KAERI/TR-2494/2003

技術報告書

인간공학 지침 HF-010 개정안 작성

Draft Revision of Human Factors Guideline HF-010

한 국 원 자 력 연 구 소

제 출 문

한국원자력연구소장 귀하

본 보고서를 2002년도 감시 및 운전지원 기술개발 과제의 기술보고서로 제출합니다.

2003. 5.

주 저 자 : 이 현 철
공 저 자 : 이 정 운
이 용 희
오 인 석

공동연구원 : 차 우 창(금오공대)
이 동 하(수원대)

요 약 문

원자력발전소의 인간기계연계체계(Man-Machine Interfaces System, MMIS) 설계시 인간공학의 고려는 안전성 및 생산성에 필수적인 요소로 인식되고 있으며, 인간공학을 설계에 적용하는데에는 인간공학적 분석기법 및 실험과 함께 인간공학 관련 표준(standard)과 지침(guideline)이 중요하게 활용되고 있다.

국내 설계회사에서는 인간공학적 설계를 위해 인간공학 지침인 Human Factors Engineering Guideline(HF-010)를 개발하여 사용하고 있는데, 최신의 디지털 MMI(Man-Machine Interfaces)에 관한 항목이 상대적으로 부족하여 개정의 필요성이 있다.

기존 HF-010의 검토결과, HF-010 Section 9. Computer Displays의 보완이 시급한 것으로 나타났으며, 원전계측제어시스템개발사업단의 감시 및 운전지원 기술개발과제에서 개발한 VDT 관련 인간공학 일반지침, PMAS Alarm System 인간공학 상세설계지침, PMAS SPADES 인간공학 상세설계지침, 그리고 전자식표시장치의 인간공학 설계지침 등을 기반으로 HF-010 Section 9. Computer Displays의 개정안을 작성하였다.

개정안은 첨단 MMI의 인간공학적 설계시 활용할 수 있는데, 디지털 기술의 발전에 맞추어 지속적인 개정을 수행하여야 높은 활용도를 유지할 수 있을 것이다.

SUMMARY

The Application of Human Factors to the design of Man-Machine Interfaces System(MMIS) in the nuclear power plant is essential to the safety and productivity of the nuclear power plants, human factors standards and guidelines as well as human factors analysis methods and experiments are weightily used to the design application.

A Korean engineering company has developed a human factors engineering guideline, so-call HF-010, and has used it for human factors design, however the revision of HF-010 is necessary owing to lack of the contents related to the advanced MMI(Man-Machine Interfaces).

As the results of the reviews of HF-010, it is found out that the revision of Section 9. Computer Displays of HF-010 is urgent, thus the revision was drafted on the basis of integrated human factors design guidelines for VDT, human factors design guidelines for PMAS SPADES display, human factors design guidelines for PMAS alarm display, and human factors design guidelines for electronic displays developed by the surveillance and operation support project of KNICS.

The draft revision of HF-010 Section 9 proposed in this report can be utilized for the human factors design of the advanced MMI, and the high practical usability of the draft can be kept up through the continuous revision according to the advancement of digital technology.

목 차

표 목차

1. 서론

원자력발전소의 인간기계연계체계(Man-Machine Interfaces System, MMIS) 설계시 인간공학의 고려는 안전성 및 생산성에 필수적인 요소로 인식되고 있으며, 인간공학을 설계에 적용하는데에는 인간공학적 분석기법 및 실험과 함께 인간공학 관련 표준(standard)과 지침(guideline)이 중요하게 활용되고 있다.
설계자는 설계시 인간공학을 고려하기 위해서 내부에서 축적된 경험과 더불어 다양한 분야에서 제공하고 있는 인간공학 표준이나 지침을 기반으로 설계를 진행하게 되는데, 각 설계자 혹은 설계사는 고유의 설계지침이나 표준을 개발하기 마련이다. 국내 설계회사인 한국전력기술㈜에서는 인간공학적 설계를 위해 인간공학 지침인 Human Factors Engineering Guideline(이하 HF-010이라고 함)를 개발하여 사용하고 있다[1].

300여개의 많은 항목으로 구성되어 있는 HF-010은 8개의 큰 항목으로 구분되어 있다(표 1 참조). HF-010의 내용은 주로 1981년에 발간된 NUREG-0700[2]을 기반으로 작성된 것으로 최신의 디지털 MMI(Man-Machine Interfaces)에 관한 항목이 상대적으로 부족하며, NUREG-0700이 2002년에 Revision 2[10]로 개정되면서 첨단 MMI부분을 대폭적으로 추가한 바 있으나 HF-010에 이에 대한 반영은 미흡하다.
2002년에 원전계측제어시스템개발사업단의 감시 및 운전지원 기술개발과제에서는 색상 및 조작특성 관련 한국인의 Stereotype조사실험을 수행하였고 이의 결과에 따라 HF-010를 개정할 필요가 있음을 보고한 바 있으며[3], 첨단 디지털 MMI인 Computer Display에 대한 중요도가 강조되고 있는 현실을 반영하기 위해 내용의 수정보완의 필요하며 이를 위해 감시 및 운전지원 기술개발과제에서 개발한 인간공학 설계지침을 활용하는 방안이 제기되었다[4].
본 보고서에서는 HF-010의 개정을 위해 수행한 작업 및 그 결과를 기술하고 있다.

표 1. HF-010의 목차

2. HF-010 개정안 작성

2.1 개정안의 기반

원전계측제어시스템개발사업단의 감시 및 운전지원 기술개발과제에서는 다음과 같은 인간공학 설계지침을 2002년과 2003년에 개발하였다.

- ◆ 조작 stereotype 조사분석 및 관련 지침[3]
- ◆ VDT 관련 인간공학 일반지침[5]
- ◆ PMAS Alarm System 인간공학 상세설계지침[6]
- ◆ PMAS SPADES 화면 인간공학 상세설계지침[7]
- ◆ 전자식 표시기에 대한 인간공학 설계지침[8]
- ◆ DPPS FPD 화면 설계지침(styleguide)[9]

위의 지침들 중에서 HF-010의 개정에 활용된 지침은 VDT 관련 인간공학 일반지침, PMAS Alarm System 및 SPADES 화면 인간공학 상세설계지침, 그리고 전자식 표시기에 대한 인간공학 설계지침이다.

VDT 관련 인간공학 일반지침는 미국 FAA(Federal Aviation Administration) 인간공학 지침, MIL-STD, NASA STD 등, 미국 정부기관 지침 자료, ANSI, ISO 등의 국제표준, NUREG-0700 Rev.2[10] 등의 원자력 분야 인간공학 지침 등을 망라하여 VDT 관련 인간공학 지침자료를 데이터베이스화하였고 이를 VDT 일반 인간공학 설계지침으로 정리한 것이다.

개발된 VDT 일반 인간공학 설계지침은 크게 Information Display, Interaction, Hardware, Environment의 4 종류로 분류하였으며 주요 지침별 VDT 지침항목 현황과 세부 항목 및 각 항목별 추출 지침의 개수는 다음의 표 2와 같다.

PMAS관련 인간공학 상세설계지침들은 VDT 관련 인간공학 일반지침를 토대로 작성되었는데, Alarm System과 SPADES화면에 관한 상세설계지침의 구성이 표 3과 4에 나타나 있다.

전자식 표시장치에 관한 인간공학 설계지침은 기존 원자력 분야의 지침에서 해당 지침 내용이 산재해 있거나 부족한 디지털 Bargraph, Paperless Recorder 등과 같은 전자식표시장치에 대한 지침을 개발하여 최근 추진되고 있는 국산화 개발에 도움을 주고자 개발하였으며 지침의 내용은 표 5와 같다.

표 2. VDT 지침 분류 항목 현황

	TITLE	대표항목 개수	가이드라인 개수
Information Display	1.1 Color	16	49
	1.2 Coding	22	105
	1.3 Display Elements	41	349
	1.4 Text Entry and Display	26	390
	1.5 Controls	14	173
	1.6 Windows	36	263
Interaction	2.1 Command dialogues	36	101
	2.2 Dialogue principles	10	8
	2.3 Direct manipulation	19	8
	2.4 Form-filling	22	30
	2.5 Menu dialogues	26	203
	2.6 User guidelines	77	232
Hardware	3.1 Visual Displays Quality	29	54
	3.2 Input devices	48	454
Environment	4.1 Control Room Environment	29	61
	4.2 Local Control Stations	31	62

표 3. 경보화면 상세설계지침 목차구성

표 3. 경보화면 상세설계지침 목차구성 (계속)

표 4. SPADES 화면 상세설계지침

표 5. 전자식표시장치의 인간공학 설계지침 내용

(1) General 1.1 Scope 1.2 Underlying Human Factors Principles 1.3 Definitions (2) Scale Design of Electronic Displays 2.1 Numbering of Scales 2.2 Axis Labels 2.3 Identification of Units of Measurement 2.4 Numeric Scales Start at Zero 2.5 Numbering Grids 2.6 Discontinuous Axes 2.7 Scale Range (3) Pointer Design Of Electronic Displays 3.1 Tip Style 3.2 Tip Position 3.3 Color and Contrast 3.4 Pointer Visibility (4) Design of Numeral on Scale of Electronic Displays 4.1 Numeral Orientation on Scale 4.2 Orientation on Circular Scales 4.3 Numeric Readouts (5) Electronic Recorders 5.1 Legibility 5.2 Contrast 5.3 Illumination 5.4 Visibility 5.5 User Annotation Capability 5.6 Smudging/Smearing 5.7 Scale Design 5.8 Scale Compatibility (6) Electronic Indicators 6.1 Precautions to Assure Availability of Electronic Indicators 6.2 Precautions to Assure Unambiguous Sensing by Operators 6.3 Precautions to Avoid Misinterpretation 6.4 Use as Alerting Indicators 6.5 Identification of Meaning 6.6 Emitting diode Intensity (7) Label design on Electronic Displays 7.1 Simplicity 7.2 Meaningfulness 7.3 Unambiguousness 7.4 Consistency 7.5 Compatibility 7.6 Readability 7.7 Salience	(8) Bar Type Graph Design on Electronic Display(general) 8.1 Demarcation of Groups 8.2 Actual System/Equipment Status 8.3 Choice of Setpoints 8.4 Readability Conditions of Top of Bar Type Graph (9) General Coding Guidelines on Electronic Display 9.1 Coding Display Items Requiring Rapid Discrimination 9.2 Meaningful Codes 9.3 Consistent Coding Across Displays 9.4 Readability of Coded Information 9.5 Coding and Transmission Time 9.6 Display Background Color for Coding (10) Alphanumeric Characters for Labels and Text used in Electronic Display Media 10.1 Style 10.2 Dimensions of Labels (11) Numeric Data in Digital Display 11.1 Number System 11.2 Leading Zeros 11.3 Maintaining Significant Digits 11.4 Display Range 11.5 Rate of Display Change 11.6 Direction of Change in Digital Display 11.7 Direct Display of Differences 11.8 Orientation of Numbers (12) Continuous Text Display used in Electronic Display 12.1 Standard Text Format 12.2 Consistency Between VDU-Based Text and hard copied Text 12.3 Clarity of Wording 12.4 Distinct Wording 12.5 Concise Wording 12.6 Inter-Line Spacing 12.7 Attention Symbols in Alphanumeric Displays 12.8 Hardcopy for Lengthy Text Displays (13) Color Coding in Electronic Display 13.1 Color Coding for Graphics 13.2 Use of Color 13.3 Color Coding to Draw Attention 13.4 Color Selection 13.5 Redundant Coding Dimensions

표 5. 전자식표시장치의 인간공학 설계지침 내용(계속)

(14) Analogs and Graphs used in Electronic Display (Electronic Recorder) 14.1 Dynamic Display Movements 14.2 Positive Indications 14.3 Display Failure Indications 14.4 Interpreting Graphs 14.5 Labeling Curves 14.6 Legend Ordering (15) Bar Graphs(specifications) 15.1 Labeling Single Bars 15.2 Labeling Paired Bars 15.3 Bar Spacing 15.4 Consistent Orientation of Bars 15.5 Zero Reference on Deviation Bar graphs 15.6 Normal Range on Deviation Bar graphs 15.7 Indication of Magnitude on Deviation Bar graphs 15.8 Size of Bar 15.9 Deviation Bar Graphs	(16) Flashing (17) Icons and Symbols used in Electronic Displays 17.1 Size of symbol 17.2 Number of Symbols

2.2 개정안의 작성

NUREG-0700은 1981년에 최초로 발간된 이후 Revision 1과 Revision 2[10]까지 발간된 인간공학 설계검토 지침으로 원자력발전소의 MMI를 대상으로 하고 있는 유일한 문서이다. HF-010이 이 문서를 참조하여 작성된 것은 당연하지만 NUREG-0700의 개정이 지속적으로 이루어지고 내용상으로도 확대된 것을 감안한다면 HF-010의 확대재편은 불가피한 현실이다. 특히 VDT관련 항목이 NUREG-0700 Rev.2에 상당부분 포함된 것에 비하여 HF-010의 Section 9. Computer Display의 내용은 부족한 실정이다. VDT관련 항목에 대해 NUREG-0700 Rev.2와 HF-010의 내용을 우선적으로 비교검토해 본 결과 많은 부분이 보충되어야 하는 것으로 드러났다. 부록 A에서는 두 개의 지침에서 공통적으로 포함하고 있는 부분과 NUREG-0700 Rev.2에만 포함되어 있는 항목을 보여준다.

원자력발전소 MMI중 VDT 기기의 사용증가로 인해 VDT관련 지침은 인간공학 지침에 반드시 포함되어야 하며 HF-010의 경우에는 추가하여야 할 필요성이 있는데, HF-010의 기타 부분은 기존 제어실로부터의 변화가 거의 없으므로 그대로 유지하는 할 수도 있지만, 기존의 Section 9. Computer Display에 항목추가는 불가피하고 최우선적으로 수행하여야 할 사항이다.

기존의 HF-010 Section 9. Computer Display에 최신의 지침을 추가하기 위해서는 세부목차의 조정이 필요하다고 판단하였는데, Section 9. Computer Displays 개정안의 구성은 현 지침 체제를 유지하기보다는 전반적으로 재구성이 불가피하므로 VDT 관련 인간공학 일반지침의 구성을 기반으로 하고, 여기에 개발된 기존 지침을 이용하고 구체적으로 계통설계를 지원하기 위해 Alarm과 SPDS를 추가하기로 결정하였다. VDT 관련 인간공학 일반지침이 Information Display, Interaction, Hardware, 그리고 Environment 등으로 구성되어 있으므로 Section 9의 세부목차는 6개로 결정되었지만 Hardware와 Environment의 내용을 통합하여 총 5개의 세부목차로 확정하였다.

목차의 결정이후 각 지침내용의 상세성정도에 대한 논의가 대두되었는데, HF-010이 계통설계 전반적으로 적용되고 있으므로 개정안에 포함되어야 할 지침의 수준은 특정계통에 적합하도록 개발된 상세설계지침보다는 일반 지침 수준을 갖도록 하였다. 이에 따라 VDT 관련 인간공학 일반지침 및 PMAS 관련 인간공학 상세설계지침의 내용중 HF-010의 전반적으로 상세성 수준에 비하여 너무 상세한 수준인 항목들은 개정안에서 제외하였다. 개별적으로 작성된 상세설계지침은 VDT 관련 인간공학 일반지침과 유사한 지침항목이 많이 존재하는데, 상호 공통적인 항목들은 VDT 관련 인간공학 일반지침에 관련된 Information Display와 Interaction에서만 언급하도록 하였으며, Hardware and Environment에 관련된 전자식 표시기에 대한 인간공학 설계지침은 상세한 항목들이 많아서 전반적으로 상향조정하였다. 기존 HF-010에 포함되어 있던 지침항목들은 개정안의 작성시 우선적으로 포함되도록 하였다.

작성된 HF-010 Section 9. Computer Display의 개정안이 부록 B에 기술되어 있다.

3. 결론

국내 설계사에서 활용하고 있는 인간공학 지침인 HF-010은 최신의 디지털기술이 적용된 MMI에 활용하기에 충분한 내용을 포함하고 있지 못하여 개정이 필요하였다. 본 연구에서는 원전계측제어시스템개발사업단의 감시 및 운전지원 기술개발과제에서 개발한 VDT 관련 인간공학 일반지침, PMAS Alarm System 인간공학 상세설계지침, PMAS SPADES 인간공학 상세설계지침, 그리고 전자식표시장치의 인간공학 설계지침 등을 기반으로 HF-010 Section 9. Computer Displays의 개정안을 작성하였다.

개정안은 첨단 MMI인 VDT기반의 인간공학적 설계시 활용할 수 있는데, 디지털기술의 발전에 맞추어 지속적인 개정을 수행하여야 높은 활용도를 유지할 수 있을 것이다.

참고문헌

[1] KOPEC, Human Factors Engineering Guideline, HF-010.
[2] NRC, Guidelines for Control Room Design Reviews, NUREG-0700, 1981.
[3] KAERI, 제어조작 관련 Stereotype 조사실험 및 인간공학 지침개발, KAERI/TR-2388/2003, 2003.
[4] KAERI, 인간공학 설계지침 검토세미나, 2003년 3월.
[5] KAERI, VDU 기반 워크스테이션의 일반 인간공학 설계지침 개발, 발간중, 2003.
[6] KAERI, PMAS 경보화면 설계지침 개발, 발간중, 2003.
[7] KAERI, PMAS SPADES 화면설계의 인간공학 지침 개발, 발간중, 2003.
[8] KAERI, 전자식 표시기에 대한 인간공학 설계지침 개발, 발간중, 2003.
[9] KAERI, DPPS FPD 화면설계를 위한 스타일가이드 개발, 발간중, 2003.
[10] NRC, Human System Interface Design Review Guidelines, NUREG-0700 Rev.2, 2002.

부록 A. VDT 관련 일반 인간공학 지침 비교 분석

▣ HF-010과 NUREG-0700 Rev.2에 있는 공통항목 (괄호안의 관련 항목 수)

[1. Information Display]

1.1.8 Unique Assignment of Color Codes

*** HF-010 (1)**

*** NUREG0700 (1)**

1.2.7.3 Area Coding

*** HF-010 (1)**

*** NUREG0700 (1)**

1.2.7.5 Display Range Coding

*** HF-010 (1)**

*** NUREG0700 (1)**

1.3.1.1 Between-Character Spacing

*** HF-010 (1)**

*** NUREG0700 (1)**

1.3.1.14 Character Height-to-Width Ratio

*** HF-010 (1)**

*** NUREG0700 (1)**

1.3.1.15 Character Stroke Width-to-Height Ratio

*** HF-010 (1)**

*** NUREG0700 (1)**

1.3.5 Numeric Data

*** HF-010 (2)**

*** NUREG0700 (8)**

1.3.9.1 Scales, labels, and coding

*** HF-010 (2)**

*** NUREG0700 (4)**

1.3.9.3 Lines and curves

*** HF-010 (2)**

*** NUREG0700 (11)**

1.3.9.6 Bar charts and histograms

*** HF-010 (1)**

*** NUREG0700 (10)**

1.4.5.1 Alphanumeric coding

*** HF-010 (1)**

*** NUREG0700 (2)**

1.4.6 Numeric and date/time format

*** HF-010 (1)**

*** NUREG0700 (8)**

1.6.1.1 Title bar and title

*** HF-010 (1)**

*** NUREG0700 (3)**

1.6.6 Window navigation

*** HF-010 (1)**

*** NUREG0700 (8)**

[2. Interaction]

2.5.1.1 Structuring into levels and menus (overall structure)

*** HF-010 (2)**

*** NUREG0700 (3)**

2.5.6.1 General

*** HF-010 (1)**

*** NUREG0700 (27)**

[3. Hardware]

3.1.1.1.2 Fill Factor

*** HF-010 (4)**

*** NUREG0700 (3)**

3.1.3.5 Blink coding

*** HF-010 (1)**

*** NUREG0700 (4)**

3.1.4.3 Screen Reflections

*** HF-010 (1)**

*** NUREG0700 (4)**

3.1.4.5 Image Polarity

*** HF-010 (1)**

*** NUREG0700 (2)**

3.1.5.3 Display Information Consistent with User Conventions

*** HF-010 (4)**

*** NUREG0700 (4)**

3.2.2.1.1 Palm-rests

*** HF-010 (1)**

*** NUREG0700 (7)**

3.2.4.2.3 Legend Pushbuttons

*** HF-010 (5)**

*** NUREG0700 (5)**

[4. Environment]

4.1.1.2.1 Air Quantity

*** HF-010 (1)**

*** NUREG0700 (1)**

4.1.1.2.2 Air Velocity

*** HF-010 (1)**

*** NUREG0700 (1)**

4.1.1.3.4 Task Area Luminance Ratios

*** HF-010 (1)**

*** NUREG0700 (1)**

4.1.1.3.6 Glare

*** HF-010 (9)**

*** NUREG0700 (1)**

4.1.1.3.7 Reflectance

*** HF-010 (1)**

*** NUREG0700 (2)**

4.1.2.4.1 Illumination Levels

*** HF-010 (6)**

*** NUREG0700 (1)**

▣ NUREG-0700 Rev.2 에는 있지만 HF010에는 없는 항목

1. Information Display

1.1.2 Foreground/background (3)

1.1.3.4 Use of Color (1)

1.1.6 Color Coding for Discrete Data Categories (1)

1.1.7 Color Coding for Relative Values (1)

1.1.9 Redundant Color Coding (1)

1.1.10 Unplanned Patterns from Color Coding (1)

1.1.11.1 Pure Blue (1)

1.1.11.2 Pure Red (1)

1.1.11.3 Red-Green Combinations (1)

1.2.5 Distinctive Coding of Critical Information (1)

1.2.6 Coding and Transmission Time (1)

1.2.7.1 Consistent Line Coding (1)

1.2.7.2 Line Coding (1)

1.2.7.4 Ordered Coding (1)

1.2.8.1 Limited Use of Size Coding (1)

1.2.8.2 Size Coding Proportional to Data Value (1)

1.2.8.3 Length Coding (1)

1.2.8.4 Pattern Coding of Extreme Values (1)

1.2.9.1 Flash Coding for Text (1)

1.2.9.2 Coding by Flash Rate (1)

1.2.10 Auditory Coding (24)

1.2.10.1 Distinctive Coding (1)

1.2.10.2 Pulse Coding (1)

1.2.10.3 Frequency Change Coding (1)

1.2.10.4 Discrete Frequency Coding (1)

1.2.10.5 Coding by Intensity (1)

1.3.1.9 Consistent Character Appearance (1)

1.3.1.10 Distinguishability of Characters (1)

1.3.1.11 Character Height (2)

1.3.1.12 Character width (1)

1.3.2 Abbreviations and Acronyms (8)

1.3.3 Labels (9)

1.3.4 Icons and Symbols (12)

1.3.6 Borders, Lines, and Arrows (5)

1.3.7 Highlighting by Brightness and Flashing (15)

1.4.4.6 Text font (2)

1.4.7 Paging (10)

1.4.8 Lists (7)

1.4.9 Tables (9)

1.5.4 Push buttons (14)

2. Interaction

2.1.2 Structure and syntax (1)

2.1.3 Feedback and help (1)

2.1.4 Command entry (1)

2.1.5 Complexity of command language (1)

2.1.8 Command entry area (1)

2.1.9 Distinctive wording of command (1)

2.1.10 Consistent wording of command (1)

2.1.11 Familiar wording (1)

2.1.12 Abbreviation of command (1)

2.1.13 Selection of command (1)

2.1.19 Punctuation (3)

2.1.24 Aiding Command Recall (1)

2.1.25 Command names (1)

2.1.26 Function keys and hot keys (33)

2.1.30 Misspellings (1)

2.1.31 Defaults (3)

2.2.8 Selection of Dialogue Types (1)

2.2.9 Flexible Interaction Design (1)

2.2.10 Dialogue Sequencing Flexibility (1)

2.3.1 When to Use Direct Manipulation (1)

2.3.2 Other Features of the Direct Manipulation Interface (1)

2.3.3 Fast Computer Response with Direct Manipulation (1)

2.3.4.1. Immediate Effect of Direct Actions (1)

2.3.6.2 Pointing and selecting (2)

2.4.1.1 General (14)

2.4.1.3 Fields and labels (4)

2.4.4.1 Initial cursor position (1)

2.5.5 Menu bars (3)

2.5.6.2 Selection of Menu Options (14)

2.5.6.4 Hierarchical Menus (14)

2.5.6.12 Arrangement of Menu Options (5)

2.5.6.13 Wording and Coding Menu Options (8)

2.6.1.2 General recommendations (72)

2.6.2.3 Prompting (7)

2.6.2.8 Prompting Command Entries (1)

2.6.2.9 Prompting User Entries (1)

2.6.2.10 User-Requested Prompts (2)

2.6.3.20 Feedback for User Entries (1)

2.6.3.21 Periodic Feedback (1)

2.6.3.22 Feedback During Data Entry (1)

2.6.4.5 Status of other systems or users (2)

2.6.5.3 Error correction by the system (6)

2.6.5.5 Error message (15)

2.6.6.6 On-Line Guidance (1)

2.6.6.7 HELP Request (1)

2.6.6.8 HELP Guidance (1)

2.6.6.9 Context-Sensitive HELP (1)

2.6.6.10 Clarifying HELP Requests (1)

2.6.6.11 Multilevel HELP (1)

2.6.6.12 Browsing HELP (1)

2.6.6.13 Return from HELP (1)

2.6.7.1 Validation on input (13)

3. Hardware

3.2.2.1.5 Profile of keyboard (1)

3.2.2.1.7 Keyboard placement (1)

3.2.2.1.8 Keyboard slope adjustment mechanism (1)

3.2.2.2.1 Key layout and center-line spacing (1)

3.2.2.2.2 Keytop design (3)

3.2.2.2.3 Key displacement and force (2)

3.2.2.6 Key repeat function (1)

3.2.2.8 Cursor keys and keys in the editing section (2)

3.2.2.9 Numeric keypad (2)

3.2.3.3.1 Mouse and Puck Devices (9)

3.2.3.3.2 Trackballs (7)

3.2.3.3.3 Joysticks (9)

3.2.3.3.4 Styli and Light Pens (7)

3.2.3.3.5 Tablets and Overlays (7)

3.2.3.3.6 Touch-Sensitive Panels (10)

3.2.4.2.1 General (3)

3.2.4.2.2 Round Pushbuttons (6)

3.2.4.3.2 J-Handless (1)

3.2.4.3.3 Key-Operated Controls (8)

3.2.4.3.4 Continuous Adjustment Controls (4)

3.2.4.3.5 Rotary Selector Controls (6)

3.2.4.4.1 Thumbwheels (4)

3.2.4.4.2 Slide Switches (6)

3.2.4.4.3 Toggle Switches (3)

3.2.4.4.4 Rocker Switches (5)

4. Environment

4.1.1.1.1 Comfort Zone (1)

4.1.1.1.2 Temperature Differential (1)

4.1.1.3.1 Illumination Levels (1)

4.1.1.3.2 Uniformity (1)

4.1.1.3.3 Supplemental Light (1)

4.1.1.3.5 Shadows (1)

4.1.1.3.9 Ambient Illumination and VDUs (1)

4.1.1.3.10 Use of Colored Ambient Illumination (1)

4.1.1.3.11 Illuminance of Areas Immediately Surrounding VDUs (1)

4.1.1.4.1 Automatic Action (1)

4.1.1.4.2 Operability(1)

4.1.1.4.3 Emergency Lighting Levels (1)

4.1.1.5.1 General (1)

4.1.1.5.2 Background Noise (1)

4.1.1.5.3 Background Noise Level (1)

4.1.1.5.4 Further Reductions (1)

4.1.1.5.5 Noise Distractions (1)

4.1.1.5.6 Reverberation Time and Sound Absorption (1)

4.1.2.1.1 Heat Stress (1)

4.1.2.1.2 Engneering Controls (1)

4.1.2.1.3 Work Practices (1)

4.1.2.1.4 Water Replacement (1)

4.1.2.2.1 Outdoor Equipment (1)

4.1.2.2.2 Wind Chill (1)

4.1.2.2.3 Effects of Cold on Performance (1)

4.1.2.2.4 Engineering Controls (1)

4.1.2.2.5 Work Practices (2)

4.1.2.3.1 Quieting the Work Process (1)

4.1.2.3.2 Limiting Noise Transmission (1)

4.1.2.3.3 Limiting Noise Exposure (1)

4.1.2.3.4 Hearing Protection (1)

4.1.2.3.5 Sound Attenuating Enclosures (1)

4.1.2.3.6 Auditory Capabilities of Users (1)

4.1.2.3.7 Communications and Hearing Protection (1)

4.1.2.4.2 Portable Lighting (1)

4.1.2.5.1 Permanent Means of Access (1)

4.1.2.5.2 Temporary Means of Access (1)

4.1.2.5.3 Appropriate Means of Access (1)

4.1.2.5.4 Sufficient Clearance (1)

4.1.2.5.5 Impediments to Access (1)

4.1.2.6.1 Vibration Levels (1)

4.1.2.6.2 Reducing Vibration (1)

4.1.2.6.3 Limiting Transmission of Vibration (1)

4.1.2.6.4 Reducing the Effects of Vibration (1)

부록 B. HF-010 개정안

9. COMPUTER DISPLAYS

9.1 INFORMATION DISPLAY

General Principle - Computer displays shall be designed for clarity, rapid error-free interpretation, and accurate presentation of information. Computer displays which are designed to perform control functions should comply with the guidelines of section 9 as much as practical. Computer hardware shall be designed to support this principle.

9.1.1 Display Format

Date, time, and page number except MENU page should appear on all displays which are supported by vertical and horizontal paging. This information may be deleted from other displays where it would add undue clutter

All displays should contain a clear title in double-height characters, located centered at the top of each page or another prominent method of identifying the display should be used.

All CRT displays shall use format, units and limits (scale range) that correspond to control board instrumentation and control.

To avoid "BUSY" screens, data should not change more often than 1 time a second and rapidly oscillating data shall be smoothed out.

9.1.2 Color

9.1.2.1 Foreground/background

A uniform nondistracting background color should be used with a hue/contrast that allows the data (foreground) to be easily visible and

which does not distort or interfere with the coding aspects of the display.

9.1.2.2 Color selection

Pure blue on a dark background should be avoided for text, for thin lines, or for high-resolution information.

Dominant wavelengths above 650 nanometers in displays should be avoided.

Whenever possible, red and green colors should not be used in combination.

9.1.3 Coding

9.1.3.1 Color Coding

Where color is used for coding, it should be employed conservatively and consistently.

Brighter and/or more saturated colors should be used when it is necessary to draw a user's attention to critical data.

Colors for coding should be based on user conventions with particular colors.

When color coding is used to group or highlight displayed data, all of the colors in the set should be readily discriminable from each other.

When color coding is used, each color should represent only one category of displayed data.

The following CRT colors and associations are recommended. Other color schemes compatible with MCB indicator, annunciator and demarcation colors may be used provided it can be demonstrated by the supplier that the standards of NUREG-0700 are met.

Red : On - Energized - Use to indicate status of plant components in graphic displays.

Yellow : Caution Alarm - Good attention getter - Use for priority 2 CRT alarms
(Amber)

Green : An easily visible but non-attention getting color. Use for displaying bars on charts, scale numbers, normal parameters.

Off : Deenergized - Use to indicate status of plant components in graphic displays.

Black : Use as the background color. May be used as the character color when reverse video (negative imaging) is used.

White : Another easily visible but non-attention getting color. Use white for alphanumeric data, titles, normal analog values, and page numberings, as well as menus, scale tics and X-Y lines.

Cyan : (Light Blue) - Looks similar to white. Use cyan for demarcation lines, status message and error messages.

Blue : Poor contrast - Limit use to advisory messages, graph scale lines and demarcation (Dark) lines.

Magenta : Good attention getting color but harsh to the eye. Use for radiation displays and stand-out items such as interrupt messages and priority 1 alarms.

Orange : A good attention getting color - Use for paging messages,

titles, and interupt messages.

Dim White : A non-attention getting color. Use for non-essentials and demarcation lines.

When using other than these color screens described above colors must be readily discriminable. Some options for more colors are light and dark green, light brown, light and dark red, and pink.

9.1.3.2 Brightness/intensity coding

Coding by differences in brightness should be used for applications that require discrimination between only two categories of displayed items on a VDU and up to three on a transilluminated display.

The bright state should be at least 100 percent brighter than the normal state.

9.1.3.3 Symbol coding

If a user wishes to defer entry of a required data item, the user should be required to enter a special symbol in the data field to indicate that the item has been temporarily omitted rather than ignored.

Symbol coding may be used to enhance information assimilation from data displays. Symbols shall be analogs of the event or system element they represent or be in general use and well known to the expected users. Where size difference between symbols is employed, the major dimensions of the larger shall be not less than 150% of the major dimension of the smaller. Not more than three size levels shall be used.

Graphic symbols should be readily understood, commonly used and should be consistent with or based upon standard P&ID symbols as much as is practical.

9.1.3.4 Spatial coding

Spatial coding should be used to give meaning to an item of information such as to identify it as a menu item, or to indicate title pages, information fields, alarms, and active and static display areas.

Standard information fields (such as the title, message area, location of labels for hard-wired multi-function keys, etc.) that are repeated on a set of displays should be placed in the same location on all of the displays.

9.1.3.5 Multidimensional coding

Coding dimensions may be combined when multiple meanings are appropriate. For example, a red object combined with blinking may combine the meanings "exceeds setpoint" and "attention urgently required."

9.1.3.6 Format Coding

Line coding should be used consistently across graphs.

Lines can be used to aid in focusing the user's attention on related information or to separate unrelated groupings of information. Line borders delineate the boundaries of menu bars, display control options, and entire windows. Lines can be coded by such attributes as width or thickness, color, and pattern (e.g., solid, dashed, and dotted).

When the orientation of a line is used to code direction or value, contextual information should also be provided.

The maximum number of widths for linewidth coding should be three.

Major display sections (for data display) should use one or two pixel wide demarcation lines for separation, or other methods such as spacing

allowing easy discerning of separation of display sections.

9.1.3.7 Size and Pattern Coding

Size coding should be used only for applications where displays are not crowded.

When patterns are used to code displayed areas, simple rather than elaborate patterns should be used.

Pattern density should vary with the value of the coded variable so that the least dense pattern is associated with one extreme and the most dense pattern with the other extreme.

9.1.3.8 Highlighting

When critical text merits emphasis to set it apart from other text, that text should be highlighted by bolding/brightening or color coding or by some auxiliary annotation.

Blinking (flashing) displays can be used for transition to computer alarm state (and suppressed when acknowledged) and for graphic displays where plant parameters exceed the setpoint and are shown out of bounds. Blink rates for these should not detract from readability.

No more than two flash rates should be used.

When flash coding must be used on text, the flash rate should be 1/3 Hz to 1Hz with an on/off cycle of 70%.

9.1.3.9 Auditory Coding

Auditory signals should be provided to alert the user to situations that require attention, such as an incorrect input action or a failure of the HSI to process an input from the user.

The intensity, duration, and source location of the signal should be compatible with the acoustical environment of the intended receiver as well as with the requirements of other personnel in the signal area.

Sound sources (speakers or buzzers) should direct sound toward the center of the main operating area.

When an audio signal must bend around major obstacles or pass through partitions, its frequency should be less than 500 Hz.

9.1.3.10 Text Coding

Within a text file or table, the use of a different font style should be preferred over the use of a different size for highlighting information.

When a line is placed under an item to mark or emphasize it, the line should not impair the legibility of the item, e.g., by obscuring the descenders.

Codes such as bold, italics, and underline should not be used to identify selection points if other conventional uses of these codes in the text, such as to emphasize certain words, is likely to confuse the user.

Paragraphs of text shall be separated by one blank line and be left justified.

9.1.4 Characters

Messages shall be concise but complete. Lettering shall be easily discriminable and readable.

Horizontal separation between characters or symbols should be between 10 and 65 percent of character or symbol height.

The font and size of alphanumeric characters should be consistent within a table and between related tables.

For a given font, it should be possible to clearly distinguish between the following characters: X and K, T and Y, I and L, I and 1, O and Q, O and 0, S and 5, and U and V.

The height of characters in displayed text or labels should be at least 16 minutes of arc and the maximum character height should be 24 minutes of arc.

Character height should subtend a visual angle of 15 minutes (viewing distance multiplied by 0.004) as a minimum; a visual angle of 20 minutes (viewing distance multiplied by 0.006) is preferred.

Characters used on labels should be sized to take into account viewing distances and illumination conditions.

Letter width-to-height ratio should be between 1:1 and 3:5. Numeral width-to-height ratio should be 3:5 except for the numeral "4," which should be one stroke width wider, and the numeral "1," which should be one stroke in width.

For fixed (as opposed to proportionally spaced) presentations, the height-to-width ratio should be between 1:0.7 to 1:0.9.

A minimum of two stroke widths or 15 percent of character height, whichever is greater, should be used for spacing between lines of text. Stroke width to character height ratio should be between 1:5 and 1:10.

9.1.5 Abbreviations and Acronyms

Abbreviations and acronyms should be used consistently and limited to those well known to the users.

Abbreviations should be avoided (except when terms are commonly referred to by their initialisms, e.g., SPDS).

When defining abbreviations that are not common to the user population, a simple rule should be used that users understand and recognize.

Abbreviations should be distinctive so that abbreviations for different words are distinguishable.

Abbreviations and acronyms should not include punctuation.

The use of the letters O and I in a non-meaningful code should be avoided since they are easily confused with the numbers 0 (zero) and 1 (one), respectively.

When codes combine both letters and numbers, letters should be grouped together and numbers grouped together rather than interspersing letters with numbers.

9.1.6 Labels

Clear visual definition of data fields should be provided so that the data are distinct from labels and other display features.

A field group heading should be centered above the labels to which it applies.

When headings are located on the line above related screen fields, the labels should be indented a minimum of five spaces from the start of the heading.

Labels should be meaningful words or accepted technical terms.

Label formats should be consistent across and within displays.

Labels should be worded consistently, so that the same item is given the same label whenever it appears.

Labels should be separated from one another by at least two standard character spaces.

The annotation of graphic displays, including labels for the axes of graphs, should be displayed in a normal orientation for reading text.

The label for a specific graphical object (e.g., an icon) should be placed in close proximity to the object.

9.1.7 Icons and Symbols

The primary use of icons in graphic displays should be to represent actual objects or actions.

An icon or symbol should be highlighted when the user has selected it.

Icons should be accompanied by a text label.

If icons are used to represent control action options, a label indicating the action should be associated with the icon.

Icons should be designed to look like the objects, processes, or operations they represent, by use of literal, functional, or operational representations.

Icons should be simple, closed figures when possible.

Abstract symbols should conform to user conventions or to common electrical and mechanical symbol conventions when user conventions do not exist.

Each icon and symbol should represent a single object or action, and should be easily discriminable from all other icons and symbols.

Special symbols to signal critical conditions should be used exclusively for that purpose.

Icons and symbols should always be oriented 'upright.'

Icons and symbols should be large enough for the user to perceive the representation and discriminate it from other icons and symbols.

9.1.8 Numeric Data

Columns of numeric data should be justified with respect to a fixed decimal point; if there is no decimal point, then numbers should be right-justified.

Numeric values should ordinarily be displayed in the decimal number system.

When users must compare aggregate quantities within a display, or within a series of displays, scaling of numeric data should begin with zero.

9.1.9 Borders, Lines, and Arrows

Meaningful differences between lines appearing in graphic displays, such as flow paths, should be depicted by using various line types, e.g., solid, dashed, dotted, and widths.

In flow charts and other graphics displays, arrowheads should be used in a conventional fashion to indicate directional relations in the sequential links between various elements.

Unnecessary borders should not be used in the display.

A border should be used to improve the readability of a single block of numbers or letters.

If several labels or messages are clustered in the same area, distinctive borders should be placed around the critical ones only.

Graphic lines should have a minimum density of 40 pixels per inch.

9.1.10 Graphs

Graphs should convey enough information to allow the user to interpret the data without referring to additional sources.

Scales and Units - Graphs on computer generated displays should use the same scales and units that operators are familiar with from MCR instrumentation and plant procedures.

The dependent variable should be on a consistent graph axis.

Bar charts should be used only when the operator can clearly and rapidly interpret them. All bars should be a minimum of 10 pixels wide to facilitate this. Color coding on bar charts should be used as delineated in the color section.

Wherever operationally feasible, small fluctuations shall be removed from limit lines and values for graphs and the limit lines made linear

(straight).

9.1.11 Lists

When a list of numbered items exceeds one display page, the items should be numbered continuously in relation to the first item on the first page.

Complete numbers should be displayed for hierarchic lists with compound numbers, i.e., repeated elements should not be omitted.

Lists should be formatted so that each item starts on a new line.

Where lists extend over more than one display page, the last line of one page should be the first line on the succeeding page.

For a long list, extending more than one displayed page, a hierarchic structure should be used to permit its logical partitioning into related shorter lists.

If a list is displayed in multiple columns, the items should be ordered vertically within each column rather than horizontally within rows and across columns.

Subclassifications in hierarchical lists should be indented by three (3) spaces with each new level of nesting

9.1.12 Tables

A table should be constructed so that row and column labels represent the information a user has prior to consulting the table.

Each row and column should be uniquely and informatively labeled and should be visually distinct from data entries.

Labels should include the unit of measure for the data in the table; units of measurement should be part of row or column labels.

Units should be included in column or row headings, not after every data entry (for tabular data).

Consistent column and row spacing should be maintained within a table, and from one table to another. Similarly, spacing between rows should be consistent within a table and between related tables.

In dense tables with many rows, a blank line, dots, or some other distinctive feature (to aid horizontal scanning) should be inserted after a group of rows at regular intervals.

9.1.13 Windows

Windows should be identified by a label consistently located at the top of the window's border.

The scroll motion rate should allow the user to scroll by line or by display unit.

ROLL and SCROLL commands should refer to the display window, not the text/data.

Additional Information: The display window should appear to the user to be an aperture moving over stationary text.

The user should have the ability to scroll through the contents of a window both horizontally and vertically.

Window types should be perceptually distinct.

An upper limit on the number of windows allowed to be open at one time should be defined to ensure that system response time is not compromised. If several windows are displayed at once, the window(s) in which action can be taken should be indicated.

The action that opens a window should automatically make that window active.

A temporary window object should not obscure critical control information and command entry interfaces of the active window.

Under normal operating conditions, active windows should be front most on the display.

User control of windows should operate consistently from one display to another for each type of window.

As appropriate to the user task, windows should be capable of the following operations: scrolling/panning, resizing, moving, hiding, activating, deactivating, copying to/from, zooming in/out, tabbing, and undo-last.

When control actions such as command entry may be taken by a user working within a window, those control actions should be consistent from one window to another.

Users should be able to select separate data windows that will share a single display screen.

When multiple windows are open simultaneously, the user should have the capability to easily tile, layer, or sequentially view the windows.

Automatically updated windows should have display freeze capability.

9.2 INTERACTION

9.2.1 Controls

Screen control locations and control options shall be clearly and appropriately indicated.

Icons may be used to represent operations, processes, and data structures graphically, and they may be used as a means of exercising control over system functions, components, and data structures.

Input and control devices provided for interacting with the HCI should be appropriate for the user's task requirements.

Designers should display fewer than 20 icons simultaneously on the same screen.

A push button shall have either a text or graphic label.

To ensure that the user knows that a pushbutton has been pressed far enough for activation, a positive indication should be provided.

Radio buttons shall be used if it is required that one and only one of a set of mutually exclusive options be selected.

Check boxes shall be provided if a user must be able to select any number including none of a set of options.

Combo boxes should be used when the user needs to be able to either select one of the displayed responses or enter a new response.

A graphic control allows for a simple interpretation of what the control represents and how it works. Specially designed graphics maintain this idea with each graphic being unique in appearance and function.

A specialized graphic clearly represents an actual physical object and is only used when it is less complicated than other options offered by the application.

Sliders are appropriate and should be used when users must set a value within a fixed range and the precise value is less important than relative position.

9.2.2 Dialogue

The selection of dialogue types should be based on anticipated task requirements, user skills, and anticipated system response time.

9.2.3 Direct manipulation

Direct manipulation should be used primarily in tasks with actions and objects that lend themselves to pictographic representation, and in which the actions and objects need not be modified for the successful interpretation of the command by the system.

When direct manipulation interaction is used, the system or application should use a pointing device as the primary means of manipulation.

9.2.4 Form-filling

Form filling should be provided as an aid for composing complex command entries.

9.2.5 Menu

All displayed information about a menu item shall be on a single page when feasible.

Broad and shallow menu structures, rather than narrow and deep menu structures should be used.

Menus should have a limited number of items in breadth and in depth.

Hierarchic menus should be organized and labeled to guide users within the hierarchic structure.

If meaningful categories cannot be developed for menu options then visual groups should be created for long menus.

9.2.6 User guidance

Users should be allowed to control the processing of information or commands by explicit action.

The results of any entry should be compatible with user expectations, so that the system changes in a 'natural' way in response to user actions.

When processing in response to an entry is lengthy, the user should be given some positive indication of subsequent completion.

Prompt messages should provide direction to the operator and shall display required action or options.

Error messages will be used when invalid (out of range) input is detected. They should specify corrective actions when appropriate.

Feedback messages should inform the operator of changes in system status.

9.2.7 Navigation

Multiple navigation paths should be provided to items in the display system.

Short navigation paths should be provided between display pages that will

be used one after the other.

Navigation targets should be easily detectable.

Users should be allowed to move easily from one page to another for displays which are partitioned into separately displayable pages.

Navigational links to and from high-level and lower-levels of information and to reference and supporting information should be provided when needed for operators' tasks.

Navigational links to cross-referenced information and to notes, cautions, warnings, reference material, and communication and help facilities should be provided.

9.2.8 Cursors

Cursors should have distinctive visual features (shape, blink, or other means of highlighting).

The cursor should not move beyond the display boundaries or disappear from sight.

The cursor should not be so distracting as to impair the searching of the display for information unrelated to the cursor.

The displayed cursor should be stable.

On the initial appearance of a data entry display, the cursor should appear automatically at some consistent and useful location.

When there is a predefined HOME position for the cursor, that position should be consistently defined on all displays of a given type.

When the user must repeatedly return the cursor to the origin or other specific screen location, automatic return or repositioning of the cursor should be provided.

9.3 HARDWARE AND ENVIRONMENT

Note - Hardware shall be supplied by NSSS, Turbine/Generator, and other vendors as part of plant package. However, the following criteria still apply.

9.3.1 Glare

All MCR CRTs should be fitted with glare shields or anti-glare screens or mounted at an angle empirically determined to minimize glare.

9.3.2 Resolution

CRTs should be capable of high resolution graphics.

Resolution shall exceed to a level so that all the elements on the screen can be seen naturally.

9.3.3 Contrast

Luminance contrast between display and background should be 15:1 minimum and 20:1 preferred.

9.3.4 Regeneration

Screen regeneration rate should be high enough to prevent perceptible flicker.

9.3.5 Refresh rate

Data refresh rates should not exceed once per second as this would be meaningless to the operator.

Refresh rates for data should, in general, be determined by task analysis and ability of plant detectors, both as determined by the supplier.

9.3.6 Luminance

Character luminance and screen luminance shall be 23 foot-lamberts

minimum and 46 foot-lamberts preferred. Less than 25% shall be through diffuse reflection of ambient illumination.

9.3.7 Response time

Computer response times shall correspond to NRC guidelines (Appendix D) or be empirically determined not to impact operator performance.

9.3.8 Input device

Keyboards shall support convenient display page access. Vertical and horizontal access keys shall permit quick maneuvers within a display hierarchy. Immediate access to crucial displays shall be provided.

9.3.9. Viewing Distance

A nominal viewing distance of 510 mm (20 in.) for VDT use shall be provided.

9.3.10. Viewing Angle

All areas of the display surface shall be legible from within at least 30 degrees of the axis centered on, and normal to, the screen.

9.3.11 Image formation time

Flat panel displays should ·have an image formation time less than 55ms.

9.3.12 Electromagnetic Compatibility

The magnitude of environmental magnetic fields should not exceed the susceptibility of the computer workstation display.

9.1.13 Static Electricity

The computer workstation should be free of electrostatic potentials in excess of ±500 volts. It should be cleaned of tactically precipitated dust periodically.

9.4 ALARM SYSTEM

9.4.1 Alarm Display Functions

The alarm display should support the user's ability to rapidly discern :

- -Priority (e.g., urgency for action and importance to plant safety);
- -Distinct alarm states: new, acknowledged, and cleared;
- -The first-out alarms for reactor trip;
- -The need to access other displays to verify or clarify the alarm state; and
- -The difference between alarms which can be cleared through ongoing corrective actions (i.e., by operations personnel) and alarms that require significant maintenance intervention.

To satisfy all alarm information needs, multiple alarm display formats, such as dedicated tile-like display and message lists may be necessary.

9.4.2 Alarm Information Content

The alarm should provide the following information:

- -Alarm title or legend;
- -Alarm source, i.e., the particular sensor or group of sensors supplying the signal;
- -Alarm priority;
- -Set-point and parameter values;
- -Required immediate operator actions; and
- -Reference to procedure for more detailed follow-up actions.

However, this information should be presented whenever possible, so long as it does not result in a confusing display or overload the operator with information. The system should not provide excessive information in a single display and should not employ excessive levels and/or dimensions for coding information

9.4.3 Use of Spatially Dedicated, Continuously Visible Displays

Spatially dedicated, continuously visible (SDCV) alarm displays should be considered for:

-Regulatory Guide 1.97 Category 1 parameters,
-Alarms that require short-term response,
-The most important alarms used in diagnosing and responding to plant upsets, and
-The most important alarms used to maintain an overview of plant and system status.

Spatial dedication means that the alarm messages always appear in the same position. Continuously visible means a parallel presentation method is used, i.e., the alarm information is always available to the operator, as opposed to serial presentation methods in which the operator must select the information to be seen..

9.4.4 Alarm Coding Consistency

Coding(e.g., flash-rate, intensity, and color coding) conventions should be consistently applied throughout alarm displays.

9.4.4.1 Redundant Coding Dimensions

Redundant codes (e.g., fast flashing or bright) should be used for alarms that require rapid operator action.

9.4.4.2 Coding of Alarm Priority

A method of coding the visual signals for the various priority levels should be employed.

Acceptable methods for priority coding include color, position, shape, and symbolic coding. Color and position (top to bottom) are especially effective visual coding methods. However, coding priority by alarm element position can disrupt the functional grouping of elements and

should not be used when the loss of functional grouping may affect the operator's ability to effectively use alarm information. In this case, another dimension, such as color, should be used for priority coding.

9.4.4.3 Spatial Coding

Spatial coding may be used to indicate alarm importance.

Spatial coding can be effective especially in VDU types of alarm presentation. In an otherwise variable alarm display, having a dedicated or consistent location for presentation of important alarms will enhance operators' ability to detect them

9.4.5 Functional Grouping of Alarms

Alarms within a display should be grouped by function, system, or other logical organization.

9.4.5.1 Visual Distinctness of Functional Groups

Alarm functional groups should be visually distinct from one another.

Although the concept of functional grouping is typically applied in the context of spatially dedicated, continuously visible displays, it can be applied to alarm lists as well.

9.4.5.2 Message Listing Options

In addition to priority grouping, operators should have the capability to group alarm messages according to operationally relevant categories, such as function, chronologicl order, and status (unacknowledged, acknowledged/active, cleared).

Grouping alternatives should not interfere with the operator's detection of high-priority alarms

9.4.5.3 Simultaneous Display of High-Priority Alarms

For non-spatially dedicated alarm presentations such as VDU message lists, sufficient display area should be provided for the simultaneous viewing of all high-priority alarms.

If non-spatially dedicated alarm displays are used, they should have sufficient display space available for simultaneous presentation of all high-priority alarms under the worst credible conditions. Operators should never have to page or scroll a display to view high-priority alarms

9.4.5.4 Listing by Priority

Lists of alarm messages should be segregated by alarm priority with highest priority alarms being listed first

9.4.6 Alarm Text/Legend

Alarm text should be clearly understandable, use standard terminology, and address conditions specifically.

9.4.6.1 Alarm Source Identification

The content of each message should provide information that identifies the alarm source.

9.4.6.2 Setpoint Values

If an alarm condition requires verification before action is taken, the relevant setpoint limits should be included in the alarm message when alarm information is presented on a VDU or is printed.

9.4.6.3 Parameter Values

Deviant parameter values should be included in the alarm message where alarm information is presented on VDU or printer displays.

9.4.7 Blank Lines for the Alarm Lists

Alphanumeric alarm lists should have a separation (blank row) between every four or five alphanumeric messages.

9.4.8 Coordination of Alarm Alerting and Informing Functions

When alarm alerts are displayed separately from detailed alarm information, the design should support the operator in making rapid transitions between alerts and detailed information.

9.4.9 Presentation of Alarm Priority with Detailed Alarm Information

When alarm alerts are displayed separately from detailed alarm information, the detailed alarm information display should provide an indication of the priority and status(e.g., new and acknowledged) of the alarm condition.

9.4.10 Separation of Status Indication

Status indications, messages that indicate the status of plant systems but are not intended to alert the operator to the need to take action, generally should not be presented via the alarm system display because they increase the demands on the operators for reading and evaluating alarm system messages.

If the presentation in the alarm display of status indications is justified on the basis of the unique aspects of the design, such status messages should be designed so that operators may readily distinguish them from true alarm messages.

9.4.11 Alarm Graphics

The graphics related to alarm presentation should be designed such that the display is fully contained in one VDU screen.

For example, the operators should not have to scroll the graphic of the

overall reactor system, a major subsystem such as the primary system, or a portion of the subsystems, such as the pressurizer, to access a complete set of related alarm messages.

9.4.12 Indication of Alarm Status

New, acknowledged, and cleared alarm states should have unique presentations to support the operators' ability to rapidly distinguish them

9.4.12.1 New Alarms

New alarms should be indicated both by visual (e.g., flashing) and audible means

9.4.12.2 Notice of Undisplayed New Alarms

If the operator is not currently viewing the VDU display where new, unacknowledged alarm messages appear, the alarm system should notify the operator that a new alarm message is available, the priority of the alarm message, and the location where the alarm message can be found.

9.4.12.3 Acknowledged Alarms

After the operator has acknowledged an alarm (e.g., pressed the acknowledge button), the alarm display should change to a visually distinct acknowledged state and the alerting function (e.g., audible tone) should cease.

Reverse video (or dark letters on light background) can be used to highlight acknowledged but uncleared alarms and for urgent messages.

9.4.12.4 Clearing Alarms/Ringback

If the operator is required to take action when an alarm clears (i.e., the parameter returns to the normal range from an abnormal range), the return to normal conditions should be indicated by visual and audible

means.

9.4.13 Required Immediate Operator Actions

Immediate operator actions should be presented or made available directly upon operator request when alarm information is presented on VDU or printer displays.

To meet the general alarm system principle of guiding the operator's response to an alarm, the immediate actions should be provided to the operator. For conventional alarm systems, the immediate operator actions should be available in Alarm Response Procedures that are clearly and simply keyed to an alarm tile and located nearby for easy and quick reference.

9.4.14 Format for Tile Displays

The format of messages on alarm tiles or tile-like displays should be consistent for all alarms. Information on a tile might be organized as follows: top line, name of alarmed parameter; middle line, alarm setpoint value; bottom line, indication of severity.

9.4.15 User-Defined Alarms/Setpoints

The alarm system may provide temporary, user-defined alarms and user-defined set points for specific conditions where such alarms are determined to be of assistance in selected evolutions (e.g., temporary alarms to support increased monitoring of a problem component, or at other times when the user wants to know of a parameter trend that is approaching a limit).

9.4.15.1 Interference of User-Defined Alarms/Setpoints with Existing Alarms

User-defined alarms and setpoints should not override or interfere with the existing alarms and setpoints.

9.4.15.2 Indication of User-Defined Alarms/Setpoints

The alarm system should provide clear indication of user-defined alarms and setpoints as distinct from the alarm/setpoints designed into the system.

9.4.16 Message Overflow

Alphanumeric alarm messages that overflow the first page of alarm messages should be kept on subsequent alarm pages.

9.4.17 Preclude of Message Scrolling

The method of adding alarm messages to the list should preclude message scrolling.

Scrolling makes it difficult to read alarm messages, especially when many alarms are coming in. An alternative method of viewing alarm lists, such as paging, is preferred.

9.4.18 Paging in One or Multiple Page Increments

Users should be able to page in one page or multiple page increments.

The user might page multiple pages directly by moving the page icon on the scroll bar, at which time the display might move to the location in the file that corresponds to the page number on the page icon.

9.4.19 Provisions for Control Functions

Separate controls should be provided for silence, acknowledgment, reset (acknowledging an alarm that has cleared and returning it to normal), and testing.

9.4.20 Distinct Coding of Control Functions

Alarm system controls should be distinctively coded for easy recognition..

9.5 SPDS

General

SPDS should have functions to aid control room personnel during abnormal and normal operating conditions in determining the safety status of the plant.

SPDS should provide a concise display of critical plant variables to the expected users to aid in rapid and reliable assessment of the safety status of the plant.

SPDS should serve as an aid to evaluate the current status of and/or the challenges to the plant safety, in executing function-oriented procedures and monitoring the impact to the safety during anticipated transients and the initial phase of accident as well as the emergencies.

SPDS should adhere to all guidelines in Section 9 of this document.

9.5.1 Readily perceived and comprehended information

SPDS displays should be designed to be readily perceived and comprehended by the expected users.

Display conventions should be consistent throughout all SPDS displays.

SPDS display should be readable from the emergency station of control room operators responsible for evaluating the safety status of the plant.

The displayed contents should be readable by satisfying the human factors criteria for viewing angle, viewing distance, flicker, glare, noise, contrast, and location for standing and seated positions of the designated operating crew members.

9.5.2 Sufficient, minimum and critical information

SPDS should display critical information enough to aid the expected users in assessing, evaluating and mitigating the plant safety status.

SPDS should display a specific minimum set of parameters and the safety functions pre-determined by human factors and other technical analyses.

The minimum information to be provided by SPDS should be sufficient to provide information to plant operators about the pre-determined critical safety functions.

To monitor the process and the safety status of the plant, the operators must be able to evaluate each of the pre-determined critical safety functions or their equivalents.

A pre-determined minimum set of critical plant variables will help the expected users evaluate plant safety. The variables selected for SPDS should be ensured by the supporting analyses. The design of the display should have single primary display format for each mode of plant operation.

For each operating mode, display formats may either be automatically displayed or manually selected.

9.5.3 Concise display

SPDS displays should be concise for the expected users to figure out the meaning of the information.

A concise display of critical plant variables will help the expected users compare data from related plant functions and assess the safety status of the plant.

9.5.4 Rapid and reliable determination of safety status

In order for the expected users to rapidly and reliably determine the safety status of the plant, the displayed data represent the current and correct status of critical plant variables.

In order to keep the expected users current on the safety status of the plant, the display should be responsive to transient and accident sequences.

To prevent misleading the expected users, displayed data should be validated on a real-time basis where practical.

To instill the expected users' confidence in the use of displayed data, members of operating crew should be provided with the information and criteria they need to perform an operability evaluation of the SPDS. In addition, the crew must be able to easily recognize a failed SPDS.

9.5.5 Aid to control room personnel

To aid the control room personnel in evaluating the safety status of the plant during conditions that could have safety significance, the display should be capable of presenting magnitudes and trends of critical plant variables or derived variables.

To help control room operators detect abnormal conditions which warrant corrective actions, the SPDS, where feasible, should include perceptual cues to alert the personnel to the abnormal operating condition.

9.5.6 Convenient location

To be convenient to the expected users, the SPDS may be located on the control board. If the SPDS is a part of control boards, it must be easily recognized and readable.

To be convenient to the expected users, the display system should not interfere with the users' normal movement. The display system should not interfere with full visual access to other operating systems and with displays important for safe operation.

9.5.7 Continuous display

SPDS should continuously display information from which the safety status of the plant can be readily and reliably assessed by the expected users, especially control room personnel responsible for the avoidance of degraded and damaged core events.

A continuous single-format primary display is not necessary. The primary display may be a continuous indication of individual plant variables. The main concern is that the expected users are made aware of important changes in critical safety-related variables when they occur and that the users can readily obtain information from the SPDS to help them determine the safety status of the plant.

9.5.8 VDT syndrome

SPDS should avoid the possible negative VDT syndrome due to the psycho-physiological and visual-auditory characteristics of the provided hardwares.

9.5.9 Procedure and training

Control room personnel should be trained to respond to accident conditions both with and without the SPDS available.

Procedures will be developed in parallel with the development of SPDS. Procedures should describe the timely and correct safety status assessment when the SPDS is and is not available.

As the SPDS is not a Class 1E qualified display, compensatory measures

should be provided for control room operators when the SPDS is inoperable.

No additional operating staff other than the normal control room operating crew should be needed to operate the display during normal and abnormal plant operation and during display outages.

서 지 정 보 양 식

수행기관보고서번호	위탁기관보고서번호	표준보고서번호	INIS 주제코드
KAERI/TR-2494/2003			

제 목 / 부 제	**인간공학 지침 HF-010 개정안 작성**
연구책임자 및 부서명 (AR,TR 등의 경우 주저자)	이현철(계측제어.인간공학연구부)
연 구 자 및 부 서 명	이용희, 오인석, 이정운 (이상 계측제어.인간공학연구부) 차우창(금오공과대학교), 이동하(수원대학교)

출 판 지	대전	발행기관	한국원자력연구소	발행년	2003
페 이 지	57 p.	도 표	있음(0), 없음( )	크 기	Cm.
참고사항					
비밀여부	공개(0),대외비( ),__ 급비밀		보고서종류	기술보고서	
연구위탁기관			계약 번호		

초록 (15-20줄내외)

원자력발전소의 인간기계연계체계(Man-Machine Interfaces System, MMIS) 설계시 인간공학의 고려는 안전성 및 생산성에 필수적인 요소로 인식되고 있으며, 인간공학을 설계에 적용하는데에는 인간공학적 분석기법 및 실험과 함께 인간공학 관련 표준(standard)과 지침(guideline)이 중요하게 활용되고 있다.
국내 설계회사에서는 인간공학적 설계를 위해 인간공학 지침인 Human Factors Engineering Guideline(HF-010)를 개발하여 사용하고 있는데, 최신의 디지털 MMI(Man-Machine Interfaces)에 관한 항목이 상대적으로 부족하여 개정의 필요성이 있다.
기존 HF-010의 검토결과, HF-010 Section 9. Computer Displays의 보완이 시급한 것으로 나타났으며, 원전계측제어시스템개발사업단의 감시 및 운전지원 기술개발과제에서 개발한 VDT 관련 인간공학 일반지침, PMAS Alarm System 인간공학 상세설계지침, PMAS SPADES 인간공학 상세설계지침, 그리고 전자식표시장치의 인간공학 설계지침 등을 기반으로 HF-010 Section 9. Computer Displays의 개정안을 작성하였다.
개정안은 첨단 MMI의 인간공학적 설계시 활용할 수 있는데, 디지털 기술의 발전에 맞추어 지속적인 개정을 수행하여야 높은 활용도를 유지할 수 있을 것이다.

주제명키워드

인간공학, 설계지침, Computer Display

BIBLIOGRAPHIC INFORMATION SHEET

Performing Org. Report No.	Sponsoring Org. Report No.	Standard Report No.	INIS Subject Code
KAERI/TR-2494/2003			

Title / Subtitle	**Draft Revision of Human Factors Guideline HF-010**
Project Manager and Department (or Main Author)	Hyun-Chul Lee (I&C/Human Factors Research Dep't)
Researcher and Department	Yong-Hee Lee, In-Seok Oh, Jung-Woon Lee (I&C/Human Factors Research Dep't) Woo-Chang Cha (Kumoh National Univ. of Technology) Dhong-Ha Lee (Suwon University)

Publication Place	Daejeon	Publisher	KAERI	Publication Date	2003
Page	57p.	Ill. & Tab.	Yes(o), No ( )	Size	Cm.
Note					
Classified	Open(V), Restricted( ), ___ Class Document		Report Type	Technical Report	
Sponsoring Org.			Contract No.		

Abstract (15-20 Lines)

The Application of Human Factors to the design of Man-Machine Interfaces System(MMIS) in the nuclear power plant is essential to the safety and productivity of the nuclear power plants, human factors standards and guidelines as well as human factors analysis methods and experiments are weightily used to the design application.
A Korean engineering company has developed a human factors engineering guideline, so-call HF-010, and has used it for human factors design, however the revision of HF-010 is necessary owing to lack of the contents related to the advanced MMI(Man-Machine Interfaces).
As the results of the reviews of HF-010, it is found out that the revision of Section 9. Computer Displays of HF-010 is urgent, thus the revision was drafted on the basis of integrated human factors design guidelines for VDT, human factors design guidelines for PMAS SPADES display, human factors design guidelines for PMAS alarm display, and human factors design guidelines for electronic displays developed by the surveillance and operation support project of KNICS.
The draft revision of HF-010 Section 9 proposed in this report can be utilized for the human factors design of the advanced MMI, and the high practical usability of the draft can be kept up through the continuous revision according to the advancement of digital technology.

Subject Keywords (About 10 words)

Human Factors, Design Guideline, Computer Display