Considerations of technical competence of SMR operators

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1. Introduction

In September 2024, KAERI's SMART-100 small and modular reactor(SMR), with supported from Korea Hydro & Nuclear Power(KHNP) and Saudi Arabia's King Abdullah City for Atomic and Renewable Energy(K.A. CARE), has been finally granted its Standard Design Approval (SDA) from Nuclear Safety and Security Commission(NSSC). With its first-ever Standard Design Approval(SDA) of SMART, KAERI has been developing various SMRs based on its experience in constructing and operating research reactors. Since the development and operation of the HANARO research reactor in 1995, KAERI has accumulated the reactor operation expertise through projects such as the export of the Jordan research reactor and the construction of the KiJang Research Reactor (KJRR). In addition to its operation and design expertise, it is still requested the qualification technical capacity requirements for training SMR operators.

In December 2022, the Nuclear Safety and Security Commission (NSSC) revised its appointment criteria for senior managers such as plant managers, operations managers, and technical managers. While the previous appointment criteria for senior managers was only considering whether manager has the Senior Reactor Operator (SRO) licenses or not, the new revised regulations require compliance with the America National Standards Institute and America National Standards (ANSI/ANS)-3.1, which mandates independent verification of training and education technical capability of the manager. Korea nuclear industry are well known the quality assurance framework based on Korea Electric Power Industry Code-Quality Assurance Program (KEPIC-QAP) and America Standard for Mechanical Engineering(ASME) NQA-1(Quality Assurance requirements for nuclear facility applications), applying the 18 quality assurance requirements to nuclear safety-related items. While the United States also has applied its own standards, ASME NQA-1, while the European countries have adopted the quality management system based on the IAEA safety standards and ISO 9001.

In addition to KEPIC-QAP-2020 on examination and qualification requirement of auditor, NSSC, under the Nuclear Safety Act Article 84 on licensing, has regulated the operator who want to operating nuclear reactor should have several licenses or radiation management engineer ad provided for in the National Technical Qualification Act. Besides these mandatory requirements, the operator is needed to have additional technical competence.[1][2][3] For this technical competence, this study investigates U.S. cases of reactor operator to determine the technical competence that reactor operators must be trained and educated, emphasizing the Structured Approach to Training (SAT).

2. US technical competence of reactor operator

The U.S. NRC, through the Atomic Energy Act of 1954 (Sec. 107), mandates the establishment of regulatory requirements, qualifications, decision criteria, and licensing conditions for reactor operators. Under the Nuclear Waste Policy Act of 1982 (Sec. 306), the NRC is required to establish requirements for simulator training, requalification examinations, and practical examinations on simulators for applicants participating in reactor operator licensing and requalification training programs. The detailed requirements that reactor operators for the licensing must meet in practice are specified in NUREG-1021 and US NRC 10 CFR Part 55.[4][5]

2.1 General Requirement

The safe and efficient operation of nuclear power plants (NPPs) requires stringent personnel qualification standards. The ANSI/ANS-3.1-2014 (R2020) standard defines criteria for selecting, qualifying, and training personnel to ensure regulatory compliance and safety. The nuclear personnel must meet minimum qualifications before assuming their roles, including education, experience, and on-site training. The qualifications vary by its role in the NPP but it is generally required as follows:

- A combination of formal education (from the high school diploma to a bachelor's degree in engineering or science),
- Specific experienced years in nuclear or non-nuclear power plants,
- On-the-job training (OJT)
- Task Performance Evaluation (TPE)
- Certification by qualified professionals.

2.2 Reactor Operator(RO) and Supervisory Roles Requirements

The reactor operators (ROs) must hold;

- more a high school diploma

- possess at least two years of plant experience, including one year in a nuclear facility,
- 0.5 years of on-site training

The Supervisory Operators require ;

- a minimum of 1.5 years of responsible nuclear experience,
- a reactor operator license,
- site-specific training.

2.3 *Management and Supervisory Roles*

The plant managers(PM) must have ;

- an engineering or related science degree,
- 6 years of power plant experience,
- at least 4 years in nuclear operations

The operations and maintenance managers require;

- four years of power plant experience, including three years in nuclear plants,
- supervisory experience.

The training and quality assurance managers must have;

- specialized knowledge and certification in their respective fields, along with experience in plant operations and regulatory compliance.

2.4 *Structured Training and Certification*

The structured approach to training (SAT) is a critical component of personnel development. SAT ensures:

- Competency-based training,
- Realistic simulation exercises,
- Regular performance evaluations,
- Documentation of training records.

3. licensing and technical qualification in nuclear

The nuclear licensing and technical qualification system in Korea is a means of ensuring nuclear safety as part of the national radiation safety management system. The technical competence of operators with these license and technical qualification certification can affect the operation of nuclear reactors, the handling of nuclear fuel materials or radioactive isotopes, and safety management tasks to workers of NPP with specific qualifications and competencies, with protecting workers and the public from the potential radiation risks of radiation.

Total of seven types of licenses based on the Nuclear Safety Act, the act of physical protection and radiological emergency, other acts and guidelines are classified;

- Two categories in nuclear reactor operation
- Three categories in radiation handling
- Two categories in nuclear fuel material handling

Furthermore, nuclear reactor operation licenses are classified into 14 subcategories based on reactor type and model. To obtain a license, individuals must pass a government-administered licensing examination, which is a prerequisite for licensure.

The licensing examination is conducted to assess whether candidates possess the knowledge and practical skills required for the relevant profession or job role. The rational administration of the licensing examination is essential to maintaining the effectiveness of the licensing system.

The NSSC announced that the licensed must pass a medical examination for his license renewal from November 2024.

Additionally, the National Technical Qualifications Act defines three types of nuclear-related national technical qualifications:

- Radiation Safety Engineer
- Nuclear Power Generation Engineer
- Nuclear Engineer

To obtain these national technical qualifications, candidates must pass a national technical qualification examination administered by the KINS, delegated its administration from the government.

The national technical qualification examination is conducted to select skilled technical personnel required for NPP sites. The effective administration of the examination is fundamental to ensuring the validity and efficiency of the national technical qualification system.

Furthermore, the exam criteria for both licensing and national technical qualification examinations directly impact the curriculum design and operation of educational and training institutions that train candidates for relevant occupations. This underscores the importance of managing licensing and national technical qualification examinations systematically.

4. Conclusion

This study tried to contribute to investigate the technical competence of reactor operators with previous US standards, ROK licensing and technical qualification. While many of major concepts of technical competence in Korea are similar with US's standards, there are still differences between two standards.

This study has its limitations because it contains relatively narrow standards only for commercial nuclear power plant not for exact SMR. Accordingly, future study will be needed the investigation and analysis of its real case of SMR in Korea.

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