An Overview of the IEEE Human Factors Standard Development Activities – 2017

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ABSTRACT

Since 1980 the Institute of Electrical and Electronics Engineers (IEEE) has supported development of human factors (HF) standards. Within IEEE, Subcommittee 5 (SC5) of the Nuclear Power Engineering Committee develops and maintains HF standards applicable to nuclear facilities. These standards are structured in a hierarchical fashion. The top-level standard defines the HF tasks required to support the integration of human performance into the design process. Five lower tier documents expand upon the upper tier standard. Presently, two new HF standards projects are underway; one to provide HF guidance for the validation of the system interface design and integrated systems operation and another for designing and developing computer-based displays for monitoring and control of nuclear facilities. In addition to producing and maintaining HF standards, SC5 is also involved in outreach activities, including sponsorship of a series of conferences on human factors and nuclear power plants.

Key Words: human factors, guidelines, nuclear power, control rooms, standards

1 INTRODUCTION

The Institute of Electrical and Electronics Engineers (IEEE) standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (SA) Standards Board. The IEEE develops its standards through a consensus development process approved by the American National Standards Institute. The process engages volunteers representing varied disciplines, agencies, and organizations to ensure that a range of viewpoints are considered in developing the institute's guidance documents.

Since 1980 the IEEE has supported development of human factors standards. Within the Nuclear Power Engineering Committee (NPEC) of the IEEE Power and Energy Society, Subcommittee 5 (SC5) develops and maintains human factors standards applicable to nuclear facilities. SC5 members have extensive expertise in application of human factors engineering principles and human reliability analysis for nuclear power plants and other nuclear facilities. NPEC manages human factors standards development and maintenance by overseeing the activities of SC5, and approving new or revised draft standards for ballot by members of the IEEE SA.

Currently, the subcommittee has nine active/attending members and approximately thirty contributing/corresponding members. The members are employed by the electric power industry, including utilities, the Nuclear Regulatory Commission, the Department of Energy (DOE), DOE laboratories, architect/engineering firms, consulting companies, and related industries. For budgetary or other reasons, contributing/corresponding members typically do not attend meetings but keep abreast of the subcommittee's activities through meeting minutes. As matters arise that align with their individual areas of interest and expertise, these individuals take a more active role by supporting the review of draft

standards under development, and existing standards under revision, by providing comments and participating as members of the ballot pool.

SC5 meets three times per year, usually in January, July, and October. The first two meetings of the year are planned to coincide with NPEC's biannual winter and summer meeting, while the fall meeting is SC5 only. To make best use of their time and resources during the meetings, the subcommittee usually splits into working groups. Members may participate in more than one working group. All of the meetings last three days, which includes one day for the NPEC meetings in January and July. While a great deal of technical work is accomplished during the meetings, many members accept writing and review assignments outside of the meetings. In addition, to manage the workload and maintain steady progress on standard development and revision initiatives, many of the working groups elect to conduct their business remotely through conference calls and web conferencing services.

SC5 has structured its standards in a hierarchical fashion. The top-level SC5 guidance document is IEEE Std 1023 [1]. IEEE Std 1023 is an upper tier document that defines the human factors tasks required to support the integration of human performance into the design process and promotes the systematic integration of human performance considerations in the life cycle of commercial nuclear power facilities. Presently, five lower tier documents expand upon the upper tier standard. IEEE Std 845 presents methods for measurement of human performance [2]. IEEE Std 1082 contains guidance for incorporating human reliability analysis (HRA) into probabilistic risk assessments of nuclear generating facilities [3]. IEEE Std 1289 presents HF guidance for design of computer-based display systems [4]. IEEE Std 1786 is a guide for the design and use of computerized operating procedure systems at nuclear generating stations [5]. Finally, IEEE Std 1707 provides a recommended practice for the investigation of events at nuclear facilities [6].

In addition to these existing standards, two new human factors projects are currently underway. IEEE P2411 will be a guide to provide HF engineering guidance for the validation of the system interface design and integrated systems operation. IEEE P2421 will be an HF guide for designing and developing computer-based displays (CBDs) for monitoring and control of nuclear facilities. IEEE P2421 will differ from IEEE Std 1289, which has a similar scope, in that it will focus on the process of designing and developing computer-based displays rather than specific criteria for design elements.

2 THE STANDARDS DEVELOPMENT PROCESS

IEEE standards are developed and maintained through the standards development lifecycle process depicted in Figure 1.

Figure 1: **IEEE Standards Development Lifecycle**

Initiating the Project. The development of a new standard or revision of an existing one is initiated by a Project Authorization Request (PAR) submitted to the IEEE Standards Association (IEEE SA). The request is developed by a sponsoring body, which is an individual or entity, such as an SC5 Working Group (WG) in charge of the standard. The WG completes a PAR form, which includes the standard's title, scope, purpose, brief description of the need for the project, key dates, and contact information for the sponsoring society (Sponsor) and committee, the WG chair and the standards representative. The IEEE SA mandates, oversees, and helps facilitate the process for standards development. The Sponsor for the standards project assumes responsibility for the respective area of standards development, including the organization of the standards development team and its activities.

Mobilizing the Working Group. Once the IEEE SA approves the request for a new standard development project, the sponsor follows the rules and processes to recruit and assemble a collaborative team (Working Group) to actively engage in standard development. Working Groups are comprised of individuals and entities (e.g., companies, organizations (including non-profits), and government agencies) who volunteer to support the development of standards. Working Group officers may either be elected by the Working Group members or appointed by the Sponsor and they oversee the standard development project.

The IEEE Standards Association (IEEE-SA) has established rules related to membership and participation to ensure that highly dedicated individuals lead participation and no single interest dominates the standards development process. Working Groups establish their own organizational, communications, and meeting structures to support standard development and to address matters such as consensus building, decision making and balloting.

Drafting the Standard. Upon approval of the PAR by IEEE, an outline is produced and writing assignments are agreed upon. Each standard is assigned a project champion who assumes a leadership role by working with the WG Chair to ensure the standard progresses in a collegial and timely fashion through the writing process. Typically the WG members meet on a bimonthly basis to provide review and comment on each other's work, which is carried out independently between WG meetings. The standards development process is conducted in an iterative manner, in which sections of the standard are written, drafts are submitted for review and comment, and sections are revised to address comments that represent a consensus view of the subject matter experts. Eventually the standard is ready for review by the entire subcommittee.

Balloting the Standard. Following SC5 approval, the draft standard is ready for presentation to NPEC. The standard is previewed at an NPEC meeting to see if it is acceptable for IEEE to ballot. If judged ready to ballot, a ballot pool is formed and the standard is distributed to those members of the IEEE SA who expressed an interest and willingness to review and vote on the standard. It is important to note that the composition of the ballot pool must meet IEEE SA guidelines to ensure that a diversity of organizations and associated interests/views are represented in the ballot pool. A successful ballot requires a minimum 75% response rate by the ballot pool and approval votes by at least 75% of the individuals casting ballots. Ballots may include comments and in such cases these comments must be reviewed and dispositioned. If substantive changes are necessary to resolve comments a recirculation ballot may be required.

Gaining Final Approval. Upon successful completion of the Sponsor ballot, the draft is submitted to the Review Committee (RevCom). The balloted draft is reviewed by RevCom and then submitted to the Standards Board for approval. After submission, review, and acceptance, the approved standard is published and issued for ten years, after which time it is automatically withdrawn if no further action is taken to reaffirm or revise the standard. Development of a standard typically takes five years from project inception to issuance by IEEE.

Maintaining the Standard. It is important to remember that standards are "living documents," which may be iteratively modified, corrected, adjusted, and updated based on lessons learned from operating experience and advances in methods, tools, and technologies, among other factors.

The remainder of this paper provides a high level overview of the current status of SC5 standards

activities, and introduces additional SC5 business by order of the working groups that are responsible for the activity.

3 SC5 WORKING GROUP ACTIVITIES

IEEE SC5 comprises four working groups that are charged with overseeing the development and maintenance of human performance standards for the nuclear industry.

3.1 WG 5.1 – Human Factors Analysis and Measurement

WG5.1 is responsible for maintaining two existing standards, and currently has a third standard under development.

Human Factors Analysis Standard – IEEE Std 1023-2004 is the upper tier or "mother" standard of SC5. It was originally published in 1988 and underwent a major revision in 2004 to provide more comprehensive guidance and to improve its coordination with the lower tier standards, especially the performance measurement standard. This document provides recommended practices to engineering personnel for development of integrated programs for applying human factors engineering to the design, operation, and maintenance of nuclear power generating stations and other nuclear facilities. It contains guidance for program organization, the design aspects to consider, the human factors methodologies and tools to apply, and for developing a human factors program plan. By following the standard, the diverse activities of design, construction, and procedures development can be integrated to improve human-system performance. The standard was reaffirmed in 2010, which approved use of the standard until 2020.

Human Performance Measures Standard – IEEE Std 845-1999 was originally published in 1988 and underwent a complete revision in 1999. This document provides guidance for evaluating human-system performance related to systems, equipment, and facilities in nuclear power generating stations. It summarizes specific evaluation techniques and presents a rationale for their application within the integrated systems approach to design. This document provides guidance for the selection and application of human performance evaluation techniques and presents recommendations for their application. The standard was reaffirmed in 2011 with use approved until 2021.

Validation of Systems Design and Integrated Systems Operations – P2411 is a standard presently under development to provide human factors engineering guidance for the validation of the system interface design and integrated system operation. The PAR was approved by the IEEE-SA in March 2014. The project will provide guidance to be used by nuclear facility designers, applicants, licensees, architect/engineers and regulators to assure reasonable confidence that the integrated system can be safely operated by personnel during a representative set of operating conditions that could be encountered during the facility's operation. This guidance will provide acceptable means to:

1) Identify performance criteria
2) Collect sufficient evidence of performance
3) Plan and conduct validation tests,
4) Analyze and resolve validation results.

With the exception of industry-based consensus standard IEC 61771 [7] and the limited guidance on validation that is presented in IEEE-Std-1023-2004, there is currently no dedicated IEEE standard governing the conduct of validation, including integrated system validation, for nuclear power generating stations and other nuclear facilities. Yet there is a need for such guidance to support design certifications and combined operating license applications given the regulatory expectations set forth in NUREG-0800 [8] and NUREG-0711 [9].

3.2 WG 5.2 – Interface Design

WG5.2 is responsible for maintaining two existing standards, and currently has a third standard under development.

Computer-Based Controls and Display Standards – IEEE Std 1289-1998 was originally published in 1998 and reaffirmed in 2004. The standard is intended for use by managers and engineers who must replace, modify, or design instrumentation and control (I&C) systems. The standard provides system design considerations, identifies information display and control techniques for use with computer-based displays, and provides human factors engineering guidance for the use of these techniques in nuclear power generating stations.

The original standard was created when utilities were first beginning to consider using computerized graphical user interfaces (GUIs) in nuclear plants with broader capabilities than those found in the simple plant process computers or safety parameter display systems available at that time. Subsequently, much of the basic technical guidance contained in the standard has become available in later revisions of NUREG-0700 [10] and other industry standards such as ANSI/HFES-100 [11] and ANSI/HFES-200 [12]. The nuclear industry has gained a great deal of experience developing GUI based I&C systems in control room modernization projects involving digital system upgrades, as well as for the new generation of NPP.

SC5 has recognized the need to capture that experience so that it can be reflected in its standards and in March 2010 SC5 gained approval for a project to update IEEE Std 1289. Although the WG initially made good progress with the revision effort, it became necessary to suspend the update while SC5 focused on other projects. In July 2014, SC5 voted to allow the existing PAR to expire in 2016 and create a new PAR when adequate resources could be dedicated to the update. In November 2015 SC5 considered options for future guidance efforts related to computer-based displays and opted to request a PAR for a new standard focused on the process of designing and developing computer-based displays. NPEC approved this request in February 2016. The new standard under development is known as P2421 and will be a principal work activity of SC5 over the next several years. In the meantime WG5.2 is currently assessing the need for an update to IEEE Std 1289. If the standard is not revised then IEEE Std 1289 will become inactive in 2018.

Computer-Based Procedures Standard – IEEE 1786 was published in 2011 as a standard for computerized operating procedure systems (COPS). The purpose of the standard is to provide application guidance, based on current industry experience, for the design and use of COPS in nuclear power generating stations and other nuclear facilities. The guide supports developers, users, and reviewers of COPS, and identifies acceptable practices and important considerations for applying COPS to facility operations within the control room. The existing revision is valid until 2021.

In June 2010, the IEEE-SA Standards Board approved the joint development by IEC and IEEE of a computer-based procedure (CBP) standard. IEC/SC45A took the lead role in writing this standard, with IEEE/SC5/WG5.1 primarily providing review and comment. During the process it was agreed not to issue a co-logo standard at that time, and IEC issued edition 1 of IEC 62646 in September 2012. The IEC standard is broader in scope than IEEE P1786, including guidance for implementing all types of procedures that a utility may decide to computerize. The scope includes procedures for use outside the main control room, as well as guidance for formulating a utility policy about which procedures to computerize and to what extent. IEC 62646 has undergone a recent revision and Edition 2 of the standard was published in October 2016 [13].

3. 3 WG 5.3 – Human Performance and Reliability

WG5.3 is responsible for maintaining two existing standards.

Human Reliability Analysis (HRA) Standard – First published in 1997, IEEE Std 1082-1997 provides an orderly process framework for the inclusion of human-system interactions in probabilistic risk assessments (PRAs). The document is intended to improve the analysis of human-system interactions in PRAs, to help ensure that conclusions are reproducible, and to standardize the documentation of such analyses. Rather than describing a specific method for doing HRA, the standard presents a method for integrating the HRA process into PRA, including a systematic technique for structuring,

conducting, and documenting the results of an HRA. The sole standard under this working group was reaffirmed in 2003 and again in 2010. In parallel with the recent reaffirmation ballot, working group A8 to IEC/subcommittee 45A conducted a review of the standard to determine its suitability for adoption as a dual logo standard. Based on the comments received by IEC and additional comments made by the IEEE WG 5.4, in response to their review of WGA8 comments, the decision was made to revise the standard. The revision will include editorial enhancements (e.g., clarification of existing terminology, new definitions, updated bibliography), as well as substantive changes to reflect the updated practices that are influencing contemporary HRA as part of PRAs. In January 2016 IEEE/NPEC granted SC5's request to ballot the draft revision of this standard. The ballot resulted in unanimous approval but received a number of minor editorial comments. The comments are currently being addressed in a revision that will be recirculated for final ballot. The updated HRA standard should be available before the end of 2017.

Event Investigation Standard – Until recently, the nuclear industry lacked a standard that establishes a common practice for event investigations and a common terminology for communicating the tools, methods, and results of such investigations. To address this need, SC5 formed a working group in early 2006 to begin development of a recommended practice for event investigations. After a period of early development, work on the standard slowed significantly due to various resource challenges, but resumed again in 2013 and continued at a steady pace until it was published in December 2015. IEEE Std 1707 provides a common basis for planning, conducting, and reporting event investigations, including common definitions and elements of corrective action plans. The document is intended for use by staff and management at nuclear facilities and those tasked with evaluating event investigation reports. The standard is broad in scope and provides considerations for preserving data analysis while implementing early actions to manage the event along with recommended practices to assist in planning the scope, team composition, and timeline for conducting an investigation. The document provides methods for data gathering and analysis as well as cause determination and corrective action identification. The practices focus not only on narrow issues and failures, but also on the entire organizational infrastructure, including lessons learned. Organizational aspects needed to support the investigation, including management oversight, training, record keeping, roles and responsibilities, are described along with the recommended attributes of a report on the investigation.

3.4 WG 5.4 – Conferences and Liaison

Under the leadership of WG5.4, SC5 sponsors an international conference on human factors in nuclear power plants. The conference has been held approximately once every five years since 1980, but the last one was held in 2007. The 8th IEEE Conference on Human Factors and Power Plants was held in collaboration with the Human Performance, Root Cause and Trending (HPRCT) group in 2007. In more recent years WG5.4 has collaborated with ANS for the Nuclear Power Instrumentation Control (NPIC) and Human Machine Interface Technologies (HMIT) conferences.

4 SUMMARY

SC5 is the subcommittee within NPEC that is concerned with the analysis of the human performance aspects of systems and equipment, the development of control facilities criteria, and the treatment of all matters relating to human reliability analysis for nuclear facilities. Included are the development of human factors criteria for systems; equipment and facility design; operation, maintenance, and testing; and the development of methodologies for human performance data collection, modeling, model evaluation, and model validation.

SC5 prepares and reviews technical papers, disseminates information to industry on new developments, and responds to requests for interpretation. The subcommittee has responsibility for coordination with other groups with respect to the acquisition, evaluation, and application of human factors data, control facilities criteria, human reliability data, and the coordination of nuclear standards. Lastly, SC-5 supports or sponsors technical conference sessions and educational courses, including international conferences on human factors in the nuclear power industry.

Currently, SC5 is responsible for maintaining six IEEE human factors standards and is in process of

developing two new standards. SC5 is also working in partnership with IEC to revise and update the existing IEEE HRA standard for adoption as a co-logo standard by IEC. SC5 is always open to suggestions for new standards.

5. ACKNOWLEDGEMENTS

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