# Visually Determining the Thermal Expansion of a Triple Bubbler System in Pyroprocessing Molten Salt

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## INTRODUCTION

Pyroprocessing is a high-temperature electrochemical processing technology for treating spent nuclear fuel (SNF). Electrorefining, which is a pivotal step of pyroprocessing, uses a molten salt electrolyte in order to recover uranium (U) and plutonium (Pu). Determining the mass of U and Pu for material accountancy, safeguards, and process monitoring is a challenge without some knowledge of the salt density and the vessel volume (depth).

A triple bubbler system has been developed at the Idaho National Laboratory to monitor the molten salt density, surface tension, and depth in vessels used in pyroprocessing of SNF[1]. However, due to the high operating temperatures as well as the varied temperature profile within the electrorefiner, the thermal expansion of the tubes has led to large uncertainties in the actual tube depths. The goal of this work is to visually measure the thermal expansion of the bubbler tubes at a number of different temperatures. In these experiments, a transparent furnace containing the bubbler immersed in LiCl-KCl salt will be used. An immersion thermocouple provides an accurate temperature profile of the system (used to calculate the expected thermal expansion) while photographs (with an appropriate reference) are used to visually determine the tube expansion.

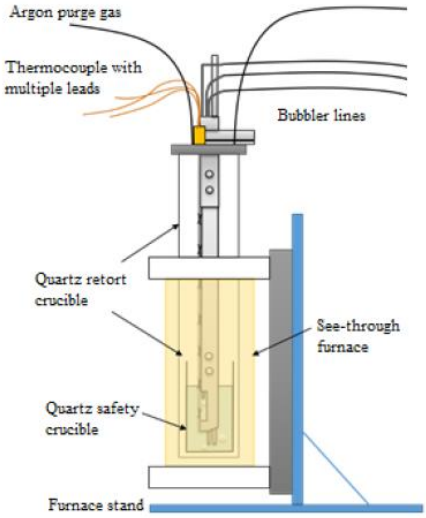


Fig. 1. Illustration of the molten salt bubbler experimental setup.

## METHOD

An illustration of the experimental setup is shown in Fig. 1. Furnace temperatures during experimentation were varied from 525°C to 400°C. A digital camera was used to capture images and video of the bubbler tips at discrete time intervals and at multiple temperature set points. A quartz reference (low thermal expansion) contained in the salt was used to set the scale for the measurements. The free software ImageJ was used to analyze the photos.

## RESULTS

Fig. 2 shows a representative photo of the two lower tubes in the molten salt at 500°C. Using ImageJ, the length of the bubbler tubes at different temperatures were measured with respect to the reference. Then the tube lengths at different temperatures were compared to determine the relative change in length. In Table I, preliminary results of the observed thermal expansion change between 500°C and 525°C as well as the expected (calculated) changes are presented. The percent difference between the measured and expected expansions were 22.7% and 5.6% for tube 1 and tube 2, respectively. Though the percent difference for tube 1 was at ~23%, the absolute difference was quite small (0.015 mm). The analysis is ongoing and more results will be presented at the conference.

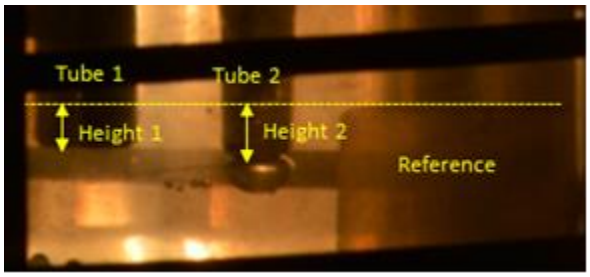


Fig. 2. Photo of the bubbler tubes immersed in molten salt.

TABLE I. Preliminary data showing the change in tube length from 500°C to 525°C.

| Tubes numbers | 1 | 2 |
|---|---|---|
| Expected change (mm) | 0.066 | 0.108 |
| Measured change (mm) | 0.051 | 0.102 |
| Percent difference (%) | 22.7% | 5.6% |

## REFERENCES

1. Williams, A. N., Galbreth, G. G., & Sanders, J. (2018). Accurate determination of density, surface tension, and vessel depth using a triple bubbler system. *Journal of Industrial and Engineering Chemistry*.