

EVALUATION AND
CRITIQUE OF
NUREG/CR - 1580

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INTRODUCTION

The following report represents a summary of technical problem areas identified in NUREG/CR-1580, Human Engineering Guide to Control Room Evaluation. These areas were identified following a detailed review of the technical content of the document.

The majority of the problem areas identified fell into five distinct problem areas during the review process. These were problems related to:

1. Lack of criteria validation of NUREG/CR-1580 Guidelines to the control room environment.
2. Errors of Omission.
3. Errors of Technical Content.
4. Ambiguity in Rationale, Guidelines, Procedures and Intent.
5. Contradictions Among Criteria.

The following comments have been presented as five sections corresponding to the five general problem areas.

Several methods were used to examine and critique NUREG/CR-1580. The document was compared to a number of existing human factors engineering references and evaluated for corresponding accuracy. Errors of omission and problems with ambiguity were identified. Finally, problem areas were identified where the relation of the NUREG/CR-1580 criteria to the circumstances of the nuclear power plant control room was in question, and additionally, where contradictions with other criterion were found.

The comments contained in this report have been presented in four sections per each issue of concern. The general issue of concern is stated, followed by the location of the issue within NUREG/CR-1580. A remark regarding the concern is then provided, followed by a recommended change.

PREFACE

During the review of NUREG/CR-1580 two general problem areas seemed to evolve: the lack of criteria validation of the guidelines to the control room environment and the lack of distinction between safety-related and non-safety-related functions or operator tasks.

Several of the problems identified in NUREG/CR-1580 were classified into these areas. However, due to the acute impact of these two problem areas on the validity of the guidelines a special remark is pertinent at this time.

It should be noted that within the field of Human Factors Engineering, the primary value of systems evaluation rests on the successful definition of criteria. This criteria problem is familiar with all human factors engineers who have used design guidelines or checklists as predictors of system performance or effectiveness.

Prior to a determination of system effectiveness, a pre-determined standard of proper design or performance must be established. The lack of both a theoretical and empirical bases for establishing a standard threatens the validity of the resultant measure of design or performance effectiveness. NUREG/CR-1580 suffers from the symptoms of lack of performance criteria and, therefore, a lack of criteria validation. Until these two major shortcomings are corrected, the value of the guidelines remains questionable.

SECTION 1

LACK OF CRITERIA
VALIDATION IN THE
CONTROL ROOM

CONCERN: Validation that guidelines are applicable to Control Room.

LOCATION: Volume I, page xi, last paragraph

COMMENT: This paragraph implies that the guidelines and evaluation procedures were validated on nuclear power plants. However, the techniques employed to validate the guidelines are not presented in the document. Guidelines used by human factors engineers for making design decisions are usually validated using human performance data acquired from prototype systems or, whenever possible, within an operational environment. This paragraph implies that the guidelines are founded on such data and contradicts the statement in Volume I, page 2, paragraph 1 which implies that the guidelines are valid since they are used in military and aerospace applications.

RECOMMENDATION: Remove validation statement or reference control room data showing validation of guidelines.

CONCERN: Applicability of Human Factors Engineering guidelines to modification of the Control Room.

LOCATION: Volume I, page 2, paragraph 1

COMMENT: This paragraph states that the guidelines are established, however, the guidelines were established within military and aerospace engineering design constraints. The establishment of these guidelines within the community does not indicate that they are valid within the operation and design constraints of the nuclear power plant control room. In addition, the application of these guidelines to existing control rooms requiring modifications appear inappropriate when the original design criteria were adequate but not optimum.

RECOMMENDATION: Design issues within the power plant control room which have been linked to documented human errors should be cited and emphasized as a guidance tool for human factors engineers working in the control room.

CONCERN: Applicability of Human Factors Engineering guidelines to the Control Room

LOCATION: Volume I, page 2, paragraph 2

COMMENT: Previous statements regarding the guidelines suggests that they have been validated in the control room. This paragraph states that no human factors standard has been developed specifically for the nuclear power plant control room. However, the paragraph states, further, that these guidelines "appeared" to be valid "in most cases." Where are these guidelines valid or not valid?

RECOMMENDATION: Delete any guideline that is not valid for nuclear power plants.

CONCERN: HED Priority Determination

LOCATION: Volume I, Appendix IX-1

COMMENT: The technique presented which establishes a priority of human error deficiency suggests that it has been used successfully within the nuclear power plant control room environment. However, human factors engineering empirical data supporting the validation, in the control room, of HED Priority Determination has not been referenced or provided.

RECOMMENDATION: Provide the results of previous applications of the HED determination technique to the nuclear power plant control room.

CONCERN: Illumination Levels

LOCATION: Volume I, CRE - 10

COMMENT: An ambient illumination range between 30 and 50 foot candles is recommended. This range corresponds to the proper lighting level conducive to effective visual task performance. However, within a nuclear power plant control room the use of 30 - 50 foot candles illumination threatens the effectiveness of a "Green Board" indication control board. Valid criteria for lighting levels under these circumstances must be developed prior to specifying lighting levels.

RECOMMENDATION: Determine illumination levels needed for "Green Board" concept or modify criteria to allow trade offs of ambient illumination with contrast.

CONCERN: Console Dimensions for the Standing Operator

LOCATION: Volume II, WA - 24, 25

COMMENT: 1. As presented, these guidelines will have a significant impact on the modification requirements of the majority of control room boards. The human factors criteria employed to develop this guideline is based upon a particular frequency of control board use and criticalness of operation. Before this guideline is applied to the nuclear power plant control room, cross validation of criteria should first be established.

2. The dimensions presented in the figure were established under conditions where the operator was required to perform certain functions, at a certain rate. The applicability of this diagram to the control board and its operator can only be established once the similarity and frequency of operator functions is demonstrated.

RECOMMENDATION: Review diagram and provide rationale supporting the dimensions or modify appropriately. Validation of dimensioned criteria should first be established before this guideline is applied to the nuclear power plant control room.

CONCERN: Console Dimensions for the Seated Operator

LOCATION: Volume II, WA - 26, 27

COMMENT: The task responsibilities of a control room operator, while sitting, should be well-defined prior to establishing console design constraints. (Refer to comments under "Console Dimensions for the Standing Operator").

RECOMMENDATION: Define the type of seated operator's task relevant to the criteria.

CONCERN: Placement (of visual displays)

LOCATION: Volume II, VD - 18

COMMENT: 1. Importance. Degree of importance as it relates to a safety related criterion should be better defined. Which displays are not important or critical?

2. Consistency. The impact of minor arrangement of controls and/or displays should be assessed prior to the establishment of a consistency guideline.

RECOMMENDATION: These guidelines were based on a criteria of display placement established for the control room. Clarify where these guidelines (on the control board) are valid.

CONCERN: Representational Displays

LOCATION: Volume II, VD - 14, #1

COMMENT: The use of bars or lines to depict trends in graphic displays is task specific. There is no human factors engineering data supporting the use of this guideline for all display information-processing requirements.

This guideline employs the term "read better." Human factors engineering studies attempt to be more refined in describing human performance variables. "Better" has no meaning within the field of human factors engineering.

RECOMMENDATION: Clarify the guideline and provide a clearer definition of expected increase in performance as a function of display design.

CONCERN: Location and Arrangement

LOCATION: Volume II, VD-22,23

COMMENT: The following three areas regarding visual displays require greater clarification in terms of control room applicability:

1. Accuracy - normal operating position must be better defined in terms of sitting, standing, distance and location.
2. Reflection - a technique of assessing system performance degradation should be developed and specified.
3. Maximum Viewing Distance - A realistic maximum/minimum viewing distance is not specified.

RECOMMENDATION: These guidelines were based on a criteria of display location and arrangement established for the control room. Clarify where these guidelines (on the control board) are valid.

CONCERN: Assessment of Mechanical Instruments

LOCATION: Volume II, VD - 67, #3

COMMENT: Placement of Pointers. What is the rationale supporting the placement of pointers to the right of vertical scales? Some control rooms have pointers to the right of the scale and other control rooms have pointers to the left. To date, readability experiments conducted in control rooms with either type of pointer have revealed no significant difference in operator readability.

RECOMMENDATION: Eliminate criteria from guideline.

CONCERN: Dial Marking

LOCATION: Volume II, VD - 75

COMMENT: The advantages of multiple color coding for use in control room indicators is questionable. No known human factors engineering empirical data exists which demonstrates the advantages of multiple color band coding on indicators for check-reading. The criteria cited were developed for aircraft cockpit applications, where accurate operational status must be ascertained under severe time constraints.

RECOMMENDATION: Obtain data to support criteria or eliminate criteria from guideline.

CONCERN: Dial Marking

LOCATION: Volume II, VD-74,75

COMMENT: The placement of zone markings on the indicator window creates severe parallex problems when viewed at moderate angles of the line of sight. Such markings are important aids to operator control board scanning and system status determination. The probability of erroneous judgements due to indicator location errors are increased when zone markings are placed on the indicator window. However, the effectiveness of this approach must be ascertained within the control room prior to its establishment as a guideline.

RECOMMENDATION: Provide data or guidelines regarding where the use of dial markings are valid or delete from guidelines.

CONCERN: Reflectance

LOCATION: Volume II, CRE - 6

COMMENT: 1. General recommendation for ceiling reflectance is between 60 and 95% (VanCott and Kinkade, 1972), rather than the 80 to 90% specified.

2. General recommendation for wall reflectance is between 40 and 60% (VanCott and Kinkade, 1972), rather than the 50 ro 15-20% specified.

3. Appropriate reflectance values depends, to a great extend, on room size and task conditions. Data supporting the validity of the values listed in CRE-6 are not available from the open literature.

RECOMMENDATION: Review the validity of this guideline in reference to control rooms and correct guideline.

CONCERN: Shelf Dimensions

LOCATION: Volume II, WA-8

COMMENT: The rationale and reference cited for "Under no circumstances" is not obvious from the original technical source referenced (Woodson and Conover, 1964).

RECOMMENDATION: The validity of this restriction is under question. Provide the reasoning for this guideline or modify appropriately.

CONCERN: Standard Console Dimensions

LOCATION: Volume II, WA-23

COMMENT: The following footnote from the original reference has been omitted from this section:

"Design values for each console established to accomodate 95 plus percent of USAF population."

RECOMMENDATION: This footnote reflects, to a certain degree, the validity of the data appearing in the table. Review the norm population used, compare to the norm of control room operators and modify the guideline appropriately.

CONCERN: Reactor Control Panel Colored Pink

LOCATION: Volume I, page 29, Section 3.3.3

COMMENT: Given the size of control board system panels, there is absolutely no human factors engineering rationale for painting the reactor control board pink. There is a point at which the human factors engineer must rely on training and its interaction with design.

RECOMMENDATION: Remove the design convention of a pink reactor control board.

CONCERN:

LOCATION:

COMMENT:

RECOMMENDATION:

SECTION 2

ERRORS OF
OMISSION

CONCERN: Taxonomy of Human Errors

LOCATION: Volume I, page 5, paragraph 1

COMMENT: The taxonomy of errors presented suggests that the errors are independent of each other. Interactions play a significant role during the performance evaluation of systems. Human factors engineering studies have shown that interactions of various performance variables are significant contributors to human errors (i.e., control/display errors).

RECOMMENDATION: Include a list of interactions as contributory to human error.

CONCERN: Safety Related Priorities not recognized.

LOCATION: Volume I, page 2, Phase I and Volume I, page 6, paragraph 2.1.1.

COMMENT: The primary concern of safety-related priority is not obvious in Phase I or the planning process.

One of the major tasks of the evaluation team is to develop criteria regarding safety and non-safety related operator functions or plant systems.

RECOMMENDATION: Phase I on page 2 should include a statement to define scope of evaluation. Paragraph 2.1.1 - objectives should recognize scope, e.g., the objective is to improve the operator's capability of accessing abnormal conditions of safety related equipment and taking corrective action under normal and stress conditions.

CONCERN: Task Analysis

LOCATION: Volume I, page 18, paragraph 2.5.6.2

COMMENT: The recommended source of data to be used for task analyses considers only experienced control room operators. One of the objectives of task analyses is to improve the design and operation of systems.

A number of human factors engineering studies have shown that data from inexperienced users can be an extremely valuable source of information regarding design and operation problems.

RECOMMENDATION: Add the requirement for interviewing inexperienced operators and define the meaning of experienced and inexperienced.

CONCERN: Task Analysis

LOCATION: Volume I, page 18, paragraph 2.5.6.2

COMMENT: Task Analyses should concentrate on emergency and abnormal operating procedures.

RECOMMENDATION: First sentence should read: "Task analysis will be conducted on emergency and abnormal operating procedures."

CONCERN: Generic Human Factors Engineering Issues

LOCATION: Volume I, page 22, paragraph 3.1

COMMENT: It is implied that Appendix II contains generic problems throughout the industry at all plants. This is questionable. The evaluation team should be checking the areas in the Appendix to verify that they do not cause human error problems.

RECOMMENDATION: Remove terms common and generic from paragraph 3.1 and remove generic from the title of Appendix II.

CONCERN: Noise Survey

LOCATION: Volume I, page 24, paragraph 3.3.1.3a

COMMENT: Noise measurements within the control room are dependent, to a great extent, upon plant operating status. The recognition of plant status must be considered.

RECOMMENDATION: The objective of the survey is to measure the ambient noise level under normal control room conditions.

CONCERN: References

LOCATION: Volume II, page 6 & 7

COMMENT: A number of references cited in Volume II have not been included under "references." These include references to Lutz, Conrad, Conrad and Hill, Heglin, LAMPS, and MIL-STD-1471 Essex Revision, MIL-STD-1472C (1980), Paul, et al.

RECOMMENDATION: Include appropriate references.

CONCERN: Noise Survey

LOCATION: Volume I, page 24, paragraph 3.1.1

COMMENT: The following areas should be clarified prior to acquiring or evaluating noise survey data:

1. A clearer definition of indirect noise must be provided (bandwidth, time of day, average reading, 1/3 or 1/10 octave).
2. Operator position needs to be defined.
3. Methods of assessing the impact of noise on verbal communication and signal detection and classification needs to be determined.

RECOMMENDATION: Clarify this paragraph.

CONCERN: Backfits

LOCATION: Volume 1, page 42, Bottom paragraph

COMMENT: The use of graphic displays have proven to be a useful information display tool. Considerable attention has been devoted to this display technique within the human factors engineering literature. Greater use of graphic devices must be considered as the backfit for augmenting and clarifying plant status information. Furthermore, the integration of additional control room modification requirements (i.e., SPDS) will have a significant impact on the availability of plant status information. This information will augment the information needs of the operator and rectify current information availability problems.

RECOMMENDATION: Add new bullet: Use of graphic displays to augment plant status information available to the operator.

CONCERN: Glare

LOCATION: Volume II, CRE - 3

COMMENT: Adequate lighting in the control room requires the use of a sufficient number of overhead lamps. Due to the size of the environment, certain lamps will be unavoidably positioned at adverse angles. The use of selected ceiling diffusers would be an appropriate backfit if other human factors engineering illumination guidelines are not violated.

RECOMMENDATION: Add the use of ceiling diffusers as a backfit alternative.

CONCERN: Luminance Ratio

LOCATION: Volume II, CRE - 8 Backfit

COMMENT: Varying the surface (reflectance) is an effective backfit alternative under these circumstances. Adjusting the light source would have a greater degree of impact on the criteria related to room illumination and glare.

RECOMMENDATION: Add the backfit alternative of adjusting the light source.

CONCERN: Illumination Levels

LOCATION: Volume II, CRE-10

COMMENT: Required emergency lighting levels are not provided. The operability of the control during emergency conditions depends, to a great extent, on proper room illumination. A criteria of illumination under such conditions is not presented.

RECOMMENDATION: Include a criteria value for emergency room illumination.

CONCERN: Placement

LOCATION: Volume II, VD - 18

COMMENT: The following area should be added to this section:

Frequency of Use. Displays most frequently used within each system should be grouped together.

RECOMMENDATION: Correct guideline.

CONCERN: Control Placement for Standing Operators

LOCATION: Volume II, WA-3, #5a; #7, #8 and Documentation

COMMENT: 1. There are a number of single controls which affect multiple displays. This guideline requires a greater degree of definition in terms of functional grouping.

2. #7: "74 inch" should read "70 inches".
3. #8: "57 inch" should read "53 inches".
4. #8: Centerline and lateral criteria should be added.
5. MIL-STD-1472B (1976 Revision) should be referenced not 1974.

RECOMMENDATION: Correct guideline.

CONCERN: Cathode Ray Tubes

LOCATION: Volume II, VD-48

COMMENT: 1. Guideline relevant to color displays are lacking.

2. There exists a number of effective human factors engineering display and optical image evaluation techniques for assessing CRT performance. The use of these techniques to support a guideline will clarify otherwise ambiguous requirements (i.e., gray levels, resolution, geometric distortion, graphics, etc.)

3. An acceptable range of viewing distances for displays in the control room of different designs needs to be established.

4. There are a number of information enhancement coding techniques which may be presented alone or in combination for the display of alphanumeric and geometrical information (i.e., brightness coding, reverse video, blinking and character styles.)

RECOMMENDATION: Correct guideline.

CONCERN: Check - reading dial layout

LOCATION: Volume II, VD-85, paragraph B, Guideline

COMMENT: "Wherever possible" should be added to the first sentence in paragraph #1.

"Wherever possible" should be added to the first sentence of the last paragraph.

This guideline conflicts with operator activity associated with the location of controls and related displays on auxiliary electrical panels.

RECOMMENDATION: Clarify the guideline.

CONCERN: Control Surfaces

LOCATION: Volume II, CON-2, paragraph E-Typical Backfit

COMMENT: 1. Control surface coding can be an effective coding device under conditions of low room illumination. However, surface coding should not be used for all controls, but only for selected controls within a system or subsystem.

2. Frictionalized control surfaces are more effective for minimizing control selection errors than for reducing chances of hand slippage.

3. Frictionalized control surfaces on commonly used controls will irritate operator's fingers and hands.

RECOMMENDATION: Eliminate guideline.

CONCERN: Primary Control Location

LOCATION: Volume II, CON-7, Guidelines

COMMENT: This guideline refers to frequently used and important controls:

1. A clearer definition of "frequently used" and "important" is required.
2. Relations to safety related or non-safety related would be appropriate here. That is, control location as well as frequency of use and importance can be clarified by referring to a safety-related criteria.
3. There is limited space on some areas of control boards. Guidelines should be expanded to recognize the identification of controls as a means to improving control response.

RECOMMENDATION: Include the backfit of color coding or demarcation lines.

CONCERN: Consistency of Control Location and Arrangement

LOCATION: Volume II, CON - 8, Backfit

COMMENT: Color coding techniques have been proven to be an effective backfit alternative, especially where separation criteria must be met.

RECOMMENDATION: B. Guideline. Functionally similar or identical primary controls should be consistently arranged, located or color coded from panel to panel or throughout control room.

E. Typical Backfit: Rearrange or color code controls.

CONCERN: Control Functional Grouping

LOCATION: Volume II, CON-9, Backfit

COMMENT: The use of color coding is an effective backfit alternative.

RECOMMENDATION: B. Guideline: Add at the end . . . or color code.

E. Typical Backfit: Add at the end . . . color code.

CONCERN: Controls - Sequential Grouping

LOCATION: Volume II, CON-10, Backfit

COMMENT: The use of mimics has proven to be an effective backfit under conditions where separation criteria must be met or where console space is limited.

RECOMMENDATION: E. Typical Backfit: Add at the end.....or use mimics to show sequence or flow path.

CONCERN: Multiple Controls
Multiple Displays

LOCATION: Volume II, CON-21, CON-22, Backfit

COMMENT: Other backfit alternatives are mimics and color coding.

RECOMMENDATION: E. Typical Backfit (for Multiple Controls and Multiple Displays). Add the use of mimics and color coding.

CONCERN: Operator/Computer Interface and Dialog

LOCATION: Volume II, OCI-11, Backfit

COMMENT: Redesign of both hardware and software are not always necessary.

RECOMMENDATION: Change "and" to "and/or".

CONCERN: Command Language

LOCATION: Volume II, OCI-21 Backfit

COMMENT: Redesign of both hardware and software are not always necessary.

RECOMMENDATION: Change "and" to "and/or".

CONCERN: Desks

LOCATION: Volume II, WA-16

COMMENT: Work Surface. The term "wherever practical" should be added to the end of the last paragraph in this section (MIL-STD-1472B (1976)).

RECOMMENDATION: Correct guideline.

CONCERN: Standard Console Dimensions

LOCATION: Volume II, WA-23

COMMENT: The following footnote from the original reference has been omitted from this section:

"Design values for each console established to accomodate 95 plus percent of USAF population."

RECOMMENDATION: Review the source of norm data and modify or qualify values presented in the table.

CONCERN: Location and Arrangement

LOCATION: Volume II, VD-24

COMMENT: The following phrase has been omitted from the transition between VD-23 to VD-24: "...limitations, which shall be compensated for by..."

RECOMMENDATION: Correct text.

CONCERN: Test Circuits

LOCATION: Volume II, AD-10

COMMENT: The original reference (MIL-STD-1472B) indicates that "other means of operability tests" would be appropriate.

RECOMMENDATION: Correct guideline.

CONCERN: Rocker Switch Dimensions

LOCATION: Volume II, CON-69

COMMENT: The reference cited, "MIL-STD-1472B (1974) should be "MIL-STD-1472C (1980).

RECOMMENDATION: Correct reference.

CONCERN: Keyboard Slope

LOCATION: Volume II, CON-76

COMMENT: For the case of portable keyboards, the slope can be varied according to the preference of the operator. (MIL-STD-1472B, 1974.)

RECOMMENDATION: Correct guideline.

CONCERN: Microphone/Telephone Handsets

LOCATION: Volume II, COM-17

COMMENT: The figure presented at the bottom of the page is without two legends:

right: "Mike parallel and close"

left: "close contact"

RECOMMENDATION: Correct figure

CONCERN: Headsets - Hands Free Operation

LOCATION: Volume II, COM-20

COMMENT: "under normal working conditions" should be added to the end on the sentence under Guideline.

RECOMMENDATION: Correct guideline.

CONCERN: Flashing Rate for Warning Indicators

LOCATION: Volume II, VD-16

COMMENT: A flashing rate or range should be provided in the table under "warning or caution".

RECOMMENDATION: Recommend a flashing range between 1 and 10 cycles per second. The flash frequency should be at least 4 cycle greater or lesser than other flash rates in use.

CONCERN:

LOCATION:

COMMENT:

RECOMMENDATION:

CONCERN: Lights for Warning Signals.

LOCATION: Volume II, VD-97

COMMENT: Confusion could result where warning lights are located in the vicinity of red status indicator lights.

RECOMMENDATION: Specify a convention to follow where warning lights are located in the vicinity of red status indicator lights.

CONCERN:

LOCATION:

COMMENT:

RECOMMENDATION:

CONCERN: Maintenance

LOCATION: N/A

COMMENT: There is no maintenance guideline section. Little reference is made to maintenance criteria throughout the document.

RECOMMENDATION: Incorporate all maintenance information into one guideline section. Especially important would be recommendations for documenting maintenance information on control board tags.

CONCERN: Human Error

LOCATION: Volume I, page 1

COMMENT: The introduction stresses human error as a fundamental cause of accidents and/or reduced system reliability. Operator actions do not occur in a vacuum. Errors are due to a poor interface between man and machine. It is this interface which is of primary concern to the field of human factors engineering.

RECOMMENDATION: Clarify the introduction and stress the importance of examining and improving the interface between the operator and the control board.

CONCERN: Operating Procedures

LOCATION: N/A

COMMENT: The guidelines provide little or no information regarding style, layout or content conventions for operating procedures.

RECOMMENDATION: Add the following categories, with the proper descriptive information, to a guideline for procedures:

1. Style
 - a) reading level
 - b) distinction between required actions and operating actions.
2. Layout
 - a) location of instructions, graphics, etc.
 - b) Coding of cautionary statements.
3. Content
 - a) Automatic system actions
 - b) Estimates of system response time.

CONCERN: Accidental Activation of controls located near the floor.

LOCATION: Volume II, CON-14

COMMENT: Controls located near the floor increase the probability of accidental activation.

RECOMMENDATION: Add to "Guidelines", #8. Controls located close to the floor (less than 3 feet), unless recessed, should be minimized or eliminated.

CONCERN: Location as a Form of Control Coding

LOCATION: Volume II, CON-16

COMMENT: The table presented on page CON-16 indicates that control location is not considered as a technique of identifying control position. However, the location of indicators above OT2 switches, for instance, is a method of identifying the control setting.

RECOMMENDATION: Include location as an advantage for identifying control setting.

CONCERN: Developing and Conducting Control Room Survey

LOCATION: Volume I, page 11, Section 2.5.2

COMMENT: The development and implementation of a control room survey should be conducted under normal operating conditions. However, in the case of units under construction or in multiple unit stations, special considerations should be noted. These considerations include but are not limited to: time of day, system line-ups and multi-unit activity interactions.

RECOMMENDATION: Include a statement in this section addressing the variables cited above.

CONCERN: The Benefit of Using Inexperienced Operators During Walk-throughs

LOCATION: Volume I, page 16, second paragraph

COMMENT: Walk-throughs should include newly trained operators so that flaws in procedures will become more apparent. Lack of experience can help reveal subtleties of plant design problems.

RECOMMENDATION: Include the recommendation of using inexperienced plant operators.

CONCERN: Evaluation Teams Understanding of Plant Systems

LOCATION: Volume I, page 22

COMMENT: Each member of the evaluation team should have an understanding of each system and component before the initiation of the data collection procedure. If a member of the team lacks this understanding, then a provision should be made to review the inexperienced team member's comments and recommendations.

RECOMMENDATION: Include a statement in the introduction of Section 3 regarding the requirement for an experienced team of evaluators.

CONCERN: Operating Procedures

LOCATION: N/A

COMMENT: NUREG/CR-1580 provides little information regarding the review of plant normal, emergency and abnormal operating procedures. The coordination of NRC personnel responsible for procedure reviews and those responsible for human factors engineering safety should be stated in the document.

RECOMMENDATION: Include a statement regarding the criteria applicable to plant operating procedures.

CONCERN: Control Placement and Frequency of Use

LOCATION: Volume II, WA-3, #2

COMMENT: The placement of controls are also determined by their frequency of use. Due to limitations of space, infrequently used non-safety related controls must be located in non-primary or secondary areas.

RECOMMENDATION: Modify guideline to include the parameter of frequency of control use.

CONCERN: Control Room Design Conventions

LOCATION: Volume I, page 29, Section 3.3.3

COMMENT: The "green board" concept is becoming more prevalent as a indicator design convention. Consequently, a "red" open valve indicator will become unconventional in many plants.

RECOMMENDATION: Include the color and shape coding conventions for a green board:

VALVE ABNORMAL POSITION = RED

VALVE NORMAL POSITION = GREEN

VALVE POSITION CLOSED = 

VALVE POSITION OPEN = 

CONCERN: Human Engineering Discrepancies and their priority

LOCATION: Volume I, page 43, Section 4.2

COMMENT: The compliance or non-compliance of a design feature can be effectively evaluated by considering its impact on the plant at the following levels:

- a) Control level
- b) Protection level
- c) Safety analysis level

RECOMMENDATION: Include these levels as evaluating parameters during the human engineering discrepancy priority determination procedure.

CONCERN:

LOCATION:

COMMENT:

RECOMMENDATION:

SECTION 3

ERRORS OF TECHNICAL CONTENT

CONCERN: Evaluation Team Management Structure

LOCATION: Volume I, page 7, Figure 2-1

COMMENT: 1. Little emphasis on coordination with licensing personnel is identified.

2. Emphasis on training (a critical element of human factors engineering review processes) is lacking.

3. I & C personnel should split time between Data Collection and HED processing sections.

4. The size of the evaluation team places severe limitation on the availability of utility human resources. The degree of individual participation should be clarified.

RECOMMENDATION: Review guideline and modify to address points 1 through 4.

CONCERN: Operator Questionnaire

LOCATION: Volume I, page 23, paragraph 3.2, 3.2.2

COMMENT: A previous EPRI report as well as previous human factors engineering studies have found inexperienced operator comments a valuable, objective source of design and operations deficiency data.

RECOMMENDATION: Correct guidelines

CONCERN: Display Placement for Standing Operators

LOCATION: Volume 1, WA-1, Documentation

COMMENT: MIL-STD-1472 (1976 Revision) should be referenced, not 1974.

RECOMMENDATION: Change 1974 Revision to 1976 Revision.

CONCERN: General Information (Combined Information)

LOCATION: Volume II, VD-1, 2, 3, (VD-6)

COMMENT: The integration of troubleshooting information (open/closed) with operational information (abnormal/normal) has proven to be effective for operating a "Green Board". Furthermore, integrating (combined) operational information within a single display has proven to be effective (reduced reaction time, greater control accuracy) for certain applications.

RECOMMENDATION: Clarify the use of troubleshooting information necessary for operation rather than maintenance.

CONCERN: Cathode Ray Tubes

LOCATION: Volume II, VD-56, Documentation

COMMENT: MIL-STD-1472, Essex Revision (1980) is not available and has not been identified by the Naval Publications and Forms Center as a government document.

RECOMMENDATION: Remove from guideline.

CONCERN: Assessment of Mechanical Instruments

LOCATION: Volume II, VD-68, Documentation

COMMENT: MIL-STD-1472 (Essex Revision, 1980) is not available and has not been identified by the Naval Publication and Forms Center as a government document.

RECOMMENDATION: Delete reference.

CONCERN: Display Illumination

LOCATION: Volume II, VD-93, Guideline, 2nd Paragraph

- COMMENT:
1. "Lumination level" should read "illumination level".
 2. "Required viewing distance" should be clarified.

RECOMMENDATION: Correct and clarify the guideline. Add to end of guideline "...to take corrective action."

CONCERN: Dial Marking

LOCATION: Volume II, VD-75

COMMENT: The replacement of zone markings should not be applied on the indicator window. Parallax problems would result when viewed at moderate angles from line of sight. Green markings are important aids to operator control board scanning and system status determination. The probability of erroneous judgements due to indicator location errors are increased when zone markings are placed on the indicator window.

The use of yellow and red markings should be optional. Operators are trained to respond to meter indications close to the edge of a set point. The operators should be conditioned not to respond to the pointer when in the green zone range, but take action when the pointer is outside of the green range.

RECOMMENDATION: After item E: the use of yellow and red zone markings may not be applicable to every meter.

CONCERN: Display Illumination

LOCATION: Volume II, VD-93, Guideline 2nd paragraph

- COMMENT:
1. "lumination level" should read "illumination level.
 2. "Required viewing distance" should be clarified.

RECOMMENDATION: Correct and clarify the guideline. Add to end of guideline "... to take corrective action."

CONCERN: Indicator and Warning Lights - Specifics

LOCATION: Volume II, VD-98

COMMENT: There exists no clear evidence supporting the enhanced detectability of warning lights within foveal vision. Some evidence exists supporting the increased detectability of flashing warning lights presented to the peripheral visual field. Consequently, a requirement for warning lights to be located within the central view of the operator is impractical and unrealistic.

RECOMMENDATION: Remove requirement for locating warning lights in the "central portion of the panel".

CONCERN: Coding of Controls

LOCATION: Volume II, CON-20, Documentation

COMMENT: MIL-STD-1472, Essex Revision (1980) is not available and has not been identified by the Naval Publications and Forms Center as a government document.

RECOMMENDATION: Delete reference from guideline.

CONCERN: Limb Support for Joystick Controls

LOCATION: Volume II, CON-83, Documentation

COMMENT: MIL-STD-1472, Essex Revision (1980) is not available and has not been identified by the Naval Publications and Forms Center as a government document.

RECOMMENDATION: Delete reference from guideline.

CONCERN: Continuous Thumbwheel Control Dimensions/Off position.

LOCATION: Volume II, CON-97, CON-99

COMMENT: MIL-STD-1472, Essex Revision (1980) is not available and has not been identified by the Naval Publications and Forms Center as a government document.

RECOMMENDATION: Delete reference from guideline.

CONCERN: Screen Layout and Structuring

LOCATION: Volume II, OCI-6, Backfit

COMMENT: Modifying the software would be an effective backfit alternative.

RECOMMENDATION: Add software backfit.

CONCERN: Representational Displays

LOCATION: Volume II, VD-14

COMMENT: The use of bars or lines to depict trends in graphic displays is task specific. There is no known human factors engineering data supporting the use of this guideline for all display information processing requirements.

RECOMMENDATION: Obtain supporting data or eliminate guideline.

CONCERN: Control Placement for Standing Operators

LOCATION: Volume II, WA-3, #5a, #7, #8 and Documentation

COMMENT:

1. #7: 74 inch should read "70 inches".
2. #8: 57 inch should read "53 inches".
3. #8: Centerline and lateral criteria should be added.

RECOMMENDATION: Correct guideline.

CONCERN: References

LOCATION: Documentation

COMMENT: Over 25 errors in reference citations have been found. The ability to properly substantiate or seek further guideline clarification is dependent upon accurate citation of reference material. NUREG/CR-1580 severely lacks the caliber of reference citations that is required of a document of such significance.

RECOMMENDATION: Proof read document and cite references appropriately.

CONCERN: Shelf Dimensions

LOCATION: Volume II, WA-8

COMMENT: The rationale and reference cited for "Under no circumstances" is not obvious from the original technical source referenced (Woodson and Conover, 1964).

RECOMMENDATION: Clarify the reasoning behind "under no circumstances".

CONCERN: References

LOCATION: Volume II, page 5

COMMENT: 1. "ANSI/ANS N2.3, Illinois: American Nuclear Society, 1967" should read:

ANSI/ANS-N 2.3, Immediate evacuation signal for use in industrial installation. Illinois: American Nuclear Society, 1979.

2. "Chapanis, A. Man-Machine engineering. Monterey, Cal.: Brooks/Cole, 1965," should read: Chapanis, A. Man-Machine Engineering. Monterey, CA: Belmont and Wadsworth, 1965..

RECOMMENDATION: Correct Reference

CONCERN: Reflectance

LOCATION: Volume II, CRE-6

COMMENT: 1. General recommendation for ceiling reflectance is between 60 and 95% (Van Cott and Kinkade, 1972), rather than the 80 and 90% specified.

2. General recommendation for wall reflectance is between 40 and 50% (VanCott and Kinkade, 1972), rather than the 50 or 15-20% specified.

3. Appropriate reflectance values depends, to a great extent on room size and task conditions. Data supporting the validity of the values listed on CRE-6 are not available from the open literature.

RECOMMENDATION: Correct guideline.

CONCERN: Ventilation

LOCATION: Volume II, CRE-15

COMMENT: The guidelines require that ventilation systems shall be so located as to preclude/prevent the introduction of contaminated air. As stated in MIL-STD-1472B, "Ventilation or other protective measures shall be provided to keep gases, vapors, dust, and fumes within the limits specified in the American Conference of Governmental Industrial Hygienists Threshold Values. Intakes for ventilation systems shall be so located as to minimize the introduction of contaminated air..."

RECOMMENDATION: Modify the guideline to read "minimize."

CONCERN: Cathode Ray Tubes (CRT)

LOCATION: Volume II, VD-45

COMMENT: The requirements of a "character or symbol of complex shape" being represented by no less than 10 lines (scan) or resolution elements is ambiguous. VD-14 #3, specifies that CRT displays are "most effective" when there are seven or more scan lines per mm. The resolution required for complex shapes should be well within the optical performance characteristic of the CRT.

RECOMMENDATION: Correct guideline.

CONCERN: Mimic Boards and Graphic Panels

LOCATION: Volume II, VD-59

COMMENT: The diagram presented is incorrect. The circle of valve number 2 is distinguished from valves 1, 3 and 4 by its illuminated conditions. However all bars are dark, presenting contradictory information to the observer. Either the bar for Valve #2 should be illuminated or bars for Valves 1, 3 and 4 illuminated. The go condition is where all illumination conditions across the row of symbols is true.

RECOMMENDATION: Correct diagram.

CONCERN: Critical Audible Signals

LOCATION: Volume II, AD-25

COMMENT: The original reference (MIL-STD-1472) indicates that, regardless of the duration of the signal, "all essential information shall be transmitted in the first 0.5 sec."

RECOMMENDATION: Correct guideline.

CONCERN: Rotary Control Pointer Contrast

LOCATION: Volume II, CON-25

COMMENT: The word "cover" under Guideline should read "color".

RECOMMENDATION: Correct text.

CONCERN: Discrete Rotary Control Range Stops

LOCATION: Volume II, CON-34

COMMENT: The guideline presented is appropriate where the operational range limits are discrete. However, particular controls which are required to be operated beyond the end position for testing or calibration purposes should be noted as such in the guideline.

RECOMMENDATION: Correct guideline.

CONCERN: Lever Dimensions

LOCATION: Volume II, CON-85

COMMENT: The maximum lateral displacement of a lever should be 38 rather than 33 as noted (MIL-STD-1472B, 1974).

RECOMMENDATION: Correct guideline.

CONCERN: Speech Reception Equipment

LOCATION: Volume II, COM-5

COMMENT: The value of "4000 HZ" should read "4800 HZ".

RECOMMENDATION: Correct guideline.

CONCERN:

LOCATION:

COMMENT:

RECOMMENDATION:

CONCERN: Control Compatibility with Emergency Gear

LOCATION: Volume II, CON-4

COMMENT: The possibility of inadvertent activation stated under "human Error" is not compatible with the guideline.

RECOMMENDATION: Either include a statement regarding inadvertent activation of controls due to bulky emergency clothing or drop "inadvertent activation" from Section C.

CONCERN: Prevention of Accidental Activation of Controls

LOCATION: Volume II, CON-13, paragraph 1.

COMMENT: The statement regarding the location of controls to prevent accidental activation is not specific. A specific guideline stating a minimum distance between controls should be provided.

RECOMMENDATION: Provide a minimum distance between controls as a criteria.

CONCERN: Contrast Enhancement

LOCATION: Volume II, OCI-7

COMMENT: Number 1, under Guidelines, should read "Contrast enhancement", not contract enhancement.

RECOMMENDATION: Correct guideline.

CONCERN: Human Engineering Discrepancies and Their Priority

LOCATION: Volume I, page 43, Section 4.2

COMMENT: The compliance or non-compliance of a design feature can be effectively evaluated by considering its impact on plant boundaries:

- a) fuel clad
- b) primary coolant system (PWR)
- c) containment zone
- d) exclusion zone

RECOMMENDATION: Include these boundaries as evaluating parameters during the human engineering discrepancy priority determination procedure.

SECTION 4

AMBIGUITY IN RATIONALE,
GUIDELINES, PROCEDURES, AND INTENT

CONCERN: Handle Dimensions

LOCATION: Volume II, WA-11

COMMENT: The guidelines provided apply to errors of equipment handling. Some clarification is required for criteria related to control board switch handles.

RECOMMENDATION: Review guideline and modify to correspond to application to control rooms.

CONCERN: Storage Space

LOCATION: Volume II, WA-33

COMMENT: Clearer definition of the time required to access operational or maintenance procedures is needed. The variable of access time impacts storage location alternatives.

RECOMMENDATION: Delete the term "maintenance" from the guideline.

CONCERN: Definition of Safety-related Task

LOCATION: Volume I, page xi, paragraph 3

COMMENT: The applicability of a human factors engineering guideline to a safety-related task can only be made if a criteria is established for what constitutes a safety-related task.

RECOMMENDATION: Apply the guideline to tasks using safety-related equipment.

CONCERN: Selection of Power Plants for Initial Government Review

LOCATION: Volume I, page 4, section 1.2, paragraph 1

COMMENT:

1. Combustion Engineering (C.E.) units are not represented.
2. Only two (2) older BWR plants were evaluated.
3. Questionable use of Dreseden #1 (unique design).

RECOMMENDATION: Qualify the extent to which the data gathered at these sites are applicable to other control rooms of different design.

CONCERN: Reviewing the Cause of Operator Error

LOCATION: Volume I, 1. Introduction, page 1, paragraph 1.

COMMENT: Human factors engineers and the criteria they use can not remove the cause of operator error. It has been accepted throughout the human factors engineering community that errors are due, for the most part, to machine design, human performance variables and the interaction between the two. The field of human factors engineering is far from understanding the contribution of each of these factors to error. Causes for error can be reduced, not eliminated.

RECOMMENDATION: Change the word "remove" to "reduce".

CONCERN: Satisfactory Backfit Alternatives

LOCATION: Volume I, page 4, paragraph 1

COMMENT: Little discussion or guidance is provided regarding the evaluation or validation of backfit selections. What data or rationale is required of the utility industry to support a backfit alternative?

In addition, this paragraph recognizes backfits for human engineering discrepancies do not necessarily involve hardware modifications. This fact has not been applied to the backfit guidelines in Volume II.

RECOMMENDATION: Review each guideline in Volume II and indicate the satisfactory alternatives in place of modifying hardware.

CONCERN: Rationale Supporting Expected Errors

LOCATION: Volume I, page 5, paragraph 1

COMMENT: Human factors engineering rationale in support of expected errors should be provided.

RECOMMENDATION: Clarify the relationship between the design discrepancies identified and the method of determining the type of human error.

CONCERN: Selection of Evaluation Team

LOCATION: Volume I, page 6, 2.1

COMMENT: The meaning or determination of an acceptable backfit is unclear. The term operational benefit should be added.

RECOMMENDATION: Include in this paragraph the operational benefit expected for each backfit alternative recommended.

CONCERN: Qualifications of Personnel

LOCATION: Volume I, page 7, paragraph 1

COMMENT: The responsibility for identifying qualifications for team members is not identified.

RECOMMENDATION: Specify who is responsible for qualifying a team member.

CONCERN: Planning Process Flow

LOCATION: Volume I, page 9, Figure 2-2.

COMMENT: The integration of training and maintainability tasking is not obvious from this figure.

RECOMMENDATION: Clarify or modify figure.

CONCERN: Refinement of Operator Interview

LOCATION: Volume I, II, Paragraph 2.5.1.2

COMMENT: The term "generic problems" is used instead of "potential problems".

RECOMMENDATION: Change the term "generic problems" to "potential problems".

CONCERN: Checklist Content

LOCATION: Volume I, 15, paragraph 1

COMMENT: To what extent will the contents of the checklist in Appendix V be modified?

RECOMMENDATION: Clarify guideline.

CONCERN: Same - Vintage Plants

LOCATION: Volume I, page 22, paragraph 3.1.1

COMMENT: All operating plants regardless of age per NUREG guide should be specified.

Construction, A-E and NSSF vendor should be considered as variables.

RECOMMENDATION: The paragraph should refer to all operating plants and "generic" should be changed to "potential problems".

CONCERN: Noise Survey

LOCATION: Volume I, page 25, paragraph 3.3.1.3b, 3.3.1.4

COMMENT: Provide the utility and applicability of using noise weighting networks for dB(B) and dB(C), since criteria is in dB and dB(A) scales.

RECOMMENDATION: Clarify paragraph or guideline.

CONCERN: Light Survey

LOCATION: Volume I, page 15, paragraph 3.3.2, 3.3.2.3

COMMENT: A clear definition of ambient illumination and normal lighting is not provided.

RECOMMENDATION: Define "ambient illumination" and "normal lighting" in such a manner that it can be clearly understood by the user.

CONCERN: Plant Safety

LOCATION: Volume I, page 41, paragraph 1

COMMENT: Criteria for "importance in plant safety" is required.

RECOMMENDATION: Clarify the meaning of "importance in plant safety."

CONCERN: Safety-related Devices

LOCATION: Volume I, page 50, c

COMMENT: No clear distinction has been made between safety and non-safety (see Preface).

RECOMMENDATION: Clarify the distinction between safety and non-safety related devices.

CONCERN: Personnel Qualifications

LOCATION: Volume I, Sections I-1 through I-6

COMMENT: The qualifications stated are ambiguous and ill-defined. Training or experience-related qualifications should be documented only.

RECOMMENDATION: Clarify guideline.

CONCERN: Acoustical Noise

LOCATION: Volume II, CRE-11

COMMENT: Normal operating conditions should be clearly defined in terms of time of day, frequency range, and method of measurement.

RECOMMENDATION: Clarify guideline.

CONCERN: Ventilation

LOCATION: Volume II, CRE-15

COMMENT: Control room ventilation criteria are specified by heating ventilation and air conditioning standards. Another criteria in the guideline appears inappropriate.

RECOMMENDATION: Delete this guideline or modify.

CONCERN: General Workspace Hazards

LOCATION: Volume II, CRE-17, #4, #5

COMMENT: 1. Work areas and access areas should be better specified.

2. Radius of 0.40 inch should read .04 inch.

RECOMMENDATION: Clarify and correct guideline.

CONCERN: Malfunction

LOCATION: Volume II, CRE-21

COMMENT: The frequency of monitoring a piece of equipment is not properly defined as "regularly monitored". A guideline regarding type of equipment and frequency of monitoring should be documented.

RECOMMENDATION: Clarify guideline.

CONCERN: Control Placement for Standing Operators

LOCATION: Volume II, WA-3, 5a; 7, 8, Documentation

COMMENT: There are a number of single controls which affect multiple displays. This guideline requires a greater degree of definition in terms of functional grouping.

RECOMMENDATION: Clarify the guideline.

CONCERN: Console Dimensions for the Seated Operator

LOCATION: Volume II, WA-26, 27

COMMENT: The task responsibilities of a control room operator, while sitting should be well-defined prior to establishing console design constraints.

RECOMMENDATION: Clarify the task responsibilities of the seated operator in a control room.

CONCERN: Location and Arrangement

LOCATION: Volume II, VD-22,23

- COMMENT:
1. Accuracy - normal operating position must be better defined in terms of sitting, standing, distance and location.
 2. Reflection - a technique of assessing system performance degradation should be developed and specified. A significant reduction in information transfer should be avoided.
 3. Maximum Viewing Distance - A realistic maximum/minimum viewing distance is not specified. The 28 inch maximum viewing distance criterion appears to have been specified for the average military height. There are control room operators and shift foremen that do not meet this average height.

RECOMMENDATION: Replace words "shall not exceed" to "should be".

CONCERN: Visual Display Layout

LOCATION: Volume II, VD-20

- COMMENT: 1. Warning Lights and Primary Displays - the size of a control room increases the probability of excessive operator head movement. Frequency of head movement, line of sight and operator/control board distances should be specified.
2. Secondary Displays - frequently used operational displays should be defined in great detail.

RECOMMENDATION: Provide greater clarity for the meaning of primary and secondary displays.

CONCERN: Cathode Ray Tubes

LOCATION: Volume II, VD-48

COMMENT: 1. There exists a number of effective human factors engineering display and optical image evaluation techniques for assessing CRT performance. The use of these techniques as a guideline evaluation tool will clarify otherwise ambiguous requirements (i.e., gray levels, resolution, geometric distortion, graphics, etc.)

2. Response Time - response time depends upon display density. Well designed, effective graphic displays of high density will exceed the three second response time requirement given current image processing hardware/software technology.

3. Symbology - the distinction between the requirement of 16 minutes of visual angle for geometric and pictorial symbols and 20 minutes of arc for "size symbols" is not clear.

RECOMMENDATION: Clarify guideline.

CONCERN: Pointers

LOCATION: Volume II, VD-70

COMMENT: The human factors engineering rationale for matching pointer color with meter values is not clear.

RECOMMENDATION: Remove this criteria from the guideline.

CONCERN: Primary Control Location

LOCATION: Volume II, CON-7, Guidelines

COMMENT: A clearer definition of "frequently used" and "important" is required.

RECOMMENDATION: Clarify guideline.

CONCERN: Placement

LOCATION: Volume II, VD-18

- COMMENT:
1. Grouping. Clearer definition of necessary displays should be provided.
 2. Importance. Degree of importance as it relates to a safety related criterion should be better defined.
 3. Consistency. The impact of minor arrangements of controls and/or displays should be assessed prior to the establishment of a consistency guideline.

RECOMMENDATION: Clarify guideline.

CONCERN: Coding (frequency)

LOCATION: Volume II, AD-15

- COMMENT:
1. "Frequency levels" (#2) should be changed to "frequency."
 2. Guidelines should be provided for minimum frequency separation at designated absolute frequencies.
 3. Tolerance limits should be established for the auditory alarm to ambient signal-to-noise ratio.

RECOMMENDATION: Correct guideline.

CONCERN: Display Illumination

LOCATION: Volume II, VD-93, Guideline

COMMENT: A realistic criteria for a required viewing distance has not been documented.

RECOMMENDATION: "Required viewing distance" should be clarified.

CONCERN: Auditory Displays as Warning Signals

LOCATION: Volume II, AD-23, #2

COMMENT: 20dB above threshold contradicts AD-4 guideline B, item 8 and AD-15, guideline B item 3.

General ambient level requires clarification (i.e., time of day, bandwidth, type of measurement).

RECOMMENDATION: Clarify guideline.

CONCERN: Mimic Boards and Graphic Panels

LOCATION: Volume II, VD-57

COMMENT: "The extent to which the elements of the display are static or dynamic" depends not only on system complexity but on the operational conditions. There is a tradeoff to be made between system complexity and available time to initiate an operator action. The application of a safety-related criteria would clarify the intent of this guideline.

RECOMMENDATION: Relate system complexity to a safety-related criteria.

CONCERN: Counters

LOCATION: Volume II, VD-83

COMMENT: The diagram presented on the upper right hand corner is ambiguous. As presented, both proportions demonstrate effective height-to width ratios. The characters for the "poor" display should be elongated to demonstrate the proper 3:2 ratio and resultant distortion on curved drum surfaces.

RECOMMENDATION: Correct diagram.

CONCERN: Counters

LOCATION: Volume II, VD-83

COMMENT: The diagram presented opposite "digit window" is not clear. The "8" with the large window should display a portion of a seven (7) above it and a portion of a nine (9) below it.

RECOMMENDATION: Correct diagram.

CONCERN:

LOCATION:

COMMENT:

RECOMMENDATION:

CONCERN: Evaluating the Impact of Human Factors Engineering Design Deficiencies on System Safety and Reliability.

LOCATION: Volume I, page 2, #3

COMMENT: The impact of human factors engineering design deficiencies on system safety and reliability is typically measured by acquiring empirical data. NUREG/CR-1580 provides no reference to techniques or tools that can be used by the utilities to evaluate these deficiencies.

RECOMMENDATION: Create a section within NUREG/CR-1580 which presents various techniques that can be used by a utility to empirically evaluate the impact of a particular design on human performance reliability and/or system safety.

CONCERN: Plant Reliability

LOCATION: Volume I, page 41, first paragraph

COMMENT: "Reliability" should be addressed only to the extent that it affects plant safety.

RECOMMENDATION: Clarify guideline.

CONCERN: Handle Dimensions for the Gloved Operator

LOCATION: Volume II, WA-11

COMMENT: The dimensions of a control should be specified for a given type of glove.

RECOMMENDATION: Define the type of glove (i.e., surgical, work, etc).

SECTION 5

CONTRADICTIONS AMONG
CRITERIA

CONCERN: Glare

LOCATION: Volume II, CRE-3

COMMENT: Adequate lighting in the control room requires the use of a sufficient number of overhead lamps. Due to the size of the environment, certain lamps will be unavoidably positioned at adverse angles. The use of selected ceiling diffusers would be an appropriate backfit if other human factors engineering illumination guidelines are not violated. This guideline conflicts with the lighting requirements for a control room.

RECOMMENDATION: Add the backfit alternative of ceiling diffusers to minimize direct lighting.

CONCERN: Displays for System Status

LOCATION: Volume II, VD-8,9 (Backfit #2)

COMMENT: Greater clarity is required for the meaning of "annunciators in the central position". Locations in central positions violates annunciator/control/display annunciation requirements.

RECOMMENDATION: Clarify guideline.

CONCERN: Auditory Displays as Warning Signals

LOCATION: Volume II, AD-23, #2

COMMENT: 20dB above threshold contradicts AD-4 and AD-15.

RECOMMENDATION: Clarify guideline or standardize criteria.

CONCERN: Illumination Levels

LOCATION: Volume II, CRE-10

COMMENT: An ambient illumination range between 30 and 50 foot candles is recommended. This range corresponds to the proper lighting level conducive to effective visual task performance. However, within a nuclear power plant control room, the use of 30-50 foot candles illumination threatens the utility of a "Green Board" indication control board. Valid criteria for lighting levels under these circumstances must be developed prior to specifying lighting levels.

RECOMMENDATION: See ILLUMINATION LEVELS, Section 1 of this document.

CONCERN: Console Dimensions for the Standing Operator

LOCATION: Volume II, WA-24,25

COMMENT: Adherence to this guideline would impact the size and manning requirements and therefore challenge human factors engineering limitations established with other related criteria.

RECOMMENDATION: Review console dimensions and modify to correspond to the constraints of the control room.

CONCERN: Coding of Controls

LOCATION: Volume II, CON-19

COMMENT: The use of the noted primary colors violates guidelines referring to stereotypical use of colors.

RECOMMENDATION: Revise to allow the use of more than five (5) colors.

CONCERN: Visual Presentation of Information

LOCATION: Volume II, VD-10, 11, 12, 13

COMMENT: Presence of Other Displays - the requirement for displays not looking "too much alike" contradicts the grouping of similar system displays. Look-alike displays need labelling for proper identification.

RECOMMENDATION: Clarify guideline.

CONCERN: Cathode Ray Tubes (CRT)

LOCATION: Volume II, VD-45

COMMENT: The requirements of a "character or symbol of complex shape" being represented by no less than 10 lines (scan) or resolution elements is ambiguous. VD-14 #3, specifies that CRT displays are "most effective" when there are seven or more scan lines per mm. The resolution required for complex shapes should be well within the optical performance characteristic of the CRT.

RECOMMENDATION: Clarify guideline.

CONCERN: Priority of Print/background color combinations

LOCATION: Volume II, PA-58, PA-59

COMMENT: PA-58 ranks blue printing on a white background as the highest priority of print/background color combinations. PA-59 ranks black letters on a white background as the highest.

RECOMMENDATION: Correct guidelines.

CONCERN:

LOCATION:

COMMENT:

RECOMMENDATION: