Development of Forced Helium Dehydration (FHD) Test System for Spent Fuel Canister

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1. Introduction

The Spent Nuclear Fuel (SNF) in the domestic NPP's is to be stored in dry storage instead of wet storage according to national radioactive waste management plan. The process of transferring SNF from the wet storage facility to the dry storage facility in the same site is called the short-term loading operations, which includes the drying, backfilling with inert gas, transfer of the cask to the storage pad [1]. Drying is one of the main processes for the prevention of corrosion and hydration of cladding during dry storage and transportation of SNF. There are two commercialized drying methods; vacuum drying and forced gas dehydration. Vacuum drying is very simple in the system, while FHD has advantages of keeping the SNF cladding safe during drying and shortening drying time, etc.

Accordingly, the development of FHD is required. Data for development a commercial grade FHD will be acquired by operation of the FHD test system.

2. FHD Test System

2.1 General information

The test system consists of a drying skid, chiller skid, reduced model canister and real size model SNF; drying skid circulates the process gas through the canister to remove the remaining moisture, and a chiller skid provides drying skid refrigerant for cooling the process gas. The size and weight of each skid are shown in Table1 and shown in Fig. 1.

Table1. Dimension and Weight

No	Length (mm)	Width (mm)	Height (mm)	Weight (kg)
Drying skid	2,500	1,600	1,952	1,320
Chiller skid	2,900	1,000	1,952	660

Fig.1. Left: drying skid / right: chiller skid.

2.2 Configuration of the test system

The configuration and arrangement of the test system is as following Fig. 2.

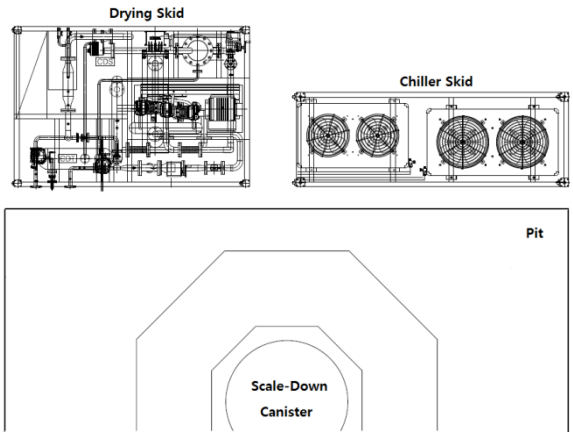

Fig. 2. The test facility layout.

This test system is defined by series connected each module. Heated process gas is moved to canister by a pipe line connected to vent line of canister. The Drain line of canister is in turn connected to the condenser and the freezer. Outlet of freezer is connected to suction of circulating pump. The process gas from the circulating pump is heated in the heater and flows into the canister through flow control. Configuration features of test system are; heater can operate steadily because heater is located after flow controller and flow fluctuation can be minimized. Process gas is supplied through vent line for maximizing evaporation rate. First cooled process

gas again is strongly frozen for further removing residual moisture. The chiller skid is connected to the condenser and the freezer in the drying skid to supply refrigerant as a cooling source for removing moisture in the process gas.

Drying test system is designed and manufactured with appropriate skid size, ease of transportation and safety and operational convenience. The test system installed at the test site is shown in Fig. 3.

Fig. 3. The site placement.

2.3 Instrumentation and control

The test system performs logic processing of the input signal sequentially by the program, and controls the external device by the programmable logic controller (PLC) used for the sequential control using the output. The PLC is connected to the Human Machine Interface (HMI) touch panel, and is capable of monitoring all operation status of the drying test system, and be set operational parameters and controlled all component such as the gas circulation pump, condenser and freezer on and off, the opening and closing of automatic valve. Also all data such as pressure, temperature, dew point flow rate are acquired. Information on component operating states is indicated on the touch screen

Major operation variables are recorded and stored in the portable memory in real time. In the event of loss of power, the main equipment and the control power signal of the drying test system are shut down. UPS) is installed for supplying essential power to instrument and control device.

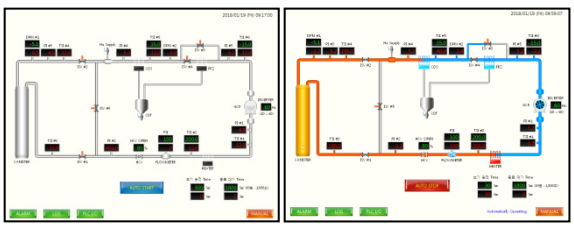

Fig. 4. HMI main screen.

2.4 Operation mode

There are two operation mode; manual operation mode and automatic operation mode. Automatic operation mode consists of the initial operation, the automatic operation and the termination waiting operation. Automatic operation control logic is shown in Fig. 5.

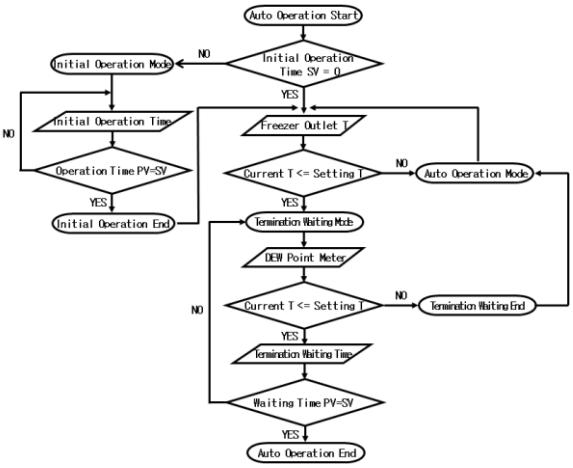

Fig. 5. Automatic operation control flow chart.

3. Conclusion

The test system is intended to test the removal of residual moisture in the canister during SNF transportation and dry storage. The data generated by the test confirm the drying performance of the test facility and produce design data for the development of commercial forced gas dehydration. Also it is expected to contribute not only establish the operation procedure of the drying process, but also to produce the data necessary for dry safety evaluation.

Acknowledgement

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References

[1] NUREG-1536 Revision 1 “Standard review plan for spent nuclear fuel dry storage system at a general license facility”.

[2] ASTM C1553-16, “Standard Guide for Drying Behavior of Spent Nuclear Fuel[1]”, ASTM, 2016.