Basic Human-System Interface

Revision 1

Non-Proprietary

March 2017

REVISION HISTORY

Revision	Date	Page	Description
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1	March 2017	vii (Table of Contents)	Basic HSI Style Guide is changed to Style Guide R_374-8481(97)
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		2 (2)	Basic HSI Style Guide is changed to Style Guide R_374-8481(97)
		7 (3.1.3)	Description for IFPD deleted R_383-8458(107)
		13 (3.5.2)	Description for Type A variable deleted. R_38-8281(07.05-01)
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		52 (4.7.6)	Description for Custom Displays added R_374-8481(101)
		53 (4.8.3)	Description for CBP design to be consistent with design review criteria added R_383-8458(105)
		55 (4.8.10.2)	Description for CBP design to be consistent with design review criteria added R_383-8458(105)
		56	Description for CBP design to be consistent with design

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		67 (4.11.3)	Description for Switch Configuration revised R_383-8458(106)
		75 (4.15.4)	Description for BISI Function added R_400-8425(118)
		77 (4.15.5.3)	Description for Custom Alarms added R_374-8481(101)
		79 (4.16.1)	Description for RSR Configuration added R_383-8458(106)
		82 (5)	Description for IFPD performance revised R_348-8279(14)
		83 (5)	HSI/I&C is changed to I&C engineering R_250-8282(27)
		A2-A3 (Appendix A)	Basic HSI Style Guide is changed to Style Guide R_374-8481(97)
		A4 (Appendix A)	Description for Temporary Display/Custom Alarms added R_374-8481(101)
		84 (6)	Editorial corrections. (references)

ABSTRACT

This document describes the conceptual design of the Advanced Power Reactor 1400 (APR1400) Basic Human-System Interface (HSI), which establishes the generic indication, alarm, control and procedure methods applied to all systems and functions controlled from the main control room (MCR) and the remote shutdown room (RSR). These same HSI methods apply to the safety parameter display system (SPDS) indications provided in the MCR and the technical support center. The APR1400 Basic HSI also defines indication, alarm, and control methods for local control stations used for important human actions (IHA).

The APR1400 Basic HSI (also referred to as Basic HSI) is derived from the Basic HSI of the APR1400 predecessor design, Shin Kori nuclear power plant units 3 and 4 (SKN 3&4). The Basic HSI for SKN 3&4 reflects an evolution from previous operating plants in Korea and around the world. The APR1400 Basic HSI reflects changes from SKN 3&4 primarily for compliance to US regulatory criteria. The conceptual design of the APR1400 Basic HSI, as described in this document, is the starting point for development of the complete APR1400 Basic HSI, which is developed during the Human Factors Engineering (HFE) Human-System Interface Design (HD) program element (PE). The HD PE is described in the HD implementation plan (IP) (Reference 5).

Section 1 of this document defines the purpose of the Basic HSI and the purpose of this document. Section 2 establishes the scope of the Basic HSI. Section 3 provides an overview of the Basic HSI conceptual design. Section 4 provides the details of the conceptual design. Section 5 describes the history and design process that lead to the Basic HSI. Appendix A demonstrates compliance of the design to the NUREG-0711 Review Criteria for the HD PE.

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ACRONYMS AND ABBREVIATIONS

AMI	accident monitoring instrumentation
AOO	anticipated operational occurrence
AP	auxiliary panel
APR1400	Advanced Power Reactor 1400
ARP	alarm response procedure
BISI	bypassed and inoperable status indication
BOP	balance of plant
CBP	computer-based procedure
CCF	common-cause failure
CFM	critical function monitoring
CFR	Code of Federal Regulations
CIM	component interface module
CPC	core protection calculator
CPPF	critical power production function
CSF	critical safety function
D3CA	diversity and defense-in-depth coping analysis
DI	design implementation
DIHA	deterministically important human action
DIS	diverse indication system
DMA	diverse manual actuation
DPS	diverse protection system
EDG	emergency diesel generator
EO	electrical operator
EOF	emergency operation facility
EOG	emergency operating guideline
EOP	emergency operating procedure
ESCM	ESF-CCS soft control module
ESF	engineered safety features
ESF-CCS	engineered safety features-component control system
FRA	functional requirements analysis
GOP	general operating procedure
HA	human action
HD	human-system interface design
HDSR	historical data storage and retrieval

HED	human engineering discrepancy
HFE	human factors engineering
HSI	human-system interface
HSIS	human-system interface system
HVAC	heating, ventilation, and air conditioning
I&C	instrumentation and control
IA	important alarm
ICC	inadequate core cooling
IFPD	information flat panel display
IHA	important human action
IPS	information processing system
KEPCO	Korea Electric Power Corporation
KHNP	Korea Hydro & Nuclear Power Co., Ltd.
LCS	local control station
LDP	large display panel
LOOP	loss of offsite power
MC	monitoring console
MCR	main control room
MIC	minimum inventory control
MT	master transfer
NFPD	QIAS-N flat panel display
NRC	Nuclear Regulatory Commission
NSSS	nuclear steam supply system
OC	operator console
OM	operator module
P-CCS	process-component control system
PE	program element
P&ID	piping and insturumentation diagram
PFPD	QIAS-P flat panel display
PPS	plant protection system
PRA	probabilistic risk assessment
QIAS-N	qualified indication and alarm system-non-safety
QIAS-P	qualified indication and alarm system-p
RIHA	risk important human action
RG	Regulatory Guide
RMS	radiation monitoring system

RO	reactor operator
RSC	remote shutdown console
RSR	remote shutdown room
RT	reactor trip
SC	safety console
SDCV	spatially dedicated and continuously visible
SGA	system group alarm
SLI	system level initiation
SME	subject matters expert
SKN 3&4	Shin Kori nuclear power plant units 3 and 4
SOP	system operating procedure
SPADES+	safety parameter display and evaluation system plus
SPDS	safety parameter display system
SRO	senior reactor operator
SS	shift supervisor
STA	shift technical advisor
TA	task analysis
TAA	transient and accident analysis
TO	turbine operator
TS	trade secret
TSC	technical support center
TT	turbine trip
US	United States
VDU	visual display unit
VoIP	voice over internet protocol

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1. PURPOSE

This document describes the APR1400 Basic HSI, which establishes the generic indication, alarm, control and procedure methods applied to all systems and functions controlled from the main control room (MCR) and the remote shutdown room (RSR). These same human-system interface (HSI) methods apply to the safety parameter display system (SPDS) indications provided in the technical support center (TSC). The APR1400 Basic HSI also defines indication, alarm, and control methods for local control stations (LCS) used for important human actions (IHA). The APR1400 Basic HSI ensures the same HSI design is consistently applied throughout the plant systems of APR1400 and at the HSI locations credited for controlling the critical safety functions (CSF) and critical power production functions (CPPF) defined by the human factors engineering (HFE) functional requirements analysis (FRA), during normal and degraded HSI conditions.

This document describes the conceptual design of the APR1400 Basic HSI which includes, by reference, the APR1400 Style Guide (Reference 1) (also referred to as Style Guide). The Basic HSI concept includes the HSI accommodations for the plant's operating staff, such as the ergonomic designs of operator consoles (OC) and the safety console (SC), and their architectural configuration to ensure visibility and hearing for crew coordination. The Basic HSI concept also defines the criteria and methods for spatially dedicated and continuously visible (SDCV) HSI, the methods for safety and diverse HSI, and the strategies for managing degraded HSI.

The implementation plan (IP) for the HD PE (Reference 2) governs the evolution of the APR1400 Basic HSI concept into the complete APR1400 Basic HSI detailed design through documentation of detailed functional designs, prototype development, and design tests using United States (US) licensed reactor operators.

All figures in this document that show video displays or control panel layouts depict the design standards of the Style Guide and the design basis inventory content of the Basic HSI. But the actual HSI inventory for the video displays and control panels for the APR1400 Human System Interface System (HSIS) will reflect the APR1400 plant design. For example, the typical large display panel (LDP) shown in Figure 3-3 employs the graphical standards of the Style Guide and the design basis content of CSFs and CPPFs (and their preferred normal and emergency success paths). However, the actual APR1400 LDP will reflect the CSFs and CPPFs for APR1400 (and their preferred normal and emergency success paths). Therefore, the APR1400 LDP graphic may have a different inventory and mimic configuration than the graphic shown in Figure 3-3. The design of all APR1400 displays and control panels is based on the Style Guide criteria and the analyses of personnel roles (job analysis), and systematic strategies for organization, such as arrangement by importance, and frequency and sequence of use.

2. SCOPE

The APR1400 Basic HSI encompasses the physical design of the MCR, which includes OCs, the SC, the LDP, and furnishings such as bookcases and worktables. The APR1400 Basic HSI defines the generic methods for controls, alarms, information displays, and procedure displays. These generic HSI methods are applied to Basic HSI functions, such as computer-based procedures (CBP), critical function monitoring (CFM), success path monitoring, accident monitoring instrumentation (AMI), and bypassed and inoperable status indication (BISI). All Basic HSI functions are seamlessly integrated through Basic HSI features such as the information display hierarchy, single point alarm acknowledgment, intuitive diagnostic drill down and inter-function navigational hyperlinks. These physical and functional resources constitute the APR1400 Basic HSI, within which the HSI inventory for the APR1400 design is implemented.

The scope of the APR1400 Basic HSI includes:

- The design basis (i.e., the HSI inventory selection criteria) for SDCV indications and alarms to be displayed on the non-safety LDP and safety related displays.
- The design basis for SDCV controls and their location within the HSI facilities.
- The methods (e.g., dynamic video symbols, conventional HSI components) for all displays, alarms and controls, including distinctions required to accommodate safety HSI, diverse HSI, and LCS HSI.
- Criteria for alarm applicability and prioritization, and the display and control methods for alarm states and priorities.
- Design criteria for graphic displays including density, graphic symbol and character size, line thickness, and information orientation (as defined in the Style Guide).
- The video display hierarchy, including the function, task and system design content of each hierarchical level.
- The navigation methods between and within hierarchical display levels, and between alarms, displays, controls and CBPs.
- CBP methods, including navigation within and among procedures, place keeping, annotations and bookmarks, multiple procedure usage, independent step verification, archiving, automated data checking, and provisions for continuous action steps.
- Configuration of OCs and the SC, and their arrangement within the HSI facilities.
- Methods for control transfer between HSI facilities.
- Nomenclature and labeling standards for all elements of both soft and conventional HSI, including abbreviations and syntax for labels and alarm messages.

The APR1400 Basic HSI includes the APR1400 Style Guide. This document defines the design standards for visual display unit (VDU) and conventional HSI devices, including screen and panel layout standards, visual coding standards (e.g., shapes and colors) and all alphanumeric styles.

While the Style Guide establishes the format and fonts for labels used on all HSI elements, the APR1400 Nomenclature and Labeling Guide establishes the naming, abbreviations, acronyms, numbering and syntax rules for components of the plant used by plant operators. This includes:

- HSI components
- Room and plant area labels
- Instrumentation and control (I&C) and electrical cabinet labels
- Labels for components in plant systems (e.g., pumps valves)

For examples, since it is not practical to use complete English names and complete identification numbers for all labels, this guide defines the portions of names and numbers used on all media (soft and conventional nameplates) and at all hierarchical levels to ensure distinct unambiguous labeling. This guide also defines standard syntax and rules for alarm titles and messages to minimize the need for unique operator training and promote clear and rapid operator understanding. The Basic HSI Nomenclature and Labeling Guide is not part of the Basic HSI conceptual design, but is developed as part of the Basic HSI detailed design during the HSI design (HD) program element (PE).

APR1400 Basic HSI also establishes standard functional specifications for the indications and controls associated with plant instrumentation and components. This is referred to as the APR1400 Basic HSI Component Control and Instrumentation Design Guide. This guide ensures HSI and control method consistency across all APR1400 plant systems. The Basic HSI Component Control and Instrumentation Design Guide is not part of the Basic HSI conceptual design, but is developed as part of the Basic HSI detailed design during the HD PE.

All LCSs employed for IHAs are designed in accordance with the Style Guide, the APR1400 Nomenclature and Labeling Guide and the APR1400 Basic HSI Component Control and Instrumentation Design Guide.

The same SPDS information displayed in the MCR and TSC, as defined by the Basic HSI, is also transmitted to the Emergency Operation Facility (EOF) for display within the EOF HSI system. The EOF HSI system and the EOF physical configuration design are outside the scope of the APR1400 Basic HSI.

3. OVERVIEW

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Figure 3-1 Main Control Room

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3.5.1.2 Reactor Operator

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3.5.1.3 Turbine Operator

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3.5.1.4 Electrical Operator

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Figure 4-2 Horizontal Viewing Angle from TO Console to LDP

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Figure 4-4 Horizontal Viewing Angle from SS Console to LDP

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Figure 4-6 Vertical Viewing Angle from OC to LDP

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Figure 4-7 Horizontal Viewing Angle from Meeting Room to LDP

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Figure 4-8 Horizontal Viewing Angle from Meeting Room to Operator Consoles

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4.1.5 Mobility within the MCR

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4.2 Operator Consoles

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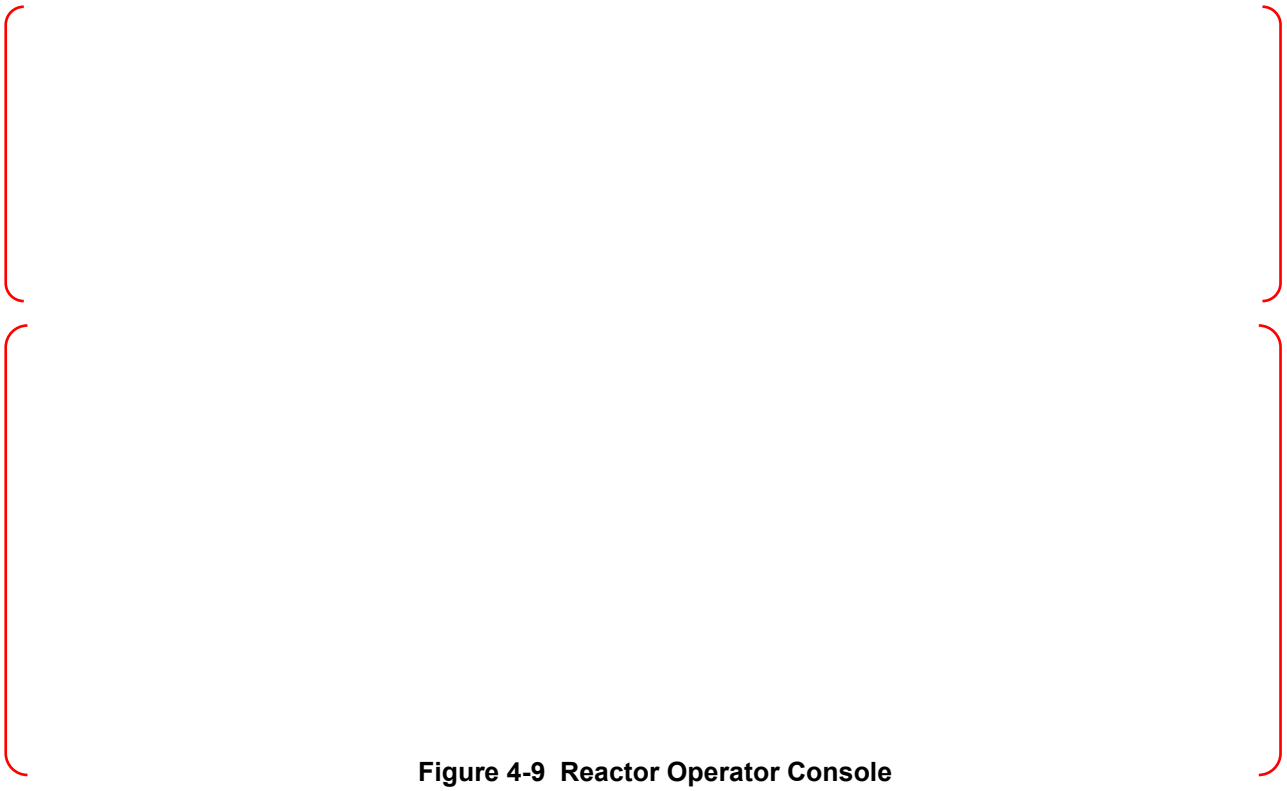

Figure 4-9 Reactor Operator Console

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Figure 4-11 Turbine Operator Console

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Figure 4-12 Shift Supervisor Console – Left

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Figure 4-13 Shift Supervisor Console – Right

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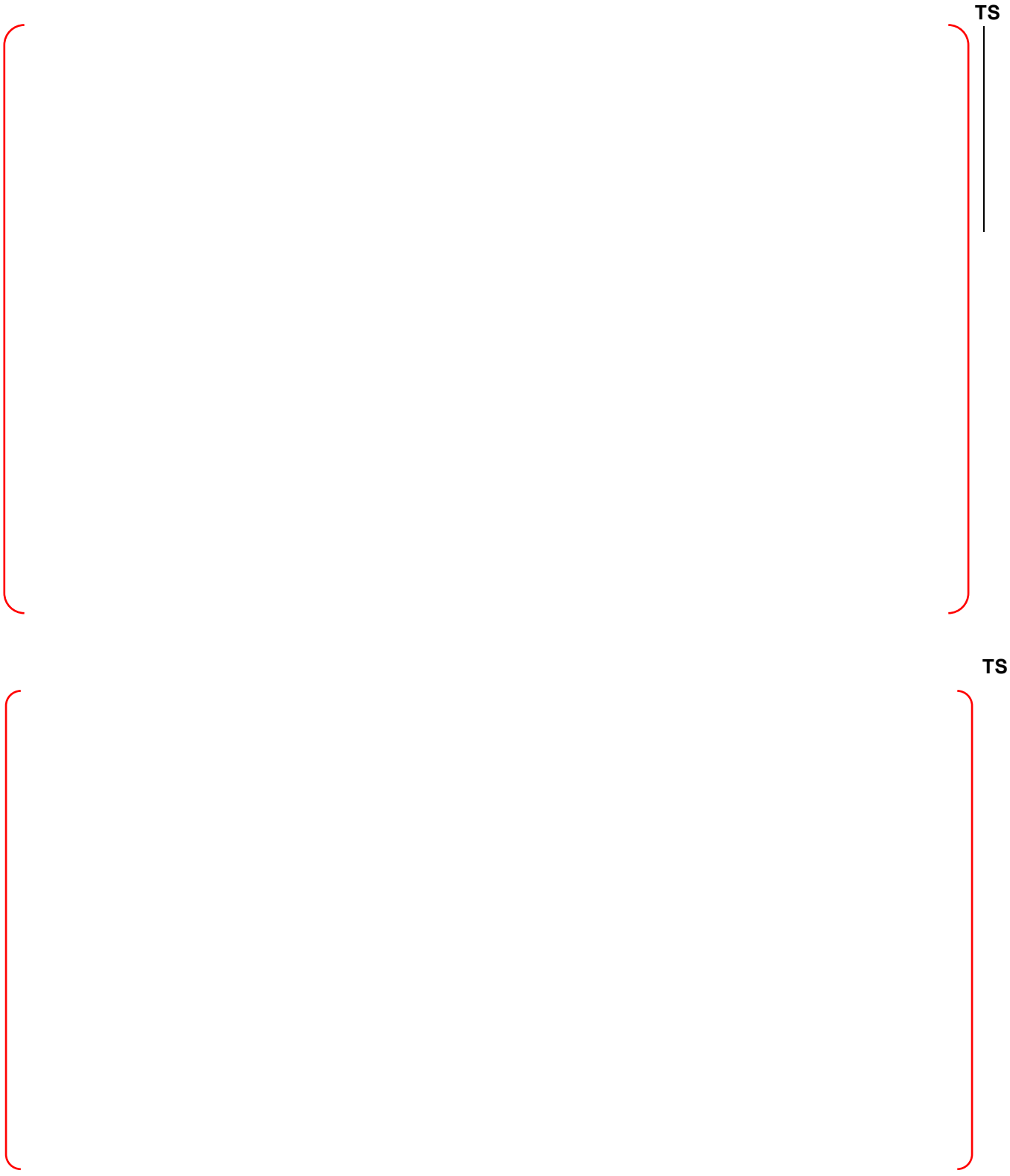

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[redacted]

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[redacted]

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Figure 4-28 Computer-based Procedure Display

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4.7.2.1 Display Page Directory

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Figure 4-29 Display Page Directory for Primary Systems

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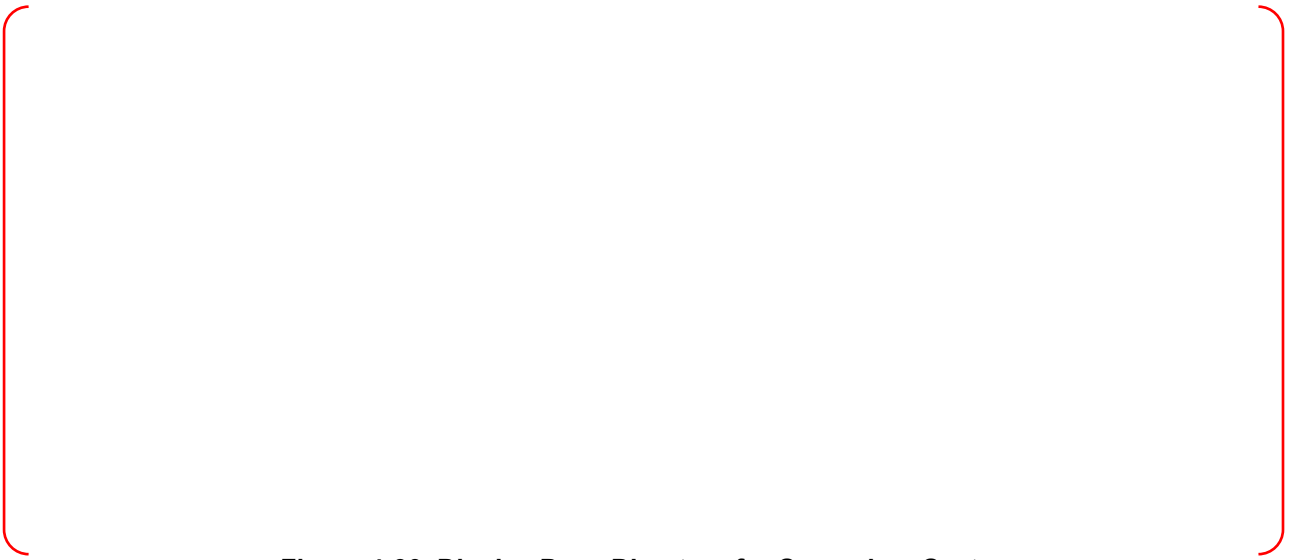

Figure 4-30 Display Page Directory for Secondary Systems

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Figure 4-31 Display Page Directory for Global Aids

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Figure 4-32 Display Page Directory for Procedure Support

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Figure 4-33 Direct Display Page Access

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Figure 4-36 Format Chaining for Safety Soft Control

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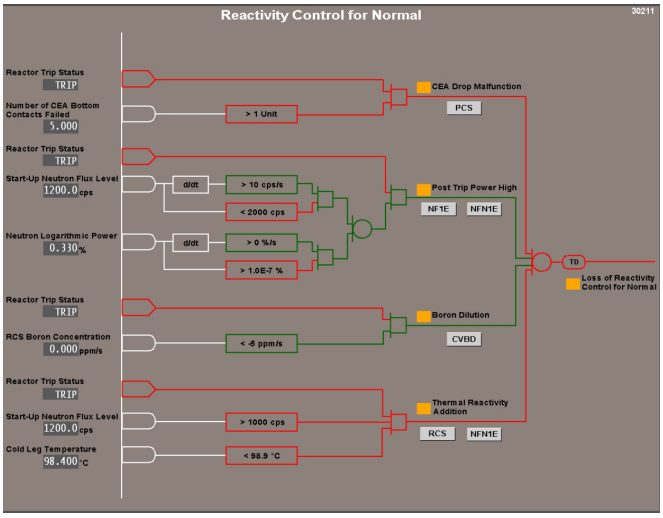

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Figure 4-45 Soft Control Template for Component Control

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4.11.5.3 Active Interlock Controls

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4.12 QIAS-N display

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Figure 4-47 QIAS-N Mini-LDP RO Section

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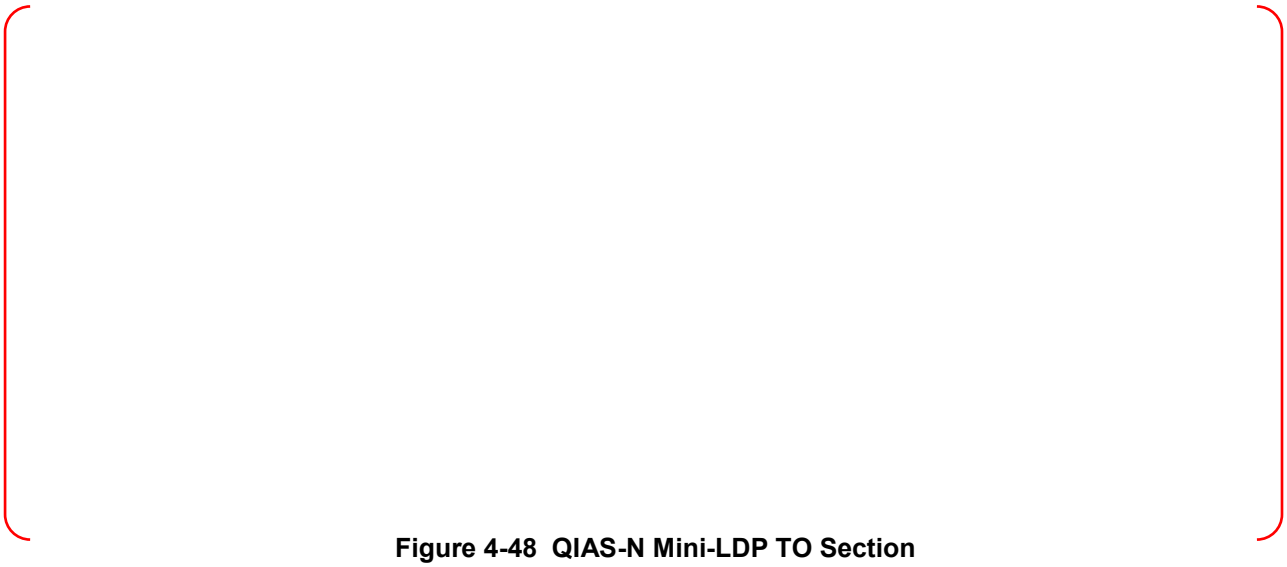

Figure 4-48 QIAS-N Mini-LDP TO Section

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Figure 4-49 QIAS-N Selectable Display

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Figure 4-50 QIAS-N Display Directory

4.13 QIAS-P Display

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4.18 Emergency Operations Facility

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5. DEVELOPMENT PROCESS

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7. DEFINITIONS

APR1400 Basic HSI	The generic indication, alarm, control and procedure methods applied to all systems and functions controlled from the MCR and the RSR. These same HSI methods apply to the SPDS indications provided in the MCR and the TSC. The APR1400 Basic HSI also defines indication, alarm, and control methods for LCSs used for IHAs.
APR1400 HSI Design	The complete integration of the APR1400 HSIS and APR1400 HSI Facilities (see definitions below).
APR1400 HSI Facilities	The APR1400 MCR, RSR, TSC and LCSs. The facility designs accommodate the APR1400 HSIS (see definition below) as well as storage, communication, meeting and other habitability features important to support required operating crew performance, during all facets of plant operation.
APR1400 HSIS	The specific soft and conventional indications, alarms, controls and operating procedures that encompass the HSI inventory defined by the TA PE and APR1400 plant system designs, within the generic HSI methods defined by the APR1400 Basic HSI.

Appendix-A NUREG-0711 REV. 3 REVIEW CRITERIA COMFORMANCE TABLE

NUREG-0711 Rev. 3 Review Criteria	Section and Paragraph
8.4 Review Criteria 8.4.1 HSI Design Inputs (1) *Analysis of Personnel Task Requirements* – The applicant should use the following analyses, performed in earlier stages of the design process, to identify requirements for the HSIs:	See HD IP
• *Operational Experience Review* – An input to the HSI design should encompass lessons learned from other complex human-machine systems, especially predecessor designs and those involving similar HSI technology.	
• *Functional Requirements Analysis and Function Allocation* – The HSIs should support the roles of personnel in the plant, e.g., appropriate levels of automation.	
• *Task Analysis* – The set of requirements to support the role of personnel is provided by task analyses that should identify: − tasks needed to control the plant during a range of operating cond itions from normal through accident conditions − detailed information and control requirements (e.g., requirements f or display range, precision, accuracy, and units of measurement) − task support requirements (e.g., special lighting and ventilation re quirements) − important HAs, as defined in Section 7 of this document, that sho uld be given special attention in the HSI design process	
• *Staffing and Qualifications* – The findings from analyses of staffing/qualifications should provide input for deciding upon the layout of the overall control room and allocating controls and displays to individual consoles, panels, and workstations. The staffing/qualifications analyses establish the basis for the minimum and maximum number of personnel to be accommodated, and requirements for coordinating activities between them.	
(2) *System Requirements* – The applicant should identify any constraints on the HSI design imposed by the overall I&C system, e.g., constraints on the information that can be presented due to sensor data availability.	
(3) *Regulatory Requirements* – The applicant should identify the applicable regulatory requirements as inputs to the HSI design process.	3.5.2 (items 4-6), 4.6, 4.7.1.4, 4.14, 4.17
(4) *Other Requirements* – The applicant should identify any other requirements, such as customer requirements, that are inputs to the HSI design.	5.0

NUREG-0711 Rev. 3 Review Criteria	Section and Paragraph
8.4.2 Concept of Use and HSI Design Overview (1) The applicant should develop a concept of use stating the roles and responsibilities of operations personnel based upon anticipated staffing levels. The concept of use should: • provide a high-level description of how personnel will work with H SI resources • address the coordination of personnel activities, such as interactio ns with auxiliary operators and the coordination of maintenance a nd operations *Additional Information*: Examples of the types of information the applicant may identify include the allocation of tasks between the main control room or to local control stations, whether personnel will work at a single large workstation or at individual ones, to what types of information each crew member will have access, and what types of information will be displayed to the entire crew.	3.4, 3.5 including all subsections
(2) The applicant should provide an overview of the HSI, covering the technical bases demonstrating that they constitute a state-of-the-art HSI design supporting personnel performance. These bases may include analyses of operating experience and the literature, tradeoff studies simultaneously considering multiple alternatives, and engineering tests and evaluations. The overview should include a description of: • facility layouts, including workstations, large screen displays, and t he nominal staff working positions • key HSI resources and their functionality, such as alarms, display s, controls, computer-based procedures, and other support and jo b aids • technologies to support teamwork and communication within the main control room and between the main control room, the remote shutdown facility, the TSC, EOF, and local control stations • the responsibilities of the crew for monitoring, interacting, and ove rriding automatic systems and for interacting with computerized pr ocedures systems and other computerized operator support syste ms	3.0 including all subsections, 4.8, 4.11.4, 4.11.5 including all subsections
8.4.3 HFE Design Guidance for HSIs Applicants should employ design-specific HFE design guidance in designing the features of the HSIs, their layout, and environments. Although design guidance documents are called by different names, NUREG-0711 refers to them as “style guides.” Applicants may use one or more individual documents to serve this purpose. The HFE guidelines in NUREG-0700 may serve to support the NRC staff's review of the guidance in an applicant's style guide.	3.6 (see separate Style Guide)
(1) The topics in the applicant’s style guide(s) should address the scope of HSIs included in the design, and address their form, function, and operation, as well as the environmental conditions in which they will be	4.0 including all subsections

NUREG-0711 Rev. 3 Review Criteria	Section and Paragraph
used that are relevant to human performance. *Additional Information*: NUREG-0700 lists HSI topics around which a style guide(s) may be organized.	
(2) The guidance in the applicant's style guide(s) should be developed from generic HFE guidance and HSI design-related analyses. It should be tailored to reflect the applicant's design decisions in addressing specific goals of the HSI design. *Additional Information*: Analyses related to the HSI design might include an evaluation of recent literature, analysis of current industry practices and operational experience, tradeoff studies, and the findings from design-engineering experiments and evaluations.	5.0
(3) The individual guidelines in the applicant's style guide(s) should be expressed precisely and describe easily observable HSI characteristics, such as "Priority 1 alarms are shown in red." The guidelines in the style guide(s) should be sufficiently detailed so that design personnel can deliver a consistent, verifiable design meeting the applicant's guidelines.	3.6 (see separate Style Guide), 4.15.1
(4) The applicant's style guide(s) should contain procedures for determining where and how HFE guidance will be used in the overall design process. They should be written so designers can readily understand them; the text should be supplemented with graphical examples, figures, and tables to facilitate comprehension.	See HD IP and Style Guide
(5) The applicant should maintain the style guide(s) in a form that is readily accessible and usable by designers, and is easily modified and updated as the design matures. The guidance should include a reference(s) to the source upon which it is based.	See Style Guide
8.4.4 HSI Detailed Design and Integration The criteria in this section are divided into the following subsections: 8.4.4.1, General 8.4.4.2, Main Control Room 8.4.4.3, Technical Support Center 8.4.4.4, Emergency Operations Facility 8.4.4.5, Remote Shutdown Facility 8.4.4.6, Local Control Stations Many criteria in this section are based on HFE guidance from other documents. We listed these documents and give the full references for them, including the specific revision or year of publication, in Section 14, References.	No criteria
8.4.4.1 General (1) For important HAs (see Element 7), the applicant's design should minimize the probability that errors will occur, and maximize the probability	2.0, 3.4, 3.5.2, 3.5.3, 4.3, 4.3.1, 4.3.2, 4.7.1.2, 4.12, 4.14

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that any error made will be detected.	
(2) The applicant should base the layout of HSIs within consoles, panels, and workstations on (1) analyses of personnel roles (job analysis), and (2) systematic strategies for organization, such as arrangement by importance, and frequency and sequence of use.	1.0
(3) The applicant should design the HSIs to support inspection, maintenance, test, and repair of (1) plant equipment, and (2) the HSIs. The applicant should design the latter so that inspection, maintenance, test, and repair of the HSIs do not interfere with other plant-control activities (e.g., maintenance tags should not block the operators' views of plant indications).	See HD IP
(4) The applicant's design should support personnel task performance under conditions of minimum-, typical-, and high-level or maximum staffing. *Additional Information*: Minimum staffing is that defined by plant's technical specifications. Typical staffing is that specified and used by the licensee for routine plant operations. Maximum staffing includes the augmented staff for accident situations.	3.5
(5) The applicant's design process should account for using the HSIs over the duration of a shift where decrements in human performance due to fatigue may be a concern. *Additional Information*: As an example, simulation tests can evaluate fatigue caused by using touch screens for long periods	5.0
(6) The characteristics of the applicant's HSIs should support human performance under the full range of environmental conditions, ranging from normal to credible extreme conditions, such as loss of lighting and of ventilation. For the remote shutdown facility and local control stations, the applicant's HFE design should consider the ambient environment (e.g., noise, temperature, contamination) and the need for and type of protective clothing. *Additional Information*: For example, consideration should be given to the effects that protective clothing may have on task performance (e.g., protective gloves may make manual dexterity tasks more difficult and increase the time necessary to complete them).	3.1.1, 3.1.2, 3.5.4.2, 4.1.3.3, 4.6, 4.15.4,
(7) The applicant should identify how in an operating plant: • the HSIs are modified and updated • temporary HSI changes are made (such as modifying the set points) • personnel-defined HSIs are created (such as temporary displays that personnel define for monitoring a specific situation)	For modifications and updates: see HD IP For temporary displays: 4.7.7, 4.15.5.4
(8) Additional Considerations for Reviewing the HFE Aspects of Plant Modifications	Not applicable

NUREG-0711 Rev. 3 Review Criteria	Section and Paragraph
8.4.4.2 Main Control Room In some of the criteria below, we italicize and underline the word “how” to emphasize it. The word refers to the means by which the information identified in the criterion is displayed by the HSIs to personnel, e.g., how displays depict the information that operators need for monitoring tasks.	No criteria
(1) *Safety Parameter Display System* – The applicant should describe the safety parameter display system (SPDS), addressing the following: • *Identification of Critical Safety Functions (CSFs)* – The CSFs nee ded to meet the requirement for an SPDS should be identified. NU REG-1342 Section III.F, Minimum Parameters for Display, lists th e five CSFs that personnel monitor using an SPDS for boiling wat er reactor (BWRs) and pressurized water reactor (PWRs). For ne w designs, applicants should verify that these CSFs are suitable f or their design, identifying any changes needed based on their de sign’s detailed characteristics. • CSFs may differ for non-light water reactor designs, such as high-temperature gascooled reactors and liquid-metal reactors. • *Identification of the Parameters Personnel will use to Monitor Eac h CSF* – The applicant should identify the plant parameters perso nnel need to monitor each CSF and describe the means by which plant data are synthesized, combined, or otherwise evaluated to p rovide the information presented in the SPDS display. • Section III.F of NUREG-1342 has guidance on acceptable parame ters for the current fleet of PWRs and BWRs. The applicant’s iden tification of parameters should consider the unique characteristics of the plant’s design. • *Evaluation of SPDS HSIs* – The applicant should verify that the S PDS HSIs conform to acceptable HFE practices using NUREG-07 00, Section 5 and other SPDS HFE guidance. *Additional Information*: SPDS requirements are described in 10 CFR 50.34(f)(2)(iv), and related guidance in NUREG-0835, NUREG-1342, Supplement 1 of NUREG-0737, and NUREG-0700, Section 5. These NUREGs discuss the NRC’s review guidance for SPDS, with NUREG-0700 being the primary one; the others encompass supplemental guidance, examples, and technical bases.	4.9
(2) *Bypassed and Inoperable Status Indication* – The applicant should describe *how* the HSI assures the automatic indication of the bypassed and inoperable status of a safety function, and the systems actuated or controlled by the safety function. [10 CFR 50.34(f)(2)(v) - I.D.3] Regulatory Guide 1.47 includes the following guidance related to the display of bypassed and inoperable status of safety systems: • The status indication should be in the main control room. • Administrative procedures should be supplemented by an automa tic indication system that shows, for each affected safety system o r subsystem, the bypass or deliberately induced inoperability of a	2.0, 3.5.2, 4.6, 4.7.1.3, 4.7.2, 4.15.5.1

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safety function, and the systems it actuates or controls. • Provisions should be made allowing the operations staff to confir m that a bypassed safety function was properly returned to servic e. • Annunciating functions for system failure and automatic actions b ased on the selftest or self-diagnostic capabilities of digital comput er-based I&C safety systems should be consistent with the above bullets. • The indication system for bypass and inoperable status should inc lude the ability to ensure its operable status during normal plant o peration to the extent to which the indicating and annunciating fun ctions can be verified. • Bypass and inoperable status indicators should be arranged such that personnel can determine whether it is permissible to continue operating the reactor. • The control room of all affected units should receive an indication of the bypass for their shared system safety functions.	
(3) *Relief and Safety Valve Position Monitoring* – The applicant should describe *how* the HSI indicates the position of the relief and safety valves (open or closed) in the control room. [10 CFR 50.34(f)(2)(xi)- II.D.3]	See HD IP
(4) *Manual Feedwater Control* – The applicant should describe *how* the HSI provides automatic and manual initiation of the auxiliary feedwater system, and indicates auxiliary feedwater system flow in the control room. [Applicable to PWRs only, 10 CFR 50.34(f)(2)(xii) - II.E.1.2]	See HD IP
(5) *Containment Monitoring* – The applicant should describe *how* the control room's HSIs (alarms and displays) inform personnel about: (A) containment pressure; (B) containment water level; (C) containment hydrogen concentration; (D) containment radiation intensity (high level); and (E) noble gas effluents for all potential, accident release points. [10 CFR 50.34(f)(2)(xvii) - II.F.1]	See HD IP
(6) *Core Cooling* – The applicant should describe *how* the HSI provides unambiguous indication of inadequate core cooling, such as with primary coolant saturation meters in PWR's, and a suitable combination of signals from indicators of coolant level in the reactor vessel and in-core thermocouples in PWRs and BWRs. [10 CFR 50.34(f)(2)(xviii) - II.F.2]	
(7) *Post-accident Monitoring* – The applicant should describe *how* the HSI assures monitoring of plant and environmental conditions following an accident including core damage. [10 CFR 50.34(f)(2)(xix) - II.F.3, and RG 1.97]	2.0, 3.5.2 items 5, 6 and last paragraph, 4.1.4.1, 4.3.2.1, 4.6, 4.13
(8) *Auxiliary Heat Removal* -- The applicant should describe *how* that necessary automatic and manual actions can be taken to ensure proper functioning of auxiliary heat removal systems when the main feedwater system is not operable. [Applicable to BWRs only, 10 CFR 50.34(f)(2)(xxi)	See HD IP

NUREG-0711 Rev. 3 Review Criteria	Section and Paragraph
- II.K.1.22]	
(9) *Reactor Level Monitoring* – The applicant should describe *how* the HSI gives a record of the reactor vessel's water level in one location on displays that meet normal postaccident recording requirements. [Applicable to BWRs only, 10 CFR 50.34(f)(2)(xxiv) - II.K.3.23]	See HD IP
(10) *Leakage Control* – The applicant should describe *how* the HSI provides for leakage control and detection in the design of systems outside containment that contain (or might contain) accident-source-term radioactive materials after an accident. [10 CFR 50.34(f)(2)(xxvi) - III.D.1.1]	See HD IP
(11) *Radiation Monitoring* – The applicant should describe *how* the HSI provides appropriate monitoring of in-plant radiation and airborne radioactivity under a broad range of routine and accident conditions. [10 CFR 50.34(f)(2)(xxvii) - III.D.3.3]	See HD IP
(12) *Manual Initiation of Protective Actions* – The applicant should describe *how* the HSI supports the manual initiation of protective actions at the system level for safety systems otherwise initiated automatically. [Regulatory Guide 1.62.]	3.1.3, 4.3.2.2
(13) *Diversity and Defense-in-depth* – The applicant should describe *how* the HSI provides displays and controls in the MCR for manual, system-level actuation of critical safety functions, and for monitoring those parameters that support them. These displays and controls are independent of, and different from, the normal I&C. [I&C BTP7-19, Point 4]	3.5.2, 4.3, 4.3.2.3, 4.14
(14) *Important HAs* – The applicant should describe *how* the HSI provides the controls, displays, and alarms that ensure the reliable performance of identified important HAs. Section 7 of this document discusses important HAs.	2.0, 3.4, 3.5.2, 3.5.3, 4.3, 4.3.1, 4.3.2, 4.7.1.2, 4.12, 4.14
(15) *Computer-Based procedure platform* - The applicant's computer-based procedures should be consistent with the design review guidance in NUREG-0700, Section 8, Computer-Based Procedure System and in Section 1 of DI&C-ISG-5 (NRC, 2008).	3.5.4.3, 4.7.1.7, 4.8 including all subsections
8.4.4.3 Technical Support Center NUREG-0696 states that HFE should be incorporated in the design of the on-site Technical Support Center (TSC), and considers both operating and maintenance personnel. The criteria in this section are applicable to the HFE aspects of the review of the TSC. The applicant's submittal should include the following:	3.3, 3.5.2, 4.6, 4.8.2, 4.9.3.1, 4.9.3.2, 4.17 including all subsections
(1) The applicant should describe *how* the HSIs give personnel the information needed to: • analyze the plant's steady-state and dynamic behavior before and throughout an accident so TSC personnel can guide the MCR ope rators in managing the abnormal conditions and mitigating the acc	See SPDS

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ident without interfering with the MCR activities • undertake the needed environmental- and radiological-monitoring functions of the EOF when it is not operational • offer technical support to personnel during recovery operations aft er an emergency • provide reliable voice-communications facilities to the control roo m, the operations support center, the EOF, the NRC, and with stat e and local operations centers	
(2) The applicant should describe *how* the HSIs give personnel the information needed for: • determining the plant's steady-state operating conditions before th e accident • ascertaining the transient conditions producing the initiating event • gauging plant systems' dynamic behavior throughout the accident • reviewing the accident sequence • deciding upon appropriate mitigating actions • evaluating the extent of any damage • assessing the plant's status during recovery operations	See above
(3) The applicant should describe *how* the HSIs provide an SPDS that replicates the SPDS in the MCR (to improve the exchange of information between personnel in the main control room and the EOF). If the SPDS in the main control room is composed of multiple displays, then multiple displays also should be provided in the TSC.	See SPDS
(4) The applicant should describe *how* the HSIs provide as a minimum, the set of variables specified in Regulatory Guide 1.97, Revision 4, plus all sensor data and calculated variables not specified in Reg. Guide 1.97 but included in the data sets for the SPDS, for the EOF, or for transmission to offsite locations.	See SPDS
(5) The applicant should describe *how* the HSIs allow all TSC personnel to complete their assigned tasks with unhindered access to alphanumeric and/or graphical representations of: • plant systems variables • in-plant radiological variables • meteorological information • offsite radiological information	See SPDS
(6) The applicant should describe *how* the HSIs provide the trend-information displays and time-history displays that give the TSC personnel a dynamic view of the plant's status during abnormal operating conditions.	See SPDS

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(7) The applicant should describe *how* HFE was incorporated into the TSC design to ensure that personnel easily understand and use the HSIs.	See above
8.4.4.4 Emergency Operations Facility NUREG-0696 states that HFE should be incorporated in the design of the Emergency Operations Facility (EOF) considering both operating and maintenance personnel. The criteria in this section are applicable to the HFE review of the EOF.	4.6, 4.9.3.1, 4.18
(1) The applicant should describe *how* the HSIs assure the acquisition, display, and evaluation of all radiological, meteorological, and plant-system data essential to determining offsite protective measures.	See SPDS
(2) The applicant should describe *how* the HSIs continuously indicate radiation dose-rates and concentrations of airborne radioactivity inside the EOF while it is used during an emergency, including local alarms with trip levels set to provide early warning to EOF personnel of adverse conditions that may affect the facility's habitability.	See SPDS
(3) The applicant should describe *how* the HSIs support reliable voice communications to the TSC, the main control room, the NRC, and the state and local emergency response facilities.	4.18
(4) The applicant should describe *how* the HSIs supply data sufficient to assess the actual and potential onsite and offsite environmental consequences of an emergency, and information on the general condition of the plant.	See SPDS
(5) The applicant should describe *how* the HSIs provide radiological, meteorological, and other environmental data to: • assess environmental conditions • coordinate radiological monitoring • recommend implementing offsite emergency plans As a minimum, the EOF data should include (1) sensor data of the variables specified in Reg. Guide 1.97, Revision 4, and (2) the meteorological variables specified in the proposed Revision 1 to Regulatory Guide 1.23, "Meteorological Measurements Programs in Support of Nuclear Power Plants," and in NUREG-0654, Revision 1, Appendix 2.	See SPDS
(6) The applicant should describe *how* the EOF HSIs provide all data that are available for display in the TSC, including information sent from the plant to the NRC.	See SPDS
(7) The applicant should describe *how* the HSIs allow all EOF personnel to perform their assigned tasks with unhindered access to alphanumeric and/or graphical representations of: • plant system variables	See SPDS

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• in-plant radiological variables • meteorological information • offsite radiological information	
(8) The applicant should describe *how* the HSIs display the needed trend information and time-history data in the EOF. The displays should be partitioned to facilitate the different functional groups in the EOF retrieving this information.	See SPDS
(9) The applicant should describe *how* the HSIs provide an SPDS to improve the exchange of information between the MCR and the TSC. If the SPDS in the MCR comprises multiple displays, they should also be provided in the EOF.	See SPDS
(10) The applicant should describe *how* HFE was incorporated into the EOF design to ensure that personnel easily understand and use the HSIs.	4.18
8.4.4.5 Remote Shutdown Facility (1) The applicant should describe *how* the HSI provides a design capability for remote shutdown of the reactor outside the main control room. [10 CFR 50, Appendix A, General Design Criteria 19]	3.2, 4.16 including all subsections
(2) The applicant should describe *how* the HSIs at the remote shutdown facility are consistent with those in the main control room.	3.2
8.4.4.6 Local Control Stations (1) The applicant should describe the basis for deciding which HSIs will be included in the main control room design, and which will be provided locally.	3.4
(2) The applicant should describe *how* HFE was incorporated into the HSIs for local control stations to ensure they are consistent with those in the MCR, and that personnel easily understand and use the HSIs.	3.4
8.4.5 Degraded I&C and HSI Conditions (1) The applicant should identify: • the effects of automation failures and degraded conditions on personnel and plant the performance • HFE-significant I&C degradations; i.e., the failure modes and degraded conditions of the I&C system that might adversely affect the HSIs personnel use to accomplish important HAs *Additional Information*: The I&C system is made up of four subsystems: Sensor, monitoring, automation and control, and communications. In this criterion, automation is considered separately due to its well-known human performance challenges and their potential impact on safety. The focus of this criterion is on HFE-significant I&C degradations. An example is a sensor degradation that results in a control room display that confuses	3.1.2, 3.1.3

NUREG-0711 Rev. 3 Review Criteria	Section and Paragraph
personnel into thinking there is a process disturbance.	
(2) The applicant should specify the alarms and other information personnel need to detect degraded I&C and HSI conditions in a timely manner, and to identify their extent and significance.	See HD IP
(3) The applicant should determine any needed back-up systems to ensure that important personnel tasks can be completed under degraded I&C and HSI conditions.	3.1.2, 3.1.3, 3.5.3, 4.1.1, 4.1.3.2, 4.1.4.3, 4.3
(4) The applicant should determine the necessary compensatory actions and supporting procedures to ensure that personnel effectively manage degraded I&C and HSI conditions, and the transition to back-up systems.	See HD IP
8.4.6 HSI Tests and Evaluations Tests and evaluations (T&Es) of concepts and detailed design features are conducted during the process of developing HSIs to support design decisions. This section provides review guidance for two types of T&Es: • Trade-off evaluations are comparisons between design options, based on aspects of human performance that are important to successful task performance, and to other design considerations. • Performance-based tests involve assessing personnel performance, including subjective opinions, to evaluate design options and design acceptability.	5.0, see HD IP
8.4.6.1 Trade-off Evaluations (1) In comparing design approaches, the applicant should consider those aspects of human performance important to performing tasks. The applicant should take into account the following factors when developing criteria to apply in selecting one design approach over another: • personnel-task requirements • human-performance capabilities and limitations • HSI-system performance requirements • inspection and testing needs • maintenance demands • use of proven technology and the operating experience of predecessor designs *Additional Information*: Including selection criteria for human performance will help to ensure that the differential effects of design options on human performance can be assessed, along with other considerations. For example, when analyzing trade-offs between using either a mouse or a touch screen as a computer-input device, the fatigue caused by using the device, and the time required to perform actions using each device should be considered.	5.0
(2) The applicant should state explicitly the relative benefits of design	5.0

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alternatives and the basis for the design approach selected.	
8.4.6.2 Performance-Based Tests (1) The applicant should identify the specific objectives of the tests. *Additional Information*: Performance-based tests have many different purposes, such as choosing between design alternatives or verifying that an aspect of the HSI meets performance criteria.	5.0
(2) The applicant should base the general approach to testing on the test's objective(s). The following aspects of the tests should be described (note that not all items are applicable to every type of test): • participants • testbed • design features or characteristics of the HSI being tested • tasks or scenarios used • performance measures • test procedures • data analyses	5.0
(3) The conclusions from the tests and their impact on design decisions should be described. Additional Considerations for Reviewing the HFE Aspects of Plant Modifications	5.0