Effectiveness Verification of the Representative Sampling Location Scale Down to Reflect the Latest Standards

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1. Introduction

The technical standards for gas leakage radiological monitoring of nuclear power plants are designed and constructed in accordance with ANSI N13.1.

It was revised in 1999 after it was published in 1969. Domestic nuclear power plants were designed and constructed in accordance with the revised version(1999) from Shin-Kori unit 1. The previously constructed nuclear power plant was built by the standards issued in 1969.

In order to reflect the latest standards of the power plants reflected in the existing standards, we need to perform the proof test or scale down test of the representative sampling locations. In order to perform the scale down test, we tried to verify effectiveness of the scale down.

2. Test Method

The representative sampling locations of the representative nuclear gas radiation monitors are to comply with the ANSI N13.1 code requirements, as follows: 40 CFR 60, APP. A Method 1 shall be satisfied.

Table 1. 40 CFR 60, APP. A Method 1

Item	Acceptance criteria
Flow angle	< 20°
Velocity	COV < 20%
Tracer gas	COV < 20%
	COV_{Max} < 20%
Paticle	COV < 20%

* COV : Coefficient Of Variation

2.1 Reset the sampling location

Considering the field operation and environment, we decided to carry out the scale down test in the laboratory. The CFD(Computational Fluid Dynamics) analysis was reset the representative sampling location before the proof test.

The velocity distribution COV, flow angle and trace gas concentration distribution COV at the sampling location are evaluated to meet the design requirements of ANSI/HPS N13.1-1999

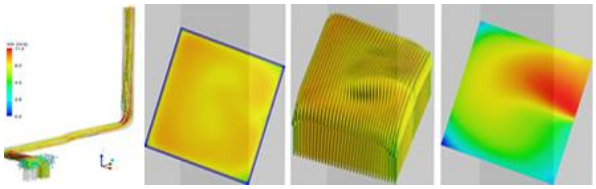

Fig. 1. CFD Analysis Results.

2.2 Effectiveness Verification tests

In order to verify the validity of the proof test model, we installed ducts of the actual and scale models for the RE-053 system and verified that they meet the requirements of ANSI N13.1 (1999).

○ Scale model validation criteria

- Obtain geometric similarity between scale model and actual duct in sampling position
- Reynolds number of scale model: 10,000 or more
- Conditions of hydraulic diameter and average flow velocity of scale model and actual duct

$$\frac{V_{actual}\, D_{h,actual}}{6} \leq V_{scale}\, D_{h,scale}$$

- Velocity homogeneity: COV 5% or less

○ Duct installation

Fig. 2. Photographs for actual model.

Fig. 3. Photographs for scale model(2.032:1).

○ Scale model scale and velocity design

Table 2. Design specification

RE-053	Actual	Scale down (V_{actual}=V_{scale})	Scale down (Re_{actual}=Re_{scale})
Streamline (CFM)	19,800	4,795	9,744
Velocity (m/sec)	8.62	8.62	17.52
Reynolds number	580,397	285,629	580,397
Hydraulic Diam.(m)	1.04	0.51	0.51
Velocity X Diam.	8.97	4.42	8.97
Scale Ratio	2.032	2.032	1

3. Test Result

Since the actual model and the scale-down model of RE-053 satisfy all 5 conditions of sampling position approval condition (flow velocity, flow angle, particle distribution, trace gas distribution, tracer gas maximum value) of ANSI N13.1 (1999) it was suitable as a sampling location.

Geometric similarity was maintained, and the COVs of the actual model, flow velocity equal-scale model, and Reynolds number equal-scale model of 2.032: 1 were 4.6%, 5.3%, and 4.1% The validity of the scale model for the verification test was verified.

Comparing the experimental results for five sampling conditions, it was found that the scale model with the same Reynolds number had the similarity with the actual model.

Table 3. Test result

RE-053	Acceptance criteria	Actual	Scale down (V_{actual}=V_{scale})	Scale down (Re_{actual}=Re_{scale})
Flow angle(°)	< 20	3.6	9.7	9.3
Velocity COV(%)	< 20	4.6	5.3	4.1
Tracer gas COV(%)	< 20	2.3	2.3	3.2
Tracer gas COV_{Max}(%)	< 30	4.8	2.6	4.9
Particle COV(%)	< 20	11.9	16	12

4. Conclusion

To validate the latest standards, the radiation monitoring system of nuclear power plants was used to verify the validity of sampling location of one representative radiological survey.

We set up sampling locations according to the design requirements of ANSI-HPS N13.1 (1999) through CFD. The validity of the scale model was verified by preparing the actual model and the scale model for the reset sampling location.

The scale model proof test was carried out under the same conditions with the actual model at the same flow rate and the same Reynolds number. All three models were satisfied with the ANSI N13.1 (1999) code sampling location requirements.

REFERENCES

[1] ANSI/HPS N13.1-1999, “Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities”, American National Standards Institute and the Health Physics Society.

[2] 40 CFR 60, Appendix A, Method 1. “Method 1— Sample and Velocity Traverses for Stationary Sources.” Code of Federal Regulations, U.S. Environmental Protection Agency.