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Design and Assessment of Aerosol Sampling System for RMS of HANARO

S.-H. Lee*, T. W. Go, S. E. Jeong, K. P. Hong
[a]*Korean Atomic Energy Research Institute(KAERI), 989-11 Daedeok-daero, Yuseong-gu, Daejeon, Korea*
**Corresponding author:leesungho@kaeri.re.kr*

1. Introduction

A radiation monitoring system (RMS) is used to detect presence of radioactive substances and provide its numerical data [1]. In KAERI, the RMS has been operated to sample and monitor airborne radioactive substances released from a multi-purpose research reactor, HANARO which has been operated since 1995. The existing RMS equipment that has run over 20 years becomes superannuated. For the reliable management of the nuclear facility, the modernization of the RMS for HANARO has recently been required.

Fig. 1 shows an aerosol sampling system in a stack or duct; it consist of the sampling probe, transport line, and RMS equipment. The transport system including the probe and transport line performs obtaining the representative aerosol sample in a stack or duct and transferring that to the RMS equipment. Thus, according to the design of the transport system, the performance and reliability of the overall system are determined. ANSI/HPS N13.1 that has been amended since 1999 specifies some guidelines for representative sampling from stacks and ducts of nuclear facilities such as the selection of the sampling probe and the design guideline of the sampling transport line [2].

In this paper, the design methodology of the transport system for the RMS of HANARO is introduced, and its assessment is presented. A modernized infrastructure for the RMS of HANARO is designed accordance with ANSI/HPS N13.10, and is evaluated with a software, DEPOSITION CAL.

2. Design and Assessment

Table I shows system parameters used to analysis the infrastructure for RMS.

TABLE I. System parameters

Parameters	Value or range
Free stream velocity	4.834-5.544m/s
Sample flow rate	57L/min
Aerosol diameter (AD)	10μm monodisperse
Ambient temperature	20°C
Ambient pressure	760mmHg
Sample tube diameters	25.4mm

Sample flow rate is determined by what equipment system is used; this work is performed for a radiation monitor, PING209L (MIRION Corp.) with a nominal flow rate 57L/min. The free stream velocity is measured in HANARO' stack.

2.1 Selection of Sampling Probe

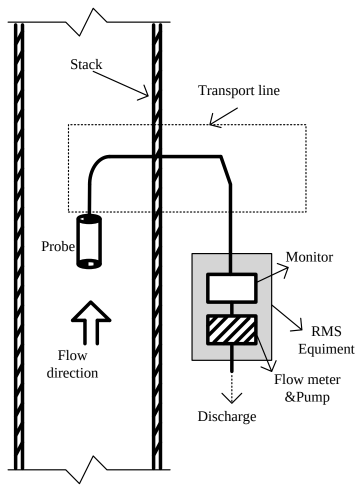


Fig. 1. Aerosol sampling system for RMS in a stack.

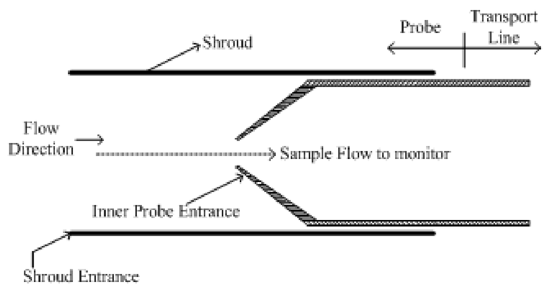


Fig. 2. Diagram for a generic shroud Probe.

According to ANSI/HPS N13.1, for the selection of the sampling probe, the transmission ratio T_r should be considered, and be within 0.8-1.3; T_r is the ratio of the aerosol concentration C_e at the probe exit plane to the aerosol concentration C_∞ in the free stream as

$$T_r = \frac{C_e}{C_\infty}. \quad (1)$$

In the past, the conventional probe configuration with the various isokinetic probes had been widely used. However, many studies have pointed out that it has high wall loss and high sensitivity to free stream velocity and sampling flow conditions [3].

To alleviate the problems, the shrouded probe as shown in Fig. 2 was introduced in [4]. It is designed to make the stream velocity within the shroud be decelerated; this allows the inner probe to sample the

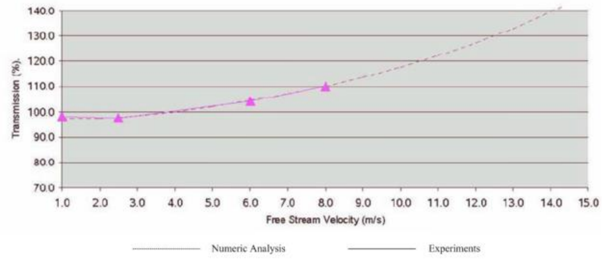


Fig. 3. Transmission ratio T_r for sampling probe RF2-112

almost same aerosol particle concentration as the stream in probe exit plane. Selection of a shroud probe is based on the range of the free stream velocity in a stack and sample flow rate. Thus, considering the parameters in Table I, a commercial shrouded probe, RF2-112 (Hi-Q) is selected as the sampling probe in the HANARO stack for RMS. Fig. 3 shows the assessment of the sampling probe RF2-112 alone. It is noted that T_r is almost unity for the free stream velocity given in Table I; this satisfies the requirement in the standard, ANSI N13.1.

2.2 Transport System Design and Assessment

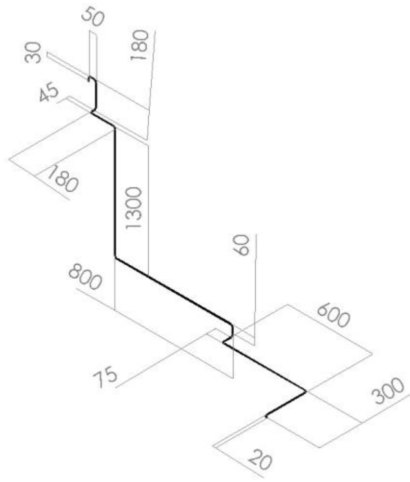
The transport line is a route where the sample obtained from the probe is transferred to the RMS equipment. Due to this fact, the transport line could be considered as one of design factors which determine the installation location.

To evaluate the validity of the overall system, a simulator, DEPOSITION CAL can be used; the code allows calculations of aerosol transmission efficiency through sampling systems that contain one or more the following components: inlet probe, straight tube, bend, contraction, expansion, and flow splitter. Moreover, by reflecting the system parameters as shown in Table I, it provides the more reliable data.

Fig. 4 shows the diagrams of the two transport systems. The transport system *A* in Fig 4a has shorter total length compared to that of the system *B* in Fig 4b. However, there are more changes in the direction of pipe runs. Table II shows the transmission efficiency yielded from DEPOSITION CAL according to the transport system. It is observed that the efficiencies in both systems decrease as the particle size increases. Although the same probe (RF2-112) is applied to both systems, the system *A* has lower efficiency in general; this results is due to the large total length of horizontal pipe runs. ANSI/HPS N13.10 specifies that the transmission efficiency with 10μm AD aerosol particles should be higher than 50%. Accordingly, only the system *B* satisfies the criteria required from ANSI N13.10.

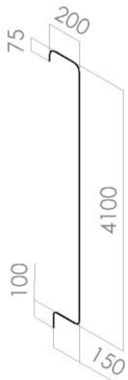
TABLE II. Transmission Efficiency

Particle size	System *A*	System *B*
1μm	99.68%	98.80%
5μm	64.62%	90.27%
7μm	39.31%	75.74%
10μm	12.76%	50.68%



unit : cm

(a)



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(b)

Fig. 4. Two transport systems including the shrouded probe. (a) Transport system *A*. (b) Transport system *B*.

3. Conclusions

In this paper, the design methodology of the transport system for the RMS which used to monitor airborne radioactive substances released from HANARO is introduced, and its assessment is presented based on ANSI/HPS N13.1. For selection of the sampling probe, the transmission ratio should be considered. Once the probe has been determined, the transport line is designed. At this time, the length of the horizontal pipe runs should be minimized to satisfy the requirement in the standard. The two transport systems are designed and are evaluated with the software, DEPOSITION CAL. Finally, the system *B* meets the criteria, thereby being considered as the more suitable candidate.

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