Development of Gaseous Iodine Generation and Sampling Systems Operated under High Pressure and Temperature Conditions for CFVS Performance Test

Hyun-Chul Lee [a], Woo-Young Jung [a], Jong-Chan Lee[a], Gyu-Tae Kim[a], Doo-Yong Lee [a*]
[a] *FNC Technology Co. Ltd, Heungdeok IT Valley, Heungdeok 1-ro, Giheung-gu, Yongin-si, Gyeonggi-do, 446-908, Korea*
[*] *Corresponding author: dylee@fnctech.com*

1. Introduction

A Containment Filtered Venting System (hereafter CFVS) is one of the major features to prevent the damage of the containment integrity from the severe accident such as a station blackout. The main functions of CFVS are the filtration of particulate and gaseous form of fission products from the containment. In severe accidents, elemental iodine and organic iodides are main gaseous iodine species in the containment building of nuclear power plant. One of the important purposes of CFVS is to minimize the risk caused by the release of fission products such as radioactive materials. For these reason, the experiment of iodine scrubbing efficiency is very important performance parameter for the CFVS.

Generally, Sublimation is an easy way to make gaseous elemental iodine in this system. Because, it is need not heat up to boiling point of I_2 [1]. In elemental iodine generation system, the system can control the pressure and temperature to make sublimation condition of iodine by argon gas and circulating thermostat. Moreover, the elemental iodine vapor pressure is estimated by data sheet shown in Reference 2. The organic iodine such as CH_3I is generated with two-fluid nozzle technique. The two-fluid nozzle can generate fine CH_3I droplets which are easily evaporated from liquid to gas. Elemental iodine sampling system has online and off-line sampling scrubbing columns. Organic iodides sampling system also has volatile organic compounds (VOCs) meter for online sampling and scrubbing bottle for off-line sampling. The scrubbing column is filled with chemical adsorbent for iodine adsorption. In this system, gaseous iodine flow in the scrubbing column of sampling system then the iodides adsorbed in scrubbing solution. In this study, the development of the generation and sampling systems of the gaseous elemental iodine and organic iodide is described.

2. Development of Iodine Systems

2.1 Elemental Iodine Generation System (EIG)

The Schematic of elemental iodine generation system is shown in Fig 1. The sublimation chamber is filled with iodine powder and the chamber is heated by oil bath to sublimate iodine powder. At the same time, heated argon gas is feed in the sublimation chamber to increase pressure. The sublimated iodine is mixed with argon gas in the chamber and injected to test sections..

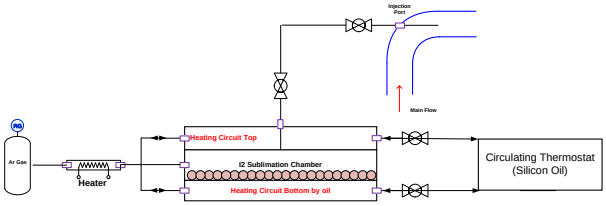

Fig 1. Schematic of Elemental Iodine Generation System

2.2 Organic Iodine Generation System (OIG)

The organic iodide generation system is shown in Fig 2. This system generates the methyl iodide (CH_3I) as the organic iodide. The evaporation chamber of organic iodine generation system is covered with heating jacket to evaporate CH3I droplets made by two-fluid nozzle.

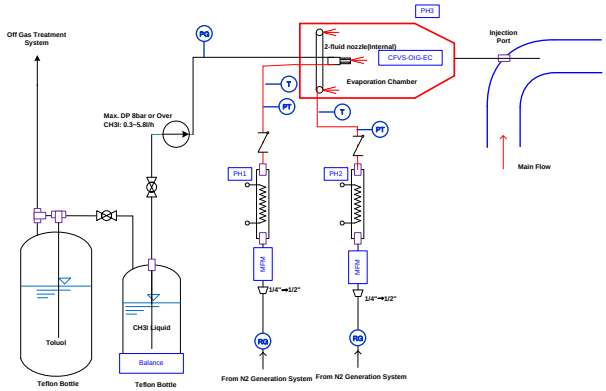

Fig 2. Schematic of Organic Iodine Generation System

The liquid methyl iodide is pumped into the two-fluid nozzle with nitrogen gas. The fine CH_3I droplets are generated as and are mixed with the nitrogen as carrier gas. If the system has an emergency, the CH_3I flow in an off-gas treatment system throughout toluene bottle. Because of toluene is a typical organic solvent.

2.3 Iodine Sampling System (ISS)

Iodine sampling system is composed of the elemental iodine sampling part and organic iodides sampling part. Fig. 3 shows the schematics of iodine sampling system.

The elemental iodine sampling uses the scrubbing column which is filled with scrubbing solution. On the other hand, an Ion Selective Electrode (ISE) is used to measure elemental iodine concentration as real-time measurement. The ISE measures ion activity across a semi-permeable membrane submerged in a solution and delivers an electric signal corresponding to the potential difference measured across the membrane according to the Nernst Law. The I_2 scrubbing solution is ascorbic acid. The iodine ions are chemically adsorbed in ascorbic acid solution by reduction of iodide.

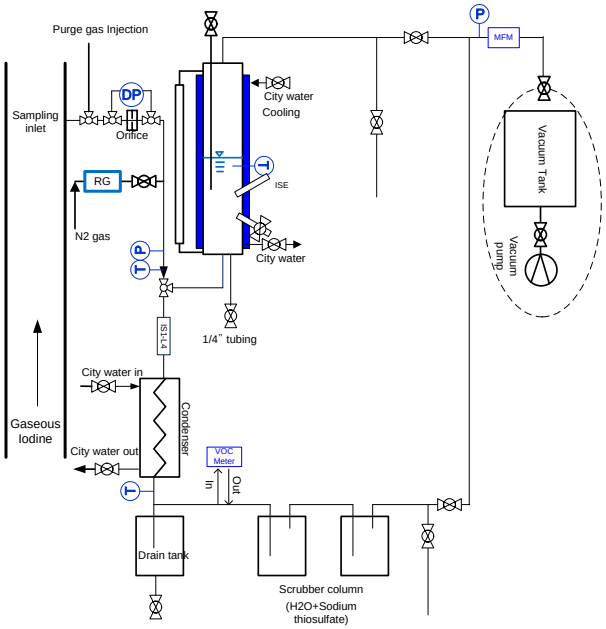

Fig 3. Schematic of Iodine Sampling System

Second part is an organic iodine sampling. According to reference 3, sodium thiosulfate ($Na_2S_2O_3$, THS) dissolved in scrubbing water is used to capture gaseous CH_3I during sampling. On the other hand, the VOC meter is used to detect the organic iodide concentration as real-time measurement.

The critical orifice located at the inlet sampling line reduces the upstream pressure to atmospheric pressure. The cooler as well as cooling jacket condenses and reduces the upstream temperature to the temperature below 40℃.

3. Conclusions

In this study, the iodine generation and sampling systems is developed to be used in the iodine scrubbing test for the CFVS. The system can generate the gaseous elemental iodine and organic iodide to be injected into test section at high pressure and temperature conditions. The sampling system can sample the gaseous elemental iodine and organic iodide from test section at high pressure and temperature conditions. The sampling gas under high pressure and temperature is regulated by the critical orifice and cooling system and then is sparged into the scrubbing solution. The ISE and VOC meter are used for the real-time measurement of the elemental iodine and that of the organic iodide, respectively.

ACKNOWLEGEMENT

This work was supported by the Nuclear Research & Development of the Korean Institute of Energy Technology and Planning (KETEP) grant funded by the Korean government Ministry of Trade, Industry and Energy. (No. 20141510101680)

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