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July 14, 1980
TLL-346

Office of Nuclear Reactor Regulation
Attn: R. W. Reid, Chief
Operating Reactors Branch No. 4
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Sir:

Three Mile Island Nuclear Station Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
Control Room Human Engineering Review

Since numerous criticisms have been made of the human factors design of nuclear power plant control rooms, GPU has undertaken to perform a human engineering review of the TMI Unit 1 control room. We consider this a prudent measure even though Unit 1 has had excellent availability and relatively few operational problems.

Attachment 1 to this letter describes the major features of the control room human engineering review including the makeup of the review team. The review involves:

- Development of guidelines and objectives;
- Construction of a full scale control room mockup;
- Walk-throughs of operating procedures; and
- Detail human factors review of displays and controls, alarms, and control room environment.

The guidelines and objectives we have developed for the control room review are included as Attachment 2 to this letter. We anticipate expanding these guidelines to provide additional detail with respect to CRT's and annunciator systems as we continue our review. A full scale mockup has

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already been constructed and has been used to perform walk-throughs of representative normal and emergency operating procedures with the plant operators. Although the review is still in process, we have made substantial progress. Accordingly, we will be pleased to discuss these areas with you on July 21, 1980, as part of the opening sessions of your control room design review.

Sincerely,

J R Thorpe
for J. G. Herbein
Vice President
TMI-1

JGH:EGW:bjo
Enclosures
cc: H. Silver

Attachment 1

DESCRIPTION, CONTROL ROOM DESIGN REVIEW, TMI UNIT 1

Unit 1 at Three Mile Island has had an excellent availability record over five years of operation (1974-1979). It had relatively few operational problems during this period and very few, if any, which can be assigned, unambiguously, to human factors problems in the arrangement and design of controls and displays in the main control room. These facts notwithstanding, because of the criticisms which have been made of the human factors design aspects of nuclear power control rooms in general, GPU has undertaken a detailed engineering review of the Unit 1 control room design.

The review is being performed by a team made up of:

(i) Members of the GPU engineering staff;

(ii) TMI Unit 1 operating personnel from Metropolitan Edison;

(iii) Engineers from MPR Associates, Inc., a firm with a broad background in the design and operation of power plants;

(iv) Dr. J. M. Christensen, who is associated with SSSV, Inc. and who is an expert in human factors evaluations in the aerospace and other industries; and

(v) Dr. T. M. Sheridan, Professor of Engineering and Applied Psychology at the Massachusetts Institute of Technology.

The review includes the following elements:

1. Guidelines and objectives have been developed whereby the specifics of the control and display designs may be evaluated. The components of the TMI Unit 1 control room have a record of good reliability. Unit 1's operators have grown used to the present control room arrangement. For these reasons, judgement has to be used in applying these guidelines and objectives.

2. A full-scale control room mock-up has been constructed to allow evaluations as described in 3 and 4 below. Panel fronts have been reproduced by a combination of photographic and Xerox enlargements of a gridwork of high quality photographs. It is GPU's intent to use the mock-up for operator training, subsequent to the completion of the design review. Figures 1 and 2 are photographs of the mock-up during assembly in the Unit 1 turbine hall.

3. Key operational and emergency procedures are being walked-through, to develop a clear understanding of how, when, by whom and in what way displays, controls and means of communications in the control room are used and what changes, if any, would be desirable. Qualified Metropolitan Edison operating personnel are performing the simulated operations, with the evaluations being performed by the review team mentioned previously.

   Operating procedures being walked-through include plant heatup and startup (including operations at power), shutdown and cooldown, and refueling.

   Emergency procedures being walked-through include reactor trips from a variety of causes, turbine trips with and without reactor trips, a variety of losses of feedwater flow and other upsets in the feed system, a spectrum of losses of reactor coolant with a variety of postulated causes, and a spectrum of steam system leaks. In certain of these emergencies additional complications are superimposed such as fire, personnel injury and abnormalities with regard to the levels and locations of radioactive material.

4. Displays and controls on the principal panels and consoles are being individually reviewed separately from the walk-throughs. The object of this review is to ensure that items such as scale divisions, selections of units, legend readability, all of which might not be picked up in the walk-throughs, are evaluated.

5. A review of alarm systems is being performed to evaluate the usefulness of the information presented to the operator in both normal and off-normal situations.

6. The environmental conditions in the control room are being surveyed to evaluate whether they adequately support the operators therein. The conditions include temperature, humidity, normal and emergency lighting, noise, creature comforts, arrangement of equipment and facilities, etc.

The course of action to be followed with respect to any changes to Unit 1 control room will depend on specific findings and recommendations of the review. Preliminary findings and recommendations are expected in early July, 1980.

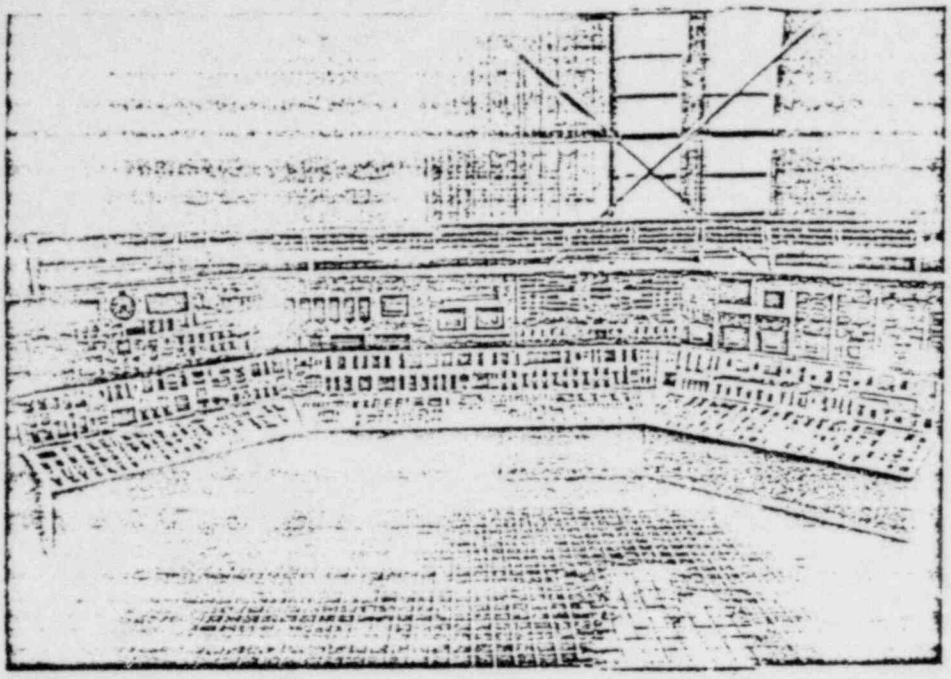

FIGURE 1

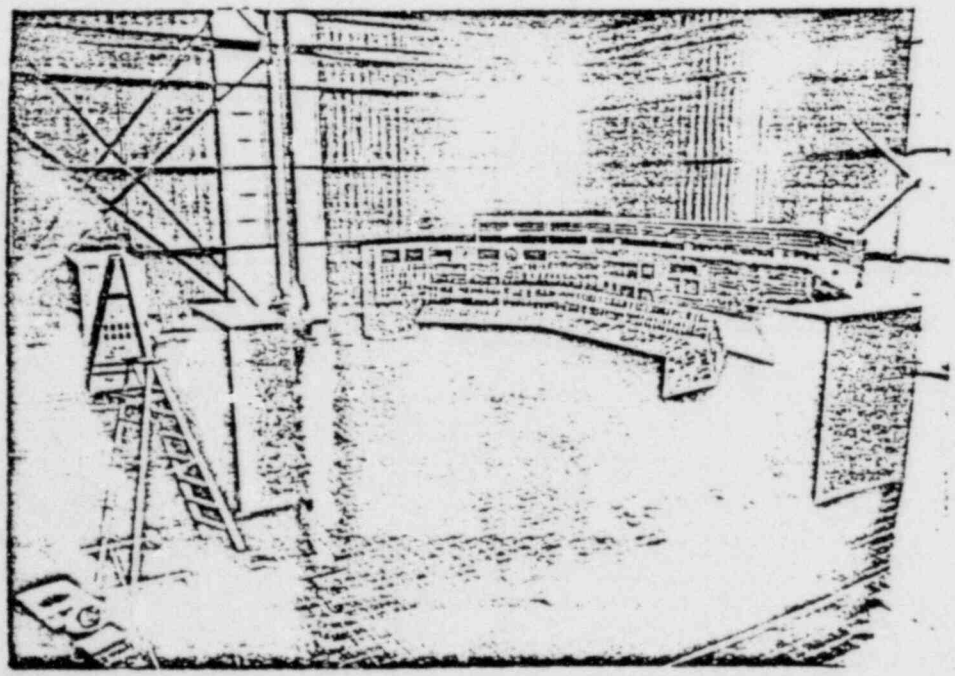

FIGURE 2

MPR ASSOCIATES, INC. April 18, 1980

TMI UNIT 1

GUIDELINES FOR CONTROL ROOM REVIEW

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TMI UNIT 1
GUIDELINES FOR CONTROL ROOM REVIEW

I. PURPOSE

The purpose of these guidelines is to provide a basis upon which to evaluate the TMI Unit 1 Control Room. They are intended to assist in the identification of those aspects of the current control room which may need improvement and to provide guidance for any modifications. Where the existing control room does not follow these guidelines, it does not necessarily imply that a hardware change must be made. Judgment on a case-by-case basis must be used. The potentially negative training aspects of changing an existing configuration, the seriousness of the potential problems, and the practicality of hardware changes must all be weighed in determining what should done when an existing control room feature fails to meet one of these guidelines. Some hardware changes may be desirable and practical; however, in many instances the most practical way to meet the concern that the guideline addresses may well be through the use of new procedures and training which would be specifically directed at compensating for the existing configuration.

It is to be expected that future system design considerations, as well as operational considerations, will generate changes to the control room over and above those

resulting from the control room review. It is intended that these guidelines would be applied to such changes to ensure that they are compatible with the overall control room design.

II. OPERATIONAL GUIDELINES

A. Functions Performed in Control Room

The control room operators who man the main console should be provided with appropriate controls and displays to perform a set of defined functions. Controls and displays, including annunciators, which are not needed to perform those defined functions tend to divert the control room operators' attention and should not normally be provided to them. It should be an objective to move out or keep out of the control room itself those personnel, controls, and displays which are not related directly to the defined functions. In any case, those other functions which may be done in the control room should be arranged so that they can be done by personnel other than those manning the main console and panels without causing interference or distractions.

The functions of the control room operators manning the main console are defined to be the following:

1. Maintain control of the reactivity of the reactor core.

2. Maintain control of the energy production by the reactor, its transfer in the reactor coolant system, its transfer in the steam generators to the steam system, its transfer in the steam and feed systems, the conversion of some of it to electricity in the turbine generator, and the rejection of the remainder through the condenser and circulating water system.

3. Maintain an adequate inventory of thermodynamically and chemically suitable water in the primary (reactor coolant) system.

4. Maintain an adequate inventory of thermodynamically and chemically suitable water in the secondary (steam) system.

5. Distribute electrical power and other necessary services (such as air and cooling water) to the plant auxiliaries and control the production and the distribution of emergency electric power.

6. Maintain control of radioactive material which may be contained in any of the systems under the control room operators' control. This includes the responsibility to maintain the leaktight integrity of the reactor building.

7. Maintain control of the inventory and location of fissionable material during refueling. (Fuel storage pool activities while the reactor is operating should not be the control operators' responsibility.)

8. Maintain control of and complete entries in the operators' logs, procedures, and checklists.

9. Maintain administrative control of the maintenance, repair, testing, calibration, etc. in those systems under their control.

10. Initiate those fire fighting actions which are controlled from the control room, e.g., activating deluge valves, starting pumps, obtaining help in fire fighting. In addition, the operators are responsible to initiate those actions in the systems under their control which may be needed to compensate for fire damage.

The following are examples of items which should not be the responsibility of the control room operators' manning the main console or panels:

1. Security or access control except access which may affect the leaktight integrity of the reactor building.

2. Communications not directly related to their responsibilities, e.g., routine plant telephone calls, except in rapidly developing emergencies where no other personnel may be available.

3. Routine operation of the liquid waste disposal system.

4. Routine chemical control in support systems.

5. Control of fissionable material external to the reactor when the reactor is operating.

B. Items Provided to Operators in the Control Room

Those controls and displays presented directly to the control room operators manning the main console and panels, i.e., those directly visible to them when they are at their normal stations, should be limited to those for which a clearly defined need can be established. Additional guidelines which may be applicable to the location of controls and displays in the control room are:

1. A control or display may have to be located in the control room if its location elsewhere would not permit its use in a timely manner.

2. A control may have to be located in the control room if the only location for the displays needed to operate the control is also in the control room.

3. A control or display used only for test purposes or only for certain planned plant evolutions may have to be located in the control room if it involves the use of other controls or displays which are located only in the control room.

Note that these guidelines may not require the controls and displays be located so that they are presented directly to the operators stationed at the console.

C. Availability of Personnel

The control room arrangement shall be such that any anticipated off-normal operational evolution can be effectively carried out in the short term with the personnel complement present for the normal evolution then underway. Specifically, the response to off-normal conditions may not assume that any more personnel are available for the first 10 minutes than would normally be present in the control room when the initiating event occurs. After this time other on-site personnel can be assumed to be available if they have no other duties in the event. After 2 hours off-site personnel who are on call can be assumed to be available.

D. Arrangement Priority

The control room and panel arrangements should provide, in a convenient manner, those controls and displays

which are needed for normal planned plant evolutions and steady state operation (plant startup and planned shutdown, steady state power, hot standby, and refueling); however, higher priority for arrangement should be given to the controls and displays which are involved with the operators carrying out their assigned responsibilities under those off-normal conditions which are both highly likely and which require timely action. Those events include:

1. Reactor and turbine trip;

2. Partial or complete loss of feedwater;

3. Loss of coolant accidents, particularly those from valve opening or major seal failures;

4. Partial or complete loss of control or instrumentation power or air; and

5. Overcooling accidents, particularly those from steam system valves stuck open or excessive feed.

E. Key Process Variables

In addition to the displays provided specifically to achieve redundancy of some information provided to the operators, it should be an objective to provide the operators with the means necessary to qualitatively confirm the reasonableness of the information they are

presented on certain key process variables. These means should preferably be diverse from the normally used displays.

These key process variables fall into three general categories: reactor reactivity balance, reactor coolant conditions, and steam system conditions. They include such specific items as:

1. Reactor Reactivity

   - When critical, the operators should have the process variables necessary to assess whether the reactivity contributions of the following are in the expected relationship: rod position, boron concentration, power level, coolant temperature, and prior operating history.

   - When subcritical, the operators should have the process variables necessary to assess the shutdown margin of the reactor and whether the following are in the expected relationship: rod position, boron concentration, coolant temperature, prior operating history, and neutron level.

2. Reactor Coolant Conditions

   - Inventory of reactor coolant (pressurizer level)

   - Thermodynamic state of coolant (temperature and pressure)

   - Coolant flow rate

   - Radioactivity in coolant

3. Steam System Conditions

   - Inventory of secondary coolant (hotwell, steam generator, heater shell, and drain tank levels)

   - Steam pressure

   - Feedwater flow

   - Radioactivity in steam

III. HUMAN ENGINEERING GUIDELINES

The guidelines for the human engineering review of the TMI Unit 1 Control Room will be those contained in MIL-STD-1472B, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, where they are applicable. Since the military standard is directed toward military applications and covers types of equipment which are not in the control room, some parts of it are inappropriate. The guidelines listed below are intended to identify those which are particularly important to the control room review and to amplify or clarify them for direct application to the control room review. It is recognized that in the course of the review, situations may be encountered which are not adequately addressed by MIL-STD-1472B and the guidelines included below. In such cases other human engineering references may be consulted, for example:

- Van Cott, H.P. and Kinkade, R. G., Human Engineering Guide to Equipment Design, Government Printing Office, 1972
- Woodson, Wesley E. and Conover, Donald W., Human Engineering Guide for Equipment Design, University of California Press, 1964

A. General Guidelines

1. The controls and displays should have compatible locations, that is:

   - Where timely operator action may be needed, the sources of information from which the operator concludes that he needs to take action, and that action is permissible, should be located close to where the control action is taken.

   - When a control action is taken, the operator who takes the action should have immediate feedback that the controlled element has responded and, if practical, that the plant or system itself has responded. This usually involves the location of the related displays close to where the control action is taken.

2. Consistent and unambiguous methods should be provided to inform the operators of the operational status, e.g., open or closed valve position, and of the conditions, e.g., temperatures or flow, in those systems under their control. Likewise, status and conditions in other systems in the plant which could affect the action the operators may take should be provided in a consistent and unambiguous manner.

3. Where a control or display is intended to provide information to the operators as to whether conditions are "off-normal," this should be done in a consistent and unambiguous manner. This should include consideration of what conditions are to

be defined as "normal" in a particular system as well as avoiding confusion between indicating status (see item A.3, above) and indicating "normal" or "off-normal."

4. There should be some means for the operator to know that a control or display is not functioning properly. It is particularly important to know when a display or control has lost power. The most desirable situation would be to have the malfunction evident to the operators without any action on their part, e.g., by having a unique "power lost position" for a meter. This may be impractical. If so, other ways to make the operator aware of failures may have to be used, such as:

   - Providing means for periodic testing of a control or display,
   - Providing the operator with immediate feedback (see A.1. above), or
   - Providing redundant or diverse displays which allow cross checking.

   For some critical items it may be appropriate to utilize several ways to make the operators aware of malfunctions and to provide them with special training and guidance in the procedures.

5. Communication of a control room operator with an auxiliary operator outside the control room shall be

considered the same as operating a control or reading a display. These communications should not require the use of communication links which may involve interference or may be unavailable because of other activities. The communications should consider the potential for unusual environmental conditions: noise, respirators, etc. Voice communications should be carried out in a formal and consistent manner which identifies the initiator and receiver of the message and provides for repetition and confirmation of each transmission.

6. Tag-out of a control or display should:

   - Be unambiguous as to which control or display is tagged
   - Not obscure the identification of the control or display which is tagged, and
   - Not obscure any other controls or displays or interfere with operations.

7. For any changes to the console and panels, replacement and servicing should be considered. In that case such guidelines on maintainability as the following should be applied:

   - Replacement and servicing should not require the removal of other items on the panel.

- Replacement or servicing of an item should not involve operations which preclude proper operator response to a plausible off-normal event. This includes putting an excessive number of other items out of service in order to perform the maintenance.
- Replacement should involve a minimum risk of improper reconnection.
- Replacement or servicing should involve a minimum risk to personnel.
- Replacement or servicing should involve a minimum risk of inadvertent actuation of other controls.

If some specific problems with maintenance have been experienced in the TMI-1 control room, these should be considered in the control room review.

8. The capabilities required of the operators to perform the assigned functions should be reasonable in terms of work load, span of mental concentration, physical endurance, amount of memorization, and time available to perform a function. The assigned functions should be consistent with the physical capabilities required of the operators.

9. Changes to existing arrangements should be sufficiently distinct that when an operator uses the new control or display it is unlikely that previous training and habits will cause errors. Consideration should be given to using completely different types of controls in such applications, for example, using push buttons in place of a rotary switch rather than changing the direction of rotation of the rotary switch.

B. Guidelines for Controls

1. Location

a. The most often used controls should be given priority in location, except where this would conflict with the use of controls or displays for off-normal conditions.

b. Controls for off-normal conditions should be placed in a readily accessible location but clearly distinguished from controls used for normal conditions.

c. The progression of controls, numerically or alphabetically, should be consistent throughout the panel. It is preferred that they progress left-to-right and top-to-bottom.

d. All controls for multiple elements should have the same arrangement, that is, either horizontal or vertical.

e. If controls are operated in sequence, they should be located in a consistent left-to-right or top-to-bottom progression.

f. Where multiple controls affect the same element, e.g., valve control push buttons, their relationship should be consistent and readily apparent to the operator without detail comparison of the legends.

g. Mirror image groups of controls should not be used.

2. Operation

a. The control should be capable of operation without special aids for the operator, e.g., a stool, screw driver, or special tools, except where required to prevent inadvertent actuation.

b. The forces and motions required to actuate the control must be within the capabilities of all the plant operators.

c. The direction of operation should follow a consistent set of conventions, for example:

- Rotary valve controls should rotate clockwise to close the valve.
- Pushbutton valve operators should have the "open" button on top, if vertically arranged; if horizontally arranged, the "open" button should be on the right.
- Rotary controls for circuit breakers and electrical motors, (except valve operators) should rotate clockwise to turn the item "on," i.e., close a breaker or start a motor.
- The "Auto" position of a rotary control should be a consistent direction of rotation.
- "On" or "start" pushbuttons should be above the "stop" pushbuttons.
- Rotary controllers should rotate clockwise to increase the controlled quantity.

d. The direction of motion of the controller should be consistent with the direction of motion of the display which responds to the control.

e. Key operated controls should follow a standard set of conventions, e.g., detents oriented upward and slot vertical is the condition with the key removed.

3. <u>Protection</u>

a. Adequate distance between controls and between groups of controls to allow the operator to easily recognize the controls and to avoid inadvertent actuation should be provided.

b. Controls which may be confused and which have serious consequences if actuated, should be protected or special steps taken to highlight or distinguish them. This may include such means as covers, separate handles, the use of two hands to operate, or key operated controls.

c. Controls which may be inadvertently actuated by clothing, cleaning operations, etc. should be relocated or protected.

4. Identification

a. Each control should be positively identified with both a descriptive name and a particular identifying number for the controlled element.

b. Nomenclature should be consistent with that used in the procedures and system diagrams and that on related displays.

c. Legend plates should be located over the control to which they apply. If this cannot be done, some special visual clue of the unusual relation should be provided to the operator.

d. Where special precautions apply to the operation of a control this should be clearly stated and it should be clear to what control(s) they apply.

e. Legend plates on controls should meet consistent standards of letter size.

f. Legend plates on controls should meet consistent standards of durability. Temporary label plates should not be used.

g. The color of legend plates should conform to a consistent code, for example:

- Identification labels should be black letters on a white background.
- Precaution labels should be red with white letters.
- Information of a reference nature for the assistance of the operator should be white letters on a black background.

5. Maintenance

a. All light bulbs should be commonly stocked types and should be replaceable from the front of the panel without special tools and without risk of inadvertent actuation of the control.

C. Guidelines for Displays

1. Location

a. The display should be located properly with respect to its related controls. (See Criteria II.A.1.)

b. The orientation of multiple displays should be consistent with normal conventions for progression of numerical or alphabetical quantities, i.e., top-to-bottom or right-to-left.

c. The orientation (horizontal or vertical) of an array of displays should be consistent with the orientation of related controls.

d. The operation of the control related to a display should not obscure the display.

2. Scales

a. The graduations on a scale should be consistent with the resolution required by the operator.

b. The scale range should be adequate for all normal and off-normal conditions under which the display is required.

c. The major scale divisions should be a usual numerical progression. Scale multipliers should be avoided, but where used should be in a consistent location and easily read. Only multiples of 10 should be used.

d. The units of the scales should be consistent between rate and integral displays for related items. For example, all the flows into or out of a tank should be provided in consistent units of volume and time and the tank contents should be displayed in units which are consistent with the units of the flows.

e. Where multiple displays are provided of the same parameter, e.g., wide and narrow ranges, these instruments should have consistent scale units and consistent zero points. For example, steam generator start-up, operating and wide-range level instruments could all be referenced from the top of the lower tube sheet as "zero."

f. The arrangement and scale design of multiple displays should involve a minimum risk of confusing the readings, e.g., erroneously matching the pointer on one instrument with the scale on another.

3. Identification

a. Each display should be identified with both a descriptive name and, where applicable, an identifying number which relates the indication unambiguously to a particular instrument or sensor.

b. The nomenclature should be consistent with that used in the procedures and system diagrams and that on related controls.

c. Legend plates should normally be located over the display to which they apply. If this cannot be done, some special visual clue of the unusual relation should be provided to the operator.

d. If the limits or set points of the displayed variable are needed by the operator when the display is used, then they should be presented in a clear and unambiguous manner. It is particularly important that memorization of numbers by the operators be minimized. The method of identifying set points and limits should be consistent among the displays.

e. Legend plates on displays should meet consistent standards of letter size. Note that if the display is intended to be read from a distance longer than normal, the size of lettering may need to be increased above that normally provided.

f. Temporary label plates should not be used.

g. The color of the legend plates used on displays should follow the same general rules as for controls (see B.4.g).

h. Where colors are used as an integral part of the information displayed, a consistent coding should be used. Color codes may include:

- Red to show that a component, usually a motor, or breaker is "on" or energized.
- Green to show that a component, usually a motor or breaker, is "off" or de-energized.
- A yellow display to indicate that a system is in a transitional condition or that a "bypassed" condition exists.
- A white display to indicate a status condition.

4. Maintenance

   a. Replacement of bulbs should take place from the front of the panels and all light bulbs should be commonly stocked types. Special tools should not be required.

   b. The risk that a display will be reassembled in such a manner that it gives erroneous information, for example, by switching lighted windows, should be minimized.

5. Recorders

   a. A recorder should meet the same requirements for visibility, scales, units, etc. as any other display.

   b. Where multipoint or multi-pen recorders are used, the recorded data should be unambiguous.

   c. When different inputs can be selected for the same recorder, switching transients should not be such that they can be mistaken for signal changes.

   d. When different inputs can be selected for presentation there should be some positive way to determine what specific input the trace represents.

f. The amount of the recorded trace which is visible should be adequately long to cover the time span of interest to the operators. Reference to portions of the trace which are not visible should not involve blocking other critical displays or controls or risking inadvertent actuation of controls.

g. The recorder should provide for a tolerance on the timing for changing paper or ink of at least two hours. That is, chart paper and ink should be replenished when there is at least two hours of recording left. This is to insure that if an emergency evolution takes place there will be at least a two hour capability to follow it without servicing the recorder.

h. It is preferable for charts to have time as the horizontal coordinate increasing to the right.

i. Changing chart paper or ink should require a minimum of time and should not block other critical controls or displays.

6. CRT Displays

a. A CRT display should not be used to simply repeat information already available to the operator from other console or panel displays.

b. The loss of any CRT display or other single failure in the associated hardware (power supplies, computer, keyboards, etc.) should not preclude the performance of an emergency procedure.

c. Information orientation and zones, titles, label locations and parameter locations should be standardized. Standard sets of characters, symbols, and abbreviations should be used.

d. Color assignments should be consistent from display-to-display and should be consistent with color conventions used on the console and panels.

e. Mimic displays should be oriented from left-to-right or top-to-bottom unless this conflicts with existing panel mimics or the arrangements of items on the panels. Procedure steps or decision "trees" should be oriented from top-to-bottom. Time should be displayed from left-to-right.

f. Each display should have a descriptive title. This title should be in a consistent location and have a consistent color and format.

g. Display characters should be selected from a standard set (such as ASCII). The height should be 0.20 to 0.25 inch. The height to width ratio should be 1:1 to 3:2. The stroke width should be one-sixth of the character width. Capital letters should be used.

h. The display loading (text and graphical content) should be limited to about 25 percent, excluding the title and any alarm notes.

i. The refresh rate of the displays should be 60 Hz or more.

D. Overall Control Room Environment

The overall control room environment should be suitable for the operators to carry out their required functions. This includes consideration of the following:

1. Adequate temperature and humidity control should be provided.

2. Adequate ventilation should be provided.

3. Adequate lighting should be provided for both normal and emergency conditions. In an emergency, lighting should be provided even in the event of temporary failure of the diesel generators to start.

4. The noise level should be adequately low. There should not be conditions in the plant operation which result in large changes in noise level.

5. There should be adequate provision for the control of traffic in the control room and accommodating visitors or observers without adversely affecting operations.

6. There should be adequate provision for the storage of personal items.

7. There should be adequate workspace for the operators to use reference material and to support any on-the job training.

8. There should be adequate provisions for storage and use of the following without blocking access to any controls or displays:

   a. Procedures
   b. Manuals
   c. Diagram snd Drawings
   d. Logs
   e. Personnel Rosters
   f. Other Files

9. There should be direct and defined access to the supervisor's office.

10. There should be adequate rest room and kitchen facilities.

11. There should be adequate and defined access for maintenance of the control room equipment including availability of technicians, tools, and spares.

12. There should be adequate access from the control room to the remainder of the plant.

13. The control room and its associated spaces should contain adequate provisions for communications. This includes particular consideration of:

    - Means for paging in the rest rooms, kitchen and any other associated spaces should be provided.
    - Communication facilities should be provided for the shift supervisor, shift foreman, and other personnel in the control room so that they do not interfere with or confuse the communication links used by the operators on the main console and panels.

15. The control room should be free of personnel hazards such as: Items which could trip the operators, sources of electric shocks, etc.

16. There should be adequate safeguards on the systems which control temperature and ventilation so that, in case of failures in these systems, proper working conditions can be re-established before they deteriorate excessively.