Evaluation of Acceptance Criterion for Dryness of Canister and Spent Nuclear Fuel for Dry Storage

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1. Introduction

As the transition to storing the spent nuclear fuel (SNF) from spent fuel pool in dry storage facilities for extended period, NPPs must be prepared to dry SNFs. The Forced Helium Dehydration (FHD) technology has been developing to preserve the integrity of SNFs and fuel storage system as a R&D project of KETEP. FHD drying is specified for a canister that contains high-burn up fuel assembly.

For commercial SNF, the typical acceptance criterion is maintaining a 3.0 torr pressure for 30 minutes. Other measurement techniques may be used to show drying adequacy. Application of those techniques and the metrics for dryness would need concurrence from the regulatory agency. Adequacy of water removal should be evaluated by pressure rebounding measurement or monitoring the moisture content in process gas removed from the dried container.

Monitoring the moisture content in process gas method can be used for FHD drying. There are several practical methods for moisture content such as relative humidity (RH), temperature measurement of process gas and dew-point (DP) measurement of process gas in the canister corresponding to the partial pressure of water vapor at 3 torr. It is necessary to select a reasonable measurement method and measurement guide as a regulation.

2. Moisture Measurement Technology

2.1 FHD Drying Concept

The fuel drying by FHD process is effectuated by circulating the heated process gas such as Helium and removing the moisture through condenser and freezer.

Adequate dryness for FHD can be confirmed by DP of canister exit process gas, the temperature of the process gas exiting the freezer and, or humidity.

2.2 Selection of measuring technology for dryness confirmations

The adequate moisture removal verification should be verified by proper method to applied system. There are two methods as a industrial applicable methods; one is capacitive sensor, other optical (chilled mirror) hygrometer.

Capacitive sensors (CS) respond to small changes in water vapor pressure feature. The sensor measures the capacitive or resistive output of a sensing element. Capacitive sensor measures relative humidity and others can provide by calculating and converting between humidity values in terms of DP, vapor pressure.

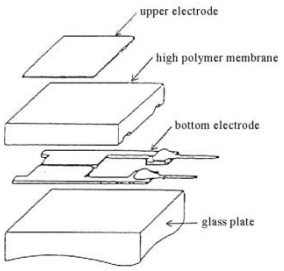

Fig. 1. Structure of CS with polymer membrane.

DP is defined as the temperature that moisture just begins to condense on a surface. The chilled mirror DP sensor measures this parameter directly. Since the mirror surface is always at the dew point, measuring the mirror temperature provides actual DP.

The chilled Mirror is more precise than capacitive technology offering accuracy to ± 0.1℃ to versus ± 2.0℃ for capacitive.

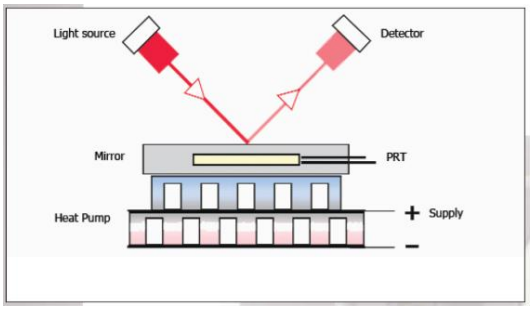

Fig. 2. Structure of Chilled mirror Detector.

Measurement techniques include direct insertion in the gas and sample by pass methods. Sample bypass system diverts a sample of the gas to the sensor. Sampling systems are critical to insure accurate and reliable moisture measurements. Materials of construction, length of flow path, diameter of tubing and myriad other factors are critical in the design of a properly functioning system.

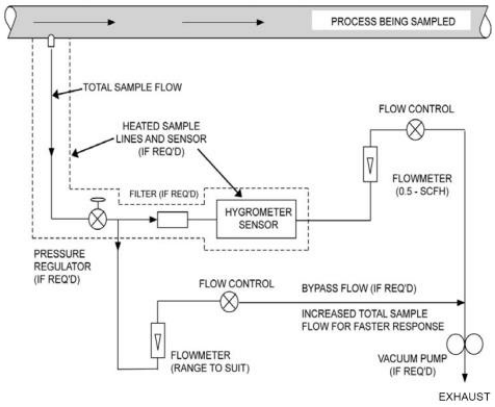

Fig. 3. Typical sampling system.

3. Summary

Canister is considered to be dry when the temperature of the gas exiting the freezer or canister exit gas is below the preset temperature or DP for 30 minutes which correspond to the partial pressure of the water vapor in the canister of less than 3 torr.

The chilled Mirror is more precise and proper method for FHD drying confirmation than capacitive technology.

Regulatory guide for measuring technology for dryness identification must be prepared by regulatory body.

REFERENCES

[1] Standard Guide for Drying Behavior of SNF (ASTM C-1553-16).

[2] Standard Review Plan for SFDSS at a GENERAL license Facility (NUGER-1536 Revision 1).