NUREG-0801

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EVALUATION CRITERIA FOR DETAILED CONTROL ROOM DESIGN REVIEWS

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ABSTRACT

NUREG-0801 provides criteria to be used by the NRC staff to evaluate the Detailed Control Room Design Reviews (DCRDRs) performed by licensees/applicants. Also included is an acceptable methodology for assessing human engineering discrepancies (HEDs). Licensees/applicants may also use the information provided in this document as guidance on how to acceptably document their DCRDR efforts.

The NRC staff evaluation of the licensee/applicant DCRDR efforts will consist of: the evaluation of a program plan report. an in-progress audit at selected sites; the evaluation of a DCRDR summary report; a possible onsite preimplementation audit; and the preparation of a Safety Evaluation Report (SER).

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FOREWORD

In response to the accident at Three Mile Island Unit 2, the Nuclear Regulatory Commission (NRC) developed a comprehensive and integrated plan designed to improve the operational safety of nuclear facilities. NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident," contains descriptions of the tasks that make up this plan. NUREG-0737, "Clarification of TMI Action Plan Requirements," provides additional information on the plan.

Task I.D of the NRC Action Plan is "Control Room Design." The objective of this Task, as stated in NUREG-0660, is to improve the ability of nuclear power plant control room operators to prevent accidents or to cope with accidents that occur by improving the information provided. Item I.D.1 of Task I.D is "Control Room Design Reviews." This Item states that operating licensees and applicants for operating licenses will be required to perform a Detailed Control Room Design Review (DCRDR) to identify and correct design discrepancies. The description of Item I.D.1 also states that the NRC will formulate design review guidelines to be used by the licensees/applicants and evaluation criteria to be used by the NRC to judge the acceptability of the licensees' and applicants' DCRDRs.

SECY-82-111, dated March 11, 1982, requested Commission approval of a set of basic requirements for emergency response capability (Safety Parameter Display System, Detailed Control Room Design Reviews; Regulatory Guide 1.97, Revision 2, Upgrade of Emergency Operating Procedures; and Emergency Response Facilities) and approval for the NRC to work with licensees to develop plant-specific implementation schedules. On July 16, 1982, the Commission approved SECY-82-111, subject to a number of modifications. The basic requirements were published as Supplement 1 to NUREG-0737, which was issued on December 17, 1982.

The Office of Nuclear Reactor Regulation's Division of Human Factors Safety (DHFS) published NUREG-0700, "Guidelines for Control Room Design Reviews," in September 1981. NUREG-0801, which contained draft evaluation criteria for the DCRDRs, was published for public comment in October 1981. Comments on NUREG-0801 were received and reviewed by the DHFS Human Factors Engineering Branch. The draft document has been revised to reflect these public comments, Commission guidance, and additional staff development work. The document is now being issued as NUREG-0801, "Evaluation Criteria for Detailed Control Room Design Reviews."

NUREG-0801 provides guidance, and compliance with this document is not a requirement. Departures by licensees/applicants from the methodologies recommended in NUREG-0700 and in this document will be acceptable if the methodologies that are used accomplish the same objectives.

Appendix E summarizes significant changes in the NRC approach for control room design reviews from that presented in NUREG-0700.

The information collection requirements covered by this document were approved by the Office of Management and Budget under Clearance No. 3150-0065 for NUREG-0737.

The Human Factors Engineering Branch, Division of Human Factors Safety, was responsible for the preparation of this document. Any questions concerning the content of this document should be directed to the Chief of the Human Factors Engineering Branch at (301) 492-7014 or at the following address:

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1 INTRODUCTION

1.1 Purpose and Scope

Item I.D.1, "Control Room Design Reviews," of the NRC Action Plan developed as a result of the TMI accident (NUREG-0660 and NUREG-0737) states that the NRC will require all licensees and applicants for operating licenses (OLs) to conduct a Detailed Control Room Design Review (DCRDR). The Commission has established requirements and provided guidance for the performance of the DCRDRs in Supplement 1 to NUREG-0737, which will impose these requirements on the licensees/applicants as provided in 10 CFR 50.54(f) as a condition of license. The requirements as stated in Supplement 1 to NUREG-0737 are as follows:

(1) Identify modifications to control room configurations that would contribute to a significant reduction in risk and enhancement of the safety of operation. The objective of the control room design review is to "improve the ability of nuclear power plant control room operators to prevent accidents or cope with accidents if they occur by improving the information provided to them" (from NUREG-0660, Item I.D.1). As a complement to improvements of plant operating staff capabilities in response to transients and other abnormal conditions that will result from implementation of the Safety Parameter Display System (SPDS) and from upgraded emergency operating procedures, this design review will identify any modifications of control room configurations that would contribute to a significant reduction of risk and enhancement of the safety of operation. Decisions to modify the control room would include consideration of long-term risk reduction and any potential temporary decline in safety after modifications resulting from the need to relearn maintenance and operating procedures. This should be carefully reviewed by persons competent in human factors engineering and risk analysis.

(2) Conduct a control room design review to identify human engineering discrepancies. The review shall consist of

   a. The establishment of a qualified multidisciplinary review team and a review program incorporating accepted human engineering principles.

   b. The use of function and task analysis (that had been used as the basis for developing emergency operating procedures Technical Guidelines and plant-specific emergency operating procedures) to identify control room operator tasks and information and control requirements during emergency operations. This analysis has multiple purposes and should also serve as the basis for developing training and staffing needs and verifying SPDS parameters.

   c. A comparison of the display and control requirements with a control room inventory to identify missing displays and controls.

d. A control room survey to identify deviations from accepted human factors principles. This survey will include, among other things, an assessment of the control room layout, the usefulness of audible and visual alarm systems, the information recording and recall capability, and the control room environment.

(3) Assess human engineering discrepancies to determine which are significant and should be corrected. Select design improvements that will correct those discrepancies. Improvements that can be accomplished with an enhancement program (paint-tape-label) should be done promptly.

(4) Verify that each selected design improvement will provide the necessary correction, and can be introduced in the control room without creating any unacceptable human engineering discrepancies because of significant contribution to increased risk, unreviewed safety questions, or situations in which a temporary reduction in safety could occur. Improvements that are introduced should be coordinated with changes resulting from other improvement programs such as SPDS, operator training, new instrumentation (Regulatory Guide (RG) 1.97, Revision 2), and upgraded emergency operating procedures.

Supplement 1 to NUREG-0737 also specifies that documentation shall be provided from licensees and associated NRC staff review as follows:

(1) All licensees/applicants shall submit a program plan within 2 months of the start of the control room review that describes how the items 1, 2, 3, and 4 above will be accomplished. The NRC staff will review the program plans as licensees conduct their reviews, and selected licensees will undergo an in-progress audit by the NRR human factors staff based on the program plans and advice from Project Managers and resident inspectors.

(2) All licensees/applicants shall submit a summary report of the completed review outlining proposed control room changes, including their proposed schedules for implementation. The report will also provide a summary justification for any human engineering discrepancies with safety significance that are to be left uncorrected or partially corrected.

(3) The staff will review the summary reports, and within 2 weeks after receipt of a licensee's/applicant's summary report, will inform the licensee whether a pre-implementation onsite audit will be conducted. The decision will be based on the content of the program plan, the summary report, and the results of NRR audits in progress, if any. The licensees/applicants selected for pre-implementation audits may or may not include licensees/applicants selected for in-progress audits.

(4) For a licensee whose control room is selected for pre-implementation onsite audit, within 1 month after receipt of the summary report, the NRC staff will conduct

a. A pre-implementation audit of proposed modifications (e.g., equipment additions, deletions and relocations, and proposed modifications).

b. An audit of the justification for those human engineering discrepancies with safety significance to be left uncorrected or only partially corrected.

The audit will consist of a review of the licensee's/applicant's record of the control room reviews, discussions with the licensee/applicant review team, and usually a control room visit. Within a month after this onsite audit, the NRC staff will issue its safety evaluation report (SER).

(5) For a licensee for whose control room NRC staff does not perform a pre-implementation onsite audit, the NRC staff will conduct a review and issue its SER within 2 months after receipt of the licensee's summary report. The review shall be similar to that conducted for pre-implementation plants under paragraph 4 above, except that it does not include a specific audit.

The SER shall indicate whether, based on the review carried out, changes in the licensee's modification plan are needed to ensure operational safety. Flexibility is considered in the control room review, because certain control board discrepancies can be overcome by techniques not involving control board changes. These techniques could include improved procedures, improved training, or the SPDS.

(6) The following approach will be used for OL review: For OL applicants whose plants the Supplemental Safety Evaluation Report (SSER) will be issued before June 1983, licensing may be based on either a Preliminary Design Assessment (PDA) or a Detailed Control Room Design Review (DCRDR) at the applicant's option. However, applicants who choose the PDA option are required to perform a DCRDR after licensing. For applicants with SSER dated after June 1983, a DCRDR will be required before licensing.

(7) After the staff has issued an SER and a licensee/applicant has addressed any open issues, the licensee/applicant may begin the upgrade according to an approved schedule that has been negotiated with the staff.

The purpose of the DCRDR is to identify existing human engineering discrepancies (HEDs) in the control room and to correct those HEDs that represent significant design discrepancies whose correction will improve the operational safety of the nuclear facility. To help the licensee/applicant conduct the DCRDR, NRC developed and published NUREG-0700, "Guidelines for Control Room Design Reviews."

NUREG-0801 provides criteria to be used by the NRC staff to evaluate the DCRDRs performed by the licensees/applicants. The NRC will use these criteria to confirm that the basic requirements established by the Commission and the objectives of the DCRDR program stated in NUREG-0700 have been met. The NRC staff will also use the information provided in this document as guidance for verifying the selection of a qualified DCRDR team and the preparation of acceptable DCRDR documentation.

Departures by licensees/applicants from the methodologies recommended in NUREG-0700 and in this document will be acceptable if the methodologies that are used accomplish the same objectives.

The NRC staff evaluation of licensee/applicant DCRDR efforts will consist first of an evaluation of the program plan report submitted by the licensee/applicant. Second will be a scheduled visit to some of the plant sites to audit the progress of the DCRDR programs. Third will be an evaluation of the licensee's/applicant's DCRDR summary report. Fourth is a possible pre-implementation audit. The final step is the preparation of a Safety Evaluation Report (SER) by the NRC staff that will present the results of the NRC evaluation.

1.2 Integration and Coordination of the DCRDR with Other Programs

The NRC Action Plan, as described in NUREG-0660 and NUREG-0737 and supplemented in Supplement 1 of NUREG-0737, includes initiatives in addition to the DCRDR. These include the design of a Safety Parameter Display System (SPDS); the design of instrument displays based on RG 1.97, Revision 2, guidance; the development of function-oriented emergency operating procedures; and the training of the operating staff. It is essential that all of these initiatives be integrated with respect to the overall improvement of the operator's ability to comprehend plant conditions and cope with emergencies. Information needs and display formats and locations should be assessed by each licensee in conjunction with the design of the SPDS. Installation of the SPDS should not be delayed by slower progress on other initiatives, and should not be contingent on completion of the control room design review. Moreover, other initiatives, such as upgraded emergency operating procedures, should not be impacted by delays in SPDS procurement.

The requirements for these initiatives are stated in Supplement 1 to NUREG-0737; the detailed guidance on performing and implementing them is described in the referenced NRC documents. The three groups of initiatives--SPDS, control room improvements, and emergency response facilities (the Technical Support Center, Emergency Operations Facility, and Operational Support Center)--have the following interrelationships:

(1) The SPDS is an improvement because it enhances operator ability to comprehend plant conditions and interact in situations that require human intervention. The SPDS could affect other control room improvements that licensees may consider. In some cases, a good SPDS could obviate the need for extensive modifications to control rooms.

(2) The SPDS and control room improvements are essential elements in operator training programs and the upgraded plant-specific emergency operating procedures.

(3) Acquisition, processing, and management of data for SPDS, control room improvements, and emergency response facilities should be coordinated.

Exhibit 1-1 is a flow diagram illustrating the interrelationship between the tasks. Exhibits 1-2 through 1-4 are examples of the details involved in performing the DCRDR, upgrading the emergency operating procedures, and developing the SPDS.

All programs that involve physical or operational changes to the control room described in Supplement 1 to NUREG-0737 should be integrated and coordinated with the DCRDR. In addition, the corrective action modifications resulting

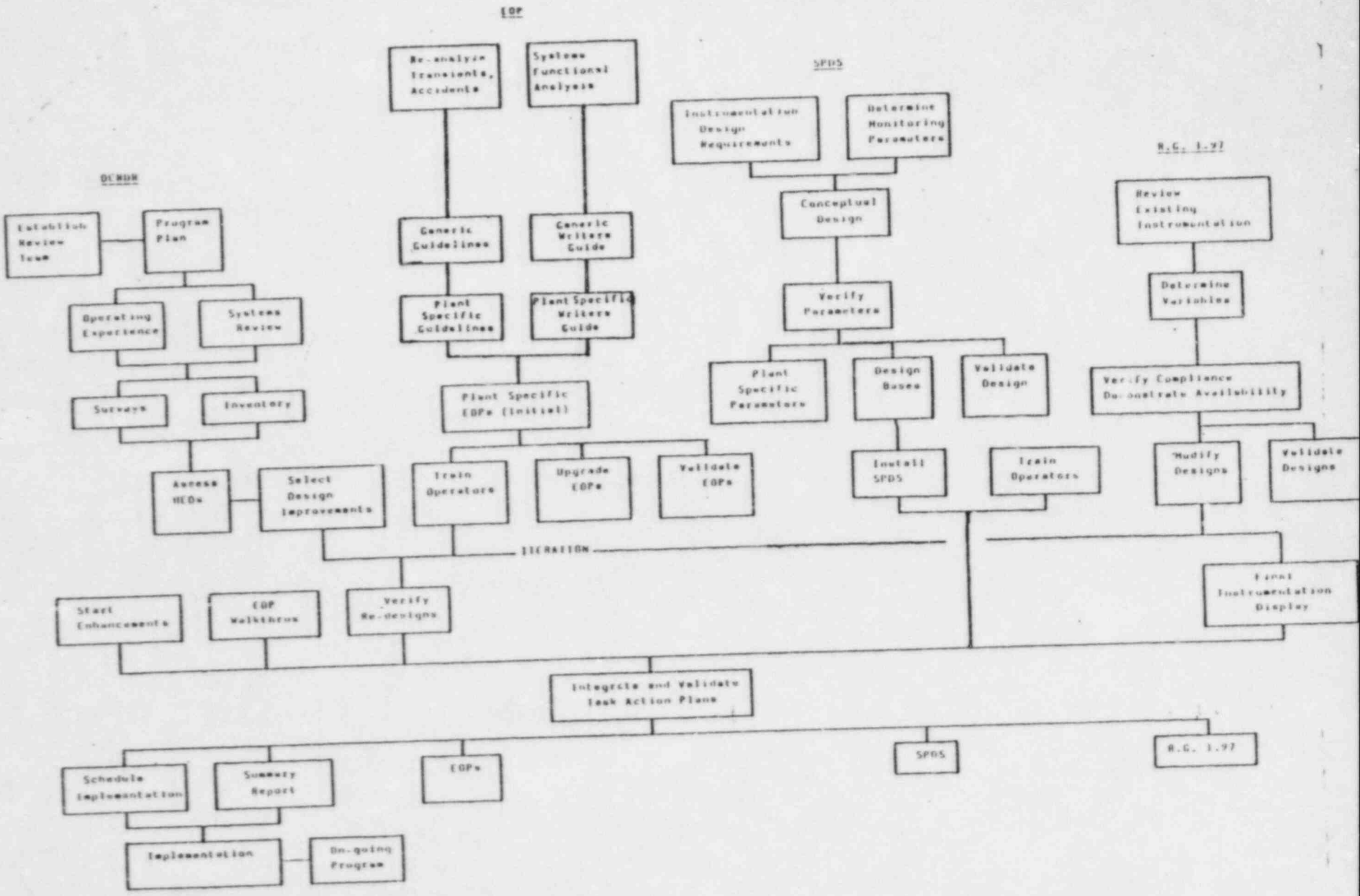
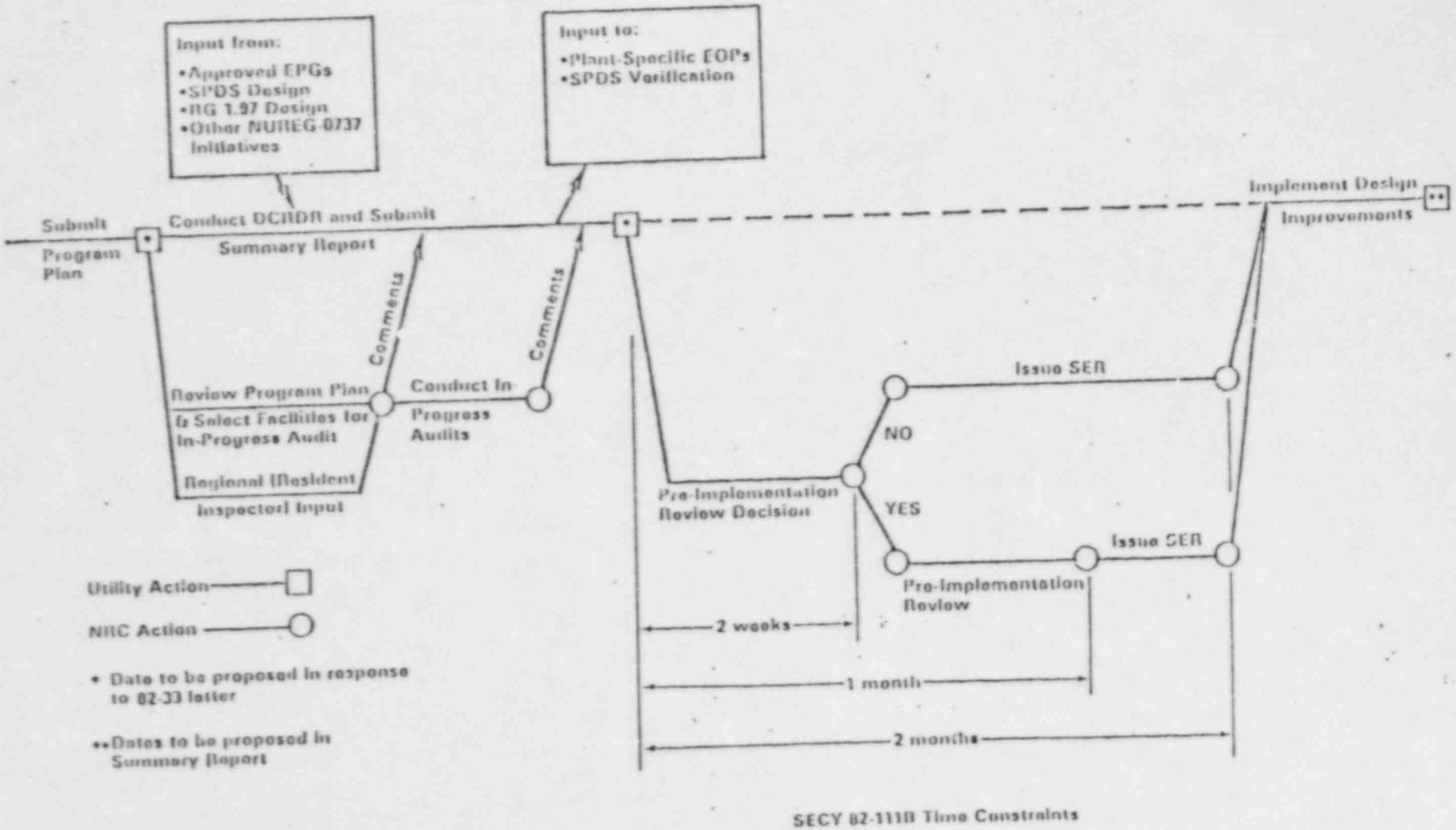


Exhibit 1-1: Coordination and Integration of the Initiatives (Supplement 1 of NUREG-0737)

Note:
- Diagram illustrates interrelationship of the DCRDR with other initiatives.
- Flow paths shown are suggested sequences.
- Prompt implementation of the SPDS is recommended.



SECY 82-111B Time Constraints

Exhibit 1-2: Detailed Control Room Design Review (DCRDR)

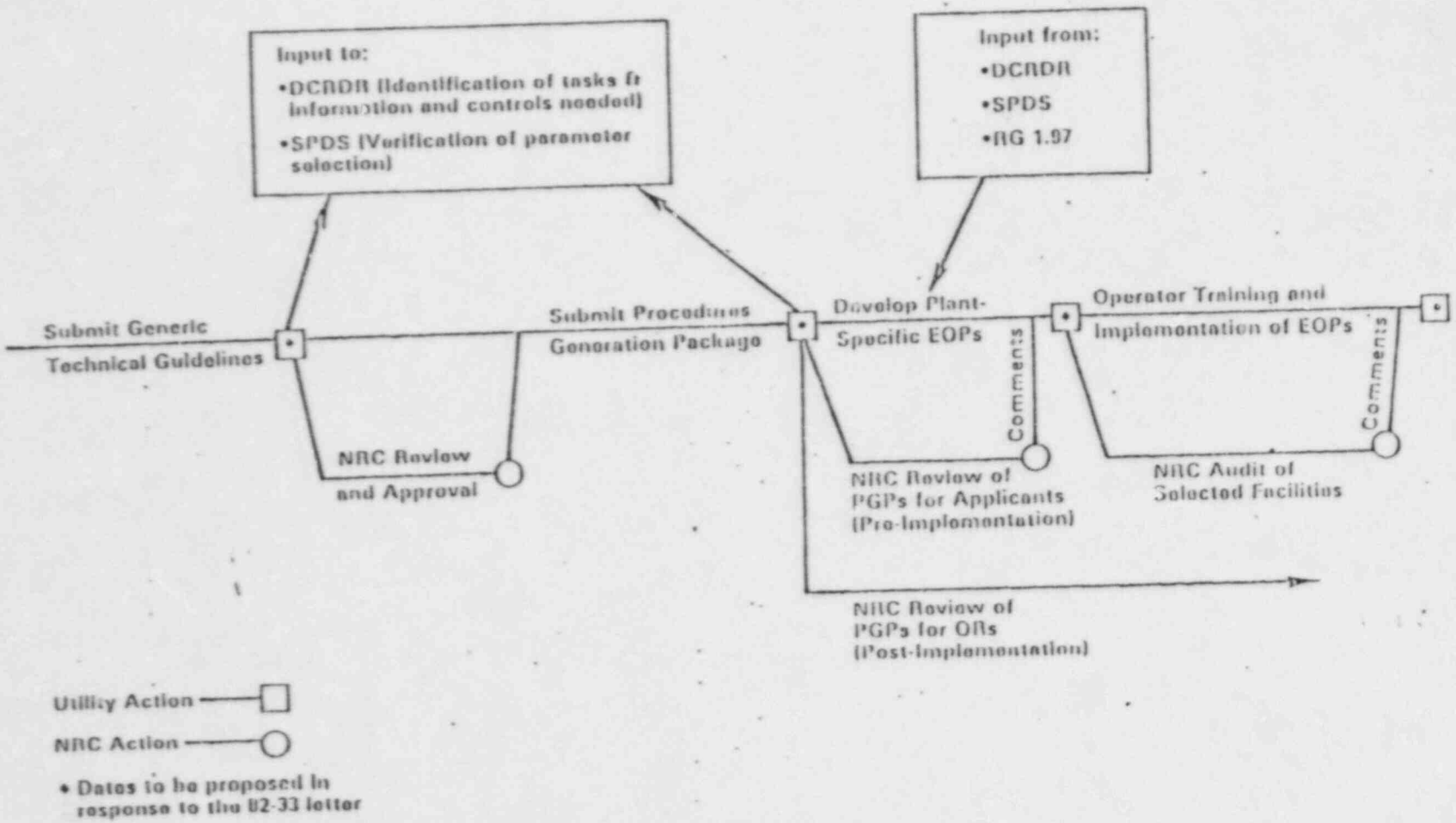


Exhibit 1-3: Upgrade of Emergency Operating Procedures (EOPs), Plants Using Generic Guidelines

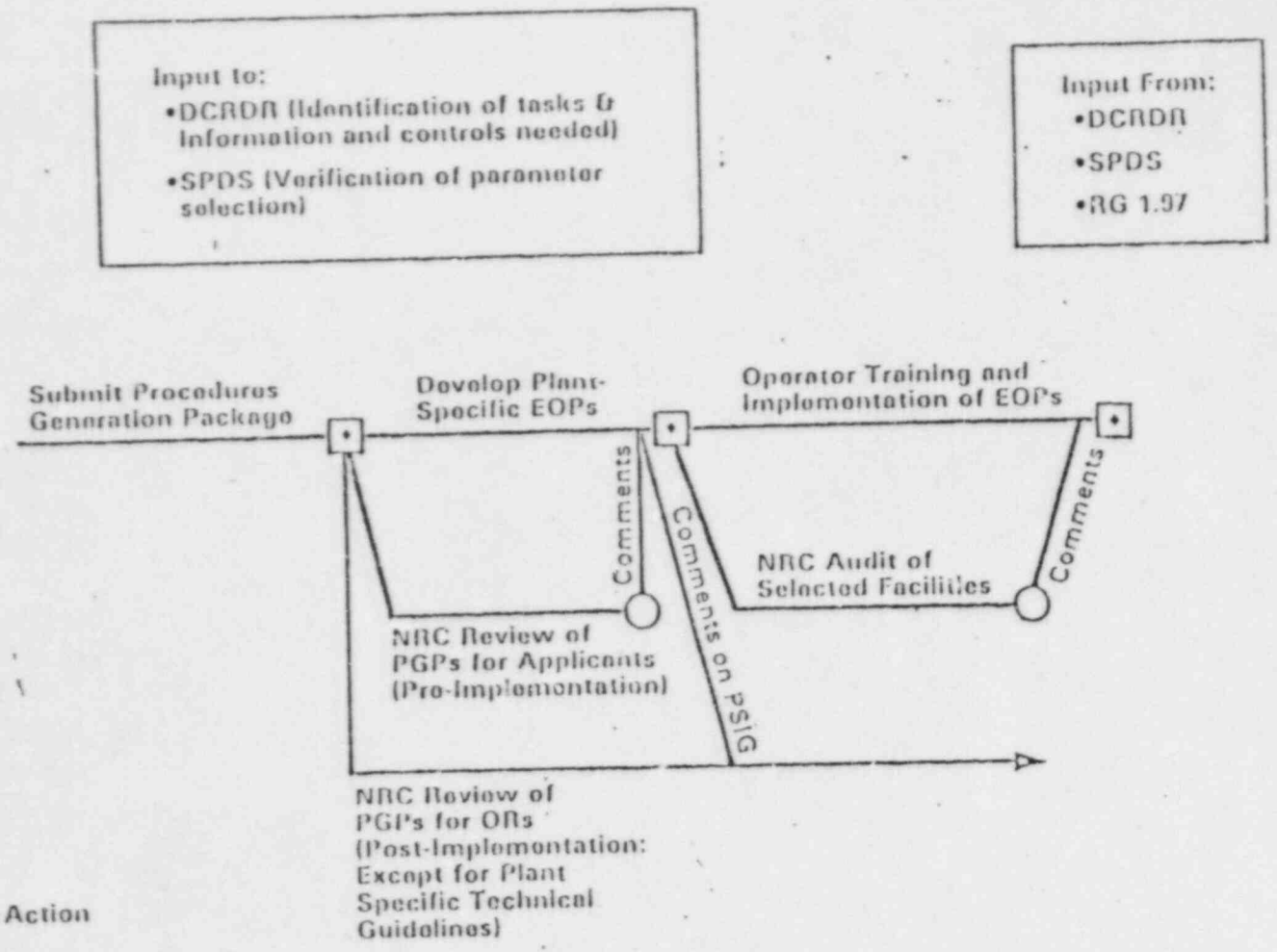


Exhibit 1-4: Upgrade of Emergency Operating Procedures (EOPs), Plants Not Using Generic Guidelines

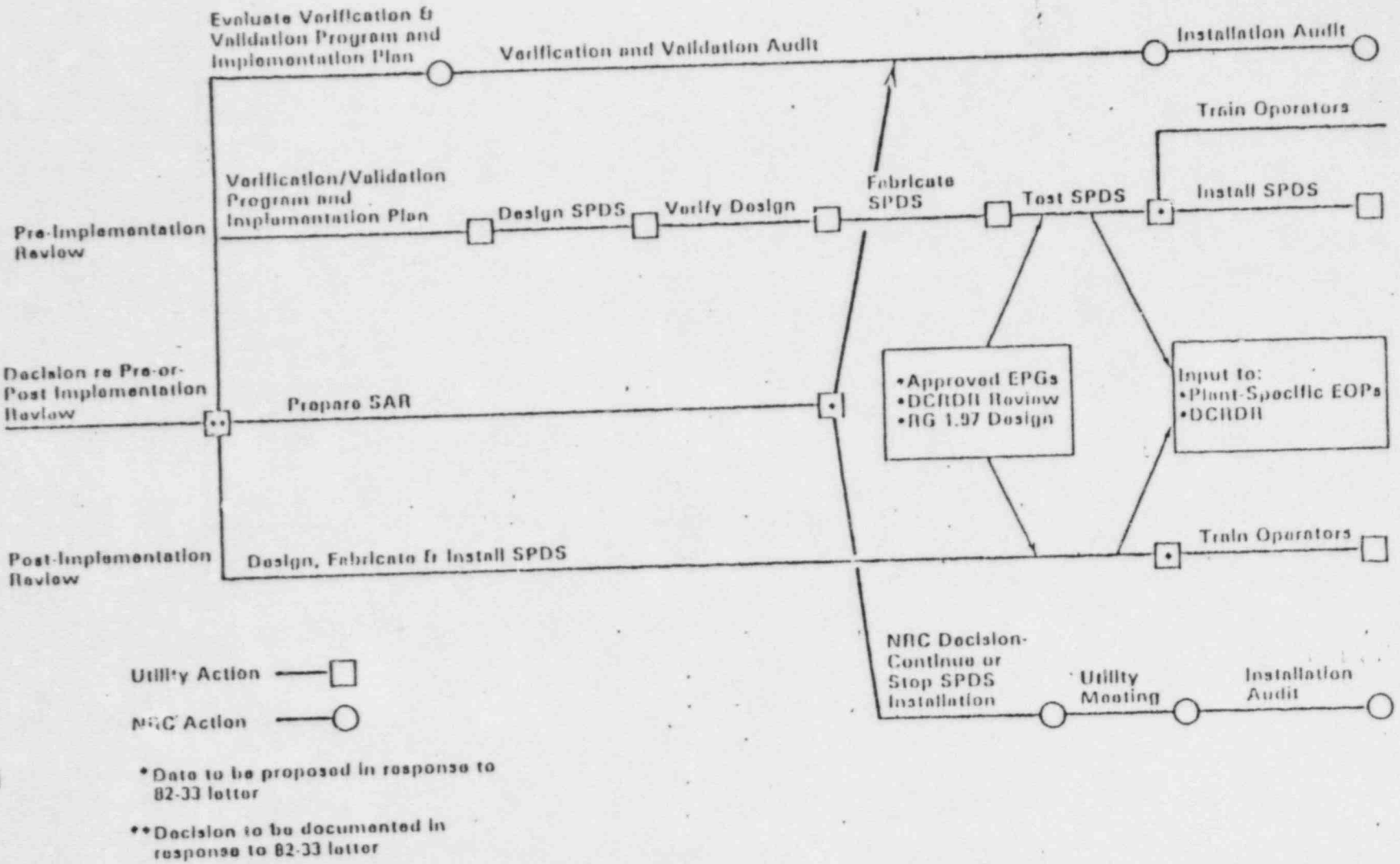


Exhibit 1-5: Development of a Safety Parameter Display System

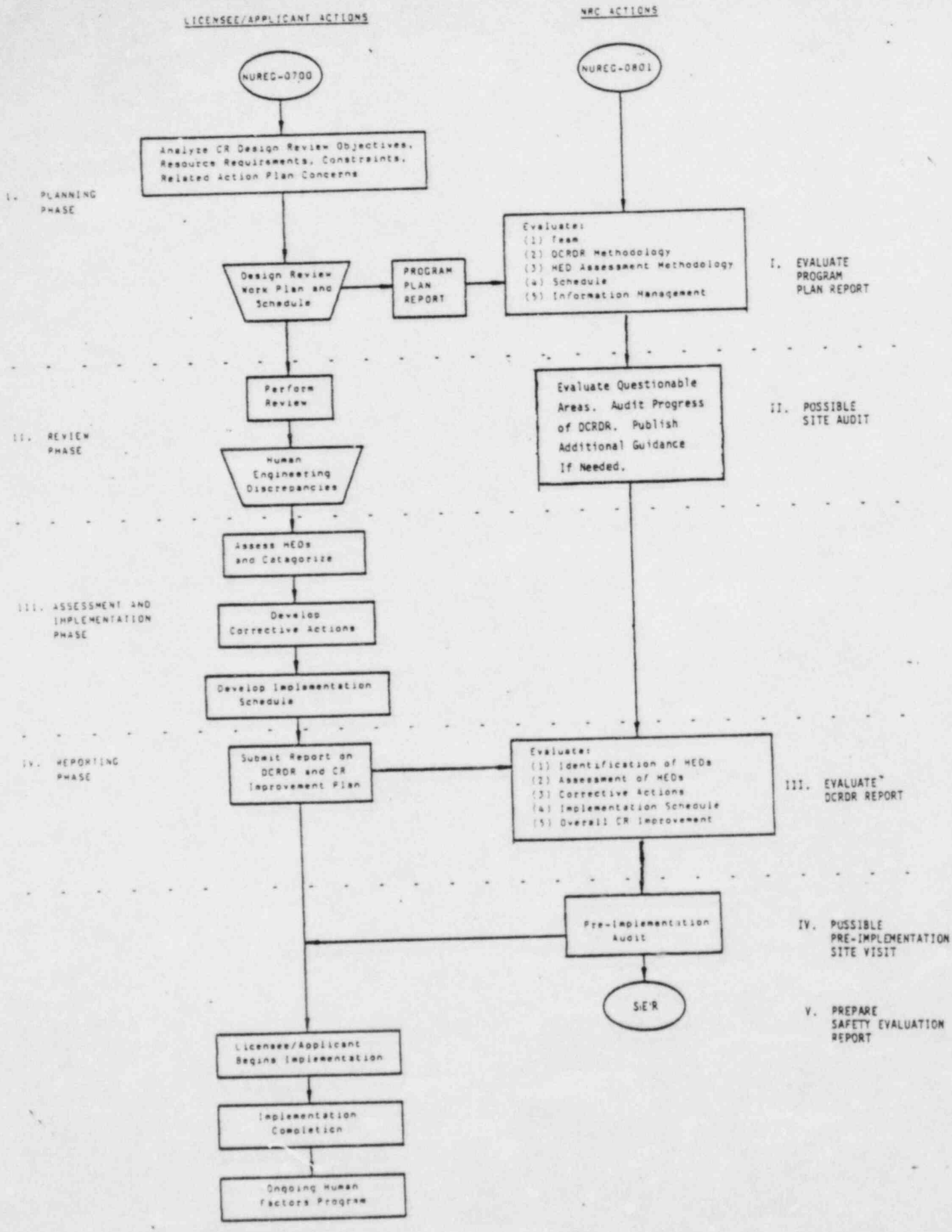


Exhibit 1-6: Relationships between DCRDR phases and NRC evaluation

from the DCRDR should be evaluated for their effects on these other programs. The coordination of the DCRDR and these other programs should include provisions for any necessary operator retraining and upgrading of operating procedures to reflect the physical changes made to the control room.

Functions and tasks should be analyzed to determine information and control requirements and identify operator tasks during emergency operations. This analysis should be used in writing the emergency procedure guidelines and should serve as the basis for developing training and staffing needs and verifying the SPDS parameters. Although additional analyses will be required, the function and task analysis required by NUREG-0899, "Guidelines for the Preparation of Emergency Operating Procedures, Resolution of Comments on NUREG-0799," can be used in defining the scope of the systems reveiw for NUREG-0700 and the improvements in operator training. For further details, see Appendix D.

Although development of a human factors engineering program is not a requirement, the NRC recommends that each licensee/applicant develop an ongoing human factors engineering program to examine any future changes that may be proposed for the control room after the DCRDR corrective actions are implemented. A human factors analysis could then be performed as part of the design and validation of any future control room modification.

1.3 Overview of DCRDR and NRC Evaluation Activities

NUREG-0700 describes four phases of the DCRDR to be performed by the licensee/applicant. These phases are

- planning
- review
- assessment and implementation
- reporting

NUREG-0700 and this document describe the activities to be performed by the NRC staff. The NRC staff's evaluation activities are briefly identified in the following subsections. The criteria to be applied during this evaluation process are presented in detail in Chapters 2.0 through 5.0.

Exhibit 1-6 illustrates the relationships between the four review phases of the DCRDR that will be performed by the licensee/applicant and the NRC staff's evaluation activities.

1.3.1 Evaluation of DCRDR Program Plan Report

The licensee/applicant should develop a program plan early in the DCRDR effort. A report describing the program plan should be submitted to the NRC.

The NRC staff will review the submitted report. NRC approval of the program plan is not required. However, the licensee/applicant will be informed of any

questionable areas the NRC identifies in the review. In addition, the results of the review of the program plan reports will help to determine which plants are selected for in-progress site audits.

1.3.2 NRC Site Audits During the Review Phase

Selected licensees and applicants will undergo in-progress site audits by the NRC staff. The sites will be selected for audit based on the NRC review of the submitted program plan reports and advice from Project Managers and resident inspectors.

The purpose of these selective audits will be to observe the review and identify to the licensee/applicant any potential inadequacies in the DCRDR program. The in-progress site audit will serve as one input to the NRC staff evaluation of the completed DCRDR. In addition, the NRC staff will evaluate the need for additional guidance or revision to existing guidance to ensure meaningful completion of the DCRDRs. The site audits will be pre-announced and will be scheduled at suitable stages of the DCRDR.

1.3.3 Evaluation of DCRDR Summary Report

The licensee/applicant will prepare a summary report that presents the results of the DCRDR program and the proposed actions to correct any identified control room design discrepancies. This report should be submitted to the NRC staff before the licensee/applicant begins any major modifications to the control room.

1.3.4 Pre-implementation Audit

On the basis of the NRC staff evaluation of the DCRDR summary reports, content of program plan, and the results of any in-progress audits, some licensees/applicants will be selected for pre-implementation audits. During these onsite audits, the NRC staff will perform a more detailed evaluation of the licensee's/applicant's DCRDR. The evaluation will include an examination of the licensee's/applicant's DCRDR documentation, discussions with the review team, inspection of the existing control room, and inspection of any mockups of proposed corrective action modifications.

1.3.5 Preparation of Safety Evaluation Report

After the NRC staff completes its evaluation of the licensee's/applicant's DCRDR effort, the staff will issue a Safety Evaluation Report (SER). This SER will be based on the evaluation of the submitted program plan report, the results of any in-progress site audits, the evaluation of the submitted DCRDR summary report, and the results of any pre-implementation audit.

2 EVALUATION OF DCRDR PROGRAM PLAN REPORT

The first phase of the DCRDR is the development of a program plan by the licensee/applicant. Section 2, "Planning Phase," of NUREG-0700 provides guidelines for the areas that the licensee/applicant should consider during the development of this plan. The report should be submitted to the NRC staff early in the review process.

The NRC staff will review the submitted report against the general requirements established by the Commission in Supplement 1 to NUREG-0737 and the DCRDR guidance for meeting these requirements as stated in NUREG-0700. NRC staff approval of the program plan is not required. The results of the NRC evaluation of the program plan reports will help to determine which plants are selected for in-progress site audits. In addition, the NRC will provide feedback to the licensee/applicant on any areas identified as questionable.

The following sections contain the criteria to be used by the NRC staff for review of the program plan reports submitted by licensees/applicants. The licensees/applicants may also use the information provided in this chapter as guidance for the selection of a qualified DCRDR team and preparation of program plan report. The program plan report should describe:

- DCRDR team
- DCRDR methodology
- HED assessment methodology
- DCRDR schedule
- DCRDR information management

2.1 DCRDR Team

The quality of the review effort and the results of the DCRDR will depend on the composition and balance of the team performing the review. The composition of a good review team can vary widely. Each licensee/applicant will select a team from available internal and external resources. The NRC staff will confirm that the disciplines represented on the licensee/applicant review team are appropriate for the performance of a meaningful DCRDR and that there is continuous support by human factors experts and operational personnel.

Although the composition of each licensee's/applicant's DCRDR team may vary, there are some general evaluation guidelines that can be applied during the NRC staff review. These guidelines are categorized as follows:

- management and structure
- composition and qualifications

- responsibilities
- orientation

2.1.1 Management and Structure

The management and structure of the review team will vary for the different DCRDR efforts because of the differing needs and capabilities of the various utilities and the differing resources available to them. The degree of utilization of in-house and outside personnel is left to the discretion of the individual licensee/applicant, as long as the necessary multi-disciplinary expertise is provided.

The NRC staff recommends that the DCRDR team management and structure include the following:

Administration: Overall administrative leadership of the DCRDR program should be provided by a utility employee, because the ultimate responsibility for the DCRDR lies with the licensee/applicant.

Human Factors: The DCRDR team should have capabilities and extensive experience in the human factors field, with experience in coordinating projects similar to the overall performance of the DCRDR. Human factors should be especially considered in the program planning phase of the DCRDR.

Technical Review Leaders: The different tasks of the DCRDR program will have varying technical leadership needs. The licensee/applicant should select an appropriately qualified technical review leader for each task. The licensee/applicant should also assign human factors personnel to support the technical leadership of each portion of the DCRDR program.

Extensive use of human factors personnel throughout all portions of the review is necessary to ensure that the DCRDR is conducted from the proper human factors perspective. Human factors personnel should be involved in the actual performance of the review tasks and in all decisions involving design changes; they should not be limited to purely advisory roles.

Any additional individuals or groups that support the DCRDR should be described in the program plan report. For example, the licensee/applicant may assign an individual or group of support personnel to manage the extensive DCRDR data base. This individual or group should be identified in the program plan report.

In evaluating the structure of the licensee's/applicant's review team, the NRC will consider the different aspects of the technical review tasks and the resources that will be needed by the team. Although the degree of participation of the various team members will vary for the different tasks, all team members should participate to some extent in most team activities. This will help the team operate from a common perspective, and will preserve the multi-disciplinary approach by having each specialist bring his or her expertise to each task.

Exhibit 2-1 provides a sample list of some of the major review tasks of the DCRDR with the disciplines that should be emphasized for each effort. The

Review Process	Discipline Emphasis
1. Operating Experience Review	
o Examination of Available Documents	Nuclear Systems Engineering/ Reactor Operations
o Control Room Operations Personnel Survey	Human Factors/Reactor Operations
2. Review of System Functions and Analysis of Operator Tasks	
o Identification of Event Sequences	Nuclear Systems Engineering
o Function Identification	Nuclear Systems Engineering
o Function Analysis	Human Factors/Systems Analysis
o Operator Task Identification	Nuclear Systems Engineering/ Reactor Operations
o Task Analysis	Human Factors/Systems Analysis
3. Control Room Inventory	Instrumentation and Control/ Reactor Operations
4. Control Room Survey	Human Factors/Subject Specialists
5. Verification of Task Performance Capabilities	
o Verification of Availability	Instrumentation and Control/ Reactor Operations
o Verification of Human Engineering Suitability	Human Factors
6. Validation of Control Room Functions	Instrumentation and Control/ Reactor Operations/Human Factors/Systems Analysis

Exhibit 2-1: Major DCRDR Tasks and Recommended Discipline Emphases

information provided in this exhibit will be used as a guide by the NRC staff in evaluating the review team structure proposed by the licensee/applicant. The recommendation of a particular discipline for a specific review task as shown in Exhibit 2-1 does not imply that only the team member with that expertise is needed to perform this task.

The proposed assignments and levels of effort of each review team member will necessarily be only estimates at the time the program plan report is submitted. The NRC staff will evaluate the appropriateness of the proposed assignments and responsibilities of each of the DCRDR team members based on the individual team member's qualifications.

2.1.2 Composition and Qualifications

It is recommended that the DCRDR team described in the licensee's/applicant's program plan report should have a core group of specialists in the fields of human factors engineering, plant operations (e.g., licensed operators), instrumentation and controls engineering, and nuclear engineering. This core group should be supplemented by other disciplines, as required, such as mechanical engineering, electrical engineering, industrial engineering, architectural engineering, reliability and risk analysis, systems engineering, operations analysis, etc. At various times during the course of the review, the licensee/applicant should plan to provide additional specialists (e.g., lighting and acoustics, visual performance assessment, etc.) for specific tasks, as required.

The program plan report should contain detailed documentation of the qualifications of the DCRDR team members. In particular, the roles of the team members, including the human factors specialists, should be reported.

Whenever possible, the review team should have access to the original control room designers as resource persons and to original design documentation, if possible, especially during the delineation of system functions, operator task analyses, and control room inventory efforts. However, individuals who were extensively involved in the design of the existing control room should not be directly responsible for directing those portions of the DCRDR process that require objectivity about the quality of that design.

Criteria that can be used in evaluating the qualifications of the personnel who will make up the DCRDR team core group are given below.

2.1.2.1 Human Factors Specialist*

A qualified human factors specialist should have both academic background and relevant work experience. Neither credential alone is assurance of a completely qualified individual. Because qualified human factors specialists may

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*This document uses the term "human factors specialist" rather than "human factors engineer" to avoid the possible implication that only human factors personnel with engineering degrees will be considered acceptable by the NRC staff to provide the human factors input to the DCRDR.

have received their formal training in a variety of disciplines ranging from engineering to the behavioral sciences, the relevant work experience of each individual will determine whether he/she has the appropriate perspective to provide human factors input to the DCRDR program.

Formal Education: A degree, preferably at the graduate level, in human factors engineering or engineering psychology, is recommended. If the education of the proposed human factors specialist is in the more traditional fields of engineering or psychology, his or her supplemental course work should include some of the following subjects:

- human factors engineering
- human performance theory
- sensory/perceptual processes
- experimental psychology
- quantitative methods/statistics
- ergonomics
- anthropometry
- survey design
- industrial engineering/design

Professional Experience: As a guideline, at least 5 years of relevant human factors experience is recommended for the Senior Human Factors Specialist who is given the overall advisory role in the DCRDR program. Less experienced human factors personnel may share the technical leadership of the specific review tasks under the direction/advisory guidance of this Senior Human Factors Specialist.

Experience in process control system design and plant operations is preferred. Demonstration of extensive experience in the application of human factors engineering and engineering psychology to other large, complex human-machine systems (e.g., command and control systems, submarine control-display layouts) would be an acceptable alternative. At least one of the human factors professionals included on the DCRDR team should have experience in systems analysis and task analysis.

Experience should include the application of human factors to the design and/or evaluation of the following subject areas:

- operator job definition
- workspace layout
- panel design (control and display layout)
- environmental conditions (e.g., lighting and acoustics)
- procedures and training

Although membership in the Human Factors Society may indicate that a person has some involvement in human factors engineering, membership alone does not necessarily indicate qualification as a human factors specialist for the DCRDR program.

2.1.2.2 Reactor Operator

It is recommended that the DCRDR team should include at least one currently licensed reactor operator because only an operator can provide the perspective of the "human" in the "human-machine interface." The participation of operators is especially important during the review of operator response to operating conditions.

Professional Experience: For operating plants, at least one reactor operator with a minimum of 2 years of experience, preferably in the specific control room being reviewed, should be included on the DCRDR team. For operating license applicants, a licensed operator of that plant, and/or a licensed operator with 2 years of operating experience in a control room similar to the one being reviewed is recommended.

2.1.2.3 Instrumentation and Control Engineer and Nuclear Engineer

It is recommended that at least one instrumentation and controls engineer and a nuclear engineer be included as members of the core group. Individuals with expertise in the disciplines of nuclear engineering are necessary participants in the review process. Their knowledge of plant systems makes them best qualified to determine what instrumentation and system changes are feasible without impairing plant safety.

Formal Education: A bachelor's degree in engineering or equivalent is recommended as a minimum.

Professional Experience: At least 5 years of applied experience is recommended. Most, if not all, of this experience should have been gained in the nuclear field, preferably at a nuclear power plant similar to the one under review. The instrumentation and control engineer should be familiar with the regulations, standards, and design constraints that have an impact on nuclear power plant control room design. The nuclear engineer should be familiar with the design and operation of the nuclear steam supply system and the auxiliary systems of the plant under review.

2.1.2.4 Other Disciplines

General evaluation criteria for the team members representing the other disciplines recommended in Section 2.1.2 for the DCRDR team are as follows:

Formal Education: A bachelor's degree or equivalent in a course of study relevant to the specific discipline is recommended as a minimum.

Professional Experience: At least 3 years of relevant experience is recommended. Previous experience in power plants or other process control applications is preferred. Experience with other complex commercial, industrial, or military facilities and systems is an acceptable alternative.

Professional licenses or certification and appropriate society memberships should be considered in evaluating competency. However, membership in a technical society alone should not be considered as sufficient proof of acceptable qualification.

2.1.3 Responsibilities

The program plan report submitted by the licensee/applicant should include a statement of how the DCRDR team will interact with other organizations within the utility. Of particular interest is the authority that will be given to the DCRDR team to carry out its mission. To ensure freedom of operation it is recommended that the DCRDR team have certain access, support, and non-interference, including

- access to information (records, documents, plans, procedures, drawings, etc.)
- access to required facilities (control room, computer room, etc.)
- access to people with useful or necessary information (reactor operators, equipment designers or planners, utility management, etc.)
- access to adequate support (word processing, computers, photography, etc.)
- freedom to document dissenting opinions

2.1.4 Orientation

The licensee/applicant should develop an orientation program for the personnel selected for the DCRDR team. This orientation should ensure that team members share a basic understanding of the DCRDR before they begin the review. The orientation could include seminars, workshops, training manuals, short courses, and other methods.

The program plan report should describe the areas of review that will be covered during the DCRDR team orientation and how the orientation will be accomplished. As a recommended minimum, the DCRDR team should receive orientation in the following areas:

- human factors engineering objectives and methodologies
- general design and operation of the plant under review
- the contents of NUREG-0700 and NUREG-0801
- the DCRDR program plan, when developed, including the methodologies that will be used

2.2 DCRDR Methodology

The NRC will evaluate the submitted report to determine whether the licensee/applicant has developed a program plan that will accomplish the basic requirements established by the Commission. The program plan report should include a

list of the review tasks that the licensee/applicant will perform during the DCRDR.

Section 3, "Review Phase," of NUREG-0700 states the objectives of the DCRDR effort and describes the separate tasks of the review. It also describes source data, methods, and procedures for developing and applying the reference or benchmark information. The NRC staff will use the guidance of Section 3 to evaluate the list of review tasks proposed by the licensee/applicant. If the licensee/applicant chooses to use a methodology different from that recommended in NUREG-0700, the program plan report should include a description of the approach to be used. This description should be sufficiently detailed so that the NRC staff can confirm that the results of the approach will be appropriate.

The general guidelines that the NRC staff will use to evaluate the DCRDR methodology described in the program plan report are as follows:

(1) All source data that will be needed for the DCRDR will be available. If some results of previous work will be used instead of basic sources, the program plan report description should demonstrate that these results are in a form suitable for use in the DCRDR.

(2) The human engineering standards used to identify HEDs (if different from those provided in Section 6 of NUREG-0700) are appropriate.

(3) The results of previous work (such as task analyses) used directly for the DCRDR were appropriately directed and are sufficiently detailed, and, where required, prior NRC review and approval have been obtained.

(4) The methods used to perform the review tasks described in Section 3 of NUREG-0700 (or proposed alternative tasks) will result in the comprehensive identification of HEDs and the development of appropriate corrective actions and implementation schedules.

All information that is necessary to completely describe the proposed licensee/applicant DCRDR methodology should be submitted in the program plan report. It is recommended that the licensee/applicant include a flowchart of the proposed DCRDR methodology to clarify the written description that is provided. Example flowcharts of the various DCRDR phases are provided in NUREG-0700.

2.3 HED Assessment Methodology

Chapter 4 of this document presents an acceptable methodology for the assessment of HEDs. If the licensee/applicant chooses not to use the methodology presented here, the program plan report should include a detailed description of the HED assessment methodology that will be used. The NRC staff will evaluate the proposed methodology to determine whether it will result in an adequate assessment of the HEDs.

The guidelines that the NRC will use to evaluate the HED assessment methodology described in the program plan report are as follows:

(1) The relative degree of degradation of operator performance caused by each HED is adequately assessed.

(2) The effect on plant safety of each HED is adequately assessed.

(3) The possible interactions of HEDs are adequately considered.

(4) The resulting priority for implementing corrective action is appropriate. HEDs that have resulted in errors should have a high correction priority.

2.4 DCRDR Schedule

The program plan report should include a milestone chart that shows the licensee's/applicant's proposed DCRDR schedule. Each identified review task for the DCRDR phases should be included in the proposed schedule. An example of a DCRDR schedule milestone chart is given in Exhibit 2-2.

Each licensee/applicant is to develop and submit a plant-specific schedule that will be reviewed by the assigned NRC Project Manager. The NRC Project Manager and licensee/applicant will reach an agreement on the final schedule that will provide for prompt implementation of important improvements while optimizing the use of utility and NRC staff resources.

2.5 DCRDR Information Management

The efficient management of review data is a key element in performing an effective DCRDR. It is recommended that a standardized method of collecting, recording, and storing DCRDR data should be developed by the licensee/applicant. This information managment system should be described in the program plan report.

The information management system that is developed by the licensee/applicant should allow all relevant historical information for each HED to be easily retrieved. All the data necessary to document how the HED was identified, recorded, analyzed, and resolved should be included in the system. A standardized method will facilitate identifying generic problems and solutions. All documented data should be available at the site for NRC staff review.

PHASE	TASK	CORRESPONDING NUREG REFERENCE	TIME (Months)											
			1	2	3	4	5	6	7	8	9	10	11	12
I PLANNING	Analyze Objectives and Integrate	2.1 (0700)												
	Review Team Selection	2.3 (0700)												
	Organize Methodology	2.4-2.6 (0700)												
	Prepare and Submit Program Plan	1.0 (0801)												
II REVIEW	Operating Experience Review	3.3 (0700)												
	System Function and Task Analysis	3.4 (0700)												
	Control Room Inventory	3.5 (0700)												
	Control Room Survey	3.6 (0700)												
	Verify Task Performance Capabilities	3.7 (0700)												
	Validate Control Room Functions	3.8 (0700)												
	Compile Discrepancy Findings	3.9 (0700)												
III ASSESS AND DEVELOP CORRECTIONS	Assess HEDs and Categorize	4.2 (0700)												
		3.2 (0801)												
	Select/Design Corrective Actions	4.2.2 (0700)												
		3.3 (0801)												
	Develop Schedule	3.2.3 (0801)												
IV REPORT AND IMPLEMENT	DCRDR Report	3.0 (0801)												
	Begin Implementation	4.3 (0700)												
	Finalize Implementation	4.0 (0801)												
	Develop Ongoing Human Factors Engineering Program	1.2 (0801)												

Exhibit 2-2: Example DCRDR Schedule Milestone Chart

Note: Schedule with respect to time will be negotiated with project manager for each plant.

3 NRC IN-PROGRESS SITE AUDITS DURING THE REVIEW PHASE

3.1 Purpose

The NRC staff will select some licensees/applicants for onsite audits during the review phase of the DCRDR. Licensees/applicants will be selected for in-progress audits if the NRC staff evaluation of their submitted program plan reports reveals areas of concern. Additional licensees/applicants will be selected for audits if the resident inspectors at specific plants or Project Managers identify potential problem areas in the DCRDR programs. The purpose of these selective audits will be to resolve any questionable areas found in the program plan reports or identified by the resident inspectors. In addition, the NRC staff will try to determine whether the guidance provided in NUREG-0700 and in this document is adequate for the meaningful completion of the DCRDRs.

3.2 Scheduling

The NRC site audits will be pre-announced and will be scheduled at various stages of the DCRDR programs. The scheduling of the visit to each selected site will be coordinated with the responsible NRC Project Manager and with the utility. The NRC staff will determine the appropriate times for the site audits from the DCRDR schedules submitted by the licensees/applicants in their program plan reports (see Section 1.4 of this document).

3.3 Performance

In visiting the selected plant sites, the NRC staff will perform a general audit of the status of the DCRDR program, with special emphasis given to those areas of concern identified during the staff evaluation of the program plan report or by the resident inspector. During the audit, the NRC staff may:

- survey the control room
- interview review team members
- examine the licensee's/applicant's information management system
- review additional information about the program plan that was questionable or that was not submitted in the program plan report
- discuss the identified areas of concern with the program with the DCRDR team, the licensee/applicant, and the NRC resident inspector

3.4 Results

The NRC staff, in cooperation with the responsible Project Managers and utilities, will try to resolve any areas of the licensee's/applicant's program plan that it feels will not result in an acceptable DCRDR. The NRC staff may

propose possible changes to the program, if any are needed to accomplish the requirements established by the Commission.

If, as a result of the site audits, the NRC staff determines that the guidance in NUREG-0700 and this document is being widely misinterpreted or that additional guidance is needed, clarifications or additional guidance will be promptly developed and disseminated to the licensees/applicants.

4 EVALUATION OF DCRDR SUMMARY REPORT

The second phase of the DCRDR is the review phase. Details of this phase are described in Section 3 of NUREG-0700. The objectives are

(1) To determine whether the control room provides the system status information, control capabilities, feedback, and performance aids necessary for control room operators to accomplish their functions and tasks effectively, and

(2) To identify characteristics of the existing control room instrumentation, controls, other equipment, and physical arrangements that may detract from operator performance.

Section 3 of NUREG-0700 identifies six tasks that will accomplish these objectives and aid in the identification of HEDs. They are

(1) a review of operating experience

(2) a review of emergency system functions and an analysis of the tasks involved in control room operator functions

(3) an inventory of control room instrumentation and equipment

(4) a survey of the human engineering acceptability of control room components and environmental conditions

(5) verification of task performance capabilities

(6) validation of control room functions and integrated performance capabilities

To document the results of the review, the licensee/applicant should submit a summary report of the completed review outlining proposed control room changes, including the proposed schedule for implementation. This summary report should be submitted to the NRC after the DCRDR is completed, but before the licensee/applicant begins any major modifications to the control room. The NRC staff will review the submitted DCRDR summary report within 2 weeks after receipt to confirm that the basic requirements established by the Commission and the DCRDR objectives as stated in NUREG-0700 were accomplished by the licensee/ applicant and will inform the licensee/applicant whether a pre-implementation onsite audit will be conducted.

The following areas will be reviewed by the NRC staff in its evaluation of the DCRDR summary reports:

(1) a description of any significant changes that were made from the program plan report that was previously submitted, and an explanation of why these changes were made

(2) a description of the proposed control room modifications with an explanation of how the HEDs were resolved (chosen for correction or non-correction)

(3) a summary justification for HEDs with safety significance to be left uncorrected or partially corrected

(4) a proposed schedule for implementing the modifications

During the review of the summary report or during the pre-implementation onsite audit, the NRC staff may find it necessary to discuss or examine the documentation generated at the plant during the DCRDR. The NRC staff recommends that the licensee/ applicant have available at the plant the following:

(1) a complete listing of all the HEDs identified during the DCRDR

(2) a concise description of the HEDs including

- o the system, subsystem, and task affected by the HED
- o the NUREG-0700 Section 6 guideline or other human factors engineering standard violated to result in the HED
- o any numbering system used by the licensee/applicant to identify the HED and the corrective action

(3) a description of any cumulative effects or interactions between the HED and other HEDs including a description of the effect of the HED on plant safety

(4) a description of the proposed corrective action for the HED

(5) a justification and analysis of any significant HED that the licensee/ applicant does not intend to correct.

The above list need not be submitted to the NRC; it represents only a subset of the data that should be contained in the licensee's/applicant's information management system. All the data stored in the information management system should be available to the NRC upon request. Standardization of information management systems by the industry is recommended to facilitate communication and information exchange. A sample format and procedure for documenting HEDs are presented in Appendix C.

4.1 Identification of HEDs

In evaluating the DCRDR, one of the items on which the NRC staff will focus will be the completeness and accuracy of discrepancy identification.

To identify HEDs, NUREG-0700 describes four review processes that can be used. The processes and the sections of NUREG-0700 in which they are addressed are

(1) Operating Experience Review, Section 3.3

(2) Emergency Systems Function and Task Analysis, Section 3.4

Physical Performance

- Fatigue
- Discomfort
- Injury
- Control suitability

Sensory/Perceptual Performance

- Distraction
- Boredom
- Visibility
- Readability
- Audibility
- Noise
- Display adequacy
- Inconsistency with stereotypes and conventions

Cognitive Performance

- Mental overload
- Mental boredom
- Confusion
- Stress
- Sequential or compound errors

Task Variables

- Task duration
- Task frequency
- Task criticality
- Task difficulty
- Communication needs
- Delay or absence of necessary feedback
- Concurrent task requirements
- Job aids required
- Mission response characteristics
  - (a) accuracy requirements
  - (b) speed requirements

Exhibit 4-1: Examples of Performance-Shaping Factors

To what extent do you agree with the following?

1. This discrepancy will cause undue operator fatigue.

2. This discrepancy will cause operator confusion.

3. This discrepancy will cause operator discomfort.

4. This discrepancy presents a risk of injury to control room personnel.

5. This discrepancy will increase the operator's mental workload (for example, by requiring interpolation of values, remembering inconsistent or unconventional control positions, etc.).

6. This discrepancy will distract control room personnel from their duties.

7. This discrepancy will affect the operator's ability to see or read accurately.

8. This discrepancy will affect the operator's ability to hear correctly.

9. This discrepancy will degrade the operator's ability to communicate with others (either inside or outside the control room).

10. This discrepancy will degrade the operator's ability to manipulate controls correctly.

11. This discrepancy will cause a delay of necessary feedback to the operator.

12. Because of this discrepancy the operator will not be provided with positive feedback about control tasks.

13. This discrepancy violates control room conventions or practices.

14. This discrepancy violates nuclear industry conventions.

15. This discrepancy violates population stereotypes.

Exhibit 4-2: Sample Questions for HED Assessment

16. Operators have attempted to correct this discrepancy themselves (by self-training, temporary labels, "cheaters," "helper" controls, compensatory body movements, etc.).

17. Tasks in which this discrepancy is involved will be highly stressful (i.e., highly time constrained, of serious consequence, etc.),

18. This discrepancy will lead to inadvertent activation or deactivation of controls.

19. If this discrepancy caused a specific error, it is probable that another error of equal or more serious consequence will be committed.

20. This discrepancy is involved in a task which is usually performed concurrently with another task (e.g., watching water level meter while manipulating a throttle valve control).

21. This discrepancy involves controls or displays that are used by operators while executing emergency procedures.

22. Assuming that this HED caused an operating crew error, it is likely that this error would result in:

    a. A violation of a technical specification, safety limit, or a limiting condition for operation.

    b. The unavailability of a safety-related system needed to mitigate transients or system needed to safely shut down the plant.

23. This discrepancy involves controls or displays that are part of an engineered safety function or are associated with a reactor trip function.

Exhibit 4-2: (Continued)

All HEDs that are known to have previously contributed to an operating crew error, as documented in an LER or other historical record, or as established by interview or questionnaire responses, should be considered significant. All other HEDs should be systematically assessed to determine their significance.

It is suggested that these HEDs be subjected to a series of statements or questions that could aid the review team in assessing the impact of those HEDs on operating crew performance and plant safety.

Responses to these statements should be more than just a binary yes-no or pass-fail. They should be formulated to allow responses that reflect a varying degree of compliance. It is suggested, therefore, that a four-point or five-point qualitative scale be used in conjunction with each question; this allows for degrees of agreement between graders. In some instances, a quantitative approach assigning a numerical rating to the scale could be of some additional help.

To aid in assessing significance of HEDs, it is suggested that they be considered by categories. The categories will not only aid in ranking significance, but may suggest the priorities according to which the HEDs are considered for corrective action. The actual scheduling, using some systematic way of determining priorities, should be negotiated with the NRC staff. The suggested methodology and criteria described below can be used for assessing significance. A simplified flow diagram of the process is shown in Exhibit 4-3.

In assessing significance, the review team should consider the probabilities of a committed error being detected early enough so it can be corrected before the consequence becomes serious. The team should make allowances for an operating crew versus an individual operator making a decision and taking action. Studies have indicated that the probabilities of committing an error are reduced when more than one individual is involved in making the decisions or carrying out an action, and that the probabilities of early detection and recovery from an error are improved.

Category I - HEDs Associated with High Probability Errors and High Consequences

Category I should include all HEDS that were

(1) identified from operating experience or assessed as being significant and having a high probability of contributing to operator error, and

(2) associated with systems important to safety and determined that an error could result in unsafe operation or the violation of a technical specification (high consequences).

Category I should include all HEDs identified from actual operating experience and those assessed as being significant. This category should include those discrepancies that are known to have caused or nearly caused operating crew errors as documented in LERs or other historical records, or identified through interviews and questionnaires. See Section 3.3.1.3 of NUREG-0700 for other suggested information sources. All HEDs in this category should be considered for prompt corrective action, i.e., at the first refueling outage after submittal of the DCRDR summary report or the first outage after the receipt of the material needed for correction (expedited). Applicants for operating

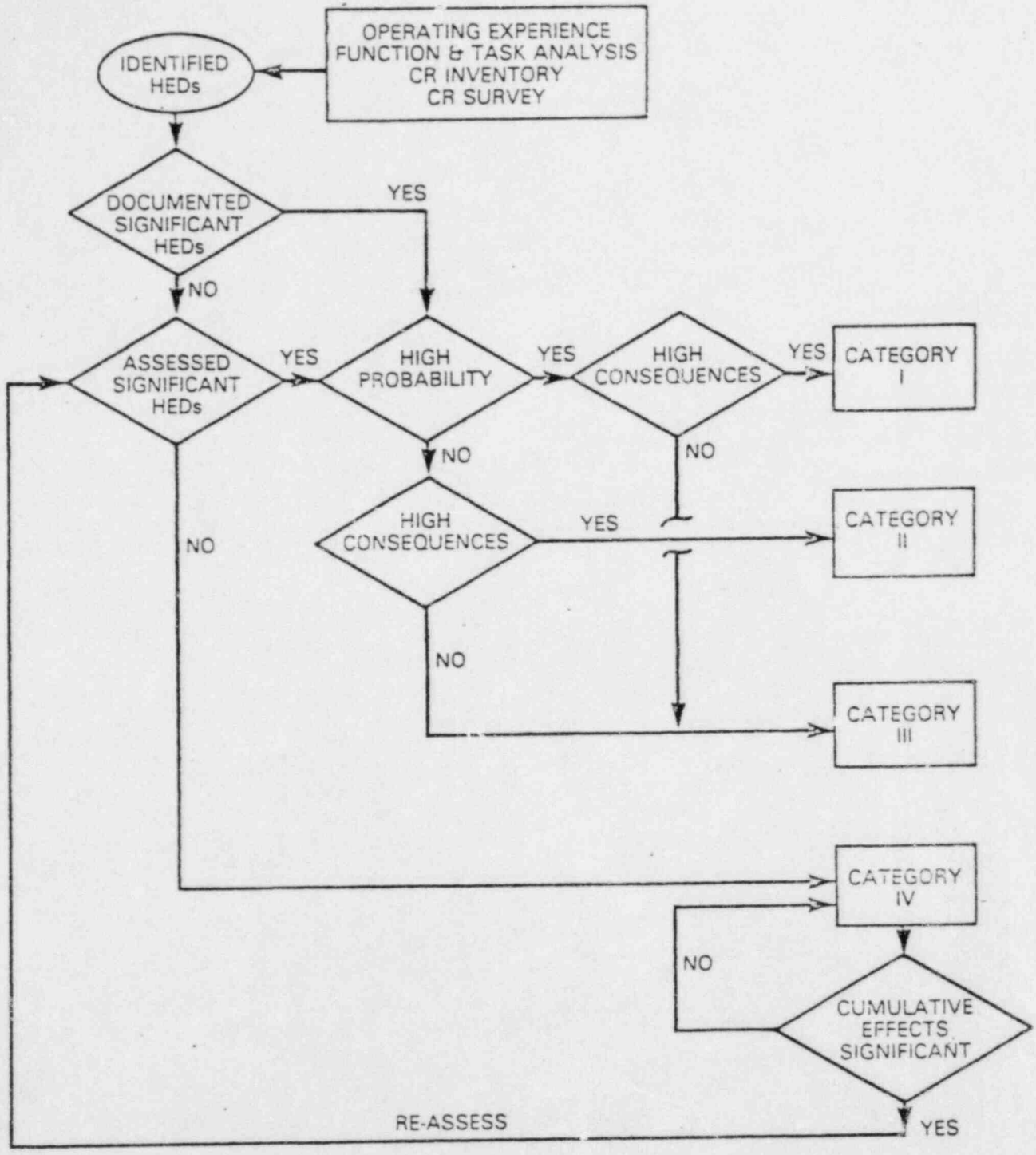

Exhibit 4-3: HED Assessment Process
(See NRC Actions Exhibit 1-6, Item III(2))

licenses should implement all Category I corrective actions prior to issuance of an operating license. Category I HEDs that involve systems important to safety should be considered for correction before those that are not.

By definition, Category I applies only to plants with an operating history. It is suggested, however, that information about Category I HEDs be disseminated to plants under construction with similar control rooms through owners groups, industry organizations, or, in the case of utilities with both operational and pre-operational plants, through utility management, so that plants under construction will benefit from the past experience of operating plants. All remaining categories discussed below are equally applicable to both operating plants and applicants for operating license.

Category II - HEDs Associated with Low Probability Errors and High Consequences

Category II should include all HEDs that were

(1) identified through surveys or other means and assessed as being significant and having a low probability of contributing to operator error, and

(2) associated with systems important to safety and determined that an error could result in high (unacceptable) consequences.

Although the probability of their occurrence is determined as being low, HEDs identified in this category should be considered significant because of the resulting consequences. But because of the low probability of their occurrence, corrective action need not be considered, on as urgent a time schedule as those in Category I.

Category II HEDs should be corrected on a near-term priority, on a schedule acceptable to the NRC staff. A reasonable schedule for the implementation of Category II corrective actions might be during the second refueling outage after submittal of the DCRDR summary report. Operating license applicants with less than 2 years before their estimated licensing date should implement near-term priority corrective actions, either before licensing or at the first scheduled refueling outage. All other applicants should implement Category II corrective actions before licensing.

Category III - HEDs Associated with High or Low Probability Errors and Low Consequences

Category III should include all HEDs that were

(1) identified through surveys or other means and assessed as being significant and having a high or low probability of contributing to operator error, and

(2) associated with systems important to safety but determined that an error could not result in unsafe operation or the violation of a technical specification (low consequences).

HEDs identified in this category should be considered for corrective action but correction will be at the option of the utility. The influencing factor in determining corrective action should be the possible resulting consequences,

not whether the probability of error is high or low. HEDs in this category were assessed as being significant and, therefore, could degrade operator performance. The extent of correction, full or partial, should be dependent on the cost and the effects of the possible resulting low consequences. These HEDs selected for corrective action could be implemented on a long-term schedule. Prioritization and implementation should be based on the frequence of use and the importance of that system to safety. All the HEDs not scheduled for corrective action should be reassessed for cumulative effects or interactions with other HEDs (see Category IV). Correction of those HEDs determmined not to contribute to an accumulative effect will be at the discretion of the licensee/applicant.

Category IV - HEDs Assessed As Not Being Significant

Category IV should include all HEDs that were identified through surveys or other means and assessed as not being significant.

HEDs identified in this category should be re-examined and assessed for their cumulative effects or interactions with other HEDs. An HED that does not seem to cause a problem by itself may actually cause substantial degradation of operator performance because of the interrelated effects of associated HEDs. For example, display numerals that are only slightly smaller than the recommended size may not actually represent a significant design discrepancy in a well-lighted and well-organized control room. However, if the display is in a location that is poorly lighted or if the display is placed above the recommended viewing height, the size of the numerals may cause substantial degradation of operator performance. If it is determined during the reassessment process that the cumulative effects could result in an error, in unsafe operations, or in the violation of a technical specification, the HEDs should be reassigned to a higher priority category. Correction of the remaining HEDs is optional and at the discretion of the utility.

4.2.3 Scheduling of Corrective Actions

The licensee/applicant should include a proposed corrective action implementation schedule in the DCRDR summary report. If licensees/applicants decide to correct Category II or Category III design discrepancies on a lower priority schedule than that described in this subsection, they should provide detailed information for this decision in their DCRDR summary report. The NRC will evaluate the actions to determine if the proposed delayed implementation schedule is acceptable.

Unless the licensees/applicants are notified that they are selected for a pre-implementation audit (see Chapter 5), they should proceed with the implementation of the corrective actions on the schedule proposed in their DCRDR summary report. The licensee/applicant should notify the NRC of any slippage of the proposed schedule, with an explanation, and should provide a revised schedule. Insignificant changes in schedule need not be reported but should be coordinated with the responsible project manager.

The determination of an appropriate corrective action implementation schedule should be based on the degree of degradation of operator performance caused by the HEDs, the effect of the HED on the safety of the plant, whether the equipment affected by the HED is part of a safety system, and the availability of

resources needed for correction. Although the criteria presented in this subsection recommend specific schedules for implementation, both operating and non-operating plants are encouraged to implement all corrective actions on as short a schedule as possible to avoid problems with operator retraining.

The ranking of a discrepancy by applying the criteria stated in the previous section can be used as the basis for determining the urgency of corrective action. As stated earlier, all discrepancies that were determined to be significant should be scheduled for corrective action. A suggested schedule is as follows:

Prompt: Implement promptly on schedule approved by NRC. Enhancement corrections should be made before the report is submitted to NRC. For corrections involving equipment replacement or reallocation, make changes at the first refueling after submittal of the report or the first outage after receipt of equipment (expedited).

Near Term: Implement on delayed schedule approved by NRC. Enhancement corrections are made before the report is submitted to NRC unless acceptable justification is provided to NRC. For corrections involving equipment replacement or reallocation, make changes at the second refueling outage after submittal of the report.

Long Term: Implement corrections of those individual or cumulative discrepancies considered "better to correct" on a much delayed schedule approved by the NRC.

Note: Enhancement corrections do not require NRC approval.

4.3 Proposed Corrective Actions

The DCRDR summary reports submitted by licensees/applicants should include descriptions of all corrective actions that they propose to implement. These descriptions should be sufficiently detailed so that the NRC staff can determine whether the proposed corrective actions adequately resolve the HED.

The NRC staff will evaluate the proposed corrective action to determine whether the licensee/applicant has adequately:

- brought the HED into agreement with acceptable human factors engineering standards or provided another solution that counteracts the effect of the HED,
- assessed the proposed corrective action to verify that the safety of the plant will no longer be degraded,
- verified that the modification does not introduce new problems to the control room while correcting the HED,
- verified that the specific information and control requirements of all tasks involved with equipment to be modified will be met after the modification,

- verified that the modification complies with all safety criteria such as fire protection, physical separation, and equipment qualifications, and

- provided retraining of operating personnel and revising of procedures, where necessary, because of the modification of the control room.

The DCRDR summary report should include general descriptions of how the licensee/ applicant performed the above tasks and arrived at the correction action selected. To have adequately performed these tasks, the licensee/ applicant should rely on the guidance presented in Section 3 of NUREG-0700.

Some of the HEDs identified in performing the control room review will be correctable using approaches that can be implemented during normal plant operations or planned plant shutdown. Any one of several approaches (i.e., enhancement, procedures, training, relocation, or removal or addition of instrumentation, or any combination of these) can be considered for correcting an HED. Some corrective actions will be more involved and time consuming than others. Corrective actions such as enhancement or operator training can be accomplished with a minimum amount of disruption to plant operation or personnel. For the most part, "enhancement" will be limited to the application of paint, labels, and tape. This type of enhancement as well as others are discussed in the Electric Power Research Institute (EPRI) document NP-2411, "Human Engineering Guide for Enhancing Nuclear Control Rooms." The enhancement guide also addresses the violation of design conventions. It cautions that any changes involving design conventions carry the risk of violating an existing explicit or implicit convention. It also suggests that where explicit conventions do not exist they should be created and documented as part of the review and design process.

4.4 Overall Control Room Improvement

The objective of the DCRDR is to modify the control room so that it is the safest that can be designed within the licensee's/applicant's present constraints. The operator's detection and response capabilities should be enhanced by the proposed modifications and the probability of operator error under stressful conditions should be lessened, thus improving the safe operation of the plant.

In the conclusions of the DCRDR summary reports, the licensee/applicant should summarize the steps that they took to ensure the overall improvement of the control room by the DCRDR process. The conclusions should also include descriptions of any control room-wide problems that were revealed and resolved during the DCRDR.

Licensees/applicants are encouraged to evaluate proposed control room modifications before they are implemented by using mockups, mosaics, and/or simulator implementation. This will give the operators and the DCRDR team a chance to assess the overall improvement of the control room and suggest additional changes, if needed, before actual hardware modification begins. Licensees/applicants are encouraged to use mockups, mosaics, and/or other methods of simulating actual operation to evaluate proposed control room design modifications before they are implemented. This gives the operator and the DCRDR team a chance to assess the overall improvement of the control room

and allows for making changes in design before costly hardware modifications are implemented.

The use of mockups to simulate actual operation has many advantages. They can be

- economically constructed using cardboard, photographs, blueprints, or other representations of the instruments and controls
- constructed in varying degrees of complexity
- used in performing the task analysis and to document recommended corrective actions
- used in developing as-built drawings, training operators, and developing test procedures

5 PREPARATION OF SAFETY EVALUATION REPORT

5.1 Pre-implementation Audit

On the basis of the NRC staff evaluation of the DCRDR summary reports, some licensees/applicants will be selected for preimplementation audits. These audits will take place before the SER is issued and before the licensee/applicant begins any major modifications to the control room. A licensee/applicant may be selected for a preimplementation audit if the NRC staff has any questions on the identification, assessment, or resolution of HEDs. During the onsite audits, the NRC staff will perform a more detailed evaluation of the licensee's/applicant's DCRDR. The evaluation will include examination of the licensee's/applicant's DCRDR documentation, discussions with the review team, inspection of the existing control room, and inspection of any mockups of proposed corrective action modifications.

5.2 Results

The result of the NRC staff evaluation of the licensee's/applicant's DCRDR effort will be a Safety Evaluation Report (SER). This NRC staff SER will be based on the staff evaluation of the submitted program plan report, the results of any in-progress site audit, the evaluation of the submitted DCRDR summary report, and the results of any preimplementation audit.

When the SER is issued, licensees/applicants should proceed with the corrective action implementation schedules they submitted in their DCRDR summary reports unless exceptions are taken in the SER.

The SER will state whether the NRC staff concludes that the proposed modifications to the licensee's/applicant's control room equipment and operations as a result of the DCRDR will accomplish the basic requirements established by the Commission. Any additional corrections or schedule modifications necessary to comply with the basic requirements established by the Commission will be documented in the SER.

APPENDICES

APPENDIX A: Reference Documents for Programs Related to DCRDR

APPENDIX B: Glossary

APPENDIX C: Management of HED Information

APPENDIX D: Function and Task Analysis

APPENDIX E: Changes in NRC Position on Control Room Reviews from that Presented in NUREG-0700

APPENDIX A

REFERENCE DOCUMENTS FOR PROGRAMS RELATED TO DCRDR

- NUREG-0654, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants"
- NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident"
- NUREG-0696, "Functional Criteria for Emergency Response Facilities"
- NUREG-0700, "Guidelines for Control Room Design Reviews"
- NUREG-0737, Supplement 1, "Clarification of TMI Action Plan Requirements"
- NUREG-0835, "Human Factors Review Guidelines for the Safety Parameter Display System"
- NUREG-0899, "Guidelines for the Preparation of Emergency Operating Procedures, and Resolution of Comments on NUREG-0799"
- Regulatory Guide 1.23, "Meteorological Programs in Support of Nuclear Power Plants"
- Regulatory Guide 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems"
- Regulatory Guide 1.97, "Instrumentation of Light Water Cooled Nuclear Power Plants to Assess Plant Conditions During and Following an Accident"

APPENDIX B

GLOSSARY

Assessment Criteria	Criteria used to determine whether an HED degrades operator performance and plant safety; also used to determine priority for appropriate corrective action implementation. These criteria are provided in this document.
Cumulative Effect	An effect on human and/or machine performance that results from the addition of the individual effects of two or more HEDs. This cumulative effect may represent a substantial degradation of performance, while the individual effects of the HEDs do not.
Detailed Control Room Design Review (DCRDR)	The control room design review as required by NUREG-0660, Item I.D.1., and as described in detail in NUREG-0700.
DCRDR Summary Report	Final report of the results of the DCRDR. Described in NUREG-0700 and in this document (Chapter 3).
Enhancements	Surface modifications to improve the control board that do not involve major physical changes (equipment relocation, switch replacement, etc.). Examples of enhancements are demarcation, labeling changes and painting.
Evaluation	NRC staff review of licensee/applicant submittals and programs.
Evaluation Criteria	Criteria used by the NRC staff in determining the acceptability of the DCRDR. These criteria can also be used by the licensee/applicant as guidance during the performance of the DCRDR and during the preparation of the DCRDR documentation.
Function	An activity (or a static role) performed by one or more system constituents (people, mechanisms, structures) to contribute to a larger activity or goal state.
Functional Analysis	The examination of system goals to determine what functions they require; also, examination of the required functions with respect to available staff, technology, and other resources to determine how the functions may be allocated and executed. In

	NUREG-0700, it is primarily the identification of established functions and examination of how they are allocated and executed.
Functional Allocation	The distribution of functions among the human and automated constituents of a system.
Human Engineering Discrepancy (HED)	A departure from some standard or benchmark of system design suitability for the roles and capabilities of the human operator.
Licensee/Applicant	Holder of an operating license and/or an applicant for an operating license.
Program Plan Report	Report submitted by licensee/applicant after the DCRDR planning phase is completed. It describes DCRDR team, DCRDR methodology, HED assessment methodology, and DCRDR schedule and allows early NRC feedback on any problem areas. It is described in detail in NUREG-0700 and in this document.
Review	Licensee/applicant DCRDR effort.
System	An organization of interdependent constituents that work together to accomplish an objective, goal, or mission, or that functions as a whole by virtue of the interdependence of its parts.
System(s) Analysis	Examination of a complex organization and its constituents to define their relationships and the means by which their actions and interactions achieve an objective, goal, or mission.
Task	A specific action, performed by a single system constituent (person or equipment) that contributes to the accomplishment of a function.
Validation	The process of determining whether an operational system performs its tasks and functions as specified.
Verification	The evaluation of a set of functional criteria or requirements to determine whether they achieve a defined goal.

ACRONYMS

CR	Control Room
DCRDR	Detailed Control Room Design Review
DHFS	Division of Human Factors Safety
ECCS	Emergency Core Cooling System
HED	Human engineering discrepancy
VTR	Video tape recorder

APPENDIX C

MANAGEMENT OF HED INFORMATION

C.1 INTRODUCTION

The quality of the DCRDR will be improved if a systematic process for the identification and documentation of HEDs is developed by the licensee/applicant before the review process begins. This system should preserve all pertinent information regarding the equipment, systems, and tasks involving each HED in an easily retrievable format. If such a system is not developed, information may be lost, which may mean that work must be redone to justify any HED resolution that is questioned during the NRC staff evaluation of the DCRDR.

This appendix addresses suggested methods for three phases of HED information management. These phases are

- the organized identification of HEDs during the control room survey task of the DCRDR review phase
- the recording of all pertinent HED information during the tasks of the DCRDR review phase
- the storage and retrieval of all HED information resulting from the DCRDR

C.2 IDENTIFICATION OF THE HEDs

The DCRDR team performing the control room survey portion of the DCRDR review phase (Section 3.6 of NUREG-0700) will be examining control room equipment for violations of human engineering guidelines (from Section 6 of NUREG-0700 or some other acceptable standard). It will be helpful if the licensee/applicant identifies applicable guidelines for each piece of equipment before the survey. For example, reviewers examining a pushbutton control would not need to consider the guidelines for rotary controls.

After the control room inventory portion of the review phase (Section 3.5 of NUREG-0700) is completed, a listing of applicable guidelines for each identified piece of equipment could be prepared. This listing could be done in tabular form, as illustrated in Exhibit C-1. The listing could be organized by individual equipment item, by system, and/or by panel. Multiple pages would be necessary to include all equipment identified during the control room inventory and to accomodate all applicable guidelines for each piece of equipment. The licensee/applicant may wish to include more information than is illustrated in Exhibit C-1. System information, label content, etc. might be helpful.

EQUIPMENT IDENTIFIER	EQUIPMENT DESCRIPTION	PANEL LOCATION	NUREG-0700 GUIDELINES (Controls)						
			6.4.1.1	6.4.1.2	6.4.2.1	6.4.2.2	6.4.3.1	6.4.3.2	6.4.3.3
HU-153-8S	J-handle Control	01MX802	X	X	X	X			
HU-153-9S	Toggle Switch	01MX802	X	X	X	X			
(etc.)									

PAGE 1

EQUIPMENT IDENTIFIER	EQUIPMENT DESCRIPTION	PANEL LOCATION	NUREG-0700 GUIDELINES (Controls)						
			6.4.1.1	6.4.1.2	6.4.2.1	6.4.2.2	6.4.3.1	6.4.3.2	6.4.3.3
HU-153-8S	J-handle Control	01MX802	X	X			X		
HU-153-9S	Toggle Switch	01MX802							
(etc.)									

PAGE 2

EQUIPMENT IDENTIFIER	EQUIPMENT DESCRIPTION	PANEL LOCATION	NUREG-0700 GUIDELINES (Controls)						
			6.4.1.1	6.4.1.2	6.4.2.1	6.4.2.2	6.4.3.1	6.4.3.2	6.4.3.3
HU-153-8S	J-handle Control	01MX802							
HU-153-9S	Toggle Switch	01MX802	X						
(etc.)									

PAGE 3

EQUIPMENT IDENTIFIER	EQUIPMENT DESCRIPTION	PANEL LOCATION	NUREG-0700 GUIDELINES (Labels)				
			6.6.1.1	6.6.1.2	6.6.2.1	6.6.2.2	(etc.)
HU-153-8S	J-handle Control	01MX802	X	X	X	X	
HU-153-9S	Toggle Switch	01MX802	X	X	X	X	
(etc.)							

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Exhibit C-1: Example Listing of Applicable Guidelines

C.2 RECORDING

It is crucial that all pertinent HED data be recorded as they are identified. Unless a systematic process for such recording is developed, the DCRDR team may have to repeat work to reconstruct lost information that is needed later.

Section 3.6.2.2 of NUREG-0700 contains an example of a Human Engineering Discrepancy Record that was developed during the NRC human factors engineering design review/audits of operating license applicant control rooms. A form of this type would be useful during the control room survey portion of the DCRDR to record the data from that process. Similiar forms should be developed to record all pertinent data from any DCRDR process that results in the identification of HEDs.

C.3 STORAGE AND RETRIEVAL

A large volume of information will be generated during the DCRDR. The efficient management of this information will be a key element in performing an effective review. The easiest way to manage this volume of information will be to use an automated data processing method, such as a computer or a punched card sorter.

One benefit from the development of an efficient information management system will be the ability to identify and combine HEDs that are related in various ways. This could help the DCRDR team find interactions, cummulative effects, and problems that are widespread in the control room. An efficient system could also help the team when it is developing corrective actions, because the team should be able to retrieve all HEDs that involve a specific piece of equipment and coordinate all necessary corrections simultaneously.

It would be helpful to all users of the data generated from the various DCRDR processes if all pertinent information for each HED were organized according to a standard format. This format could be stored in a computerized file, a word-processing document, a conventional report sheet, or any other data management form. No matter what format is used, the information stored should be the same. Exhibit C-2 gives an example of a conventional report sheet. Exhibit C-3 provides a supplementary explanation of the example report sheet in Exhibit C-2.

HED Report Sheet

Date: _____

Page _____ of _____

- Licensee: _____ Plant: _____ Reviewer: _____
- Plant System: _____ (Reactor Coolant, Reactivity Control, Environment, etc.)
- Plant SubSystem: _____ (Pumps, Valves, HVAC Controls, etc.)
- Equipment Item or Topic – Control Board Section (name/number) _____
  – Control Board Panel (panel identifier) _____
  – Component or Topic Item
  (e.g., C/D layout, lighting, maintenance procedures, etc.) _____
- NUREG-0700 ID: _____ (Applicable Section & Subsection of NUREG-0700, Section 6)

HED DESCRIPTION:

1. Description of HED:

HED SERIAL NUMBER: *(if used)*

PHOTO ID NUMBER:

2. This HED Relates to:
   a. Event: (From NUREG-0700 Section 3.4.2.2, 3.8.2, etc.)
   b. Function/Task: (Needed to mitigate the event, from NUREG-0700 Section 3.4.2.3, 3.4.2.4, Exhibits 3-3, 3-5, etc.)
3. Safety Consequences:
4. Interaction of HED with other HEDs, systems, events, functions/tasks, etc.

ACTION PROPOSED TO CORRECT HED:

(NUREG 0700 Section 4)

CORRECTION SCHEDULE

COMMENTS: This section contains other pertinent explanatory or supplementary information including:

- Identification of HED with applicable steps or substeps of system review (NUREG-0700 Section 3.2-3.8)

NOTE: This Report Sheet is not intended to be an additional task step to be done. It is meant to provide:

1. A single place to summarize the results of the review steps described in NUREG-0700.
2. A source of information for NRC staff reviewers of licensee NUREG-0700 DCRCRs to use as they apply the evaluation criteria described later in NUREG-0801.

Exhibit C-2: Sample HED Report Sheet

- System (Subsystem): The information for these items from the system analysis in NUREG-0700, Section 3. If numerical coding of system/subsystem has been used by the licensee, this should be included with the narrative description.

- Equipment Items or Topic Items: The purpose of this item is to identify the specific control board components or topic. Thus, board section or panel number, and instrument/control name/number should be indicated. In some cases, the HED may involve a whole panel or section, e.g., panel layout HED or more than one panel, e.g., control-display integration HED. For such situations all involved components/panels/sections should be identified. Also, if procedures, maintenance, etc. are involved in the HED, they should be specified on this line.

- The HED Serial number is a number which uniquely identifies each HED.

- The photo ID number will allow reference to photos which may have been taken to clarify the HED.

- HED Description: The purpose of these three parts is to describe the HED but also to show how the HED relates to operating events, functions, and tasks, and then, safety consequences. Examples of events, functions, and tasks with references to applicable NUREG-0700 sections are:

Events	0700 Ref.
Transients	3.4.2.2
Start Up	3.4.2.2
Shut Down	3.4.2.2
Change in power level	3.4.2.2

Functions/Tasks	0700 Ref.
Increase to 5% power	Exhibit 3-3
Place automatic control	Exhibit 3-3
Withdraw control rods	Exhibit 3-5
Determine IR detectors are on scale	Exhibit 3-5

- Action proposed to correct HED: The correction already made or proposed should be described here. If a partial or no-correction is proposed, the justification should be presented.

Exhibit C-3: Supplementary Explanation of the HED Report Sheet

APPENDIX D

FUNCTION AND TASK ANALYSIS

Section 1.2 of this document lists those initiatives that should be coordinated and integrated in conjunction with performing the DCRDR because of their interdependency. The basis for starting any of the initiatives should be the reanalysis of transients and accidents as described in Section I.C.1 of NUREG-0660 and clarified in Item I.C.1 of NUREG-0737. The results of the reanalysis can serve as input to developing the function-oriented emergency operating procedures (EOPs), identifying the parameters and variables for the design of the SPDS, and the instrumentation required by Regulatory Guide 1.97, Revision 2, and performing the system function and task analysis review of the DCRDR. Once the reanalysis is completed, the sequence of implementing the initiatives will be at the option of the licensee/applicant, although it is suggested that the development of the SPDS be considered as the highest priority.

Certain tasks of the review phase of the DCRDR (i.e., review of operating experience, and performing an inventory of the control room instrumentation and equipment) can be initiated once acceptable Technical Guidelines, preferably plant-specific, are available. The survey and review of system functions and an analysis of tasks are best performed using valid plant-specific EOPs. The Technical Guidelines and EOPs should be developed as described in NUREG-0899. The coordination and integration of the initiatives and a suggested sequence of their implementation are shown in Exhibits 1-2 through 1-4.

The purpose of the reanalysis is to reexamine those Design Basis Accidents (DBA) and any additional accidents identified as a result of lessons learned for multiple and common mode failures and to identify those functions necessary to neutralize and mitigate the events that caused them. As stated in NUREG-0899, "Technical Guidelines represent the translation of engineering data derived from transient and accident analyses into information presented in such a way that it can be used to write EOPs. Technical Guidelines are documents that identify the equipment or systems to be operated and list the steps necessary to mitigate the consequences of transients and accidents and restore safety functions." It is this documentation that is necessary for initiating the systems review of the DCRDR. The information collected from the analyses must be detailed enough to ensure a meaningful review. To ensure the proper degree of detail needed to perform the DCRDR, the Technical Guidelines should, with the aid of the Procedure Generation Package (PGP), translate the operator's actions (tasks) into cognitive and physical steps that will permit interaction with the machine. The contents of the PGP and how it is used in developing and implementing plant-specific EOPs are described in NUREG-0899. It is the responsibility of each licensee/applicant to provide, for the functions identified, a complete description of the tasks (man and machine) necessary to restore and maintain plant safety. Each task should be analyzed to determine what information the control room operator needs to interact with the systems and subsystems. The analysis should provide enough information to answer the following questions:

(1) What decisions must the operator make to accomplish each function (i.e., reduce pressure or restore water level)?

(2) What information is required for each decision (i.e., available systems that will reduce pressure or available water inventory)?

(3) What action is required to execute the decision (i.e., sequential steps for accomplishing the necessary function)?

(4) Does the operator have the necessary instrumentation and equipment to implement the decisions?

The results of the task analyses should be documented and available at the plant to serve as the basis for the DCRDR.

Using the above documentation, the control room review team can evaluate the adequacy of the design of the controls and displays and the operator's ability to interact with them. In performing the inventory, the review team will identify the existing instrumentation and equipment; the design adequacy will be verified by comparing the precision and accuracy of the instrumentation and resulting data against the engineering data that were generated for developing the Technical Guidelines.

In performing the survey, using Section 6 of NUREG-0700 and from operator interviews, the review team will be able to identify HEDs in the existing design. During the walk-/talk-throughs, the review team, using plant-specific EOPs, will be able to (1) verify that each operator task can be performed in the allotted time sequence, (2) validate the control room design when each system accomplishes its intended function, and (3) confirm human-machine interface by observing operator behavior with respect to the instrumentation and equipment. The operator behavior will include examining the processes involved (i.e., perceptual, mediational, communication, and motor) as well as specific behavior (i.e., detect, identify, interpolate, plan, communicate, activate, adjust, etc.). The analysis of operator tasks and the walk-/talk-throughs will also aid in determining the significance of some of the HEDs by offering the review team an opportunity to observe (1) the effect of an HED on the ability of the operator to perform the intended function and (2) the validity of the EOPs.

APPENDIX E

CHANGES IN NRC POSITION ON CONTROL ROOM DESIGN REVIEWS FROM THAT PRESENTED IN NUREG-0700

This appendix presents a description of significant changes in the staff approach for control room design reviews from that covered in NUREG-0700, "Guidelines for Control Room Design Review," including reasons for the changes.

The requirements for the control room design review contained in Supplement 1 to NUREG-0737 are a condensation of the essential elements and goals of NUREG-0700. With the exception noted below, the requirements of Supplement 1 to NUREG-0737 encompass the full scope of NUREG-0700. Many of the tasks outlined in NUREG-0700 are not specifically mentioned in the condensed requirements of Supplement 1 to NUREG-0737. However, except as noted below, the performance of the tasks outlined in NUREG-0700 or comparable tasks is necessary to meet the requirements of Supplement 1 of NUREG-0737.

The control room design review approach outlined in NUREG-0700 divides the review into four major phases: (1) planning, (2) review, (3) assessment and implementation, and (4) reporting. Supplement 1 of NUREG-0737 addresses each of these phases. Except for the review phase of the control room design review, there are no significant differences between the requirements of Supplement 1 of NUREG-0737 and the guidance of NUREG-0700.

The significant change between Supplement 1 of NUREG-0737 and NUREG-0700 is the review of system functions and control room tasks. NUREG-0700 is not prescriptive as to the events to be analyzed. However, NUREG-0700 recommends that the sequence of events include a spectrum of events with emphasis on abnormal and emergency conditions. In addition to transients and accidents, NUREG-0700 recommends that plant startup, shutdown, or refueling and significant changes in operating power during normal operation be addressed. The guidance of NUREG-0700 responds to the TMI-2 Lessons Learned Task Force recommendation that licensees should evaluate the adequacy of information presented to the operators to reflect plant status for normal operation, anticipated operational occurrences, and accident conditions (NUREG-0585).

Supplement 1 of NUREG-0737 reduces the scope to consideration of only emergency operations. As a result, analysis of control room operator tasks associated with normal and abnormal operating procedures is not required. The scope was reduced to reduce the cost and effort of the control room review for licensees/applicants and keep the effort focused on those tasks considered to provide the greatest improvement in safety. Upgrading of abnormal and normal operating procedures will be considered in the long-term program, Item I.C.9 of the Task Action Plan.