Development of Auto Flow Rate Calibration Program for Continuous Air Radiation Monitors

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1. Introduction

Radiation monitoring system is one of the key systems used in many industrial fields such as a nuclear plant, research reactor, radioactive waste management facility, and medical center. Korea Atomic Energy Research Institute (KAERI) has the legal obligation to protect the public and workers on site from any unjustified exposure to radiation.

A radiation monitor, such as a continuous air radiation monitor (CAM), provide measurements in volumetric radioactivity concentration. Therefore, the flow rate information is essential. To ensure the reliability of the flow rate provided by the radiation monitor, periodic flow rate check and calibration are necessary.

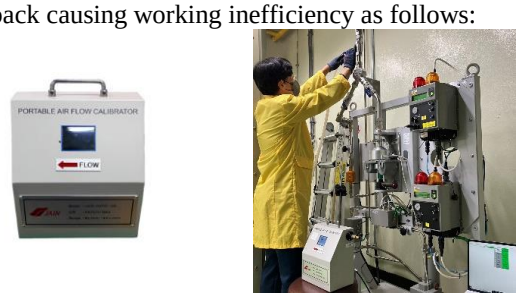
In KAERI, measurements were taken on-site using standard flowmeters as shown in Fig 1a, and recorded manually. Subsequently, the recorded measurements were entered into a separate report template to generate the final report. Furthermore, if the flow rate information from the radiation monitor deviates beyond the acceptable range compared to the standard flowmeter, it requires flow rate calibration by a proficient expert through the maintenance program provided by the monitoring equipment manufacturer. As a result, the existing flow rate calibration process has the following drawbacks:

In this paper, to address the inefficiencies mentioned in the existing workflow process, the development of a new radiation monitor flow automatic calibration program is introduced. This study involved the development of a new standard flowmeter, which is compact and light. The new standard flowmeter is designed to interface with a PC-installed auto flow rate calibration program. The auto flow rate calibration program could interface with both the radiation monitor and the standard flowmeter simultaneously. This allowed for enabling the generation of the final report upon the completion of the on-site measurement automatically.

2. Development of Auto Flow Rate Calibration Program for Radiation Monitor

2.1 Disadvantages of Conventional Workflow Process

In conventional workflow process, there are several drawback causing working inefficiency as follows:



(a) (b)

Fig. 1. Methods for Conventional workflow process for flow rate calibration. (a) Conventional standard flowmeter, (b) Connection between the conventional standard flowmeter and the CAM

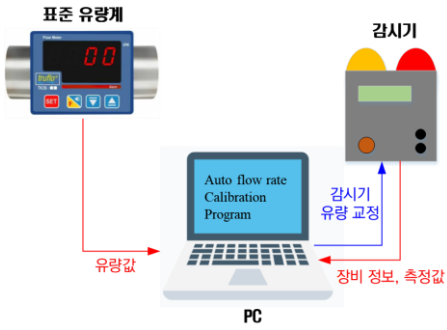


Fig. 2. Concept of Auto Flow Rate Calibration for CAM

1) The conventional standard flowmeter is heavy and requires a wired power source (Fig 1a).
2) Additional accessories are required to connect the conventional standard flowmeter to the radiation monitor (Fig 1b).
3) On-site workers are required to manually record the flow rate provided by the radiation monitor, which could lead to the possibility of human errors.
4) The manually recorded data must be transcribed into a separate report template, resulting in reduced work efficiency.

2.2 Concept of Auto Flow Rate Calibration for CAMs

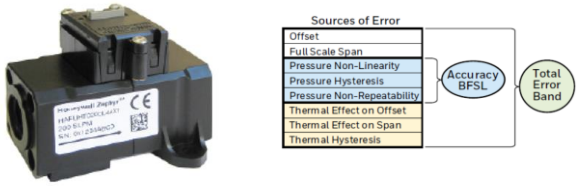


Fig. 3. Digital Flow Sensor, HAF Series (Honeywell)

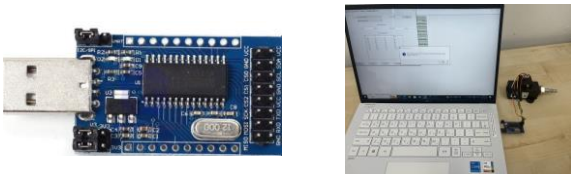


Fig. 4. USB to I2C interface module based on CH341 for Flow sensor, HAF Series

The new standard flowmeter is designed to be smaller than the conventional flowmeter shown in Fig 1a. The power supply is designed to be obtained through the USB port of a laptop with an auto flow rate calibration program. To achieve this, Honeywell's digital flow sensor, the HAF series, was employed as shown in Fig. 3. The HAF series compensates for flow variations based on pressure and ambient temperature, providing more accurate flow measurements despite its small size, and offers high precision flow values with a 12-bit resolution [1]. Additionally, the flow information flowing through the sensor can be provided to the external environment via I2C communication. However, direct communication with a regular PC using I2C is not possible, so an IC called CH341 is used to interface with the sensor. CH341 provides an interface between a PC's USB port and peripheral devices with SPI, I2C, and UART specifications.

To perform the auto-generation of flow rate measurement report including the information from the standard flow meter, obtaining flow data from the radiation monitor is necessary. In this study, target radiation monitors are Mirion Technologies's product line. The sequence for interfacing with the radiation monitor is as follows:

1) Find the available COM Port for connection.
2) Identify the Active Slave Address from the selected COM Port.
3) Retrieve channel information for flow calibration (user selection && Algorithm Number == 7).
4) Obtain the flow value for the selected channel.

MIRION's radiation monitor can have numerous channel information depending on its purpose, and for each channel, Algorithm number can be selected. The flow measurement information obtained through the radiation monitor is defined as "Analog input," represented by Code No. 7. The reason for including the

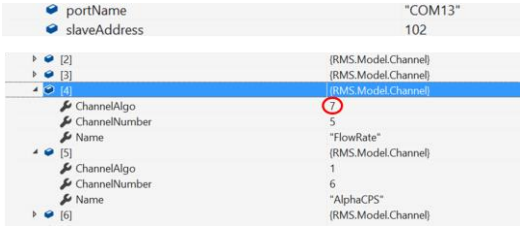


Fig. 5. Channel Information and "flow rate" channel selection from Mirion's radiation monitor

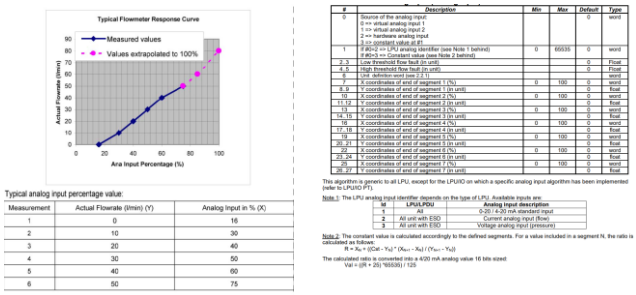


Fig. 6. Channel Information and "flow rate" channel selection from Mirion's radiation monitor

algorithm number when selecting channel information is to prevent potential errors in channel selection caused by human error. From both flow rate data, we can obtain the final report with pre-defined format upon the completion of the on-site measurement automatically.

Furthermore, the radiation monitor can be calibrated for the provided flow values through an automatic flow calibration program. This process involves the concept of curve fitting, where standard flow values (Y) and corresponding analog values (X) are measured at 6 points. By adjusting the internal parameters (Fig 6b) of the radiation monitor based on these measurements, it becomes possible to calibrate the flow values accurately.

3. Conclusions

In this paper, to improve maintenance efficiency of periodic test and calibration related to continuous air radiation monitors, the development of a new radiation monitor flow automatic calibration program is presented. The developed program obtains flow information from the own developed standard flowmeter and commercial radiation monitor, and provides flow rate measurement reports upon the completion of the on-site measurement automatically as well as radiation monitor flow calibration. Therefore, this program offers various advantages such as increasing work efficiency and minimizing residency time within the radiation workspace.

REFERENCES

[1] Honeywell Digital Airflow Sensor, HAF Series (2021): Datasheet from "sps.honeywell.com/ast