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Applying Current Human Factors Engineering Guidance to Control Room Design

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ABSTRACT

The Westinghouse Savannah River Company (WSRC), a contractor to the Department of Energy, has compared Revisions 1 and 2 of NUREG- 0700 – Human System Interface Design Review Guideline, from the United States

Nuclear Regulatory Commission Nuclear Regulatory Guide. The comparison has been made between the two different revisions of NUREG-0700; specifically with respect to which guidelines remained the same, the guidelines that were reformatted or reworded, additional guidelines, and deleted guidelines. This comparison was made in preparation of revising the previously developed Human Factors Engineering Analysis Tool (HFE-AT) for automating the review, analysis, and evaluation of human system interface designs. This tool has been described at a previous IEEE Conference on Human Factors and Power Plants and the merits and benefits of the tool described at the 13th Annual Joint ISA/POWED/EPRI Controls and Instrumentation Conference. The tool has been successfully applied by WSRC to over eight facilities at the Savannah River Site (SRS).. This paper describes the methodology and results of the comparison and the plans to enhance the already successful automation tool. The number of criteria in NUREG-0700 increased from approximately 1650 in Revision 1 to almost 2200 in Revision 2. Approximately 1600 criteria remained the same, though they were significantly reorganized; while about 100 were reworded or reformatted to clarify or expand the guidance provided. Around 600 guidelines were added and approximately 70 deleted. The majority of the changes and additions reflect the recent impact that computer technology has had on industrial process control system human system interfaces and control rooms.

INTRODUCTION

The importance of human factors considerations in the design of process control systems has often been made painfully obvious. The accident at Three Mile Island was a classic example in which operator errors were committed in-part by human factor deficiencies in control room design. The Westinghouse Savannah River Company (WSRC) operates and maintains numerous nuclear and chemical process facilities at the Savannah River Site (SRS) in Aiken, SC. In an effort to minimize the opportunity for human error, WSRC has implemented the practice of conducting detailed Human Factors Engineering (HFE) design reviews of its existing and planned process control systems Human System Interfaces (HSI). Of the many existing standards addressing HFE, WSRC has found that NUREG 0700 [1] provides the most comprehensive set of guidelines for evaluating process control systems and control room design.

Conducting an HFE design review can be a very arduous and time consuming process. Therefore, WSRC recently developed a software application, HFE-AT (Human Factors Engineering – Automation Tool), that automates the design review process [2]. HFE-AT is a PC compatible, user friendly, application that enables the user to automatically select the appropriate design review guidelines contained in NUREG 0700 Revision 1, evaluate a given human system interface design against the selected guidelines, and produce a compliance report summarizing the results. HFE-AT applies a graded approach to generate an appropriate list of review guidelines based on safety function and the presence of

computer automation in the (HSI) design. Using the software tool has provided a more consistent and cost effective method for conducting reviews. HFE-AT maintains a database (MS Access) of completed design reviews making it possible to easily recall and modify existing reviews or create templates from previous reviews for evaluating similar systems. To date, eight HFE design reviews have been conducted by WSRC using HFE-AT. This experience has shown that design reviews which previously took months to conduct could now be completed in several weeks [3].

The current version of HFE-AT incorporates the HFE guidelines contained in NUREG 0700 Revision 1, 1996. In 2002, the NRC issued NUREG 0700 Revision 2, which contains most of the original 1648 design review guidelines. In addition, 600 guidelines were added in order to remain current with recent advances in computer automation, computer system architecture, information technology, and control room design.

This paper will describe the differences between Revision 1 and Revision 2 of NUREG- 0700 – Human System Interface Design Review Guideline, from the United States Nuclear Regulatory Commission Nuclear Regulatory Guide. A review using these new guidelines can be made on present control rooms even when an upgrade is not being planned or implemented.

BACKGROUND

It is not the intention of this paper to describe previous Human Factors Guides, IEEE Standards #845 [4], #1023 [5], #1046 [6], and #1289 [7], previous IEEE paper [2], previous ISA paper [3], nor NUREG-0700 Revision 1[1] and Revision 2 [8] but to describe the work performed by Westinghouse Savannah River Company to compare Revision 1 with Revision 2 guidelines in preparation of upgrading the tool described above. A previous paper [2] described the tool developed to automate the HFE review.

NUREG-0700, Revision 1 [1] provides the Human Factors Engineering (HFE) guidelines, which can be used to review a specific HSI design and/or implementation. The HFE review guidelines address both advanced and conventional HSI's. The contents of the individual sections of the Revision 1 guideline are:

1. Information Display
2. User-System Interaction
3. Process Control and Input Devices
4. Alarms
5. Analysis and Decision Aids
6. Inter-Personnel Communication
7. Workplace Design

8. Local Control Stations

In a previous study [2], it was determined that approximately 20 % of the guidance applied only to non-computer based components of the HSI. These covered hardwired panel indications and controls, alarms, communications systems, and work place environment. An additional 32 % of the guidelines were general enough as to apply to both non-computer and computer based components, with the remaining 48 % applying specifically to computer automated functions. Of the 1648 guidelines, 110 were considered to be general concepts with supporting detail provided by more than 600 subordinate guidelines. Approximately 740 guidelines were considered to be standalone. Approximately 45 % of all the guidelines were considered to apply only to systems performing safety functions. This breakdown of the design review guidelines in Revision 1 provided the basis for automating the design review process. By selecting the main focus areas of a process control system to be evaluated, designating its importance to safety, and indicating the use computer automation, the HFE-AT selectively produced an appropriate subset of design guidelines to use in conducting the design review.

Although not all industries are required to use NUREG-0700, it does provide a baseline which facilities can use to substantiate their control room designs and implementation, especially when queried by their respective regulatory agencies.

COMPARISON OF REVISION 1 WITH REVISION 2

Most of the original guidelines in Revision 1 have been included in Revision 2, though much of it has been reorganized to the point that most guidelines in Revision 2 no longer retain the same reference number used in Revision 1. This has made it difficult to compare reviews conducted using Revision 1 with those using the guidelines in Revision 2. In addition, Revision 2 has reworded more than 100 guidelines and added approximately 600 new guidelines. Approximately one third of the new guidelines provide additional guidance on many of the original topics mentioned earlier, particularly on the subjects of information display and user-system interface. The remaining two thirds provides new guidance concerning many of the new features and functions that computer automation and information technology has added to the HSI during the last decade. Some of the topics covered include:

- the use of "soft" control systems
- computer automated procedure systems
- navigation, display and data hierarchy
- data validation and error detection
- present and future process and system status
- using multiple displays and windows
- computer automated operator support systems such as electronic status boards and automated round sheets

Reinforcing its historical emphasis on safety, NUREG 0700 Revision 2 has devoted a separate section on guidelines concerning systems that monitor safety functions and parameters. Most of the guidelines in this section can be applied to either digital or hard-wired systems. Finally, a major portion of the new guidelines involves HFE design guidelines that affect the maintainability of a digital based monitoring and control system. FIGURE 1 – NUREG 0700 REVISION 1 VERSUS REVISION 2 indicates how the guidelines are broken down in NUREG 0700 Revision 2 versus Revision 1. The blue and white columns represent the number of original guidelines contained in Revision 1 and the purple columns indicate the number of guidelines added to each topic area.

NUREG-0700, Revision 2, [8] provides five additional chapters of guidelines. The majority of the changes and additions reflect the recent impact that computer technology has had on industrial process control system human system interfaces and control rooms. The additional and revised chapters of Revision 2 versus Revision 1 are shown in TABLE 1 – COMPARISON OF CHAPTER TITLES AND NUMBER IN REVISION 1 WITH REVISION 2. Color coding is used in Table 1 to indicate the chapters that are the same or essentially the same in revisions 1 and 2. TABLE 2 - SUMMARY OF THE GUIDELINE DIFFERENCES IN REVISION 2 VERSUS REVISION 1 summarizes the number of guidelines, by chapter, that are the same in Revision 1 and Revision 2; those reworded; and the additional guidelines.

TABLE 1 – COMPARISON OF CHAPTER TITLES AND NUMBER IN REVISION 1 WITH REVISION 2

Chapter	Revision 1	Revision 2
1	Information Display	Information Display
2	User-System Interaction	User-Interface Interaction & Management
3	Process Controls & Input Devices	Controls
4	Alarms	Alarm System
5	Analysis and Decision Aids	Safety Function & Parameter Monitoring System – <u>NEW</u>
6	Inter-Personnel Communications	Group-View Display System- <u>NEW</u>
7	Workplace Design	Soft Control System- <u>NEW</u>
8	Local Control Stations	Computer-Based Procedure System- <u>NEW</u>
9		Computerized Operator Support System- <u>NEW</u>
10		Communication System
11		Workstation Design
12		Workplace Design
13		Maintainability of Digital Systems- <u>NEW</u>

**TABLE 2 - SUMMARY OF THE GUIDELINE DIFFERENCES IN REVISION 2
VERSUS REVISION 1**

	NUREG-0700	Same	Reword	New	TOTAL R2	TOTAL R1
	Sub-Total - Sections 1, 2, 3, 4, 10, 11, & 12	1487	102	210	1799	1648
	Sub-Total - New Sections - 5, 6, 7, 8, 9, & 13			396	396	
	TOTAL	1487	102	606	2195	
Ch						
1	Information Display	386	15	43	444	
2	User-Interface Interaction & Management	511	8	107	626	
3	Controls	128	14	12	154	
4	Alarm System	98	35	14	147	
5	Safety Function & Parameter Monitoring System	3	0	19	22	
6	Group-View Display System	0	2	50	52	
7	Soft Control System	0	0	64	64	
8	Computer-Based Procedure System	0	0	76	76	
9	Computerized Operator Support System	0	0	18	18	
10	Communication System	89	7	0	96	
11	Workstation Design	130	13	11	154	
12	Workplace Design	142	8	23	173	
13	Maintainability of Digital Systems	0	0	169	169	
	TOTAL	1487	102	606	2195	1648

FUTURE PLANS

HFE-AT was developed using the design review guidelines contained in NUREG 0700 Revision 1. The automated guideline selection process implemented in HFE-AT was based on an exhaustive screening process that involved the classification of each of the design guidelines according to its importance to safety, level of design detail, and applicability to computer and non-computer based systems. To take advantage of the guidance that has been added in Revision 2 requires that the 600 plus new guidelines will have to be reviewed by the same screening process. WSRC is in the process of conducting this screening process, and expects to have a NUREG 0700 Revision 2 compliant version of HFE-AT available in the latter part of 2005.

REFERENCES

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NOMENCLATURE

HFE..... Human Factors Engineering
HSI.....Human Systems Interface
HFE-AT..... Human Factors Engineering Analysis Tool
WSRCWestinghouse Savannah River Company
SRSSavannah River Site

ATTACHMENTS

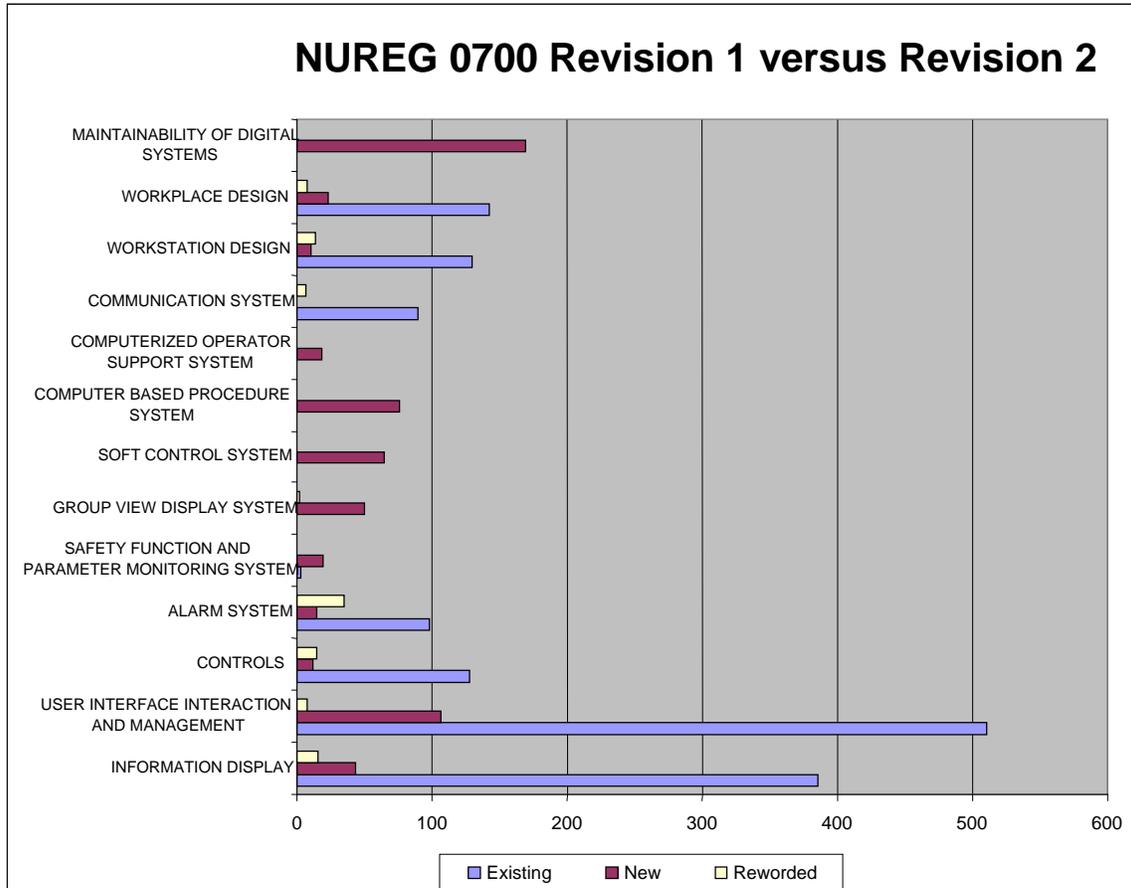


FIGURE 1 – NUREG 0700 REVISION 1 VERSUS REVISION 2