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April 16, 1981

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attn: Director of Human Factors Safety

Dear Sirs:

This letter transmits INPO comments on NUREG-0659, "Staff Supplement to the Draft Report on Human Engineering Guide to Control Room Evaluation." Attachment 1 contains comments developed by INPO's Human Factors Section. Attachment 2 is a copy of comments supplied to us by Joseph L. Seminara, a consultant to INPO.

Consideration of both sets of comments leads us to the following conclusions:

1. Review opportunity should be provided for NUREG-0700, as NUREG-0659 does not contain programmatic information. Current reviews, therefore, could not determine implementation requirements and schedule, nor determine what justification might be required for alternative approaches. Review of NUREG-0700 is also essential to the utilities' abilities to determine what the impact of compliance would be.

2. The reviewers were uncertain about the efforts and benefits involved in system reviews. Although some reviewers estimated 5-10 man-years per plant, some savings should result if the procedures upgradings required by NUREG-0660 Task I.C.1 have been done. Additional savings may result if some of the industry performs systems reviews thoroughly on a few plants and shares the results with the rest of the industry. NUREG-0700 should encourage such approaches.

3. The overall benefit and impact of the approach described in NUREG-0659 should be considered against the one described by Mr. Seminara in Attachment 2. We strongly endorse the overall thrust of Mr. Seminara's comments.

We hope you find these comments useful in your development of the guide.

Sincerely,

Randall W. Pack
Director, Special Projects

RWP:pyc
Attachments

IV. Systems Review

GENERAL COMMENTS

As we understand the review process for this document, NUREG-0700 will be issued in final form by combining NUREG/CR-1580 and NUREG-0659 plus comments received on both documents. We think a comment period on NUREG-0700 should be allowed, since the final form of this important document has not been seen and will not be seen prior to the issue date.

Overall, we agree that a Control Room Evaluation as described in NUREG-0659 (Draft) is a valid and worthwhile method to assess the human engineering adequacy of a given control room design. While a systems analysis/review is a useful design tool, its adequacy as a procedure to evaluate existing control rooms depends on the expertise applied to the review process. Obviously, the systems review described in the subject document does not require a fullblown analysis, but, rather, a review of systems and procedures as they exist. Even for such a scaled-down activity, however, we believe the NRC should give greater consideration to the problems of manpower requirements and schedules for minimum operational disruptions.

The manpower requirements imposed by this systems review will exceed the supply of qualified human factors and system analytic professionals. Most utilities do not have in-house human factors expertise and the consulting community is too small to carry this demand. Organizations such as INPO have a small number of qualified people, but they must spread their expertise over the nuclear industry as a whole. NRC should suggest a schedule which will allow the utilities to timeshare the available human factors resources.

There is no timetable mentioned in NUREG-0659 (Draft). We estimate that a systems review of this scope will require between 5-10 man years per utility. The "Operating Experience Review" and the "Control Room Inventory and Survey" will also require a resource commitment, but the "Systems Review" is the limiting factor. The impact ot the "Verification" and "Validation" activities on plant operation should be considered. These activities must be done at a non-operating plant, unless there exists a high fidelity simulator for a particular plant.

DETAILED COMMENTS

2.3.1 General Methodology

The references listed in this section are mostly written to describe human factors methods for new designs. There is very little information in the open literature concerning reviews of existing designs. Some language should be inserted to caution potential users that some of the methodology described in the references is not applicable to their reviews.

2.4 Staffing

The supply of professional human factors engineers and systems analysts is limited. These disciplines should certainly be included in the review team, but a two-year implementation schedule may be necessary since all utilities will attempt to use the same resource pool at the same time.

The operator should be a member of the review team. However, the experienced operator's view of what constitutes "realistic control room problems" may conflict with requirements that specific transients and operating modes be analyzed. Delete everything after "Items" in last sentence of this section.

2.5 Approach

The overview shown in Figure 4-1 is an open-loop arrangement. After the HED Assessment, Backfit Design, and Implementation, a feedback loop should be made to the Systems Review path. See comments on Section 3.

2.5.1 Identify System Elements

If the system-subsystem-component terminology is to be used consistently, then the definitions from Appendix B should be moved to or referenced in this section.

2.5.3 Function Identification

There should be emphasized that the function allocation described in this section refers to the allocation for the as-built plant, not a theoretical allocation between operator and machine.

The last paragarph on page IV-11 implies that procedures may be used as the only source of function

Detailed Comments (Continued)

allocation. Even with procedures meeting the specified conditions, their use in function identification should be supplemented by consultation with operators and, to the extent available and useful, by the analytic information used in upgrading the procedures.

2.5.5.1 Operator Task Performance Verification

Instead of going back to checklists and guidelines in Sections 6 and 7 of Part III, this may be the appropriate place to do the entire control room inventory and survey. By using the results of previous systems review steps, the emphasis in the control room survey can be placed on those areas most likely to affect the ability of operators to perform necessary tasks.

2.5.5.2 Procedure Performance Validation Walk-Throughs

This step has the potential for seriously interfering with plant operations. The walk throughs must be completed either when the real plant is shut down for some reason or in a high fidelity plant simulator. A minimum of seven events must be walked through and the suggestion is made that more than one crew walk through each event.

The required output of this setp (i.e. time lines, movement diagrams, etc) may necessitate either film or videotape records of each procedure. It is suggested that any schedule set forth for these activities should allow each utility to plan around their existing operating commitments.

3.0 HED Assessment and Backfit Design/Implementation

This section deals with the process of prioritizing HEDs and planning corrective or mitigating actions. Unfortunately, this entire process is open-loop. That is, the only way suggested to guard against design changes which are useless or which actually degrade performance is to ". . . draw upon the proper technical expertise. . ."

There should be a feedback path in this review so that changes in the control room design or procedures can be re-evaluated against performance requirements.

In addition, there is no real consideration given to

prioritizing HEDs. Besides the "relative safety significance" of an HED, there should be a cost/benefit analysis of each HED. This is a worthwhile procedure, since it will provide an objective comparision between potential safety improvement (benefit) and necessary resource allocation (cost).

V. NRC Evaluation of Licensee Control Room Design Review

It seems unlikely that the Commission has now, or is likely to have in the near future, the number of qualified personnel to evaluate the utility's output from NUREG-0700 (as previewed in NUREG-0659 Draft).

The footnoted suggestion that the utilities implement enhancements to correct idnetified HEDs before submitting the control room design review report to the NRC may not be followed by most utilities. The industry's experience with similar implementation policies has caused individual utilities to be extremely reluctant to commit resources until they are certain of the Commission's posture regarding changes to their plants.

REVIEW OF NUREG-0659 .....Joseph L. Seminara
April 15, 1981

INTRODUCTION

The Institute of Nuclear Power Operations has invited the writer to comment on NUREG-0659. The comments made here should be considered an extension of an earlier review of NUREG/CR-1580, dated October 15, 1980 and published in the Appendix to NUREG-0659 (pps. A-82 to A-92).

IMPROVEMENTS ON NUREG/CR-1580

NUREG-0659 reflects many improvements over the antecedant document, NUREG/CR-1580. Its originators have been highly responsive to industry comments, criticisms, and concerns. Some notable improvements include:

- An obvious attempt to provide guidelines that are more specific to the power industry as opposed to primarily military-aerospace guidelines.
- A streamlining of the guidelines to eliminate superfluous and meaningless "typical backfit" and "human error" statements.
- An expression of latitude in the selection of human factors methods to meet enhancement goals.
- An expressed intent to avoid massive, bureaucratic documentation approaches with regard to HEDs
- Well formatted checklists that should simplify control room reviews and evaluations.

This list could be elaborated further, but suffice it to say that the pains taken to answer the collective concerns of the industry are evident.

SYSTEMS REVIEW

The major innovation provided in the subject document is the description of a systems review procedure intended to be "the core task of the design review." Section IV of NUREG-0659 provides an excellent description of the process for incorporating human factors considerations in the design of a control room. This section should be "required reading" for design organizations involved in developing the nuclear power plant of the future, assuming that any new plants will be developed. However, the validity and effectiveness of applying the systems approach on an "after-the-fact" basis for remedial purposes on a plant-by-plant basis is highly questionable and not likely to be cost-effective. The enormous effort involved, if the systems review process is to be conducted conscientiously, will not yield an appropriate return on investment in meeting public needs either for maximum safety or for power generation.

The massive amounts of labor and funds that would be consumed in applying the systems review process, as defined, at each of seventy or so operational plants and a larger number of non-operational plants in varying stages of development or review, could more effectively be applied in developing major improvements to present control rooms. The present course is likely to lead to atomistic, piecemeal, compromise-ridden "enhancements" that are just as likely to further degrade existing control rooms as to achieve the desired improvements. I will attempt to justify this pessimistic outlook below.

HISTORICAL PERSPECTIVE

Existing nuclear power plants were designed largely on the design foundation established by earlier fossil fuel plants. There was no tradition of providing a special or formal recognition of human factors considerations from the outset. While the potential dangers of nuclear radiation were obvious to all involved, it was assumed that automation was the key to eliminating the operator as a source of system unreliability. In the event of a serious transient, all the operator had to do was to stand back for ten minutes and "let the machine do its thing." The operator's role in an emergency was primarily to verify that automatic system responses had taken place and intervene manually when automatic responses failed to occur. With such automated systems in place to ensure a safe nuclear reactor, there appeared to be no pressing need for the industry or its regulators to concern themselves with human factors methods and principles of control room or plant designs. This "mind set" was shattered in the aftermath of TMI.

It is also important to consider that power plants were designed for a nominal forty year life span including the control room. When we consider that the development process for a nuclear plant can extend ten or more years, the assumption is that the control room will be servicable at the end of its life span with technology that is fifty or more years old. Present control rooms reflect technology that is fifteen to twenty years old, assuming that the initial designs reflected the state-of-the-art then existant (the writer does not make this charitable assumption).

By way of contrast, military systems are not built on a one-of-a-kind basis. Consequently, many diverse talents can be applied in employing the systems approach to the development of a new system with the cost of this talent distributed across many copies of a standard model. Furthermore, the assumption is made that by the time the military system becomes operational it is obsolete and it is time to start work on the next generation of the system to reflect the rapidly advancing state-of-the-art. No amount of upgrading, even with the systematic application of the systems review process would render the B-17 useful in today's military environment.

ENHANCEMENT OPTIONS

Can we upgrade existing control rooms in any meaningful way? Existing control rooms show many signs of modifications since their inception. In one control room, where space was lacking on the control boards, all new requirements for additional controls and displays are added to an add-on console that is on the periphery of the control room. These new instruments are entirely divorced from their functionally related main control board elements. In the interest of satisfying separation criteria related elements of some systems are so separated that they are operationally unwieldy. To meet new seismic requirements access to equipments may be highly limited by steel beams. The list goes on and on. In this writer's experience, most of the backfits observed in control rooms have been compromise-ridden and have introduced a new set of problems often as serious as the ones that

were presumably corrected. This points to the necessity of making modifications to control rooms in a more systematic and judicious manner than has been the case.

After reviewing some two dozen control rooms in varying degrees of depth, the writer is convinced that we need to approach enhancement on several levels. In the very near term there is much that can be done without a very elaborate systems review process. The limits of the near term enhancement process are described in EPRI NP-1118 Volume 1, entitled: Human Factors Enhancement of Existing Nuclear Control Rooms. On a minimum risk basis we can make dramatic improvements that are cost-effective in such areas as:

- Functional demarcation of related panel element groupings
- Improved labeling techniques
- Application of effective coding methods to controls and displays
- Improved control room illumination and noise environments
- Elimination of the potential for accidental control activation
- Meter and chart recorder banding
- Improved emergency lighting systems
- Better communications systems
- Formal configuration control approaches regarding modifications
- Improved procedures and access to procedural information
- Improved control room access provisions to preclude distractions from too many visitors
- Reorganization of operational stations and supervisory stations
- Improved habitability features
- Job restructuring to avoid excessive overtime, improved shift practices, clear-cut divisions of responsibilities, etc.

- o Validated training programs
- o Improved maintenance practices, e.g., replacement of expended indicator lamps.

This list could be expanded further but the essential message that emerges is that important and obvious improvements can be made without elaborate functions allocation, functional analyses, task and time-lines analyses, video-taped walkthroughs, or other "big gun" approaches that are all out of proportion to the nature of the fixes that are possible in the near term. A well designed checklist and clearly stated remedial groundrules are all that are required for immediate retrofits. The guidelines should clearly be differentiated to distinguish those that can realistically and safely be applied on a backfit basis from those that clearly apply to new equipments that are being introduced into existing control rooms or for the design of new plants. Anthropometric guidelines, for example, are generally useless for retrofit purposes but extremely valuable for application to new equipment being designed or procured. The insistance on dual lamp reliability or lamp test circuitry as a remedial avenue is of highly questionable value when we consider the possible negative impact on circuitry reliability and the unreasonable expense involved. While all self-respecting human factors specialists would insist on lamp test or redundant lamp features at the design table, the value of lamp test vs better discipline in changing lamps is not so clearcut a choice when we are considering backfit tradeoffs. In this writer's view, the list of remedial possibilities is relatively small for the near term and a comprehensive checklist describing real and risk-free evaluation points could be described in ten pages or less.

Having stated my reservations regarding near-term enhancement possibilities, let me hasten to add that I do not feel that the near-term fixes that are likely to result from either an abbreviated review procedure or the elaborated NUREG-0659 systems review plan are going to address the fundamental problems that have been documented in EPRI NP-309 before it was fashionable to find fault with the human factors aspects of control rooms. In this writer's view, long-term, validated solutions to existing problems are necessary and have the only hope of leading to the basic improvements that are vitally needed. These long-term solutions will not come from armchair analyses or the necessity to act quickly for the sake of taking action to seemingly satisfy public, regulatory, or other pressures. Effective solutions to such fundamental problems as providing effective means for diagnosing system perturbations, providing operators with warning systems that are meaningful and avoid sensory overload situations, providing the optimal degree of system automation, etc. will not be found by means of a multitude of parallel plant system reviews. Such solutions require the systems approach applied on a generic basis to arrive at candidate solutions that are then validated empirically in simulation testbeds.

To achieve the objectives of NUREG/CR-1580, NUREG-0659, and NUREG-0700, it will be necessary to channel the enormous effort and expenditures being called for by the NUREG-0659 system review process into (1) the immediate, relatively inexpensive, improvements that are possible now with little or no risk and (2) the development of "crash" programs

with the best talent available (including space and military expertis to devise and validate lasting solutions to existing control room deficiencies.

In this writer's judgment, the kinds of solutions called for will not take the form of moving a given control two feet in one direction or another, shape coding identical controls that have been colocated, backlighting displays on a retrofit basis, or eliminating a display that has been found to be superfluous. We are extremely limited in our attempts to upgrade hard-wired control boards that are in my judgment obsolete. Basic solutions are likely to take the form of new stations in the control room that are advanced computer-based CRT systems to supplement the existing hard-wired boards. The present requirement to add a Safety Parameter Display System to the control rooms is one step in this direction. This step should be enlarged to provide the means to fully upgrade the control room leaving the hard-wired boards essentially as they are now with the exception of surface or minor modifications that can readily be implemented.

The writer does not underestimate the magnitude of effort required to find meaningful solutions to present control room deficiencies. Such solutions will not come from plant specific reviews, from utility personnel acting on an individual basis, from regulators, or from human factors specialists, A/Es, NSSS vendors and assorted consulting firms. It will take a unified effort representing each of these interests but managed and integrated by individuals outside the industry with no vested interest in the past.