Development of Tritium Filling Technology for Gaseous Tritium Light Sources

Soon-hwan Son, Ji-seon Kim, Seok-kyu Choi, Houng-gon Cha
AGENCORE Co., Uigwahak 2-ro, Jangan-eup, Gijan-gun, Busan, Korea
**Corresponding author: shson@agencore.net*

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1. Introduction

AGENCORE is developing three shapes (tube type, semi-ring type, and disk type) of gaseous tritium light sources (GTLS). The GTLS contains tritium with a half-life of 12.3 years in a glass container coated with a phosphor (ZnS:Cu) [1]. The GTLS has the advantage of self-luminating for more than 10 years using the energy of tritium beta rays without supplying external power. A robust technology that can accurately fill a very small amount of tritium into the above glass containers has been developed. In consideration of safety and efficiency, tritium is supplied using both a uranium-getter bed and a TTT-getter bed [2]. And it was designed to quantitatively fill tritium by measuring pressure change at a predetermined volume so that it can be determined by the P-V-T method. AGENCORE manufactured a tritium filling facility to produce the three shapes of GTLS, and for safe handling, the facility was installed in a tritium handling glove box.

2. Design of Tritium Filling System

2.1 Design Requirements for Tritium Filling System

The tritium filling system should basically have two functions. The first is the tritium transfer between the uranium-getter bed and the temporary tritium transfer (TTT)-getter bed [4]. The second is the tritium filling into the designated phosphor-coated glass containers. The key design requirements for the tritium filling system are as follows [3].

- Low leakage of tritium, secondary containment and appropriate atmospheric conditions shall be provided to limit the potential exposure of workers.
- The tritium-containing equipment should have a low leakage pressure boundary and a helium leakage rate of 10^{-6} atm ·cc/sec.
- Metering of tritium is a batch type to limit the heat load generated during tritium desorption and storage, and to limit tritium leakage due to malfunction.

2.2 Tritium Filling System Configuration

The main equipment of the tritium filling system is a uranium-getter bed, a TTT-getter bed, flow through getter bed, metering tank, and vacuum pump. A schematic diagram of this system is shown in Figure 1.

The leakage of this system can be evaluated by the following equation.

$$Q_L = \Delta P \cdot V / \Delta t \quad (1)$$

where Q_L is the leak rate, ΔP is the change of pressure during the observed time Δt, V is the volume of the vacuum region.

The amount of tritium filled is obtained by the P-V-T method.

$$n = PV/RT \quad (2)$$

where n is the number of tritium moles, P is pressure, V is volume, R is ideal gas constant.

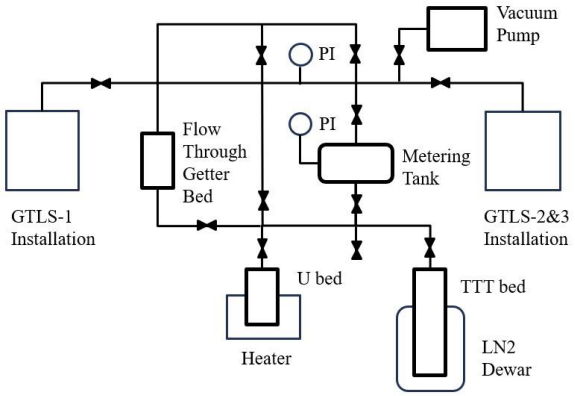

Fig 1. A schematic diagram of a tritium filling system.

3. Installation of Tritium Filling Facility

Figure 2 shows a picture of the tritium filling facility installed in the glove box. The three getter beds mentioned above, glass cutting/sealing torches, MFCs for O_2 and LPG, heaters, a LN2 dewar, a glass transfer port and I&C for the glove box operation are installed. The glove box has a volume of 5.6 m^3 and a separate tritium recovery facility. The volume of each area where tritium was filled was measured so that the tritium filling amount could be accurately determined by measuring pressure change [4,5].

The tritium filling procedure is shown in Figure 3. To fill tritium into the specified, coated glass containers the system has to be prepared to have good vacuum. Then the system first does the decanting of tritium from the previously connected uranium getter bed to the TTT-getter bed with the amount of tritium that is needed for the targeted production [5]. The filling work is not done in both regions at the same time, but only for one shape at a time.

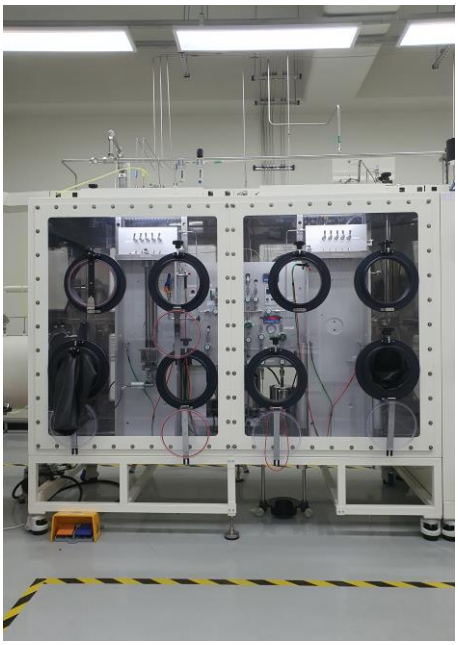

Fig. 2. Picture of tritium filling facility for GTLS

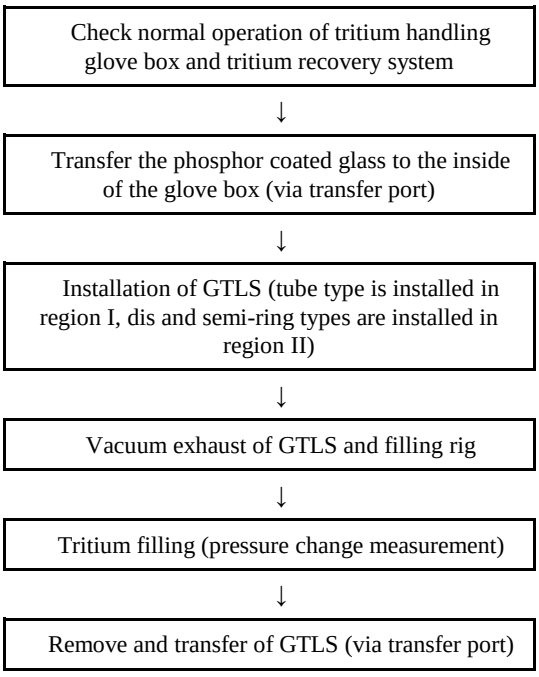

Fig. 3. Tritium filling procedure for GTLS

4. Conclusions

AGENCORE has developed and installed a new tritium filling facility for manufacturing three shapes of GTLS. This facility used both a uranium-getter bed and a TTT-getter bed to safely supply tritium. The exact volume of the region containing tritium was measured, and the pressure change was measured to determine the amount of tritium filling by P-V-T method. This facility will be used to fill a very small amount of tritium into small glass containers for producing the GTLS. Currently, the license for tritium filling facility is being reviewed.

Acknowledgements

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REFERENCES

[1] K. Kim, K. S. Kim, S, H. Son, and W. S. Kim, Manufacturing Process of Self-Luminous Glass Tube (SLGT) Utilizing Tritium Gas: Design of Tritium Handling Facilities, Korean Journal of Chemical Engineering, Vol.21, No.3, 562-566, 2004.
[2] J. Joubert, P. Valérie, F. Cuevas, J. Zhang, and M. Latroche, $LaNi_5$ related AB_5 compounds: Structure, properties and applications, Journal of Alloys and Compounds, Vol. 862, 2021
[3] S, H. Son, S. W. Baek, and K. J. Lee, Development of Tritium Application Technology, KETEP R-2006-1-245, KEPRI, 2009
[4] P. Burkhalter and S. Schneider, Design specifications of filling rig for ITTSAN, PR900055105, Smolsys ltd. 2019.
[5] P. Burkhalter and S. Schneider, Operating the filling rig for ITTSAN, Smolsys ltd. 2019.