

Assessment of Application Example for a Sodium Fire Extinguishing Facility using Safety Control of Dangerous Substances Act

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1. Introduction

Liquid Sodium is widely used in liquid metal cooled reactor systems, and various experimental activities to verify its feasibility are currently progressing in Korea.

Sodium is under regulation of four kinds of laws including the Safety Control of Dangerous Substances Act and it is under categorized as Class 3(pyrophoric material, water-prohibiting substance). The classification of dangerous substances is listed in Table 1. To obtain a license for a sodium experiment facility, the codes and regulations must be satisfied in the Safety Control of Dangerous Substance Act.

However, there are some parts that need to be discussed in related regulations in the Safety Control of Dangerous Substance Act because there are differences with the actual features of sodium. To apply for an actual sodium facility, it is necessary to give a supplementary explanation regarding the regulations. The objective of this study is to assess the application example of a sodium experiment facility using the above mentioned laws and to propose the necessity of an amendment for conventional laws in regard to fire extinguishing systems and agents.

Table.1 Classification of dangerous substances by the Safety Control of Dangerous Substances Act

Class	Official Title
1	Oxidizing Solid
2	Flammable Solid
3	<u>Pyrophoric Material & Water-prohibiting Substance</u>
4	Flammable Liquid
5	Self-reactive Substance
6	Oxidizing Liquid

2. Assessment of application example

The standards of establishment regarding fire extinguishing system are specified in the regulations relative to the application of the Safety Control of Dangerous Substance Act. The fire extinguishing systems are classified into 7 types as follows.

1. Indoor fire hydrant
2. Outdoor fire hydrant
3. Sprinkler fire extinguishing system
4. Spray fire extinguishing system
5. Large-sized manual fire extinguishing system

6. Small-sized manual fire extinguishing system
7. Special Fire extinguishing agents

Among these systems, an available fire extinguishing systems for a water-prohibiting substance such as Na and K are for spray and manual fire extinguishing systems using powder. The extinguishing agent that makes direct contact with a fire should be filled in these systems. Hydrogen carbonate powder, dry sand, and expanded vermiculite are mentioned in the regulations as effective fire extinguishing agents for a sodium fire, which are actually applicable to general water-prohibiting substance fire and unsuitable for sodium fire for the following reasons.

1. Hydrogen carbonate powder reacts with sodium (Na) and its use has been banned in foreign countries.
2. Dry sand is heavier than sodium (Na), and thus the fire extinguishing effect wears off in comparison with other well-known agents.
3. Expanded vermiculite is bulky and thus it is difficult to keep a large-quantity of it.

To choose a suitable fire extinguishing agent, the characteristics of the sodium (Na) fire and class D fire extinguishers need to be considered for more effective fire control.

The basic characteristics of a sodium fire are as follows. First, it is accompanied by the production of dense sodium aerosols. The aerosol includes Na_2O , Na_2O_2 and NaOH , which are harmful products to the human body. Second, the flames of sodium fire are very low since such a fire is not from the combustion of gas but that of heavy vapor particles.

Fire extinguishers are classified using a letter-symbol system, which denotes the type of fire they are able to extinguish. Sodium fire belongs to Class D fires, which consist of combustible metals such as Mg, K, Ti, and Zr. Metal fires usually represent a unique hazard because people are often unaware of the characteristics of these kinds of fires. Therefore, even a small metal fire can spread and become a larger fire in the ordinary surrounding ordinary combustible materials. Only special extinguishing agents are currently used in advanced countries in the field of SFR (sodium-cooled fast reactor), some of which are shown in Table 2.

Table.2 Fire extinguishing agents available for a Class D fire

Name	Main Ingredients	Application Fire
MET-L-X	NaCl	Mg, Na, K
NaX	Na ₂ CO ₃	Na
Graphite	Carbon	Na, Li
TEC powder	KCl+ NaCl	Na, K, NaK
LITH	Graphite	Na, Li
SUPER D DRY POWDER	NaCl	Na

To obtain permission for a fire extinguisher (including the agent), the model approval procedures take precedence according to the inspection standards (KOFEIS) by the Korea Fire Institute (KFI). The fire-fighting products in accordance with Article 37, Enforcement Decree of Installation, Maintenance, and Safety Control of Fire-Fighting Systems Act can be sold or used after obtaining a model certificate and product inspection by KFI. Because there has been no record of going through the model approval procedures of fire extinguishers in the domestic market, international accredited sodium fire extinguishers have been introduced in sodium experiment facility.

Table.3 Fire extinguishing systems established in the sodium experiment facility

Type	Number	Capacity (kg)	Extinguishing Agent
Stationary fire extinguishing system (nozzle spray)	1	300	SUPER D DRY POWDER
	1	600	
	1	1,000	
Stationary fire extinguishing system (hose reel)	7	50	SUPER D DRY POWDER
Mobile manual fire extinguishing system	8	13.5	SUPER D DRY POWDER
	2	68	

Table 3 is a summary of the kinds of fire-fighting equipment installed in a sodium experiment facility. All of the above mentioned extinguishers have been accredited as suitable ones through a pre-test by the fire safety regulatory body before the examination of completion.

In particular, a nozzle spray extinguishing system based on gas-release method has been established in a large-capacity sodium experiment facility, STELLA-1(Sodium Integral Effect Test Loop for Safety Simulation and Assessment), to cope automatically with sodium leakage accidents. In addition, a total of 7 large-sized manual fire extinguishing systems were fixed to the floor of the facility against a ground fire. For easy access, small-sized manual fire extinguishers

are also used in the case of a small fire.

There is no standard regarding the designated quantity of a sodium fire extinguishing agent, and thus a safer standard has been applied for the system. For example, the quantity of dry chemical powder filled in an extinguisher is different depending on the classification (1, 2, 3, 4 class powder) of the agent. In this case, the greatest amount of powder quantity corresponding to class 1 has been applied for these kinds of system.

3. Conclusions

In this work, an application example of a sodium experiment facility using the Safety Control of Dangerous Substances Act, and the necessity of amending the existing laws in regard to fire extinguishing systems including the agent used, was assessed. The safest standard was applied for cases in which the consideration of a sodium fire is not mentioned in conventional regulations. For the construction of the PGSFR (Prototype Gen-IV Sodium-cooled Fast Reactor), the described regulations in this work should be reviewed and improved carefully by the fire safety regulatory body.

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