

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.: 353-8372
SRP Section: 18 – Human Factors Engineering
Application Section: NUREG-0711 Section 8.4.3 HFE Design Guidance for HSIs
Date of RAI Issue: 12/22/2015

Question No. 18-85

Regulations: 10 CFR 52.47(a)(8) and 10 CFR 50.34(f)(2)(iii)

Regulatory Guidance: NUREG-0700 Section 1.6.1 criterion 1.6.1-2 VDU contrast

Evaluation: Contrast ratio for the Large Display Panel and printers are addressed. This characteristic is not addressed for VDUs.

Question: Explain why there is no specification on VDU contrast ratio.

Response

Section 4.1.1, "Information Flat Panel Display," of the Style Guide will be revised to address the video display units (VDUs) contrast ratio, as indicated in the attachment associated with this response.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical report APR1400-E-I-NR-14012-P/NP, Rev.0, "Style Guide," Subsection 4.1.1 will be revised, as indicated in the attachment associated with this response.

4 DISPLAY AND CONTROL DEVICES

4.1 Display Device

4.1.1 Information Flat Panel Display

- a) VDU Resolution - The display should have adequate resolution; i.e., users can discriminate all display elements and codes from maximum viewing distance.
- b) Geometric stability - The display should be free of "jitter".
- c) Image Continuity - The display should maintain the illusion of a continuous image, i.e., users should not be able to resolve scan lines or matrix spots.
- d) VDU Image Linearity - The display should be free of geometric distortion.
- e) Luminance Uniformity - All illuminations that are supposed to be the same intensity should appear to be the same intensity.
- f) VDU Controls - Frequently used controls should be easily visible and accessible to the VDU user from the normal working position.
- g) VDU Luminance Control - A control to vary the VDU luminance from 10 percent of minimum ambient luminance to full luminance should be provided.
- h) Refresh Rate - To avoid visible flicker, the refresh rate of VDU screens should be at least 55 Hz, and should be at least 70 Hz (100 Hz for dark characters on light background).
- i) Luminance - The minimum level of luminous intensity (see Definitions) for characters on a VDU screen should be 70 cd/m² (20 fL), and the preferred display luminance should be 80 to 160 cd/m² (47 fL). VDUs should provide a brightness adjustment to the user, but should limit minimum brightness to a visible level.

4.1.2 Large Display Panel

j) VDU Contrast - The contrast ratio of the display should be greater than 3:1; a contrast ratio of 7:1 is preferred.

- a) Provision - A LDP comprised of single or multiple screens should be provided in the control room to support operators in performing rapid assessment of plant status and in maintaining awareness of the big picture.
- b) Dedicated Display - The LDP should include both fixed (dedicated) and variable display regions. The LDP design should preclude information in dedicated regions from being obscured, modified or deleted during LDP use.
- c) Variable Display Region - The management of variable display region is performed by the reactor operator (RO), turbine operator (TO), electrical Operator (EO), and shift supervisor (SS). The selected display from operation console should be projected in the variable display.
- d) Alarm Indications - The LDP should allow operators to verify either the existence or absence of the dedicated alarm conditions that are displayed on the LDP. Alarm acknowledgment, including the LDP, should be integrated across display systems.
- e) Printout - Hard copy of the current indications on the LDP should be available on demand.
- f) Visibility - The LDP should provide unimpaired visibility from all consoles.
- g) Readability - The LDP should be designed for readability from the RO, TO, EO, SS, and shift technical advisor (STA) consoles.
- h) Timing Issues - The LDP data should be updated promptly so that agreement with other general display systems is maintained. Relevant timing issues should be considered, including rate of display update, display heartbeat, and system response time.
- i) LDP Maintenance - Choice of LDP technology and installation of hardware should consider impact of maintenance and repair requirements on continuous LDP availability.
- j) Control of Critical Information Display - Control of large-screen group display systems should be such that critical information cannot be modified or deleted inadvertently or arbitrarily.
- k) Projected Display Luminance Ratio - The luminance ratio provided by the projection system should be adequate for the type of material being projected.
- l) Minimize Keystone Effects - If projected displays are used, projector and screen should be arranged so as to minimize "keystone effect," i.e., distortion of projected data proportions due to non-perpendicularity between projector and screen.
- m) Minimum Viewing Distance - The display should not be closer to any observer than half the display width or height, whichever is greater.

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Question No. 18-88

Regulations: 10 CFR 52.47(a)(8) and 10 CFR 50.34(f)(2)(iii)

Regulation: NUREG-0700 Chapter 11, "Workstation Design"

Evaluation: The KHNP Style guide only addresses control room ergonomic configurations for the male population (Chapter 6, "Workstation and Workplace Design").

Question: Address control room ergonomic configurations for the female population.

Response

Descriptions and values of Section 6.1.2, "Sit-Down Console Design" and Section 6.1.3, "Stand-Up Console Design" in APR1400-E-I-NR-14012-P, "Style Guide" will be revised to address the 5th percentile female adult population. Also, Section 4.2, "Operator Consoles" of APR1400-E-I-NR-14011-P, "Basic Human-System Interface" will be revised, as indicated in the attachment associated with this response.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

- Technical report APR1400-E-I-NR-14012-P/NP, Rev.0, "Style Guide," Subsection 6.1.1 and 6.1.2 will be revised, as indicated in the attachment associated with this response.
- Technical report APR1400-E-I-NR-14011-P/NP, Rev.0, "Basic Human-System Interface," Subsection 4.2 will be revised, as indicated in the attachment associated with this response.

6 WORKSTATION AND WORKPLACE DESIGN

6.1 Console Design

6.1.1 General Console Design Guidelines

- Availability of Indications and Controls - Control rooms should have all the controls and displays needed to detect abnormal conditions and bring the facility to a safe condition, as required by Availability Analysis.
- Accessibility of Instrumentation and Controls - The operators should not need to leave the controlling workspace to attend to instrumentation on back panels during operational sequences which require continuous monitoring or timely control actions. Actions that must be taken promptly to assure plant safety should be capable of being performed directly from the control room.
- Operator Freedom of Movement - Operators should be able to move freely in the control room without overcoming obstacles such as filing cabinets, storage racks, or maintenance equipment. Adequate space should be available for the operator to freely get in and out from console operating positions.
- Communications - Dimensions and placement of desks, consoles and panels should not hinder voice communication between the primary operator and any other person in the primary operating area in not hindered or compromised.
- Field of View - Operators at desks/consoles in the controlling workspace should have an unobstructed view of all controls and displays on the consoles and the LDP.
- Procedure Laydown Space - Procedure laydown space should be assigned for each console.
- Dimensions - The guidelines apply to both operation and safety consoles.

6.1.2 Sit-Down Console Design

114 cm (45 inches)

69 cm (27 inches)

6.1.2.1 Sit-Down Console Dimension

female

- Console Height to See Over - Console height should be no more than approximately ~~76.3 cm (30 inches)~~ above the seat to accommodate the 5th percentile adult ~~male~~ when the seated operator must see over the console. Assuming seat height is adjusted to ~~40.6 cm (16 inches)~~, maximum console height therefore should be ~~116.9 cm (46 inches)~~ above the floor. 46 cm (18 inches)
- Seated Clearance - A seated operator should have at least 91 cm (36 inches) separating a console and any surface or fixed object behind him. The seated operator should also have at least 76 cm (30 inches) of space for lateral movement.
- Seat Position - Workstation seat position should not be permanently fixed, so that operators can adjust their location at the console. See also Section 6.1.2.3, Chairs.
- Leg and Foot Room - Sufficient leg and foot room should be provided to enable seated operators to avoid awkward and uncomfortable positions.
- Writing Space - Writing spaces should be at least 41 cm (16 inches) deep and 61 cm (24 inches) wide. If appropriate space is not provided on the panel for writing, a desk or other writing surface should be provided in the immediate work area. Writing space should supplement procedure laydown space.
- Control Height - All controls on a sit-down console should be within the reach radius of the 5th percentile ~~male~~. female
- Benchboard Slope - The benchboard slope, in conjunction with its depth, should be such that all controls are within the functional reach radius of the 5th percentile ~~male~~ all displays and markings can be read. 75
- Display Height and Orientation - All displays, including alarm indicators, should be within the upper limit of the visual field (~~70~~ degrees above the horizontal line of sight) of the 5th percentile ~~male~~, and should be mounted so that the angle from the line of sight to the display face is 45 degrees or greater. female and
(LOS)
- Location of Frequently Monitored Display - Video displays which require frequent or continuous monitoring, or which may display important (e.g., alarm) information, should be located not more than 35 degrees to the left or right of the operator's straight-ahead ~~Line Of Sight (LOS)~~, and not more than ~~25~~ degrees above ~~5th percentile male~~ and 40 degrees below ~~the 95th percentile male~~ the operators'

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horizontal LOS, as measured from the normal operator workstation.

- j) Location of Infrequently Monitored Display - Video displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located not more than 95 degrees to the left or right of the operator's straight-ahead LOS, as measured from normal operator work stations which permit full operator head and eye rotation.
- k) VDU Viewing Distance - The viewing distance should be 33-80 cm (13-31 inches), with 46-61 cm (18-24 inches) preferred.
- l) Use of Procedures and Other Reference Materials at Consoles - Provision should be made so that the procedures, manuals, and other reference materials can be consulted easily while task sequences are performed at the consoles.

6.1.2.2 Desks

- a) Working Space - Desks should provide enough clear working space for all materials required for task performance.
- b) Chair Positions - The desk should allow for different chair positions as required, with adequate knee space.
- c) Operator Comfort - The relationships of working surface height and area, knee room, and chair height should allow operators to work comfortably.

6.1.2.3 Chairs

- a) Backrests - Console chairs should have firm back rests, supporting the lumbar and cervical regions.
- b) Mobility - Chairs should pivot so that operator can readily adjust position.
- c) Armrests - Console chairs should have armrests.
- d) Cushioning - Console chairs should be well cushioned, with remaining resilience when the seat is occupied.
- e) Seat Adjustability - For chairs at sit-down stations, seat height should generally be adjustable from 38-45 cm (15 to 18 inches). ← from 41 to 52 cm (16 - 20.5 inches)
- f) Footrests - An adjustable footrest or heel catch should be provided to support the feet at a level no more than 18 inches below the seat surface. If a footrest is part of the chair, a circular design is recommended, diameter 18 inches. The footrest might be provided on the console base.

6.1.3 Stand-Up Console Design

6.1.3.1 Stand-Up Console Dimension female

- a) Standing Clearance - A single operator standing between two consoles should have at least 125cm (50 inches) between the consoles within which to move. Two operators working between two consoles should have at least 250 cm (96 inches) between the consoles.
- b) Control Height - The highest control on a stand-up console should be within the highest reach of the 5th percentile ~~male~~ without stretching or using a stool or ladder, while the lowest controls should be within the lowest reach of the 95th percentile male without bending or stooping.
- c) Benchboard Slope - The benchboard slope, in conjunction with its depth, should result in all controls being within the reach radius of the 5th percentile ~~male~~. ← female
- d) Control Distance from the Front Edge of the Console - Controls should be set back a minimum of 7.6 cm (3 inches) from the front edge to protect against accidental activation. LOS
- e) Display Height and Orientation - All displays, including alarm indicators, should be within the upper limit of the visual field (85 degrees above the horizontal ~~line of sight~~) of the 5th percentile male, and should be mounted so that the angle from the line of sight to the display face is 45 degrees or greater. 75
- f) Location of Infrequently Monitored Display - Video displays which do not require frequent or continuous monitoring, and which will not display important (e.g., alarm) information, should be located not more than 95 degrees to the left or right of the operator's straight-ahead LOS, as measured from normal operator workstations which permit full operator head and eye rotation.

6.1.4 Labeling, Demarcation, and Painting (coating)

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4.1.5 Mobility within the MCR

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4.2 Operator Consoles

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