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AN OVERVIEW OF THE APPLICATION OF HUMAN FACTORS GUIDANCE TO CONTROL ROOM DESIGN

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Abstract:

A new power plant design has the goal of making major improvements in cost and ease of operation over previous designs. Improvements in the way information is organized and presented to control room operators based on established Human Factors Engineering (HFE) criteria is key to achieving these goals. An overview of the process and methods being employed in an ongoing design effort will be discussed, including the ways in which current Human Factors guidance is being applied in a unique operating environment.

I. Introduction

This document describes an HFE process created to support the implementation of guidance in the Human Factors Engineering Program Review Model (NUREG-0711) and the Human-System Interface Design Review Guidelines (NUREG-0700). HFE design tools were created to bridge the gap between NUREG guidance and specific actions taken by engineers in the system design process to ensure that sound HFE practices are part of a new plant design. These tools were used by several design agencies in a collaborative design effort. The paragraphs that follow will describe the specific tools created and how they were used.

II. HFE Development Process

A working group was formed to focus on HFE issues and guidance for a new plant design. The goal of the working group was to provide tools to plant designers to ensure that graphical user interfaces for control and indication reflect current HFE guidance and employ common features. Common display features are especially important in an environment employing multiple design agencies and two distinct plant control and indication systems. The working group developed an HFE process using the guidance provided in NUREG 0711. To support the process, design tools were developed to assist engineers in incorporating appropriate HFE practices in their design work. The design tools, or "HFE Toolset" that was developed consists of the following:

A. HFE Guidelines: A compilation of human factors engineering guidance from known standards like NUREG 0700 and MIL STD 1472 in a format that allows project specific comments to be added to assist developers in implementing the guidance. Comments are based on plant operating experience and HFE - related specifications from prior design agency projects to ensure that the new design benefits from the best practices of prior efforts.

B. Operator Task Analysis Template: A template to provide consistency in the structure and format of task analyses that are developed to study operator workload in the newly designed control room. It specifies a listing of plant procedures impacting the operator, required actions, and necessary indications/controls to execute such actions.

C. Display Task Description Template: A template to assist developers in defining the purpose of each display page and the alarms, indications, and controls to be displayed. A list of actual I/O required for the display is included, along with relevant portions of system diagrams. The intended users of the display as well as navigation requirements between multiple display pages are also documented.

D. Icon Library: A library of graphical icons to allow display developers from the different design agencies to use standard icons when creating display pages. This ensures consistency in the color and shape of the graphical icons that are used to represent plant components.

III. The components of the HFE Toolset are described in more detail in the sections that follow:

A. Human Factors Engineering Guidelines

NUREG 0700 Revision 2 was the primary reference used to develop the HFE Guidelines because it encompasses most of the human factors guidance developed to date. Each guideline within NUREG 0700 was reviewed for its applicability to the efforts of the design agencies involved in the new plant design. As applicable, amplifying material was added to each guideline that incorporates "best practices" from prior agency projects. A spreadsheet format was used for the guidelines to facilitate sorting the data for specific areas of HFE guidance, such as alarm management or soft controls. An example of the HFE guideline spreadsheet containing sample data is shown in Table of Appendix (1).

B. Task Analysis

A template was created to support commonality when preparing a task analysis for the control room operators. This common method utilizes plant procedures from a similar (previous) design as a starting point, allowing users to evaluate the procedures with regard to their applicability to similar systems in the current design. The task analysis further identifies the information required to perform specific tasks, the necessary operator actions, the

duration of the task, and the frequency of the task (once per shift, etc.). An example of the Task Analysis Template with sample data is shown in Table II of Appendix (1).

C. Display Task Description Template

A Display Task Description (DTD) template was created to provide Instrumentation and Control (I&C) engineers with a tool to assist in planning and documenting the specifics of graphical displays used for control and indication of plant systems. The DTD provides a medium for a written description of the display purpose, the intended users, and required I/O. The task analysis and the DTD precede the actual development of the graphical display page. By reviewing the DTDs for the various plant systems, the HFE working group can evaluate the displays that are to be created, ensuring consistency in the control and indication strategy. The DTD template will be completed by I&C engineers involved with plant graphical display development. The I&C engineers and the HFE working group will ensure that the resulting displays support operator needs identified in the Task Analysis effort (see section III.A.). An example of the Display Task Description Template containing sample data is shown in Table III of Appendix (1).

D. Icon Library

A graphical Icon Library was created to support selection of common graphics for plant control and indication displays. The Icon Library is based on standards for equipment representation that have been established within the respective design agencies. Examples of some of the icons are shown in Figure I of Appendix 1. The Icon library contains a common palette of symbols that the control and monitoring screen developers will use when developing graphical displays. The library includes symbols for valves, pumps, electrical circuit breakers, generators, and other equipment used in plant graphical displays.

IV. Summary of HFE Process

By creating the HFE design tools discussed in this paper, the HFE working group assisted multiple design agencies in ensuring sound HFE practices and commonality in the control and indication strategy for a new plant design.

V. References

Human Factors Engineering Program Review Model, NUREG 0711 Rev. 1, May 2002

Human Systems Interface Design Review Guidelines, NUREG 0700 Rev. 2, May 2002

Department of Defense Design Criteria Standard for Human Engineering, MIL-STD-1472E, October 1996

VI. Biographies

George Karlewicz is an Instrumentation and Controls engineer employed by Lockheed Martin with responsibilities in Human Factors Engineering. He became a member of IEEE in 2002.

Paul Yondola is an Instrumentation and Controls engineer employed by Bechtel-Bettis with responsibilities in Human Factors Engineering. He became a member of IEEE in 2002.

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Appendix 1

Table I

Sample of Typical comments made to the NUREG 0700 Guidelines

NUREG 0700 Section	Section Title	Guideline	Additional Information	Ref. 1	Ref. 2	HFE WG Comments or additional information
1.1-17	Consistent Coding Across Displays	Consistent meanings should be assigned to codes, from one display to another.	Additional Information: When coding is not consistent, the user's task of display interpretation may be made more difficult than if no auxiliary coding were used at all.	5908	0700	See the Graphics Design Standard V2 for typical Coding Methods
1.1-18	Coding and Transmission Time	Coding should not increase transmission time.		5908		An example of coding increasing transmission time would be where the processing time associated with an algorithm increases the latency with which the operator receives the data. See 1472, Table XXII for maximum system response times.
1.1-19	Annotating Displays With Time Data	When task performance requires or implies the need to assess currency of information within a display, the information should be annotated with time information.		5908		Having a time reference is important when seeing information graphed in reference to time. Ensuring that all values that are graphed with the same time reference.

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NUREG 0700 Section	Section Title	Guideline	Additional Information	Ref. 1	Ref. 2	HFE WG Comments or additional information
1.1-20	Alert to Higher Level Displays	While viewing secondary (lower-level) displays, a perceptual (audible or visual) cue should be provided by the system to alert the user to return to the primary (higher-level) display if significant information in that display requires user attention.		0800		It is the intention of the HFE Working group to not mask information with a pop-up window (ie use a dedicated window space for pop-ups). However, if a pop-up window is absolutely necessary, then it is imperative that the additional guidance of notifying the user be followed.

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Table II – Task Analysis

Task	Information Requirement	Actions Taken	Duration of Event	Frequency of Event	Difference in Performing Task Compared to Existing Design	Communication With Other Operators	Comments and Discussion (Optional)
High Bearing Temp.	INDIRECT: Report of Hot Bearing.	From the control station the operator will operate the following controls: Emergency Secure Machine	no data	no data	Control room operator has additional automation allowing more steps to be taken remotely from the control room.	Control Room Supervisor	
Charge and Discharge	Charging System Valve Position Indications. Discharging System Valve Position Indications Flow rate; Charge rates, discharge rates.	The Operator monitors charge and discharge activity and may change charging pump alignment by operating the Charging Pump.	Varies	Monthly	Task based displays will bring relevant indications and controls from multiple systems together on a single display page, allowing better coordination of this task.	Control Room Supervisor	Low Difficulty

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Table III: Display Task Description (DTD)

	Title	Power Generation Machinery Lubricating Oil Control Page
	Description	This page is used for control and monitoring of the Machinery Lube Oil system pumps, sump, and heat exchangers.
	Expected User	Turbine Support Room Operator
	Display Type	System/Component

Controls and Indicators							
System Diagram Description	I/O List Item No	Parameter	System	Indicated Value	Icon	Control	Indication
LO-RT1	946	Sump Heater A Local Lube Oil Temperature	MLO	Temperature			
	948	Manual Control of Sump Heater A	MLO	Status	Switch	x	
	949	Sump Heater A Status	MLO	NA	Indicator Lights		x
LO-RT3	950	Sump Heater B Local Lube Oil Temperature	MLO	Temperature	Temperature		x
	952	Manual Control of Sump Heater B	MLO	Status	Switch	x	
	953	Sump Heater B Status	MLO	NA	Indicator Lights		x
1LO-RT2	954	Sump Oil Temperature	MLO	Temperature	Temperature		x
LO-RT4	955	Oil Supply Temperature	MLO	Temperature	Temperature		x
LO-V7	957	Manual Control of Temperature Regulating Valve	MLO	Position	Valve control	x	
LO-V7	958	Position of Temperature Regulating Valve	MLO	NA	Valve position		x
LO-LT1	975	Sump Oil Level	MLO	Level	Tank level		x
LO-PT1	976	Strainer Inlet Oil Pressure	MLO	Pressure	Pressure		x
LO-PT2	977	Strainer Outlet Oil Pressure	MLO	Pressure	Pressure		x

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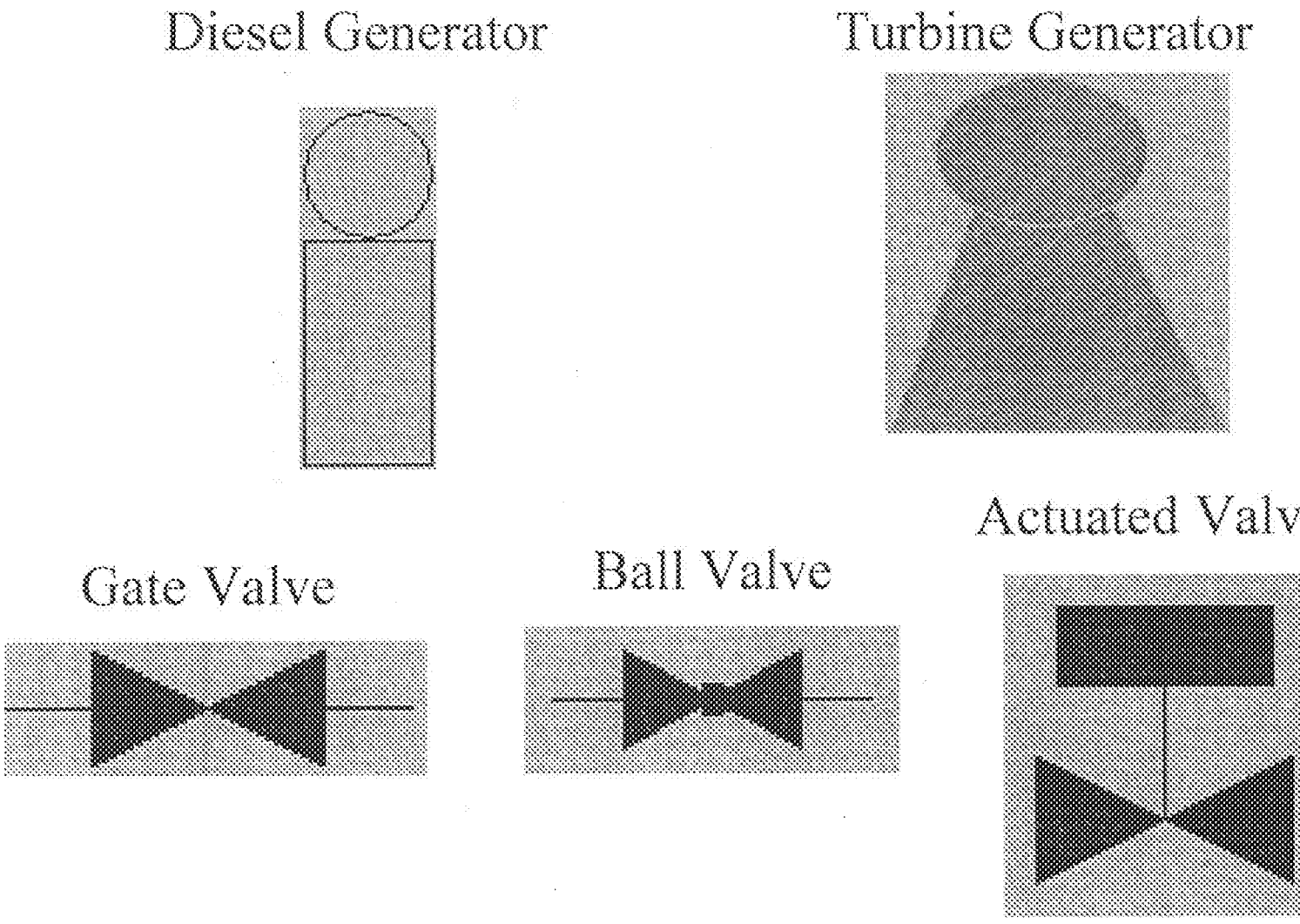

Fig 1. Example of typical ICONs from the ICON Library