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Applicability Evaluation on the Latest IEEE Standards for the I&C Systems Design of High Power Research Reactors

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1. Introduction

KAERI is constructing the Ki-Jang research reactor (KJRR) and performing the basic design of high performance research reactor (HPRR). The main difference between the KJRR and HPRR is the direction of water flow inside the reactor pool. The direction of water flow of KJRR is downward but the HPRR is upward. We can achieve more efficient design feature from the upward water flow direction than the downward direction. However, it is more difficult to hold the reactor structure in the upward direction than the downward direction. This is a challenging point in the design of HPRR.

This paper is to briefly evaluate the latest IEEE standards application for the HPRR. The reference research reactor for the HPRR is KJRR. Thus, this paper briefly evaluates the latest IEEE standards application by comparing to the IEEE standards that were applied to KJRR. The cut-off date of KJRR is March 31st, 2012.

2. The applicability evaluation on the latest IEEE standards

In order to evaluate the latest IEEE standards, we listed USNRC RG and KINS/RG in Table 1. The IEEE standards that are endorsed by the RG and applied to KJRR are shown in the left column of Table 1 and the latest IEEE standards are in the right column of Table 1. This paper picked IEEE Std. 323 and 7-4.3.2 as examples of the evaluation. The IEEE Std. 323-2003 is applied to KJRR although IEEE Std. 323-1974 is endorsed by RG-1.89 because IEEE Std. 323-2003 is the latest version as of KJRR cut-off date. The previous revision of RG-1.89 was issued in June 1984, which endorsed the use of IEEE Std. 323-1974. The IEEE updated this standard in 1983 and 2003. However, the USNRC did not officially endorse these versions. In 2016, the IEEE standard was issued as a joint logo International Standard with IEC (IEC/IEEE 60780-323, Edition 1, 2016-02), which will be applied to the HPPR. The IEEE Std. 7-4.3.2-2003 is applied to KJRR, which is endorsed by RG-1.152. The RG-1.15 (Rev. 4) endorsed IEEE Std. 7-4.3.2-2016. The title of IEEE Std. 7-4.3.2 is changed from digital computers to programmable digital device as shown in Table 1, which applies to lower level of digital device such as a firmware (hard-coded) device. It also emphasizes secure development and operational environment (SDOE), commercial grade dedication (CGD), etc.

Table 2 shows the latest IEEE standards that are not endorsed by USNRC RGs but were applied to KJRR. We can see the title of IEEE standards 730 and 1016 are changed, which means that the application of IEEE standards are more confirmed. Thus, we need to follow up the changes.

Table 2: The IEEE standards that are not endorsed by USNRC RGs

IEEE Standards Applied in KJRR		The Latest IEEE Standards	
No. and Revision	Title	No. and Revision	Title
IEEE Std 352-1987	IEEE Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Safety Systems	IEEE Std 352-2016	IEEE Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Systems and Other Nuclear Facilities
IEEE Std 420-2013	IEEE Standard for the Design and Qualification of Class 1E Control Boards, Panels, and Racks Used in Nuclear Power Generating Stations	IEEE Std 420-2023	IEEE Standard for Design and Qualification of Class 1E Control Boards, Panels, and Racks Used in Nuclear Power Generating Stations
IEEE Std 577-2012	IEEE Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Stations	IEEE Std 577-2022	IEEE Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Stations and Other Nuclear Facilities
IEEE Std 627-1980(R1996)	IEEE Standard for Design Qualification of Safety Systems Equipment Used in Nuclear Power Generating Stations	IEEE Std 627-2019	IEEE Standard for Qualification of Equipment Used in Nuclear Facilities
IEEE Std 628-2001	IEEE Standard Criteria for the Design, Installation, and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations	IEEE Std 628-2020	IEEE Standard Criteria for the Design, Installation, and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations
IEEE Std 690-2002	IEEE Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations	IEEE Std 690-2018	IEEE Standard for Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations
IEEE Std 730-2002	IEEE Standard for Software Quality Assurance Plans	IEEE Std 730-2014	IEEE Standard for Software Quality Assurance Processes
IEEE Std 1016-1998	IEEE Recommended Practice for Software Design Descriptions	IEEE Std 1016-2009	IEEE Standard for Information Technology-Systems Design-Software Design Descriptions
IEEE Std 1023-2004	IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities	IEEE Std 1023-2020	IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities

3. Conclusions

This paper evaluated the applicability of the latest IEEE standards for the I&C Systems Design of HPRR based on the design of KJRR. Although this paper did not include full evaluations, we found many changes of the IEEE standards. Thus, it is required to follow up the changes and evaluate the applicability along with the latest IEEE standards. The detailed evaluation will be presented in a future paper. This evaluation will be applied to the design I&C systems of HPPR.

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REFERENCES

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Table 1: The USNRC RGs and IEEE Standards

Regulatory Guide Applied in KJRR							The Latest Regulatory Guide					
Regulatory Guide			KINS/RG		IEEE Standard				KINS/RG		IEEE Standard	
No.	Rev.	Date	No.	Rev.	No. and Revision	Title	Rev	Date	No.	Rev.	No. and Revision	Title
1.47	1	02/2010	N08.04	2	IEEE Std 603-1991 IEEE Std 603-1998(Applied)	IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations						
1.53	2	11/2003	N08.05	2	**IEEE Std 379-2000**	IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems						
1.62	1	06/2010	N08.06	2								
1.75	3	02/2005	N09.07	1	**IEEE Std 384-1992**	IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits						
1.89	1	06/1984	N03.03	0	IEEE Std 323-1974 **IEEE Std 323-2003(Applied)**	IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations	2	04/2023	N03.03	2	IEC/IEEE 60780-323-2016	IEC/IEEE International Standard - Nuclear facilities - Electrical equipment important to safety - Qualification
1.97	4	06/2006	N08.08	1	IEEE Std 497-2002 IEEE Std 497-2010(Applied)	IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations	5	05/2019	N08.08	2	IEEE Std. 497-2016	IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations
1.100	3	09/2009	N03.02	1	**IEEE Std 344-2004**	Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations	4	05/2020	N03.02	2	IEEE 344-2013	IEEE Standard for Seismic Qualification of Equipment for Nuclear Power Generating Stations
					ASME QME-1-2007 ASME QME-1-2002(Applied)	Qualification of Active Mechanical Equipment Used in Nuclear Power Plants					ASME QME-1-2017	Qualification of Active Mechanical Equipment Used in Nuclear Facilities
											IEEE Std C37.98-2013	IEEE Standard for Seismic Qualification Testing of Protective Relays and Auxiliaries for Nuclear Facilities
1.105	3	12/1999			ISA-S67.04-1994 ISA-S67.04-2000(Applied)	Setpoints for Nuclear Safety-Related Instrumentation	4	02/2021	N08.09	2	ANSI/ISA 67.04.01-2018	Setpoints for Nuclear Safety-Related Instrumentation
1.118	3	04/1995	N08.10	1	IEEE Std 338-1987 IEEE Std 338-2006(Applied)	IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems						
1.151	1	07/2010	N08.12	2	**ANSI/ISA-67.02.01-1999**	Nuclear-Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants	2	02/2020			ANSI/ISA-67.02.01-2014	Nuclear-Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants
					IEEE Std 622-1987(Withdrawn)	IEEE Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Systems					IEEE Std. 622-1987(Withdrawn)	IEEE Recommended Practice for the Design and Installation of Electric Heat Tracing Systems for Nuclear Power Generating Systems
1.152	3	07/2011	N08.13	3	**IEEE Std 7-4.3.2-2003**	IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations	4	07/2023			IEEE Std. 7-4.3.2-2016	IEEE Standard Criteria for Programmable Digital Devices in Safety Systems of Nuclear Power Generating Stations
1.153	1	12/1985			IEEE Std 603-1991 IEEE Std 603-1998(Applied)	IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations	DG-1251	12/2025			IEEE Std. 603-2018	IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations
1.168	1	02/2004	N08.15	1	IEEE Std 1012-1998 IEEE Std 1012-2004(Applied)	IEEE Standard for Software Verification and Validation	2	07/2013	N08.15	2	**IEEE Std 1012-2004**	IEEE Standard for Software Verification and Validation
					IEEE Std 1028-1997 IEEE Std 1028-2008(Applied)	IEEE Standard for Software Reviews					**IEEE Std 1028-2008**	IEEE Standard for Software Reviews and Audits
1.169	1	07/2013	N08.16	2	**IEEE Std 828-2005**	IEEE Standard for Software Configuration Management Plans						
1.170	0	07/2013	N08.17	1	IEEE Std 829-1983 IEEE Std 829-1998(Applied)	IEEE Standard for Software Test Documentation	1		N08.17	2	IEEE Std. 829-2008	IEEE Standard for Software and System Test Documentation
1.171	1	07/2013	N08.18	2	IEEE Std 1008-1987 IEEE Std 1008-2002(Applied) -> IEEE Std 1008-1987(R2009)	IEEE Standard for Software Unit Testing						
1.172	1	07/2013	N08.19	2	**IEEE Std 830-1998**	IEEE Recommended Practice for Software Requirements Specifications						
1.173	1	07/2013	N08.20	2	**IEEE Std 1074-2006**	IEEE Standard for Developing a Software Project Life Cycle Process						
1.180	1	10/2003	N03.09	3	IEEE Std 1050-1996	IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations	2	12/2019	N03.09	4	IEEE Std 1050-2004	IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations
					MIL-STD-461E	REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT					MIL-STD-461G	REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT
					IEC 61000-3	IEC 61000-3-2(2001), IEC 61000-3-4(1998)					IEC 61000-3(2017)	
					IEC 61000-4	IEC 61000-4-1(1992), IEC 61000-4-2(1995), IEC 61000-4-3(1995), IEC 61000-4-4(1995), IEC 61000-4-5(1995), IEC 61000-4-6(1996), IEC 61000-4-7(1991), IEC 61000-4-8(1993), IEC 61000-4-9(1993), IEC 61000-4-10(1993), IEC 61000-4-11(1994), IEC 61000-4-12(1996), IEC 61000-4-13(1998), IEC 61000-4-16(1998)					IEC 61000-4(2012)	IEC 61000-4-2(2008), IEC 61000-4-3(2010), IEC 61000-4-4(2012), IEC 61000-4-5(2014), IEC 61000-4-6(2013), IEC 61000-4-8(2009), IEC 61000-4-9(2001), IEC 61000-4-10(2001), IEC 61000-4-12(2006), IEC 61000-4-13(2015), IEC 61000-4-16(2011)
					IEC 61000-6	IEC 61000-6-4(1997)					IEC 61000-6(2011)	IEC 61000-6-4(2006)
					IEEE Std C62.41-1991	IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits					IEEE Std. C62.41.1-2002	IEEE Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits
											IEEE Std. C62.41.2-2002	IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits
					IEEE Std C62.45-1992	IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits					IEEE Std. C62.45-2002	IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and less) AC Power Circuits
1.209	0	03/2007	N03.10	1	**IEEE Std 323-2003**	IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations						
1.30	0	08/1972			IEEE Std 336-1971 IEEE Std 336-2010(Applied)	IEEE Standard Installation, Inspection, and Testing requirements for Instrumentation, and Electric Equipment During the Construction of Nuclear Power Generating Stations	1	04/2024			IEEE Std 336-2020	IEEE Recommended Practice for Installation, Inspection, and Testing for Class 1E Power, Instrumentation, and Control Equipment at Nuclear Facilities
1.32	3	03/2004	N09.04	1	**IEEE Std 308-2001**	IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations	4	01/2025			IEEE Std 308-2020	IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations
1.73	0	01/1974			IEEE Std 382-1972 IEEE Std 382-1996(Applied)	IEEE trial-use guide for type test of Class 1 electric valve operators for nuclear power generating stations	1	10/2013	N03.05	2	IEEE Std 382-2006	IEEE Standard for Qualification of Safety-Related Actuators for Nuclear Power Generating Stations
							2	01/2024			IEEE Std 382-2019	IEEE Standard for Qualification of Safety-Related Actuators for Nuclear Power Generating Stations and Other Nuclear Facilities
1.211	0	04/2009	N03.06	1	**IEEE Std 383-2003**	IEEE Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations	DG-1442	07/2025			IEEE Std 383-2023	IEEE Standard for Qualifying Electric Cables and Splices for Nuclear Facilities