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TECHNICAL ISSUES RELATED TO NUREG 0800, CHAPTER 18:
HUMAN FACTORS ENGINEERING/STANDARD REVIEW PLAN

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I. Introduction

The revision of Chapter 18 of NUREG 0800, Human Factors Engineering Standard Review Plan (SRP) will be based on SECY 82-111 and guidance contained in NUREG 0700, NUREG 0801 and NUREG 0835, plus other references.

In conducting field reviews of control rooms, the NRC has identified technical issues which can be used to enhance the development of the revised version of NUREG 0800, and to establish priorities among the list of possible Branch Technical Positions (BTP) in NUREG 0800, Rev. 0, Table 18.0-2.

This report is a compilation of comments and suggestions from the people who used NUREG 0700 in the Control Room field reviews. This information was used to establish possible BTP topic priorities so that the most important BTPs could be issued first. The comments and suggestions are included for HFEB review in conjunction with the table of priorities. The contributors are listed in Part VIII.

II. Standard Review Plan Issues

The issues which must be resolved before an effective Human Factors Engineering Branch (HFEB) Standard Review Plan can be developed are:

- o An effective Standard Review Plan must be based on a clear and comprehensive definition of what the NRC wants to find in the SARs to be reviewed.
- o The SRP must ensure that reviewers will be able to determine that an applicant has done all of the things necessary to acceptably comply with the guidelines and the BTPs which should be issued to supplement them.
- o The HFEB SRP should be coordinated with those of other related branches.

III. Branch Technical Position Issues

A Branch Technical Position is an instruction to staff reviewers that outlines an acceptable approach to a particular issue. Its function is to supplement the acceptance criteria established in the Regulations, Regulation Guides, referenced standards, etc. It is therefore important to reviewers because it updates older guidance.

An effective series of Branch Technical Positions will require that the HFEB carefully review and coordinate the philosophy upon which its positions will be based. This should include consideration of

- a) Control Room review field experience
- b) feedback which has been received from applicants/licensees
- c) HFEB opinions
- d) The urgency of issue of possible BTPs

The BTPs can provide references upon which to base reviewer determination of SAR acceptance, and eventual revision or replacement of existing guidance. As far as is possible, final positions should be consistent with interim positions.

IV. Resolution of Issues

The NRC should begin immediately to resolve the issues described in Part II and Part III.

The NRC should decide how quickly and completely it wants to respond to the need to publish the BTPs because the BTPs will be needed by reviewers who will be using the revised SRP. The titles and schedules of the expected BTPs should be coordinated with the writers of the revised SRP so that they can be included in the SRP references.

A reviewer can assume that possible BTP topics that remain unscheduled are adequately covered by current guidance.

The BTPs should be published in order of priority as indicated in Part V, with consideration given to the proposed combinations of topics suggested in Part VI.

The determination of the BTP sequence of publication within a priority category will be aided by consideration of the summary of comments contained in Part VII.

The interaction of the BTP publication schedule and available HFEB effort will determine whether HFEB can perform the tasks or will need to secure supplemental effort from subcontractors. This issue should be resolved so that any subcontracted work can begin in time to meet the delivery schedules.

A suggested procedure is listed below.

Resolution of Branch Technical Position Issues

- o Make a decision to complete the following by an HFEB selected date
- o Assign a BTP project leader
- o Select staff members to review possible BTPs to be written
- o Review the BTP topics listed in Table 1 and Table 2
- o Review the summary of comments, Part VII
- o Select topics to be deleted
- o Add new topics
- o Determine sets of topics to be placed in single BTPs
- o Make a final list of BTPs to be published
- o Estimate the effort needed to complete each BTP
- o Assign a completion date for each BTP
- o Assign authors or subcontractors for each BTP
- o Setup a timeline vs task schedule for each BTP. Include
 - Staff/subcontractor Orientation
 - Research
 - Writing
 - Staff discussions
 - Review and critique
 - Editing
 - Printing
- o Write the BTPs

V. Possible BTP Topic Priorities

The responses to requests for data to determine priorities among possible BTP topics revealed that a strong consensus which sharply defines the priorities does not exist. Instead, the overlapping nature of the responses provided only a loosely defined basis for Table 1.

Among the numbered topics, Priority 1 was assigned to those topics identified as high priority by three or more respondents. Priority 2 was assigned to topics identified as moderate priority by a predominant number of respondents. Priority 3 was assigned to the remainder of topics, including those judged to be acceptably covered in the current edition of NUREG 0700.

The lettered topics are additional topics suggested by respondents and have been assigned the priorities selected by the sources.

Table 1 - Possible BTP Topic Priorities

- NOTE:
- o Physical position in the list does not indicate order of importance.
 - o Numbers in parentheses are NUREG 0800, Rev. 0, Table 18.0-2 item numbers.
 - o Letters in parentheses are suggested additions.

1 - High Priority - Do First

- (7,Ø) Mirror Imaging
- (11) Lamp Test
- (12) Color Coding
- (16) Alarms/Annunciators - First out panels
- (17) Alarms/Annunciators - Color Coding
- (18) Alarms/Annunciators - Prioritization
- (45) A Dark' Board Concept
- (51) Alarms/Annunciators - Annunciator Operations
- (54) Alarms/Annunciators - Normally "on" Tiles
- (A) CRT Display Format Guidance
- (B) Computer/Operator Interaction Modes
- (I) Special Identifications for RG 1.97 Instruments
- (J) ESF Bypass or Out-of-Service Status Indicators (Required by RG 1.97)
- (K) Acceptable System Review/Task Analysis for DCRDR
- (L) CRT Requirements

2. - Moderate Priority - Do Next

- (9) Control Display Relationship
- (10) Arrangements of Control Display Groups
- (13) Multi-Unit Control Rooms
- (14) Types of Coding of Auditory Signals
- (15) Periodic Testing of Annunciators
- (19) Functional Grouping - Alarms
- (22) Functional Grouping - Controls
- (23) Functional Grouping - Primary Control Location (Definition of Primary Controls)
- (24) Control separation distances
- (26) Coding of controls
- (27) Accidental activation of controls
- (31) Control Room Workspace Emergency Equipment
- (33) Visual Displays
- (34) Controls - Standardization
- (35) Controls - Outside the Control Room
- (36) Panel Layout Consistency and Standardization
- (43) Flash Coding (Lights, CRT)
- (44) Annunciator "Blank" Tiles
- (48) Alarms Tile Bulb Replacement
- (50) Alarms Window Labeling
- (55) Multi-Input Alarm Tiles
- (56) Alarm Operation and Diagnostic Procedures
- (57) "Out of Service" Alarm Tiles
- (C) Feasibility of an Industry-wide Standard for Symbols and Abbreviations
- (D) Indication of Failed Meters
- (E) Distinction Between Legend Indicators and Legend Pushbuttons
- (F) CRT Display Resolution
- (M) Consistency of the Person-Machine Interface Throughout the Plant
- (W) Panel Meter Modifications vs Meter Qualifications (e.g., addition of color banding)
- (N) Use of Alpha-numeric labeling on matrices of closely spaced controls
- (P) Panel components layout which agrees with physical plant layout but does not agree with NUREG Q700 guidelines (e.g., layout order ABC, 123, top-to-bottom, left-to-right, etc.)
- (S) CR floor surface (e.g., slippery tiles vs type of service)

3. - Low Priority - Presently OK in NUREG 0700, or do on a long term basis

1. Environment - Maintenance
2. Environment - Acoustics
3. Environment - Illumination
4. Control Room Workspace
5. Control Room Workspace, General Layout
6. Control Room Workspace, Work Station Design
20. Alarm Tile Flash Rates
21. Alarm Controls and Locations
25. Control Direction of Movement
28. Display Character Size vs Viewing Distance (Visual Angle)
29. Meter Scale Graduations
30. Display Illumination
37. Control Room Workspace Habitability/Access
38. Clusters of Displays or Controls
39. Control/Display Movement Ratio
40. Label Size Graduation
41. Label Orientation
42. Label Location
46. Alarm Controls, Identification
47. Alarm Tile Matrix Identification
49. Alarm Tile Contrast
52. Alarm Tile Location
53. Annunciator Tile Readability
58. Alarm Frequency Range (Preferred)
59. Alarm Signal Intensity

VI. Combination of BTP Topics

Table 2 lists sets of topics that were suggested by respondents to be combined to express a position on a single BTP subject. The overlapping of some sets of topics with other sets will need to be resolved by intra-HFEB discussions.

Table 2 - Proposed Combinations of Possible RTP Topics by Subject

- A. CR Design
 - o 5, 6, 7, 13, 31, 32
- B. Environment
 - o 1, 2, 3, 37
- C. Annunciators and/or Alarms
 - o 17, 18
 - o 45, 54
 - o 46, 51
 - o 50, 51, 52, 53
 - o 51, 56
- D. Controls
 - o 21 through 27, 34, 35, 38
- E. Displays
 - o 11, 12, 14, 15 through 20, 28, 29, 30, 33, 38, 40 through 59
- F. CD Integration
 - o 8, 9, 10, 36, 39

VII. Summary of Comments

The following comments were collected during the discussions of field use of NUREG 0700, and they are included with only minor editing and reorganization. These comments can help to organize a work plan for writing the BTPs and revising the Chapter 18 SRP. The topics of some of the comments might be suitable for BTPs.

1. Task Analysis (NUREG 0700-3.4)

Program Plan (NUREG 0700-Ch 2)

Licensee program plans for task analysis submitted to NRC have not been as good as expected. This may be because the methodology described in NUREG 0700 is not prescriptive enough. It was reported that the NRC Research Division/BioTechnology/General Physics study now in progress has developed a methodology which could beneficially supplement the NUREG 0700 guidance.

2. CR Inventory (NUREG 0700 - 3.5)

For the SRP, evidence of a design inventory is needed but may not be a justifiable requirement to include in an SAR, since unused controls and displays can be identified without an inventory. A BTP could be written to describe a methodology to do this.

3. Verification and Validation (NUREG 0700 - 3.7, 3.8, Appendix B)

These two topics, Verification of Task Performance Capabilities and Validation of Control Room Functions have not been satisfactorily addressed in licensee reports reviewed by HFEB reviewers. The reason is thought to be that the subject matter is complex and abstract. A BTP should be written so that the user can better understand how he is expected to respond.

4. NUREG 0700, Ch 6

For evaluating an initial design, most sections of Chapter 6 are satisfactory. For an existing design, some sections are reported to be difficult to use because there are no statements which explain the application of human factors principles to existing control rooms. Also, the checklist format of Chapter 6 was both praised and criticized. These subjects could be covered in a BTP, and the use of checklists or alternatives could be resolved.

5. Control Room Security (NUREG 0700 - 6.1.1.7)

A definite position concerning control room access should be stated.

6. Environment (NUREG 0700 - 6.1.5)

- a. Measurements of the quantities described in this section do not lend themselves to checklist methodology. It would be beneficial to re-orient this guidance in a BTP, so that the guidance matches the work that must be done to determine compliance, and states what variations from guidelines will be acceptable to NRC.
- b. Lighting guidance needs more details for
 - o operator capabilities under loss of normal light
 - o operations on emergency lights
 - o operations "black" when all lights are lost
 - o work space lights vs room lights
- c. A position should be stated regarding acceptable modifications of comfort guidelines for infrequently occupied areas (e.g., RSP) such as,
 1. Temperature/humidity levels vs operator performance capability to perform within a reasonable time span.
 2. Higher noise level if no auditory alarms are used, or no face-to-face communication is necessary.

7. Communications Network (NUREG 0700-6.2)

A position should be stated regarding redundancy needs and consistency among persons, systems and equipment interfaces.

8. Annunciators and Alarms (NUREG 0700 - 6.3)

This section should be reviewed and positions stated because:

- o The guidelines for out-of-service annunciators are not clear
- o In modes of operation other than normal, some system parameters may stray into sensor alarm/tile trip zones when a dangerous condition does not actually exist for that parameter in that mode. A logic or switches to adjust alarm response to each mode could eliminate misleading alarms and possible operator confusion.
- o The text is not clear in places concerning statements on dark board, normally "on" tiles, blank tiles, first out panels, color codes, prioritization, extraneous indications, non-critical indications, auditory alarm inhibits, etc.. A BTP statement of the philosophy underlying the guidance would clarify the issues.
- o The material in the PNL "Guidelines for Near-Term Improvements in Nuclear Power Plant Control Room Annunciator Systems" should be considered for inclusion in a BTP.

9. Controls not covered by NUREG 0700 - 6.4

A specific BTP should be written to cover two types of combined controls that are not clearly covered by section 6.4 guidance. These are:

- o Bailey Controllers
- o Cutler Hammer CHE-30 controls

10. Trend Recorder Acceptability (NUREG 0700 - 6.5.4, 6.7.3)

There is a need to state a position which defines

- a) what type of records are acceptable/necessary
- b) what is an acceptable level of operator effort to obtain the records.

11. Process Computers (NUREG 0700 - 6.7)

A position needs to be stated explaining how and in what ways the NRC will give credit for computer-presented information for EOP or operating procedures. The guidance should be reviewed and supplemented to update guidance which was derived from old literature.

12. Printer Characteristics (NUREG 0700 - 6.7.3)

A study of all facets of data requirements should be made and a clear position stated describing what printer capability NRC expects applicants/licensees to provide. Topics should include:

- o Is 300 lines per minute the only acceptable speed?
- o What data needs to be printed at high speed?
- o What non-critical data and alarms do not need to be printed at high speed?
- o How much high speed printout data can an operator absorb?
- o How much lost data is acceptable?
- o Guidance regarding printout priorities for first-out vs sequence of events
- o Guidance regarding ordering or intermingling of printout items
- o Can printer be close to, or must it be in the CR?
- o The need for single vs multiple printers?
- o What data can be stored and later printed out?
- o What memory capacity is needed?

13. Front Panel Displays (NUREG 0700 - 6.8.1)

A position and rationale should be stated which lists things NRC does not want to see displayed on front panels.

14. Work Load, Mental Capacity, Spare Capability Guidance (NUREG 0700 App. B)

These attributes are difficult to measure. The guidance is not practical and would be difficult to apply to existing control rooms. A BTP on work load analysis is needed.

15. Applications of NUREG 0700 Guidance to Local Panels and Plant Maintenance

It would be beneficial to plant operation if local panels followed the same human engineering guidelines as described in NUREG 0700 for Control Rooms, including Chapter 1 through 5 as well as Chapter 6. Local panel operators may not be as well trained as CR operators. Consistent good human engineering is important because of this.

It would also be beneficial if human factors were included in the design of equipment and procedures for effective maintenance operations. Such things as labeling, parts removal and assembly, equipment location and accessibility, status and position monitoring, and procedures to reduce chances for related errors should be covered in the guidance.

16. Coding and Conventions

There are several aspects to this subject, which includes audio signals, symbols, colors, abbreviations, etc.

- A) Color codes, conventions and abbreviations should be consistent throughout the CR and plant.
- B) A position should be stated regarding
 - (1) the maximum acceptable number of colors and sounds, beyond which degradation of operator performance might occur,
 - (2) coding methods which are acceptable or unacceptable to NRC.
- C) Consider writing a BTP for this subject, which could include guidance on how to evaluate it in a CR, and how to evaluate utility conventions that differ from the guidance.

17. Labels and Characters

It was suggested that a separate guidance document cover all applications of character size, style, etc., and that it include a guideline regarding space between the edges of the label and the characters on the label.

18. Deviations from Guidelines

A BTP should be issued stating NRC positions and rationale for the following:

- o to what extent will NRC accept deviations from the guidelines? (e.g., 3 button vs recommended 4 button annunciator controls)
- o how will deviations be addressed, oriented to the degree of deviation?
- o to what extent will NRC accept economic factors as items of consideration?
- o Examples from Mimics and Mirror Imaging (NUREG 0700 - 6.6.6.4, 6.8.3.3)
 - a. When is mirror imaging acceptable and when is it not acceptable?
 - b. Does mimic fidelity take precedence over "no mirror" guidance?
 - c. Is a perfect mirror mimic of a small portion of the plant acceptable?
 - d. Is a mirror of the actual physical plant acceptable?
 - e. Mimic arrangements per plant layout vs logical arrangement (e.g., flow paths, sequence of operation).

19. Eyeball and Eardrum Tests for Guideline Compliance

A simplified non-instrumental methodology should be considered to determine compliance with the objectives of visibility, readability, legibility, audibility. Design criteria in an appendix could be used to diagnose discrepancies and determine corrective actions.

20. Hostile Environments

BTPs should be written to cover:

- o protective clothing and equipment
- o communications capability when wearing protective clothing
- o protection against radiation and toxic gases
- o protection against catastrophic events such as falling ceilings and light fixtures
- o operating capability when wearing protective clothing

21. Rationale of the Guidelines

It would be beneficial to users if a BTP supported the guidelines by explaining their rationale in limited detail.

22. Integration of Multiple Inputs

In situations which require the consideration and integration of several sources of information, a good prescriptive methodology or training would enhance a user's subjective judgments concerning evaluation, diagnosis, decisions or determinations of subsequent actions. The multiple sources can be other persons, displays, or guidance from more than one section of the guidelines. An example is the need to integrate the guidelines to resolve the requirements for specific functions which might be performed by common vs multiple equipment. (e.g., first out alarms, sequence of events, alarm records, on a per-panel vs total plant basis). Another example is the consideration of data vs information, or component vs system level, displays which may guide an operator to optimal responses.

23. Reactor Protection System

A BTP should consider whether there is presently too much of these systems on the backs of the boards and not enough on the main board.

24. Definition of CR Operation Area

A BTP needs to be written to define the CR operating area in order to define when operators are in or out of the CR and help evaluate staffing and scheduling.

25. Safety Consequences

The issues of direct, indirect and minor safety consequences should be studied and a position stated which explains whether and how the NRC will consider differences among them.

26. Relationships of Fall-back and First Line Controls/Display Systems

The functional relationships expected by the NRC should be stated, e.g.,

- o Should RSPs include the capability for both hot shutdown and cold shutdown?
- o Are remote facilities adequate to perform their functions under emergency conditions?
- o Is displayed information complete enough to monitor the function being executed?

VIII. Contributors

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