Development of Fire Brigade Drill Scenarios for HANARO

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Keywords: HANARO, Fire Brigade Drill, Fire Protection, Fire Drill Scenario

1. Introduction

The HANARO (High-flux Advanced Neutron Application Reactor) is a 30 MWth multipurpose research reactor operated by the Korea Atomic Energy Research Institute (KAERI). In a nuclear facility, fire safety is of paramount importance not only for protecting personnel and property but also for maintaining reactor safety functions during and after fire events. The fire brigade serves as the first line of defense in fire emergency response, and requires comprehensive training to ensure effective performance under emergency conditions.

This paper presents the development of diversified training scenarios for the HANARO fire brigade based on the facility's fire hazard analysis report. The scenarios are designed to enhance the fire response capabilities of the brigade while addressing regulatory compliance requirements and lessons learned from previous operational experience.

2. Background

Following the 2024 fire protection program implementation review (pursuant to Article 18 of NSSC Notice "Regulations on Fire Protection Plan Establishment and Implementation"), recommendations were made to diversify training scenarios as a follow-up action. The review identified that training reports did not fully incorporate all training elements required by NSSC regulations, and quarterly training exercises were conducted repeatedly at identical locations. As corrective actions, training reports were revised to include all required elements specified in NSSC notices, and training locations were expanded across various facility areas.

Section 3.2.3 of the HANARO Fire Protection Operation Plan specifies that the Fire Response Coordinator (HANARO Operation Management Team Leader) is responsible for developing fire brigade training materials and fire scenarios.

3. Methodology

The training scenarios were developed based on design basis fires identified in the HANARO Fire Hazard Analysis Report. A design basis fire represents a fire that grows to its maximum burning rate in the absence of suppression actions. The facility was divided into five major fire zones.

A. Reactor Room (cable insulation fires affecting control rod drives)
B. Auxiliary Area (bearing oil fires in primary cooling pumps)
C. General Management Area (control panel fires requiring halon suppression)
D. Pump Room (diesel fuel fires)
E. Underground Duct (cable fires with automatic sprinkler protection)

Each scenario specifies fire location, combustible materials, fire classification, potential impact on reactor safety, and appropriate suppression strategies.

The scenarios are rotated quarterly to ensure comprehensive training coverage. Training combines tabletop exercises with hands-on drills, with performance evaluation focusing on fire alarm response, brigade assembly time, equipment selection, procedural knowledge, and individual role performance.

4. Training Scenario Execution

The training scenario follows a structured timeline to simulate realistic fire emergency response. Table 1 presents the sequence of events during a typical training exercise, progressing from reactor full power operation through fire detection, initial response, suppression attempts, and handover to external fire departments.

Table 1. Training Scenario Timeline

■ Situation Presentation ►Response actions

Elapsed Time	Event Sequence and Response Actions
H+00:00	■ HANARO reactor operating at full power (30MWth) - Control room operators on normal duty
H+00:05	■ **Scenario initiation** Fire zone scenarios A. Reactor Room: Pool top control rod pump motor overheating fire B. Auxiliary Area: Primary cooling pump bearing overheating fire C. General Management Area: 2nd floor electrical room battery fire D. Pump House: Diesel engine drive fuel fire E. Underground: Duct cable insulation fire ■ **Fire alarm panel activation** ► Take actions in accordance with the step-by-step response guidelines in the 'Fire Emergency Response'

	Procedures - (Shift Supervisor) Dispatch fire brigade, announce evacuation of fire area, request plant fire brigade and external fire department - (Fire Brigade) Put on fire protection equipment and proceed to fire location
H+00:10	**■ Fire continues and spreads** **■ Fire area personnel evacuation complete** ► Fire brigade enters fire area and initiates suppression: - (Fire Brigade Leader) Assess fire situation and report to control room, evaluate the impact on reactor safe shutdown capability - (Fire Brigade) Conduct fire suppression using portable extinguishers - Evaluate need for manual reactor shutdown based on fire conditions ► Control room operators report incident: - Execute the 'Failure and Accident Reporting' Procedures - NSSC Notice (Regulations on Reporting and Disclosure of Accidents and Malfunctions at Nuclear Facilities)
H+00:13	**■ Initial fire suppression unsuccessful** ► Fire brigade member stands by at HANARO main gate to guide plant fire brigade/external fire department to fire location
H+00:16	**■ Plant fire brigade/external fire department arrival** ► Fire brigade member guides plant fire brigade/external fire department to fire area ► Transfer fire situation (fire location, spread status, personnel casualties, etc.) ► Fire brigade withdraws from fire scene (provides support as needed)

5. Results and Discussion

The implementation of the diversified training scenarios has demonstrated several benefits for the HANARO fire brigade program. The systematic rotation through different fire scenarios ensures that all shifts are exposed to the full range of potential fire hazards rather than repetitive training on identical scenarios. This approach has improved brigade members' understanding of facility-specific fire hazards and appropriate response strategies for different fire classifications and locations.

The scenario-based approach has enhanced training documentation quality and regulatory compliance. Each training session includes specific training objectives tied to the scenario fire zone characteristics. Whereas evaluations were previously limited to qualitative assessments, the approach has been improved to incorporate scoring based on training objectives, enabling both quantitative performance metrics and qualitative observations to be captured.

The scenarios have proven effective in identifying gaps requiring further attention. For example, initial training sessions revealed that some brigade members were unfamiliar with the appropriate extinguishing agents for Class B flammable liquid fires versus Class C electrical fires. This finding led to supplemental training on fire classification and agent selection. Similarly, the scenarios revealed variations in communication methods among participating groups. To address this, measures are currently being developed to standardize communication protocols across all groups, with the aim of ensuring clear communication and preventing human errors.

The integration of both tabletop and practical exercises enhances overall training realism and effectiveness, ensuring the development of both cognitive understanding and physical proficiency. Tabletop scenarios facilitate discussion of escalating fire situations, enabling participants, without the time constraints of actual firefighting, to deliberate on response strategies for more severe contingencies and propose procedural improvements. Practical exercises validate hands-on skills with fire suppression equipment and breathing apparatus.

6. Conclusions

This paper presents the development and implementation of diversified fire brigade training scenarios for the HANARO research reactor. The five scenarios, based on design basis fires from the fire hazard analysis report, provide comprehensive coverage of facility fire zones and fire classifications.

The scenario-based training approach has demonstrated clear benefits in terms of training quality, documentation, regulatory compliance, and brigade preparedness. By exposing fire brigade members to diverse fire situations, this approach enhances overall fire safety at the HANARO facility. Future enhancements may include more complex scenarios involving multiple simultaneous fires or fires combined with other emergency conditions, to further strengthen brigade capabilities and nuclear facility fire safety.

The training scenario development methodology presented in this paper can serve as a model for other research reactor facilities seeking to improve their fire brigade training programs.

REFERENCES

[1] Nuclear Safety and Security Commission, "Regulations on Fire Protection Plan Establishment and Implementation," NSSC Notice No. 2024-10, 2024.
[2] Nuclear Safety and Security Commission, "Technical Standards for Nuclear Reactor Facilities," NSSC Rule No. 2024-5, Article 59, 2024.
[3] Korea Atomic Energy Research Institute, "HANARO Fire Hazard Analysis Report," KAERI/TR-2023/001, 2023.
[4] Korea Atomic Energy Research Institute, "Initial Fire Brigade and Fire Suppression," Revision 5, 2024.
[5] Korea Atomic Energy Research Institute, "HANARO Fire Protection Operation Plan," Revision 12, 2024.