U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

8.0 HUMAN FACTORS ENGINEERING

REVIEW RESPONSIBILITIES

Primary -- Organization responsible for the review of human performance

Secondary -- None

I. ~~I.~~ AREAS OF REVIEW

This document provides the regulatory guidance used by the U.S. Nuclear Regulatory Commission (NRC) staff while reviewing Human Factors Engineering (HFE) ~~Program~~ considerations of ~~The organization responsible for the review of human performance reviews the HFE programs of applicants (e.g., for a construction permit (CP);~~ operating license ~~(OL); standard~~applications, design ~~certification (DC); and combined license (COL)) and licensees (e.g., for~~certifications, plant modifications ~~and changes to a licensee's design or licensing basis).~~, and important human actions. The purpose of these reviews is to improve safety by verifying that acceptable HFE practices and guidelines are incorporated into the ~~plant's design. The guidance provided in this document, and in the supporting documents referenced, is used to conduct these HFE reviews.~~ plant's design as follows:

~~Revision 2 - March 2007~~
Draft Revision 3 –July 2015

USNRC STANDARD REVIEW PLAN

This Standard Review Plan (SRP), NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission (NRC) staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC regulations. The SRP is not a substitute for the NRC regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide an acceptable method of complying with the NRC regulations.

The SRP sections are numbered in accordance with corresponding sections in Regulatory Guide (RG) 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of RG 1.70 have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) are based on RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

These documents are made available to the public as part of the NRC policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to NRO_SRP@nrc.gov.

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1. Operating License Applications

The organization responsible for the review of human performance reviews the applicant's HFE control room design described in the operating license application. The submittal should address all 12 elements described in NUREG-0711, "Human Factors Engineering Program Review Model." Areas that interface with operating programs (e.g., procedures, training) should be coordinated with the organization responsible for reviewing operating programs

to determine the level of effort needed in reviewing Chapter 18 of the applicant's safety analysis report (SAR). The purpose of these reviews is to assure safety by verifying that acceptable HFE practices and guidelines are incorporated into the control room design.

2. Combined License Applications

The organization responsible for the review of human performance reviews the applicant's HFE control room design as described in the final safety analysis report (FSAR). In most cases a combined license (COL) application will "Incorporate by Reference" an approved design certification (DC). The staff verifies the COL applicant has addressed each COL action item from the DC and any additions and departures/exemptions from the DC. The additional material is evaluated against the applicable sections of NUREG-0711. The purpose of these reviews is to assure safety by verifying that the COL applicant's FSAR provides any additional documentation specified by the DC.

3. Design Certification Application

The organization responsible for the review of human performance reviews the applicant's HFE control room design described in the design certification application. The submittal should address all 12 elements described in NUREG-0711. This may require deferring site- or plant-specific elements to future COL applicants via COL action items. Elements that interface with operating programs (e.g., procedures, training) should be coordinated with the organization responsible for reviewing operating programs to determine the level of effort needed in reviewing Chapter 18 of the applicant's SAR. Typically the evaluation of operating programs will be done within Standard Review Plan (SRP), Chapter 13 as discussed in Section II, "Interfaces." The purpose of these reviews is to assure safety by verifying that acceptable HFE practices and guidelines are incorporated into the plant's design.

~~This SRP chapter will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR Part 50 and 10 CFR Part 52. This SRP chapter describes a process for evaluating (1) designs, (2) design processes, (3) design reviews, and (4) operator actions submitted by applicants and licensees for the broad range of NRC review responsibilities. Specific applications are discussed in "Applications" below. The chapter identifies 12 areas of review that are needed for successful integration of human characteristics and capabilities into nuclear power plant design. These areas of review include:~~

- ~~HFE Program Management~~

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- Operating Experience Review
- Functional Requirements Analysis and Function Allocation
- Task Analysis
- Staffing and Qualifications
- Human Reliability Analysis
- Procedure Development
- Training Program Development
- Human-System Interface Design
- Human Factors Verification and Validation
- Design Implementation
- Human Performance Monitoring

While the process defines 12 areas of review, not all may be applicable to reviewing a particular applicant's or licensee's HFE program. This is discussed in "Graded Approach to Review" below.

2. Inspection, Test, Analysis, and Acceptance Criteria (ITAAC). For DC and COL reviews, the applicant's proposed information on the ITAAC associated with the HFE areas related to this SRP section is reviewed in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria - Design Certification," and 14.3.9, "Human Factors Engineering." The staff recognizes that the review of ITAAC is performed after review of the rest of this portion of the application against acceptance criteria contained in this SRP section. Furthermore, the ITAAC are reviewed to assure that all systems, structures, and components (SSCs) in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3 and 14.3.9.

3. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Applications

NRC HFE reviews in three application areas are described below:

1. Review of the HFE Aspects of a New Plant This chapter describes the staff's review activities to verify that accepted HFE principles are incorporated during the design process and that the human system interfaces (HSIs) reflect a state of the art HFE design. If an applicant proposes to build a new plant under 10 CFR Part 50 requirements, an HFE review of the new license application is performed.

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~~Nuclear power plant (NPP) designers and vendors may submit designs for new standardized NPPs to the NRC for review and approval under 10 CFR Part 50 or they may submit designs for new standardized NPPs under 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," (see Part 52 Subpart B, "Standard Design Certification"). To obtain a standard design certification under Part 52, applicants must submit technical information which is technically relevant to the design. The technical information should include the HFE program. However, since technology is continually advancing, details of the applicant's HFE design might not be complete before the NRC issues a design certification. In such cases, reviews under 10 CFR Part 52 would primarily focus on the HFE design process.~~

~~An applicant may obtain a COL to operate a standardized NPP that has already received a design certification under 10 CFR Part 52. Portions of the facility design not covered by the design certification are reviewed at the COL stage. Thus, for new NPPs, HFE reviews can occur at different points within the 10 CFR Part 52 application and licensing process. These reviews can include the following:~~

- ~~Design documentation, such as design specific HFE guidance documents and specifications~~
- ~~Prototype designs~~
- ~~Completed designs~~
- ~~HFE related ITAAC (to verify that an as-built plant will be built and will operate to the standard design certification)~~
- ~~HFE-related design acceptance criteria (to verify that the applicant properly executes the design process after certification)~~

~~For new NPPs (under 10 CFR Part 52), some HFE program elements may be deferred to the COL application. However, all HFE review criteria will be addressed before plant startup.~~

~~2. Review of the HFE Aspects of~~

4. Plant and Control Room Safety-related Modifications~~—~~

The NRC staff conducts reviews of license amendment ~~applications~~requests involving voluntary modifications of HFE aspects of ~~HSIs. This chapter can be used to review~~the control room and other safety-related interfaces to verify they are acceptable under Title 10 of the *Code of Federal Regulations* (10 CFR) 50.90, "Application for Amendment of License, Construction Permit, or Early Site Permit." These reviews include changes or modifications to the control room and other significant human-system interfaces (HSIs~~.~~). Modifications may be extensive, such as a large-scale modernization of control room HSIs, using computer-based technology as part of a digital instrumentation and controls (I&C) upgrade program. Such a program can result in substantial modifications to alarms, controls, and displays that are associated with ~~SSCs~~structures, systems and components important to safety. The NRC may also review

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certain plant modifications involving changes to the FSAR as part of the change process described in 10– CFR– 50.59-, "Changes, Tests, and Experiments." Guidance related to 10- CFR 50.59 is provided in Regulatory Guide (RG)- 1.187, -"Guidance for Implementation of 10- CFR- 50.59, Changes, Tests, and Experiments-," and Nuclear Energy Institute (NEI) publication 96-07, -"Guidelines for 10 CFR 50.59 Implementation-."

5. 3. Review of the HFE Aspects of Modifications Affecting Risk-Important Human Actions The NRC staff reviews modifications to ensure they are acceptable.

This SRP chapter can also be used to review changes or modifications to licenses for nuclear power plants that include or result in changes to human actions. While HSI modernization may be– a large-scale modification, even smaller-scale modifications may be risk-important, especially when they affect operator actions that are credited in the safety analysis report (SAR).SAR or other accidents of high or moderate frequency which may not be analyzed in the SAR. An HFE review is conducted if such a modification affects the role of personnel or the tasks they perform, the sequence of actions, the timing, or the overall workload, and is potentially significant to plant safety. Modifications affect the role or tasks of personnel if they impose new or different demands on them to operate or maintain the plant, or otherwise ensure safety. An example of such a modification would be substituting manual actions for automatic actions for performing –design functions described in the SAR- (See IN 97-78, "Crediting of Operator Action In Place of Automatic Actions and Modification of Operator Actions, Including Response Times." for further guidance). The NRC may also review certain plant modifications involving changes to the SAR as part of the change process described in 10– CFR 50.59. Additional guidance related to 10 CFR 50.59 is provided in RG 1.187 and Nuclear Energy Institute (NEI) publication– 96-07, "Guidelines for 10 CFR 50.59 Implementation." .

Graded Approach to Review

Previous revisions of HFE guidance documents have focused on the review of risk important human actions. Experience is showing that there are additional human actions that need to receive similar reviews because they are specifically credited in design analyses. Consequently the guidance has been generalized to address important human actions as identified in:

Operator actions credited in the diversity and defense in depth analysis supporting the diverse actuation system described in SRP, Chapter 7, "Instrumentation and Controls."

Operator actions credited in the design bases analyses described in SRP, Chapter 15, "Transient and Accident Analysis."

Risk-important human actions identified in the human reliability analysis contained in SRP, Chapter 19, "Severe Accidents."

The review guidance may also be useful in reviewing operator manual actions associated with fires especially alternate safe shutdown, flooding, beyond design basis events, and decommissioning activities. See Attachment A and NUREG-1764 for specific review guidance.

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6. Local Control Stations

Local control stations are not specifically addressed in the Commission's regulations. In practice the staff has used the graded approach (See Section IV, "Review Procedures") to evaluate risk-important human actions that are conducted from local control stations.

Applicants have found it useful to apply guidance in NUREG-0711 to the central and secondary alarm stations associated with security measures. The staff has historically not reviewed central and secondary alarm station HFE designs as there is not a regulatory basis for doing so.

The emergency operating facility (EOF) and technical support center (TSC) are also included within the scope of HFE reviews. Again, a graded approach is used. NUREG-0711, Revision 3 provides more specific direction on which review criteria are applied to these facilities. NUREG-0696, "Functional Criteria for Emergency Response Facilities," also includes general HFE criteria for these facilities and the staff has accepted a commitment to implement these criteria as an alternative to the NUREG-0711 criteria.

7. Decommissioning Activities

The HFE reviews of the control room design can occur in all phases of control room activities from initial design through operation and subsequent decommissioning. In decommissioning a graded approach is again used as functional requirements decrease. The review focus is on maintaining a highly functional configuration for the controls, alarms and displays associated with the safety functions. In some cases, the controls, displays and alarms may be moved to local control panels or existing local control panels may become more important. In these cases the important human actions associated with these local control stations, and the physical design of the stations can be evaluated using the guidance in NUREG-0711 and NUREG-0700, "Human-System Interface Design Review Guidelines".

~~The degree to which the NRC staff applies the review methodolgy in this SRP and evaluates an applicant's HFE design will reflect the specific circumstances of individual applications. For example, generally the review of the HFE aspects of a new plant will entail a comprehensive, detailed evaluation (see Section II.A), while the review of individual modifications to existing designs may be less extensive. In its complete form as applied to the review of the HFE aspects of a new plant, the review process provides a comprehensive, detailed evaluation (see Section II.A). However, the level of staff review of an applicant's HFE design should reflect the unique circumstances of the review. In addition, staff reviews should also reflect risk-informed regulation and considerations. The NRC, the nuclear industry, and the public have moved to a broader consideration of risk in many activities associated with NPPs. Therefore, risk importance is taken into account when deciding which particular items to review and the depth of review necessary. This aspect of grading the review is discussed in Section II.C below and can be applied to both risk informed and non-risk informed submittals~~

~~This chapter provides detailed examples of graded review criteria for several reviews:~~

- ~~Control room modifications (see Section II.B)~~
- ~~Modifications affecting human actions of high risk importance (see Section II.C.2)~~

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- ~~Modifications affecting human actions of moderate risk importance (see Section II.C.3)~~
- ~~Modifications affecting human actions of lower risk importance (see Section II.C.4)~~

The reviews may also include an evaluation of the proposed certified fuel handler training program, and proposed administrative controls and technical specifications. Both reviews should be complete before the licensee submits its request to move into decommissioning status.

II. REVIEW INTERFACES

~~Within these graded review criteria, the guidance is further tailored each specific review. The areas of review with respect to an applicant's submittal are based on:~~

- ~~An evaluation of the information provided by the applicant~~
- ~~The similarity of the associated HFE issues to those recently reviewed for other plants~~
- ~~The determination of whether items of special or unique safety significance are involved~~

~~Review Interfaces~~

Other SRP ~~sections~~Chapters interface with this section as follows:

1. Chapter 18 addresses important manual actions under the "Treatment of Important Human Actions" element of NUREG-0711. These reviews should be coordinated with the following Chapters:

   - ~~1.~~ Chapter 6, Section 6.3~~,~~ "Emergency Core Cooling System (ECCS)~~,~~" ~~Section 6.3 addresses the review of ECCS. Section III.19),~~" discusses the review of operator manual actions that may be necessary during ECCS operation in accident sequences up through the time of long~~-term core cooling. Chapter 18 addresses important manual actions under the HRA element. Thus, the reviews of Section 6.3 III.19 and Chapter 18 should be conducted in a coordinated manner.~~ -term core cooling.

   - ~~2.~~ Chapter 7, ~~"~~Section 7.8, "Diverse Instrumentation and Control Systems" addresses manual actions credited in the diverse actuation system.

   - Chapter 15, "Transient and Accident Analysis," addresses anticipated operational occurrences and postulated accidents. These analyses provide the basis for safety system operation and operator actions which are inputs to the HFE design process of Chapter 18. Reviewers should verify all manual actions identified in Chapter 15 are addressed in Chapter 18.

   - Chapter 19, "Probabilistic Risk Assessment and Severe Accident Evaluation," addresses probabilistic risk assessments for site-specific safety risks. It

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identifies the risk important human actions that are an input to the HFE design, procedures, staffing, and training. Typically the Chapter 18 material will reference the appropriate Chapter 19 table identifying risk important human actions. Reviewers should verify all risk important manual actions identified in Chapter 19 are addressed in Chapter 18.

Manual actions may be identified in other Chapters but the organizations responsible for those chapters will contact the organization responsible for Chapter 18 if additional help is needed.

2. 10 CFR 50.34(f)(2)(iv) requires a plant safety parameter display systems (SPDS) console that displays to operators a minimum set of parameters defining the safety status of the plant, capable of displaying a full range of important plant parameters and data trends on demand, and capable of indicating when process limits are being approached or exceeded. The staff's review needs to ensure the following areas are consistent.

   - Chapter 7 addresses the adequacy of controls and instrumentation with regard to the features of automatic actuation, remote sensing and indication, and remote control. RG 1.97 parameters are identified within this chapter.

   - Chapter 13, Section 13.3, "Emergency Planning," addresses emergency planning including the TSC and EOF and the implementation of SPDS in these facilities.

   - Chapter 15 addresses design basis analyses which include the parameter responses that must be monitored and controlled to maintain reactor safety.

   - Chapter 18 identifies controls, displays and alarms needed by the operator to address abnormal operating occurrences and postulated accidents.

3. Chapter 7, "Instrumentation and Controls," ~~Descriptions of HSI,~~ describes components and characteristics ~~are addressed by both Chapters 7 and 18 reviews~~included in the Chapter 18 review. As appropriate, the review results of one chapter should be considered in the review activities for the other chapter.

~~3.~~ ~~Section~~4. Chapter 13, Section 13.1.1, "Management and Technical Support Organization," ~~Section 13.1.1,~~ addresses ~~review of the corporate level management and technical organizations of the applicant and its major contractors. Section 13.1.1 addresses~~ the need for clearly defined management and organizational responsibilities ~~with regard to HFE considerations in plant design~~. Chapter 18, under Acceptance Criteria, requires a comprehensive summary of management's role in ensuring that HFE is adequately considered in new plant design and in the modification of an existing plant. The reviews of Section 13.1.1 and Chapter 18 should be ~~conducted in a coordinated manner~~verified to be consistent.

~~4.~~ ~~Section~~5. Chapter 13, Sections 13.1.2-13.1.3, "Operating Organization," ~~Section 13.1.2-13.1.3,~~ addresses ~~the review for specific~~ staffing requirements. ~~In addition,~~ Chapter 18 specifies a systematic analysis of operational staffing requirements that includes a thorough understanding of task requirements and applicable regulatory requirements. The Chapter 18 analysis ~~addresses~~verifies the basis for the minimum

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manning requirements ~~from Section 13.1.2-13.1.3 as an input.~~of 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." remain intact. Reviewers should verify that ~~staffing requirements addressed under Section 13.1.2-13.1.3 are properly considered in the~~ the Chapter 18 ~~analysis~~review conclusions support the Chapter 13 review conclusions.

~~5.~~ ~~6.~~ Chapter 13, Sections 13.2.1, ~~"~~"Reactor Operator and Requalification Program; Reactor Operator Training" and SRP Section 13.2.2, ~~"~~"Non-licensed Plant Staff Training~~."~~." The training program is an operational program identified in SRP Section 13.4. For a new nuclear power plant (NPP) the training program will usually be reviewed during the COL FSAR review rather than the DC. SRP Sections 13.2.1 and 13.2.2 provide specific criteria for reviewing training programs for reactor operators and non-licensed plant staff~~. Chapter 18 contains an area~~ and the evaluation of ~~review titled "Training Program Development," which provides criteria for reviewing the process by which training programs are developed. It~~ the applicant's training program is conducted in accordance with the guidance in this Chapter. While NUREG-0711 addresses training as it interfaces with the HFE design process DC applicants do not need to address this element as part of Chapter 18 since the same information is provided in Chapter 13. If information is provided, the staff will coordinate the Chapter 13 and 18 reviews. Other submittals, such as safety related modifications meeting review requirements, should address this element if appropriate.

7. ~~the relationship~~SRP Section 13.3, "Emergency Planning," addresses emergency planning including the TSC and EOF. Chapter 18 addresses the HFE design associated with these facilities. Typically the HFE design responsibility is split between ~~training development and the overall HFE design process. These reviews should be conducted in a~~ the DC applicants (identifies the displays and alarms) and the COL applicant (identifies facility layout, radiation level data, and communications). NUREG-0696 has been accepted as one method for addressing the COL applicant's HFE design responsibilities. The Chapter 18 review results should be coordinated ~~manner. Topics from~~with the ~~SRP~~ Chapter ~~18 area of~~13 reviewers to ensure review ~~that~~results are ~~related to the review of Sections 13.2.1 and 13.2.2 are cross referenced~~consistent.

8. ~~6. Sections~~SRP Section 13.5.1.1, ~~"~~"Administrative Procedures – General~~"~~," SRP Section 13.5.1.2, ~~"~~"Administrative Procedures – Initial Test Program~~"~~," SRP Section 13.5.2.1, ~~"~~"Operating and Emergency Operating Procedures~~,~~," and SRP Section 13.5.2.2, ~~"~~"Maintenance and Other Operating Procedures~~."~~ ~~Sections 13.5.1.1, 13.5.1.2, 13.5.2.1, and 13.5.2.2~~," provide specific criteria for the content of administrative ~~procedures and~~, operating and maintenance procedures. ~~Chapter 18 contains an area of review titled "Procedure Development," which provides criteria for the review of the procedure development process rather than the actual procedures. These reviews should be conducted in a coordinated manner. Topics from the Chapter 18 review that are related to the review of Sections 13.5.1.1, 13.5.1.2, 13.5.2.1, and 13.5.2.2 are cross referenced.~~

~~7. Section 13.6.1, "Physical Security – Combined License and 13.6.2, "Physical Security – Design Certification." Sections 13.6.1 and 13.6.2 provide criteria for review of the~~

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~~central alarm station (CAS) and secondary alarm station (SAS).~~ While NUREG-0711 addresses procedures as they interface with the HFE design process, DC applicants do not need to address this element as part of Chapter 18 ~~reviews the CAS and SAS from a human factors perspective~~since the same information is provided in Chapter 13. Other submittals, such as safety related modifications meeting review requirements, should address this element when applicable.

~~8. Section 14.3.9, "Human Factors Engineering (Tier 1)." Section 14.3.9 addresses the review of an applicant's Design Control Document (DCD) specifically to assure the acceptability of Tier 1 information for the main control room (MCR) panels, remote shutdown (RSP) panel, and local control station (LCS) panels. The organization responsible for the review of human performance also has primary review responsibility for additional material applicable to multiple systems of the standard design in Tier 1 pertaining to human factors engineering, if such material is provided by the applicant. The organization responsible for the review of human performance is responsible for providing input to other technical review organizations regarding the minimum inventory of alarms, controls and indications appropriate for the MCR and RSP.~~

~~9. Chapter 15, "Accident Analysis." Many organizations have responsibility for the review of Chapter 15, which addresses anticipated operational occurrences and postulated accidents. Information from analyses conducted to address the criteria of Chapter 15 should be incorporated as input to the HFE design process.~~

~~10. Chapter 19, "Probabilistic Risk Assessment and Severe Accident Evaluation." Chapter 19 addresses probabilistic risk assessments for site-specific safety risks. The Chapter 18 review area "Human Reliability Analysis" addresses the relationship between HFE activities and probabilistic risk analysis/human reliability analysis (PRA/HRA) activities and the use of risk insights in the HFE program. These reviews should be conducted in a coordinated manner. Topics from the SRP Chapter 18 area of review that are related to the review of Chapter 19 are cross-referenced.~~

9. SRP Section 14.3.9, "Human Factors Engineering - Inspections, Tests, Analyses, and Acceptance Criteria," verifies the Tier 1 description of the HFE program is complete and consistent with Tier 2 material. It also verifies that appropriate Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) have been identified. Reviewers need to ensure the Chapter 18 and SRP Section 14.3.9 review results are consistent.

~~II~~

~~The specific acceptance criteria and review procedures are contained in the referenced SRP sections.~~

~~II~~.III ACCEPTANCE CRITERIA

~~Requirements~~

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Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations[1]:

Requirements

~~1. 10 CFR 50.34(f)(1)(i)~~

~~2.~~

1. 10 CFR 50.34(f)(2)(iii) – Provide, for Commission review, a control room design that reflects state-of-the-art human factor principles prior to committing to the fabrication or revision of fabricated control room panels and layouts.

   This is the most encompassing HFE related regulation. Acceptance criteria for HFE design methodology are provided in NUREG-0711. NUREG-0711 references NUREG-0700, "Human-System Interface Design Review Guidelines," which provides detailed acceptance criteria for HFE design attributes.

2. The following regulations address general requirements related to the main control room that influence the HFE design:

   - 10 CFR 50.34(f)(2~~)~~)(ii) – continuing improvement of HFE and procedures
   - ~~3.~~ 10 CFR 50.34(f)(~~3)(ii~~2)(iv) – safety parameter display system
   - ~~4.~~ 10 CFR 50.34(f)(3)(~~vii~~)i) – use of operating experience
   - ~~5.~~ 10 CFR 50.54 (i) to (m) – staffing
   - ~~6.~~ 10 CFR ~~50.120~~52.47 – level of detail required in DCs

     ~~7.~~ 10 CFR 52.47 (a)(8~~.~~) – inclusion of 10 CFR 50.34(f) for Part 52 applications
   - 10 CFR 52.79 – content of COL applications

     ~~9. 10 CFR 52.80~~

     ~~10. 10 CFR Part 55~~

~~The~~

3. The following regulations address specific ~~aspects~~requirements related to the main control room that influence the HFE design:

   - 10 CFR 50.34(f)(2)(v) – automatic indication of the bypassed and operable status of safety systems
   - 10 CFR 50.34(f)(2)(xi) – relief and safety valve indication
   - 10 CFR 50.34(f)(2)(xii) – auxiliary feedwater system flow indication
   - 10 CFR 50.34(f)(2)(xvii) – containment related indications
   - 10 CFR 50.34(f)(2)(xviii) – core cooling indications
   - 10 CFR 50.34(f)(2)(xix) – instrumentation for monitoring post accident conditions that includes core damage

[1] For 10 CFR Part 50 applicants not listed in 10 CFR 50.34 (f), the provisions of 10 CFR 50.34(f) ~~will~~should be made a requirement during the licensing process.

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- 10 CFR 50.34(f)(2)(xxi) – auxiliary heat removal (Boiling Water Reactor only)
- 10 CFR 50.34(f)(2)(xxiv) – reactor vessel level monitoring (Boiling Water Reactor only)
- 10 CFR 50.34(f)(2)(xxvi) – leakage control
- 10 CFR 50.34(f)(2)(xxvii) – radiation monitoring

The regulatory guidance provided in NUREG-0711 addresses all the human factors elements of these requirements ~~are detailed in the applicable SRP Acceptance Criteria discussion~~.

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SRP Acceptance Criteria

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~~Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations previously identified follow for the review described in this SRP section.~~ The SRP is not a substitute for the ~~NRC's~~NRC regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

Acceptance criteria are specific to the type of application being reviewed. Table 1 below lists the NUREGs that contain the acceptance criteria used to verify the requirements listed above have been met. The table also summarizes when the NUREGs are used. Each NUREG provides more specific direction on when and how its contents are used.

Table 1: Acceptance Criteria Sources

New control room design, no design acceptance criteria (DAC)	NUREG-0700 (primary) NUREG-0711 (secondary)
New control room design, DAC	NUREG-0711 (primary) NUREG-0700 (secondary)
Combined License application that does not reference a DC	NUREG-0700 (primary) NUREG-0711 (secondary)
Major control room modernization	NUREG-0700 (primary) NUREG-0711 (secondary)
Control room modification	NUREG-0700 (primary) NUREG-0711 (secondary)
Evaluation of important human actions	NUREG-1764 SRP Chapter 18, Attachment A
Workload evaluation	SRP Chapter 18, Attachment B

Changes resulting from plant modifications, procedure changes, equipment failures, justifications for continued operations, and identified discrepancies in equipment performance or safety analyses	NUREG-1764
Decommissioning activities	NUREG-1764 NUREG-1220 SRP Chapter 18, Attachment A Draft NUREG-1625, "Proposed Standard Technical Specifications for Permanently Defueled Westinghouse Plants"

1. NUREG-0711 describes acceptance criteria for an HFE design process that the staff has found acceptable. The NUREG identifies 12 elements needed for successful integration of human characteristics and capabilities into nuclear power plant design.

2. NUREG-0700 describes acceptance criteria for the physical and functional characteristics of HSIs. The HFE Guidelines are organized into four basic parts. Part I contains guidelines for the basic HSI elements: displays, user-interface interaction and management, and controls. These elements are used as building blocks to develop HSI systems to serve specific functions. Part II contains the guidelines for reviewing six such systems: alarm system, group-view display system, soft control system, computer-based procedure system, computerized operator support system, and communication systems. Part III provides guidelines for the review of workstations and work places. Part IV provides guidelines for the review of HSI support, i.e., maintainability of digital systems.

   In addition to the review of actual HSIs, the staff can use the guidelines to evaluate a design-specific HFE guideline document (style guide), control room modifications, local control station layouts, and control room reconfiguration modifications that might occur during decommissioning.

3. Attachment A, "Guidance for Evaluating Credited Manual Operator Actions," provides acceptance criteria for evaluating important human actions.

4. Attachment B, "Methodology to Assess the Workload of Challenging Operational Conditions In Support of Minimum Staffing Level Reviews," a methodology to identify high-workload operational conditions and analyze the workload associated with them. The methodology is rooted in task analysis and relies on the identification of appropriate challenging scenarios, realistic portrayals of task performance that is complicated by separate, but often necessary, dependent and independent tasks, and the judgment of SMEs obtained in a manner conducive to obtaining realistic workload estimation.

5. NUREG-1764, "Guidance for the Review of Changes to Human Actions," is particularly useful when evaluating changes resulting from plant modifications, procedure changes,

equipment failures, justifications for continued operations, and identified discrepancies in equipment performance or safety analyses. This guidance uses a graded, risk-informed approach that is consistent with Regulatory Guide (RG) 1.174, "An Approach to Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis." As such, this guidance uses risk insights to determine the level of regulatory review the staff should perform. This approach can be accomplished for licensee submittals that are either risk-informed or non-risk-informed. Human actions that are considered more risk-significant receive a detailed review, while those deemed less significant receive a less detailed review. When a human action is significant the analysis method described in Attachment A is a useful complement to the guidance in this NUREG.

IV. REVIEW PROCEDURES

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In general, reviews should follow these steps:

1. Completion of the pre-acceptance and acceptance reviews in accordance with the applicable Office Instructions:

   - NRR- LIC-109, "Acceptance Review Procedures."
   - NRO-REG-104, "Pre-application Readiness Assessment"
   - NRO-REG-100, "Acceptance Review Process for Design Certification and Combined License Applications."

2. Verification that the licensee/applicant is using an acceptable HFE design method. An acceptable standard is described in NUREG-0711 (new designs, modifications) or NUREG-1764 (human actions).

3. Verification that the HFE design conforms to industry standards as described in NUREG-0700, "Human-System Interface Design Review Guidelines."

4. Verification that exemptions from regulations or alternate methods for complying with regulations have specific analyses supporting them (see NRR- LIC-103).

5. Verification that HFE design effectiveness has been demonstrated in a performance based integrated system validation test as described in NUREG-0711.

This sequence can be applied across the spectrum of HFE review areas by applying the graded approach concepts provided in the next section.

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Graded Approach to Review

~~A. Review of the HFE Aspects of a New Plant~~

~~A.1 HFE Program Management~~

The objective of this review is to confirm that the applicant has adequately considered the role of HFE and the means by which HFE activities will be accomplished. The review should verify that:

- The applicant has identified plans to oversee design and construction of the nuclear facility in accordance with the requirements of 10 CFR 50.34(f)(3)(vii), as described in SRP Section 13.1.1, "Management and Technical Support Organization."

- The applicant has an HFE design team with the responsibility, authority, placement within the organization, and composition to ensure that the design commitment to HFE is achieved. There is, however, no assumption that HFE is the responsibility of a single organization or that there is an organizational unit called the HFE design team.

- The team is guided by an HFE program plan to ensure the proper development, execution, oversight, and documentation of the HFE program.

- The overall HFE program appropriately considers and address the deterministic aspects of the design, as discussed in RG 1.174.

  The HFE program plan should describe the technical program in sufficient detail to ensure that all aspects of the HSIs, procedures, and training are developed, designed, and evaluated on the basis of a structured top-down systems analysis using accepted HFE principles.

The applicant's HFE program management should be evaluated in accordance with the review criteria of NUREG-0711, "Human Factors Engineering Program Review Model."

A.2 Operating Experience Review

The objective of this review is to verify that the applicant has identified and analyzed HFE-related problems and issues in previous designs so that these problems and issues may be avoided in the development of the new design. This review should also verify that the applicant has retained positive features of previous designs. The operating experience review (OER) should be evaluated in accordance with the review criteria of NUREG-0711 and should satisfy the requirements of 10 CFR 50.34(f)(3)(i) and 52.49(a)(21).

A.3 Functional Requirements Analysis and Function Allocation

Functional requirements analysis is the identification and analysis of those functions that must be performed to satisfy plant safety objectives; that is, to prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public. Function allocation analysis is the analysis of requirements for plant control and the assignment of control

functions to (1) personnel (e.g., manual control), (2) system elements (e.g., automatic control and passive, self-controlling phenomena), and (3) combinations of personnel and system elements (e.g., shared control, automatic systems with manual backup).

The objective of this review is to verify that (1) the plant's functions that must be performed to satisfy plant safety objectives have been defined, and (2) that the allocation of those functions to human and system resources has resulted in a role for personnel that takes advantage of human strengths and avoids human limitations. Functional requirements analysis and function analysis should be evaluated in accordance with the review criteria of NUREG-0711.

A.4 Task Analysis

Task analysis is the analysis of human performance that results from the allocation of functions to personnel and the identification of HSI characteristics needed to support personnel task accomplishment. The objective of this review is to ensure that the applicant's task analysis identifies the specific tasks that are needed for function accomplishment and their information, control, and task support requirements. The task analysis should be evaluated in accordance with the review criteria of NUREG-0711.

A.5 Staffing and Qualifications

The objective of this review is to verify that the applicant has analyzed the requirements for the number and qualifications of personnel in a systematic manner that includes a thorough understanding of task requirements and applicable regulatory requirements. The applicant's staffing and qualifications analyses should be evaluated in accordance with the review criteria of NUREG-0711 and should satisfy the requirements of 10 CFR 50.54 (i) through (m). If an exemption from these requirements is being sought, the analysis and justifications should be presented [see also NUREG/CR-6838, "Technical Basis for Regulatory Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)" and NUREG-1791, "Guidelines for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operating Staff Requirements Specified in 10 CFR 50.54(m) — Final Report"]. The full staffing program is considered to be an operational program as discussed in SECY-05-197 and in RG-1.206 "Combined License Applications for Nuclear Power Plants (LWR Edition)", Section C.IV.4, "Operational Programs."

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A.6 Human Reliability Analysis

Human reliability analysis (HRA) is an evaluation of the potential for and mechanisms of human error that may affect plant safety. The objectives of this review are to ensure that (1) the applicant has addressed human error mechanisms in the design of the HFE aspects of the plant to minimize the likelihood of personnel error, and detect errors and recover from them; and

(2) the HRA activity effectively integrates the HFE program and PRA. A design-specific PRA/HRA is required by 10 CFR 50.34(f)(1)(i), 52.47(b)(1) and 52.79, and is addressed in SRP Chapter 19 and RG 1.206 Section C.II.1. RG 1.206 Section C.II.1 specifies the purpose and objectives of the PRA, as well as the required scope and level of detail. In order to accomplish the above objectives, the HRA/PRA and the modeling of HAs must be of sufficient quality (see SRP Chapter 19 and RG 1.206 Section C.II.1).

Review of the HRA should be coordinated with SRP Section 6.3.III.19 and RG 1.206 Section C.I.6.3.2.8 as they relate to manual actions for ECCS.

The integration of the applicant's HRA with the HFE program should be evaluated in accordance with the review criteria of NUREG-0711.

A.7 Human-System Interface Design

The HSI design process represents the translation of function and task requirements into HSI characteristics and functions. The objective of this review is to evaluate the process by which HSI design requirements are developed and HSI designs are identified and refined. The review should verify that the applicant has appropriately translated functional and task requirements to the detailed design of alarms, displays, controls, and other aspects of the HSI through the systematic application of HFE principles and criteria. The applicant's HSI design process should be evaluated in accordance with the review criteria of NUREG-0711, and the final design evaluated in accordance with the review criteria of NUREG-0700, "Human-System Interface Design Review Guidelines."

The HSI design should address those subsections of 10 CFR 50.34(f)(2) that are applicable to the plant's design from the following list: 10 CFR 50.34(f)(2)(i), (iii), (iv), (v), (xi), (xii), (xiii), (xv), (xvii), (xviii), (xix), (xxi), (xxiv), (xxv), & (xxvii). In addition to the HFE considerations discussed above, the following specific HSI design guidance should also be addressed:

1. Safety parameter display system requirements, as described in 10 CFR 50.34(f)(2)(iv), NUREG 0835, NUREG 1342, and Supplement 1 of NUREG 0737.

2. Periodic testing of protection systems actuation functions, as described in Regulatory Guide 1.22.

3. Bypassed and inoperable status indication for NPP safety systems, as described in Regulatory Guide 1.47.

4. Manual initiation of protective actions, as described in Regulatory Guide 1.62.

5. Instrumentation for light-water-cooled nuclear power plants to access plant and environmental conditions during and following an accident, as described in Regulatory Guide 1.97.

6. Instrumentation setpoints, as described in Regulatory Guide 1.105.

7. Functional criteria for emergency response facilities, as described in NUREG-0696.

8. A minimum inventory of controls, displays and alarms.

The HSI design should describe the process, after the plant is in operation, by which (1) HSIs are modified and updated,(2) temporary HSI changes are made (such as set point modification) and (3) operator defined HSIs are created (such as temporary displays defined by operators for monitoring a specific situation).

The HSI design review should be coordinated with the instrumentation and controls review in SRP Chapter 7.

A.8 Procedure Development

The objective of this review is to confirm that the applicant's procedure development program incorporates HFE principles and criteria, along with all other design requirements, to develop procedures that are technically accurate, comprehensive, explicit, easy to utilize, validated, and in conformance with 10 CFR 50.34(f)(2)(ii). Because procedures are considered an essential component of the HFE design, they should be derived from the same design process and analyses as the other components of the HSI (e.g., displays, controls, operator aids) and subject to the same evaluation processes. The applicant's procedure development program should be evaluated in accordance with the review criteria of NUREG-0711. The review should be coordinated with the review of procedures described in SRP Section 13.5. The full procedures program is considered to be an operational program as discussed in SECY-05-197 and in RG-1.206 Section C.IV.4.

A.9 Training Program Development

The objective of this review is to ensure that the applicant has a systematic approach for the development of personnel training. The training development should include the following five activities:

- A systematic analysis of tasks and jobs to be performed
- Development of learning objectives derived from an analysis of desired performance following training
- Design and implementation of training based on the learning objectives
- Evaluation of trainee mastery of the objectives during training
- Evaluation and revision of the training based on the performance of trained personnel in the job setting

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The training program should be developed in accordance with 10 CFR 50.120, 10 CFR 52.79, and 10 CFR Part 55 to ensure that personnel's qualifications are commensurate with the performance requirements of their jobs. The applicant's training program should be evaluated in accordance with the review criteria of NUREG-0711 and should address applicable guidance provided in SRP Section 13.2, "Training." The full training program is considered to be an operational program as discussed in SECY-05-197 and in RG 1.206 Section C.IV.4.

A.10 Verification and Validation

Verification and validation (V&V) evaluations seek to comprehensively determine that the design conforms to HFE design principles and that it enables plant personnel to successfully perform their tasks to achieve plant safety and other operational goals. The overall scope for V&V should include the main control room, the remote shutdown panel, and local control stations (including the central alarm system (CAS) and secondary alarm system (SAS) associated with the risk important HAs. The applicant's V&V activities include operational condition sampling, design verification, integrated system validation, and human engineering discrepancy (HED) resolution. The objectives of the staff review of each of these activities are identified in the following subsections.

A.10.1 Operational Conditions Sampling

The applicant's sampling methodology identifies the range of operational conditions that guide V&V activities. The objectives of the review are to ensure that the applicant has identified a sample of operational conditions that (1) includes conditions that are representative of the range of events that could be encountered during operation of the plant, (2) reflects the characteristics that are expected to contribute to system performance variation, and (3) considers the safety significance of HSI components. The use of risk importance to help select failure events, transients, and accidents for use in V&V is appropriate. The applicant's operational conditions sampling should be evaluated in accordance with the review criteria of NUREG-0711.

A.10.2 Design Verification

The applicant's verification should demonstrate that the design meets task and human requirements. Verification activities require a characterization of the HSI. The staff's review of design verification has the following objectives:

- Inventory and Characterization Review. The objective of this review is to evaluate whether the applicant's HSI inventory and characterization accurately describes all HSI displays, controls, and related equipment that are within the defined scope of the HSI design review.

- HSI Task Support Verification Review - The objective of this review is to evaluate whether the applicant verifies that the HSI provides all alarms, information, and control capabilities required for personnel tasks.

- HFE Design Verification Review - The objective of this review is to evaluate whether the applicant verifies that the characteristics of the HSI and the environment in which it is used conform to HFE guidelines.

The applicant's design verification should be evaluated in accordance with the review criteria of NUREG-0711.

A.10.3 Integrated System Validation

The objective of integrated system validation is to confirm that the integrated system design (i.e., hardware, software, and personnel elements) acceptably supports safe operation of the plant. Validation is based on performance based tests. The applicant's integrated system validation should be evaluated in accordance with the review criteria of NUREG-0711.

A.10.4 Human Engineering Discrepancy (HED) Resolution

HED resolution is the process of evaluating and resolving issues that are identified in V&V evaluations. The objectives of the staff's review are to verify that the applicant's HED evaluation acceptably prioritizes HEDs in terms of their need for improvement and that design solutions and a realistic schedule for implementation is developed to address those HEDs selected for correction. The applicant's HED resolution should be evaluated in accordance with the review criteria of NUREG-0711.

A.11 Design Implementation

The objective of this review is to verify that the applicant's as-built design will conform to the verified and validated design that resulted from the HFE design process. The applicant's design implementation process should be evaluated in accordance with the review criteria of NUREG-0711. This review should also ensure the acceptability of the applicant's plans for determining the operability of the MCR, RSP, LCSs, Technical Support Center and Emergency Operations Facility.

A.12 Human Performance Monitoring

The objective of this review is to assure that the applicant has prepared a human performance monitoring strategy for ensuring that no significant safety degradation occurs because of any changes that are made in the plant and to verify that the conclusions that have been drawn from the evaluation remain valid over the life of the plant. The applicant's performance monitoring strategy should be evaluated in accordance with the review criteria of NUREG-0711.

B. Review of the HFE Aspects of Control Room Modifications

License amendments involving major changes to the HSIs, such as control room modernization, should be reviewed using the guidance contained in Section II.A of this SRP chapter. However, since the extent of such modifications can vary, the staff's review should be tailored using the additional guidance from NUREG-0711 and presented in this section.

B.1 HFE Program Management

The goals of the HFE program should address the need to consider the effects that the modification may have on the performance of personnel. The review should address the applications plan with respect to the following:

- Planning the installation to minimize disruptions to work of plant personnel
- Coordinating training and procedure modifications with implementing the modification to verify that both accurately reflect the characteristics of the modification
- Conducting training to maximize personnel's knowledge of and skill with the new design before its implementation

B.2 Operating Experience Review (OER)

The operating experience of the plant being modified and plants with similar modifications should be reviewed as part of the OER. The OER should provide information on past performance of predecessor designs or earlier designs on which the new plant is based.

B.3 Functional Requirements Analysis and Function Allocation

Functional requirements analysis and function analysis should consider the following:

- Functional requirements analyses for modifications that are likely to change existing safety functions, introduce new functions for systems supporting safety functions, or involve unclear functional requirements that may be important to safety.
- Function allocation analyses for modifications that are likely to change the allocation between personnel and plant systems of functions important to safety.
- A change in an operator's role due to a modification should be examined within the context of its effects on the operator's overall responsibilities.

B.4 Task Analysis

The following considerations should be addressed in the review of plant modifications that are likely to affect human actions (HAs) previously identified as risk-important, cause existing HAs to become risk-important, or create new actions that are risk-important:

- The tasks analyses should be revised and updated to reflect requirements of the modification; the scope should include tasks involving the modification and its interactions with the rest of the plant, including those resulting from functions addressed in the analyses of functional requirements and function allocation. For maintenance, tests, inspections, and surveillances, attention should be given to risk-important actions that are new or supported by new technologies (e.g., new capabilities for online maintenance).

- The task analysis should identify the design characteristics of the existing HSIs that support the performance of experienced personnel (e.g., support high levels of performance during demanding situations).

B.5 Human-System Interface Design

The following considerations should be addressed in the review of design modifications:

- The extent to which HSI modifications are consistent with users' existing strategies and the licensee's SAR and Chapter 18 commitments.

- The extent to which HSI modifications support crew coordination

- The degree to which the HSI reflects changes resulting from integration among plant systems

The final design modifications should be reviewed in accordance with the review criteria of NUREG-0700, as applicable.

B.6 Procedure Development

The review should evaluate whether procedures are modified and whether their content, format, and integration accurately reflect changes in the plant, human actions, and HSIs.

B.7 Training Program Development

The review should evaluate whether any changes in training content or frequency are warranted following plant modernization programs.

B.8 Verification and Validation

1. Operational Conditions Sampling. V&V of the modification should reflect expected operational conditions and should address the potential effect of negative transfer of learning when the new and old components are different and impose different demands on personnel. The applicant's sampling should also consider any effects on performance of having both old and new versions of the same HSI components in place.

2. HSI Task Support Verification. HSI task support verification should focus on the HSIs that are relevant to the modification. For modifications to plant systems that do not include modifications of the HSIs, task support verification should identify any new demands for monitoring and control, and determine whether they are adequately addressed by the existing HSI design. HSIs for temporary configurations and situations where both old and new HSIs are left in place should be evaluated for their potential to negatively impact performance.

3. HFE Design Verification. HFE design verification should focus on the HSIs that are relevant to the modification. HSIs for temporary configurations and situations where both old and new HSIs are left in place should be evaluated for their potential to negatively impact performance.

4. Integrated System Validation. The applicant should perform an integrated system validation for all modifications that may (1) change personnel tasks; (2) change task demands, such as by changing task dynamics, complexity, or workload; or (3) interact with or affect HSIs and procedures in ways that may degrade performance. Integrated system validation may not be needed when a modification results in minor changes to personnel tasks such that they may reasonably be expected to have little or no overall effect on workload and the likelihood of error. The staff should verify that the applicant validates that the functions and tasks allocated to plant personnel can be accomplished effectively when the integrated design is implemented. The applicant's test objectives and scenarios should be developed to address aspects of performance that are affected by the modification design, including personnel functions and tasks affected by the modification.

B.9 Design Implementation

The objective of this review is to verify that the applicant's implementation of plant changes considers the effect on personnel performance and provides the necessary support for safety of operations. The applicant's design implementation should be evaluated in accordance with the review criteria of NUREG-0711. The following aspects of the design process should be addressed.

1. General Criteria. The staff's review should address whether the applicant has provided assurance that:

- The reactor fuel is safely monitored during the shutdown time period while the physical modifications are being implemented in the control room.

- Operations and maintenance crews are fully trained and qualified to operate and maintain the plant prior to starting up with the new systems and HSIs in place.

- Modifications in plant procedures and training reflect changes in plant systems, crew roles and responsibilities, HSIs, and that procedures required for the testing and operation of new systems and HSIs are in place prior to the modification being placed into service.

- The applicant has a plan to monitor the system performance to identify and address any problems that arise.

2. Modernization Programs Consisting of Many Small Modifications. The staff's review should address whether the applicant can verify that each modification follows an HFE program for the maintenance of standardization and consistency, and that modifications fulfill a clear operational need and do not interfere with existing systems.

3. Modernization Programs Consisting of Large Modifications During Multiple Outages. The staff's review should address whether the applicant can verify that:

- Task analysis is performed for each interim configuration to verify that the task demands that are unique to interim configurations are known.

- HRA addresses any unique tasks that may affect risk or any changes to existing tasks due to the interim configuration.

- The HSIs needed to perform important tasks are consistent and standardized.

- Procedures are developed for temporary configurations of systems and HSIs that are used by personnel when the plant is not shut down.

- Training is developed for temporary configurations of systems, HSIs, and procedures that are used by personnel when the plant is not shut down.

- Temporary operational configurations are evaluated using V&V.

4. Modernization Programs Where Both Old and New Equipment Are Left in Place. The staff's review should address whether the applicant can verify that the potential for negative effects on personnel performance has been evaluated.

5. Modernization Programs Where New Nonfunctional HSIs Are In Place In Parallel With Old Functional HSIs. The staff's review should address whether the applicant can verify that the potential for negative effects on personnel performance due to control room or HSI clutter arising from having both old and new HSIs available in parallel is evaluated and that the nonfunctional state of the HSIs is clearly indicated.

C. Review of the HFE Aspects of Modifications Affecting Risk Important Human Actions

The staff's review of license amendments and actions involving plant changes that affect important human actions (HAs) use a graded, risk-informed approach in conformance with Regulatory Guide (RG) 1.174. The staff's review uses a two-phase approach. The first phase is a screening analysis to determine the risk associated with the plant modification and its associated HAs using both quantitative and qualitative information (see Section C.1 below). This approach can be accomplished for submittals by licensees that are either risk-informed or non-risk-informed. Plan modifications and HAs are categorized into regions of high, medium, and lower risk. This categorization is used to determine the level of HFE review needed.

The second phase of the review is performed by the human factors analyst and consists of the HFE review. Changes that involve more risk-significant HAs receive a detailed review (see Section C.2.1 below), while those of moderate risk significance receive a less detailed review (see Section C.2.2 below). HAs in the lowest risk region receive minimal HFE review (see Section C.2.3 below).

C.1 Phase I - Risk Screening

C.1.1 Screening Process for Risk-Informed Change Requests

If the submittal is appropriately risk-informed, applicants should evaluate the risk associated with the proposed modification and the HAs associated with it. The applicant's risk screening should be evaluated in accordance with the review criteria of "Guidance for the Review of Changes to Human Actions" (NUREG-1764), as summarized in the four paragraphs below.

Determine the Risk of the Entire Modification. The first review step is to perform a risk-informed screening of the entire modification, including both equipment and HAs, in accordance with the review criteria of NUREG-1764, for both permanent and temporary changes. As part of this evaluation, the staff should determine whether the PRA information submitted as part of the risk-informed (R-I) submittal is suitable. The review criteria defined in RG 1.174 and SRP Chapter 19 should be used. If the staff determines that the information is not suitable, a generic method screening process should be used (see item C.1.2 below). RG 1.174 notes that licensee applications that lie in Region I of the acceptance guidelines for core damage frequency (or for large early release frequency) are generally not permitted. Proposed changes that are calculated to be in the Region I of three risk regions are identified as most risk significant. If the entire modification is in Region I, the staff determines whether the modification is rejected. If it is rejected, then no additional HFE review is

needed. If it is not rejected, the staff determines whether the modification contains only HAs or if it includes both equipment and HAs. If the modification contains only HAs (no equipment modifications) and was determined to be in Region I, then the HA should be reviewed using the Level I criteria in Section C.2.1 below. If the modification contains equipment and HAs, then the risk importance of the HA should be evaluated (see item 2 below).

Determine the Risk of the HAs. The second review step is to perform a risk-informed screening of the HA portion of the modification in accordance with the review criteria of NUREG-1764. This is done by evaluating both the risk achievement worth (RAW) and the Fussell-Vesely (FV) risk importance measures. HAs will be preliminarily sorted into the three Levels.

Perform Qualitative Screen of the HAs. The third risk-screening step is to identify whether there are qualitative factors that should be taken into account when determining the risk importance of the HA. This step may be used to adjust the review level either up or down. This evaluation should be in accordance with the review criteria of NUREG-1764.

Integrated Assessment of Human Actions Safety Significance. This step provides guidance on how to integrate the results from Steps 1 through 3 of the screening process for risk-informed licensing basis change requests.

C.1.2 Screening Process for Non-risk-informed Change Requests

If the submittal is appropriately non-risk-informed, the NRC will perform the risk screening as follows:

Review of Non-Risk-Informed Submittals. In keeping with RG 1.174, a licensee submittal to the NRC may or may not be risk-informed) at the licensee's option. If it is not risk informed, then the staff may choose to use an Estimated Risk **Method** or a Generic **Method** to determine risk in accordance with the review criteria of NUREG-1764. These methods will result in a proposed Level (I, II, or III) for the review. Qualitative screening is then applied to the proposed level to see if it needs to be adjusted. Alternatively, the staff may choose to perform a deterministic review without using the risk screening methodology. Also, using guidance provided in SRP Chapter 19 and NRC Regulatory Issue Summary 2001-02, "Guidance on Risk-Informed Decision Making in License Amendment Reviews", the staff may determine that "special circumstances" exist that could result in the staff requesting the license to submit risk information.

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Integrated Assessment of Human Actions Safety Significance. The integrated assessments of HA safety significance for non-risk-informed applications is similar to that for risk-informed applications, but simpler because there are fewer inputs to integrate.

C.1.3 Determine the Level of HFE Review.

Based on the quantitative and qualitative information available, the staff should classify the HA into one of three HFE review levels in accordance with the review criteria of NUREG-1764.

- Level I HAs, high risk, are reviewed using the criteria in Section C.2.1 below.
- Level II HAs, moderate risk, are reviewed using the criteria in Section C.2.2 below.
- Level III HAs, minimal risk, are reviewed using the criteria in Section C.2.3 below.

C.2 Phase II - HFE Review

C.2.1 Level I HFE Review

HAs in the high-risk category should be reviewed using the Level I review criteria provided below.

1. General Deterministic Review Criteria. The applicant should provide adequate assurance that deterministic aspects of design, such as whether the change meets current regulations, does not compromise defense-in-depth, and maintains sufficient safety margins, as discussed in RG 1.174, have been appropriately addressed. The staff should evaluate the deterministic aspects of the design in accordance with the review criteria of NUREG-1764.

2. Operating Experience Review. The applicant should identify and analyze HFE related problems and issues encountered previously in designs and human tasks that are similar to the planned modification so that issues that could potentially hinder human performance can be addressed. The OER should address the operating histories of plant systems, HAs, procedures, and HSI technologies related to the proposed changes to HAs. The staff's evaluation should be conducted in accordance with the review criteria of NUREG-1764.

3. Functional Requirements Analysis And Functional Allocation. The applicant should define any changes in the plant's safety functions (functional requirements analysis), and provide evidence that the allocation of functions between humans and automatic systems provides an acceptable role for plant personnel; i.e., the allocations take advantage of human strengths and avoid functions that would be negatively affected by human limitations (functional allocation). The staff's review should address all plant functions affected by the change in HAs, including changes to the functions and to their allocation between personnel and automatic systems in accordance with the review criteria of NUREG-1764.

4. Task Analysis. The applicant should identify the behavioral requirements of the tasks personnel are required to perform. The task analysis should form the basis for specifying the requirements for the HSI, procedures, and training. The task analyses should address HAs in their entirety, including all pertinent plant conditions, situational factors, and performance-shaping factors. While the primary focus is licensed operator tasks, tasks performed by other personnel (e.g.,emergency actions, maintenance, testing, inspection, and surveillance) that occur at the same time as the HAs and directly influence the actions are included in the task analysis. The staff should review the applicant's task analysis in accordance with the review criteria of NUREG-1764.

5. Staffing and Qualifications. The applicant should analyze the proposed change in HAs to determine the number and qualifications of personnel based on task requirements and applicable regulatory requirements. The analysis should addresses personnel requirements for all conditions in which the HA may be performed. The staffing and qualification review should be conducted in accordance with the review criteria of NUREG-1764.

6. Probabilistic Risk and Human Reliability Analysis. For risk-informed submittals, the applicant should (1) update the PRA model to reflect system, component, and HA changes that are necessary based on the proposed modification or HAs; (2) perform an analysis of the potential effects of the proposed changes upon plant safety and reliability, in a manner consistent with current, accepted PRA/HRA principles and practices, and (3) use the risk insights derived from the results in the selection of HAs and the development of procedures, HSI component lists, and training in order to limit risk and the likelihood of personnel error and to provide for error detection and recovery capability. The staff's HRA review should be conducted in accordance with the review criteria of NUREG-1764.

7. Human-System Interface Design. The applicant should translate function and task requirements into the detailed HSI design through the systematic application of HFE principles and criteria. The applicant's HSI design should be evaluated in accordance with the review criteria of NUREG-1764. The staff's review should address the design of temporary and permanent modifications to the HSI, including new HSI components and the modification of existing ones, for the proposed changes in the HAs. Where changes in HAs result in modifications to large portions of the HSI or in the use of HSI technologies that do not have proven operating histories, the review may also examine the HSI design process using the review criteria of NUREG-0711, Rev. 1. The review addresses aspects of the HSI and the work environment that affect the ability of the personnel to perform the HAs. The final design should be reviewed in accordance with the review criteria of NUREG-0700, as applicable.

8. Procedure Design. The applicant should modify applicable plant procedures and, where needed, provide guidance for the successful completion of the HAs. The procedures should adequately reflect changes in plant equipment and HAs. In the procedure development process, the applicant should apply HFE principles and criteria along with all other design requirements to develop procedure modifications that are technically accurate, comprehensive, explicit, easy to use, and validated. The applicant's procedure design should be evaluated in accordance with the review criteria of NUREG-1764.

9. Training Program Design. The applicant should develop and conduct adequate training for the HAs, including any changes in qualifications, as described in NRC Information Notice 97-78, "Crediting of Operation Actions In Place of Automatic Actions and Modification of Operator Actions, Including Response Times." The training program should include all licensed and non-licensed personnel who perform the changed HAs. The applicant's training program should be evaluated in accordance with the review criteria of NUREG-1764.

10. Human Factors Verification and Validation. The applicant should conduct V&V evaluations to (1) provide assurance that the HFE/HSI design provides all necessary alarms, displays, and controls to support plant personnel tasks (HSI task support verification); (2) provide assurance that the HFE/HSI design conforms to HFE principles, guidelines, and standards (HFE design verification); (3) provide adequate assurance that the HFE/HSI design can be effectively operated by personnel within all performance requirements applicable to the HA (integrated system validation); and (4) provide adequate assurance that the final product as built conforms to the verified and validated design that resulted from the HFE design process (final plant HFE/HSI design verification). The applicant's V&V should be evaluated in accordance with the review criteria of NUREG-1764.

11. Human Performance Monitoring Strategy. The applicant should have a human performance monitoring strategy to verify that no adverse safety degradation occurs because of the changes that are made, to provide adequate assurance that the conclusions that have been drawn from the evaluation remain valid over time, and to provide adequate assurance that personnel have maintained the skills necessary to accomplish the assumed actions. The applicant's human performance monitoring strategy should be evaluated in accordance with the review criteria of NUREG-1764.

C.2.2 Level II HFE Review –

HAs in the medium risk category should be reviewed using the Level II review criteria provided below.

1. General Deterministic Review Criteria. The applicant should provide adequate assurance that deterministic aspects of design, as discussed in RG 1.174, have been appropriately addressed. The staff should evaluate the deterministic aspects of the design, including that the change meets current regulations and does not compromise defense-in-depth, in accordance with the review criteria of NUREG-1764.

2. Analysis. The applicant should analyze the changes to the HA in terms of OER, functional and task analysis, and staffing and qualifications, and should identify HFE inputs for any modifications to the HSI, procedures, and training that may be necessary. The applicant's HFE analyses should be evaluated in accordance with the review criteria of NUREG-1764.

3. Design of HSIs, Procedures, and Training. The applicant should support the HA by appropriate modifications to the HSI, procedures, and training. The applicant's HSIs, procedures, and training design should be evaluated in accordance with the review criteria of NUREG-1764. Design modifications to the HSI should be reviewed in accordance with the review criteria of NUREG-0700.

4. Human Action Verification. The applicant should verify that the HA can be successfully accomplished with the modified HSI, procedures, and training. The applicant's verification should be evaluated in accordance with the review criteria of NUREG-1764.

C.2.3 Level III HFE Review

For an HA classified in third level, the staff review should verify that the action is, in fact, in Level III. Verification is accomplished by reviewing the licensee's analysis methods that show the placement of the action in that level. Typically no detailed HFE review is necessary. However, the staff may specify specific areas for review based on the results of the risk screening process.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

The NRC bases its HFE review on current regulatory requirements established in post-TMI orders and 10 CFR 50.34(f), "Additional TMI Related Requirements." The NRC reviews HFE aspects of new control rooms (post 1982) to verify that they reflect "state of the art human factors principles" as required by 10 CFR 50.34(f)(2)(iii) and that personnel performance is appropriately supported. For plants licensed under 10 CFR Part 52, the requirements of 10 CFR 50.34(f) are incorporated under 10 CFR 52.47 and 10 CFR 52.79. Meeting these requirements provides evidence that plant design, staffing, and operating practices acceptable and that plant safety will not be compromised by human error or deficiencies in human

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interfaces with hardware and software. In addition, the staff relies on the SRP and post TMI bulletins as guidance.

To support the review of an applicant's submittal for conformance to these 10 CFR requirements, the staff uses primarily three guidance documents: NUREG-0711, NUREG-0700, and NUREG-1764.

NUREG-0711 is (1) based upon currently accepted HFE practices, (2) well-defined, and (3) validated through experience with the development of complex, high-reliability systems in other industrial and military applications. The technical basis upon which the staff's HFE review guidance was developed was (1) general systems theory and engineering principles; (2) available NPP industry HFE guidance, standards, guidance, and recommended practices developed in the industry (e.g., IEC and IEEE); HFE guidance developed for complex systems in general (e.g., by groups such as DoD, NASA, and the Human Factors and Ergonomics Society). As part of the development process, the guidance and its associated technical reports were extensively reviewed by independent subject matter experts, professional organizations, and industry representatives. As a result the staff's guidance provides a technically valid basis upon which to review applicant HFE programs, processes, and designs.

NUREG-0711 identifies the important HFE elements in a system development, design, and evaluation process that are necessary and sufficient requisites to successful integration of human factors in complex systems. The review model also identifies aspects of each HFE element that are key to a safety review, and describes acceptance criteria by which the HFE elements can be evaluated. NUREG-0711 also serves as a technical basis for the review of ITAAC for plant HFE.

NUREG-0711 addresses the integration of HFE in the design process and was originally developed to support NRC reviews of submittals for certification of new plant designs under 10 CFR Part 52. However, because it updates the guidance of Appendix B of NUREG-0700, Revision 0, it should be used for HFE reviews of new plant designs licensed under both 10 CFR Part 50 and 10 CFR Part 52. Portions of NUREG-0711 should also be used, as appropriate, to support the NRC in its reviews of upgrades of current control rooms.

NRC guidance for a structured, top-down systems analysis of HFE was originally provided in NUREG-0700, Revision 0. This document provided a methodology for the review of existing control rooms. It recommended that additional analyses be conducted for new control rooms to optimize the allocation of functions to humans and machines and further examine advanced control system technologies. Appendix B of NUREG-0700, Revision 0, was provided as one source of guidance regarding these analyses.

NUREG-0700 now focuses on guidance for the review of plant HSIs. The guidance has been updated twice to reflect changes in HSI technologies.

NUREG-1764, addresses the human performance aspects of changes to HAs that are credited for safety, especially those involving changes in the licensing basis of the plant; e.g., use of manual action in place of an automatic action for safety system operations. Risk-informed guidance and acceptance criteria are provided for the review of licensee proposals addressing such modifications. The review method uses a graded, risk-informed approach and provides

guidance for reviewing the human performance aspects of changes to plant systems and operations. Three HFE review levels are defined: high, medium, and low risk (called Levels I, II, and III). HAs are reviewed using human factors engineering criteria to evaluate whether the proposed HA can be reliably performed when called upon in the plant. HAs in the high-risk level receive a detailed review and those in the medium-risk level receive a less detailed review that is commensurate with their risk. For HAs falling into the low isk level, minimal (or no) human factors review is performed.

Thus, the HFE review process presented in this SRP chapter incorporates guidance from all three documents.

III. REVIEW PROCEDURES

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The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

The applicant should submit review materials for each review area. RG 1.206 provides guidance to DC and COL applicants for submitting review materials. The material submitted will vary depending on the completion status of each review element. Information may be submitted as part of a Design Control Document (DCD) by a DC applicant, in an FSAR by a COL applicant, and/or in separate reports described below. These separate reports may be submitted to the NRC or referenced in licensing documents as discussed in RG 1.206. The reports that the applicant may submit include:

The general types of reports that the applicant may submit are described in NUREG-0711. These include:

1. Implementation Plan. This submittal describes the applicant's proposed methodology for meeting the acceptance criteria of a particular HFE review element. An implementation plan review gives the applicant the opportunity to obtain staff review of and concurrence in the applicant's approach before conducting the activities associated with the area. Such a review is desirable from the staff's perspective because it provides the opportunity to resolve methodological issues and provide input early in the analysis or design process when staff concerns can more easily be addressed than when the effort is completed. An early review also provides advantages to applicants by obtaining early approval for the methodology when staff concerns can be more easily and more cost effectively addressed.

2. Results Summary Report. This submittal describes the results of the applicant's efforts related to a particular HFE review area. The NRC staff use the report as the main source of information for assessing the applicant's efforts using the review criteria contained in this document.

It is not intended that submittals necessarily be provided as separate reports. Rather it is important that information on methodology and results be available to the reviewer. In some cases an applicant may choose to provide this information as part of a DCD or FSAR, in a single report or, in the case of license amendments, in the form of a safety analysis. It is also possible that, for more complex areas of review, such as HSI design or V&V, more than two reports may be submitted in order to address all review criteria. In addition to these reports, the reviewer may review sample work products (e.g., analyses and implemented designs).

In addition to the implementation plans and results summary reports, additional submittals are identified, where appropriate, in each HFE review area in NUREG-0711. The following are descriptions of special submittals and review considerations for specific areas of review:

1. HFE Program Management. The applicant should provide the following for staff review: HFE program plan describing the applicant's HFE goals/objectives, technical program to accomplish the objectives, a system to track HFE issues, the HFE design team numbers and their qualifications, and the management and organizational structure to allow the technical program to be accomplished.

2. Operating Experience Review. The reviewer may also audit the issue tracking system for examination of OER issue treatment.

3. Human Reliability Analysis. The reviewers should review the PRA/HRA report(s) to gain a better understanding of the analysis method and results.

4. Human-System Interface Design. Other design-related HSI documents may be reviewed, such as applicant-developed guidance documents, detailed trade-off studies, technology assessments, or test/experiment reports developed to support the HSI design. In addition, a variety of mockups, prototypes, or similar physical representations of the HSI design may be available for preliminary review of the design implementation.

5. Procedure Development. Generic technical guidelines and sample procedures should be available for review.

6. Verification and Validation. The HFE issues tracking system, described in NUREG-0711, should be reviewed. The actual HSI design or a high-fidelity prototype or simulator of the HSI should be available for the staff to examine in conjunction with the verification reviews. In addition, the staff may witness the integrated system validation evaluations. A documented description of the final HSI design that resulted from the HSI task support verification, HFE design verification, integrated system validation, and issue resolution verification activities should be reviewed. Finally, the installation of the completed design in the plant should be reviewed, if time and resources permit.

7. Human Performance Monitoring. Submittals for the staff's review of an applicant's human performance monitoring program should be made on a case-by-case basis.

8. ITAAC. For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 and its subsections. SRP Section 14.3 contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.

When determining the review material that should be submitted on the docket versus retained by the licensee for audit or review by NRC reviewers and inspectors, the key aspect is that the amount of information submitted on the docket must be sufficient to support the staff's safety determination. The degree to which the NRC staff applies the review methodology in this SRP will reflect the specific circumstances of individual applications. For example, the review of the HFE aspects of a new plant will entail a comprehensive, detailed evaluation, while the review of individual modifications to existing designs may be less extensive. The following elements are considered when deciding the depth of review.

- Risk importance
- The similarity of the associated HFE issues to those recently reviewed for other plants or similarity with previous approved designs

The determination of whether items of special or unique safety significance are involved That is, the final safety analysis report includes information at a level sufficient to enable the Commission to reach a final conclusion on all safety matters that must be resolved by the Commission before a COL is issued.

For a DC application there is some variability in the number and type of reviews conducted depending on the completion status of the HFE. A key determining factor for the review is the applicant's desired approval status for each of the 12 HFE elements in Section II.A previously cited. The elements could be approved at a programmatic level, at an implementation plan level, or at a completed element level. It is also possible that some elements may be partially, but not completely approved. The approval status for each element should be determined early in the review process since it affects the amount and type of material to be submitted by the applicant and reviewed by the NRC. Elements approved at the programmatic level typically would only require summary information in the DCD or Tier 2 information (information in the DCD that is approved but not certified). Elements approved at the implementation plan level would require summary information in the DCD and a more detailed implementation plan to be submitted on the docket. These implementation plans typically would become Tier 2* information (information in the DCD that is subject to NRC approval before it can be changed by an applicant or licensee). Completed elements would require summary information in the DCD and would also need a results summary report. In some cases the plans and results summary reports may be referenced (see RG 1.206 for the element by element discussion). SRP Section 14.3.9 contains a discussion of the DCD Tier 1 information (the portion of the DCD that is approved and certified).

The HFE reviewer may also need to review and close out COL action/information items that were identified in the final safety evaluation report for a design certification review and also documented in the DCD associated with the design certification. Submittals requesting the closure of these items may occur at various times post-DC. These items are mentioned in

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~~SRP Section 14.3.9.I. The review should be done in accordance with the wording of the COL item itself and will most likely require the review of a full or partial results summary report for a particular HFE element from NUREG-0711. As appropriate, the reviewer should use the acceptance criteria from the corresponding element of NUREG-0711, as amplified in Section II.A of this Chapter. There will also be HFE-related ITAAC that need closure at some time in the life cycle of a COL process. The closure process for these will be detailed in the NRC construction inspection program, and will also involve the use of the acceptance criteria from the corresponding element of NUREG-0711.~~

~~A new COL application that does not reference a DC will generally need to be complete, in that all elements should be fully addressed and reviewed by the staff. However, as noted in RG 1.206, the Design Implementation element will not be completed until the plant is constructed and the Human Performance Monitoring element, will continue after plant startup. For a COL application that references a DC, each element will have been addressed in the DC to some level of detail, as discussed previously. The COL application will then need to address, and the staff must review, any elements not already completed and certified. This may require review of an implementation plan and a results summary report, or just the results summary report.~~

~~For HFE reviews of control room modernizations, the staff's review should be tailored as described in Section II.B above. For HFE reviews of modifications that affect risk important human actions, the staff's review should be tailored as described in Section II.C above.~~

~~IV. EVALUATION FINDINGS~~

~~The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.~~

~~1. The reviewer's determination that all review criteria are satisfied, using the methods described in the SRP.~~

~~2. The reviewer's determination that alternative means of satisfying review criteria are acceptable.~~

- ~~3. The reviewer's determination that acceptable justification for deviations from review criteria exist. The justifications may be based upon such evidence~~

Generic Review Procedure\

1. Completion of the pre-acceptance and acceptance reviews

a. Office of New Reactors (NRO): Office instruction NRO-REG-104, "Pre-application Readiness Assessment" provides direction on the pre-acceptance review process. Office Instruction NRO-REG-100, "Acceptance Review Process for Design Certification and Combined License Applications," provides direction on the acceptance review process.

Office of Nuclear Reactor Regulation (NRR): Office Instruction NRR-LIC-109 addresses the Acceptance Process for operating licensee submittals.

b. Experience shows that this is a good time to read the documents, front to back, to ensure a general understanding of the material. If the reviewer encounters repetitive examples of poor sentence structure, incorrect referencing, spelling and grammar errors that all contribute to requiring the reviewer to interpret what is being said, then consider rejecting the submittal until the quality problems have been addressed.

c. Office of New Reactors: For design certification applications, "results summary reports" are preferred except for elements NUREG-0711 specifies as only needing an Implementation Plan (HFE program plan, Human Performance Monitoring). If the applicant chooses to defer the final HFE design in accordance with SECY 92-53, "Use of Design Acceptance Criteria during 10 CFR Part 52, Design Certification Reviews," the reviewer should verify a basis for using DAC has been provided and that it conforms to the SECY guidance. Additional direction on using DAC is provided in the section 2 below.

Office of Nuclear Reactor Regulation: For operating licensee submittals it is preferred that the content be results-oriented, with few, if any open items. If open items are necessary, they should be addressed in a formal commitment or a license condition (NRR-LIC-105). All twelve elements of NUREG-0711 should be addressed, or omissions justified.

2. Verification that the licensee/applicant is using an acceptable HFE design process.

a. An acceptable standard is described in NUREG-0711 or NUREG-1764. NUREG/CR-7190 also provides a review of human performance metrics used to measure workload, situational awareness, and teamwork. It provides a tool for evaluating the use of such metrics in applications (e.g., design certification) and proposed license amendments.

b. Each NUREG-0711 element lists the content of the associated "Results Summary Report." This list includes the methodologies of interest. Reviews should verify the methodology described is valid for the application in which it is used. The maturity of the design should dictate the reviewer's emphasis on methodology versus final design. Mature, complete designs typically call for a general review of the methodology and a detailed review of the design (using NUREG-0700). The evaluator may adjust the priority given to the method and the final HFE design reviews based on application specifics.

c. Design Certifications: Under a limited number of special conditions, the NRC accepts a detailed description of an HFE design process in lieu of a final design product. These conditions are identified in SECY-92-053, and are listed below:

- rapidly changing technology could cause the approved design to be obsolete prior to construction,
- as-built information (e.g., specific measurements) needed to complete the design is unavailable,
- as-procured information needed to complete the design is unavailable.

If an applicant proposes using this option, the staff will verify that at least one of these three conditions exists by reviewing the basis for the applicant's proposal and that the proposal is limited to the only those elements to which the condition applies

When DAC is applied, the HFE design process for the applicable element is submitted as an implementation plan. The reviewer evaluates this implementation plan against the acceptance criteria for the associated NUREG-0711 element. Reviewers should note that this review not only verifies method validity but also ensures the process is sufficiently detailed and measurable that there is reasonable assurance that the process will result in a safe design product. The implementation plan also establishes specific acceptance criteria for an ITAAC if it is decided that an ITAAC is needed.

d. The HFE reviews should include nonsafety-related HSIs for the following reasons:

- On integrated digital control systems, operators use the nonsafety-related control system if it is available for responding to plant events.
- Inconsistent HFE design between the nonsafety systems and the safety systems could potentially increase error rates. The operator would have to use a different, infrequently used configuration on the safety related components.
- Alarm systems and large screen displays are nonsafety-related systems providing significant input into command and control activities, event diagnostics, and operator situational awareness.
- Nonsafety systems and functions can divert the operator's attention.

3. Verification that the HFE design conforms to industry standards

a. An acceptable standard is described in NUREG-0700, "Human-System Interface Design Review Guidelines." If the Applicant/Licensee has incorporated the HFE design into a simulator or mockup, consideration should be given to conducting observations of the Simulator/mockup. Such observations provide for an efficient way to evaluate the design against the NUREG-0700 standards.

b. Verify the interfaces described in Section I have been properly coordinated. The following practices have proven effective for DC reviews:

- Contact the lead I&C reviewer and provide the HFE point of contact(s) for supporting the RG 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants" evaluation and the evaluation of manual actions credited in the diverse actuation system (DAS) design. The RG 1.97 parameters may also be significant inputs into the SPDS and large display panel designs. The DAS manual actions are contained in the Chapter 7 application. The HFE evaluator usually provides a safety evaluation input on these manual actions which is embedded in the Chapter 7 safety evaluation.

- Verify that the "important human actions" provided by the applicant are consistent with those identified in Chapter 15. This is typically done by reviewing the Chapter 15 application. If there are deviations subsequent actions should be coordinated through the Chapter 15 lead reviewer.

- If the Chapter 18 submittal provides a separate list of risk important human actions this list should be verified against the list in Chapter 19. Often the Chapter 18 submittal will reference the Chapter 19 list directly in which case no additional interface is necessary.

- The Chapter 18 safety evaluation related to the HFE design of the EOF and TSC should be sent to the lead reviewer for Chapter 13.3 for concurrence.

4. Verification that exemptions from regulations or alternate methods for complying with regulations have specific analyses that support them.

a. Verify that applicants/licensees clearly identify methods and practices that are different from what the acceptance criteria advocate as alternate methods/practices. Evaluate the alternative on its own merits. The applicant is expected to provide an evaluation of how the proposed alternative provides an acceptable method of compliance. The justifications may be based upon evidence such as analyses of recent literature, analyses of current practices and operational experience, tradeoff studies, and the results of engineering experiments and evaluations.

~~An overall review conclusion is determined by comparing the goals of the HFE review, which are based on the type and purpose of the HFE review, to the evidence provided in the applicant's submittals. Important considerations include:~~

~~1. Did the reviewer examine all relevant areas of review?~~

~~2. Did the reviewer evaluate each area of review at the appropriate level (e.g., program description level, implementation plan level, and completed area of review level)?~~

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~~3. Were the reviewer's findings for each area of review acceptable?~~

b. Exemptions are infrequent but challenging when they occur. Typically there is limited guidance available on determining the acceptability of the requests. Contacting HFE staff in other parts of the organization, particularly those in research, will help identify existing guidance and guidance under development that may be useful.

Minimum staffing appears to be the most imminent area where an exemption from 10 CFR 50.54(m) might be requested. The following NUREGs provide guidance in this area:

~~If the evidence provided by the review does not satisfy the goal of the HFE review, then additional analysis and design activities may be performed by the applicant to address the staff's concerns. These may include: (1) additional analysis and review for areas that have not been examined at the completed area of review level, (2) completion of the design or correction of design deficiencies identified through the review, and (3) appropriate testing or V&V.~~

~~For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.~~

~~In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.~~

~~V. IMPLEMENTATION~~

~~The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.~~

~~The methods described in this chapter will be used in evaluations of: (1) submittals in connection with applications for construction permits, design certifications, operating licenses, and combined licenses; (2) submittals from operating reactor licenses who voluntarily propose to initiate system modifications if there is a clear nexus between the proposed modifications and this guidance.~~

~~The provisions of this SRP section apply to reviews of applications submitted six months or more after the date of issuance of this SRP section, unless superseded by a later revision.~~

~~VI. REFERENCES~~

~~1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."~~

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2. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."
3. 10 CFR Part 55, "Operator's Licenses."

4. NUREG-0654, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants."

5. NUREG 0696, "Functional Criteria for Emergency Response Facilities."

6. NUREG 0700, Revision 2, "Human System Interface Design Review Guidelines."

7. NUREG-0711, Revision 2, "Human Factors Engineering Program Review Model."

8. NUREG-0737 and Supplement 1, "Clarification of TMI Action Plan Requirements."

9. NUREG-0835, "Human Factors Acceptance Criteria for the Safety Parameter Display System."

10. NUREG-1342, "A Status Report Regarding Industry Implementation of Safety Parameter Display Systems."

11. NUREG-1764, "1791, "Guidance for the Review of Changes to Human Actions."

- 12. NUREG-1791, "Guidelines for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operating StaffOperator Staffing Requirements Specified in 10 CFR 50.54(m) – Final Report")"

13. NUREG/CR-2300, "PRA Procedures Guide: A Guide to the Performance of Probabilistic Risk Assessments for Nuclear Power Plants."

14. NUREG/CR-2815, "Probabilistic Safety Analysis NUREG/CR-6838, "Procedures Guide."

15. NUREG/CR 3485, "PRA Review Manual."

- 16. NUREG/CR-6838, "Technical Basis for Regulatory Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)")"

Appendix B provides additional guidance on evaluating workload In support of staffing level reviews.

5. Verification that HFE design effectiveness has been demonstrated in a performance based integrated system validation test.

a. The human system interface is subjective due to the potential for human error and is therefore difficult to describe via codes, calculations, and physical properties as

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would be done for electrical/mechanical systems. Therefore an integrated system validation (ISV) is used to validate the design effectiveness. Where feasible the ISV should be subject to an inspection or audit to verify the HFE design supports the operator actions being credited in the licensing documentation.

b. Because of the ISV's dependence on operator programs (procedures, training), the ISV may sometimes be submitted at the implementation plan level with performance of the ISV tracked as an ITAAC under the guidance of SECY 92-053. In this case the implementation plan must contain specific acceptance criteria describing how the ISV will be performed. The acceptance criteria should be identified as Tier 2* information.

c. In the case of operating reactors, the ISV must be complete prior to implementation of the proposed action or program. In the rare cases when this cannot be done, such as when the simulator upgrade is not yet complete, acceptance or approval may be based on a smaller scale "preliminary" ISV and a license condition that states that the full-scale ISV will be completed and provided to the NRC staff by a specific date.

V. EVALUATION OF FINDINGS

The reviewer verifies that the applicant has provided sufficient information and calculations (if applicable) to support their conclusions. The reviewer also states the bases for their conclusions. Conclusions of the following type should be included in the staff's SER.

1. The reviewer's determination that all review criteria are satisfied, using the methods described in the SRP.

2. The reviewer's determination that alternative means of satisfying review criteria are acceptable.

3. The reviewer's determination that acceptable justification for deviations from review criteria exist.

4. Documentation of findings:

   The evaluation for each acceptance criterion typically has three parts. The first part summarizes what the submittal says and where that information is located. The second part explains how this information conforms to the acceptance criteria. The third part provides a summary conclusion that the acceptance criterion is met. Consider the following lessons learned as these parts are written:

   - Use the word "requirement" only when referring to the *Code of Federal Regulations*. Use specification, acceptance criterion, guidance, direction, limit or other appropriate word when referring to other sources of direction.

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- Within the SER, ensure the staff evaluation is clearly distinguishable from the submittal information summary.

- Write requests for additional information (RAIs) in parallel with writing the draft SER. This ensures a tight connection with the regulatory basis and minimizes sequential RAIs.

- Consider using audits to review the style guide, scenarios, supporting procedures, and operating simulators. The audit can often provide the additional detail needed to understand documents that have been submitted and facilitates the communication between applicant/licensee and the staff on what information needs to be docketed.

- When determining the review material that should be submitted on the docket versus retained by the licensee for audit or review by NRC reviewers and inspectors, the key aspect is that the amount of information submitted on the docket must be sufficient to support the staff's safety determination. That is, the submittal (e.g., design certification, final safety analysis report, proposed technical specification revision, license amendment) includes information at a level sufficient to enable the Commission to reach a final conclusion on all safety matters.

- Ensure that the rationale for the staff conclusion is explained clearly.

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VI. ~~17. NUREG/CR-6400, "HFE Insights for Advanced Reactors Based Upon Operating Experience."~~

~~18. Regulatory Guide 1.9, "Selection, Design, Qualification, and Testing of Emergency Diesel Generation Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants."~~

~~19. Regulatory Guide 1.22, "Periodic Testing of Protection System Actuation Functions."~~

~~20. Regulatory Guide 1.47, "Bypassed and Inoperable Status Indication for NPP Safety Systems."~~

~~21. Regulatory Guide 1.62, "Manual Initiation of Protective Actions."~~
~~22. Regulatory Guide 1.81, "Shared Emergency and Shutdown Electrical Systems for Multi-Unit NPPs."~~

~~23. Regulatory Guide 1.97, "~~IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants.” Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission’s regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

VII. REFERENCES

1. Nuclear Energy Institute, NEI 96-07, "Guidelines for 10 CFR 50.59 Implementation."

2. *U.S. Code of Federal Regulations*, "Domestic Licensing of Production and Utilization Facilities," Part 50, Chapter 1, Title 10, "Energy."

3. *U.S. Code of Federal Regulations*, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Part 52, Chapter 1, Title 10, "Energy."

4. U.S. Nuclear Regulatory Commission, "Crediting of Operator Action In Place of Automatic Actions and Modification of Operator Actions, Including Response Times," Information Notice 97-78.

5. U.S. Nuclear Regulatory Commission, "Functional Criteria for Emergency Response Facilities," NUREG-0696.

6. U.S. Nuclear Regulatory Commission, "Human-System Interface Design Review Guidelines," NUREG-0700, Revision 2.

7. U.S. Nuclear Regulatory Commission, Revision 3, "Human Factors Engineering Program Review Model,"

8. U.S. Nuclear Regulatory Commission, "Training Review Criteria and Procedures." NUREG-1220, Revision 1,

9. U.S. Nuclear Regulatory Commission, "Guidance for the Review of Changes to Human Actions," NUREG-1764, Revision 1.

10. U.S. Nuclear Regulatory Commission, "Guidelines for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operating Staff Requirements Specified in 10 CFR 50.54(m) - Final Report," NUREG-1791.

11. U.S. Nuclear Regulatory Commission, "Workload, Situation Awareness, and Teamwork," NUREG/CR-7190.

12. U.S. Nuclear Regulatory Commission, "Technical Basis for Regulatory Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," NUREG/CR-6838.

13. U.S. Nuclear Regulatory Commission, "Instrumentation for Light-Water-Cooled Nuclear Power Plants To Assess Plant and Environmental Conditions During and Following an Accident~~."~~," Regulatory Guide 1.97.

~~24. U.S. Nuclear~~ Regulatory ~~Guide 1.105, "Instrumentation Setpoints."~~

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14. ~~25. Regulatory Guide 1.174, "~~Commission, "An Approach to Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis~~."~~," Regulatory Guide 1.174.

~~26.~~ U.S. Nuclear Regulatory ~~Guide 1.177, "An Approach for Plant-Specific, Risk-Informed Decision Making: Technical Specifications."~~

15. ~~27. Regulatory Guide 1.187, "~~Commission, "Guidance for Implementation of 10 CFR 50.59, Changes, Tests, and Experiments~~."~~," Regulatory Guide 1.187.

~~28.~~ U.S. Nuclear Regulatory ~~Guide 1.206,~~ Commission, "Combined License Application for Nuclear Power Plants" (LWR Edition~~) - currently DG-1145.~~

~~30. Information Notice 95-48, "Results of Shift Staffing Study."~~

~~31. Information Notice 97-78, "Crediting of Operator Action In Place of Automatic Actions and Modification of Operator Actions, Including Response Times."~~

16. ~~32. NRC),~~ Regulatory ~~Issue Summary 2001-02, "Guidance on Risk-Informed Decision Making in License Amendment Reviews."~~Guide 1.206.

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Attachment A

Guidance for Evaluating Credited Manual Operator Actions

INTRODUCTION

This attachment defines a methodology, applicable to both existing and new reactors, for evaluating manual operator actions. This attachment incorporates, with limited changes, the guidance in Section 3 of Digital Instrumentation and Control (DI&C) Interim Staff Guidance (ISG), DI&C-ISG-05, Revision 1, "Highly Integrated Control Rooms—Human Factors Issues." It has been generalized to apply to any manual operator action.

BACKGROUND

This procedure provides generic guidance for reviewing credited manual operator actions. For some applications additional specific guidance is available. These sources are listed below. In general the more immediate the need for an operator action the more detailed the evaluation of the action will be. No time limit has been established beyond which an operator action need not be evaluated because of the diversity of conditions that can potentially affect the successful accomplishment of operator actions.

STAFF POSITION

Credited operator actions should be demonstrated to be both feasible and reliable, given the time available, and that the ability of operators to perform credited actions reliably will be maintained for as long as the manual actions are necessary to satisfy the analysis assumptions. The time available for manual actions should be based upon the methods and criteria prescribed within the analysis crediting the operator action. The time required for the operator action should be estimated and validated using the guidance of this attachment. To demonstrate that the manual actions are both feasible and reliable, and that the ability to perform the actions reliably within the time available is maintained, the vendor/ licensee/applicant should follow a process of analysis, validation, and long-term monitoring consistent with this attachment.

Important human actions as defined by NUREG-0711, "Human Factors Engineering Program Review Model," and their associated interfaces (controls, displays, and alarms) should be specifically addressed in the applicant/licensee's HFE Program related submittals.

PHASE 1: ANALYSIS

This section describes the attributes of an acceptable method of analyzing the time available and time required for manual operator actions that are to be credited in an event analysis.

1.A. Method

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The analysis must demonstrate that:

- the time available to perform the required manual actions is greater than the time required for the operator(s) to perform the actions.

- the operator(s) can perform the actions correctly and reliably in the time available. The time available to perform the actions should be based on analysis of the plant response to the event of concern. The time required for operator action should be based on an HFE analysis of operator response time. The basis of the documented sequence of operator actions can be task analysis, vendor-provided generic technical guidelines for emergency operating procedure development, or plant- specific EOPs, depending on the maturity of the design. The documented sequence of operator actions should be analyzed at a level of detail necessary to identify critical elements of the actions and performance shaping factors (e.g., workload, time pressure) that affect time required and likelihood of successful completion of the action sequence. The licensee/applicant should establish time estimates for individual task components (e.g., acknowledging an alarm, selecting a procedure, verifying that a valve is open, starting a pump) and the basis for the estimates, through a method applicable to the human-system interface (HSI) characteristics of the control system. The vendor/licensee/applicant should also provide a statement as to how elements such as diagnostics, communications, travel time, and work environment affect the time required for the action.

Acceptable methods for deriving time estimates for individual task components include, but are not limited to:

- Operator interviews and surveys
- Operating experience reviews
- Software models of human behavior, such as task network modeling
- Use of control/display mockups
- Expert panel elicitation[2]
- American National Standards Institute (ANSI)/ American National Standards (ANS) 58.8, "Time Response Design Criteria for Safety-Related Operator Actions"[3]

Methods that are dependent on expert judgment to derive time estimates for task components are potentially subject to bias. In addition, the uncertainties associated with estimates derived through these methods are difficult to quantify. Accordingly, these methods should be employed using structured approaches that minimize bias and help identify and assess

[2] For an example of an expert panel elicitation, see NUREG-1852, "Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire."

[3] ANSI/ANS 58.8, "Time Response Design Criteria for Safety-Related Operator Actions," provides an acceptable task decomposition methodology for this purpose. However, the time intervals described in ANSI/ANS 58.8 were validated using analog controls and; therefore, may not be accurate for this application.

uncertainties (see example: NUREG/CR-6372, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," or "Eliciting and Analyzing Expert Judgment: A Practical Guide, Cambridge University Press," 1991).

Prior experience with tasks or subtasks similar to the actions proposed to be credited in the analysis may provide valuable insights for the analysis/estimates of operator response times. Operating experience data used to provide input to the analysis/estimates of operator response times should be supplemented with information about the similarities and differences between the credited actions and the actions identified in the operating experience.

A time margin should exist between the analyzed time(s) as the difference between time available and time required for operator action is a measure of the safety margin and as it decreases, uncertainty in the estimate of the difference between these times should be appropriately considered. This uncertainty could reduce the level of assurance and potentially invalidate a conclusion that operators can perform the action reliably within the time available. One acceptable method is for the time margin to equal the maximum recovery time for any single credible[4] operator error. The basis for the specific time margin used in the analysis should be justified and documented. Insights from the HFE program, especially the OER and human reliability analysis, should be used. The identification of potential errors, error detection methods, and error recovery paths in event trees may be used to provide estimates of how much margin should be added to the operator response time estimates. For complex situations and for actions with limited margin, such as less than 30 minutes between time available and time required, a more focused staff review will be performed.

1.B. Review Criteria

The responsible reviewers evaluate licensee/applicant's submittals for compliance with the following criteria:

- An analysis establishes the time available. The basis for the time available is documented.
- The analysis of the time required is based on a documented sequence of operator actions. The basis of the documented sequence of operator actions can be task analysis, vendor-provided generic technical guidelines for emergency operating procedure development, or plant-specific EOPs, depending on the maturity of the design.
- Techniques to minimize bias are used when estimates of time required are derived using methods that are dependent on expert judgment. Uncertainties in the analysis of time required are identified and assessed.
- The sequence of actions uses only alarms, controls, displays and equipment that would be available and functional during the subject event(s). The event and the

[4] As used here, credible operator errors are any errors of omission or commission that are plausible considering applicable operating experience and a human reliability analysis for the task.

regulatory guidance for analyzing the event typically define the alarms, controls, displays and equipment that remain functional.

- The estimated time available for operators to complete the credited action is sufficient to allow successful execution of applicable steps in the symptom/function-based EOPs or other procedural guidance[5]

- The initial MCR operating staff size and composition assumed for the analysis of time required is the same as the minimum MCR staff defined in the plant's Technical Specifications.

- If credited manual actions require additional operators beyond the Technical Specification minimum crew, the justification for timely availability of the additional staffing is provided and the estimate of time required includes any time needed for calling in additional personnel.

- The analysis of the action sequence is conducted at a level of detail sufficient to identify individual task components, including cognitive elements such as diagnosis and selection of appropriate response, and the associated performance shaping factors that affect time required and the potential for operator error. Communications, travel time, and work environment are addressed.

- The analysis identifies a time margin between the time required and time available to perform the action and documents the basis for the adequacy of the margin, including consideration of the uncertainty in the estimation of the margin.

PHASE 2: PRELIMINARY VALIDATION

This section describes the attributes of an acceptable method for preliminarily validating the time required for credited manual operator actions.

Note: Licensees upgrading existing operating plants may skip this phase and go directly to Phase 3, integrated system validation (ISV). A preliminary validation is only required for those vendors/applicants who are using the 10 CFR Part 52 process and as a result, may not have achieved the level of design development necessary to validate the operator manual actions by conducting an ISV prior to the time the staff must issue a safety evaluation applicable to the analysis.

2.A. Method

The preliminary validation should provide independent confirmation of the validity of the "time required" estimate derived in the Phase 1 analysis through the use of methods such as the following:

[5] The Phase 1 analysis may be conducted using a task sequence based on task analysis, vendor-provided generic technical guidelines for emergency operating procedure development, or plant-specific EOPs, depending on the maturity of the design. Accordingly, it is recognized that it will not be possible in all circumstances to directly assess time available relative to this criterion during the Phase 1 analysis.

- Tabletop analysis
- Walkthrough/talkthrough analysis
- Software models of human behavior, such as task network modeling
- Use of control/display mockups
- Man-in-the-loop prototype testing
- Pilot testing
- Real-time validation on a suitable[6] part-task simulator

Note: The preceding list is not all-inclusive – other validation methods may be used if sufficient technical justification is provided.

As the difference between time available and time required for operator action decreases, the importance of reducing uncertainty and minimizing potential bias in the estimates increases. Accordingly, the vendor/applicant should use several diverse methods to estimate operator response times to maximize the cross-validation value of the methods (i.e., minimize the potential for bias and reduce sources of uncertainty in the estimates of operator response times). For example, when the design has advanced to the point where a part-task simulator is available, the vendor/applicant should use it to cross-validate previous time estimates derived from other activities, such as expert elicitation, tabletop analysis, or walkthrough/talk through. It is expected that the vendor/applicant will estimate operator response time using as realistic an environment as is available at the time of the preliminary validation.

The group of individuals who conduct the preliminary validation of the analysis should not include individuals who conducted the analysis. Independence between these groups will help to ensure that any undocumented assumptions and analytical methods used in the analysis are identified and documented during the preliminary validation. However, it is recognized that communication between the groups will be necessary, especially after the preliminary validation is complete. The processes of validation and design are iterative and feedback from the preliminary validation should be used to refine the design, the procedures, and the training provided to the operators.

The preliminary validation should be rigorous and conducted by operators, system technical experts, and human factors experts. These personnel should verify that the analysis is logical for its purpose, contains a sufficient level of detail, and that the analyzed action sequence presents no physical or spatial difficulty for performance. The language and the level of information presented in the documented sequence of manual operator actions should be compatible with the minimum number, qualifications, training, and experience of the operating staff.

Operators and system technical experts should ensure that the documented sequence of manual operator actions, independent of the time required, is technically correct and will achieve the desired technical result(s). These personnel should verify the documented sequence of manual operator actions is supported by the existing or planned displays and

[6] A suitable part-task simulator is one of demonstrated scope and fidelity sufficient for the conduct of the specific validation.

controls to be used by the operator. Walkthrough/talkthrough of planned displays and controls for new plants should be conducted to the extent practical, according to the state of the design and supplemented as necessary by use of such aids as arrangement diagrams, vendor drawings, and panel fabrication drawings.

Results should be documented for NRC review. Preliminary validation results should be such that there is high confidence that the time required for manual operator actions will satisfy the success criteria for the integrated system validation described below. Unacceptable preliminary validation results should result in modification of the design strategy. If successful manual actions cannot be achieved, automation should be considered.

When the vendor/applicant believes that the analysis provides high confidence that the time required for operator action will satisfy the success criteria for integrated systems validation, the complete analysis, which provides time available and time required, and the supporting analyses, is submitted for NRC review. This analysis will be submitted as part of the supporting justification for a DC, DC amendment, COL application, or license amendment. When the NRC reviewers have high confidence that the manual operator actions will be accomplished correctly, reliably, and within the time available, the NRC staff will make a safety determination as part of the Safety Evaluation Report (SER) on the associated licensing action. Acceptable implementation shall be verified through completion of specified ITAAC or License Conditions.

2.B. Review Criteria

The responsible reviewers evaluate vendor/applicant's submittals for compliance with the following criteria:

- The preliminary validation is conducted as an independent confirmation of the Phase 1 analysis that compared time available and estimated time required to complete the action.
- The preliminary validation is conducted by a multi-disciplinary team with the knowledge and skills necessary to verify the rigor and assumptions of the analysis and validate the analysis conclusions regarding the ability of operators to perform the actions reliably within the time available.
- The preliminary validation uses methods appropriate to assessing time required for the task. For complex situations and for actions with limited margin, such as less than 30 minutes between time available and time required, the preliminary validation uses two or more methods to validate the analysis.

The preliminary validation results support the conclusion that the time required, including margin, to perform individual steps and the overall documented sequence of manual operator actions is reasonable, realistic, repeatable, and bounded by the Phase 1 analysis documentation.[7]

[7] The preliminary validation results should provide high confidence that the performance time criteria will be met in the Phase 3,

Note: As the difference between time available and time required for operator action decreases, there is increasing potential that uncertainty in the estimate of difference between these times will invalidate a conclusion that operators can perform the actions reliably within the time available.

PHASE 3: INTEGRATED SYSTEM VALIDATION

This section describes the attributes of an acceptable method for conducting an ISV of manual operator actions that are to be credited in a defense-in-depth analysis.

3.A. Method

ISV is an evaluation using performance-based tests to determine whether an integrated system design (i.e., hardware, software, procedures, training, staffing and qualification, and physical environment) meets performance requirements and acceptably supports safe operation of the plant. The licensee/applicant should conduct an ISV of credited manual actions using a plant-referenced simulator in real time. Using the validation guidance in NUREG-0711, the licensee/applicant should measure operator response times (performance times) of all operating crews in representative event simulations. Performance times should be compared to the time available (per the event analysis results) and previous estimates of time required.

In selecting personnel for event simulations, consideration should be given to the assembly of both nominal and minimum crew configurations, including shift supervisors, reactor operators, shift technical advisors, etc., that will participate in the validation tests. The composition of operations personnel need only include personnel who are relevant to the credited actions.

Acceptable validation results will provide the basis for meeting the NRC's design certification, license application or amendment request approval requirements. Unacceptable validation results will require modification of the design strategy.

Modification of the design strategy would require reanalysis, re-validation and re-submittal for NRC staff review. If a successful manual action strategy cannot be achieved, automation should be considered.

The ISV shall be implemented and documented as an ITAAC item or License Condition for plants licensed under 10 CFR Part 52 or as a License Condition for operating plants that have not upgraded the plant-referenced simulator in advance of the control room modifications. The complete analysis, which provides time available and time required, the supporting analyses and validation results shall be submitted to the NRC for verification that the credited manual action supports the design assumptions.

3.B. Review Criteria

ISV. Unacceptable ISV results will require modification of the defense-in-depth coping strategy late in the design and licensing process.

- The responsible reviewers evaluate vendor/licensee/applicant's submittals for compliance with the following criteria:

General

- The ISV is completed as part of the HFE program that is implemented in accordance with NUREG-0711.

Simulator

- The ISV is conducted using a plant-referenced simulator that meets the functional and fidelity requirements of the adopted ANSI/ANS 3.5, "Nuclear Power Plant Simulators for Use in Operator Training and Examination," and is capable of real time, high fidelity plant simulation of the event in which the operator manual action is credited.

Local Control Panels and Plant Equipment

- If operator action is required outside the control room, these actions are validated on the actual equipment or an accurate reproduction or mockup of the equipment.

- Communication with the control room, travel time, harsh environment impacts, lighting, security measures, and supporting equipment are addressed within the validation scenario. The event analysis may contain other variables that should be considered (i.e., loss of power, access restrictions). These variables and their impact on operator performance are addressed.

Personnel

- Participants in the validation are the plant personnel who would normally perform the actions.

- Actions to be performed by licensed operators are validated using individuals holding a current operating license for the unit on which the actions are to be credited. For vendor/applicants using the 10 CFR Part 52 process for a design for which there are currently no licensed operators, the crews may be composed of individuals who hold or have held an NRC-issued license to operate a commercial nuclear reactor of the same type (i.e., pressurized water reactor or boiling water reactor) for which the design is being validated.

- Actions allocated to non-licensed operators are validated using non-licensed personnel trained in accordance with a program that meets the requirements of 10 CFR 50.120.

- The MCR operating staff size and composition used in the event simulations are the same as was used for the analysis and preliminary validation.

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- All crews are included as part of the ISV. For vendor/applicants using the 10 CFR Part 52 process the minimum number of crews should be established in accordance with the guidance of NUREG-0711 (e.g., as specified in the vendor's/applicant's NRC- approved integrated system validation implementation plan).

Procedures

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- The manual operator actions to be credited in the event analysis are directed by procedure steps included within procedures and executed from the MCR.

Operational Conditions

Performance Times

- For each manual action, the mean performance time of the crews is less than or equal to the estimated time required derived from the analysis phase.

- For each manual action, the performance time for each crew, including margin determined in the time required analysis, is less than the analyzed time available.

PHASE 4: MAINTAINING LONG-TERM INTEGRITY OF CREDITED MANUAL ACTIONS

4.A. Method

Among other factors, changes in plant design, procedures, and operator training can affect the ability of operators to correctly and reliably perform manual actions. Accordingly, the licensee/applicant should establish a strategy for long-term monitoring of operator ability to reliably perform the manual operator actions credited in an event analysis. The scope of the performance monitoring strategy should provide adequate assurance that integrated system performance will be maintained within the bounds established by the ISV and continue to support the associated event analysis.

There is no expectation for the licensee/applicant to periodically repeat the full ISV; however, there should be sufficient controls to provide reasonable confidence that operators will maintain the skills necessary to accomplish the credited actions. The results of the monitoring need not be reported to the NRC, but should be retained onsite for inspection.

Consistent with 10 CFR Part 50, Appendix B, Criterion III, "Design Control," Criterion V, "Instructions, Procedures and Drawings," and Criterion VI, "Document Control," the vendor/licensee/applicant should have in place sufficient configuration and design controls to assure that procedure steps that direct the credited action are administratively protected from inadvertent change, and that the design program has sufficient controls to assure that the design will continue to support the event analysis when the plant or MCR is modified.

Consistent with 10 CFR Part 50, Appendix B, Criterion II, "Quality Assurance Program," in addition to the operations organization, training also should be provided to design personnel for the purpose of understanding the critical link between manual operator actions performed in

response to an event and the plant equipment used to implement these actions. Instructors should ensure that trainees understand the philosophy behind the approach of the procedures.

Consistent with 10 CFR Part 50, Appendix B, Criterion III, "Design Control," and Criterion XVI, "Corrective Action," long-term monitoring should have a formal mechanism for feedback such that results, including problems identified by the operating staff during operations or training, are brought to the attention of the reference plant operations department management and the design organization. The licensee/applicant may integrate, or coordinate, their long-term monitoring with existing programs for monitoring operator performance, such as periodic operator surveys or the licensed operator training program.

4.B. Review Criteria

The responsible reviewers evaluate licensee/applicant's submittals for compliance with the following criteria:

- A long-term monitoring strategy is developed and documented by the vendor/licensee/applicant that is capable of tracking performance of the manual operator actions to demonstrate that performance continues to support the associated event analysis.
- The program is structured such that corrective actions are formal, effective, and timely.

Rationale

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Guidance for HFE analyses that would be suitable to support the event analyses is described in NUREG-0711. The NRC staff has a high degree of confidence that a licensee/applicant using the NUREG-0711 model will provide adequate HSI design to allow operators to accomplish the manual actions required by their designs. However, the typical HFE Program per NUREG-0711 does not conclude until just before fuel load or startup. This attachment provides guidance for a methodology that provides early feedback in the design and regulatory review process and allows the licensee/applicant to move forward with relative confidence that credited manual operator actions will be demonstrated as both feasible and reliable in the ISV. Ultimately, the ability to reliably perform credited manual operator actions will be verified through completion of ITAAC or License Conditions related to the actions credited in the defense-in-depth analyses. Furthermore, the ability to reliably perform the credited manual actions within the time available shall be maintained through a long-term monitoring strategy.

Additional Resources

- Manual actions associated with Common cause failure of I&C software
  - Branch Technical Position (BTP) 7-19, "Guidance for Evaluation of Diversity and Defense-in-Depth in Digital Computer-Based Instrumentation and Control Systems."
  - DI&C ISG-02, "Diversity and Defense-in-Depth Issues."

- DI&C-ISG-05, "Task Working Group #5: Highly-Integrated Control Rooms — Human Factors Issues."

- Manual actions associated with Fires
  - NUREG-1852: Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire.
  - Manual actions associated with protective actions
  - Regulatory Guide 1.62: Manual Initiation of Protective Actions.

Attachment B

Methodology to Assess the Workload of Challenging Operational Conditions In Support of Minimum Staffing Level Reviews

The following material in extracted from Brookhaven National Laboratory (BNL) Technical Report No. 20918-1-2015. This report is available on the U.S. Nuclear Regulatory Commission (NRC) public web site within the Agencywide Documents Access & Management System (ADAMS) public document subdirectory under Accession No. ML15083A205.

INTRODUCTION

This attachment provides a methodology to identify high-workload operational conditions and analyze the workload associated with them. The methodology is rooted in task analysis and relies on the identification of appropriate challenging scenarios, realistic portrayals of task performance that is complicated by separate, but often necessary, dependent and independent tasks, and the judgment of subject matter experts (SME) obtained in a manner conducive to obtaining realistic workload estimation.

BACKGROUND

Plant personnel play a diverse role in plant operations and safety. They monitor plant systems and performance and various barriers that prevent release of radioactive material. They take actions to initiate, adjust, and terminate operations as needed. They also respond to transients, accidents, and other failures. They also are responsible for managing operations-related administrative duties. Personnel are supported in these tasks by human-system interfaces (HSIs), procedures, and training. To accomplish their responsibilities, personnel work in teams.

The minimum number of operators needed to fulfill all personnel roles and responsibilities is a complex question that depends on assumptions related to what the credible high-workload scenarios will be and the timeline along which additional staff are needed and available. Licensees establish a minimum staffing level to address immediate and “short-term” actions that need to be taken and the time required to augment the staff with additional personnel as needed over time.

The focus of this Appendix is the minimum staffing level needed to address immediate and short-term actions. Scenarios that evolve slowly and within time envelopes required to bring in additional staff are easier to address from a staffing perspective.

The U.S. Nuclear Regulatory Commission (NRC) has established minimum acceptable staffing levels in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.54(m). However, technological advances and changes in the Conduct of Operations have led to an interest in staffing levels below those specified in the regulations. To evaluate applicant requests for staffing exemptions that allow for reduced staffing levels, the NRC review needs criteria by which these requests can be evaluated.

A top priority criterion is task performance. An acceptable minimum staffing level is one that can successfully accomplish the most demanding tasks, under conditions that reflect real-world challenges including the demands of multi-tasking. Tasks have to be performed accurately and on time, so that overall plant operational and safety goals can be achieved. Successful task performance is the main criterion for evaluating a proposed staffing level. That is, if the crew at the minimal staffing level cannot perform their tasks, the staffing level is not acceptable. However, while task performance is an important acceptance criterion, it's not the only one.

Crew task performance can be negatively impacted by many factors and some of these factors need to be considered as well. One of the factors that can negatively impact a crew's ability to accomplish their tasks is workload. High workload can delay a task's performance until it is too late or cause a task to be missed altogether. Even when tasks are performed accurately and on time, high workload causes performance to be "fragile," in that there may be little or no margin for dealing with added complications. If additional complications are encountered, the workload level may rise to the point where task performance is negatively impacted. Thus it's important to know that not only is task performance acceptable, but workload levels are not excessive.

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In addition to workload, there are other factors that impact task performance. For example, failure to properly monitor the plant, or inattention, can also cause tasks to be delayed or overlooked. This condition is sometimes caused by "underload," i.e., insufficient workload. Insufficient workload is a concern in highly automated plants where the operator's primary role is monitoring and supervisory control. Operators perform best when workload is neither too high nor too low.

Another factor impacting task performance is situation awareness. A crew may not perform a task accurately and on time because they have a misunderstanding of the current plant state. In this case they may not perform the necessary tasks because they do know they need to be done. Poor situation awareness can result from high workload because the workload does not provide staff with the time necessary to maintain accurate situation awareness.

High workload, inattention, and poor SA are examples of the factors that can lead to poor task performance and hence should be considered in staffing evaluations. NUREG-7190 provides additional information on analysis methods for these factors.

This appendix supplements the guidance in NUREG-0800, NUREG-0711 and NUREG-1791 and is primarily focused on methods to assess workload during the task analysis phase of HFE design. The task analysis results, in turn, support the staffing and qualification analysis.

METHODOLOGY TO ASSESS THE WORKLOAD OF CHALLENGING OPERATIONAL CONDITIONS

The methodology to assess workload of challenging operational conditions is divided into seven steps, see Figure 1. Each of these steps is described below:

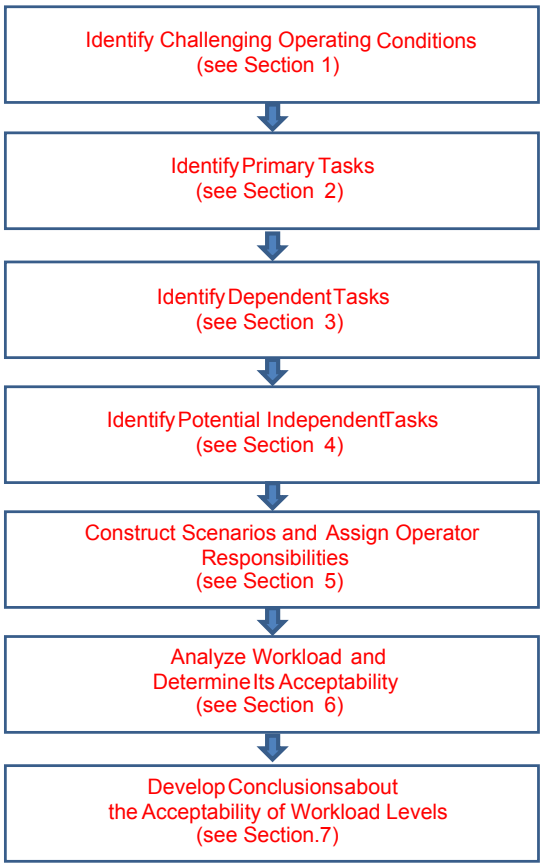

Figure 1: Methodology to assess the workload of challenging operational conditions

1. Identify Challenging Operating Conditions

The applicant should identify the plant specific operating conditions that are challenging and create high workload using the considerations presented below. Unlike integrated system validation scenario development where all operational conditions identified in the sample are addressed in a scenario, this activity should be focused on identifying conditions that most challenge the minimum staffing level. The objective of identifying these conditions is the

evaluation of the minimum staffing level needed to address immediate and short-term actions. Scenarios that evolve slowly and within time envelopes required to bring in additional staff are easier to address from a staffing perspective.

The applicant should consider the following plant conditions, personnel tasks, and situational factors in their sample of challenging conditions for workload analysis.

a. Plant Conditions

- Consider transients and accidents starting during normal operations, plant startup, shutdown, and refueling
- Consider instrumentation and control (I&C) and HSI failures and degraded conditions that encompass:
  - The I&C system, including the sensor, monitoring, automation and control, and communications subsystems
  - common cause failure of the I&C system during a design basis accident (as defined by Branch Technical Position (BTP) 7-19)
  - HSIs including, loss of processing or display capabilities for alarms, displays, controls, and computer-based procedures
  - Consider transients and accidents, such as:
  - transients (e.g., turbine trip, loss of off-site power, station blackout, loss of all feedwater, loss of service water, loss of power to selected buses or main control room (MCR) power supplies, and safety and relief valve transients)
  - accidents (e.g., main-steam-line break, positive reactivity addition, control rod insertion at power, anticipated transient without scram, and various-sized loss-of-coolant accidents)
  - reactor shutdown and cooldown using the remote shutdown system reasonable, risk-significant, beyond-design-basis events that should be determined from the plant-specific PRA
  - External events (fires, floods, seismic events, and loss of large area of the plant)

Additional Information:

The most demanding staffing requirements that a shift faces is the first hour of a severe casualty, before the emergency response facilities can be staffed. Staffing and activating the operational support center (OSC), technical support center (TSC) and the emergency

operations facility (EOF) reduce the burden on the shift. The OSC, TSC, and the EOF are typically required to be operational within thirty minutes to one hour of an emergency declaration. The emergency facility staffing would generally include extra senior reactor operators. Operating conditions selected need only be carried out far enough to address the period up to when added staffing is in place.

The NRC-approved industry Flexible Coping (FLEX) strategies, written to meet the Japan Lessons Learned mitigation strategies order for beyond design basis external events, are based on minimum shift staffing for the first two phases. Staffing analyses are to evaluate minimum staffing, so typically these analyses should include Phase 1 and 2 events and actions in the selected scenarios. For the second or transition phase, some plants may involve off-site or recalled personnel (NEI 12-06). If a plant's mitigation strategy specifies recalled/offsite personnel for selected events, then those events do not need to be included in the staffing analyses for minimum staffing.

b. The applicant should consider the following types of personnel tasks:

- *Important Human Actions* – The sample should include all important HAs, as determined in NUREG-0711, Section 7.
- *Manual Initiation of Protective Actions* – The sample should include manual system-level actuation of critical safety functions.
- *Automatic System Monitoring* – The sample should include situations in which humans must monitor a risk-important automatic system.
- *Operating Event Report - Identified Problematic Tasks* – The sample should include high-workload personnel tasks identified as problematic during the applicant's review of operating experience.
- *Range of Knowledge-Based Tasks* – The sample should include tasks that are not well defined by detailed procedures (see NUREG-0711 for additional information).
- *Range of Human Cognitive Activities* – The sample should include the range of cognitive activities that personnel perform, including:
  - detecting and monitoring (e.g., of critical safety-function threats)
  - situation assessment (e.g., interpreting alarms and displays to diagnose faults in plant processes and in automated control and safety systems)
  - planning responses (e.g., evaluating alternatives to recover from plant failures)

- response implementation (e.g., in-the-loop control of plant systems, assuming manual control from automatic control systems, and carrying out complicated control actions)
- obtaining feedback (e.g., feedback of the success of actions taken)
- *Range of Human Interactions* – The sample should include the range of interactions among plant personnel, including tasks performed independently by individual crew members, and those undertaken by a team of crew members. These interactions among plant personnel should include interactions between:
- main control room operators (e.g., operations, shift turnover walkdowns)
- main control room operators with auxiliary operators and other plant personnel performing tasks locally (e.g., maintenance or instrumentation and control (I&C) technicians, chemistry technicians)
- main control room operators and the TSC and the EOF
- main control room operators with plant management, the NRC, and other outside organizations

c. The applicant should include the following situational factors or error-forcing contexts known to challenge human performance. It also should include situations specifically designed to create human errors to assess the system's error tolerance, and the ability of personnel to recover from any errors, should these occur, for example:

- *Fatigue Situations* – To the extent possible, the sample should include situations that may be associated with fatigue, such as work on backshifts and tasks performed frequently with repetitive actions, such as repeated inputs to a touch screen during plant operations or pulling rods.

d. The applicant should include the following considerations with respect to emerging technology in NPPs, as described in more detail in Section 3 of NUREG/CR-6947.

- Automation (Section 3.1.1)
- Specific changes to operations (Section 3.1.3)
- Advances in HSI technology (Section 3.1.3)
- Complexity (Section 3.1.3)
- Disturbance and emergency management (Section 3.1.4)
- Design and evaluation of digital systems and software (Section 3.1.5)

e. The applicant should include the following considerations for Human-Performance Issues Related to Design and Operation of SMRs, if pertinent. These topics are described in more detail in Section 6 of NUREG/CR-7126.

- Plant mission (Section 6.1)
- Roles and responsibilities. This includes Multi-unit Monitoring and Teamwork, and High Levels of Automation (Section 6.2)
- Management of normal operations. This includes 10 issues of which the first seven relate to staffing and workload, while the last three relate more to HSI design. (Section 6.4)
- Management of off-normal conditions and emergencies. This includes nine issues which the first seven relate to staffing and workload, while the last two relate more to design and analysis. (Section 6.5).

2. **Identify Primary Tasks**

a. For each of the challenging operating conditions, the applicant should identify the primary plant control tasks which operators need to perform to a level of detail to support workload analyses.

Additional Information: If available, plant-specific procedures can be used to identify the tasks and task sequences for addressing each operational condition. If the actual detailed operating, off-normal, and emergency procedures are not available there may be vendor procedure guidelines or predecessor plant procedures that can be used.

Depending on their level of detail, procedures may only define the tasks that operators perform at a high level. In that case, applicants should conduct task analyses to develop the detail needed to support workload analyses. For example, one cannot determine the workload of a primary task like 'Start Pump A,' without breaking it down to more-detailed subtasks not typically described in procedures. The subtasks may include detailed actions such as: navigate to the feedwater display, locate the pump to be controlled, verify that the correct pump has been selected, assess that the preconditions for starting the pump are acceptable, click on the pump icon to access the pump controls, select "on" and click "Enter," and finally verify that the pump has been turned on and is operating properly. These subtasks are the detailed means by which the higher-level plant control task is accomplished.

b. The applicants should include an analysis of the operator tasks associated with new design features, even when the tasks are mainly cognitive activities such as monitoring.

Additional Information: For example, in a highly automated plant, operators will spend considerable time and effort monitoring the automation and assessing its performance. Cognitive task analysis techniques may to useful for analyzing such cognitive tasks.

In summary, the analysis of the operators' primary tasks may require a combination of procedures, procedure guidelines, and task analyses to identify all of the detailed tasks and activities that operators will need to perform during the challenging operating conditions.

3. Identify Dependent Tasks

For ~~33. NRC Regulatory Issue Summary 2002-22, "Use of EPRI/NEI Joint Task Force Report, Guideline on Licensing Digital Upgrades: EPRI TR 102348, Revision 1, NEI01-01:a Revision of EPRI TR 102348 to Reflect Changes to the 10CFR 50.59 Rule."~~

a. ~~———~~each of the challenging operating conditions, the applicant should identify the dependent tasks, which operators need to perform in support of the primary tasks.

Additional Information: Dependent tasks are those not specifically part of the procedure-driven primary tasks, but which operators still have to perform in the same time frame. When such tasks are performed in the same time period as the primary tasks, they contribute to crew's workload, may introduce distractions or interruptions, and reduce the time available to perform primary tasks.

Dependent tasks are divided into two categories: Generic dependent tasks and plant-specific dependent tasks. Generic tasks are those that apply to all or most plants and can be further categorized as administrative tasks, communications, and system/equipment-related actions. Generic dependent tasks are shown in Table 1.

Plant-specific dependent tasks are unique to the applicant's design. Applicants should systematically analyze the plant design, the use of new technologies and new ConOps to identify plant-specific dependent tasks that should be included in the scenarios to be analyzed (as determined in Section 5).

Applicants should consider the following in their analysis of plant-specific dependent tasks:

- Special work needed to access underground equipment
- Work related to passive systems
- Work related to operate backup systems to the passive systems
- Fuel loading
- Load-following operations
- Novel refueling methods
- Any special situation related to the primary task that results in reduced time for operators to respond
- Monitoring requirements for multiple reactor configurations

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Table 1: Generic Dependent Tasks

Type of Dependent Task	Example Activities
Administrative	Initiate Tech Spec actions
	Apply error-prevention tools, such as independent verification of valve repositioning, related to primary tasks
	Log keeping
Communications	Communicate with Auxiliary Operators
	Task briefings
	Manage command & control challenges
	Interface with in-plant emergency or support organizations
	Communicate with offsite emergency organization
	Communicate with the NRC
System/equipment-related actions	Alarm monitoring and response for primary task equipment
	Initiate emergency response actions

4. **Identify Potential Independent Tasks**

a. For each of the challenging operating conditions, the applicant should identify any independent tasks which operators may need to perform.

Additional Information: Independent tasks are not specifically linked to the primary tasks, but may need to be performed within the same time frame as primary tasks, thus may increase operator or overall staff workload. Even when independent tasks do not significantly add to workload, they can still create distractions that may impede primary task performance. An activity that shifts attention away from the primary tasks, even momentarily, can interfere with performance even if little workload is added.

An example of such an independent task is provided in NRC Information Notice (IN) 91-77 (NRC, 1991). The IN documented two instances of plants' difficulty in staffing the fire brigade during a plant fire. In another more recent example, The LER 50-259/22013-005-01, (TVA, 2014), describes a situation where the plants minimum staffing analysis did not fully consider the impact on staffing of the fire brigade, an Appendix R safe shutdown, and the emergency response organization.

In another recent example an SRO who was the fire brigade leader in case of fire was called for drug testing. After he left a fire occurred. The fire brigade responded with no leader for about 30 minutes. The SRO did not leave drug testing because previous communications had reinforced that anyone who did not complete drug testing within prescribed time frame was considered "unfit for duty."

Another example of a common independent task is communicating with plant staff on matters unrelated to the primary task.

Generally it is assumed that independent actions will be stopped when any plant transient occurs. However, operating experience shows there have been cases where confusion arises. Such conflicts should be addressed in plant administrative procedures to guide operators in how to manage independent tasks when they may impact operational primary tasks. Without such specific guidance, operators will make decisions on an ad hoc basis.

Like dependent tasks, we can divide independent tasks into generic and plant-specific tasks. Further, the independent generic tasks can be categorized as: administrative tasks, communications, and system/equipment-related. Table 2 provides independent tasks in each of these categories. Note that some of these activities that can be either a primary, dependent, or independent task (e. g., Tech Spec related activities).

Table 2: Generic Independent Tasks

Type of Independent Task	Example Activities
Administrative	Technical Specifications activities
	Apply error-prevention tools, such as independent verification of valve repositioning, unrelated to primary tasks
	Log keeping
	Drill participation
	Corrective action generation and processing
	Drug testing
	Outage schedule reviews
	Scheduling of operations, maintenance, and testing
	Training
Communications	Manage standard communications
	Communicate with Auxiliary Operators or fire brigade
	Shift turnover
	Staff meetings
System/equipment-related actions	Alarm monitoring and response for equipment unrelated to primary task
	Trouble shooting and investigations
	Manage in progress activities (operations and maintenance)
	Manage plant configuration, e.g., equipment tag-outs, operational lineups, and operability evaluations
	Monitor plant risk using the safety or risk monitor
	Perform surveillance testing and post maintenance testing
	Plant walkdowns
	Work related to unplanned shutdowns
	Participate in fire brigade

Applicants should also systematically analyze the plant design and the use of new technologies and new ConOps to identify if there are any plant-specific independent tasks that should be included. The following are examples of the types of activities to consider for identifying plant-specific independent tasks:

- Work-related handling of conditions of one unit that impact other units
- Data entries needed for using automation and computer-based human-system-interfaces.
- Managing novel maintenance hazards (e. g., reactor cooling system (RCS) partial drain for steam generator (SG) tube inspections)
- Modular construction and component replacement
- Control actions and operations and maintenance (O&M) planning related to multiple modules

A representative set of independent tasks should be included in the scenarios to be analyzed (see Section 6). The applicant need not include independent tasks are characterized by the following conditions:

- An independent task that can be delayed or stopped to permit operators to accomplish the scenario-required primary tasks, and
- An applicant has established guidance for prioritizing and/or postponing independent tasks that may arise during plant events.

The concept of giving operational activities priority attention over administrative or other independent tasks is well-recognized and generally supported by guidance from NRC, INPO, and ANSI/ANS standards. Some examples of such guidance are given here even though they don't explicitly address the situation we are concerned with here. Hence, applicants would need to establish (or commit to establish) appropriate administrative controls.

An example of addressing task postponement in the face of more important tasks is provided in ANSI/ANS-3.2-2012. Section 3.5.1, Procedure Adherence, states in part:

> *In the event of an emergency not covered by an approved procedure or an emergency not following the path upon which the approved procedure is based, operations personnel shall be instructed to take action so as to protect public health and safety and to minimize personnel injury and damage to the facility*.

This can be interpreted as allowing the postponing of less important tasks, that impacts the staffing needed to respond to events, but it doesn't require NPPs to have such specific words in their administrative controls. NRC Regulatory Guide 1.33 endorses ANSI/ANS-3.2-2012.

Two key INPO documents related to plant operations are as follows (identified here for information only):

- INPO 10-004 Principles for a Strong Plant Operational Focus, June 2013, Rev. 1

- INPO 01-002 Guidelines for the Conduct of Operations at Nuclear Power Stations, May 2001

INPO 10-004 provides the general practices needed to attain high-levels of operational safety and reliability at NPPs. It emphasizes the importance of plant operations. INPO 01-002 provides guidelines for achieving excellence in the various aspects of plant operations. One aspect noted is ensuring that administrative duties assigned to operators do not detract from their ability to safely operate the plant.

b. Applicants should identify their assumptions regarding the status of these excluded independent actions, e.g., "we have not included drug testing actions in our analysis because we assume such actions will not interfere with the primary control tasks based on administrative procedures."

5. **Construct Scenarios and Assign Operator Responsibilities**

Applicants should construct scenarios based on combining the primary, dependent, and independent tasks. These scenarios will be used to conduct the workload analysis described in Section 6. Scenario construction should follow the guidance contained in NUREG-0711, Sections 11.4.1.2, Identification of Scenarios, and 11.4.1.3, Scenario Definition) as adapted below.

a. Selection and construction of scenarios: The applicant should use the results of Sections 1 through 4 to identify a reasonable set of scenarios for subsequent staffing analysis. A given scenario may combine many of the characteristics identified in the "identification of challenging operating conditions" and other analyses. Five to ten scenarios should be sufficient provided they define what the applicant/licensee believes to be a set of the highest-workload conditions the operator might face. The applicant should use risk and cases of anticipated high workload to screen the scenarios and items contained in the scenarios.

Additional Information:

Workload can be anticipated to be high for scenarios with the characteristics listed in Table 3. This table is not meant to be comprehensive, and the characteristics identified are not mutually exclusive, but they may be useful for screening scenarios for potential high workload.

Table 3: Scenario Characteristics Associated with High Crew Workload

Characteristic	Considerations
Scenarios with Complex Relationships Among Primary Tasks	NUREG-0711 Task Analysis Criterion 4 addresses the relationships among tasks, e.g., some tasks can be carried out in any order or in parallel, some tasks have to be performed in a linear sequence, while for others the relationship is conditional (if such a condition exists, perform task A). Some tasks may involve coordinated actions among crew members or control room crew members and local personnel. These relationships can introduce task delays and multitasking requirements that contribute to the complexity and workload of performing primary tasks.
Scenarios that are unfamiliar or unusual	The scenario is not one that operators encounter frequently or on which they train. Thus, even with procedures the scenario has high uncertainties and operators have to analyze many parameters, select among many possible mental models for the situation, and evaluate multiple outcomes.
Scenarios that require knowledge based behavior	Knowledge-based task demands occur during scenarios for which there are no detailed procedures or for which procedures are not having their intended effects. Operators must assess the situation and develop response plans as they manage the situation.
Scenarios with distracting and interrupting demands	Some scenarios may produce a high level of distractions and interruptions, which raises workload and disrupts performance. An example would be a second failure occurring while operators are addressing the first failure.
Scenarios that are highly dynamic	In dynamic scenarios, the frequent onset of new or changing information makes it difficult to assess plant conditions, plan appropriate responses, or execute complex tasks. In such scenarios, operators have to frequently update and revise their understanding of the situation and how they manage the event.
Scenarios with time pressure	Complex tasks that need to be completed within a limited period of time may require operators to make a trade-off between the thoroughness of performing tasks (e.g., continuing data monitoring to assure the assessment, evaluating alternatives, confirming the actions before moving to the next step) and completing tasks in time.
Scenarios causing prolonged stress	Scenarios that require operators to work long working hours on non-routine, stressful tasks.
Rapid workload transitions	Periods of rapid workload transition are difficult to operators. For example, if an automatic system fails and operators have to suddenly perform the tasks manually, the workload experienced is typically high.
Scenarios with significant consequences	The potential consequences of the operator's performance impact workload. If the consequences are significant, then more workload is experienced than if the consequences are less severe.
Scenarios with actions having little margin for error	When operator tasks require very precise responses with little performance margin, the demands on attention are great and workload high.

b. Scenario Definition: For each scenario, the following information should be defined to reasonably assure that important dimensions of performance are addressed:

- a description of the scenario and any pertinent prior history necessary for analysts to understand the state of the plant at the start-up of the scenario
- specific initial conditions
- events (e.g., failures) that will occur during the scenario and their initiating conditions, e.g., based on time, or a value of a specific parameter
- dependent tasks related to each primary task
- independent tasks that may occur during each scenario
- definition of workplace factors, (e.g., environmental conditions)
- needs for task support (e.g., procedures and technical specifications)
- staffing level (should be the minimum levels are identified in the exemption request)
- responsibilities of each operator
- communication requirements between control room personnel and remote personnel (e.g., load dispatcher via telephone)

c. The applicant's scenarios should realistically represent operator tasks in the plant; so that the findings from the analysis can be generalized to the plant's actual operations. One important aspect of this is the timing for plant dynamics and postulated accidents. This would be provided by a full-scope plant simulator later in the design stage, but at the time of initial staffing evaluations, it may need to come from analytic work by the design team.

d. When appropriate, the scenarios should include work associated with operations remote from the main control room.

6. **Analyze Workload and Determine Its Acceptability**

a. The applicant should identify the method or methods to be used to analyze staff workload and the workload acceptance criteria for each.

b. The applicant should have a detailed task analysis of the scenarios to be analyzed.

Additional Information: To provide reasonable estimates, SME's should have a detailed analysis of crew tasks so they know not only what tasks need to be performed, but how they are performed. The task analysis should meet the review criteria provided in Section 5 of NUREG-0711, Applicants may use a combination of traditional task analysis methods, along with cognitive task analysis (CTA) methods.[8] The latter may be especially useful for cognitive and supervisory control activities and when the task situation is not well-defined from an operator's perspective. Applicants may also use human performance modelling techniques, provided they can show that those techniques can provide reasonable results. In addition, SMEs should have system descriptions to fully understand the tasks and how they are performed.

c. The applicant should conduct a timeline analysis of the time required to complete tasks with respect to the time available. The analysis should consider:

- system timing, such as the time the system takes to respond to an action before another action can be taken
- the time required to perform covert cognitive tasks, such as situation assessment and response planning
- the effects of multitasking and the potential for primary task disruption created by overlapping primary tasks, dependent tasks, and independent tasks

d. The applicant should analyze the physical and cognitive workload associated with task performance. The analysis should consider the effects of multitasking and the potential for primary task disruption created by overlapping primary tasks, dependent tasks, and independent tasks.

Additional Information: Applicants can use or adapt a subjective workload measure to obtain SME workload estimates along workload dimensions.

[8] The CTA addresses limitations in current task analysis methods, such as:

- Traditional task analysis methods mainly focus on physical activity (observable behaviors). However, as modern plants become much more highly automated, the role of personnel becomes less-and-less activity oriented, and more-and-more cognition oriented. Traditional methods are limited in their ability to analyze cognitive, supervisory control tasks.
- Traditional methods tend to focus on the ways tasks should be performed from the perspective of designers, procedure developers, and trainers. These perspectives do not always capture how work is actually performed in the plant under the demands of the real work environment. (This is one of the primary concerns addressed in this new guidance.)
- Traditional methods do not address well what makes situations demanding and difficult. However, in real world settings, task difficulty is an important determinant of performance and safety.
- Traditional methods are well-suited to clearly-defined situations, but are less well suited to analyzing unplanned and unanticipated situations, such as situations that have not been assessed by designers and not been experienced by operations experts. Yet it's just these types of situations that can pose the greatest risk to safety.

e. The applicant should evaluate the acceptability of workload by comparing time and workload results to the established criteria.

f. The applicant should evaluate unacceptable results to determine root cause and corrective actions.

Additional Information: Note that the root cause of unacceptable workload for individual scenarios may not be due to staffing levels. For example, the high workload may be due to poor HSI design rather than insufficient staff. The human engineering discrepancy (HED) evaluation process described in NUREG-0711, Section 11.4.4, can be used for this analysis.

7. Develop Conclusions about the Acceptability of Workload Levels

a. Applicants should provide overall conclusions about the acceptability of workload levels and the basis for that conclusion considering:

- Both time and workload analyses
- Consistency of results across the different challenging scenarios
- The results of HED evaluations of any findings where workload fails to meet acceptability criteria

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

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