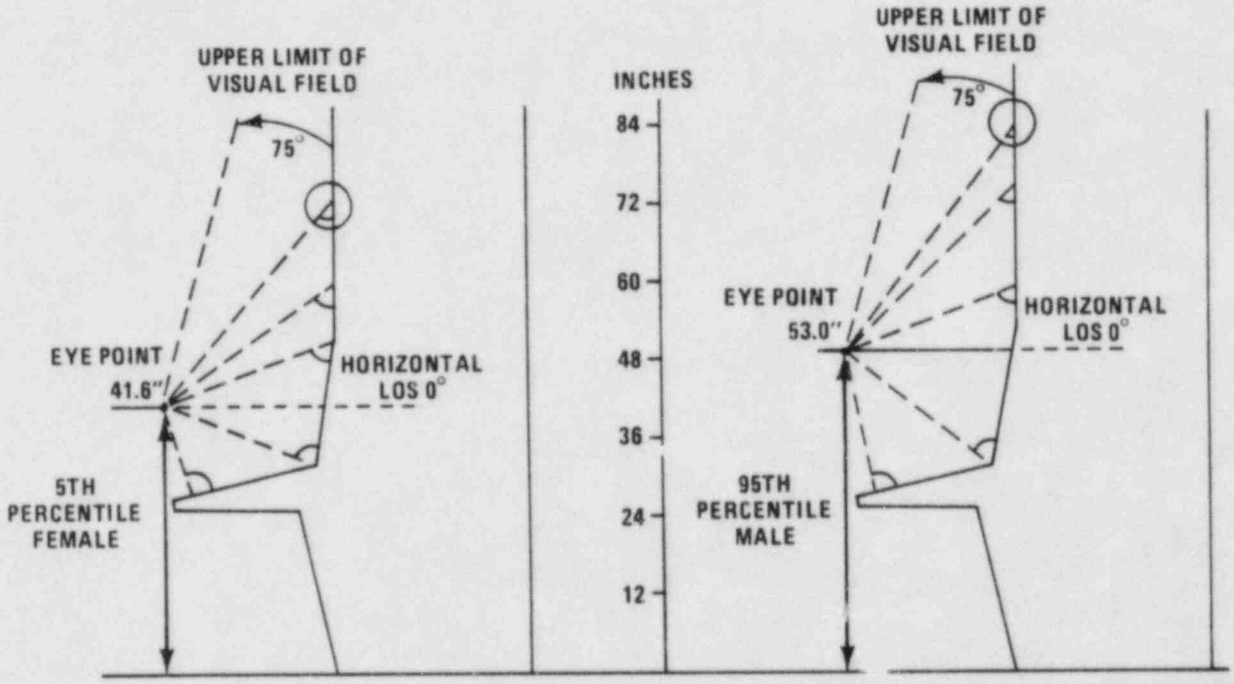
LIMIT ON HORIZONTAL DISPLACEMENT OF DISPLAYS FROM STRAIGHT-AHEAD LINE-OF-SIGHT AT THE REQUIRED READING POSITION.

Figure A-3




REACH CAPABILITIES AND CONTROL HEIGHT ON SIT-DOWN CONSOLES.

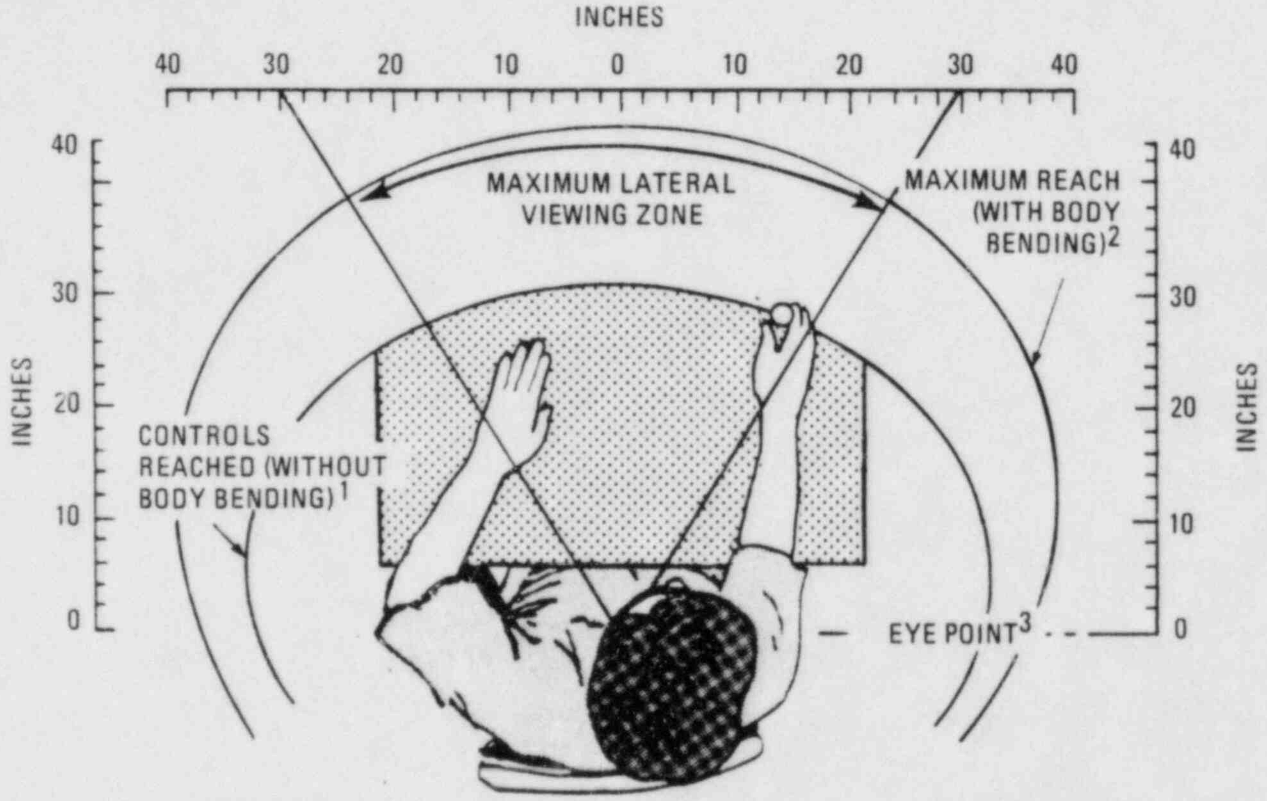
REACH CAPABILITIES AND CONTROL HEIGHT
ON SIT-DOWN CONSOLES
Figure A-4




ANGLE FROM LINE OF SIGHT TO DISPLAY FACE WOULD BE TOO SMALL FOR READABILITY UNLESS THE PANEL TILTED FORWARD AT THIS HEIGHT.

DISPLAY HEIGHT AND ORIENTATION RELATIVE TO SEATED OPERATOR LOS (LINE OF SIGHT).

DISPLAY HEIGHT AND ORIENTATION RELATIVE
TO SEATED OPERATOR LOS
(LINE OF SIGHT)
Figure A-5



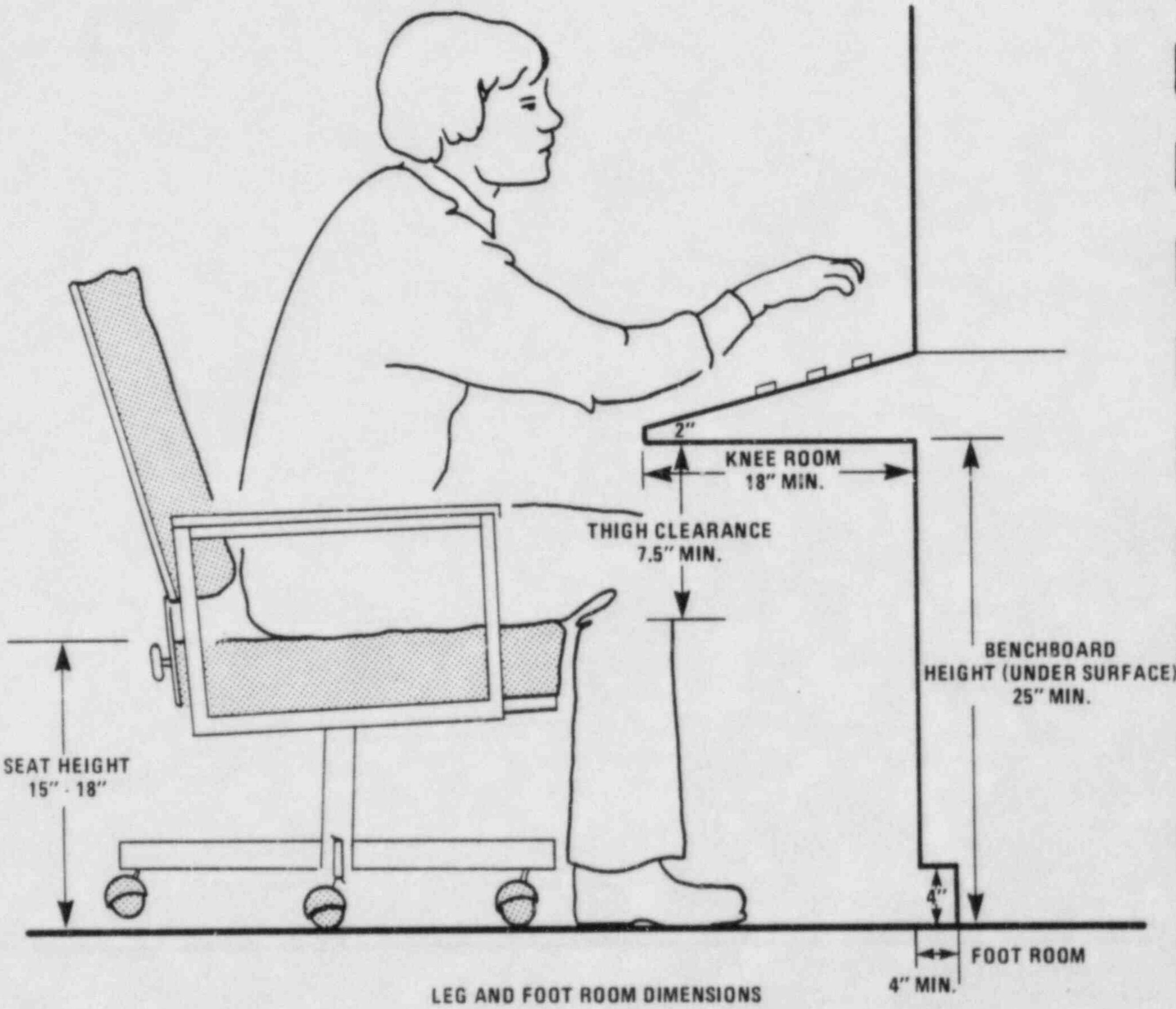

[1] 28 INCHES FORWARD OF THE EYE POINT IS THE MAXIMUM DISTANCE FOR DISPLAYS WHEN VIEWING IS LIMITED BY REACH (CONTROL-DISPLAY RELATIONSHIP). VIEWING DISTANCE MAY BE EXTENDED PROVIDED DISPLAY IS PROPERLY DESIGNED. GREATER LATERAL SPREAD OF DISPLAYS WOULD REQUIRE A WRAPAROUND PANEL.

[2] BASED ON 5TH PERCENTILE MALE DATA; LESS FOR 5TH PERCENTILE FEMALES.

[3] CONSOLE EDGE APPROXIMATELY 4" TO 6" FORWARD OF EYE POINT FOR 5TH-95TH PERCENTILE.

REACH AND VISUAL RANGE RELATED TO LATERAL AND FORWARD DISTANCE FROM CENTER REFERENCE POINT. (ADAPTED FROM KUBOKAWA, 1968; REPRINTED BY PERMISSION OF THE INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS IN THE "BIOASTRONAUTICS DATA BOOK", SECOND EDITION, 1973)

Figure A-6




LEG AND FOOT ROOM DIMENSIONS
Figure A-7

# APPENDIX B

## GUIDELINES FOR CONTROL ROOM DESKS AND CHAIRS

B.1 DESK DIMENSIONS

(Ref: NUREG-0700, Sec. 6.1.2.7)

All desks should provide adequate clear work space for all materials required for task performance. Adequate space for different chair positions with sufficient knee and leg room should be allowed. The interaction of work height, area, knee room, and chair height should be considered to provide for operator comfort.

Desk dimensions should conform to the following:

| | | |
|---|---|---|
| A. | Seated work height: | 26 to 31 inches above the floor (29 inches is standard) |
| B. | Sit-stand height: | 36 to 38 inches above the floor |
| C. | Work surface depth: | 16 inches minimum |
| D. | Work surface width: | 24 inches minimum (reading and writing only) 30 inches minimum (other tasks) |
| E. | Knee room height: | 25 inches from floor to under-desk surface (sit-down desks) |
| F. | Knee room depth: | 18 inches minimum |
| G. | Knee room width: | 20 inches minimum (more preferred) |

B.2 CHAIRS

(Ref: NUREG-0700, Sec. 6.1.2.8)

Recommended chair dimensions depend upon the comfort of the user and chair use. Generally, chairs should conform to the following specifications:

A. Chairs should pivot so operators can change position. Castored chairs should be used at sit-only consoles.

B. Chairs should support the lower back curvature (lumbosacral area). The approximate angle of the back to the seat should be 100° for office tasks. A greater angle is recommended for resting and reading.

C. At sit-down consoles, where operators may remain seated for extended periods, arm-rests on chairs should be provided. To allow the elbows to achieve a naturally restful position, adjustable or retractable arm rests should be provided.

D. A minimum of one inch compressible material should be provided as back and seat cushions. Enough material should be used to cause some resilience to remain when the chair is occupied.

E. The chair seat should be at least 17 inches wide and 15 to 17 inches deep for adequate support of the thighs and back of the knees so as to not create a condition of fatigue and circulation problems.

F. Seat height adjustability should range from 14 to 18 inches or greater at sit-down consoles. For sit-stand work stations, height adjustment range should be between 26 and 32 inches.

G. An adjustable footrest or heel-catch should be provided on chairs used at sit-stand work stations. If the footrest is part of the chair, a circular design of 18-inch diameter minimum is recommended. The footrest should be no more than 18 inches below the chair seat. A footrest may also be a part of the console base.

# APPENDIX C

## GUIDELINES FOR EMERGENCY EQUIPMENT USED BY CONTROL ROOM OPERATORS

C.1 EMERGENCY EQUIPMENT
(Ref: NUREG-0700, Sec. 6.1.4.1)

Breathing apparatus and protective clothing should be provided for operators. Such clothing and breathing apparatus must be compatible with the body sizes of the operators for maximum protection and for their tasks to provide maximum tactile sensitivity and sensory perception, (i.e., sight, reach, mobility, speech, and hearing). Emergency equipment, which includes fire, radiation, and rescue equipment, should conform to the following criteria:

A. Equipment should be subjected to regular periodic operation and maintenance checks to verify its adequacy and condition.

B. There should be a sufficient quantity of protective equpment for the required number of operators.

C. Protective clothing sizes should be clearly identifiable.

D. A supply of protective expendables, such as filters, should be available for all operators.

E. All operators should be trained in the use of the protective equipment.

F. Procedures for putting on, taking off, and controlling such protective equipment should be provided.

G. Equipment should be located in a convenient and readily accessible area within the control room envelope.

H. Storage of emergency equipment should be orderly and organized within the storage cabinets.

I. The storage area should be clearly and distinctively marked and known to all personnel to avoid confusion during an emergency situation.

APPENDIX D

CONTROL ROOM ENVIRONMENT GUIDELINES

## D.1 CONTROL ROOM ENVIRONMENT

### D.1.1 TEMPERATURE, HUMIDITY AND VENTILATION (Ref: NUREG-0700, Sec. 6.1.5.1)

The climate control system should be capable of maintaining the temperature of humidity within the comfort zone specified in Figure D-1. The following criteria should also be met for the control room environment:

A. Air temperature at floor level should not be more than 10° different from that at head level.

B. The ventilation system should have sufficient capacity to introduce outdoor or conditioned air at a rate of 15 cubic feet per minute minimum per occupant.

C. Air velocities of 45 feet per minute measured at head level should not be exceeded and should not produce a noticeable draft.

### D.1.2 ILLUMINATION ENVIRONMENT (Ref: NUREG-0700, Sec. 6.1.5.3)

Illumination of workspaces necessary to assure visual effectiveness for task performance is essential. The levels of illumination in Table D-1 should be observed, although certain specific tasks may require significantly differing illumination levels. The following criteria shall be used:

A. Overall illumination of the work areas within the control room should not vary significantly from work zone to work zone.

B. Supplemental lighting may be required for personnel performing specialized tasks in areas where fixed illumination is not adequate.

C. To ensure adequate visual performance, the task area luminance ratios in Table D-2 should not be exceeded.

D. Shadows within a work area should be avoided to minimize operator fatigue and eyestrain.

E. All ambient lighting of the control room should be of the indirect or diffuse type.

F. Labels, instructions, or other written information, including meter or display scales and dials, should not be in shadowed positions.

G. Glare from panels and instruments should be minimized to ease operator discomfort and should not interfere with the viewing or readability of all controls and displays.

H. The amount of reflected light is a function of illuminated surface colors. Surface reflectance should conform to the values recommended in Tables D-3 and D-4.

TABLE D-1

WORKSPACE ILLUMINATION

| Work Area or Type of Task | Task Illuminance, footcandles Min. | Recomm. | Max. |
|---|---|---|---|
| Panels, primary operating area | 20 | 30 | 50 |
| Auxiliary panels | 20 | 30 | 50 |
| Scale indicator reading | 20 | 30 | 50 |
| Seated operator stations | 50 | 75 | 100 |
| Reading: | | | |
| o Handwritten (pencil) | 50 | 75 | 100 |
| o Printed or typed | 20 | 30 | 50 |
| Writing and data recording | 50 | 75 | 100 |
| Maintenance and wiring areas | 20 | 30 | 50 |
| Emergency operating lighting | 10 | As above for area/task | |

(Source: Illuminating Engineering Society of North America, IES Lighting Handbook, 1981 Application Volume.)

TABLE D-2
AREA LUMINANCE RATIOS

| Areas | Luminance Ratio |
|---|---|
| Task area versus adjacent darker surroundings | 3:1 |
| Task area versus adjacent lighter surroundings | 1:3 |
| Task area versus more remote darker surfaces | 10:1 |
| Task area versus more remote lighter surfaces | 1:10 |
| Luminaries versus surfaces adjacent to them | 20:1 |
| Anywhere within normal field of view | 40:1 |

TABLE D-3

RECOMMENDED WORKPLACE REFLECTANCE LEVELS

| Surface | Reflectances | |
|---|---|---|
| | Preferred | Permissable |
| [a]Ceiling | 80% | 60-95% |
| Walls | 50% | 40-80% |
| Instruments/Displays | 80-100% | |
| Cabinet/Consoles | 20-40% | |
| Floor | 30% | 15-30% |
| Furniture | 35% | 25-45% |

a Recommended reflectances are for finish only. Overall average reflectance of acoustic materials may be somewhat lower. The upper walls (one to two feet below the ceiling) may be painted with the same paint as is used on the ceiling.

TABLE D-4

SURFACE COLOR REFLECTANCE VALUES

| Color | Reflectance |
|---|---|
| White | 85 |
| Light: | |
| Cream | 75 |
| Gray | 75 |
| Yellow | 75 |
| Buff | 70 |
| Green | 65 |
| Blue | 55 |
| Medium: | |
| Yellow | 65 |
| Buff | 63 |
| Gray | 55 |
| Green | 52 |
| Blue | 35 |
| Dark: | |
| Gray | 30 |
| Red | 13 |
| Brown | 10 |
| Blue | 8 |
| Green | 7 |
| Wood Finish: | |
| Maple | 42 |
| Satinwood | 34 |
| English Oak | 17 |
| Walnut | 16 |
| Mahogany | 12 |

D.1.3 EMERGENCY LIGHTING
(Ref: NUREG-0700, Sec. 6.1.5.4)

An emergency lighting system should be provided for the control room in the event of loss of external and internal power. It should be automatically actuated upon failure of the normal control room illumination and should conform to the following criteria:

A. Failure of the normal system should not degrade or alter the emergency lighting system.

B. An emergency lighting of 10 footcandles minimum at all work stations should be provided and maintained in the primary operating area.

D.1.4 AUDITORY ENVIRONMENT
(Ref: NUREG-0700, Sec. 6.1.5.5)

A. The acoustic design of the control room envelope should ensure no verbal communication impairment between operators. Vocal signals, signs, and sounds should be readily detected and audible distractions and irritations minimized.

B. Background noise should not be of a level to impair or distract verbal communication between operators within the primary operating area.

C. Only normal or slightly raised voice levels should be needed by the operators to maintain communication throughout the primary operating area (Figure D-2).

D. Background noise level should not be more than 65 dB(A).

E. Further reductions in background noise level may be required where communications between the primary operating area and other control room locations are essential and aided voice transmission systems are not provided.

F. All noise distractions, whether generated within or without the primary operating area, should be minimized.

G. The acoustical treatment of the control room envelope should limit reverberation time to one second or less.

D.1.5 AMBIENCE AND COMFORT
(Ref: NUREG-0700, Sec. 6.1.5.6, 6.1.5.7)

An effort to create a pleasant and comfortable work environment in view of the long hours and relative confinement of the control room operator's job should be made to reduce fatigue and boredom.

D.1.5.1 Features

A. Color coordination.
B. Color and illumination to create a cheerful environment.
C. Visual relief from instrumentation arrays.
D. Comfortable seating.
E. Carpeting to reduce fatigue from standing and walking.

D.1.5.2 Restroom and Eating Facilities

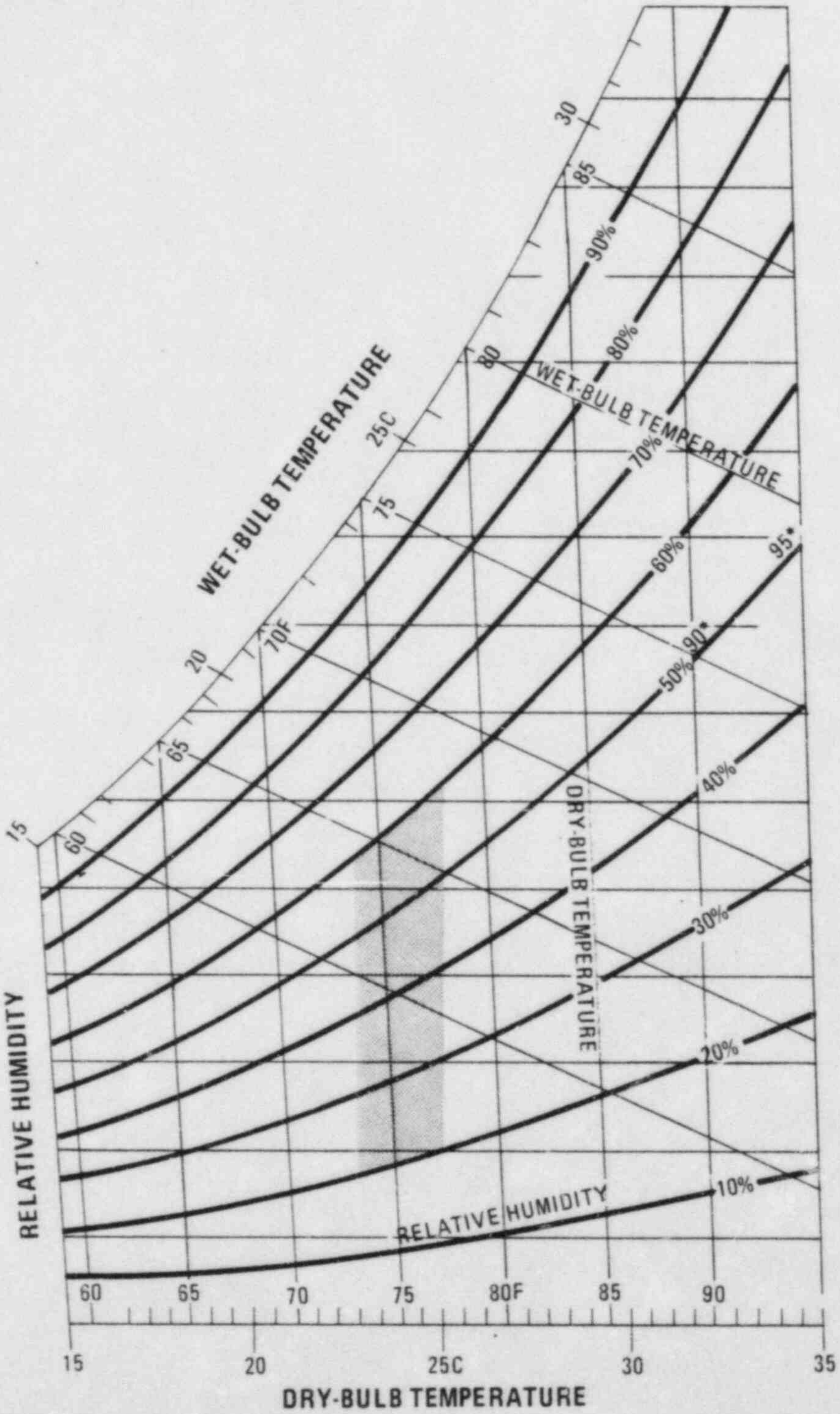
A. A restroom and kitchen or eating facility should be provided within the control room envelope.

B. Personnel should have easy access to kitchen and restroom facilities without delay, since breaks are not normally provided.

C. Kitchen and restroom facilities shall be provided within the control room envelope for use by control room personnel.

D. Provision should be made for communication if facilities are beyond voice contact so that an operator on break may be contacted by those in the control room.

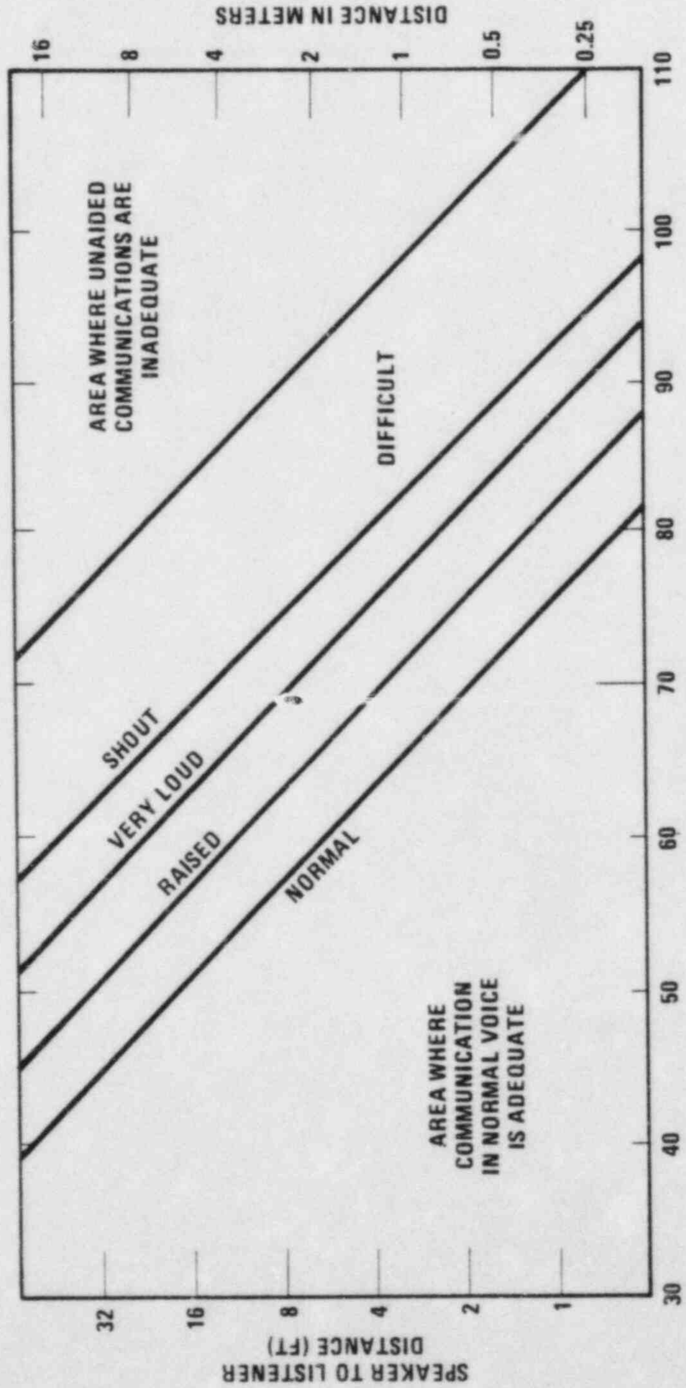
E. The inclusion of a rest or lounge area conducive to relaxation and revitalization should be considered, especially when shifts are long or tedious.




ASHRAE COMFORT STANDARD 55-74

THE ENVELOPE APPLIES FOR LIGHTLY CLOTHED, SEDENTARY INDIVIDUALS IN SPACES WITH LOW AIR MOVEMENT (LESS THAN 45 FPM).

COMFORT ZONE
Figure D-1




VOICE LEVEL AS A FUNCTION OF DISTANCE BETWEEN SPEAKER AND LISTENER AND AMBIENT NOISE LEVEL

Figure D-2

# APPENDIX E

## GUIDELINES SPECIFIC TO PUSHBUTTONS, ROTARY CONTROLS, AND JOYSTICKS

## E.1 PUSHBUTTON CONTROLS

### E.1.1 POSITIONING
(Ref: NUREG-0700 Sec. 6.4.3.1)

Pushbuttons in a row or matrix should be positioned in a logical order, or in an order related to the procedural sequence.

### E.1.2 INDICATION OF ACTIVATION
(Ref: NUREG-0700, Sec. 6.4.3.1)

To ensure that the operator knows that a pushbutton has been pressed far enough for activation, a positive indication should be provided in the form of a snap feel, an audible click, or an integral light.

### E.1.3 SURFACE
(Ref: NUREG-0700, Sec. 6.4.3.1)

For best operation, the surface of a pushbutton should offer slip resistant surface, or have a concave surface.

### E.1.4 PARAMETERS
(Ref. NUREG-0700, Sect. 6.4.3.2)

Pushbutton parameters should conform to the following:

A. Diameter for fingertip operation should be 0.385 inches (minimum) for unguarded and nonrecessed pushbuttons. For guarded or recessed pushbuttons, minimum diameter should be 0.75 inches.

B. Displacement for finger operation pushbuttons should be 0.125 inch minimum.

C. Resistance for fingertip operation should be a minimum of 10 ounces and a maximum of 40 ounces.

E.1.5 LEGEND PUSHBUTTONS
(Ref. NUREG-0700, Sect. 6.4.3.3)

Legend pushbuttons are rectangular, self-illuminated pushbuttons which display a written legend, usually as one or more small illuminated tiles. Legend pushbuttons serve both as a control (switch) and as a display (legend light). Depending on system design, a legend may be lighted either when the operator activates the pushbutton, or when a change occurs in system condition. Legend pushbuttons may have more than one display area. The following criteria should be met for all legend pushbuttons:

E.1.5.1 Discriminability

All legend pushbuttons should be readily distinguishable from legend lights. This may be achieved by distinctive shape, labeling, or other techniques. Refer to legend lights, Section 6.3 for criteria pertaining to the pushbutton legend.

E.1.5.2 Lamp Test

A. A lamp test or dual lamp/dual filament bulb capability should be provided.

B. Lamps within the pushbutton should be replaceable from the front of the panel.

C. Legend pushbuttons should not short out during lamp replacement or be susceptible to inadvertent activation during the process of lamp removal or replacement.

D. Legend covers should be keyed to prevent the possibility of interchanging the covers.

E.1.5.3 Barriers

Barriers should be used when legend pushbuttons are contiguous and barriers should have round edges.

E.1.5.4 Dimensions

Legend pushbuttons should conform to the following dimensions:

A. Size - Maximum height and width of 1.5 inches and a minimum of 0.75 inches.

B. Displacement - Maximum of 0.250 inches and a minimum of 0.125 inches.

C. Barrier width - Minimum of 0.125 inches.

D. Barrier depth - Maximum of 0.250 inches and minimum of 0.183 inches.

E. Resistance - Maximum of 40 ounces and a minimum of 10 ounces.

E.2 ROTARY CONTROLS

E.2.1 ROTARY CONTROL SHAPE CODING
(Ref: NUREG-0700 Sec. 6.4.4.1)

Rotary controls used for widely different functions that are placed on the same panel should be shape coded.

E.2.2 HIGH-TORQUE J-HANDLES
(Ref: NUREG-0700, Sec. 6.4.4.2)

High-torque J-handles should conform to the following dimensions:

A. Length - Minimum of 3.75 inches and 4.0 inches optimum.

B. Clearance - Minimum of 1.0 inch and 2.0 inches optimum.

E.2.3 CONTINUOUS ADJUSTMENT ROTARY CONTROLS
(Ref: NUREG-0700, Sec. 6.4.4.4)

Continuous adjustment rotary controls should be used when precise control along a continuous variable is needed. The following criteria should be met for all continuous adjustment rotary controls.

A. Knobs should be round in shape, with knurled or serrated edges.

B. A pointer indicating position should be used. When more accuracy is required, a line should be engraved and filled with contrasting pigment, both on top and down the side of the pointer.

C. Dimensions for continuous adjustment rotary controls should conform to the following:

1. For fingertip grasp knobs, the height should be 1.0 inch maximum and 0.5 inches minimum. Diameter should be 4.0 inches maximum and 0.375 inches minimum.

2. For thumb and forefinger encircled knobs, the diameter should be 3.0 inches maximum and 1.0 inch minimum.

3. Knob torque should be within the range of 4.5 to 6.0 inch/ounces.

E.2.4 ROTARY SELECTOR CONTROLS
(Ref: NUREG-0700, Sec. 6.4.4.5)

Rotary selector controls should be used when three or more detented positions are required, and may be used for two-detented position operation. The following criteria should be met for all continuous adjustment rotary controls.

E.2.4.1 Positioning

To ensure proper positioning of a discrete rotary control, detents should be provided at each control position and it should not be possible to position a control between detented positions.

A. A maximum of 24 positions should be used.

B. To minimize the possibility of placing a rotary selector control in an unused position, stops should be provided at the limits of the control range.

C. The position settings should be fixed with a moving pointer that is mounted close to the settings to which they point.

D. Position indication should be provided with illuminated indicator lights, a line engraved both on the top of the knob and down the side, or a pointer shape.

E.2.4.2 Dimensions

A. Length - minimum 1.0 inch.

B. Width - maximum 1.0 inch.

C. Diameter - minimum 1.0 inch.

D. Depth - minimum 0.625 inches.

E. Resistance - minimum 1.0 inch/pound; maximum 6.0 inches/pound.

## E.3 JOYSTICKS
(NUREG-0700, Sect. 6.4.5.3)

Joysticks are used when large amounts for force or displacement are involved or when multidimensional movements of controls are required. The following criteria should be met for all joysticks:

A. Positioning

To minimize the possibility of inadvertent activation or setting between control positions, joysticks should have an elastic resistance that increases as the control is moved, and drops as the switch snaps into position.

B. Feedback

Joysticks should provide a source of feedback for activation, such as an audible click.

C. Dimensions

(1) Diameter: 0.5 inches minimum
3.0 inches maximum

| | | | |
|---|---|---|---|
| (2) | Arm length: | 0.5 inches minimum<br>2.0 inches maximum | |
| (3) | Resistance: | 10 ounces minimum<br>40 ounces maximum | |
| (4) | Displacement - two position - | | 30° minimum<br>120° maximum |
| (5) | - three position - | | 18° minimum<br>60° maximum<br>25° desired |

APPENDIX F

VISUAL DISPLAYS GENERAL GUIDELINES

## F.1 USABILITY OF DISPLAYED VALUES

(Ref: NUREG-0700, Sec. 6.5.1.2)

Display scales (e.g. meter and graphic recorder scales) should be graduated so that readings are related in a direct and practical way to the operator's tasks. The following criteria should be met for all display scales:

### F.1.1 SCALE SELECTION

Scales should be consistent with the degree of precision and accuracy needed by the operator and should indicate values in a form immediately usable by the operator without requiring mental conversion.

### F.1.2 PERCENTAGE INDICATION

Percentage indication may be used when the parameter is meaningfully reflected by percentage.

### F.1.3 SCALE RANGE

Scale ranges should span the expected range of operational parameters, or be supported by auxiliary wide-range instruments. Ranges may be expanded (or contracted) by multiplying or dividing indicated scale values by powers of ten. These scales should clearly indicate whether the values should be multiplied or divided and by what factor (e.g. 10, 100, 1000).

### F.1.4 SENSITIVITY

Display dynamic sensitivity should be selected to minimize normal random variations in equipment performance.

F.2 DISPLAY READIBILITY
(Ref: NUREG-0700, Sec. 6.5.1.3)

F.2.1 CHARACTER HEIGHT

Character height should subtend a minimum visual angle of 15 minutes, or 0.004 x viewing distance. The preferred visual angle is 20 minutes, or 0.006 x viewing distance.

F.2.2 TYPE STYLE

Type styles should be simple, consistent and in only upper-case letters.

F.2.3 CONTRAST

Visual displays should contain black markings on a white background, which will provide the highest contrast.

F.2.4 CHARACTER DIMENSIONS

A. Stroke-width-to-character-height ratios should be between 1:6 and 1:8.

B. Letter width-to-height-ratios should be between 1:1 and 3:5.

C. Numeral width-to-height ratios should be 3:5.

D. Minimum space between characters should be one stroke width.

E. Minimum space between words should be the width of one character.

F. Minimum space between lines should be one-half the character height.

## F.3 PRINTING ON THE DISPLAY FACE

(Ref: NUREG-0700, Sec. 6.5.1.4

Besides scale markings and scale numbering, other information (e.g. parameter labels, indication of units) is often included on the display face. This type of information should be close enough to the display so that the scale and message are clearly associated in the viewer's mind. Often this type of information appears on the display face, or on an appropriate label adjacent to the display. The following criteria should be met for display faces:

### F.3.1 EXTRANEOUS ITEMS

Information not needed in using the display should be avoided (e.g. patent notices, manufacturer's trademark).

### F.3.2 BREVITY

Messages should be written as briefly as clarity permits to avoid distraction and interference with needed or essential markings.

### F.3.3 ABBREVIATIONS

Only standard or approved abbreviations should be used (see Appendix L for recommended abbreviations list).

### F.3.4 CONSISTENCY WITH PROCEDURES

Messages should use the same terms as the procedures in display identification, parameter identification and units displayed.

F.4 SCALE MARKING
(Ref: NUREG-0700, Sec. 6.5.1.5)

Normally, a scale contains major, intermediate, and minor graduations differing in length. Scales for quantitative reading should be provided with graduations consistent with the progression of their numerals. Scales should conform to the following criteria:

A. No more than nine graduations should separate numerals.

B. Major and minor graduations should be used if there are up to four graduations between numerals.

C. Major, intermediate and minor graduations should be used if there are five or more graduations between numerals.

D. Dimensions of graduations should conform to scales in Figure F-1.

E. Graduation heights as a function of viewing distance should conform to heights indicated in Table F-1.

F. Successive values indicated by unit graduations should conform to one of the progressions as indicated in Table F-2.

F.5 SCALE COMPATIBILITY
(Ref: NUREG-0700, Sec. 6.5.1.5)

When two or more displays of the same parameter (e.g. pressure, temperature) must be compared, scales should be compatible in numerical progression and scale organization. Logarithmic scales should be avoided unless needed to display a large range of values.

F.6 COLOR CODING
(Ref: NUREG-0700, Sec. 6.5.1.6)

Color can be effectively applied in both illuminated displays (e.g. mimics on panel surfaces and color pads) and in transilluminated displays (e.g. signal lights and CRTs). Refer to Section 6.2., Controls, for additional color coding criteria.

Colors selected for visual displays should provide good contrast. The meaning attached to a particular color should be narrowly defined. Red, green and amber (yellow) should be reserved for the following uses:

A. Red - Unsafe, danger, immediate operator action required, or an indication that a critical parameter is not within tolerance.

B. Green - Safe, no operator action required, or an indication that a parameter is within tolerance.

C. Amber - Hazard (potentially unsafe), caution, attention (yellow) required, or as indication that a marginal value or parameter exists.

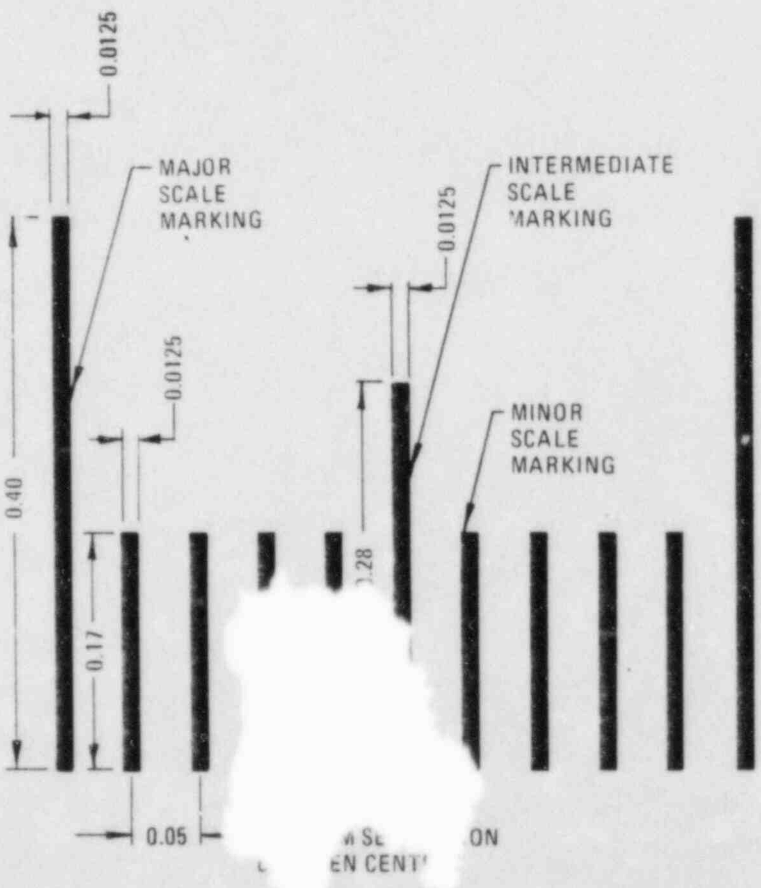
TABLE F-1
INDEX HEIGHTS FOR
VARIOUS VIEWING DISTANCES.

| Viewing Distance (feet) | Index Height (inches) Major | Intermediate | Minor |
|---|---|---|---|
| 1 1/2 or less | 0.22 | 0.16 | 0.09 |
| 3 or less | 0.40 | 0.28 | 0.17 |
| 6 or less | 0.78 | 0.56 | 0.34 |
| 12 or less | 1.57 | 1.12 | 0.65 |
| 20 or less | 2.63 | 1.87 | 1.13 |

TABLE F-2
RECOMMENDED PROGRESSION
OF VALUES

| Good | | | | | Fair | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 2 | 4 | 6 | 8 | 10 |
| 5 | 10 | 15 | 20 | 25 | 20 | 40 | 60 | 80 | 100 |
| 10 | 20 | 30 | 40 | 50 | | | | | |

From McCormick, 1976




GRADUATION DIMENSIONS IN INCHES FOR 3-INCH VIEWING DISTANCE (ADAPTED FROM McCORMICK, 1976)

Figure F-1

# APPENDIX G

## METER DISPLAYS GUIDELINES

G.1 POINTER MOVEMENT
(Ref: NUREG-0700, Sec. 6.5.2.1)

Pointer movement for the following type of scale should conform to the following:

A. Circular Scales; values should increase with clockwise movement of the pointer.

B. Vertical Straight Scales; values should increase with upward movement of the pointer.

C. Horizontal Straight Scales; valves should increase with pointer movement to the right.

G.2 POINTERS
(Ref: NUREG-0700, Sec. 6.5.2.2)

Pointers on all meters should conform to the following:

G.2.1 TIPS

Pointer tips should be simple and should not conceal scale graduation marks or numerals.

G.2.2 POINTER POSITIONING

The pointer tip should extend to within about 1/16 inch of the smallest graduation marks but should not overlap. Pointer should also be mounted close to meter face to avoid parallax errors.

G.2.3 POINTER CONTRAST

Pointer should contrast with meter face and be large enough to permit rapid recognition of pointer position.

G.3 ZONE MARKINGS
(Ref: NUREG-0700, Sec. 6.5.2.3)

Zone markings should be used to show the operational implications of various readings such as "Operating Range", "Upper Limits", "Lower Limits" or "Danger Range." The following criteria should be met for zone markings:

A. Zone markings should be conspicuous and distinctively different for different zones.

B. They should not interfere with reading of quantitative markings.

C. If color is used for zone markings, colors selected should conform to color coding criteria in Section 6.2, Controls.

G.4 ORIENTATION OF MARKINGS
(Ref: NUREG-0700, Sec. 6.5.2.4)

To facilitate reading of meters and prevent misreading, the orientation of scale markings should be consistent. The factors which are significant here are the orientation of numerals and scale end-points on dials.

G.4.1 NUMERAL ORIENTATION

Individual numerals on any type of fixed scale should be vertical. This includes circular and linear scales.

G.4.2 ZERO ORIENTATION

Where pointer movement is more than 360°, the zero point should be located at the 12 o'clock position. Where positive and negative values are displayed around a zero or null position, the zero or null point should be located at the 12 o'clock position.

G.4.3 END POINT INDICATION

Where the scale covers less than a full rotation of the pointer, scale endpoints should be indicated by a break in scale which is at least one numbered interval in length and is oriented at the 6 o'clock position.

# APPENDIX H

## INDICATOR LIGHTS GUIDELINES

## H.1 INTRODUCTION

(Ref: NUREG-0700, Sec. 6.5.3.1)

Criteria within this section include non-legend indicators (simple indicator light, bulls-eyes, jewel light) and illuminated legend indicators. Criteria for annunciators are found in Section 8.0, Control Room Annunciation Features.

Since the presence of a light is the primary means of communication of a message, it becomes essential that the light signal be physically reliable, and is sensed unambiguously by the operator, is not misinterpreted. The following criteria should be met for non-legend indicators and illuminated legend indicators.

A. A bulb-test capability should be provided or dual-bulb/dual-filament light assemblies should be used.

B. Lamp design should encourage immediate replacement of burned-out bulbs by providing for rapid and convenient bulb replacement with power on and without hazard to personnel or equipment.

C. To ascure operators do not misinterpret indicator lights, the ambient light sources should be located and controlled to avoid reflections.

D. Lights should not appear to be glowing when they are off or vice versa.

E. System/equipment status should be inferred by illuminated indicators, and not by the absence of illumination.

F. Provisions should also be made (design or procedural) to prevent interchanging of indicator lenses.

G. Alerting the operators to unfavorable status should be a function of the annunciator system and not assigned to light indicators.

H.2 NON-LEGEND INDICATOR LIGHT DISPLAYS
(Ref: NUREG-0700, Sec. 6.5.3.2)

Non-legend light indicators are represented by conventional pilot lights, bulls-eyes, and jewel lights. Color may be provided by a tinted cover glass or by a layer of colored material inside the cover.

H.2.1 IDENTIFICATION OF MEANING

Where meaning is not apparent, labeling must be provided close to the light indicator showing the message intended by its glowing. The color of the light should conform to the establish color coding for the control room and should be clearly identifiable.

H.2.2 LIGHT INTENSITY

The illuminated indicator should be at least 10% greater in light intensity than the surrounding panel.

H.3 LEGEND INDICATOR LIGHTS DISPLAYS
(Ref: NUREG-0700, Sec. 6.5.3.3)

A legend light is a transilluminated display containing an inscription which is highlighted when the light comes on. In the control room, legend light indicators are normally used to show status, the legend being worded to tell the status that is in effect when the light is glowing. Legend lights can be individually placed or grouped together in status-indicating matrices.

For example, they may be positioned adjacent to controls with legends indicating the status of the control (e.g. ON or OFF), or within mimics to show the status of subsystems or flow lines.

## H.3.1 VISIBILITY FACTORS

Light intensity of the illuminated indicators should be at least 10% greater than the surrounding panel. Legends should be legible under ambient illumination with indicator lights off and legend lettering should contrast well with background under both ambient and transilluminated lighting.

## H.3.2 LEGEND DESIGN

General legend design should be consistent throughout the control room. Legend design should conform to the following criteria:

A. Lettering should be simple and should follow criteria in Appendix M for style and size.

B. Symbolic legends should be clear and unambiguous as to their meaning.

C. Text should be short, concise and unambiguous.

D. Legend messages should contain no more than three lines of text.

E. Nomenclature and abbreviations should be standard and consistent with usage throughout the control room and in the procedures (see Appendix L for recommended abbreviation and nomenclature).

F. Legends should be worded to tell the status indicated by glowing of the light.

G. Illuminated legend indicators should be readily distinguishable from legend pushbuttons by form, size, or other factors.

H. The color of the legend background under transillumination should conform to established color coding.

# APPENDIX I

## GRAPHIC RECORDERS GUIDELINES

## I.1 INTRODUCTION

(Ref: NUREG-0700, Sec. 6.5.4.1)

The graphic recorders used in the STP control room are multi-point recorders and strip chart recorders. The following criteria applies to both types of recorders. As a general rule, recorders should be used to record trend information and material which may be needed for later reference.

## I.2 PLACEMENT OF RECORDERS

(Ref: NUREG-0700, Sec. 6.5.4.1)

Graphic recorders which must be verified and attended by the operator should in principle be located within the primary operating area rather than on back panels.

## I.3 EXPENDABLE MATERIALS

(Ref: NUREG-0700, Sec. 6.5.4.1)

Pens, inks, and paper should be of a quality to provide clear, distinct and reliable markings. For example, ink should not clog pens or smudge on the paper. Paper, ink, and other expendables should be provided and accessible in the control room. Recorder design should permit quick and easy replenishment of paper and ink.

## I.4 RECORDER CHARACTERISTICS

(Ref:, NUREG-0700, Sec. 6.5.4.1)

The following criteria should be met on all recorders:

A. Scales printed on the recording paper should be the same as the scales on the recorder.

B. Recorder scales should conform to the criteria specified in Appendis F.

C. A takeup spool should be provided to receive completed recordings and a means should be provided for tearing off completed records for storage.

D. A high paper speed option should be provided to run out records for detachment. A selection of lower speeds should also be available to permit adjustment of the time scale so that rate-of-change information can be indicated.

E. It should be convenient to annotate recordings with date and line markings, with paper speed if varied from normal, with parameter identification, or with any other relevant information.

F. Recorder design should ensure that all data will be visible through the window of the recorder and not require open-door operation to expose it.

G. Labels should identify the parameters recorded. With multiple-pen recorders, parameters should be listed in the order of the associated scales on the recorder.

H. Each pen should use a different colored ink for easy channel identification. Colors selected should be distinctly different and should afford good contrast with the paper.

I. The recorder should not be loaded beyond its design channel capacity because this adds complexity to the analysis and prolongs sampling cycle time.

J. Viewing of the channel being plotted should be done easily and not from odd and inconvenient angles.

K. Number-printing on multi-point recorders should be designed and maintained to provide clear, sharp, and small numbering to avoid crowding of data and consequent analysis problems.

L. Provision should be made to select any single channel for immediate display without awaiting completion of a sampling cycle.

APPENDIX J

GUIDELINES SPECIFIC TO DRUM-TYPE COUNTER DISPLAYS

J.1 CHARACTERISTICS

(Ref: NUREG-0700, Sec. 6.5.5.1)

Counter-type information is useful when there is a need for quick, precise reading of quantitative values and trend information is not needed.

The following criteria should be met on all drum-type counters:

A. Multi-digit numbers formed by several counter drums should be read horizontally from left to right.

B. To compensate for the distortion imposed by the curved surface of the drum, a 1:1 width to height ratio for counter numerals should be used, not 3:5 as recommended for numerals of other displays.

C. If more than four digits are required, they should be grouped and the groupings separated as appropriate by commas, decimal points, or blank spaces.

D. The color of the numerals and background should be chosen to yield high contrast. Black numerals on white drum surface is recommended.

E. The surface of the drums and surrounding areas should have a matte finish to minimize glare.

F. Drum-type counters are clearly readable only within a viewing angle that is more restrictive than the viewing angle for most displays. They should be mounted perpendicular to the operator's line of sight.

G. Counters should be mounted as close as possible to the panel surface to minimize shadows and maximize viewing angle.

H. The window should be sized to allow no more than one digit per drum to appear in the window at any one time.

I. Numbers should change by snap action rather than through continuous movement.

J. The counter drums should move upward with increasing values.

# APPENDIX K

## GUIDELINES SPECIFIC TO ELECTRONIC COUNTER DISPLAYS

K.1 CHARACTERISTICS

(Ref: NUREG-0700, Sec. 6.5.5.2)

Electronic counters using "Nixie" tubes, light emitting diodes (LEDs), or other electroluminescent devices may be preferred over mechanical counters in many control room applications. The following criteria should be met for all electronic counters:

A. Multi-digit counters should be oriented to read horizontally from left-to-right.

B. Simple character fonts should be used. Styles using variable stroke width, slanted characters, etc. should be avoided.

C. Numerals should be of such a height as to subtend a visual angle of 15 minutes from the farthest anticipated viewing distance.

D. Width-to-height ratio of numerals should be approximately 3:5.

E. Horizontal spacing between numerals should be between one-quarter and one-half the numeral width.

F. Numerals should not follow each other faster than two per second when the operator is expected to read the numerals consecutively.

G. Character-to-background contrast ratio should be between 15:1 minimum and 20:1 preferred.

## APPENDIX L

STANDARD ABBREVIATIONS LIST FOR ALL STP LABELING

## INTRODUCTION

When using the abbreviation list, the following general principles should be applied:

A. More than one abbreviation per term should not be used (note that more than one abbreviation per term has not been included.) This is not to say that all the listed alternatives are acceptable. The primary reason for this approach is to maintain and encourage consistency and to avoid multiple forms for the same term.

B. Words of four character length or shorter should not be abbreviated.

C. Two character abbreviations should generally be avoided because of readability problems and the increased probability of having one abbreviation for two or more terms. When a requirement for two character abbreviations cannot be avoided, extreme care should be taken to avoid conflict with existing abbreviations.

D. Words endings such as -ed, -ing, -s, and -es should not be included in an
2 abbreviation, using instead the root word or its abbreviation. If such
endings must be used, avoid ambiguity: for example, since "ROOM" is
"RM" and "Radiation Monitor System" is "RMS," the latter should not be
used for "ROOMS". Instead, if "ROOMS" must be abbreviated in its plural
form, an apostrophe (i.e., "RM'S") should be used.

E. There may be cases when an abbreviation is not practical. The following criteria should be used for making this determination:

1. The word is infrequently used.
2. The abbreviation is not a significant decrease in the total number of characters.
3. The only acceptable abbreviation has too many totally different terms associated with it.

F. There are cases where terms/words are most familiar as abbreviations instead of being spelled out (e.g. HVAC instead of Heating, Ventilation, & Air Conditioning). These abbreviations are noted by an asterisk (*) and should always be used even if space would permit the spelling out of the words.

2 A LIST OF ACRONYMS, ABBREVIATIONS AND TERMS[1]

| Abbreviation | Meaning |
|---|---|
| ABS | ABSOLUTE |
| ABV | ABOVE |
| AC* | ALTERNATING CURRENT |
| A/C | AIR CONDITIONING |
| ACC | ACCUMULATOR |
| ACCEL | ACCELERATION |
| ACCID | ACCIDENT |
| ACKN | ACKNOWLEDGE |
| ACP | AUXILIARY CONTROL PANEL |
| ACT | ACTIVE/ACTIVATED/ACTUATE/ACTUATOR |
| ACW | AUXILIARY COOLING WATER |
| ADD | ADDITIVE |
| ADJ | ADJUST/ADJUSTMENT/ADJUSTER |
| ADMIN | ADMINISTRATION |
| ADPTR | ADAPTER |
| ADV | ADVANCE |
| AFT | AFTER |
| AFTCLR | AFTERCOOLER |
| AFW* | AUXILIARY FEEDWATER |
| AFWP* | AUXILIARY FEEDWATER PUMP |
| AFWS* | AUXILIARY FEEDWATER SYSTEM |
| AFWPT | AUXILIARY FEEDWATER PUMP TURBINE |

[1] This list includes abbreviations from the "Procedure/Engraving Abbreviations" list from STP Nuclear Operations, 10/11/82.

* Denotes abbreviations that should be used as abbreviations, even when space would permit spelling out the word.

| | |
|---|---|
| AH UNIT | AIR HANDLING UNIT |
| AIES | AIR INTAKE AND EXHAUST SYSTEM |
| AIRB | AIRBORNE |
| ALM | ALARM |
| ALT | ALTERNATE/ALTERNATOR |
| AMB | AMBIENT |
| AMP* | AMPERES |
| AMPL | AMPLIFIER |
| ANNUN* | ANNUNCIATOR |
| AOV | AIR-OPERATED VALVE |
| ARM | AREA RADIATION MONITOR |
| ASSOC | ASSOCIATED |
| ASSY | ASSEMBLY |
| ASP | AUXILIARY SHUTDOWN PANEL 2 |
| ASR | AUXILIARY SHUTDOWN ROOM |
| ATM | ATMOSPHERE/ATMOSPHERIC |
| ATWS | ANTICIPATED TRANSIENT WITHOUT SCRAM |
| AUCT | AUCTIONEER |
| AUTO* | AUTOMATIC |
| AUX* | AUXILIARY |
| AUXBLR | AUXILIARY BOILER |
| AVAIL | AVAILABLE |
| AVG* | AVERAGE |

| | |
|---|---|
| B | BORON |
| BA | BORIC ACID |
| BAL | BALANCE |
| BANK | CONTROL ROD BANK |
| BAR | BARRIER |
| BAT | BORIC ACID TANK |
| BATCH | BATCHING |
| BATT | BATTERY |
| BCK | BACK |
| BCV | BYPASS CONTROL VALVE |
| BFP | BOILER FEED PUMP |
| BI | BORON INJECTION |
| BIST | BORON INJECTION STORAGE TANK |
| B/S | BISTABLE |
| BIT | BORON INJECTION TANK |
| BKR | BREAKER |
| BLK | BLOCK |
| BKW | BACKWASH |
| 2 BK | BANK |
| BLKD | BLOCKED |
| BLD | BLEED |
| BLDG* | BUILDING |
| BLR* | BOILER |
| BLU | BLUE |

| | |
|---|---|
| BLWDN | BLOWDOWN |
| BLWDNFT | BLOWDOWN FLASH TANK |
| BOD | BIOCHEMICAL OXYGEN DEMAND |
| BOP | BALANCE OF PLANT |
| BOT | BOTTOM |
| BPC | BYPASS CONTROL |
| BPRA | BURNABLE POISON ROD ASSEMBLY |
| BRG* | BEARING |
| BRNCH | BRANCH |
| BRS | BORON RECYCLE SYSTEM |
| BRSH | BRUSH |
| BRTG AIR | BREATHING AIR 2 |
| BSCV | BYPASS STOP AND CONTROL VALVE |
| BOOST | BOOSTER |
| BOOSTPMP | BOOSTER PUMP |
| BTFL | BUTTERFLY |
| BTRS* | BORON THERMAL REGENERATION SYSTEM |
| BTU | BRITISH THERMAL UNIT 2 |
| BTV | BLEEDER TRIP VALVE |
| B/U | BACKUP |
| BYP* | BYPASS |
| B&PV | BOILER AND PRESSURE VESSEL |

| | |
|---|---|
| C* | CENTIGRADE |
| CAB | CABINET |
| CAL | CALIBRATION/CALIBRATE |
| CARR | CARRIER |
| CAT | CHEMICAL ADDITION TANK |
| CAV | CAVITY |
| $C_b$ | BORON CONCENTRATION |
| CBP | CONDENSATE BOOSTER PUMP |
| CC | CUBIC CENTIMETER |
| CCG | CONTAINMENT COMBUSTIBLE GAS |
| CCP | CENTRIFUGAL CHARGING PUMP |
| CCS | CONTAINMENT COOLING SYSTEM |
| CCTV | CLOSED CIRCUIT TELEVISION |
| CCW | COMPONENT COOLING WATER |
| CENT | CENTRIFUGAL |
| CFC | CONTAINMENT FAN COOLER |
| CFM* | CUBIC FEET PER MINUTE |
| CFS* | CUBIC FEET PER SECOND |
| CGCS | COMBUSTIBLE GAS CONTROL SYSTEM |
| CHAR | CHARCOAL |
| CHEM | CHEMICAL |
| CHEMWST | CHEMICAL WASTE |
| CHG | CHARGE/CHARGING |
| CHK | CHECK |
| CHL | CHILL |
| CHLD | CHILLED |
| CHLOR | CHLORINATION/CHLORINE |

| | |
|---|---|
| CHLR | CHILLER |
| CHMBR | CHAMBER |
| CHNL | CHANNEL |
| CHR | CONTAINMENT HEAT REMOVAL |
| CHRS | CONTAINMENT HEAT REMOVAL SYSTEM \| 2 |
| CI | COOLANT INJECTION |
| Ci | CURIE |
| CIA | CONTAINMENT ISOLATION PHASE A |
| CIB | CONTAINMENT ISOLATION PHASE B |
| CIRC* | CIRCULATING/CIRCULATION |
| CIS | CONTAINMENT ISOLATION SYSTEM/ CONTAINMENT ISOLATION SIGNAL |
| CIV | CONTAINMENT ISOLATION VALVE |
| CK | CHECK \| 2 |
| CKCS | CRANKCASE |
| CKT* | CIRCUIT |
| CLOSEDLP | CLOSED LOOP |
| CLDN | COOLDOWN |
| CLG* | COOLING |
| CLNG | CLEANING \| 2 |
| CLNR | CLEANER |
| CLOSE | CLOSED/CLOSURE |
| CLR | COOLER |
| $CL_2$ | CHLORINE |
| CMPTR | COMPUTER |
| CNDCT | CONDUCTIVITY |
| CNDSR | CONDENSER |
| CNTMT | CONTAINMENT |
| COLL | COLLECTING/COLLECTOR |
| COMB | COMBINED |
| COMP | COMPONENT |
| COMPART | COMPARTMENT |
| COMPR* | COMPRESSOR |

| | | |
|---|---|---|
| | CONC* | CONCENTRATION/CONCENTRATED |
| | COND* | CONDENSATE |
| 2 | CONF | CONFIRMED |
| | CONN | CONNECTION |
| | CONTAM | CONTAMINATION |
| | CONT | CONTROL |
| | CONTR | CONTROLLER |
| | CONV | CONVERTER |
| | CONVC | CONVECTION |
| | COOL | COOLANT |
| | $CO_2$* | CARBON DIOXIDE |
| | CP | CONTROL PANEL |
| | CPDS | CONDENSATE POLISHING DEMINERALIZER SYSTEM |
| | CPLG | COUPLING |
| | CPM | COUNTS PER MINUTE |
| | CPR | CONDENSATE POLISHING REGENERATION |
| | CPRW | CONDENSATE POLISHING REGENERATIVE WASTE |
| | CR | CONTROL ROOM |
| 2 | CRBN | CARBON |
| | CRD | CONTROL ROD DRIVE |
| | CRDM | CONTROL ROD DRIVE MECHANISM |
| | CRDS | CONTROL ROD DRIVE SYSTEM |
| | CREL | CONTROL RELAY |
| | CRIT | CRITICAL |
| | CRS | CONTAINMENT RADIATION SIGNAL |
| | CRT | CATHODE RAY TUBE |
| | CS | CONTAINMENT SPRAY |

| | |
|---|---|
| CSAS | CONTAINMENT SPRAY ACTUATION SIGNAL |
| CSG | CASING |
| CSP | CONTAINMENT SPRAY PUMP |
| CSS | CONTAINMENT SPRAY SYSTEM |
| CSW | CONTROL SWITCH |
| CST | CONDENSATE STORAGE TANK |
| CTR | CENTER |
| C/U | CLEANUP |
| CUB | CUBICLE |
| CUR | CURRENT |
| CV | CONTROL VALVE |
| CVCS* | CHEMICAL VOLUME CONTROL SYSTEM |
| CVH | CONTAINMENT VENT HEADER |
| CVI | CONTAINMENT VENTILATION ISOLATION |
| CVP | CONDENSER VACUUM PUMP |
| CWP* | CIRCULATING WATER PUMP |
| CWS | CHILLED WATER SYSTEM/CIRCULATING WATER SYSTEM/COOLING WATER SYSTEM |
| CYL | CYLINDER |

| | | |
|---|---|---|
| | DP | DIFFERENTIAL PRESSURE |
| | DT | DIFFERENTIAL TEMPERATURE |
| 2 | DAMP | DAMPER |
| | DBA | DESIGN BASIS ACCIDENT |
| | DC* | DIRECT CURRENT |
| | DCHS | DRY CASK HANDLING SYSTEM |
| | DD | DIESEL/DRIVEN |
| | DE | DIESEL/ENGINE |
| | DEAER | DEAERATOR |
| | DECON | DECONTAMINATE/DECONTAMINATION |
| | DEF | DEFEAT |
| | DEG* | DEGREES |
| 2 | DEG F | DEGREE FAHRENHEIT |
| | DEMIN* | DEMINERALIZER |
| | DESIC | DESICCATION |
| | DESUPHT | DESUPERHEAT/DESUPERHEATER |
| | DET | DETECTED/DETECTION/DETECTOR |
| | DEV* | DEVIATION |
| | DEWPT | DEW POINT |
| | DF | DECONTAMINATION FACTOR |
| | DG | DIESEL GENERATOR |
| | DGB | DIESEL GENERATOR BUILDING |
| | DGC | DIESEL GENERATOR COMBUSTION |
| | DGCAIES | DIESEL GENERATOR COMBUSTION AIR INTAKE AND EXHAUST SYSTEM |
| | DGF | DIESEL GENERATOR FUEL |
| | DGFOSTS | DIESEL GENERATOR FUEL OIL STORAGE AND TRANSFER SYSTEM |
| | DGTL | DIGITAL |
| | DIAPH | DIAPHRAGM |
| | DIFF | DIFFERENCE/DIFFERENTIAL |
| | DIL | DILUTE/DILUTION |

| | |
|---|---|
| DISC | DISCONNECT |
| DISCH | DISCHARGE |
| DISP | DISPLACE |
| DIST | DISTRIBUTION |
| DIV | DIVISION |
| DLVL | DIFFERENTIAL LEVEL |
| DMPR | DAMPER |
| DN | DOWN |
| DNSC | DOWNSCALE |
| DO | DIESEL OIL |
| DOM | DOMESTIC |
| DPM | DECADES PER MINUTE/DISINTEGRATIONS PER MINUTE |
| DRN | DRAIN |
| DRPI | DIGITAL ROD POSITION INDICATION |
| DRV | DRIVE/DRIVEN |
| DRYR | DRYER |
| DSL | DIESEL |
| DSLVD | DISSOLVED |
| DSTL | DISTILLATE |
| DVC | DEVICE |
| DVRT | DIVERT/DIVERSION |
| DWS | DEMINERALIZED WATER SYSTEM |
| DWST | DEMINERALIZED WATER STORAGE TANK |

2

| | |
|---|---|
| E | EAST |
| EAB | ELECTRICAL AUXILIARY BUILDING |
| ECC | EMERGENCY CORE COOLING |
| ECCEN* | ECCENTRICITY |
| ECCS | EMERGENCY CORE COOLING SYSTEM |
| ECON | ECONOMIZER |
| 2 ECP | ESSENTIAL COOLING POND |
| ECW | ESSENTIAL COOLING WATER |
| ECTS | EFFLUENT CHEMICAL TREATMENT SYSTEM |
| EDT | EQUIPMENT DRAIN TANK |
| EDUCT | EDUCTOR |
| EER | ELECTRIC EQUIPMENT ROOM |
| EES | EMERGENCY EXHAUST SYSTEM |
| EMERFLTR | EMERGENCY FILTER |
| EFDS | EQUIPMENT AND FLOOR DRAIN SYSTEM |
| EFL | EFFLUENT |
| EFLTR | EFFLUENT FILTER |
| EH | ELECTRO-HYDRAULIC |
| EHC | ELECTRO-HYDRAULIC CONTROL |
| 2 EL | ELEVATION |
| ELEC | ELECTRIC/ELECTRICAL |
| EMER* | EMERGENCY |
| EMS | EMERGENCY SERVICE |
| ENCL | ENCLOSURE |
| ENG | ENGINE |
| ENT | ENTER/ENTERING |
| EQUIP | EQUIPMENT |

| | |
|---|---|
| ES | ENGINEERED SAFEGUARDS |
| ESCWS | ESSENTIAL SERVICES CHILLED WATER SYSTEM |
| ESF | ENGINEERED SAFETY FEATURE |
| ESS | ENGINEERED SAFEGUARDS SYSTEMS |
| ESSEN | ESSENTIAL |
| ESSR | ESSENTIAL SERVICE |
| ESWS | EMERGENCY SERVICE WATER SYSTEM |
| ET | EMERGENCY TRANSFORMER |
| EVAL | EVALUATION |
| EVAP | EVAPORATOR/EVAPORATION 2 |
| EXC | EXCITER |
| EXCH | EXCHANGE |
| EXCS | EXCESS |
| EXCT | EXCITATION |
| EXH* | EXHAUST |
| EXP | EXPANSION |
| EXTR | EXTRACTION |

| | |
|---|---|
| F | FAHRENHEIT |
| FAIL | FAILURE |
| 2 FBKR | FEEDER BREAKER |
| FCV | FLOW CONTROL VALVE |
| FD | FEED |
| FDR | FEEDER |
| FDRFT | FORCED DRAFT |
| FDT | FLOOR DRAIN TANK |
| FHB | FUEL HANDLING BUILDING |
| FHS | FUEL HANDLING SYSTEM |
| FI | FLOW INDICATOR |
| FIS | FLOW INDICATING SWITCH |
| FLD | FIELD |
| FLNGE | FLANGE |
| 2 FR | FLOW RECORDER |
| FLS | FLASH |
| FLTR | FILTER |
| FLX | FLUX |
| FO | FUEL OIL |
| FOPN | FULLY OPEN |
| FPMP | FEED PUMP |
| FPS | FEET PER SECOND |
| FPT | FEED PUMP TURBINE |
| FREQ | FREQUENCY |
| FRNT | FRONT |
| FT* | FOOT/FEET |
| FTS | FUEL TRANSFER SYSTEM |
| FUNC | FUNCTION/FUNCTIONAL |
| FW | FEEDWATER |
| FWD | FORWARD |
| FWIV | FEEDWATER ISOLATION VALVE |
| FWS* | FEEDWATER SYSTEM |

| | |
|---|---|
| GD | GUARD |
| GEN | GENERATOR |
| GFFD | GROSS FAILED FUEL DETECTOR |
| GL | GLAND |
| GND | GROUND |
| GOV | GOVERNOR |
| GP | GROUP |
| GPM* | GALLONS PER MINUTE |
| GR | GROSS |
| GRAD | GRADIENT |
| GRBX | GEARBOX |
| GRN | GREEN |
| GRP | GROUP |
| GUID | GUIDE |
| GWPS | GASEOUS WASTE PROCESSING SYSTEM |

| | |
|---|---|
| HC | HAND CONTROLLER |
| HCV | HAND CONTROL VALVE |
| HD | HEAD |
| HDP | HEATER DRIP PUMP |
| HDR | HEADER |
| HEPA | HIGH EFFICIENCY PARTICULATE AIR |
| HG | MERCURY |
| HH | HIGH HEAD |
| HHSI | HIGH HEAD SAFETY INJECTION |
| HI | HIGH |
| 2 HJTC | HEATED JUNCTION THERMOCOUPLE |
| HNDLG | HANDLING |
| HORIZ | HORIZONTAL |
| HOTWL | HOTWELL |
| HOUS | HOUSE |
| H. P. | HEALTH PHYSICS |
| HP | HIGH PRESSURE |
| HP | HORSE POWER |
| HPU | HYDRAULIC POWER UNIT |
| HR | HOUR |
| HT | HEAT |
| HTG | HEATING |
| HTR* | HEATER |
| H/U | HEATUP |
| $H_2$ | HYDROGEN |
| HUM | HUMIDITY |
| HIVOLT | HIGH VOLTAGE |
| HVAC* | HEATING, VENTILATION, & AIR CONDITIONING |
| HOTWTR | HOT WATER |
| HX* | HEAT EXCHANGER |
| HYD | HYDRAULIC |
| HYPCHL | HYPERCHLORIDE/HYPERCHLORINATED |
| HZ* | HERTZ |

| | |
|---|---|
| IA | INSTRUMENT AIR |
| ILRT | INTEGRATED LEAK RATE TEST |
| IMP | IMPULSE |
| IMPL | IMPELLER |
| INL | INLET |
| INACT | INACTIVE |
| INBD | INBOARD |
| INC | INCOMPLETE |
| INCM | INCOMING |
| INDIC | INDICATOR |
| INDIV | INDIVIDUAL |
| INFL | INFLUENT |
| INFO | INFORMATION |
| IN HG VAC | INCHES MERCURY VACUUM 2 |
| INIT | INITIATE/INITIATED/INITIAL |
| INJ | INJECTION |
| INOP | INOPERABLE/INOPERATIVE |
| INPT | INPUT |
| INSRT | INSERT/INSERTION |
| INSTR | INSTRUMENT/INSTRUMENTATION |
| INTLK | INTERLOCK |
| INTK | INTAKE |
| INTRPT | INTERRUPT |
| INVRTR | INVERTER |

| | |
|---|---|
| IP | INTERMEDIATE PRESSURE |
| IR | INTERMEDIATE RANGE |
| IRC | INSIDE REACTOR CONTAINMENT |
| IRM | INTERMEDIATE RANGE MONITOR |
| IRS | IODINE REMOVAL SYSTEM |
| ISOL | ISOLATION/ISOLATOR |
| ISOL VLV | ISOLATION VALVE |
| I&C | INSTRUMENTATION AND CONTROL |

| | |
|---|---|
| JKT | JACKET |
| JNT | JOINT |
| JRNL | JOURNAL |
| K | THOUSAND |
| KEFF | EFFECTIVE NEUTRON MULTIPLICATION FACTOR |
| KV* | KILOVOLT |
| KVA* | KILOVOLT - AMPERE |
| KVAH* | KILOVOLT - AMPERE HOUR |
| KVAR* | KILOVARS |
| KW* | KILOWATT |
| KWH* | KILOWATT HOUR |

| | |
|---|---|
| L | LEFT/LUBE |
| LAB | LABORATORY |
| LB | POUNDS |
| LBM | POUNDS MASS |
| LC | LOAD CENTER |
| LCKOUT | LOCKOUT |
| LCV | LEVEL CONTROL VALVE |
| LD | LOAD |
| LDS | LEAK DETECTION SYSTEM |
| LEAK | LEAKAGE |
| LED | LIGHT EMITTING DIODE |
| LETDN | LETDOWN |
| LHSI | LOW HEAD SAFETY INJECTION |
| LI | LEVEL INDICATOR |
| LIQ | LIQUID |
| LKF | LEAKOFF |
| LOLVL | LOW LEVEL |
| LLRT | LOCAL LEAK RATE TEST |
| LMT | LIMIT |
| LN | LINE |
| LNK | LINK |
| LO | LOW |
| L. O. | LUBE OIL |
| LOC | LOCAL |
| LOCA | LOSS-OF-COOLANT ACCIDENT |
| LOG | LOGARITHM OF |
| 2 LOP | LOSS OF POWER |
| LOSCNT | LOSS OF CONTINUITY |
| LOWR | LOWER |
| LP* | LOW PRESSURE |

| | |
|---|---|
| LR* | LEVEL RECORDER |
| LRTS | LIQUID RADWASTE TREATMENT SYSTEM |
| LSS | LOAD SEQUENCING AND SHUTTING |
| LSWH | LOW SOLIDS WASTE HEADER |
| LTC | LOAD TAP CHANGE |
| LTD | LIMITED 2 |
| LUBE | LUBRICATION |
| LOVOLT | LOW VOLTAGE |
| LVG | LEAVING |
| LVL | LEVEL |
| LWPS | LIQUID WASTE PROCESSING SYSTEM |
| L/U | LINEUP |

| | |
|---|---|
| MA | MILLIAMPERE |
| MAB | MECHANICAL AUXILIARY BUILDING |
| 2 MAC | MAIN AREA COOLER |
| MAG | MAGNETIC |
| MAINT | MAINTENANCE |
| MAN | MANUAL |
| MAX | MAXIMUM |
| MCB | MAIN CONTROL BOARD |
| MCC | MOTOR CONTROL CENTER |
| MCWV | MICROWAVE |
| MTRDRV | MOTOR DRIVEN |
| MEAB | MECHANICAL ELECTRICAL AUXILIARY BUILDING |
| MEAS | MEASURE |
| MECH | MECHANICAL |
| MEV | MILLION ELECTRON VOLTS |
| MFCS | MAIN FEEDWATER CONTROL SYSTEM |
| MFIV | MAIN FEEDWATER ISOLATION VALVE |
| MG | MOTOR GENERATOR |
| MIDS | MOVABLE INCORE DETECTOR SYSTEM |
| MIN | MINIMUM |
| MISC | MISCELLANEOUS |
| 2 MN | MAIN |
| MNTR | MONITOR |
| MOIST | MOISTURE |
| MOV* | MOTOR OPERATED VALVE |
| MS* | MAIN STEAM |
| MSEP | MOISTURE SEPARATOR |

| | |
|---|---|
| MSIV | MAIN STEAM ISOLATION VALVE |
| MSMTCH | MISMATCH |
| MSR | MOISTURE SEPARATOR REHEATER |
| MSV | MAIN STOP VALVE |
| MTL | METAL |
| MTR | MOTOR |
| M/U | MAKEUP |
| MV | MILLIVOLT |
| MVAR | MEGAVARS |
| MVARH | MEGAVAR HOURS |
| MW | MEGAWATT |
| MWH | MEGAWATT HOURS |
| MWP | MAXIMUM WORKING PRESSURE |
| MWS | MAKEUP WATER SYSTEM |
| M/A | MANUAL/AUTOMATIC |

| | |
|---|---|
| N | NORTH |
| NA | SODIUM |
| NAOH | SODIUM HYDROXIDE |
| NDTT | NILDUCTILITY TRANSITION TEMPERATURE |
| NEG | NEGATIVE |
| NEUT | NEUTRALIZING |
| NFCLSD | NOT FULLY CLOSED |
| 2 NFOPN | NOT FULLY OPEN |
| NIS | NUCLEAR INSTRUMENTATION SYSTEM |
| NNS | NONNUCLEAR SAFETY |
| NO | NUMBER |
| N. O. | NORMAL OPEN |
| NON-CRIT | NON-CRITICAL |
| NORM | NORMAL |
| NPSH | NET POSITIVE SUCTION HEAD |
| N/R | NARROW RANGE |
| NRC | NUCLEAR REGULATORY COMMISSION |
| NSRE | NON-SAFETY RELATED |
| NSSS | NUCLEAR STEAM SUPPLY SYSTEM |
| $N_2$ | NITROGEN |
| $N_2H_4$ | HYDRAZINE |
| NUC | NUCLEAR |
| NUTRN | NEUTRON |
| NVS | NORMAL VENTILATION SYSTEM |
| NZL | NOZZLE |



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| | |
|---|---|
| OAI | OUTSIDE AIR INTAKE |
| OG | OFF GAS |
| O/L | OVERLOAD |
| OPENLP | OPEN LOOP 2 |
| OPER | OPERATING/IN OPERATION/OPERATED |
| ORC | OUTSIDE REACTOR CONTAINMENT |
| ORIF | ORIFICE |
| $O_2$ | OXYGEN |
| OTDT | OVERTEMPERATURE DIFFERENTIAL T 2 |
| OPDT | OVERPOWER DIFFERENTIAL T |
| OUTBD | OUTBOARD |
| OUTL | OUTLET |
| OUTP | OUTPUT |
| OVERRD | OVERRIDE |
| OVERSP | OVERSPEED |
| O/A | OUTSIDE AIR |
| O/C | OVERCURRENT |
| O/V | OVERVOLTAGE |

| | |
|---|---|
| PA | PUBLIC ADDRSSS (SYSTEM) |
| PAMI | POST-ACCIDENT MONITORING INSTRUMENTATION |
| PAMS | POST-ACCIDENT MONITORING SYSTEMS |
| PAP | PLANT ADMINISTRATIVE PROCEDURES |
| PARALL | PARALLEL, PARALLELED |
| PASS | POST-ACCIDENT SAMPLING SYSTEM |
| PART | PARTICULATE |
| PCi | PICO CURIES |
| PCM | PERCENT MILLI RHO |
| PCT | PEAK CLAD TEMPERATURE |
| PCV | PRESSURE CONTROL VALVE |
| 2 PDCP | POSITIVE DISPLACEMENT CHARGING PUMP |
| PDISCH | PRESSURE DISCHARGE |
| PE | PRESSURE ELEMENT |
| PENETR | PENETRATION |
| PERM | PERMIT/PERMISSIVE |
| PERS | PERSONNEL |
| PGDS | PRESSURIZED GAS DISTRIBUTION SYSTEM |
| 2 PH | pH (HYDROGEN ION CONCENTRATION) |
| PHS | PHASE |
| PI | PRESSURE INDICATOR |
| PIC | PRESSURE INDICATOR CONTROL |
| PKG | PACKING |

2

| | |
|---|---|
| PMPHS | PUMP HOUSE |
| PMS | PRIMARY MAKEUP SYSTEM/PLANNED MAINTENANCE SYSTEM |
| PNEU | PNEUMATIC |
| PNL | PANEL |
| $PO_4$ | PHOSPHATE |
| POL | POLISHER |
| PORV | POWER-OPERATED RELIEF VALVE |
| POS | POSITIVE |
| POSIT | POSITION |
| POT | POTENTIAL/POTENTIOMETER |
| PPB | PARTS PER BILLION |
| PPM | PARTS PER MILLION |
| PR | POWER RANGE |
| PRCDR | PRESSURE RECORDER |
| PREHTR | PREHEATER |
| PREP | PREPARE/PREPARATION |
| PRESS | PRESSURE |
| PRI | PRIMARY |
| PRL | PARALLEL |
| PRM | PROCESS RADIATION MONITOR |
| PRMG | PRIMING |
| PROC | PROCESS/PROCEDURE |
| PROD | PRODUCT |
| PROP | PROPORTION |
| PROT | PROTECTIVE/PROTECTION |
| PRS | PROTECTION SET |
| PRT* | PRESSURIZER RELIEF TANK |

| | |
|---|---|
| PRTR | PRINTER |
| PRZR | PRESSURIZER |
| PSIA | POUNDS PER SQUARE INCH ABSOLUTE |
| PSIG | POUNDS PER SQUARE GAUGE |
| PSS | PROCESS SAMPLING SYSTEM |
| PSW | PLANT SERVICE WATER |
| PSWS | POTABLE AND SANITARY WATER SYSTEM |
| PT | PRESSURE TRANSMITTER |
| PT ID | POINT IDENTIFIER (COMPUTER) |
| PULS | PULSATION |
| PUR | PURGE |
| PURIF | PURIFICATION |
| PVH | PLANT VENT HEADER |
| PRIWTR | PRIMARY WATER |
| PWR* | POWER |
| PWRLOSS | LOSS OF POWER |
| PWR-OP | POWER-OPERATED |

| | | |
|---|---|---|
| QA | QUALITY ASSURANCE | |
| QDPS | QUALIFIED DISPLAY PROCESSING SYSTEM | 2 |
| RAD | RADIATION | |
| RADWST | RADIOACTIVE WASTE | |
| RAFT | RESIN ADDITION FEED TANK | |
| RAS | RECIRCULATION ACTUATION SIGNAL | |
| RC* | REACTOR COOLANT | |
| RCB | REACTOR CONTAINMENT BUILDING | |
| RCC* | ROD CLUSTER CONTROL | |
| RCCA* | ROD CLUSTER CONTROL ASSEMBLY | |
| RCDR | RECORDER | |
| RCDT* | REACTOR COOLANT DRAIN TANK | |
| RCFC | REACTOR CONTAINMENT FAN COOLING | 2 |
| RCP | REACTOR COOLANT PUMP | |
| RCS | REACTOR COOLANT SYSTEM | |
| RCV | RECEIVING | |
| RCVR | RECEIVER | |
| RCWM | REACTOR COOLANT WASTE MONITORING | |
| RCYL | RECYCLE | 2 |
| RDH | RECYCLE DRAIN HEADER | |
| RDL | RADIAL | |

| | |
|---|---|
| REC | RECORD/RECORDER |
| RECIRC | RECIRCULATING/RECIRCULATION |
| RECOMB | RECOMBINER |
| RECT | RECTIFIER |
| RECVRY | RECOVERY |
| REDUC | REDUCTION |
| REDUN | REDUNDANT |
| REF | REFERENCE |
| REFRIG | REFRIGERATION |
| REFL | REFUEL |
| REFLNG | REFUELING |
| REG | REGULATOR/REGULATION |
| REGEN | REGENERATIVE/REGENERATION |
| REHT | REHEATER |
| REL | RELAY |
| REM | ROENTGEN EQUIVALENT MAN |
| RET | RETURN |
| REV | REVERSE/REVISION |
| RHDS | REACTOR HEAD DEGASSING SYSTEM |
| RHR* | RESIDUAL HEAT REMOVAL |
| RHRS* | RESIDUAL HEAT REMAOVAL SYSTEM |
| RHT | RECYCLE HOLDUP TANK |
| RHTR | REHEATER |

2

| | |
|---|---|
| RLF | RELIEF |
| RLFV | RELIEF VALVE |
| RM | ROOM |
| RMPF | RESERVOIR MAKEUP PUMPING FACILITY |
| RMS | RADIATION MONITORING SYSTEM |
| RMT | REMOTE |
| RMW | REACTOR MAKEUP WATER |
| RMWS | REACTOR MAKEUP WATER SYSTEM |
| RMWST | REACTOR MAKEUP WATER STORAGE TANK |
| RPI | CONTROL ROD POSITION INDICATION |
| RNG | RANGE |
| RO | REACTOR OPERATOR |
| RPS | REACTOR PROTECTION SYSTEM |
| RST | RESTRAINT |
| RSVR | RESERVOIR |
| RTD* | RESISTANCE TEMPERATURE DETECTOR |
| RTN | RETURN |
| RTS | REACTOR TRIP SYSTEM |
| RUNBK | RUNBACK |
| RVWL | REACTOR VESSEL WATER LEVEL 2 |
| RWST* | REFUELING WATER STORAGE TANK |
| RX* | REACTOR |

| | |
|---|---|
| S | SOUTH |
| SAS | STATION AIR SYSTEM |
| SANI | SANITARY |
| 2 SBKR | SUPPLY BREAKER |
| SHUTDNBK | SHUTDOWN BANK |
| SCRN | SCREEN |
| S/D | SHUTDOWN |
| SDS | STEAM DUMP SYSTEM |
| SEC | SECONDARY |
| SECT | SECTION |
| SEL | SELECT/SELECTOR |
| SENS | SENSOR |
| SEP | SEPARATOR |
| SEQ | SEQUENCE |
| SEQR | SEQUENCER |
| SET | SETTING |
| 2 SETLG | SETTLING |
| SETPT | SETPOINT |
| SFA | SPENT FUEL ASSEMBLY |
| SFGD | SAFEGUARD |
| SFP | SPENT FUEL POOL |
| SFPCS | SPENT FUEL PIT COOLANT SYSTEM |
| SFTY | SAFETY |
| SG | STEAM GENERATOR |
| SGBS | STEAM GENERATOR BLOWDOWN SYSTEM |
| SGFP | STEAM GENERATOR FEED PUMP |
| SGFPT | STEAM GENERATOR FEED PUMP TURBINE |
| SHLD | SHIELD |
| SHWR | SHOWER |
| 2 SI | SAFETY INJECTION |
| SIAS | SAFETY INJECTION ACTUATION SIGNAL |

| | | |
|---|---|---|
| SIG | SIGNAL | |
| SIS | SAFETY INJECTION SYSTEM | |
| SLWTR | SEAL WATER | 2 |
| SMK | SMOKE | |
| SMP | SUMP | |
| SMPL | SAMPLE | |
| S/O | SHUT OFF | |
| S.O. | SEAL OIL | 2 |
| SPC | SPACE | |
| SOL | SOLENOID | |
| SOV | SOLENOID OPERATED VALVE | |
| SPAR | SPARE | |
| SPEC | SPECIFICATION | |
| SPKR | SPEAKER | |
| SPLY | SUPPLY | |
| SPRY | SPRAY | |
| SRC | SOURCE/SOURCES | 2 |
| SRG | SURGE | |
| SRM | SOURCE RANGE MONITOR | |
| SRO | SENIOR REACTOR OPERATOR | |
| SRST | SPENT RESIN STORAGE TANK | |
| SRT | SPENT RESIN TANK | |
| SRV | SAFETY RELIEF VALVE | |
| SS | SEAL STEAM | |
| S/S | START STOP | |
| SSPS | SOLID STATE PROTECTION SYSTEM | 2 |
| SSS | SECONDARY SAMPLING SYSTEM | |
| STORTK | STORAGE TANK | |
| STA | STATION | |

| | |
|---|---|
| STAB | STABILIZER |
| STATR | STATOR |
| STBY | STANDBY |
| STDPIPE | STANDPIPE |
| STG | STAGE/STAGING |
| STM | STEAM |
| STPEGS | SOUTH TEXAS PROJECT ELECTRIC GENERATING SYSTEM |
| STOR | STORAGE |
| STRM | STORE ROOM |
| STRN | STRAINER |
| STRT | START/STARTER/STARTING |
| STRUC | STRUCTURE |
| S/U | START-UP |
| SUBST | SUBSTITUTE |
| SUCT | SUCTION |
| SUM | SUMMER |
| SUP | SUPPORT |
| 2 SUPHTR | SUPER HEATER |
| SUPPL | SUPPLEMENTAL |
| SUPV | SUPERVISORY |
| SUR | START-UP RATE |
| STVLV | STOP VALVE |
| SVC | SERVICE |
| SW | SWITCH |
| SWGR | SWITCHGEAR |
| SWPS | SOLID WASTE PROCESSING SYSTEM |
| SWYD | SWITCHYARD |
| SYNC | SYNCHRONIZED/SYNCROSCOPE/SYNCHRONOUS |
| SYS | SYSTEM, SUBSYSTEM |

| | | |
|---|---|---|
| T AND T | TRIP AND THROTTLE | 2 |
| TAVG | AVERAGE TEMPERATURE | |
| TB | TURBINE BUILDING | |
| TBCW | TURBINE BUILDING COOLING WATER | |
| Tc or T COLD | COLD LEG REACTOR COOLANT | |
| T/C | THERMOCOUPLE | |
| TCB | TRIP CIRCUIT BREAKER | |
| TCV | TEMPERATURE CONTROL VALVE | |
| TDS | TOTAL DISSOLVED SOLIDS | |
| TECH | TECHNICAL | |
| TEL | TELEPHONE | |
| TEMP | TEMPERATURE | |
| T ERROR | TEMPERATURE ERROR (PROGRAM TAVG - TAVG) | |
| TERM | TERMINAL | |
| TG | TURBINE GENERATOR | |
| TGB | TURBINE GENERATOR BUILDING | |
| TGSS | TURBINE GLAND SEAL SYSTEM | |
| Th or T HOT | HOT LEG REACTOR COOLANT | |
| THERM | THERMAL | |
| THR | THRUST | |
| THROT | THROTTLE | |
| TI | TEMPERATURE INDICATOR | |
| TIEBKR | TIE BREAKER | |
| TK | TANK | |
| TM | THERMAL MARGIN | |
| TNL | TUNNEL | |
| TOT | TOTAL | 2 |
| TR | TEMPERATURE RECORDER | |
| TRANS | TRANSIENT | |
| TRAV | TRAVELING | |

| | |
|---|---|
| TRBL | TROUBLE |
| TRBY | TURBIDITY |
| TREAT | TREATMENT |
| TRN | TRAIN |
| TRP | TRIP |
| 2 TRQ | TORQUE |
| TURB | TURBINE |
| TURN | TURNING |
| TURNG | TURNING GEAR |
| TVR | THYRISTOR VOLTAGE REGULATOR |
| TWR | TOWER |

| | |
|---|---|
| U | URANIUM |
| UAT | UNIT AUXILIARY TRANSFORMER |
| UHTR | UNIT HEATER |
| U/F | UNDERFREQUENCY |
| UPPR | UPPER |
| UPS | UNINTERRUPTIBLE POWER SUPPLY |
| UPSC | UPSCALE |
| U/V | UNDERVOLT |
| | |
| V | VOLT/VANADIUM |
| VAC | VACUUM |
| VAR | VOLTS AMPERE REACTIVE |
| VCT | VOLUME CONTROL TANK |
| VDC | VOLTS DC |
| VENT | VENT/VENTILATION |
| VERT | VERTICAL |
| VIB | VIBRATION |
| VISC | VISCOSITY |
| VLV | VALVE |
| VOLTM | VOLTMETER |
| VOL | VOLUME |
| VOLT | VOLTAGE |
| VOLTLOSS | LOSS OF VOLTAGE |
| VPR | VAPOR |
| VOLTR | VOLTAGE REGULATOR |
| VENTLSYS | VENTILATION SYSTEM |
| VSL | VESSEL |
| V/AC | VOLTS AC |

| | |
|---|---|
| W | WEST |
| WNDG | WINDING |
| WPS | WASTE PROCESSING SYSTEM |
| WR | WIDE RANGE |
| WTRSYS | WATER SYSTEM |
| WSH | WASH |
| WST | WASTE |
| WTHDRWL | WITHDRAWAL |
| WTR | WATER |
| WTRBX | WATERBOX |
| XFER | TRANSFER |
| XFMR | TRANSFORMER |
| XMTR | TRANSMITTER |
| XOVER | CROSSOVER |
| XPORT | TRANSPORT |
| XTIE | CROSS TIE |
| XTRA | EXTRA |

# APPENDIX M

## LABEL LETTERING GUIDELINES

## M.1 LABEL LETTERING CRITERIA

(Ref: NUREG-0700, Sec. 6.6.4.1)

The speed and accuracy of human performance in identifying controls/displays is influenced by the style and size of characters used for label lettering. Labeling should conform to the following criteria:

A. Character height should subtend a visual angle of 15 minutes as a minimum, or 0.004 X viewing distance. A visual angle of 20 minutes, or 0.006 X viewing distance, is preferred.

B. Letter height should be identical for all labels within the same hierarchical level, based on maximum viewing distance.

C. To ensure adequate contrast and prevent loss of readability because of dirt, dark characters should be provided on a light background.

D. If colored print is used for coding purposes, it should conform to the established color scheme for the control room. Colors should be chosen for maximum contrast against the label background.

E. Labels should be prepared in capital letters and the design of letters and numerals should be simple, without flourishes or serifs.

F. Character width-to-height ratio should be between 1:1 and 3:5. Numeral width-to-height ratio should be 3:5 except for the numeral "4", which should be one stroke width wider, and the numeral "1", which should be one stroke in width.

G. Stroke width-to-character height ratio should be between 1:6 and 1:8.

H. The minimum space between characters should be one stroke width.

I. The minimum space between words should be one character width.

J. The minimum space between lines should be one-half of the character height.

# APPENDIX N

## LOCATION AIDS GUIDELINES

N.1 LOCATION AIDS
(Ref: NUREG-0700, Sec. 6.6.6.1)

Operator performance can be enhanced through the use of location aids such as demarcation, color, and mimics. Indiscriminate use of location aids may provide interference to effective control room operation. Their overuse or inconsistent use could result in unintended confusion or distraction and lessen the attention-getting value.

N.1.1 DEMARCATION LINES
(Ref: NUREG-0700, Sec. 6.6.6.2)

Lines of demarcation can be used to enclose functionally related displays, functionally related control and group-related controls and displays. These lines should be visually distinctive from panel background and should be permanently attached. If color is used for demarcation, it should conform to the color coded scheme used consistently throughout the control room.

N.1.2 MIMICS
(Ref: NUREG-0700, Sec. 6.6.6.4)

Mimics should be designed to integrate system components into functionally oriented diagrams that reflect component relationships and should decrease the operator's decision-making load. Mimics should conform to the following criteria:

A. Flow paths should be color coded and should conform to the color coding scheme used in the control room.

B. The mimic colors should be discriminately different from each other and should adequately contrast with the panel.

C. Mimic lines depicting flow of the same contents (e.g., steam, water, electricity) should be colored the same throughout the control room.

D. No more than four mimic lines of the same color should run in parallel if the operator must quickly identify any one of the lines.

E. Differential line widths may be used to code flow paths (e.g. significance, volume, level) and overlapping of mimic lines should be avoided.

F. Flow directions should be clearly indicated by distinctive arrowheads.

G. Mimic origin points should be labeled or begin at labeled components and destination or terminal points should be labeled or end at labeled components.

H. Component representations on mimic lines should be identified.

I. Graphic symbols should be readily understood and commonly and consistently used.

# APPENDIX O

## PROCESS COMPUTER GUIDELINES

## O.1 FUNCTION

The process computer shall provide the operators with assistance in continuous assessment and evaluation of process and system status information.

## O.2 OPERATOR - COMPUTER INTERFACE

Effectiveness and operator's acceptance of the computer assisted process monitoring depends largely on the quality of man-computer interfaces, i.e., simplicity of procedures required to identify and retrieve necessary data and suitability of formats in which the retrieved information is displayed. Therefore, the basic Human Factors criteria in the design of man-computer interface can be formulated essentially as a requirement to minimize the number and complexity of computer specific notions and procedures to be learned by the operator so that he is able to communicate with the system effectively. The following criteria shall be considered in the design of the operator-computer interface:

A. Command method, documents, procedures and CRT displays designed for the operator's use shall incorporate the operator's point of view, not the programmer's.

B. The operator shall be provided with a convenient means of selecting the major displays without searching through supplementary manuals or memorizing special codes and procedures.

C. Display formats shall be consistent with information presentation standards adopted in the control room.

D. Groups of functionally interrelated displays, e.g., those representing plant systems and corresponding subsystems, should be organized into hierarchical sets with simple access from one display to another. The hierarchy of displays shall include a list (menu) of all the display sets

available, with numerically designated items. Menus shall be functionally organized into a single multi-level system.

E. Operator input procedure shall be developed so that the operator is prompted through all the sequential steps of the input procedure. The system shall provide feedback indicating the mode of system operation, acknowledging operator actions or indicating the action's outcome and subsequent actions required. Correction of individual errors in the inputted sequence shall not require re-entry of correctly entered data. Error messages generated by the system shall include instructions on required corrective actions.

F. Most frequently requested displays shall be accessed by a group of dedicated function keys. The function keyboard shall be laid out in the format that corresponds to natural procedural sequence.

G. Process parameters that indicate an alarm state shall be represented by conspicuous (blinking) alarm messages on corresponding displays.

H. The alarm function display shall be updated to reflect most current alarm status.

I. As new alarms are received, the previous messages shall be moved down the screen. After filling the screen, the oldest messages shall be removed, but the information shall be fully retained, and the operator shall be provided with means to recall any alarm page.

J. The alarm message shall consist of the following:

1. Point identification

2. English legend

3. An alpha symbol to denote the limit exceeded

4. The value of the alarm limit

5. The value of the variable

K. The operator shall be able to remove alarm messages after the point has returned to normal.

L. The acknowledge key shall cause the blinking display to return to steady state.

M. Provisions shall be made such that operation of any of the keys on the main control panels cannot cause loss of valid alarms.

N. Hard copy reflecting the history of the alarm messages shall be generated.

O. A structured menu of all interface functions with their brief explanations shall be available to the operator. Selectable menu items shall be designated by numbers.

P. Chronological listing of event messages representing the change of state of any of the inputs designated as sequence of events shall be available at the operator request, providing a minimum of 200 sequence of event points, with time resolution of the sequence of events not greater than 1 millisecond.

Q. All CRT displays shall be conveniently located and provide unobstructed view for the operator at the normal work station. Maximum screen fill time shall be less than one second. Dynamic update time shall be as close as possible to 2 seconds.

O.2.1 SOFTWARE SECURITY
(Ref: NUREG-0700, Sec. 6.7.1.1)

Access to the process computer software and data base from the control room shall be closely controlled. The following criteria shall apply to ensure software security:

A. Provisions shall be made to ensure that only authorized personnel have access to the data base, programs, and other areas in software.

B. Preferred security method is keylock and password combination for accessing different software levels along with other built-in security deterrents.

C. The plant data acquisition system shall be protected against overwriting its operating system software due to error or improper instruction in unrelated software or due to unauthorized or inadvertent changes. One copy of the current operating software shall be stored in a specially designated remote location.

D. Certain data must be preserved through extended power outages. Power backup should be provided for a minimum of 2 hours.

E. Any operator action which might result in permanent changes to the existing data or yield significant consequences to the computer system shall be executed only after explicit operator confirmation. The confirmation shall not be a component of a routine command sequence and shall present sufficient safeguard against inadvertent actions.

## O.2.2 OPERATOR/COMPUTER DIALOGUE
(Ref: NUREG-0700, Sec. 6.7.12)

The following criteria shall apply for the operator/computer dialogue:

A. Command language utilzied in the operator/computer interaction shall be based on vocabulary and syntax suitable for use by the expected user population.

B. Keywords the operator is required to input in the dialogue shall approximate generally used words.

C. Abbreviations shall be used whenever practical to minimize the entry length. Only standard abbreviations from the Abbreviations List in Appendix L shall be used.

D. In any entry sequence, individual input words shall not have more than seven characters.

E. Entry sequences shall be initially stored in the buffer area and displayed for operator reviewing before being collectively inserted by special command.

F. Provisions shall be made so that information about the mode of system operation, currently processed file and peripheral devices summary are available upon request to indicate the status of the system and system peripherals.

# APPENDIX P

## GUIDELINES PERTAINING TO KEYBOARDS, FUNCTION CONTROLS, COMPUTER RESPONSE TIMES, AND ACCESS AIDS

## P.1 KEYBOARDS AND COMPUTER FUNCTION CONTROLS

(Ref. NUREG-0700, Sec. 6.7.1.4, 6.7.1.5)

The following criteria shall apply for the computer keyboards:

A. If alphanumeric keyboards are used they shall be of standard "QWERTY" typewriter keyboard configuration. However, dedicated function keyboards shall be the primary means of communication with the computer by the control room operators at the main control boards.

B. To maximize the effectiveness of keyboards:

1. Key dimensions and separations shall be as indicated in Table P-1.

2. Keyboard shall have a slope between 15° and 25° from the horizontal.

3. Key displacement and resistance shall be as indicated in Table P-2.

C. Control room keyboards shall contain only those keys which are used by the operators. A positive key activation feedback shall be provided to the operator.

D. Data shall be displayed as it is being entered via the keyboard.

E. Function pushbuttons located on the control panel shall be grouped together.

F. Each function key shall have a label identifying its function.

G. Terms and abbreviations used on function controls shall be consistent with those designating the associated computer function.

Refer to Appendix Q for criteria specific to CRT displays.

Refer to Appendix R for criteria specific to printers.

P.2 MASTER CONTROLS AND CONTROL DEVICES
(Ref: NUREG-0700, Sec. 6.7.1.6)

The computer's control devices shall conform to the following criteria:

A. Centrally located CRT controls shall have positive indication of what CRTs are operated by them. At the same time, individual CRTs shall have indication of whether they are under local or centrally located control.

B. Control devices shall be operable from the locations designated for operator/computer interaction.

C. Speed and accuracy of control devices shall be commensurate with the functions to be served.

D. Location and design of controls shall allow the operator sufficient freedom of movement.

P.3 COMPUTER RESPONSE TIME TO QUERIES
(Ref. NUREG-0700 Sec. 6.7.1.7)

Computer response times for each type of query shall not exceed the limits specified in Table P-3.

P.4 ACCESS AIDS
(Ref: NUREG-0700, Sec. 6.7.1.8)

A complete set of documents necessary to accomplish all of the operator-computer interface functions shall be available in the control room. Documents shall be in hard-copy form and perpared from the point of view of the control room operator. The set of documents shall include the following:

A. Manual for the computer system describing its operation, and interface procedures, including a functional diagram and location of status information.

B. Addresses of data displays which will be called up by the operator. These addresses shall be cross-indexed by: Alphanumeric or numeric codes, program name, system/subsystem identification and functional group identification.

C. Plant computer system restart log.

TABLE P-1

KEY DIMENSIONS AND SEPARATIONS

| | Key Dimension (inches) | Key Separation (inches) |
|---|---|---|
| Minimum | 0.385 | 0.25 |
| Maximum | 0.75 | |
| Preferred | 0.5 | 0.25 |

TABLE P-2

KEY DISPLACEMENT/RESISTANCE RANGE

| | Displacement (inches) | Resistance (ounces) |
|---|---|---|
| Minimum | 0.05 | 0.9 |
| Maximum | 0.25 | 5.3 |

TABLE P-3

MAXIMUM RESPONSE TIME

| Query Type | Seconds |
|---|---|
| Control activation | 0.1 |
| System initialization 3.0 | |
| Request for given service | |
| Simple | 2 |
| Complex | 5 |
| Loading and feedback | 15-60 |
| Error feedback | 2-4 |
| Response to ID | 2 |
| Information on next procedure | 2 |
| Response to simple inquiry from list | 2 |
| Response to complex inquiry | 2-4 |
| Request for next page 0.5-1 | |
| Response to 'execute problem' | 15 |
| Response to complex inquiry in graphic form | 2-10 |
| Response to graphic manipulation | 2 |
| Response to user intervention in automatic process | 4 |

When response time for a query exceeds three seconds, normal computer operation shall be periodically confirmed by delay messages.

# APPENDIX Q

## GUIDELINES SPECIFIC TO CRT DISPLAYS

## Q.1 CRT DISPLAY CHARACTERISTICS

(Ref. NUREG-0700, Sec. 6.7.2.1)

Most contemporary process computer systems include one or more CRTs. These CRTs comprise the principal interface between computer output and control room operators. It is therefore important that the characteristics of the CRT displays optimize the information transfer from the computer to the operator. The quality of the displayed image must be consistent with operator needs. The following criteria shall be used to ensure image quality:

A. Readability - All characters, both alphanumeric and graphic, shall be easily readable by the operator under all control room lighting conditions.

B. Reflected Glare - CRT screens shall be installed to minimize or eliminate glare at normal operator viewing angles.

C. Screen Luminance

1. Ambient illumination shall contribute no more than 25 percent to screen luminance.

2. When the CRT employs dark characters on a light background, the screen background luminance shall be between 23 foot-Lamberts (minimum) and 46 foot-Lamberts (preferred).

3. When the CRT employs light characters on a dark background, the character luminance shall be between 23 foot-Lamberts (minimum) and 46 foot-Lamberts (preferred).

D. Luminance Contrast

Contrast between the characters and the background shall be 15:1 (minimum) and 20:1 (preferred).

E. Geometric Distortion - No point on the CRT viewing area shall be displaced by more than 5 percent of the picture height from its correct position.

F. Resolution

1. Alphanumeric CRTs shall have a minimum of 20 resolution elements per inch.

2. CRTs for displaying complex symbols and graphic detail shall have a minimum of 100 resolution elements per inch.

3. Complex symbols which must be distinguished from other complex shapes shall have a minimum of 10 resolution elements for the longest dimensions of the symbol.

4. Alphanumeric characters shall have a minimum of 10 resolution elements per character height.

G. Regeneration Rate

The regeneration rate for a particular CRT display shall be above the critical frequency at fusion so that the occurrence of disturbing flicker is not perceptible.

H. CRT Display Controls

1. Brightness, contrast and color shall be adjustable by the operator.

2. Adjustment controls shall conform to the appropriate criteria in Section 6.2 for Controls.

Q.2 SYMBOLS AND CHARACTERS
(Ref. NUREG-0700, Sec. 6.7.2.2)

Visual angles are the vertical angles subtended at the eye by a viewed object, symbol, or character. This angle, expressed in minutes of arc, decreases in proportion to the operator's distance from the CRT. This distance varies considerably because of the operator's movement within the control room. The human eye can distinguish symbols and characters at visual angles of 5 minutes of arc under ideal conditions. However, because operational environments are not ideal, more stringent criteria than the above have to be applied. Following is a list of such criteria for seven CRT symbol/character variables.

A. Symbol Size - Complex symbols that must be distinguished subtend a visual angle of at least 20 arc minutes.

B. Alphanumeric Character Size

1. Alphanumeric characters subtend a visual angle of not less than 12 arc minutes for the required viewing distance.

2. Alphanumeric characters shall be upper-case letters.

C. Character Width-to-Height Ratio - The width-to-height ratio for alphanumeric characters shall be between 3:5 and 1:1.

D. Stroke Width-to-Character Height Ratio - Stroke width-to-character height ratio shall be between 3:5 and 1:10.

E. Graphics - Graphic lines shall contain a minimum of 50 resolution elements per inch to ensure the illusion of continuity among these elements.

F. Character and Symbol Separation

1. Horizontal separation between characters or symbols shall be between 10 percent and 65 percent of the symbol height.

2. Separation shall not be less than 25 percent of character or symbol height when any of the following degraded conditions are present:

   a. Character or symbol width is less than 85 percent of height

   b. Character or symbol luminance is less than 12 foot-Lamberts

   c. Luminance contrast is less than 88 percent

   d. CRT screen location is greater than 35° to either side of the operator's straight-ahead line-of-sight (LOS)

   e. Visual angle subtended by symbol height is less than 15 arc minutes

   f. Visual angle subtended by character height is less than 12 arc minutes

G. Character Style (Font)

1. Simple character fonts shall be used (no serifs, variable stroke widths, slanting, etc.).

2. When dot-matrix characters are used, 7x9 dot-matrix shall be used in preference to 5x7 dot-matrix.

3. Character styles such as Lincoln/Mitre or Leroy shall be used.

Q.3 <u>OPERATOR - DISPLAY RELATIONSHIP</u>
(Ref. NUREG-0700, Section 6.7.2.3)

CRTs may be either (1) fixed position mounted in a seated operator console, (2) fixed position mounted in a vertical standup panel, or (3) rotatable or moveable mounted on a stand or desktop. The following criteria will be considered regardless of the type of CRT installation and applied as necessary.

A. Viewing distance shall be at least 18 inches.

B. The minimum angle between the operator's actual line-of-sight (LOS) (as measured from the operator's normal work location) and the plane of the display screen shall be 45° or greater in either the horizontal or vertical direction.

C. Screen Location, Seated Operators

1. CRT displays requiring frequent or continuous monitoring, or which display critical (e.g. alarm) information, shall be located within the following limits as measured from the normal operator work station:

a. Horizontal Limits - Not more than 35° to either side of the operator's straight-ahead LOS.

b. Vertical Limits - Not more than 20° above and 40° below the operator's horizontal LOS.

2. CRTs not requiring frequent or continuous monitoring, and which do not display critical (e.g. alarm) information, shall be located within the following limits as measured from normal work stations permitting full head and eye rotation:

   a. Horizontal Limits - Not more than 95° to either side of the operator's straight-ahead LOS.

   b. Vertical Limits - Not more than 70° above and 90° below the operator's horizontal LOS.

D. Screen Location, Standing Operators

1. CRT displays requiring frequent or continuous monitoring, or which display critical (e.g. alarm) information, shall be located within the following limits as measured from normal operator work locations in the control room:

   a. Horizontal Limits - Not more than 35° to either side of the operator's straight-ahead LOS.

   b. Vertical Limits - Not more than 35° above and 25° below the operator's horizontal LOS.

2. CRTs not requiring frequent or continuous monitoring, and which do not display critical (e.g. alarm) information, shall be located within the following limits as measured from normal work locations in the control room permitting full head and eye rotation:

   a. Horizontal Limits - Not more than 95° to either side of the operator's straight-ahead LOS.

b. Vertical Limits - Not more than 85° above and 90° below the operator's horizontal LOS.

E. When CRTs are mounted in consoles, the console configuration, dimensions, and type of use shall conform to the criteria that apply to work station design. These criteria are given in Appendix A.

F. All data and messages shall be within the unobstructed view of an operator at the normal work station.

Q.4 DATA PRESENTATION FORMAT
(Ref. NUREG-0700, Section 6.7.2.4)

The format used in presenting CRT data shall correspond to the following criteria:

A. Usability of Data

1. Data shall be presented in a readily usable format.

2. Operators shall not be required to transpose, compute, interpolate, or mentally translate displayed data into other numerical units or bases.

B. Illustrations shall be used whenever possible to supplement text.

C. Character Grouping

1. Characters shall be grouped in blocks of three to four when five or more digits and/or non-text alphanumerics are displayed, and no natural organization exists.

2. Groups should be separated by a minimum of one blank character space.

D. Elements in a data field should be displayed in logical order (e.g. chronological)

E. Presentations of Identical Data

1. Identical data should be presented in the way the data will be used by the operator.

2. Within the limits of (1) above, identical data in different presentations shall be displayed in a consistent, standardized manner.

F. Menu Designators

1. Numbers shall be used as designators when listing selectable items. If the listing of selectable items contains numbers, alphabetic characters should be used to prevent confusion.

2. Numerical designators shall start with the number "1" or "101" (not zero).

3. If used, alphabetic designators shall start with the letter "A".

G. Lists

1. Lists shall be vertically aligned and left-justified.

2. Indentation shall be used for subclassifications.

H. Tables and Graphs - Quantitative data to be scanned and compared shall be presented in either tabular or graphic form.

I. Hyphenation - Hyphenation will be minimized.

J. Alignment

1. When presented in tabular form, alphanumeric data shall be left-justified.

2. When presented in tabular form, numeric data shall be right-justified with decimal points aligned.

K. Periods shall be placed after item selection designators and at the end of a sentence.

L. The following standardized fields will be used:

1. Telephone Number: (914) 555-1212
2. Time: HH:MM:SS, HH:MM, MM:SS:(.S)
3. Date: MM:DD:YY

M. Data Group Labeling

1. Descriptive titles shall be used for each individual data group or message.

2. Unique characteristics of the content of the data group or message shall be reflected in the selection of labels.

N. Labels shall be located in a consistent manner either above or to the left of the data group or message they describe.

O. Labels shall be horizontally (not vertically) oriented.

P. Label Highlighting

1. Labels shall be highlighted or otherwise accentuated to facilitate operator scanning and recognition.

2. The technique used to highlight labels shall be easily distinguished from that used to highlight emergency and other critical messages.

Q. When presenting a list of operation options, the label shall reflect the question or choices being posed to the operator.

## Q.5 SCREEN LAYOUT AND STRUCTURING

(Ref. NUREG-0700, Section 6.7.2.5)

Screen layouts and data structure presented on CRTs shall minimize the probability of operator error. The following criteria shall be used to achieve this goal:

A. Displayed data shall be organized in a logical, consistent manner, and shall reflect some obvious and inherent quality of the data groups (e.g. hierarchical, sequential, or mimic).

B. Consistent physical locations shall be used for specific data groups.

C. Organization and separation of information subgroups shall be made apparent through the use of blank spaces, lines, or some other form of visible demarcation.

D. Lists of options shall be organized according to the probability of selection of each item (high probability items presented first).

E. Non-option lists of equal probability options shall be presented in alphabetical or numerical order.

F. At least one blank line shall be used to separate paragraphs in continuous text.

G. At least one blank space shall be used to separate selection designators from text designators.

H. When multiple pages are used to present data, each page shall display both page number and total number of pages.

I. Items contained in a numbered list and described on "continue" pages shall be numbered relative to the first number on the first page of the list.

J. Operator instructions shall precede the list of options.

K. Urgent messages requiring immediate operator response shall be:

1. Highlighted to attract attention

2. Displayed in the same location

L. In systems where selection is made by use of a cursor, formats shall be organized to minimize positioning movements of the cursor.

M. The amount of information-bearing activated screen area shall not exceed 25% of the total screen area (excluding demarcation lines used to separate data groups).

N. Trend plot scales shall be consistent with the intended functional use of the data .

Q.6 MESSAGES
(Ref. NUREG-0700, Section 6.7.2.6)

Messages (whether prompts, error messages, or systems feedback) shall conform to the following criteria:

A. Messages shall be concise and provide information required to complete a specific action or decision sequence.

B. Information contained in messages shall be necessary, complete, and readily usable.

C. Prompts shall be used when the operator may need direction or guidance tc initiate or complete an action or sequence of actions.

D. Prompts shall contain clear and specific cues and instructions which are relevant to the action to be taken.

E. Directions shall be in the sequence to be used by the operator.

F. Error messages shall be included for any error or invalid input.

G. Error messages shall contain instructions regarding required corrective action.

H. Capability shall be provided for individual error correction without affecting adjacent valid entries.

I. Feedback messages convey system status changes to the operator.

J. When a displayed item is selected as an option or input to a system, the item shall be highlighted, or otherwise positively identified, to indicate acknowledgement by the system.

K. When system functioning requires the operator to stand by, such as when the computer is searching for requested data, periodic feedback shall be provided the operator to indicate normal system operation and the reason for delay.

L. When a process or sequence is completed by the system, positive indication shall be provided concerning the outcome of the process and requirements for subsequent operator actions.

Q.7 GRAPHIC CODING AND HIGHLIGHTING
(Ref. NUREG-0700, Section 6.7.2.7)

The following criteria shall be applied:

A. Highlighting shall be used to attract attention to displayed data that are important to actions and decisions.

B. Consistent Approach

1. Highlighting methods shall be consistent among applications.

2. Highlighting methods shall be different for normal and abnormal conditions.

C. When contrast enhancement is used for highlighting, not more than two (preferable) or three (maximum) brightness levels shall be used in a single presentation.

D. Blinking of a symbol or message shall be used for emergency (or other critical) conditions only.

E. Blink Rates

1. No more than two blink rates shall be used.

2. For a single blink rate, the rate shall be 2-3 blinks per second with a minimum of 50 msec "on" time between blinks.

3. When two blink rates are used, the fast blink shall approximate four per second and the slow rate shall approximate one per second, the on/off ratio shall approximate 50%, and the higher rate shall apply to the most critical information.

F. Image reversal (e.g., dark characters on a light background) shall be used primarily for dense data fields, such as a word or phrase in a paragraph of text, or a set of characters in a table of data.

G. Graphic coding (e.g., boxes, symbols, underlining) shall be used to present standard qualitative information or to draw attention to a particular portion of the display.

H. Graphic codes shall have the same meaning in all applications.

I. When geometric shape (symbol) coding is used, the symbols shall vary widely in shape.

J. Number of Symbols

1. The number of basic symbols used for coding shall not exceed the operator's ability to discriminate among them. This will range from 6-20 symbols depending on the display conditions.

2. Other highlighting and graphic techniques (e.g., color) shall be used as needed to display different states or qualities of a basic symbol.

K. Use of Color

The following criteria shall be applied to the use of color for CRT display presentations:

1. CRT colors shall be consistent in use and meaning with all other color codes in the control room.

2. Once colors are assigned a specific use or meaning, no other color shall be used for the same purpose.

L. Color Meanings - Where possible, color meanings shall equate with the commonly understood meanings of those colors. Following are the specific meanings for three colors - red, green, and yellow/amber. However other meanings of these colors which are commonly understood for control room use are also acceptable.

1. Red - Unsafe, danger, immediate action required, or critical parameter value out of tolerance.

2. Green - Safe, no action required, or parameter value is within tolerance.

3. Yellow/amber - Hazard, potentially unsafe, caution, attention, marginal parameter value exists.

M. Red-Green Combinations

1. Whenever possible, red and green colors shall not be used in combination.

2. Use of red symbols on a green background shall be avoided.

Q.8 MULTIPLE-PAGE CONSIDERATIONS
(Ref. NUREG-0700, SEction 6.7.2.8)

When it is necessary to include multiple pages, or when scrolling, panning, and zooming of a single page is anticipated, the following criteria will be applied:

A. All data relevant to a specific operator entry shall be displayed on a single page, and requirements for operator memory shall be minimized.

B. Location References

1. When scrolling or panning is required, location references shall be provided in the viewable portion of the frame.

2. Sectional coordinates shall be used when large schematics must be panned or magnified.

C. A capability shall exist for controlling the amount, format, and complexity of information displayed by the system.

D. If the message is a variable option list, common elements shall maintain their physical relationship to other recurring elements.

## APPENDIX R

PRINTERS GUIDELINES

R.1 CHARACTERISTICS
(Ref. NUREG-0700, Section 6.7.3.1)

The following criteria apply to the use of printers:

A. Printer Applications

1. Printers shall be part of the process computer system and be located in the primary operating area.

2. Control room printers shall provide the capability to record alarm data, trend data, and plant status data.

B. Display Copies

1. The capability shall exist to print any page appearing on the CRT.

2. If the print request is to be executed on a device remote to the operator, a confirmation (or denial) message shall be displayed.

C. Printed information shall be in a directly usable form with minimal requirements for decoding, transposing, and interpolating.

D. Printing speed shall be adequate to avoid more than one minute backlog of trend, alarm, and critical status information.

E. Printer Operation - Paper, ribbons, and ink (if used) shall be consistent with the following:

1. Hard-finish matte paper shall be used.

2. Instructions for routine maintenance (e.g. paper, ribbon reload) shall be attached to the printer.

3. When the printer is down temporarily, data which would normally be printed shall not be lost.

4. A takeup device for printed material shall be provided. This device shall require minimal operator attention.

5. Printers shall be plug-compatible and interchangeable.

F. Print Copy Accessibility

1. An operator shall always be able to read the most recently printed line.

2. Printed material shall have a contrast ratio sufficient to ensure easy reading.

3. It shall be possible to annotate the print copy while it is still in the machine.

4. Recorded matter shall not be obscured, masked, or otherwise hidden in a manner which prevents direct reading of the material.

R.2 ALARM MESSAGES

(Ref. NUREG-0700, Section 6.7.3.2)

The following criteria shall be applied to alarm messages:

A. Alarm Records

1. A printer shall be provided for recording alarm messages.

2. All annunciator alarms shall be recorded.

B. Alarm messages shall be recorded in their sequence of occurrence.

C. Upon operator request, printouts by alarm group (e.g., system, subsystem, component) shall be provided.

D. Alarm messages shall be readily distinguishable from other messages.

E. Alarm messages shall provide rapid identification of the nature of the alarm.

F. Wording in alarm message should:

1. Clearly relate to the specific annunciator tile that is illuminated if such a relationship exists.

2. Contain at least that information presented in the annunciator tile.

3. Provide additional specific data.

R.3 GRAPH AND TABLE REQUIREMENTS
(Ref. NUREG-0700, Section 6.7.3.3)

When printers are used to record/present tabular data, applicable criteria in the CRT section shall be applied.

A. If decisions are predicated on the shape of the function, a graph shall be used.

B. If interpolation is necessary, line graphs are preferable to bar graphs and tables.

C. Tables

1. Tables shall be simple, concise, and readable.

2. When table columns are long, numbers shall be separated into groups by providing a space between groups of five lines.

3. When columns are not separated by vertical lines, the columns shall be separated by at least two character widths.

# APPENDIX S

## GUIDELINES FOR THE USE OF COLOR IN CONTROL ROOM DESIGN

## S.1 REFERENCE MATERIAL

The following information on color is taken from the literature (primarily Woodson and EPRI NP-2411) for this Appendix:

### A. VISION

The eye, as a light sensitive transducer, has the following characteristics:

- o Frequency Range - 340 to 760 millimicrons wavelength (violet to red)
- o Maximum Lumens - Sun (threshold of damage)
- o Minimum Lumens - A few photons (minimum threshold)
- o Ratio of Max to Min - $10^{13}$
- o Color Discrimination - 128 hues with good illumination (10 mL or better) and saturated color, varying from 1 to 20 millimicrons. The average person can accurately distinquish 8 or 9 hues with proper lighting.
- o Average Minimum Focusing Distance:

| AGE | DISTANCE (Inches) |
|---|---|
| 20 | 4.00 |
| 40 | 8.75 |
| 60 | 40.00 |

- o Response Rate for Successive Stimuli - 0.1 Seconds

- o Best Operating Range - 500 to 600 millimicrons (green-yellow) from 10 to 200 footcandles of light

- o Visual Acuity - At low light intensity the eye can see a line subtending a visual angle of 10 minutes. At high intensity it can see a line subtending less than one second of visual angle

- o Clear Vision - Depends on the relationship of:

  - Contrast
  - Visual Angle
  - Brightness

B. COLOR

Color consists of three attributes - hue, brightness and saturation

- o Surface color recognition depends on:

  - Color of the reflecting surface(s), and
  - State of the observer's visual system

## S.2 REFERENCES TO COLOR IN CRITERIA REPORT

The following sections in the Criteria Report make reference to color. This Appendix consolidates all pertinent requirements for color and shall serve as the source material for the application of color for the South Texas Project control room design.

| SECTION | REFERENCE TO | SUBJECT |
|---|---|---|
| 6.2.1.10 | Switches | Color coding |
| 6.5.1.3 | Panel layout | Color shading groups of controls and displays |
| 8.4.4 | Annunciator | Priority coding |
| 8.5.2.1 | Annunciator | Tiles |
| 8.5.2.2 | Computer driven display | Color coding supplement to numeric priority |
| Appdx. D. para. D.7 | Control room environment | Reflectance of color |
| Appdx. F. para. F. 6 | Visual displays | Color coding |
| Appdx. G. para. G. 3 | Meter displays | Zone marking |
| Appdx. H. para. H. 2 | Indicator lights | How color is to be furnished; meaning of color |
| Appdx. J. para. J.1 | Drum type counters | Color of number |
| Appdx. M para. M. 1 | Label lettering | Basis for color selection |

| SECTION | REFERENCE TO | SUBJECT |
|---|---|---|
| Appdx. N. para. N. 1 | Location aids | Color for mimics and demarcation |
| Appdx. Q para. Q.7 | CRT displays | Color meanings |

S.3 GENERAL

This appendix allows for the ability of an average operator to relate specific meaning to color for approximately nine colors related to a specific context or subject.

Colors shall have the same meaning from context to context.

This appendix allows for some inconsistencies due to:

1. Limitations in color generating systems, i.e: CRT red is not as alarming as magenta. Magenta is used on CRT as first priority instead of red.

2. System complexity may require inconsistencies to promote clarity in communication.

3. Packaged equipment furnished by some vendors may have traditional meaning for color that may vary from standards established herein.

This appendix establishes the colors for a variety of contexts, considering the above limitations, and the ability of operators to recognize different meanings for the same color in different contexts.

The application of color in control room design should be limited in order to avoid the loss of effectiveness of using color for those very important situations for securing operator attention.

The following NUREG section 6.5.1.6 meaning of color is expanded as follows:

RED - BE AWARE THAT:

- o Equipment is operating (in steady motion, accelerating, or moving to a new position)
- o Equipment is energized (passage of current at a voltage level that can cause serious harm)
- o Unsafe or dangerous condition exits
- o Immediate operator action is required
- o A critical parameter is out of tolerance
- o A critical safety function is in jeopardy - immediate operator action is required

GREEN - BE ADVISED THAT:

- o Equipment is in a safe mode of service
- o Equipment is not energized
- o No immediate action is necessary to prevent plant safety conditions or equipment damage
- o Only routine monitoring required
- o The Critical Safety Function is satisfied - no corrective operator action is called for

AMBER - CAUTION IS REQUIRED SINCE:

- o Equipment is operating in a range approaching out of tolerance dangerous conditions
- o Operator monitoring and corrective action is required to return to the normal state
- o A hazard (potentially unsafe) condition exits that requires attention
- o A marginal value of a parameter exists that could lead to a serious condition
- o The critical safety function is not fully satisfied - operator action may eventually be needed

Consistency in the application of the above colors is mandatory, and any deviations shall be justified.

The following NUREG - 0700 section 6.5.1.6 principal of color selection shall be followed:

(1) The primary principle which should be applied in selecting colors for coding purposes which do not have the immediate safety implications of red, green, and amber is to ensure that each color is recognized as different from any other. Exhibit 6.5-7 lists 22 colors of maximum contrast. Each successive color has been selected so that it will contrast maximally with the color just preceding it and satisfactorily with earlier colors in the list. The first nine colors have been selected so as to yield satisfactory contrast for red-green-deficient as well as color-normal observers. The remaining 13 colors are useful only for color-normal observers.

(2) Colors selected for coding should contrast well with the background on which they appear.

(3) Ambient lighting in the area in which color coding is used will influence the apparent color of the coded element (especially for surface colors). Each color selected for coding should be evaluated under all illumination conditions under which it is used.

FROM SECTION 6 OF NUREG - 0700

VISUAL DISPLAYS 6.5

PRINCIPLES OF DISPLAY 6.5.1

| Color Serial or Selection Number | General Color Name | ISCC-NBS ISCC-NBS Centroid Number | ISCC-NBS Color-Name (Abbreviation) | Munsell Renotation of ISCC-NBS Centroid Color |
|---|---|---|---|---|
| 1 | white | 263 | white | 2.5PB 9.5/0.2 |
| 2 | black | 267 | black | N 0.8/ |
| 3 | yellow | 82 | v.Y | 3.3Y 8.0/14.3 |
| 4 | purple | 218 | s.P | 6.5P 4.3/9.2 |
| 5 | orange | 48 | v.O | 4.1YR 6.5/15.0 |
| 6 | light blue | 180 | v.l.B | 2.7PB 7.9/6.0 |
| 7 | red | 11 | v.R | 5.0R 3.9/15.4 |
| 8 | buff | 90 | gy.Y | 4.4Y 7.2/3.8 |
| 9 | gray | 265 | med. Gy | 3.3GY 5.4/0.1 |
| 10 | green | 139 | v.G | 3.2G 4.9/11.1 |
| 11 | purplish pink | 247 | s.p.PK | 5.6RP 6.3/9.0 |
| 12 | blue | 178 | s.B | 2.9PB 4.1/10.4 |
| 13 | yellowish pink | 26 | s.yPK | 8.4R 7.0/9.5 |
| 14 | violet | 207 | s.V | 0.2P 3.7/10.1 |
| 15 | orange yellow | 66 | v.OY | 8.6YR 7.3/15.2 |
| 16 | purplish red | 255 | s.pR | 7.3RP 4.4/11.4 |
| 17 | greenish yellow | 97 | v.gY | 9.1Y 8.2/12.0 |
| 18 | reddish brown | 40 | s.rBr | 0.3YR 3.1/9.9 |
| 19 | yellow green | 115 | v.YG | 5.4GY 6.3/11.2 |
| 20 | yellowish brown | 75 | deep yBr | 8.8R 3.1/5.0 |
| 21 | reddish orange | 34 | v.rO | 9.8R 5.4/14.5 |
| 22 | olive green | 126 | d.OlG | 8.0GY 2.2/3.6 |

Exhibit 6.5-7. Twenty-two colors of maximum contrast

(from Kelly, 1965)

S.4 CONTEXT VERSUS COLOR

The following applies to the STP control room design:

A. CONTEXT 1 - CONTROL ROOM

1. The control room surfaces shall have the following colors

- o Walls - (Later)
- o Ceilings - (Later)
- o Floors - (Later)

2. Surface color reflectance values shall be as follows:

| Areas | Luminance Ratio |
|---|---|
| Task area versus adjacent darker surroundings | 3:1 |
| Task area versus adjacent ligher surroundings | 1:3 |
| Task area versus more remote darker surfaces | 10:1 |
| Task area versus more remote lighter surfaces | 1:10 |
| Luminaries versus surfaces adjacent to them | 20:1 |
| Anywhere within normal field of view | 40:1 |

B. CONTEXT 2 - MAIN CONTROL PANELS

1. The basic finish coating shall be beige color Sherwin-Williams code BM 11-2 paint.

2. Demaracation finish paint shall be compatible colors Sherwin-Williams codes:

   - o BM 13-8
   - o BM 13-7
   - o BM 13-5
   - o BM 13-4

   Note- Other compatible nonpredominate colors may be used sparingly if necessary to avoid misinterpretation of equipment relation.

C. CONTEXT 3 - ANNUNCIATOR (PRIORITY TILE COLOR)

1. The following colored tiles shall be easily identified and shall denote the following priority levels. See Section 8.4.4. of the criteria report:

   - o PRIORITY 1 - Red
   - o PRIORITY 2 - Amber (Yellow)
   - o PRIORITY 3 - White

2. The annunciator window box flanged front surface shall be finished to match the color of the immediate section of the panel in which it is located.

D. CONTEXT 4 - COMPUTER CRT DISPLAYS

1. Alarm messages shall show priority as follows:

   - PRIORITY 1 - Magenta (Reverse Display)
   - PRIORITY 2 - Amber (Yellow)
   - PRIORITY 3 - White

2. The following colors shall be used for alphanumeric displays:

| COLOR | USE |
|---|---|
| Black | o Background |
| Light Blue | o Labels, units |
| Cyan | o Parameter values, Instructions |
| Green | o Safe operating status |
| | o Off |
| | o Close (ed) (ing) |
| Red | o Unsafe operating status |
| | o On |
| | o Open (ed) (ing) |
| | o Critical parameter is out of tolerance |
| White | o Status words for intermediate states |
| Yellow | o Approaching unsafe condition status words |
| | o A hazardous condition exists |
| | o A margain value of a parameter exists |

E. CONTEXT 5 - CONTROLS

1. Color is used in controls for quick identification of:

   - A specific (important) control in a large group of controls
   - A specific mode of a multimode controller
   - A control action in progress
   - A control designated for a gross safety action
   - A control that requires administrative, procedural or supervisory permission before it can be used.

2. SBM Switches

   - Targets

2 RED - The last movement of the switch was to "close" the circuit breaker

GREEN - The last movement of the switch was to "trip" the circuit breaker (open)

NOTE - This allows the operator the ability to match the target color with the indicating light color to confirm that the circuit breaker responded to the desired switch action

o Handles

BLACK - Basic color

3. Microswitch Series PT Switches 2

o Nameplates

Silver - Basic nameplate color
Black - Lettering for switch action

o Buttons

White - Basic color
Red - Used only for Diesel Generator Emerg. Start, 2
Aux. FW turbine trip, and S.I block/reset.

o Switch Operator

Black - Basic Color

o Switch operator selector arrow

White - Basic color

o Switchguards 2

Silver - Basic color if switchguard is required.

4. C R 2940 Switches

- o Nameplates

  Silver - Basic nameplate color
  Black - Background for lettering
  2 Silver - Lettering for switch action

- o Buttons

  White - Basic insert color
  2 Red - Used only for turbine trip

- o Button rings

  Silver - Basic color

- 2 o Switch operator

  Silver - Basic color

- o Switch operator selector arrow

  Black - Basic color

- 2 o Switchguards

  Silver - Basic color if switchguard is required
  Red - Used only for turbine trip

5. Master Specialties Switches

- o Flange

Silver - Basic color

o Window

Clear Plastic - Basic non-color
Black - Lettering

6. ESF Bypass and Inoperable Status Lights

o White - Bypassed/Inoperable

o Amber - ESF Monitoring

F. CONTEXT 6 - LABELS

1. Labels shall be colored to provide good contrast between the lettering and the background consistent with individual section color of the panel.

2. To minimize the long term problem of dirt accumulation, it is preferrable to use dark colored lettering on light colored background for those nameplates that use machined grooved letters.

3. Color shall be used in all levels of labeling as follows:

a. Plant safety component and function nameplates shall be constructed of multicolored plastic lamociod material, such that the front surface is the basic panel color and the train designation is obvious by the outer beveled edge colored as follows:

CHANNELS

I - Red
II - White
III - Blue
IV - Yellow

b. Other component and function nameplates

Background to match the basic panel front surface color; lettering shall be black.

G. CONTEXT 7 - MIMIC LINES

1. Electric Power Lines

- o Light Blue - 345 kV
- o Black - 138 kV
- o Dark Blue - 25 kV
- o Orange - 13.8 kV
- o Yellow - 4.16 kV
- o Ivory - 480 V

2. Process Mimic Lines

- o Orange

H. CONTEXT 8 - INDICATING LIGHTS

1. Associated with switches or indication and control action feedback circuits

- o Red - Valve or damper not fully closed, circuit breaker or motor starter closed (powered), equipment running (on)
- o Green - Valve or damper not fully open, circuit breaker or motor starter tripped (open, not powered), equipment stopped (off) 2
- o White - Test, status
- o Blue - Permissive
- o Amber - Auto or selected switches

J. CONTEXT 9 - VISUAL DISPLAYS

- o Meter scales shall be black on white background
- o Pointers shall be red on vertical and horizontal meters 2
- o Pointers shall be black on circular meters

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DESIGN REVIEW

APPENDIX T

GUIDELINES FOR APPLYING
HUMAN FACTORS ENGINEERING
PRINCIPLES TO CONTROL PANEL
DESIGN CHANGES

2.3.11/09123
2493W/0068W

## T.1 OBJECTIVE

The objective of this appendix is to provide guidelines for the preparation of plant procedure(s) covering the application of Human Factors Engineering principles in any control room panel design changes. The NUREG-0700 Control Room Design Review resulted in a product that received extensive human factors review and in process modifications. The application of the guidelines defined in this appendix is intended to maintain effective human factor engineered man/machine interfaces.

## T.2 GUIDELINES

The engineer responsible for the implementation of a required control panel change should consider the following instructions in the change process:

The main vehicle for these instructions is the Human Factors Design Review (HFDR) Form. Instructions for completing this form are as follows:

### INSTRUCTIONS

1. The responsible engineer (RE) should fill in the description section with a concise description of the proposed change.

2. Each section of the Criteria Report should be reviewed for applicability concerning the proposed change. Section 1 of the HFDR is provided to maintain a record of the applicable sections, and whether or not the proposed change meets the criteria. For example, if a new indicator is to be added, the criteria of Section 6.3 "Visual Display", as well as others, apply, and Section 6.4 "Labels and Location Aids" applies to the label for the new indicator. The RE should determine compliance, or non-compliance with the applicable guidelines.

3. All discrepancies noted in the review process should be reported, justified, and approved as an attachment to the HFDR form.

4. The RE should determine if the proposed change needs to be mocked-up and complete form Section 6. The RE should consider and initiate other review techniques such as: reviews by committee of subject matter experts, review using the simulator, full scale drawing markup review etc.

5. The RE should determine if the proposed change requires a review by a specialist. If, for example, the proposed change involves a change to an emergency procedure it is desireable to have a task analysis performed in the review process. Likewise if the change involves sound, lighting or other environmental changes then these should be reviewed and inspected by a specialist. The RE should have his recommendation for the review and inspection skill level and an assigned designated Human Factors Specialist approved by his manager.

6. The RE should arrange to have the proposed change reviewed by HL&P Nuclear Operations. If the change involves a mock up this facility should be made available for the operators review. The summary section of the form should indicate the composite views of operations and should note any strong dissents.

7. The RE should complete form Section 3 and, if necessary, arrange for a limited task analysis to verify that the proposed change does not compromise plant safety. A copy of the task analysis should be attached to the HFDR form.

8. The RE should determine if the proposed change involves operator training and review with the training department training implementation plans.

9. The RE should list the plant documents involved in the proposed change per form Section 5.

10. If the design change involves a significant amount of equipment or major system modification the RE should follow Appendix B of NUREG 0700 "Systems/Operations Design Analysis Techniques."

11. The signed and approved HFDR form should be used in the process for securing authorization of the proposed change.

| HOUSTON LIGHTING & POWER CO. SOUTH TEXAS PROJECT | Description ______<br>______<br>______<br>Prepared By ______ / /<br>Approved By ______ / / | HUMAN FACTORS DESIGN REVIEW<br>No. ______<br>Pg. 1 of ______ |
|---|---|---|

Equipment involved ______

Safety Class ______ Panel Location ______ Layout Panel Dwg. No. ______

1.0 The proposed change was reviewed per criteria report as noted:

| Meets Criteria | N/A | Yes | No | Meets Criteria | N/A | Yes | No |
|---|---|---|---|---|---|---|---|
| 2.0 General | | | | 6.5 • Panel Layout | | | |
| 3.0 Control Room Layout and Features | | | | 6.6 • Control – Display Integration | | | |
| 4.0 Main Control Panels | | | | 7.0 Communications | | | |
| 5.0 Aux. Shut Down Panel Layout and Features | | | | 8.0 Annunciation Features | | | |
| 6.0 Human Factors | | | | 9.0 Post Accident Monitoring | | | |
| 6.1 • Work Space | | | | 10.0 By Passed and Inoperable Status Features | | | |
| 6.2 • Control | | | | 11.0 SPDS Features | | | |
| 6.3 • Visual Display | | | | 12.0 Plant Computer | | | |
| 6.4 • Labels and Location Aids | | | | | | | |

List specific no. and title of guidelines considered (See Section A2 "Guideline Reference Metrix" of NUREG – 0700):

2.0 The proposed change was reviewed by a minimum of three licensed and plant experienced operators. The following summarizes this review:

3.0 The proposed change ☐ does not involve ☐ involves an emergency procedure.

**Note – See attached for Task Analysis to show that the proposed change does not compromise plant safety**

4.0 The proposed change ☐ does not involve ☐ involves operator training. The following describes type and how training will integrate the proposed change into the system:

5.0 List all plant documents and specific area of the documents that will require changes if the proposed change is implemented:

6.0 The proposed change ☐ was mocked up ☐ was not mocked up.

The above review verifies that established human factors principles have been considered and factored into the proposed change.

**Signature of Designated Human Factors Specialist** — / / Date

HOUSTON LIGHTING & POWER CO.

CONTROL ROOM DESIGN REVIEW

# APPENDIX U

DEMARCATION

STUDY

GUIDE

2.3.11/09123
0061W/0796P

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# DEMARCATION STUDY GUIDE

## 1.0 OBJECTIVE

The main objective of this study is to select a demarcation scheme to be used on control panels 001 through 010 prior to their shipment to the jobsite.

## 2.0 FUNCTION

The study shall result in a demarcation scheme which provides for easy identification and differentiation of panel surface-mounted devices associated with the major system, subsystem, or functional activity.

## 3.0 CRITERIA

The study shall be guided by the following criteria:

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

3.2 Demarcation is required 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.

3.3 The 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.

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

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

3.6 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.

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

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

3.9 The application of demarcation material shall not detract from the overall control room appearance.

3.10 The results of leading demarcation methods used to date in the nuclear industry shall be reviewed and factored into the decision process.

3.11 Control Panel colors shall be beige and conform to Sherwin Williams:

- BM 11-2 Base
- BM 13-4 Demarcation
- BM 13-5 Demarcation
- BM 13-7 Demarcation
- BM 13-8 Highlight

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# APPENDIX V

LABELING DESIGN GUIDE

LABELING DESIGN GUIDE

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## LIST OF TABLES



## APPENDICES



## LIST OF FIGURES

## 1.0 SUMMARY

The Control Room Design Review Labeling Guide study was prepared to establish a standard for specifying hierarchical labeling.

Hierarchical labeling described in this guide shall be used to reduce confusion, operator search time, minimize redundancy, and effectively utilize panel space. This document is intended to cover all aspects of hierarchical labeling.

Results of this study established the standard to be used for main control panel labeling. The sizes and dimensions of characters shall conform to the numbers shown in Table 1-1. High contrast, with dark characters on a light background shall be used.

TABLE 1-1

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. |

## 2.0 OBJECTIVE

To develop a control panel labeling scheme that provides personnel with logical and functional descriptive information regarding the control components mounted on it. This design guide addresses hierarchical labeling schemes to be used with the South Texas Project (STP).

## 3.0 FUNCTION

A hierarchical labeling scheme shall be used on control room (CR) panels and the Auxiliary Shutdown panel. Labels shall conform to paragraph 6.4.1.3 of the Criteria Report, Reference C. Labeling is an enhancement to assist control room personnel in quickly and accurately discriminating between and operating controls. It assures correct action and display reading. This design guide addresses labeling for the controls and displays of equipment which must be located, identified, read, or manipulated by control room personnel.

A. System labels shall be used to identify major systems or operator work stations.

B. Subsystem labels shall be used to identify functional groups.

C. Component labels shall be used to identify each discrete piece of equipment.

D. Labels shall be graduated in letter size such that system/major labels are at a minimum 25 percent larger than subsystem/subordinate labels.

# 4.0 CONTROL ROOM

## 4.1 PHYSICAL LAYOUT

Figure 4-1 is the CR layout of the STP. Table 4-1 identifies the minimum distance that each label must be read. This distance has been used to determine the label sizes.

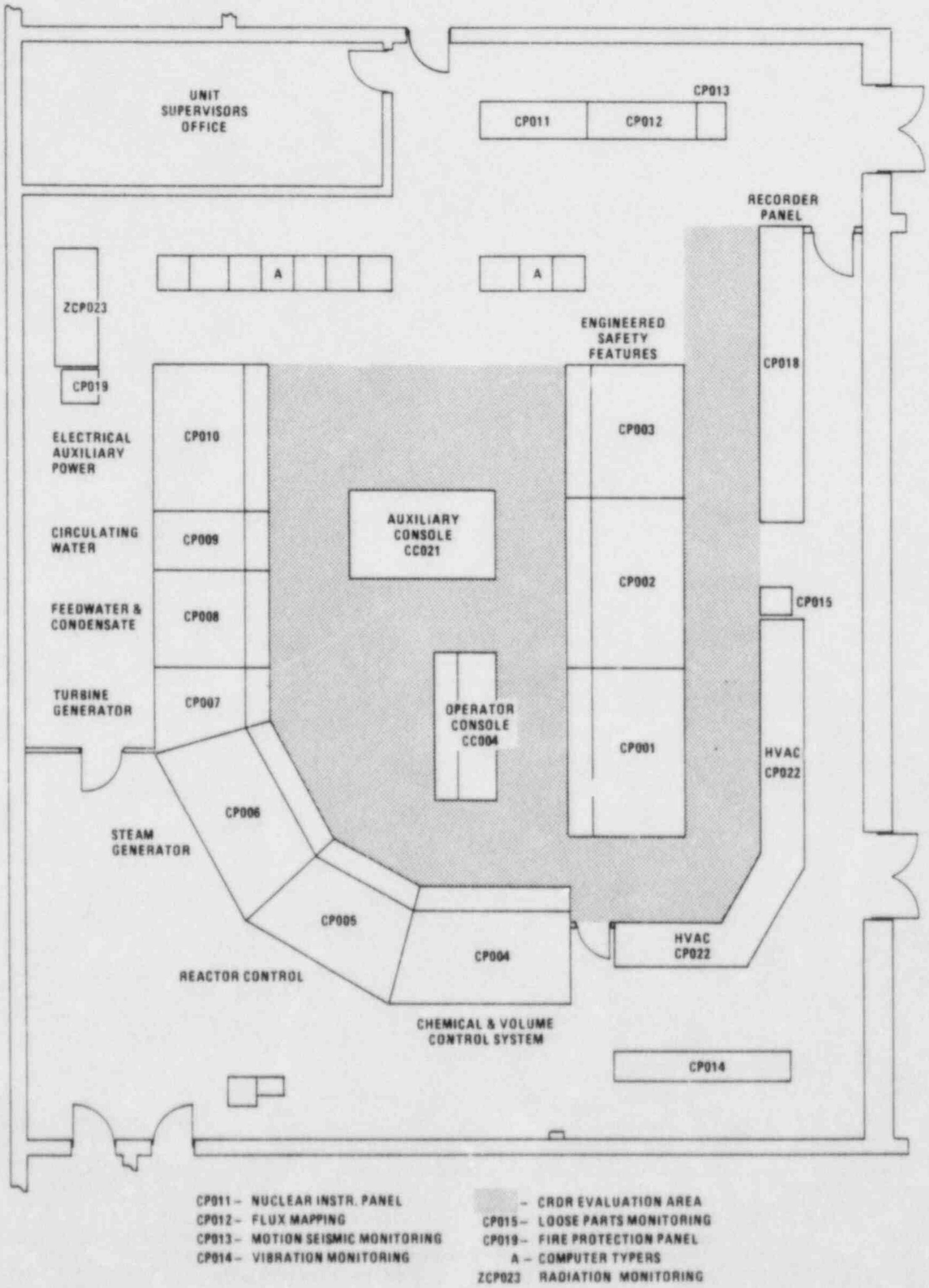
TABLE 4-1

DISTANCES FOR LABEL READING

| Position | Label | Distance Feet | Distance Inches |
|---|---|---|---|
| Operating Area Limits | Panel Identifiers | 37 | 444 |
| Within Operating Area | System Labels | 20 | 240 |
| Operator Console | Subsystem Labels | 13 | 156 |
| Panel | Component Labels | 3.5 | 42 |
| Control Action | Control Position Identifier | 1.75 | 21 |

Panel identifiers, not considered a part of hierarchical scheme, shall be readable from the CR operating area limit , a distance of up to 37 feet. Panel identifier labels shall have only one line of print and abbreviations shall not be used.* The labels shall be located and centered above the systems they identify. The panel identifiers and panel numbers are shown in Table 4-2.

*Except for commonly used abbreviations, e.g., "HVAC"




CONTROL ROOM LAYOUT
Figure 4-1

TABLE 4-2

PANEL IDENTIFIERS

| Control Panel No. | Panel Identifiers |
|---|---|
| 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 |
| CP-007 | Turbine Generator |
| CP-008 | Feedwater and Condensate |
| CP-009 | Circulating Water |
| CP-010 | Electrical Power Distribution |
| CP-018 | Recorders |
| CP-022 | HVAC* |

System Labels shall be readable within the operating areas - a distance of up to 20 feet. System labels shall have only one line of print. Abbreviations, in accordance with Appendix L of the Criteria Report, Reference C, may be used as necessary to conform with space requirements. System labeling shall be consistent within a subsystem.

Subsystem Labels shall be readable from the operator console - a distance of up to 13 feet. Subsystem labels shall have only one line of print. Abbreviations, in accordance with Appendix L of the Criteria Report, Reference C, may be used as necessary to conform with space requirements. Subsystem labeling shall be consistent within a subsystem.

*Heating, Ventilation and Air Conditioning

Component Labels shall be readable at a distance of up to 12-inches (1 foot) from the front edge of the panel. Component labels may have up to three lines of print. Abbreviations, in accordance with Appendix L of the Criteria Report, Reference C, shall be used. Component labeling shall be consistent.

Control Position Identifiers shall be readable at a distance of 21-inches. Control position labels shall use only one word to identify control position.

## 4.2 ILLUMINATION

Appendix B identifies the minimum, recommended and maximum illumination levels associated with control room work areas. The recommended illumination levels range between 30-75 footcandles and do not fall below 10 footcandles during operation.

## 4.3 READABILITY CHARACTERISTICS

Readability depends on size, contrast, character type, distance, and illumination.

A. Character size: The character size is dependent upon the viewing distance and illumination level. The viewing distances were determined from the control room layout and are described in Section 4.1, Table 4-1. The illumination requirements are described in detail in Appendix B and exceed 30 footcandles for all tasks that require label reading during normal operation.

The NUREG-0700 Guideline, Reference A, states that, "character height should subtend a visual angle of 15 minutes of arc as a minimum. A visual angle of 20 minutes is preferred." Character size, using visual angles of 15 and 20 minutes of arc, was computed for the distances of concern in this report and are included in Table C-1, Appendix C.

Figure 4-2 shows the relationship of character height size as a function of viewing distance for illumination levels above 1 foot lamberts, Reference B.

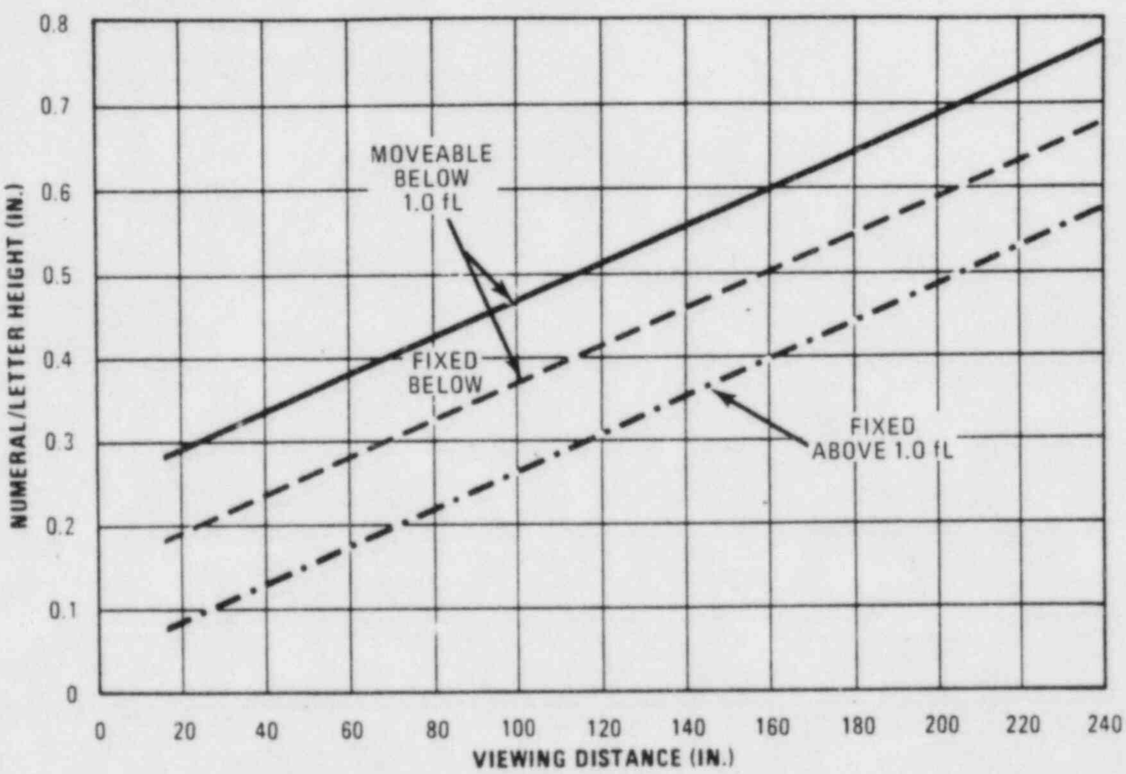
The illumination level throughout the control room will always be above 10 footcandles. Coupling the minimum illumination requirements with the graph shown in Figure 4-2, the minimum label character heights for CR viewing distances shall conform to Table 4-3. The analysis supporting this criteria is contained in Appendix C.

TABLE 4-3

LABEL CHARACTER SIZES

| Viewing Distance (inches) | DISTANCES CHARACTER HEIGHT (inches) | Label |
|---|---|---|
| 444 | 1.11 | Panel Identifier |
| 240 | < 0.60 | System Label |
| 156 | 0.38 | Subsystem Label |
| 42 | < 0.14 | Component Label |
| 21 | 0.08 | Control Position Identifier |

B. Contrast: To ensure adequate contrast and prevent loss of readability, dark characters on a light background shall be used.




Letter height versus viewing distance and illumination level (minimum space between characters, one stroke width: between words, six stroke widths). (-For instruments where the position of the numerals may vary and the illumination is between 0.03 and 1.0 fl. - For instruments where the position of the numerals is fixed and the illumination is 0.3-1.0 fl., or where position of the numerals is fixed and the illumination is above 1.0 fl.)

**CHARACTER SIZE VS VIEWING DISTANCE**
**FIGURE 4-2**

C. Legibility: To maintain legibility with character size differences, a proper stroke-width relationship must be maintained. The character dimensions and spacing shall adhere to the following criteria identified in NUREG-0700, Reference A and the Criteria Document, Reference C.

- Stroke width-to-character height ratio shall be either 1:6 or 1:8
- Letter width-to-height ratio shall be 3:5
- Numeral width-to-height ratio shall be 3:5
- Minimum space between characters shall be one stroke width
- Minimum space between words shall be the width of one character
- Minimum space between lines shall be 1/2 the character height

D. Character Type: The character type shall adhere to the following characteristics:

- Simplicity
- Consistency
- Use upper case, except for a few special abbreviations; such as, Tc and Th.

Table 4-4 is a character set that conforms to the above requirements. The type of characters closely resembles a Helvetica Medium.

| | SIZES |
|---|---|
| ABCDEFGHIJKLMN OPQRSTUVWXYZ<br>1 2 3 4 5 6 7 8 9 0<br>DISCH FLW<br>TI-0867 | Component Label 0.14 in. |
| ABCDEFGHIJKLMN<br>OPQRSTUVWXYZ<br>1234567890<br>LOOP 4 | Sub System Label 0.38 in. |

CHARACTER SET RECOMMENDED FOR LABELING
TABLE 4-4

SIZES

# ABCDEFGHIJKL

System Label 0.60 in.

# MNOPQRSTUV

# WXYZ

# 1234567890

# STEAM

# GENERATORS

# HVAC

Panel Identifier 1.1 in.

CHARACTER SET RECOMMENDED FOR LABELING
(Continued)
TABLE 4-4

## 4.4 LABEL PLACEMENT AND ORIENTATION

Labels shall be placed above the components they describe.

The following criteria shall be met for placement of labels:

A. Labels shall be placed above the items which they identify and shall not appear on the control itself.

B. Adjacent labels shall be separated by two character widths, so that they are not read as one continuous label.

C. Label location throughout a system, and within panel grouping, shall be uniform.

D. Labels shall be oriented horizontally.

## 4.5 LABEL VISIBILITY

The following criteria shall be followed for label visibility:

A. Labels shall not obscure any other information source.

B. Labels shall not detract from or obscure figures or scales which must be read by the operator, and shall not be covered or obscured by other components in the equipment assembly.

C. Labels shall be visible to the operator during control manipulation.

## 4.6 LABEL CONTENT

The primary function for labels is to describe the function of equipment items. If needed for clarity, engineering characteristics or nomenclature shall also be described. The following criteria shall be considered for the selection of words within labels:

A. Words employed shall express exactly what action is intended and they 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, Reference C.

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.

5.0 REFERENCES

A. NUREG-0700, "Guideline For Control Room Design Review", September 1981.

B. Woodson, W. E., "Human Factors Design Handbook", McGraw-Hill, 1981.

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

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APPENDIX A

LABEL SIZES

2.3.11/09123
0414W/0819P

LABEL SIZES

| Label Category | Outside Label Height (length may vary) Inches | Position Location | Recommended Lines Per Label | Distance For Readability Ft/Inches |
|---|---|---|---|---|
| Panel | 2 | Operating Area | 1 | 37/444 |
| System | 1 | Within a Operating Area | 1 | 20/240 |
| Subsystem | 0.75 | Within a System Area | 1 | 13/156 |
| Component | 0.75 | Within the System or Subsystem Area | 3 | 3.5/42 |
| Controller Position | 0.50 | Within the Control Device Outline | 1 | 1.75/21 |

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APPENDIX B

ILLUMINATION

2.3.11/09123
0414W/0819P

Adequate levels of illumination are necessary to ensure visual effectiveness. Specific task situations require different levels of illumination to perform effectively. Control Room Illumination requirements taken from Reference C, Criteria Document, are shown in Table B-1.

TABLE B-1

CONTROL ROOM ILLUMINATION REQUIREMENTS

| | Task Illuminance, footcandles | | |
|---|---|---|---|
| Work Area or Type of Task | Min. | Recomm. | Max. |
| Panels, primary operating area | 20 | 30 | 50 |
| Auxiliary panels | 20 | 30 | 50 |
| Scale indicator reading | 20 | 30 | 30 |
| Seated operator stations | 50 | 75 | 100 |
| Reading: | | | |
| o: Handwritten (pencil) | 50 | 75 | 100 |
| o: Printed or typed | 20 | 30 | 50 |
| Writing and data recording | 50 | 75 | 100 |
| Maintenance and wiring areas | 20 | 30 | 50 |
| Emergency operating lighting | 10 | NA | NA |

Illumination requirements for CR tasks do not exceed 70 footcandles and should not fall below 30 footcandles. To minimize the effects of glare on reading surfaces, proper placement of the light source, shielding, and polarization shall be considered.

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# APPENDIX C

# CHARACTER SIZE DETERMINATION

This appendix addresses an analysis of character size determination using two sources, NUREG-0700, Reference A, and Woodson, Reference B.

NUREG-0700, Reference A, shows that, "character height should subtend a visual angle of 15 minutes as a minimum, or 0.004 x viewing distance. A visual angle of 20 minutes, or 0.006 x viewing distance, is preferred".

Woodsòn, Reference B, shows the graph in Figure 4-2, Section 4.3, for character height as a function of viewing distance and illumination level above 1.0 foot lamberts.

Table C-1 was developed to compare the two methods for determining character size. It can be seen in Table C-1 that, at the 21-inch distance, the character height approximates the 15 minutes of arc. However, at other distances appropriate to this study, 42-inches and beyond, there are significant character size differences as follows:

- o At a viewing distance of 42-inches, a 15 and 20 minutes of arc computation yields 0.162 and 0.253-inches, respectively. Extrapolating for this distance from Figure 4-2 shows the size to be less than 0.14-inches.

- o At a viewing distance of 156-inches, a 15 and 20 minutes of arc computation yields 0.624 and 0.936-inches, respectively. Extrapolating for this distance from Figure 4-2 shows the size to be 0.38-inches.

- o At a viewing distance of 240-inches, a 15 and 20 minutes of arc computation yields 0.96 and 1.44-inches, respectively. Extrapolating for this distance from Figure 4-2 shows the size to be less than 0.60-inches.

These differences are acceptable for STP because of the illumination (see Table B-1) in the control room, as contrasted to the basis in NUREG-0700.

The basis for NUREG-0700, Reference A, using the 15 and 20 minutes of visual arc was derived from military research applicable to low illumination levels, below 1 foot lambert. The research supporting the graph, Figure 4-2, taken from Woodson, Reference B, is based on illumination levels above 1 foot lambert. In view of the significantly higher level of illumination required for control room personnel tasks under all illumination situations, Appendix B, the STP will utilize the character sizes extrapolated from Figure 4-2 and shown in Table 4-3. For the viewing distance beyond 240-inches, the equation recommended in Woodson, Reference B, was used.

TABLE C-1

COMPARISON OF TWO METHODS FOR DETERMINING CHARACTER HEIGHT

| Type Label | Viewing Distance (Inches) | Extrapolating From Graph (Inches) | Computation For 15 Min. of Arc (Inches) | Computation For 20 Min. of Arc (Inches) |
|---|---|---|---|---|
| System Labels | 240 | <0.60 | 0.96 | 1.44 |
| Subsystem Labels | 156 | 0.38 | 0.624 | 0.936 |
| Component Labels | 42 | <0.14 | 0.162 | 0.253 |
| Control Position Indicator | 21 | 0.08 | 0.084 | 0.126 |

Table C-2 was developed using the equation shown in Reference B for larger viewing distance; i.e.,

$$LH = \frac{VD(ft) \times 0.3 \text{ (inches)}}{10}$$ where LH = Letter Height and VD = Viewing Distance

TABLE C-2

PANEL IDENTIFIER CHARACTER HEIGHTS

| Viewing Distance (Feet) | Viewing Distance (Inches) | Character Height (Inches) |
|---|---|---|
| 37 | 444 | 1.11 |

# Control Room Design Review

## Annunciator Study Report

The South Texas Project

HOUSTON LIGHTING & POWER COMPANY