Fire prevention measures for facilities using nuclear fuel materials and hydrogen

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1. Introduction

Uranium, a nuclear fuel material, is mostly used as fuel for nuclear power plants and is also used as a measuring instrument for measuring neutrons. It is also used as a stable hydrogen carrier by absorbing hydrogen atoms with high atomic numbers and forming hydroxides. In addition, since it is a flammable material, caution is required in terms of fire prevention.

Hydrogen is composed of the smallest atoms among the elements that exist in nature, so it is lighter than air, and since it is a flammable gas, there is a risk of explosion at concentrations of 4 to 75%. Flammable gases such as hydrogen are not allowed to be stored indoors when handled, and if they must be used indoors, they must be used indoors only if a cabinet and related equipment certified by the Korea Gas Safety Corporation are installed.

2. Facility Overview

In order to use uranium for research purposes, it must be cut to an appropriate size, and powdered uranium is generated during the cutting process. Powdered uranium increases the surface area that can react with oxygen, which increases the possibility of ignition, and if static electricity is generated in dry conditions, the possibility of ignition increases significantly, so this must be taken into consideration when handling or storing it. And when handled with hydrogen, the risk of explosion increases, so various safety measures are required. In this study, we described the things to consider to prevent fires caused by static electricity when handling uranium and hydrogen, which are flammable substances, and the measures to prevent fires in facilities, thereby securing the safety of the work environment and suggesting items to focus on during inspections or inspections.

2.1 Facility operation purpose and design direction

This facility is for the development of a safe hydrogen storage and supply container and related process using metal hydride compounds for the purpose of developing a hydrogen isotope storage and supply system, which is one of the nuclear fusion fuel cycle processes.

This study aims to develop a metal hydride device that can safely store hydrogen by absorbing hydrogen into a container loaded with depleted uranium (DU) to produce uranium hydride, and conversely, to remove hydrogen through heating.

In order to ensure the safety of the facility, the safety of hydrogen experiments was given top priority by designing a filter system, dust collection system, and backfire protector system to limit external discharge of the depleted uranium container and secure the safety of hydrogen, and the construction of facilities that can minimize the generation of depleted uranium (DU) waste was the basic goal.

2.2 Uranium Usage Procedure

a) Cutting: Cut the DU in the metal (rod shape) state to a size and weight suitable for the experiment
b) Weighing: Weigh the cut sample
c) DU Bed: Inject DU into the primary container, seal it, and assemble the secondary container to prepare the DU Bed experiment
d) DU Bed/DU SPOVE: Connect the DU Bed to the DU SPOVE to conduct the hydrogen/deuterium absorption/desorption experiment
e) Glove Box: When recovering the DU in the small container that completed the experiment, weigh it in the Glove Box and store it in a storage container
f) DU Storage: Store the DU and DU Bed in the storage container

3. Risk factors

3.1 The occurrence of static electricity

Occurrence by ungrounded metal objects and electronic devices
Occurrence by work clothes and work processes
Occurrence during maintenance, etc.
Occurrence due to rapid movement of fluids

3.2 uranium powder

Occurs during the process of cutting DU in the form of a metal (rod) into a size and weight suitable for the experiment. Uranium powder of approximately 100 µm in size can be ignited even at temperatures below 100°C.

3.3 hydrogen gas

The explosive limit of hydrogen is 4.0 to 75.0 (vol%), which is a relatively wide range compared to other explosive gases.

4. Static electricity accident prevention measures

4.1 Combustible atmosphere prevention

Reduce the concentration of uranium powder and control the static electricity generating environment such as temperature and humidity of the facility. Handle in a closed space and take measures to prevent leakage so that hydrogen gas is not exposed to the atmosphere. Handle hydrogen gas concentration outside the explosive limit range. If it is difficult to prevent static electricity when stirring or using the powder, take measures to inject inert gas.

4.2 General static electricity generation suppression measures

Minimize the flow of gases such as hydrogen through the pipe. Ground metal experimental equipment to prevent charge build-up inside the experimental apparatus. Wear antistatic clothing and antistatic pants to prevent static electricity from the worker's clothing. Use antistatic equipment and control temperature and humidity using temperature and humidity control devices.

4.3 Reduce the concentration of uranium powder

The cutter uses equipment with anti-flying measures, and if possible, wet to prevent ignition due to powder flying and oxidation.

4.4 Use of Hood to Prevent Combustible Atmosphere

Using a hood to prevent flammable atmosphere, wash, dry, and weigh the cut DU, and safely handle it in a powder state. The water used for DU washing is transferred to a separate metal container and stored, and the hood's exhaust duct is connected to the air conditioning exhaust system so that the air sucked in passes through a HEPA filter and is safely discharged into the atmosphere.

4.5 DU Oxidation for Combustion Prevention

For oxidation, insert an appropriate amount of DU powder into the oxidation device inside the Glove Box, and seal the inside of the device by filling it with Ar. Move the oxidation device to the fume hood, connect the oxygen gas line, and proceed with the oxidation process. Install filters on the gas inlet and outlet ports inside the oxidation device to prevent the powder from leaking out of the device.

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