ABB
ASEA BROWN BOVERI

May 8, 1992
LD-92-065

Docket No. 52-002

Attn: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: System 80+™ Supplements to RAI Responses

References: 1. ABB-CE Letter LD-92-038, Submittal Schedule, March 25, 1992
2. NRC Letter, Review of Human Factors, April 3, 1992

Dear Sirs:

Enclosed with this letter are four attachments which provide information to support the human factors engineering (HFE) review for the System 80+ control room. This information has been discussed in recent meetings (April 16-17 and April 24) is consistent with the commitment in Reference 1 to provide "miscellaneous RAI responses" as they are completed.

Attachment 1 provides revised responses to RAIs as discussed at the April 16-17 HFE review meeting.

Attachment 2 provides initial comments on the proposed HFE review criteria. We agreed to provide early review comments at the April 24, 1992 meeting on this subject and we expect to provide additional comments in the future as the HFE review continues.

Attachment 3 provides a comparison of the HFE and control room design process proposed by ABB-CE with that reflected in the HFE review criteria proposed by the NRC staff. There is basic agreement on what the elements of the HFE process should be, but there are significant differences on the method and bases for demonstrating compliance.

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Attachment 4 provides a summary listing and actual documentation being placed on the docket to support previous responses to RAIs. This documentation was discussed in Reference 2 and in the April 16-17 HFE meeting.

If you have any questions, please call me or Mr. Stan Ritterbusch at (203) 285-5206.

Very truly yours,

COMBUSTION ENGINEERING, INC.

C. B. Brinkman
Acting Director
Nuclear Systems Licensing

CBB/ser
cc: J. Trotter (EPRI)
T. Wambach (NRC)

ATTACHMENT 1

DLH231.DOC/1

Number: 620.1

Question: Provide a detailed human factors program plan which includes (1) a scope of work, (2) the organization of the human factors group and their reporting structure, (3) a description of the human engineering and system analysis studies to be performed, (4) the standards and guidelines that will be generated as a result of human factors efforts, (5) a schedule of major human engineering milestones and technical reviews with anticipated levels of human engineering support, and an outline of the human factors test and evaluation plan.

Response: C-E's original response to RAI 620.1 is being supplemented by the submittal of a Human Factors Program Plan. This plan was submitted by C-E letter LD-92-028, dated February 21, 1992.

C-E will modify this plan to reflect the ABB-CE DAC/ITAAC for Human Factors, Element A, Human Factors Engineering Program Plan management when this document is fully developed and agreed to.

Number: 620.2

Question: Describe the human engineering studies that led to the selection of the flat panel programmable displays used on the control boards. Describe how they meet the operator and instrumentation requirements identified in the task analysis, as well as the maintainability, and reliability requirement established for control room instrumentation. Also address how they contribute to the goal of redundancy and diversity. Include relevant findings from task analyses and product evaluations.

Response: Human factors engineering was not one of the initial considerations in selecting flat panel programmable displays. These displays were originally selected based on diversity, seismic, maintenance, and reliability reasons. Hence, no 'up front' formal human factors studies contributed to the selection of flat panel displays. (1) However, as members of the Nuplex 80+ control complex design team, human factors staff contributed to the selection of these displays through a preliminary evaluation of the technology for the man-machine interface. The design team made judgements regarding the adequacy of the hardware for the intended man-machine interface application.

A preliminary evaluation initially determined if flat panel devices could acceptably provide the features required (i.e., touch selection, flash, bar charts and digital display) and that the viewing cone was acceptable for intended panel applications. Later the devices were evaluated in specific Nuplex 80+ applications during the dynamic suitability verification analysis. This analysis (1) confirmed the judgements made in the preliminary evaluation that the hardware provided an acceptable interface. Additional information on the selection of flat panel technology is provided in Section 3.6 of the Human Factors Program Plan for System 80+.

The function task analysis results indicated that for many tasks, such as monitoring pressurizer pressure, a single value of a parameter is required, not multiple channels of data that may be provided by plant instrumentation. Discrete indicators using flat panel displays meet this need specifically by providing a single validated parameter value instead of multiple channels. The operator receives a single high quality data point based on multiple channel inputs. The selectability of individual channels meets needs for other tasks such as required during equipment failure situations. Similarly, spatially dedicated displays of high priority alarms required dynamic tiles (i.e., could be either Priority 1 or 2) with the ability to display multiple messages for alarm conditions grouped in a tile. The flat panel devices met these operational needs. Process controllers were designed similar to conventional plant controllers using flat panel displays. Task analysis results providing indication and control characteristics indicated that selection of inputs, selection of setpoints, output control and mode selection were required to meet operational needs. The human factors usability of the flat panel display interfaces was assured by using the standard interfaces defined in the Nuplex 80+ Control Complex Information Systems Description (NPX-IC-SD-791-01) and adhering to the Human Factors Standards and Guidelines Document. Suitability verification evaluated their ability to support their intended user tasks.

Flat panel Electroluminesent displays are easily removable from Nuplex 80+ panels by disconnection of quick disconnect cables and removal of four bolts. Replacement of a device takes significantly less than one-half hour. The published expected MTBF of these devices is 30,000+ hours resulting in an availability of 99.998%. Actual in-service experience is exceeding this number and revised published numbers exceeding 40,000 hours can be expected.

Flat panel displays provide indications and alarms on diverse technology that are redundant to information provided on Data Processing System CRTs. This directly supports the Nuplex 80+

approach to address potential common mode failures with diversity. Additionally, flat panel displays for DIAS N and P provide redundant display of Category 1 PAMI parameters required by Regulatory Guide 1.97, with all of the required characteristics of Category 1 variables. From an operations viewpoint, diversity and redundancy provide the operator with confidence in his data by providing an easy means of cross-checking.

A flat panel product hardware study was conducted comparing Liquid Crystal Displays (LCD), Electro-Luminescent Displays (ELDs) and Plasma Displays. This study consisted of an evaluation of products from various vendors for each hardware type. The conclusion was that ELDs were the superior flat panel technology, based on electrical and seismic (not human factors) criteria. Subsequent verification evaluated ELDs from a human factors and operations viewpoint, including viability, resolution and other MMI features were checked as described in the verification report (NPX-IC-TE-790-01). (1)

DLH231.DOC/5

Number: 620.3

Question:

(1) Describe the technical and administrative methods used by C-E's human factors specialists to track the evolution of the design and to influence the design process.

(2) Describe the documentation control system that is in place to ensure that the evolution of the man-machine interface elements of the design have been documented and provide an auditable documentation trail. How are the results of studies, design decisions and trade-offs documented?

Response:

(1) The I&CE department has a comment-resolution tracking system that is used to assure future implementation of open items identified during the design process. This system was used by human factors specialists as well as by all members of the Nuplex 80+ design team. For short term tracking, human factors specialists' comments and recommendations have been documented in reports such as design review meeting minutes or the verification analyses results and then integrated into the subsequent revision to design documents. A CESSAR-DC open items list also provided tracking for specific items to be incorporated into CESSAR-DC revisions. The C-E ALWR Project Office maintains a database and tracking system which is used by the entire System 80+ design team, including human factors specialists. This tracking system includes a description of the item, due date, responsible staff members. Rather than implementing a separate tracking system for human factors issues only, human factors concerns are tracked and addressed in the same manner as other technical concerns for System 80+. This integrated system is used for subcontractor issues as well as exclusively C-E issues. The database for this system is currently being expanded to include a dedicated (segment) for tracking human factors issues and will assure that it continues to be a long-term, full-scope tracking methodology.

(2) The design was tracked as it evolved through internal memoranda and Nuplex 80+ documentation. The internal memoranda were the primary means for documenting design decisions and trade-offs. Trade-offs are discussed and evaluated as part of the integrated review process described in the human factors program plan. Internal memoranda including minutes and action items resulting from design review meetings document these trade-offs. C-E has previously committed to develop a design document that consolidates the design evolution memoranda with emphasis placed on the bases for design decisions. Results of studies are documented in either Nuplex 80+ documents or milestone reports for the DOE Advanced I&C Program. The Human Factors Program Plan for System 80+ describes the elements of the design process, the rationale for key decisions and the documents that the results are found in.

Number: 620.4

Question: How many human factors specialists are currently dedicated, on a full-time basis, to the System 80+ design? Into how many hours of face-to-face contact time does this translate with the NSSS and BOP engineering and design staffs per weeks?

Response: Currently there are four human factors positions dedicated to the Nuplex 80+ design. When other duties briefly occupy an assigned specialist, the man-hours are reallotted to another specialist. These specialists are an integral part of the Nuplex 80+ design team and would approximately account for 160 hours per week of human factors effort for Nuplex 80+. The number of human factor specialists on the design team has ranged from one (initially) to four (currently), depending on the work being performed at any given time in the design process. Section 1.2.1.1 of the Human Factors Program Plan for System 80+ provides additional details on the level of human factors efforts for Nuplex 80+.

Depending on the activities being performed, the direct contact with other design team members ranged from 15% to 75% of the human factors specialist's time with an average of approximately 25% or 10 hrs/wk. This includes face to face meetings and discussions, walkthroughs, and document review but does not include administrative time, telephone calls, and documentation or development efforts. Levels of interface varied depending on the nature of the design task. For NSSS design, the level of HF involvement is significantly higher than for BOP design because for the BOP design, the NSSS HF principles apply. Designers are merely applying the mature design, not developing it. A breakdown of the nature of HF involvement for the four principal design areas is:

Area	Involvement
1. NSSS (Control Room & RSP) Design -	Continuous involvement in planning, design development, design reviews, prototyping, verification, validation, etc.
2. Subcontractor Control Room Work -	Primarily follows HF guidance, direct HF input via design reviews, discussions. HF review of all documents, V & V.
3. BOP (Pump Handles, Architecture, etc). -	HF Review of Design
4. Local Workstations*	Follow HF guidance, HF Reviews of product, HF provides input on request of principal designer.

Human factors specialists were involved in hardware selection and software engineering as well as the man-machine interface design.

*Note that local workstations are no longer being considered as part of certification but are still being considered in the design.

Number: 620.5

Question: Chapter 18 Section 17.7.1.1.2 describes the use of 11 colors; TE 790-01 Paragraph 3.1.2, Point 1, identifies another two colors; and SD640 Paragraph 6.1.4.1 identifies two or more colors. There is no clear and concise presentation of the information coding scheme used in the System 80+ control room.

Provide a matrix of all the information coding methods and their meanings used in the control room. This would include, at a minimum, the colors, the symbols, changes to alphanumeric and symbols such as case or size, any patterns, position/location/denotation of data that would convey information, flash, flash rate, figure-background changes, reverse video, color changes (include contrast ratios), changes in intensity, etc., or any combinations thereof that are used on software driven and hardwired displays that provide some kind of quantitative or qualitative information to operators or maintenance personnel.

Response: (Revision 1)

The issue of Nuplex 80+ coding was one of the seven technical issues addressed in detail during meetings with the NRC Human Factors branch on 11/17/91 and 12/4/91) as well as in the supplemental response to RAI 620.13. This response is being provided to Question 620.5 to further clarify the matter and provide details requested in the 12/4 meeting. The following issues will be addressed:

a) The Nuplex 80+ coding scheme and the identification of the documents where details reside are provided below.

b) Examples of rationale (including Human Factors Engineering rationale) for selection and assignment of individual code dimensions.

c) Differences in coding as they pertain to different equipment (such as CRTs, flat panel displays, etc.).

The revised coding scheme matrix was provided in the table presented at the 12/4 meeting and attached here for reference, to demonstrate and provide examples of systematic use of human factors engineering in the application of information coding.

Coding conventions are explained in two project documents the Control Complex Information Systems Description and the Human Factors Standards and Guidelines (to be issued by May 23, 1992). Coding techniques were developed from standard guidance (see Ref. List RAI response 620.31) and later specified for Nuplex 80+ in the HF Standards and Guidelines Document for HWRF. This version of the S&G is being used by the team prior to the formal issue of the ALWR version.

Coding conventions do not vary across hardware or software types in Nuplex 80+. The same type of line (e.g.-thickness, style), nomenclature, color code, flash rates, and other aspects of coding are used regardless of hardware type. For example, red has (the 'big screen') as on CRT displays, pushbutton switches, and matrix provided in this response is applicable to all types of hardware. The only variance to this coding standardization is that order to provide alarms, indicators, and process controllers on qualified hardware. However, this variance does not adversely affect the man-machine interface since, in all cases, color is a secondary coding mechanism. That is, anywhere where color conveys information, such as red for an open valve, it is redundant with another coding mechanism (in this case whether the valve symbol is filled or hollow).

Coding Examples and Rationale:

Some examples are provided below to illustrate the process used in choosing coding techniques based on human factors rationale. Similar methods were used to develop all coding types and the source materials cited below were utilized as were other standard human factors publications such as Salvendy, Van Cott & Kincade, pertinent NUREGs, et. al. A full listing of main source materials may be found in CESSAR/DC and in the original response to RAI 620.31. The Design Bases Document for System 80+ Human Factors Standards and Guidelines lists all HF bases used by the design team. This document will be provided in the upcoming additions to the material docketed on 4/17/92.

Letter Height: Minimum MMI letter heights were determined using the viewing distances based on control panel size and the visual arc formula found in NUREG-0700. Larger sizes for hierarchical information were based on hierarchical label setups described in report EPRI-NP-3659. The practice was standardized in the HF Standards and Guidelines and the Information Systems documents.

Color: Based on guidance in NUREG-0700, a limited set of basic colors were chosen, to avoid the 'rainbow effect' from overcoding. The color set will be used in the context of control panels, for both control devices and information displays. The bases for this coding may be found in the HF Standards and Guidelines Bases Document. Samples of rationale are provided below.

Black: Background color, label text
(rationale: provides high contrast).

Blue: Component control status: auto/permissive/on-line
(rationale: Industry standard per EPRI NP-3659).

Green: Component status: off/inactive/de-energized/no-flow
(rationale: nuclear power industry convention, meets NUREG-0700 6.5.1.6c.(2)).

Red: Component status: on/energized/active flow status
(rationale: same as for green).

Yellow: Alarm annunciator
(rationale: good warning (attention getting) color per EPRI-3659, available on electro-luminescent displays).

Orange: Component control status: manual; non-alarm annunciator
(rationale: industry convention, supported by orange uses listed in EPRI-3659).

Light Grey (lo intensity white): Static data (e.g. menu options)
(rationale: Per NUREG-0700).

Grey: Dividing lines, piping, non-controllable components, grids, and miscellaneous items; minimally informative and static support items
(rationale: Per table 6.5-7 of NUREG-0700, also for grey and lt. grey, note that items are expected to be of low prominence).

Cyan: Descriptors of dynamic process parameter values
(rationale: draws attention well but not as readable as white, therefore provides visual search landmarks but a noon-critical distinction.

White: Dynamic data (e.g.-process parameter values & system response to operator touch)
(rationale: high contrast, used per EPRI-3659 for best readability of most informative info).

Purple: Wording on labels for post-accident monitoring indicators (rationale: good contrast with white label background; purple used sparingly per EPRI-3659).

Component and System Status Coding (Refer to Figure 2 for an example):

Use of Fill for inactive/closed/off Components: Standard based on consistency with industry convention for valves in P&ID drawings. Easily discriminable on CRTs and flat panel screens.

Use of Hollow for active/open/on: same as for fill; also provides good contrast to fill.

Use of Dark (Red/Green/Fill-no fill): Matches conventional control panels which use lights out, leaving dark red/green lenses, to indicate loss of control power. The Nuplex 80+ convention is common to the whole MMI (IPSO, CRTs, control switch backlights, etc.).

Use of Triangles for Active/Inactive System Status: Unique use of triangle shape, no existing or conflicting industry conventions for 'system'. Uses standard Nuplex 80+ red/green and hollow/fill.

Asterisk: Indicates suspect data, used for salience per NASA USE-100, unique use of this code.

Underline: Used below descriptors to indicate that there is an operator aid associated with the parameter or component (provides information but low importance). Same rationale as for asterisk.

Alarm Coding Rationale: (refer to Table 1). Below is the rationale for the alarm coding methods used in Nuplex 80+. Refer to Section 2.6 of the Human Factors Program Plan for System 80+ for a full list of design basis references for the alarm system. In general, a combination of this guidance and the practical limits on display technology, plus flash rates and other clearly specified guidance in

NUREG-0700, Sections 6.6.3 and 6.6.4 provided the design basis.

Alarm Priority: Alarms are shape and salience-coded for priority with increasing salience corresponding to higher priority. Salience levels were chosen by empirical evaluation of prototypes. See Figure 1 and Table 1 for details.

Alarm Status: Changes in status of alarms are indicated by flashing and hue, good attention-getting features (per EPRI NP 3659, et. al.). Fast and slow flash rates are used as described in Table 1. Exact flash rates are still to be determined but will fall within the ranges of NUREG-0700. Duty cycles of 50-50 and 25-75 are used as appropriate based on NASA-3000. See Table 1 and Figure 1 for details. Three hues of yellow were selected to allow coding of multiple-status alarm tiles. The 3 hues were acceptable per NASA-3000 and prevented masking, a common problem with multiple input or combined alarms on existing systems.

Audible Annunciation: Momentary audible tones give clear, unambiguous announcement of new, continuing unacknowledged, and cleared alarms. Limiting tone to momentary presence avoids disrupting operators. Tones were selected for sound characteristics per NUREG-0700 and EPRI NP-3448.

TABLE 1

EXAMPLES OF ALARM CODING

ALARM CONDITIONS

WITHIN THE ALARM SYSTEM, DIFFERENT PRIORITY CONDITIONS ARE REPRESENTED BY THE APPLICATION OF COLOR (shade), DESIGN AND FLASH RATE. THE TABLE BELOW LISTS THE CONDITIONS AND THEIR DISPLAY ATTRIBUTES:

Unacknowledged Alarms	Display Attribute (same on tile or CRT)
New Priority 1	Fast flash & reverse video
New Priority 2	Solid fast flashing wide border
New Priority 3	Solid fast flashing brackets
New Operator Aid	Fast flash orange underline
Acknowledged Alarms	
Cleared Priority 1	Slow flash, reverse video
Cleared Priority 2	Slow flash, wide border
Cleared Priority 3	Slow flash, at brackets
Cleared Operator Aid	Not displayed, goes directly to reset
Existing Priority 1	Solid background
Existing Priority 2	Solid wide border
Existing Priority 3	Solid brackets
Existing Operator Aid	Solid dark orange
Reset	Static non-flashing

Notes:

1 - Color: New-Bright Yellow, Existing=Medium Yellow, Cleared=Dull Yellow

2 - The highest priority unacknowledged alarm is shown where multiple conditions exist.

3 - The highest priority acknowledged alarm is shown where multiple conditions exist.

4 - Unacknowledged and acknowledged alarms are shown simultaneously.

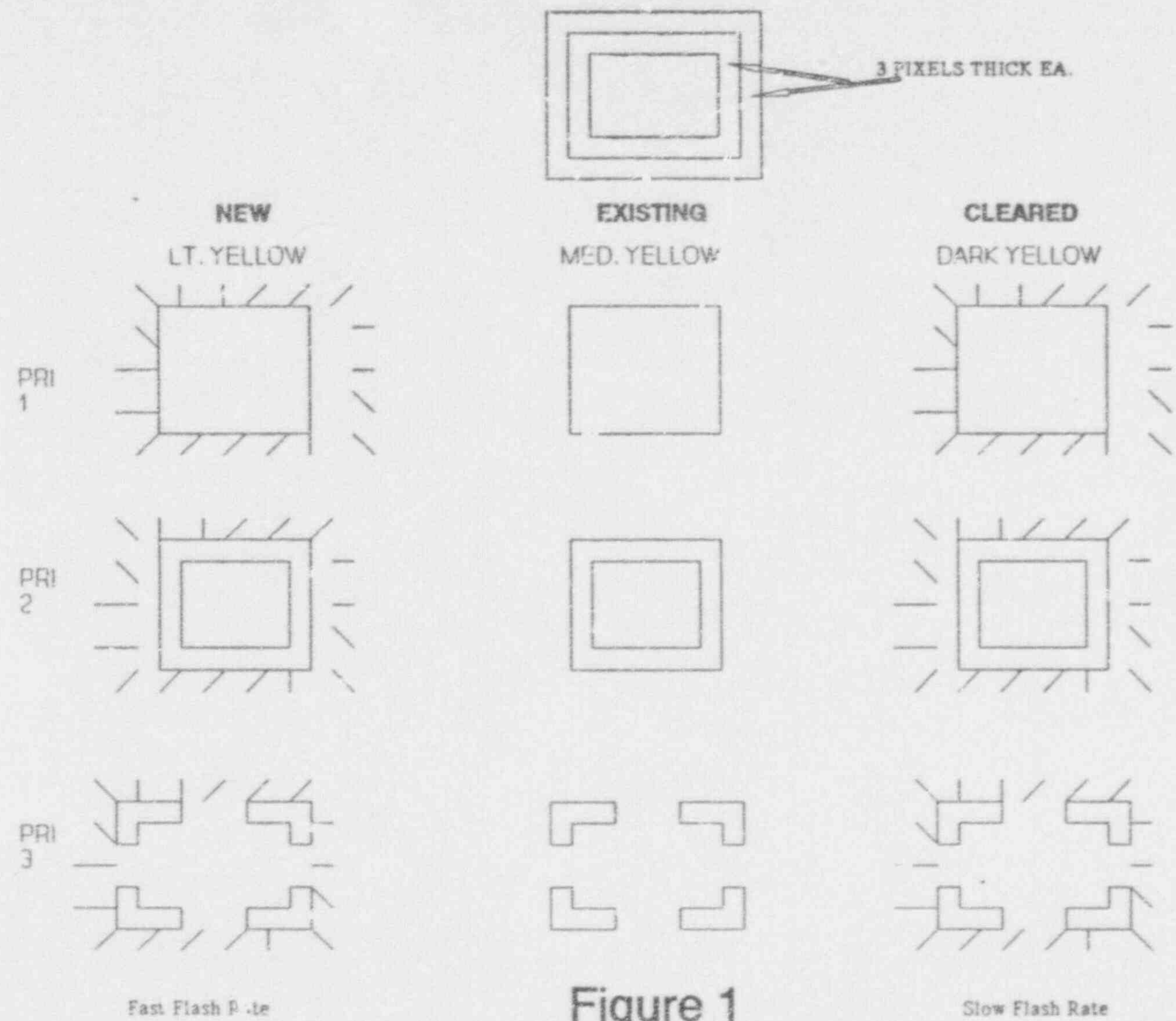

Figure 1
Examples of Alarm Coding

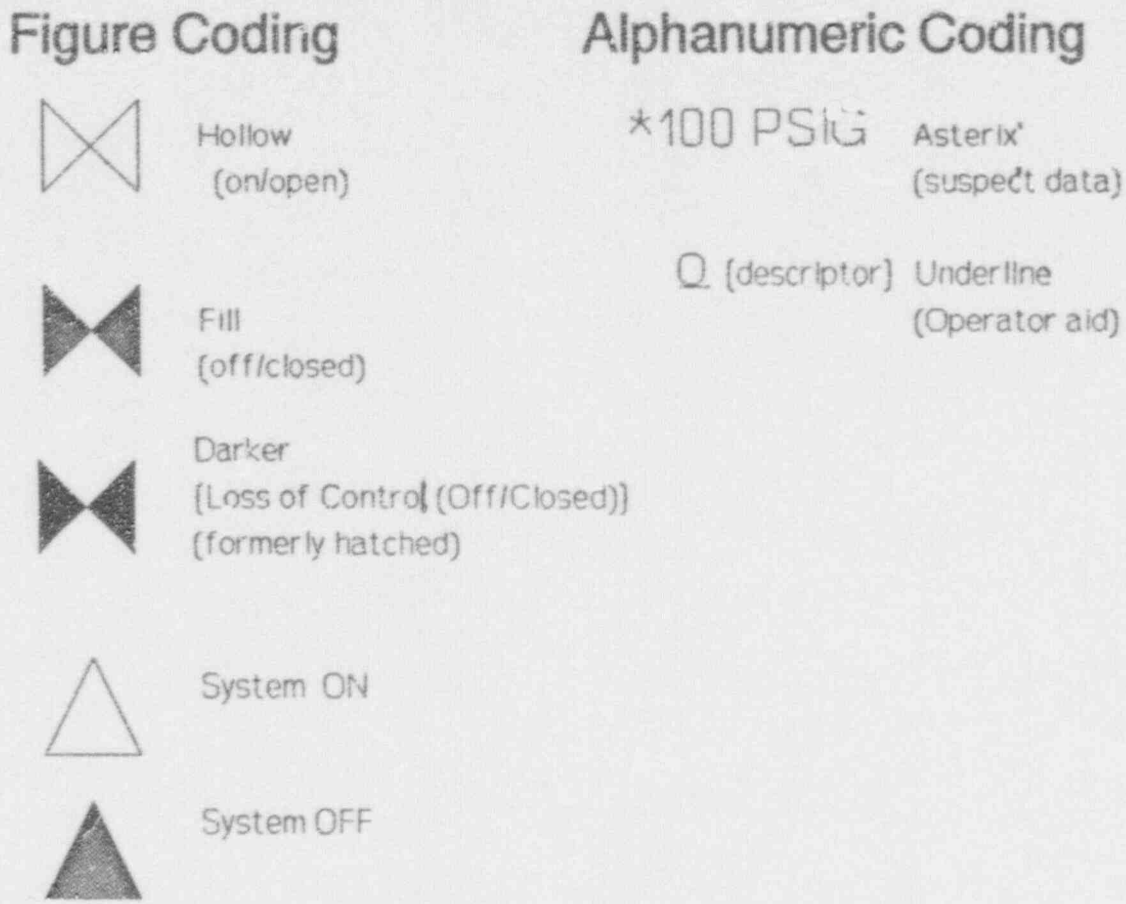

Figure 2

Examples of Nuplex 80+ Coding Techniques

(USE IN CONJUNCTION WITH 620.5-1 CODING MATRIX)

Number: 620.6

Question: Describe the standardized training materials (e.g., content, format, and development process) being provided to the purchasers of the C-E System 80+ for those aspects within the CESSAR design scope.

Number: 620.7

Question: Describe the guidance that will be provided to purchasers of the C-E System 80+ to ensure consistent adaptation of the standardized training materials to site-specific training materials.

Number: 620.8

Question: Given the advanced technology of the C-E System 80+ what are the specific skills, knowledge, abilities, and aptitudes, based on the task analysis, that will be provided to purchasers to assist in the development of site-specific personnel selection criteria?

The information provided in Section 13.5 indicates that information concerning the site-specific operator plant procedures is within the referencing applicant's scope and shall be provided in the site-specific SAR. Since this is not consistent with the staff's position on standardization, the following should be addressed.

Number: 620.9

Question: Describe the standardized normal, abnormal, and emergency operating procedures C-E will provide to the purchasers of the C-E System 80+.

Number: 620.10

Question: Describe the standardized procedural development guidelines to be provided to referencing applicants for those normal, abnormal, and emergency operating procedures (e.g., writer's guide, verification, and validation guide, procedural maintenance guide). Describe the interface information that will be provided to ensure that site-specific procedures will be consistent with the standardized procedures.

Response: Response to Questions 620.6-620.10

The C-E approach to training and procedures was provided in a letter to the NRC (LD-92-002), dated February 18, 1992.

As stated in CESSAR-DC, Sections 13.2 and 13.5, the procedures and training for a particular plant are within the scope of the site-specific SAR. C-E intends to comply with the staff's "training and procedures" position by providing standardized training and operating procedures guidance. This guidance would then be input to the site-specific training program and operating procedures. This approach is necessary as a result of site-specific component selection (meeting standard functional requirements) and utility-owner responsibility for plant operation. Of course, a particular utility/owner may contract with C-E to provide detailed training and procedures. As a result of the February 7, 1991 meeting with the staff, C-E understands that standardized, detailed training and procedures are still requested. C-E is initiating a program including architect-engineers and utilities to address the issue of training and procedures for standardized designs such as System 80+. This program will cover the complete time span from NRC design review through plant construction and startup. It is expected that the first meeting for this program will occur in the April-May 1991 time frame.

Number: 620.11

Question: Does System 80+ use advanced and intelligent operator aids based on expert systems or other artificial intelligence (AI) technologies? If so, describe the following:

a. The extent and dependence on intelligent operator aids necessary to achieve the single operator design goal.

b. The specific operator aids that are planned and technology on which they are based.

c. The methods of knowledge engineering that will be used.

d. The approach to be taken to develop operator confidence in the systems to assure that they will be appropriately utilized.

e. The methods to be used for the verification and validation of the performance of intelligent operator aids.

Response: The Nuplex 80+ ACC uses no expert systems or AI technology in any of its system designs, including the advanced operator aid designs. C-E would like not to preclude the use of expert or AI systems at some time in the design, since they may offer improved information processing and MMI performance. If they are used, approaches to develop operator confidence, perform verification and validation and assure appropriate use will be developed. If incorporated, advanced operator aids will supplement, not replace, the current features of the design on which the staff is basing their safety evaluation. Analysis will be provided to assure that supplemental features do not conflict with licensed aspects of the design.

(Note that the term "operator aids" in System 80+ does not refer to performance or job aids in the generic human factors sense. For System 80+, operator aids are a presentation of supplementary (level 4 alarm priority) type alerting information.)

(a) There are advanced operator aids in the Nuplex 80+ design that are not based on AI technology. None of these is specifically required or was specifically designed to support the single operator design goal; however, as integral parts of the MMI, they do contribute toward this goal.

(b) The advanced operator aids provided in Nuplex 80+ are primarily integrated functions within the Data Processing System (DPS). They are available on any CRT in the Nuplex 80+ design. These aids are listed below with indication of where they are described in CESSAR-DC and a brief description of their benefits to operation.

1. Core Operating Supervisory System (COLSS), Section 7.7.1.8.1

   COLSS continually calculates core related parameters and compares them to appropriate Limiting Conditions for Operation (LCO). COLSS alarms indicate any LCOs that are exceeded, tiating operator action required by technical specifications. The major benefit is automation of complex calculations providing improved monitoring and no operator burden required to perform it.

2. Critical Function Monitoring, Sections 7.7.1.10 and 18.7.1.8.2

   The major benefit of critical function monitoring is to continuously alert the operator to conditions which are having an impact on the ability to keep the plant in a safe condition or producing power. For critical safety functions, critical functions monitoring automatically and continuously performs the monitoring actions required by the emergency operating procedures.

3. Success Path Monitoring, Sections 7.7.1.10 and 18.7.1.8.2

The benefit of success path monitoring to operations is provision of a concise indication of a success path's availability to maintain, or performance in maintaining, a critical function. This benefit has been demonstrated through validations at the Halden Reactor Project, as described in the Human Factors Program Plan.

4. ESF Computer Aided Test (COMAT), Section 7.7.1.8.2

COMAT's major benefit to operations is the monitoring of pretest line-ups, recording test results and monitoring post test line-ups. This is particularly important in preventing components from remaining in test alignments which could prevent proper functioning of ESF systems.

(c) No artificial intelligence is used in the Nuplex 80+ advanced operator aids.

(d) Operators will receive training in all aspects of plant operation as part of the owner/operator training program, including the advanced operator aids. Experience with operating systems in existing plants (e.g., COLSS) and validation of prototype systems (e.g., SPM) provides assurance that operator's confidence in these systems will be high.

(e) The verification and validation of operator aids in Nuplex 80+ will be conducted as an integrated part of the verification and validation activities described in the Human Factors Program Plan. Note that the majority of the operator aids have previously been validated as independent systems.

Number: 620.12

Question: How will C-E demonstrate that the System 80+ design objectives of improving operator performance, reducing maintenance time, and improving reliability are met?

Response: The phraseology used in CESSAR-DC, such as "improving operator performance, reducing maintenance time and improving reliability," requires clarification. These are objectives for the Nuplex 80+ design; however, they are not pertinent to licensing of the design. These phrases will be deleted from CESSAR-DC. The basis for licensing is to demonstrate acceptable operator performance, acceptable maintenance considerations and acceptable reliability. Generally stated, it will be demonstrated that Nuplex 80+ acceptably meets the task needs of the end users (whether operators or maintainers).

An acceptable design shall be defined in terms of performance; namely, the operator will be able to execute his assigned tasks, as defined by all operating procedures, in the context of full scope
simulation for validating testing. Acceptable reliability and (1)
maintenance shall likewise be performance-defined. It shall be shown that hardware and software reliability shall not adversely impact operations. The specific criteria for acceptance of the design during validation shall be developed as part of the DAC/ITAAC process.

DLH231.DOC/25

Number: 620.13

Question: How does C-E plan to demonstrate that "improved plant comprehension" has been achieved over the reference design for:

a. improved alarm presentation and handling
b. continued plant operation with loss of 1 or 2 diverse information display systems
c. integration of normal and accident monitoring displays
d. improved usability of the information presentation methods used to reduce required operator information processing requirements.

Response: Item a. (Revision 1)

C-E has addressed the issue of the alarm hardware and how it was chosen, based on analyses and evolution, in Sections 3.3 and 3.4 of the Human Factors Program Plan which is being submitted as an additional response to RAI 620.1. How , it should be noted that alarm hardware specifics for Nuplex 80, not final at this time. This additional information is in respons the alarm technical areas GSI HF 5.2, GSI I.D.5(1) and to satisfy NRC requests for additional detail in 620.13 (a).

The phraseology from CESSAR/DC such as "improved plant comprehension" of the alarm system requires clarification. Features such as improved comprehension and reduced cognitive workload are desirable and, indeed, are design goals of the man-machine interface design for Nuplex 80+.

Adequate operator performance will be demonstrated through the analyses and reviews described in the Human Factors Program Plan specifically verification and validation. Operator performance during transients will provide the basis of this demonstration. Reviews of alarm inputs and systems designs from existing, licensed System 80 plants will supplement this determination. design reviews of the DIAS system (which incorporates the alarm tiles) and the CRTs continue to provide a method for human factors input to the system, as well as for input from experienced operators on the permanent staff of the design team. Prototyping provides a further opportunity for review and design input, as described in the plan.

Systematic analyses of operations are planned for the entire Nuplex 80+ design, as outlined in the program plan. These include validation, as described in the plan and following the methodology used in the Nuplex 80+ Function and Task Analysis Report and the Nuplex 80+ Verification Analysis Report, both of which have been docketed. Additional analyses will include suitability reviews and (1) validation. In lieu of a formal system analysis for annunciators, industry guidance on problems with different annunciator systems and prospective solutions to these problems were employed to develop the Nuplex 80+ alarm and annunciation scheme.

The following background studies and references contributed to the Nuplex 80+ alarm scheme:

- OECD Halden Studies HWR-213, 222-224 (Re: SPM and CFM)
- Selected DCRDRs (e.g., SONGS 2 & 3) and Industry Guidance
- EPRI ALWR URD, Chapter 10
- NUREG-0700, Chapter 6 (1)
- NUREG/CR-3217, New Term Improvements for Nuclear Power Plant Control Room Ann. Systems
- EPRI NP-3448, A Procedure for Reviewing and Improving Power Plant Annunciator Systems
- NUREG CR-2147, Nuclear Control Room Annunciators; Problems and Recommendations

These studies and references influenced the design in the following ways:

- Halden Studies: Provided basis for using critical functions and success path monitoring as bases for alarms.

Typical alarm system problems and potential solutions were based on recommended practices in industry guidance. No formal analysis was performed. Solutions were prototyped and reviewed by operators and HF specialists.

NUPLEX 80+ ALARM DEVELOPMENT

TYPICAL ALARM SYSTEMS HF PROBLEMS	THE NUPLEX 80+ SOLUTION
1. Alarm Overload/Cascading	Alarm reduction based on:
a) multiple alarms for same condition (e.g.,-channel a, b, c, d, x, y)	- signal validation prior to alarm checking, eliminates multiple channels
b) spurious alarm due to instrument failure	- signal validation eliminates spurious alarms
c) inappropriate alarms for plant/equip. status	- mode/equipment/EOG dependency ensures alarms are relevant & not due to normal line-up
d) poor organization/priority	- spatial dedication for alarms relating to significant operator actions only; provides greater salience to most important alarms
2. Nuisance Alarms	Nuisance alarms eliminated:
- alarms not value or appropriate * spurious alarms * contact bounce * phantom alarms	- software smoothing (eliminates contact bounce) - mode/equipment dependency

3. Audible Signal Problems	- No silencing required - separate tones/freq. for new & cleared alarms - momentary reminder tones (for unack. new & cleared)
4. Alarm Format Problems - wording and lettering - grouping and location - poor organization - unclear coding	Addressed via systematic application of human factors and industry guidance for: - working, letter height - alarm categorization - panel & screen location - coding and meaning
5. Conventional Hardware Problems - inconsistent lighting levels - bulb burnout - inadequate change capability - too many combined alarms a) hard to know cause of flash b) combined reflash masks priorities c) combined reflash masks existing d) combined reflash hides cleared or masks uncleared to show cleared	Eliminated via DIAS/CRT: - no bulbs or LEDs - software disable/alarm downgrade - many more inputs possible a) exact alarm messages b) sorts priority-shows highest c) alarms can be shown together (via coding) d) shows all conditions; cleared and existing
6. Hard to test	- alarm testing from same input in conjunction w. control/protection system - active display heartbeat
7. Alarm Significance Unclear	Significance Visual Mapping used to relate alarm to procedure being used

8. Classic Alarm Acknowledge Problems (Global/Local)	Alarm Acknowledge Criteria - single point, single page to ensure alarms are recognized before flashing & audibles are eliminated - stop flash/resume eliminates visual noise during conditions where the operator is unable to individually recognize/ack. each new condition
9. Alarm Access Difficulty in CRT navigation	- alarm mapping to sectors, directories allows 2-touch access to all alarms, lists allow 1-touch access; for single alarm conditions, it is automatically identified in display window
10. Multiple Alarm Conditions difficult to diagnose	- alarm lists sorted by time or plant area

* Space does not permit a full explanation of Nuplex 80+ alarm features in this column. Refer to the Control Complex Information Systems Description (NPX-IC-SD-791-01) for a full explanation.

The design method from the left to right columns included a design and design review process in which engineers, operators and human factors specialists worked as a team to find solutions to the problems. Prospective solutions were selected from industry references. Prototyping and design reviews resulted in the alarm products which were then subjected to a suitability analysis. In the case of many solutions, operator experience and engineering considerations were the driving design force with human factors providing a consulting and review function. Hence, validation will be performed to assure the adequacy of the solution from a human performance viewpoint. (1)

- EPRI ALWR Requirements: These requirements, as they pertain to alarm system design, were factored in to the Nuplex 80+ alarms scheme to develop features and definitions.

- NUREG-0700, Chapter 6: All functional requirements for the alarm system man-machine interface listed in this document were used as design goals and were met.

- NUREG CR/3217: This reference, along with many industry reports such as EPRI NP-3659 and 3448 helped form the basis for 'Nuplex 80+ Alarm Acceptance Criteria', provided (for illustration, these are not formal DAC) below:

NUPLEX 80+
Alarm Acceptance Criteria

1. Verify Mode-dependency of Alarms
(NO ALARMS INAPPROPRIATE TO PLANT MODE)

- Normal Operations
  * plant dark at power
  * no 'status' alarms (no action required) present

- Normal Transients
  * no extraneous alarms during SU, SD, HS
  * no external alarms during normal Rx trip

2. Alarms Specific to Event

- Abnormal Transients
  * alarms correct for event:
  LOCA, SGTR, ESDE, LOOOP, LOAF, BLACKOUT
  N+1 EVENT (appropriate to functional recovery)

- Normal Reactor Trip
  * alarms indicate only unusual items not normal 'wake of trip' status information

- Dynamic simulation verifies:
  * no cascading alarms (alarm avalanche)
  * no alarms based on inappropriate equipment status
  * no phantom alarms (cause must be discernible)

3. Verify Alarm Priorities

- All Alarms Must Meet Priority Definition when Simulated

4. Reduced Number of Alarms

- The number of alarm tiles actuated during events is less in Nuplex 80+ than in conventional plants)
  * examine transients noted above (high workload)
  * number of Nuplex alarms< number of alarms for reference plant (e.g.-System 80 of same size)
- (Pending Availability of a System 80 simulator)

5. Event Identification

- Through a combination of alarms, operators shall be able to identify abnormal transients during simulation.

6. Verify All Display Alarm Criteria Have been Met

* Alarms are categorized by panel and function
* Alarms can be acknowledged individually or in small groups
* Alarm status and representation (cleared, acknowledged, etc.), are as described
* Process display page, display fields, and navigation are as described
* Alarm suppression features work as described

8. Verify Useability

- Working Prototype; verify with users that:
  * Acknowledge, Test, and Reset functions and actions are understood
  * Prioritization scheme and navigation are understood
  * Various software-based coding schemes are understood

Criterion: When a novice user, after <30 minutes of instruction, can understand the above and demonstrate accurate use.

9. Functional Layout

- Alarms shall be functionally laid out with alarms on the same panel as associated controls and indicators.

-NUREG 2147: Provided details on alarm processing

EPRI NP-3448: Showed the usefulness of retaining spatial dedication

Throughout the design process, relationships between the human factors of the alarm system and other plant information and control methods are standardized and designed to conform to good human factors practice. This is accomplished by providing two documents to designers, the Nuplex 80+ Information System Description Document and the Human Factors Standards and Guidelines Document. Prior to the availability of the latter, industry guidance and studies such as those referenced above were used. These documents, which are based on the aforementioned references standardization of the MMI features such as flash rate, prioritization, letter size, color coding, location, etc. (1)

The development of Design acceptance Criteria for the alarm system will further assure that the design does not deviate from operational needs and the principles of good human factors engineering. The Design Acceptance Criteria for the alarm system add assurance that the design is acceptable in terms of its functionality and useability. Performance-oriented criteria which emphasize operations will be included.

Number: 620.14

Question: What is the projected reliability of the controls and displays in the control room?

Response: The reliability of all Nuplex 80+ control and display systems is documented based on representative hardware (final hardware selections are not made for certification). Typical of Nuplex 80+ system reliability is the availability of control room information from the DPS which has been calculated to be 99.98% with an MTTR of 4 hours. Reliability has not yet been calculated for DIAS, switches, and the Component Control System, but is projected to be approximately 0.1% unavailability for CCS. Switches are projected to have a 300,000-400,000 mean cycle rating (i.e., 300,000-400,000 on/off cycles between failures). DIAS is estimated to be 99.98% reliable. It is important to note that in the Nuplex 80+ design, information is presented through two separate system interfaces (DIAS and DPS) so the availability of information and reliability of the ensemble in providing it is higher than individual system availabilities. Additional availability analyses will be performed on other Nuplex 80+ systems in a similar manner to the DPS. (1)

Control systems (Process-CCS, ESF-CCS and PCS) have redundant controls available in the MCR via dedicated controls and system operators' modules. Thus, the availability of a given control function is significantly greater than in present control rooms. Operators Modules are flat panel displays in the Nuplex 80+ control room which communicate directly with systems such as the plant protection system rather than through DIAS or DPS. The modules are provided for the control of the I&C system functions such as implementation of bypasses. They also serve as a redundant backup to the type of operator task or system control which is better suited for physical control devices (panel switches) or task-oriented process control devices (process controllers). Operator's modules provide redundant control means for both the Engineered Safeguards Features Component Control System and Process. (1)

Number: 620.15

Question: Describe the human engineering analyses and the findings of the analyses that supported the decision to use CRTs and flat panel displays as the primary sources of operator information and hard-wired instrumentation as the back-up instrumentation.

Response: The basis for selection of flat panel displays was provided in the response to Question 620.2. Hardware types and prototypes were reviewed by operators and human factors specialists as part of the selection process. No specific human factors studies were performed during the Nuplex 80+ design process. Verification and validation analyses are being used to assure the adequacy of the man-machine interface for CRTs and flat panel displays. (1)

There are no backups used in the Nuplex 80+ design and no hardwired instrumentation is provided. The entire ensemble of computer based man-machine interfaces, including flat panel displays (DIAS), CRTs (DPS), process controllers, component controls and operators modules (control and protection systems), is treated as an integrated package. Although information and control may be accessible via two media devices, each device is designed such that its attributes encourage its use during all modes of operation. Therefore, all media are familiar to the operator and less likely to induce error under stressful conditions, such as accidents and/or operation with equipment failures. All indicators and controls are qualified to the degree required for their intended function.

Number: 620.16

Question: How was the task analysis used by those responsible for the individual panel designs? On what basis was the allocation of tasks made to specific places of equipment?

Response: (Revision 1)

C-E has addressed the issue of System 80+ task analysis in numerous documents. The following description of how task analysis is factored into control panel layout uses the RCS panel as an example. The same methodology shall be followed in all Nuplex 80+ control panel layouts for System 80+. This method is standardized. The actual panel input is done by experienced operators, not human factors specialists. The HF specialists provide support and review during the layout process. CESSAR-DC Section 18.3 details on the specific RCS panel layout method may be found in this section. Further details on the use of task analysis in the panel design process can be found in the Human Factors Program Plan which is being submitted to supplement the response to RAI 620.1.

TASK ANALYSIS AND PANEL LAYOUT
<u>NUPLEX 80+</u>

I. FTA IS THE FIRST STEP IN NUPLEX PANEL LAYOUT
(*RCS Panel is the Example)

1. - Assignment of Functions

A. Review of FTA/Computer sort of FTA data to identify functions.

B. Evaluate Functions; determine applicability to RCS

C. Engineering/Operations review of Reactor Coolant System functions

D. Compile function list.

2. - Functions Organized Into groups

A. Reactor Coolant Pumps

B. Reactor Coolant Seal/Bleed

C. Reactor Coolant System

3. - Functions Organized On Panel

* The most frequently used functions (based on operating procedures and experience, as well as FTA data) are on the central portion of the panel, others on the periphery, based on their functional relationships (hardware interface/energy flow) with the adjoining panel sections.

4. - High Level Function Analysis

A. Review list of functions and subfunctions to determine adequacy of groups, based on operations.

B. Focus on operating mode.

II. DETERMINATION AND ASSIGNMENT OF ALARMS, INDICATIONS, AND CONTROLS

1. - Develop List of Needed Alarms, Indications, & Controls

A. Review Function and Task Analysis

B. Computer Sort:

* Identify Parameters and Characteristics for the RCS

C. Evaluate Parameters and Characteristics:

* Assign to functional groups (based on procedures, systems and operating experience)

D. Independent Evaluation for Other Parameters and Characteristics; for example:
* I&C design requirements
* System 80+ RCS P&ID
* Support system P&IDs
* System 80 operating procedures

E. Engineering and Operator Evaluation
* Of parameters and characteristics

F. Compile Information Requirements List

G. Review FTA Results and Other Documents:
* To identify controls for RCS panel function

H. Engineering and Operations Evaluation:
* Evaluate list
* Modify list

2. - Further Engineering Performed

- In addition to the FTA
- Hardware selection for the MMI
- Verification and validation

Ala:ms and indications are examined separately from controls. Monitoring tasks were evaluated extensively via the Function and Task Analysis. Control tasks were evaluated to confirm that control allocations for previous System 80 plants remained applicable for System 80+. This was because the control requirements and MMI format for Nuplex 80+ were essentially the same as for existing System 80 Plants. Even in cases where flat appearance for the controllers was very similar to conventional Manual/Auto stations. Not so the indicators; although the type and nature of the information being indicated remained the same for Nuplex 80_ as in existing plants, the man-machine interface used to present it has a different format and does not operate in the same way. Therefore, a new FTA was needed primarily for monitoring tasks and to a lesser degree for control tasks.

Allocation of tasks to specific pieces of equipment was made based on a number of factors such as hardware properties of the equipment, regulatory constraints on the reliability and use of equipment, software functions possible on the equipment, operating experience, and, the human factors 'suitability' of the equipment to the task. In other words, based on reference documentation such as Salvendy's Handbook of Human Factors, MIL-STD-1472D, and Van Cott & Kincade's Human Engineering Guide to Equipment design, it is known what types of hardware are appropriate to generic task types such as monitoring, discrete component control, etc. Using this basis, different tasks were allocated to the basic equipment types: Big Screen, CRT, Electro-Luminescent Displays (ELDs), and Discrete Pushbutton Switches. The rationale for choosing these hardware types is discussed at length in the Human Factors Program Plan. The nature of the identified tasks may be found in the Nuplex 80+ Function and Task Analysis Report.

Some examples of allocation of tasks to specific pieces of equipment are illustrated below, to show design methods used. Electro-Luminescent Displays are used as the sample hardware for the tasks described. Note that required information and control characteristics were selected and this selection drove the hardware decision, as described in Section 3 of the Human Factors Program Plan.

Because of the qualification and high reliability of these devices, ELDs are appropriate for tasks which must be performed during events for which CRTs and Big screen are unqualified, i.e.-assumed unavailable, such as a seismic event. The DIAS hardware is programmable to display information and permit control in a wide variety of formats. The ability of this hardware to display digital and analog trend data for a parameter simultaneously makes it particularly suited to tasks requiring discrete and long-term monitoring simultaneously. Thus were variables such as pressurizer pressure, RCS temperatures, and steam generator levels placed on dedication of information (not possible on a CRT where a variety of displays might be called up) also made them more appropriate for frequent or key monitoring tasks.

The suitability of this hardware to discrete and analog data presentation, as well as to format of a control interface with feedback and larger 'button' sizes made the ELDs ideal candidates to replace traditional hardwired Manual Automatic Stations for process control. Hardware and software properties of the displays allow the user to change and see setpoints while also viewing actual parameter data. As a result, process control tasks such as pressurizer temperature regulation were allocated to the ELDs.

ABB-CE uses the same allocation practice for the other main pieces of hardware. The IPSO display (big screen) is suited only to overview monitoring for a variety of reasons. Pushbutton switches are suited only to discrete control tasks as so only key success path control functions were assigned to them. A description of the human factors rationale for the selection of all control room equipment types can be found in the Human Factors Program Plan.

Number: 620.17

Question: How was the adequacy of the information supplied to the operator to perform the tasks determined for the following:

a. Type of data
b. Amount of data
c. Usability of data
d. Compatibility with other forms of information/data supplied in the plant at local control stations, on specific pieces of equipment, etc.

Response: a)b) The adequacy of information required was determined using the data generated in the task analysis. The characteristics of that data are identified in CESSAR-DC Section 18.5. Specific characteristics for the information and controls of the System 80+ design were identified in the System 80+ task analysis. The Nuplex 80+ design was developed using this data and the other sources of input identified in the response to Question 620.16. This included significant input on controls requirements and the functional decomposition from DCRDR task analysis efforts for existing C-E plants because of their plant's similarity to the System 80+ design. The design was independently verified to have sufficient data with proper characteristics in the Availability Verification. This analysis is described in the response to Question 620.30.

Generic information needs not described in procedures for normal and emergency operation are determined via input from experienced operators. Because the plant systems for the System 80+ standard plant are not significantly different than the System 80, the information needed by operators is essentially the same. The Nuplex 80+ design is not based on "ground zero" and, hence, operator's experience and history are extremely relevant to determining type and amount of data necessary. The validation process and ITAAC developed for it (1) will account for information needs not addressed by procedures used in the task analysis.

c) Determination of the useability of data provided on MMI devices was the key result of the suitability verification as described in the response to Question 620.30. One evaluation was performed in selecting flat panel display technology. This evaluation is described in the response to RAI 620.2 and in Section 3.6 of the Human Factors Program Plan for System 80+.

d) Compatibility of the various forms of information throughout the plant is assured by commitment to use the same Nuplex 80+ conventions plant-wide. This is possible since System 80+ is a complete plant design. Two Nuplex 80+ documents assure consistent and compatible MMI throughout the design; the Nuplex 80+ Information Systems Description and the HFE Standards and Guidelines. The C-E document review system assures that all disciplines including human factors are aware of potential interfaces. Therefore, the design of interfaces at local control stations or specific pieces of equipment will use Nuplex 80+ conventions and be reviewed and approved by Nuplex 80+ design team members.

DLH231.DOC/43

Number: 620.18

Question: Who is on the initial design team and who is on the review team? Are they the same people or are the teams composed of different people?

Response: (This item has been deleted.)

Number: 620.19

Question: Please explain the scope, responsibility, and reporting structure of the human engineering function in the System 80+ program.

Response: The scope, responsibility, and reporting structure of human factors in the System 80+ program are identified in the Human Factors Program Plan (see RAI response 620.1). (1)

DLH231.DOC/45

Number: 620.20

Question: Identify the human engineering principles established for Nuplex 80. What analyses were used to identify the areas requiring improvement. What "specific improvements" were added?

Response: The design was based on a functional task analysis. Human factors specialists and operators were heavily involved in all phases of the design, availability and suitability verification analyses were performed and a dynamic mock-up was used to evaluate and refine the design.

A significant source used to identify areas requiring improvement in Nuplex 80 was customer feedback. Nuplex 80 was sold to TVA and New York State Gas and Electric for System 80 plants. As is indicated in CESSAR-DC, a significant amount of design work was done for TVA. The design was also bid to Tai Power in the early 1980's. A number of the areas addressed in the Nuplex 80+ were identified by customers during the design and bid processes.

A description of analyses and performance measures (past and future) can be found in the HF Program Plan.

During the Nuplex 80+ design process areas in the Nuplex 80 design requiring improvement were identified and considered through design review meetings. These meetings included operators, human factors specialists, instrumentation and controls engineers and project management. Each improvement area was considered for regulatory requirements, customer desires and technical considerations, such as advances in technology. Specific areas requiring improvement were identified and addressed as indicated in Section 18.6.1 of CESSAR-DC. These include removing hardwired backups for indications and alarms and integrating spatially dedicated indications and alarms into the primary interface with no backups. This allows the operator to use his normal interface during stressful situations such as losing CRT display capability. A dedicated console for a control room supervisor was added since utilities desired a supervisor to perform a monitoring and direction role and no workstation to support this role was available in Nuplex 80. To meet plant availability goals, Nuplex 80+ is designed for continued operation upon complete failure of the DPS instead of requiring shutdown as with Nuplex 80. Nuplex 80+ incorporates alarm handling improvements, to address industry concerns with alarm systems. These improvements include plant mode dependency, spatial dedication of alarm tiles, use of flat panel technology, significance visual mapping (relating the alarm to the procedure being used) and alarm lists sorted by plant area. Incorporation of the big board IPSO into the design provides a plant functional and system overview not available in Nuplex 80. Integration of the SPDS function into the normal man-machine interface through critical functions monitoring makes it part of the everyday interface and, thus, familiar during accident situations. Application of advanced control system improvements which were developed for conventional plants (e.g. automatic low power feedwater control) and were not available for Nuplex 80 also improve plant availability. Integration of divisional equipment into common panels rather than separation by panel sections as in Nuplex 80, allows multiple success path coordination by one operator and improved task performance.

No formal human factors analysis was done for the plant alarm system improvements, the addition of a control room supervisors' console, or the integration of PAMI/SPDS into normal indications. The design process used operations experience, design team consensus, and the design review process to enhance the baseline Nuplex 80 design. Verification and validation analyses will demonstrate acceptable operator performance as defined in DAC/ITAAC. (1)

DLH231.DOC/47

Number: 620.21

Question: How was the potential for human error identified, reduced, and documented in "Reduce the potential for human error that could affect safety or availability?"

Response: The phraseology used in CESSAR-DC, "Reduce the potential for human error that could affect safety or availability," requires clarification. This is a design goal for Nuplex 80+ but, is not pertinent to the licensing of the design. This phrase will be deleted from CESSAR-DC in a future submittal. The basis for licensing will be to demonstrate acceptable operator performance. Inherent in that determination will be an acceptable potential for human error. Human error probability will not be analyzed as a unique dependent variable.

The following paragraphs identify the approach to addressing significant human error potential as a design goal, not a licensing requirement.

Specific problem areas where there was a relatively high potential for human error were identified during the early phases of the DOE Advanced I&C program. This was accomplished by reviewing LERs, Regulatory Guides, I&E bulletins, NUREGs, EPRI reports and other industry reports (e.g., Halden reports). For example, Regulatory Guide 1.97 recommends that the same instruments should be used for accident monitoring as are used for normal operations to enable operators to use familiar instruments during accidents. This led in part to the no backup approach of Nuplex 80+. Other specific areas for improvement were identified in Chapter 10 of the EPRI ALWR-URD.

Solutions were formed for the problems identified and incorporated into the design. For example, one area identified as resulting in a high potential for operator error at conventional plants was low power feedwater control. Numerous reactor trips have resulted from manual control during this condition. Digital feedwater systems providing automatic control at low power have been installed at existing plants and have reduced the potential for error in this condition significantly. The same digital control system design is incorporated into the Nuplex 80+ ACC.

C-E will verify that new problems have not been introduced by the solutions to existing problems rather than demonstrating a reduction in error potential compared to a conventional control room. The Nuplex 80+ verification and validation analyses will show that features incorporated to solve problem areas do perform without introduction of new errors. The suitability of the interface was evaluated in the verification analysis for the RCS panel and will continue to be performed as part of the design process for the rest of the panels. Validation of the features in relation to plant operation using the complete control room design will occur later in the design process using the integrated test facility. The acceptability criteria and performance goals for validation will be identified in the DAC/ITAAC. The software based designs used in Nuplex 80+ are more suited to incorporating changes identified during V&V because of the relative ease in making changes in software rather than hardware.

DLH231.DOC/49

Number: 620.22

Question: How was the reduction of operator information processing identified, reduced, and documented in "Reduce the operator's information processing while meeting all of his information needs."

Response: The phraseology used in CESSAR-DC, "Reduce the operator's information processing while meeting all of his information needs," requires clarification. This is a high level design goal for Nuplex 80+. The basis for evaluating workload information needs will be acceptable operator performance, as demonstrated through verification and validation using Design Acceptance Criteria. Integral in that evaluation will be the operator's ability to get required information from the plant data available.

The approach to addressing stimulus overload is addressed qualitatively in the remainder of this response.

Based on the stimulus overload problem documented in industry references and NUREG-0700, the Nuplex 80+ goal to reduce the amount of data operators must process, while still meeting their information needs, was formulated through design review meetings and discussions with operators. This resulted in plant data being converted to information required by the operator to operate the plant safely and effectively. It was identified that additional information resulting from I&C design and licensing requirements (e.g., 16 instrument channels of the same parameter) was partly responsible for data that added to the operators task loading. Alarm systems presenting more alarms than can be comprehended during upsets, including non-applicable alarms, were also a contributor. The Nuplex 80+ approach is to integrate information to meet the operators needs (as identified in the functional task analyses) while reducing the amount of data to be sifted through to obtain that information.

The amount of processing required of the operator was reduced by validating process signals to provide one correct "process representation value," instead of indicating all parameter channels. That value is used on all spatially dedicated displays and all video displays, including IPSO. Individual sensor values are available on specific Level 3 diagnostic CRT displays. The "process representation value" is also used in all application programs, including control system algorithms and alarm algorithms. The result is that all systems, and the operator, make their decisions based on the most accurate information available. Other processing which was provided to reduce that required by operators includes alarm grouping and mode dependency, critical function and success path monitoring, and the IPSO display which provides a continuous plant overview.

DLH231.DOC/51

Number: 620.23

Question: How will C-E demonstrate that improvements in the reliability of the man-machine interface have been achieved, as noted in the statement, "Improve the reliability of the man-machine interface through redundancy, segmentation, and diversity"? Does the term man-machine interface refer to the reliability of the hardware or a reduction in human error?

Response: Response deleted. - This does not refer to human error, but to equipment reliability, a matter discussed in RAI 620.14. (1)

DLH231.DOC/52

Number: 620.24

Question: Describe the workload analysis for one and three-person operation of the controlling workspace. Describe how the task loading and work loads change.

Response: To clarify phraseology from CESSAR-DC and previous draft responses to this RAI, the discussion on the range of potential task loadings (e.g., infinite) are not germane to the issue of workload analysis of proposed crew sizes. The goal of one person operation applies not to the entire control room, but only to the controlling workspace. More than one operator would be present in the control room at all times. The full (three-person) crew to be present would not be required in the immediate controlling workspace. This is an important distinction. The basis for designing a controlling workspace for a one person crew was provided by Requirement 4.2.4, Chapter 10 of EPRI-ALWR-URD. (1)

The Nuplex 80+ Function and Task analysis found that, for anticipated conditions, the one person crew was able to handle the normal workload demands of operation. Those conditions analyzed for the one person crew size included only normal steady-state operations and escalation from hot standby to full power operations, as well as immediate post-trip actions. Nuplex 80+ is not designed such that cold shutdown to hot standby, recovery from trip, and normal shutdown could be managed by the one person crew.

Walkthroughs were performed with the emergency procedure guidelines for System 80 and it was concluded that workload demands on a single operator were highest immediately post trip. A description of the analysis can be found in Section 18.5.1.8 of CESSAR-DC with full details in the aforementioned FTA report (NPX80-IC-DP-790-02).

Crew sizes will be validated at the integration test facility using design acceptance criteria. Refer to Sections 2 and 6 of the Human Factors Program Plan for supplemental information.

The following high level tasks were considered for different operating modes:

Hot Standby to Normal Operations:

*Complete Plant Monitoring and Operations

Normal Start-up/Shutdown:

*Reactor Plant Monitoring and Control

*Turbine Plant Monitoring and Control

Post Trip:

*Primary System Success Paths and Control Functions

*Secondary System Success Paths and Control Functions

*Emergency Success Paths (at ESF panel)

A further discussion of the operating crew options for Nuplex 80+, potential roles of additional operators (allocation of tasks), and workload analysis for Nuplex 80+ may be found in the response to RAI 620.25.

Number: 620.25

Question: Describe the basis for the design goal of one person control of operations between hot standby and full power. Were separate task analyses performed for one and three person operations? How does the allocation of tasks among the staff change in the control room for one person, three person and a full six person shift?

Response: To clarify phraseology from CESSAR-DC and previous draft responses to this RAI, discussion on the range of potential task loadings (e.g., infinite) are not germane to a description of chosen crew sizes. The basis for designing a controlling workspace for a one person crew was provided by Requirement 4.2.4, Chapter 10 of EPRI-ALWR-URD. The three and six-person crew sizes do not reflect specific NRC goals but, rather, represent a range of potential crew sizes based on typical utility staffing levels. The six-person crew size is the EPRI shift complement defined in Chapter 10. (1)

Separate analyses were not performed for the one, three and six-person crew sizes. Although the assignment of tasks and the number of crew members may change, depending on a given utility's preference, the number and nature of the tasks do not. Nor is there a difference in the functions the plant systems must perform or the control room information needs based on task size. Though not individually analyzed prior to design, each of these crew sizes will be as part of validation. (1)

The allocation of tasks between multiple crew members is a key design consideration. This has been addressed in the design of the Nuplex 80+ control complex, through the floor plan design and allocation of systems to panels. With the crew size of three (for post-trip recovery), there is still only one operator envisioned to be at the Master Control Console (MCC) area to control normal success paths, hence the task analysis would not change at all for the bulk of normal operations, since these are all controlled from the MCC. The remaining two operators in the three-person crew size would include one operator assigned to the safety and auxiliary consoles to control emergency success paths and one senior reactor operator at the CRS console, monitoring overall critical functions and directing success path strategies. For other plant operating modes, other staff allocations are possible but the three-person crew is considered the minimum crew size for the limiting cases of operation.

The crew size of six is envisioned to include two operators at the MCC. However, these individuals will not interfere with one another since every section of the MCC has its own spatially dedicated displays and any CRT display can be called up on any of the CRT screens. Further, since the panel layouts mimic plant energy flow, the task sequence moves logically around this "horseshoe," allowing for an even break-off of tasks without interference.

The other four crew members are envisioned to be one each at the safety and auxiliary consoles, and two at the control room supervisor's console. The crew at safety and auxiliary consoles will have no job overlap, since the functions assigned to these two sets of panels are quite different. During emergencies, this will consist of monitoring and restoration of success paths. the two crew members at the supervisor's console are envisioned to be supervisory and STA/advisor personnel. They will have the ability to call up any CRT display on their own two CRTs and to monitor the plant via the IPSO display; however, they will not perform any control tasks. The six-person crew is not a routine staffing level, but might represent extra consulting and/or backup personnel brought in by a given utility, should an abnormal transient occur.

Although separate analyses for the larger crew sizes were not performed, it should be noted that further human factors analyses are planned for the Nuplex 80+ control room. These will include walk-through/talk-through type analysis and further review of the control room design using System 80 (or System 80+, if available)

Emergency Procedure Guidelines as the task basis. For this analysis, a simulated full operating crew will be used. Crew size validation will be included in the Nuplex 80+ validation and as design acceptance criteria as they are developed.

A summary of logic for operating crew sizes is provided below:

	Crew Size	
Mode	Minimum	Maximum
Start-up	Bounded by normal and post-trip operating minimums	6
Normal Operations	One person (at controlling workspace; two others in control room)	6
Post-Trip	Three-person	6

Crew sizes will be validated at the integration test facility. A further discussion of the operating crew options for Nuplex 80+, potential roles of additional operators (allocation of tasks), and workload analysis for Nuplex 80+ may be found in the response to RAI 620.24

DLH231.DOC/57

Number: 620.26

Question: How does the Nuplex 80+ configuration minimize required access to the controlling workspace? A desk/barrier does not appear to reduce the requirement for maintenance personnel access to control room equipment and face-to-face communications with the operating staff.

Response: The reduction of personnel access requirements to the controlling workspace is a design goal of Nuplex 80+. It is more appropriate to state that the Nuplex 80+ Advanced Control Complex includes a number of features designed to address the concern of required access to and traffic in the controlling workspace during both normal and emergency operations. These features are discussed below.

To access information Nuclear Equipment Operators (NEOs) can use CRTs in the Auxiliary Reactor Operator (ARO)/NEO support office or the TSC without entering the controlling workspace. For maintenance, testing and other routine interfaces between operators and NEOs (or other plant staff) the design allows the interface to occur at the CRS desk, outside the controlling workspace or in control room offices. By having interactions with plant staff occur in these locations, no disruption of normal operations activities in the controlling workspace is caused. In other words, the maintenance tasks have been <u>moved</u> out of the controlling workspace and into an office so that maintenance does not impinge on (1) operations.

Having local maintenance and test panels on the Component Control System (CCS) and the fact that all tests and calibration not requiring licensed operators are performed outside the main control room, further reduces traffic. No cumbersome testing equipment is required to be brought into the MCR. NEOs primarily need to enter the main control room for discussion.

Nuplex 80+ panel design features further reduce potential maintenance interference. Panels are designed for quick equipment removal. Typically, removal of four screws and detachment of quick disconnect connectors will allow removal of flat panel devices. Thus, all discrete indicators, alarm tiles and controllers are easily and quickly removable. Switches are modular and easily replaced. Items whose maintenance would not interfere with operators (e.g., power supplies) are in the less accessible, rear portions of the panel.

Data Processing System CRT interfaces are provided in all three MCR offices as well as in the TSC. For both normal and emergency operations the availability of all CRT monitoring displays in the SS and CRS offices will reduce control room access requirements. Access to plant status information to support management and operations discussions is available without entry into the controlling workspace. The direct viewing window from the TSC will minimize control room access needs of emergency response personnel during emergencies by enhancing communication between TSC personnel and the operating staff. It also allows visitors or plant staff to view the main control room without entry during normal conditions. DPS CRTs, with all the same displays as in the control room, are located in the TSC to meet the information needs of emergency response personnel.

DLH231.DOC/59

Number: 620.27

Question: Describe the duties and responsibilities of the control room supervisor and describe the tasks expected to be performed at the CRS console in the control room. Which tasks will be performed in the supervisor's office? Who will be the primary operators of the CRTs on the control room supervisor's console and what displays are they expected to use or access?

Response: The control room supervisor (CRS) may perform a wide range of duties related to administration of the operations crew and plant evolutions, monitoring of plant status, and interfacing with maintenance and technical personnel. The basic responsibility of the CRS in the Nuplex 80+ ACC is to oversee and direct, and does not differ notably from his duties at current LWRs. The exact nature of his duties and responsibilities will be determined by the individual owner/operator and its operating philosophy. A general description, which forms a guideline for positions for Nuplex 80+ crews, is found in the EPRI ALWR URD. The CRS may be in his office having meetings, conducting administrative tasks, or communicating with other groups when his presence is not required in the controlling workspace. All of the CRS's activities can be performed in his offices, except where face-to-face communication with operators at the panel is required. Further details on the CRS console and control room offices are provided in CESSAR-DC Sections 18.6.5.3 and 18.6.5.4, respectively.

The CRS, shift supervisor and shift technical advisor will use the CRS console in the control room. All DPS CRT display page selections are available to these individuals on two CRTs at the CRS console. Their use of the CRT interface depends on plant condition and the operations in progress. Control room operators will not use this console, as it is primarily a monitoring station with no controls. However, any and all Nuplex 80+ CRT displays can be accessed from the CRS console. If it is determined during the design process that additional CRT displays are required specifically for a CRS's use, they will be added to the display hierarchy.

During the detailed design of the console, EPRI position descriptions will be examined and task analysis conducted to determine the needs for ancillary staff. This will include establishment of duties, space equipment and software needs, as well as hardware requirements. This determination will be based on operations and will be validated later at the integrated test facility.

Number: 620.28

Question: Explain how the control room design addresses the issues of habitability and the storage requirements for working documentation, procedures, supplies and personal effects. Describe the process used to establish the requirements for areas that support the control room such as the Technical Support Center, shift supervisor's office, etc.

Response: Habitability, in this case meaning operator comfort and occupancy features, was addressed by providing features such as washroom and kitchen facilities immediately adjacent to the control room. It was further addressed by providing offices and storage space adequate for all anticipated control room needs, both work and personal. Because such features are largely architectural and must be determined early in the design, ABB-CE relied on operating experience, operator input and architect/engineer input to determine the type and quantity of these features. Provision was made for emergency equipment and personal effects. However, no formal human factors analysis was performed on this matter.

Storage areas in the control room are equal to or greater than previous plant designs. An evaluation of currently operating plants indicated that control room information (procedure/drawings/books) are normally stored in cabinets, bookshelves and hanging files. The evaluation indicated that procedures require approximately 175 linear feet of shelf space, books require an additional 40 linear feet, and drawings require 16 linear feet. The Nuplex 80+ control room shall provide this much space, at a minimum, for documents, drawings and books needed in the control room. The document room in the control room contains over 200 square feet of floor space. Additional document storage is located in the control room offices. Storage inside the controlling workspace is provided on the back side of the Control Room Supervisor's desk and on the two Reactor Operators desks. Personal effects for the Shift and Control Room Supervisors will be stored inside their control room offices.

Reactor Operators will have ample space for personal effects in the Reactor Operators' offices.

In short, the control room contains large amounts of storage space for all operator and staff needs related to comfort, safety equipment and operations-related documentation. These requirements were based on an evaluation of utility experience and operator input, not on a formal human factors analysis. However, validation will assure that human performance concerns are addressed. (1)

DLH231.DOC/63

Number: 620.29

Question: How was "sufficient instrumentation" identified for the Remote Shutdown Panel? Describe the human engineering efforts or studies which contributed to the design of the Remote Shutdown Panel and the "convenience controls" distributed at equipment locations

Response: The RSP receives the same design process and analysis as the MCR panels. Sufficient instrumentation for the RSP was identified based on a function task analysis, as with the main control panels. The description of the human factors engineering task analysis for safe shutdown is described in Section 18.8.1 of CESSAR-DC. In addition, C-E's extensive experience in designing remote shutdown panels for Palo Verde 1, 2 an 3 and other plants was considered. Sections 7.4 and 7.5 of CESSAR-DC give full listings of what was determined to be sufficient instrumentation for the RSP using existing System 80 plants as a baseline. This list was reviewed by all engineering disciplines within C-E to assure all system designer requirements, as well as operational requirements, were met.

Essentially the same design process was followed for the RSP as for the main control room panel designs. The RSP design is based on the standard Nuplex 80+ indication and control methodologies (CESSAR-DC, Section 18.7.1) and HF design criteria (Section 18.7.2). Special needs which differentiate the RSP from MCR panels are described in Section 18.8.1.2-4. The RSP design features similar diversity as the MCR in terms of having diverse means of obtaining information as well as diverse methods for control. This diversity precludes a common mode failure from resulting in loss of either sufficient information availability or control capability at the RSP. Nuplex 80+ diversity is discussed in the response to Question 420.23.

As indicated in Section 18.8 of CESSAR-DC, cold shutdown is achievable from the RSP without the need for local equipment controls. No local "convenience controls" will be distributed at local workstations. The entire remote shutdown process to cold shutdown is envisioned to occur at the RSP.

DLH231.DOC/65

Number: 620.30

Question: Describe the human engineering test and evaluation methodologies that have been, or will be, used. How does the human engineering test and evaluation program fold into the System 80+ verification and validation program?

Response: The human factors test and evaluation methodologies can be divided into three phases; those occurring before the start of the Nuplex 80+ design, those occurring during the design certification process and those that will occur after certification. All of these test and evaluation methodologies are described in the Human Factors Program Plan for System 80+. Future tests and evaluation methodologies will be further described in the DAC and ITAAC as they are developed.

Number: 620.31

Question: The System 80+ control room design currently includes several types of control and display instrumentation. Some of it is new to control room applications, some is not. This paragraph states, "The man-machine interface is based on accepted human engineering methods, principles and criteria such as those presented in NUREG-0700." Identify the principal human engineering source documents used in the development of the man-machine interfaces, such as:

a. Identify which elements of the man-machine interface were developed based on existing human engineering documentation. Identify the documentation.

b. Identify which elements of the man-machine interface required the development of additional human engineering guidance. Identify the guidance.

c. Describe the means C-E will use to ensure (1) that the man-machine interface aspects of the new technology will be compatible with that of the established technologies, (2) that the new man-machine interfaces will meet the requirements of the tasks, as defined by the human engineering studies, and (3) that the differences as well as the similarities among the man-machine interface devices enhance operator and maintainer performance.

Response: The Nuplex 80+ Human Factors Standards and Guidelines is currently the principal document which assures that the MMI is based on accepted human engineering principles and criteria. This document provides the design choices for Nuplex 80+ (i.e., standards) and not just guidance (i.e., available selections). A HF Standards and Guidelines Basis document defines the source (document or rationale) for each standard or guideline. Table 620.31-1 lists the source documents used to assemble the HF Standards and Guidelines. These source documents were used in the initial stages of the Nuplex 80+ (1)

design process. Later, they were superseded by the Heavy Water Reactor Facility Human Factors Standards and Guidelines which continues to fill this role until the upcoming formal issue of the ALWR documents.

a. Most of the Nuplex 80+ man-machine interface elements were developed based on existing principles and criteria. This was possible because elements were either similar to conventional control room technology or an evolution from conventional technology. Man-machine hardware elements for which criteria exist include IPSO, flat panel displays used for alarm tiles, discrete indicators and controls, CRTs and switches. In addition, format of software, display pages, ambient environment labels and demarcation, color coding, and the full range of MMI elements are included. The source documents used for criteria for these interfaces are provided in Table 620.31-1. The HF Standards and Guidelines is a subset of this list.

b. The only element of the man-machine interface which required some additional human engineering guidance was the use of touch screen interfaces for the CRTs, flat panel displays and controls. Existing guidance used for target size, target separation, response time, input duration, input sequence, and feedback was adequate. However, two other criteria were developed for implementation of Nuplex 80+ touch screen interfaces because the industry guidance was not sufficient in these limited areas. These areas are open items which are being tracked.

   1. Actuation occurs upon removal of touch from the screen not engagement. This allows the operator the ability to correct any incorrect selections that may have occurred before actuation. Operators considered a two-step "select" "enter" key. This may not be optimal for all

activities; however, this may be desirable for certain operations. The issue is being examined currently.

2. Touch targets will be identifiable from other display elements. Systematic target conventions and spatial dedication of the targets will allow the operator to clearly identify which targets are selectable and which are not. Final guidance and convention have not yet been selected.

c. 1. The Nuplex 80+ design uses consistent and compatible interfaces and conventions throughout the interface. In other words, the design is standardized across the control room in terms of format, coding, and all other conventions. This is to enhance human performance through a positive transfer of training across different aspects of the control room. Technologies for implementing the interface were selected to support compatibility. A good example of Nuplex 80+ interface compatibility is provided by CRT displays and other MMI devices in the MCR. A standard set of graphic symbology is used between CRTs, switches and controller displays.

The suitability analysis of the Nuplex 80+ verification process evaluated the compatibility of the different technologies used in the man-machine interface. As identified in Part b, there was only one application of new technology in the Nuplex 80+ MMI, the flat panels. Other hardware devices being used in Nuplex 80+ have been used previously in control room applications. Compatibility has been controlled and ensured throughout the design process through the use of industry guidance, project HF Standards and Guidelines, and the Control Complex Information Systems Description.

2. The suitability analysis of the Nuplex 80+ verification analysis specifically evaluated whether task performance requirements were met by the interface devices. Documentation is provided in the reference design documentation in NPX80-IC-TE790-01.

3. The Nuplex 80+ design uses the similarities and differences in the MMI technologies employed to enhance human performance. For example, similarities in technologies allow consistent coding conventions to be employed across all interface devices. Specifically, alarms presented on DIAS alarm tiles and through the CRTs use the same flash rates and shape codes for priority. For example, the hardware technologies used in the interface (types of hardware, fiber optics,multiplexing, etc.) are all employed in existing nuclear plant control rooms, though Nuplex 80+ extends the use of these technologies. Similar combinations of different technologies have been made in other industries, including fossil power plants.

   The suitability analysis has evaluated the acceptability of the interface, including the similarities and differences between technologies. In order to prevent making interpretation of control and display relationships difficult, Nuplex 80+ uses lines of demarcation, functional or system mimic groupings and system-related panel orientation. This supports familiarly with a component's operation (e.g., a switch or ELD device) while putting it on the context of system operation.

   Other human factors studies, such as function and task analysis, validation, and further verification analysis, address adequacy of the hardware, software and configuration to the identified tasks. Analysis which have been done or are scheduled are identified in the Human Factors Program Plan. Criteria for human performance measure will be identified in DAC and ITAAC.

Table 620.31-1

Sources of Human Factors Guidance Used for Nuplex 80+

1. MIL-STD-1472D, "Department of Defense Human Engineering Design Criteria," 1989

2. DOD-HDBK-761A, "DOD Management Information Systems Guidelines," 1987

3. ESD-TR86-278, "User-System Interface Software Guidelines," Smith and Mosier, 1986

4. ANSI/HFS-100, "ANSI VDT Workstation Standard," 1988

5. "User-Computer Interface in Process Control: A Human Factors Engineering Handbook," Gilmore, et al, 1989

6. NASA-STD-3000, "NASA Man-Systems Integration Standards," 1989

7. NASA-USE-100, Ver. 2.1, "NASA Space Station Freedom Program Human Computer Interface," 1989

8. EPRI NP-3659, "Human Factors Guide for Nuclear Power Plant Control Room Development. 1984

9. EPRI NP-4350, "Human Factors Engineering Design Guidelines for Maintainability," 1985

10. NUREG/CR-3517, "Recommendations to NRC on Human Engineering Guidelines for Nuclear Power Plant Maintainability," 1986

11. NUREG-0700, "Guidelines for Control Room Design Reviews," 1981

DLH231.DOC/71

Number: 620.32

Question: In the context of being presented as a design basis for Nuplex 80+ this paragraph states, "The number of physical display devices and the quantity of data presented to the operator is reduced compared to control rooms for existing plants."

Provide the human engineering studies C-E has done to determine the benefits and drawbacks of reducing the number of display devices and quantity of data presented to the operator. Include specifically the studies which determined the optimal levels of reduction of display devices and data. Include the results of human engineering studies which were used to support the quantity of data presented to the operator, any consolidation of instrumentation, and any changes in the modes of displaying data to the operator in the Nuplex 80+ control room.

Response: The statement made in CESSAR-DC regarding reducing the number of physical displays requires clarification. This statement was a design goal for Nuplex 80+ and was not intended to be a licensing basis for the design. The basis for licensing Nuplex 80+ is to provide adequate information such that acceptable operator performance is achieved. Acceptable operator performance will be demonstrated through verification and validation activities (as discussed in the Human Factors Program Plan for System 80+). The approach to information reduction as a design goal was qualitative in nature, and is discussed qualitatively in the following paragraphs.

The intent of this design basis statement was to partially address the stimulus overload concern. This issue was discussed in the response to Question 620.22 as it relates to increasing the operator's information processing burden. By reducing the number of physical displays in an appropriate manner, the information required for task performance is presented to the operator without all the clutter added by presenting all available data. The need to reduce stimulus overload and, hence, the number physical devices and amount of data provided to operators, has been documented in various industry sources. This includes the EPRI ALWR-URD, industry reports (e.g., NUREG-3448 for alarms), and papers (many identifying this concern as a result of TMI).

Qualitative analyses were performed to evaluate the benefits and drawbacks of reducing the number of physical display devices. An assessment was made based on using the combination of serially presented information (via CRTs) and spatially dedicated information (on flat panel discrete indicators and alarm tiles) to determine an acceptable combination. All data is accessible at any panel through the CRT's serial presentation of information. Thus, the focus of the assessment was on how much spatially dedicated data should be presented in a parallel manner. The result of the assessment led to spatial dedication of Priority 1 and 2 alarms and key parameters on discrete indicators and IPSO. Key parameters for discrete indicators were defined as frequently monitored parameters, parameters most indicative of critical safety function and success path status, Regulatory Guide 1.97 Category 1 parameters and parameters required for investment protection or continued operation without the DPS. The design was then evaluated through the availability and suitability analyses of the verification to assure that an acceptable amount of spatially dedicated data was presented. No quantitative studies were performed to determine optimal levels of reduction, since optimal can only be determined if all possible transients and events are known.

Figure 620.5-1 Nuplex 80+ Coding Matrix

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PROPERTY/CODING	ASTERISK	UNDERLINE	TRIANGLE	HASH	HOLLOW	FILL	BOX	BRACKETS	RED	GREEN	BLUE	BT YELL	MED. YELL	DARK. YELL	GREY	FLASH	CYAN	WHITE	ORANGE	PURPLE	UPPER CASE	LOWER CASE	CONTRAST RATIO	REV VIDEO	CIRCLE	ARROWS
ACTIVE/ON/OPEN					X				X*																	
INACTIVE/CLOSED/OFF						X				X*																
LOSS OF CONTROL				X																						
AUTO											X															
NEW PRI 1 ALRM												X				X(F)								X		
NEW PRI 2 ALRM							X					X				X(F)										
NEW PRI 3 ALRM								X				X				X(F)										
NEW OP AID		X														X(F)			X							
EXISTING PRI 1 ALRM													X													
EXISTING PRI 2 ALRM							X						X													
EXISITNG PRI 3 ALRM								X					X													
EXISTING OP AID		X													X				X							
CLEARED PRI 1 ALRM														X		X(S)								X		
CLEARED PRI 2 ALRM							X							X		X(S)										
CLEARED PRI 3 ALRM								X						X		X(S)										
RESET ALARM (1)																										
DYNAMIC DATA																		X								
STATIC DATA															X											
STATIC DATA LABELS															X											
YNAMIC DATA LABELS																	X									
SYSTEM			X																							
ABNORMAL MAN CNTL																			X							
INES/BORDERS/PIPES																										
SUSPECT DATA	X											X(crt)														
EG GD 1.97 PARM LBL																				X						
O CODING MEANING																					X	X	X			
ELECTED TO CH TARG																										
O PARAM. TREND																									X	
R. PARAM. TREND																										X

(crt)=crt only (S)=slow rate (F)=fast rate (A)= Alarm Tiles only (I)= Indicators (C)= Controllers * Indicates that component is designed to be controlled from the control room

(1)= Reset alarms shown in pre-alarm condition coding

Number: 620.34

Question: What studies did C-E perform to determine the amount and type of "operator information overload?" Provide the quantitative and qualitative results of the investigations.

Describe the baseline control room in which the studies were performed and the parameters that were measured or assessed. Were the studies replicated on the C-E System 80+ control room design? What thresholds were established for acceptable and unacceptable levels of operator cognitive loading? How does the System 80+ control room design specifically address each of the parameters assessed by the studies?

Response: The phraseology "operator information overload" was not intended as a measurable criteria for demonstration as part of the licensing basis, but only as a Nuplex 80+ design goal. As discussed in the response to RAI 620.32, the basis for licensing is to provide adequate information such that acceptable operator performance is achieved. This is demonstrated through task analysis and verification analysis. Providing the operator with the required information in the form needed for task performance, instead of all available plant data, will help facilitate the operator performance demonstration. "Operator information overload" will not be looked at as a separate, measurable criteria. In other words, operator workload will not be too high; this will be demonstrated through such as acceptable execution of EOPs on a simulation of an accident. The acceptable threshold of workload will be defined in DAC/ITAAC. Other RAI responses dealing with this issue include 620.13, 620.22 and 620.32.

Qualitative analyses identified the amounts and types of information overload in conventional nuclear plant control rooms. These analysis were industry studies such as those referenced in Table 620.31-1. Primary areas identified were information overload from the alarm system after a reactor trip and overload of information from multi-channel indicators of the same process parameter.

The System 80+ control room reduces displayed information by validating process signals prior to display or alarm, grouping alarms into a relatively small number of alarm tiles, and eliminating Priority 3 alarms and operator aids (e.g., permissives which were previously alarms in many existing control rooms) from spatially dedicated displays. Additional reduction in information overload is provided by reducing the number of alarm actuations during transient events. This is provided in Nuplex 80+ by validating signals before generating alarms and mode and equipment status dependent logic. The design also provides operator aids such as critical function monitoring (to support normal operation and emergency procedure response), success path monitoring (to aid in identifying and restoring success path problems) and IPSO (which provides a plant overview for operators). Each of these advanced features performs a function automatically and continuously that otherwise would have to be performed by operators. For example, IPSO takes several thousand plant parameters and reduces them to a few easily understood process representation symbols.

Quantitative studies were performed comparing the numbers of alarm tiles and indicators for conventional control rooms and Nuplex 80+. Results from the studies have shown a 60% reduction in alarm tiles and an 80% reduction in the number of spatially dedicated displays for Nuplex 80+ compared to conventional units. Cognitive loading levels were analyzed as part of the task analysis for specific events, as discussed in the response to Question 620.24. This analysis is documented in Section 18.5 and the task analysis report in the reference design documents. Acceptable levels of loading were based on determining cumulative processing times for tasks performed during an event and identifying situations of operator overload based on cognitive loading.

Number: 620.35A

Question: This paragraph states, "The effectiveness of modern man-machine interface devices will be demonstrated through the use of prototypes and HFE evaluations." Does this refer to demonstrating the software and hardware attributes of the instrumentation? Or does it refer to human factors and human performance evaluations of (1) the device (as a stand-alone instrument) and (2) in the context of the System 80+ control room environment. When in the design process are the HFE evaluations scheduled to occur? Describe in detail the HFE evaluations that will be performed. Provide a basis for the criteria that will be used to determine a device's effectiveness (as a stand-alone instrument) from the human performance perspective. Also provide the assessment methodology that will be used to determine the suitability of a device for incorporation into the System 80+ control room design.

Response: This statement refers to both demonstrating hardware and software attributes and the suitability of the interface from a human factors perspective. The Nuplex 80+ design process has already and will continue to do hardware attribute evaluations using prototypes, and hardware configuration studies on prototypes to assure adequate throughput. Software studies have prototyped software implementations using ladder logic programming in programmable logic controllers and software required for data processing features such as success path monitoring, alarm processing and signal validation. As described in other RAI responses, these evaluations have not been formal human factors studies.

The man-machine interface devices have also been evaluated from a human performance perspective as part of the verification analysis documented in the Verification Analysis Report NPX-IC-TE-790-01 and discussed in the response to Question 620.30. The suitability analysis evaluated both the man-machine interface devices as stand-alone devices and in the context of the ensemble of Nuplex 80+ interface devices.

HFE evaluations are scheduled throughout the Nuplex 80+ design process. The design process and scheduling of HFE evaluations are discussed in the Human Factors Program Plan for System 80+, as is the type of HFE evaluations performed. The criteria used to evaluate the man-machine interfaces were developed from the list of references being used to develop the Human Factors Standards and Guidelines document and in the response to Question 620.31. Similarly, the assessment methodology for the suitability analysis is provided in the verification analysis (NPX80-IC-TE-790-01). The eventual determination of a device's suitability was determined not only from the human factors acceptability, determined in the suitability analysis, but also by other tests and prototype evaluations. Examples of the design process are provided in the response to questions 620.2 and 620.13.

Prototype Expansion/Validation

Complete MCC

MCC Validation
(Normal Ops/One Man Ops)

Feedback to Design

Complete SC

EOP Validation
(Abnormal ops)

Feedback to Design

Complete AC

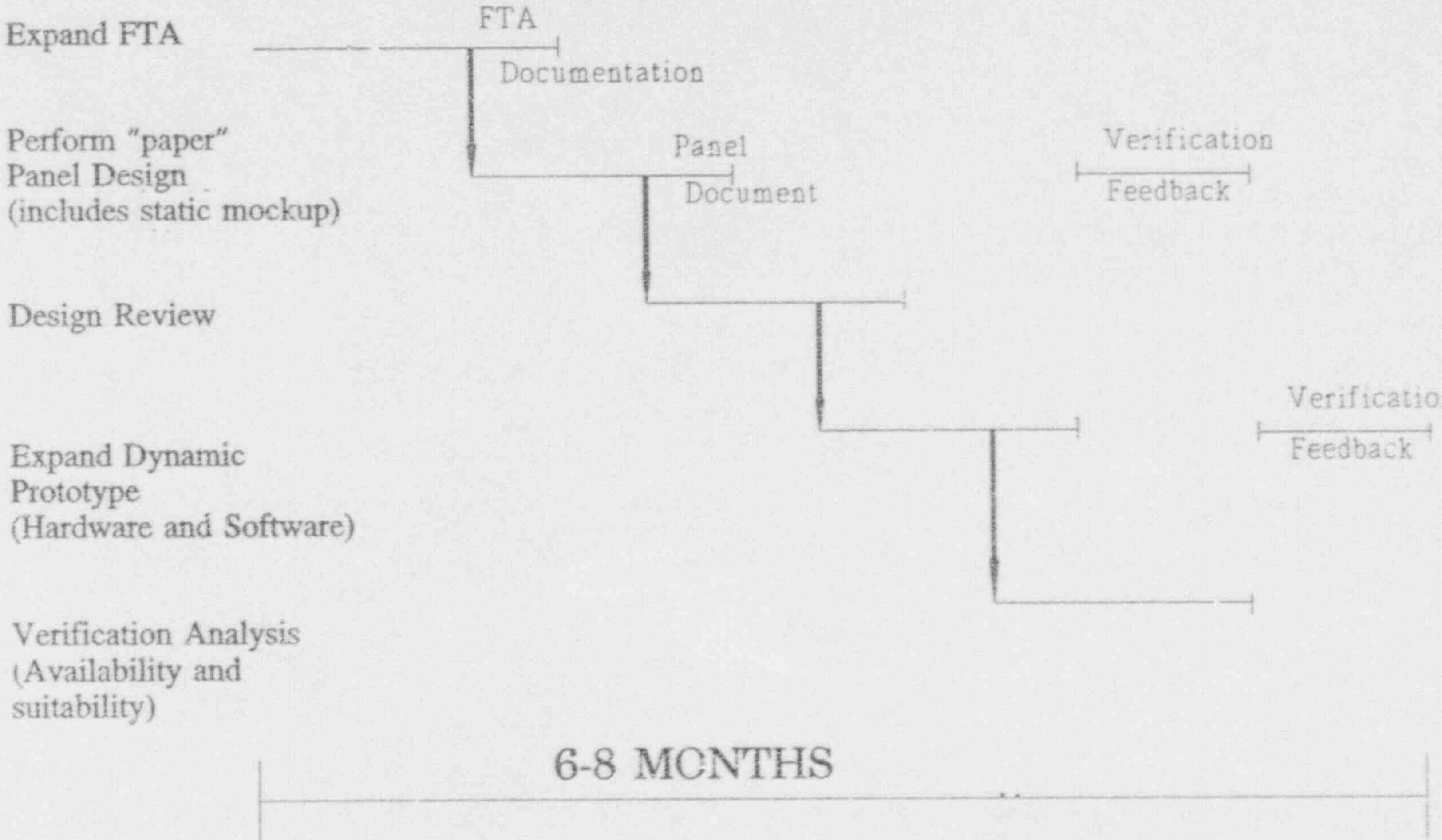
Startup/Shutdown Validation

Feedback to Design

Complete Integration Test Facility

Final Validation

Panel Expansion Schedule
(For design of any one of remaining panels)



Number: 620.35B

Question: A) This paragraph states, "Under degraded conditions, operators will continue to have access to all required information. Equipment failures impacting automated data process and presentation features are accommodated by increased operator surveillance."

What constitutes a degraded condition? Is it the loss of one computer driven display, one electrical bus (potentially affecting many instruments) or all digitally driven equipment?

B) How does increased surveillance on the part of the operator compensate for the loss of technical data? Are the data and the synthesized information normally available through the computer database available from other sources? Where will the alternate sources of information be located?

C) From the human performance perspective, how will "increased surveillance" compensate for loss of the computer? Will operators be required to perform calculations, adjustments, or operations (manual, cognitive, decision-making, etc.) that would normally be done by the computer? Describe the impact on operator and crew performance in the control room, at the Technical Support Center and at the Emergency Operations Facility.

Response: A) A degraded condition referred to in this paragraph is constituted by credible equipment failures, including failure of processors, data communications or a display device itself. The worst case degradations assumed are total loss of DIAS-N or DIAS-P or DPS failure. These worst case conditions encompass loss of an electrical bus. Loss of all digitally driven equipment is not a credible failure and is therefore not considered in the design. This position is acceptable because digital electrical equipment is protected against EMI and the diverse designs used in man-machine interface systems preclude other common mode failures, including software failures, from rendering both diverse designs simultaneously inoperable.

Figure 7.5-1 of CESSAR-DC illustrates the architecture of the Nuplex 80+ monitoring systems. The following credible failures were considered as degraded conditions: failure of the entire DPS system and, thus, all CRT displays, failure of DIAS-P channel or failure of DIAS-N. Each of these cases will be discussed individually.

The worst case degraded condition from an information access perspective is complete failure of the DPS. This is a highly unlikely event, since the DPS is a redundant system with a calculated and demonstrated availability of greater than 99.98% with an MTTR of less than 4 hours. To address this failure, the DIAS has been designed to provide operators with all information required to continue operation for 24 hours. Increased surveillance is not required to compensate for loss of technical data but rather to accomplish technical specification monitoring and to support information access that is normally enhanced by the DPS and panel CRTs. All functions of the DPS can be performed manually, with additional staff, without the DPS. The main case where the operator will have extra tasks due to degraded conditions is the Core Operating Limit Supervisory System (COLSS) DPS function which provides core surveillance.

This increased operator surveillance will not require calculations and will be similar to tasks performed in current System 80 control rooms during loss of COLSS situations. All required data for this function is available to the operator on DIAS or other displays from the control and protection systems. A separate analysis of this surveillance activity is not planned, but performance under degraded conditions will be analyzed during validation.

Synthesized information from critical function monitoring (CFM) and success path monitoring will also not be available upon complete DPS failure. Since these functions have been designed to support procedures, not replace them in Nuplex 80+, these functions can be performed manually by additional operating staff. For example, the CFM function of performing safety function status checks, normally done by the DPS automatically, can be performed by an STA. This is currently the practice at conventional plants. The alternate source of data will be the DIAS displays, which are located on each panel as part of the primary man-machine interface. Additional information will be provided by operator's modules (CCS and PPS) and switch indicators for component status which are also part of the primary integrated interface. A description of the operator's modules and their function may be found in the Control Complex Information System Description (NPX-IC-SD-791-01).

The impact of DPS failure on the TSC and EOF will be the same as for existing plants. No CRT data would be available in either location and, hence, plant status would not be available via CRT. This situation would be partially compensated for in the Nuplex 80+ TSC design by visibility into the MCR. The viewing window includes a view of IPSO which will continue to be driven by DIAS to provide an overview of plant status. In the event of a loss of DPS, DIAS will drive IPSO. Moreover, critical functions status information will not be available. The viewing window also enhances communication with control room operators.

The other credible failures relate to loss of DIAS Channels P or N (see CESSAR-DC Figure 7.5-1). DIAS P is an independent channel segment of the system which provides one redundant method of monitoring all Regulatory Guide 1.97 Category 1 parameters, including ICCM parameters. Its primary MMI is two flat panel displays of these parameters on the safety monitoring panel. If this channel is lost (though it too has redundant communication and processing), Regulatory Guide 1.97 parameters are still available to operators. Parameter indications are on DIAS N displays dispersed at appropriate functional panel locations throughout the MCR and through any CRT at any panel. This degraded condition will have no functional impact on operations in either the MCR or TSC; however, a technical specification LCO is anticipated to limit the time DIAS-P can be unavailable, since both DIAS-N and P are required to meet the required level of redundancy for qualified systems.

Failure of the DIAS N channel is the other credible degraded condition, though all DIAS N segments have redundant processors and communication. DIAS N failure would render inoperable all spatially dedicated indicators and alarms on the panels. DIAS failure is indicated by use of the heartbeat ("spinning packman") symbol. No information would be lost, because all information processing, including signal validation, would still be available through the DPS. Operators would use the DPS for alarm acknowledgement and plant status monitoring as is normally the case, but without the support of spatially dedicated information. IPSO would be unaffected. Little additional surveillance would be required and impact on the operating crew would be significantly less than in the failure of DPS case. This degraded condition has no impact on operations in the TSC.

Other degraded conditions, such as loss of individual display devices (e.g., CRT or ELDs), loss of any electrical bus, loss of a control device or failure of individual processors (DIAS segments or DPS) are all bounded in terms of impact on the operating crew by the above cases. Failure of individual devices is indicated by the asterisk code presented on CRT and flat panel screens. (1)

In summary, for the worst case degraded condition, failure of the DPS, increased surveillance will be required to monitor continued compliance with technical specifications. This surveillance is, however no greater than tasks currently performed by operators. All required data is available on other MCR devices. Some additional calculations and decision-making operations will be required by operators which is expected to be handled by additional crew members in the controlling workspace. These would be related primarily to advanced operator aids (as discussed in the response to RAI 620.11) and DPS application programs (see CESSAR-DC Section 7.7.1). Examples of additional tasks required are manual core limit monitoring (COLSS unavailable), critical power production function monitoring, manual Reg. Guide 1.47 Bypass and Inoperable Status monitoring and Secondary Calorimetric calculations. As the task analysis is completed for System 80+ (see the HF Program Plan for System 80+), all additional tasks and calculations required for operation without the DPS will be identified and documented. No impact on controls, e.g., additional adjustments or manual operations, is expected. However, the issue of workload assessment under degraded conditions will be addressed in the design acceptance criteria and analyzed during validation. The primary impact on crew performance will be additional coordination requirements because of the additional surveillance and potential for manual information processing such as critical function monitoring. Coordination will be the responsibility of the CRS

Operation under degraded conditions, including complete failure of the DPS (i.e., no CRT information), will be evaluated as part of the validation of Nuplex 80+. Design acceptance criteria will be established for these degraded conditions as part of the certification process.

Number: 620.36

Question: This paragraph states that, "A standard set of display and access conventions is applied consistently for all information presentation methods." Provide the human engineering document that identifies and discusses the standardized display and access conventions for all the information presentation methods. Do the standards apply to vendor supplied equipment and "off the shelf" hardware and/or software?

Response: The display and access conventions for Nuplex 80+ are provided in the NPX80-IC-SD791-01, Rev. 1, document (Control Complex Information Systems Description).

Off the shelf hardware and software used in Nuplex 80+ is configured to meet the conventions of the Human Factors Standards and Guidelines document. Vendor supplied equipment in the MCR receives a human factors specialist's inspection and review. Human factors specialists also help in preparing procurement specifications to assure that ergonomics is adequately addressed. It is the intent that this equipment conform to the Nuplex 80+ conventions. If this is not possible, C-E will ensure that no conflicts exist between that design and standard conventions which could potentially lead to significant human errors. It is also the intent that vendor-supplied equipment outside the MCR conform to the Nuplex 80+ conventions. Again, if this is not possible, C-E will ensure that no conflicts exist which could potentially lead to significant human errors. (1

Number: 620.37

Question: This paragraph states that, "Critical functions established for both safety and power production serve as a primary basis for information and alarm presentation." What is the definition of the term "critical function?" How were "critical functions" identified? Was a critical task analysis performed on critical operator and maintainer tasks in the control room and to what level of detail were the critical task analyses performed? If a critical task analysis was not performed, explain why. How were the contributions of the human engineering task analysis and the critical task analysis integrated into the development of information and alarm presentations?

Response: A critical function is one of a minimum set of functions required to be controlled to keep the plant either in a safe, stable condition (critical safety functions) or producing power (critical power production functions). The critical functions approach to monitoring the safety of a plant is required by NUREG-0696 and NUREG-0737, Supplement 1. These documents identified a minimum set of critical safety functions. C-E, in development of the critical function monitoring system as an SPDS, has identified additional critical functions for safety. Power production functions were identified as part of the Nuplex 80+ design process. Some of the initial concepts relating to power production functions were developed in the EPRI Disturbance Analysis and Surveillance System Program (EPRI NP-1684 and EPRI NP-3595).

Critical task analysis, as defined in NUREG-0700, Section 3, and MIL-46855B consists of a task analysis performed specifically for those tasks which must be executed in an extremely rapid, time dependent manner. Because of the evolutionary nature of System 80+, the plant will function with the typical slow response of nuclear plants. Therefore, no operator actions are required in a time-critical manner (see the discussion of design philosophy "Accuracy vs. Speed" in Section 1.2 of the Human Factors Program Plan for details). Hence, no "critical task analysis" has been or will be performed for System 80+. In lieu of this, Emergency Procedure Guidelines specifying all tasks needed for safe emergency operation have been used in Function Task Analysis and will be used in validation work at the integration test facility. The HRA for System 80+ will identify critical tasks which impact safety. If any are identified, these tasks will be given additional consideration in the scheduled future human factors analyses.

Further, the definition of "critical" task analysis in Appendix B of NUREG-0700 includes all tasks "critical" to safety, health, environment, equipment, operations, etc. This appears to be almost all control room tasks. The benefits of a separate analysis of these tasks is not apparent.

Number: 620.38

Question: This paragraph says, "Operating staff targets for Nuplex 80+ were established to accommodate a variety of staffing assignments during both normal and emergency operations." How many extra people are expected to be in the control room and the Technical Support Center during an emergency? Provide the analysis that identifies and describes the duties, responsibilities, and capabilities of the additional personnel and the space, equipment, and information they will require. Describe how the current configurations of the control room and Technical Support center meet the requirements and support the duties to be performed.

Response: The control room staffing levels necessary for safe operations will never exceed three operators for any design basis event. This is for the maximum workload post-trip evolution identified in the System 80+ Functional Task Analysis. Nuplex 80+ is designed to accommodate crew size of up to six which would include supervisory personnel. Additional staff beyond this is not required. Other personnel who may be in the control room and are provided for as active observers include an NRC representative, one plant owner management personnel and one communications specialist (per EPRI ALWR URD). They are provided information in the control room offices and are expected to interface (without interfering with operations in the controlling workspace) with the control room supervisor who is easily accessible. The specific duties, responsibilities and capabilities of the additional personnel entering the MCR during emergencies are the responsibility of the plant owner/operator. A separate or expanded task analysis to include these individuals is not planned at this time.

The Technical Support Center (TSC) is part of the Nuplex 80+ advanced control complex which contains monitoring-only interface with the controlling workspace, through the ability to view IPSO and to call up displays on a Data Processing System (DPS) CRT. No control tasks are performed at the TSC and the TSC staff are not directly involved in safety monitoring. Hence, the staffing levels, information needs, etc., are not scheduled for a formal analysis. TSC staffing and monitoring will be evaluated as part of the normal MMI design process.

The number of people expected in the TSC is highly variable, but NRC regulations require that it be designed for 25 people (NUREG-0737). The Nuplex 80+ TSC is designed with adequate space, information through the DPS CRTs, personnel access and communication to meet the regulatory requirements. The Nuplex 80+ TSC is described in CESSAR-DC, Section 13.3.3.1. No additional design requirements beyond the ALWR-URD have been imposed on the TSC.

ATTACHMENT 2

Attachment

COMMENTS ON DRAFT BNL CRITERIA FOR AN HFE REVIEW PROCESS

ABB-CE has performed an initial review of the Draft Human Factors Review Criteria for the Design Process of an Advanced Nuclear Power Reactor, prepared by Brookhaven National Labs (the BNL Report). Though this is a draft, the BNL Report serves as a good starting point for the development of acceptable ITAAC and/or DAC specific to the ABB-CE certification process. The following comments on the BNL Report are offered as part of the effort to determine a more specific and appropriate set of criteria for the ABB-CE design.

The BNL Report embodies what is basically the DOD's Systems Approach to design. In the DOD framework, there is heavy emphasis on formal processing; in BNL's version, there has also been a movement of Human Factors Engineering (HFE) to the center of much of the design process, around which other activities have been organized. While the goals and many of the interim products of the BNL approach are agreed to be valid and practical (and, we feel, are shared by ABB-CE's approach), the BNL framework is not entirely an appropriate organization of design review activities for ABB-CE.

One general concern is that, despite the expressed goals of being workable and well-defined, the BNL Report presents open-ended criteria that do not permit closure of the review process. Other general concerns limit the blanket applicability to System 80+ of the BNL approach, which:

- defers specific technical criteria on design products,
- stresses restrictive planning criteria on program,
- interprets 10 CFR 50 references very broadly in scope, but specifically in implications,
- makes no distinction between Tier 1 & Tier 2 ITAAC/DAC activities,
- has unnecessary elements and reduced applicability for evolutionary design.

Also, the BNL approach is unreceptive to products that embody the desired technical results, but have not been produced in the particular form or style, or delivered along the specified route of program organization. This is arbitrary, and unacceptable in a retroactive requirement.

State-of-the-Art Human Factors

One concern is with the BNL interpretation (Section 3.2, Paragraph 2) of the reference to "state-of-the-art human factors principles" (the original context is control room design) in 10 CFR 50.34(f)(2)(iii):

For purposes of clarification, "state-of-the-art human factors principles" is defined as those principles currently accepted by human factors practitioners. "Current" is defined with reference to the time at which a program management or implementation plan is prepared. "Accepted" is defined as a practice, method, or guide which is (1) documented in the human factors literature within a standard or guidance document that has undergone a peer-review process and/or (2) can be justified through scientific/industry research/practices [documented in HFE] literature that has undergone a peer-review process.

The BNL definition appears to intend (but does not make sufficiently clear) that conformance to HFE principles cannot be required by reviewers if those principles have only "been accepted" (i.e., entered the literature) subsequent to the implementation of the HFE program plans.

Furthermore, the state-of-the-art is referenced to generic (i.e., conservative) guidance, which is often not optimal (too restrictive) for any actual design that must incorporate tradeoffs.

Ultimately, differences over what constitutes the state-of-the-art will hinge on what is meant in Section 3.2, Paragraph 2 by "can be justified." As defined, this is wide open to interpretation, and does not address the issues of resolving 1) conflicts in "accepted" practice, 2) context-specific engineering tradeoffs, or 3) design decisions based on original thinking.

Human Factors Engineering Program Management (Element A)

The BNL approach places HFE at the center of activities of which HFE should be a part; thus, the design team becomes the HFE team. However, placing the HFE discipline above other design team disciplines is not necessary and perhaps undesirable. The superordinate status of HFE is further implied by references to, for example, "independence from cost and schedule considerations" in Criterion 5, and special stop-work authority over vaguely defined "unsatisfactory conditions" in Criterion 4.

Operating Experience Review (Element B)

The BNL Report presumes that this phase of activity lies ahead. However, while not complete (it remains ongoing), much of this activity is past history for System 80+.

System Functional Requirements Analysis (Element C)

The introductory BNL material categorically fails to identify the specific purpose, method, or products of this analysis. There is also a requirement for a form of graphic description (Criterion 7) that seems unwarranted in its specificity.

Generally, for an evolutionary plant and control room design whose operating and safety functions are well-understood and validated by experience, a top-down analytic reassessment of these functions is believed to be unnecessary.

Allocation of Function (Element D)

The rather elaborate analytic and documentary activities specified in the BNL Report for function allocation are not appropriate or cost effective for an existing, evolutionary design. An evolutionary design philosophy minimizes revision of successful technology; appropriately, there have been few changes to the basic allocation of operating functions in the System 80+ plant (e.g., automatic reactor trips are still provided where plant monitoring and time response demands exceed human capabilities.) Due to the present sufficiency of the operators role in existing System 80 plants, no major conceptual changes to it were envisioned or embodied in System 80+.

Task Analysis (Element E)

In general, the technical contents of Element E are consistent with ABB-CE's goals and methods of Task Analysis (TA). However, the expansion of TA scope to all maintenance, test, and inspection tasks per Criterion 3 must be done in a controlled fashion since it is unclear and without historical precedent how these tasks should be treated in terms of analyzing the operators role, or evaluating their impact on safety. It is agreed, however, that human actions found to significantly affect plant risk in PRA analyses should be considered "critical."

Human-System Interface Design (Element F)

The BNL Report identifies a number of program elements that are managed through various mechanisms in the System 80+ design process (e.g., use of mockups and prototypes, Availability Verification, development and implementation of HFE Standards and Guidelines.) Why these issues are treated here, rather than under Program Management (Element A), Verification and Validation (Element H), or other, more specific headings (e.g., HFE Design Guidance), is an arbitrary choice of program organization (and thus, should not in itself be a requirement).

Plant & Emergency Operating Procedure Development (Element G)

While part of the overall System 80+ certification effort, this element is not within the scope of the control room design, and is managed via an entirely separate mechanism (i.e., NPOC Strategic Plan Building Block Seven.)

Human Factors Verification & Validation (Element H)

Criterion 5 lumps the verification of Availability and Suitability together as a single, unelaborated activity. These are distinct activities, as defined in NUREG-0700, and warrant separate treatments, since they are of the utmost importance to evaluating MMI design product adequacy.

ATTACHMENT 3