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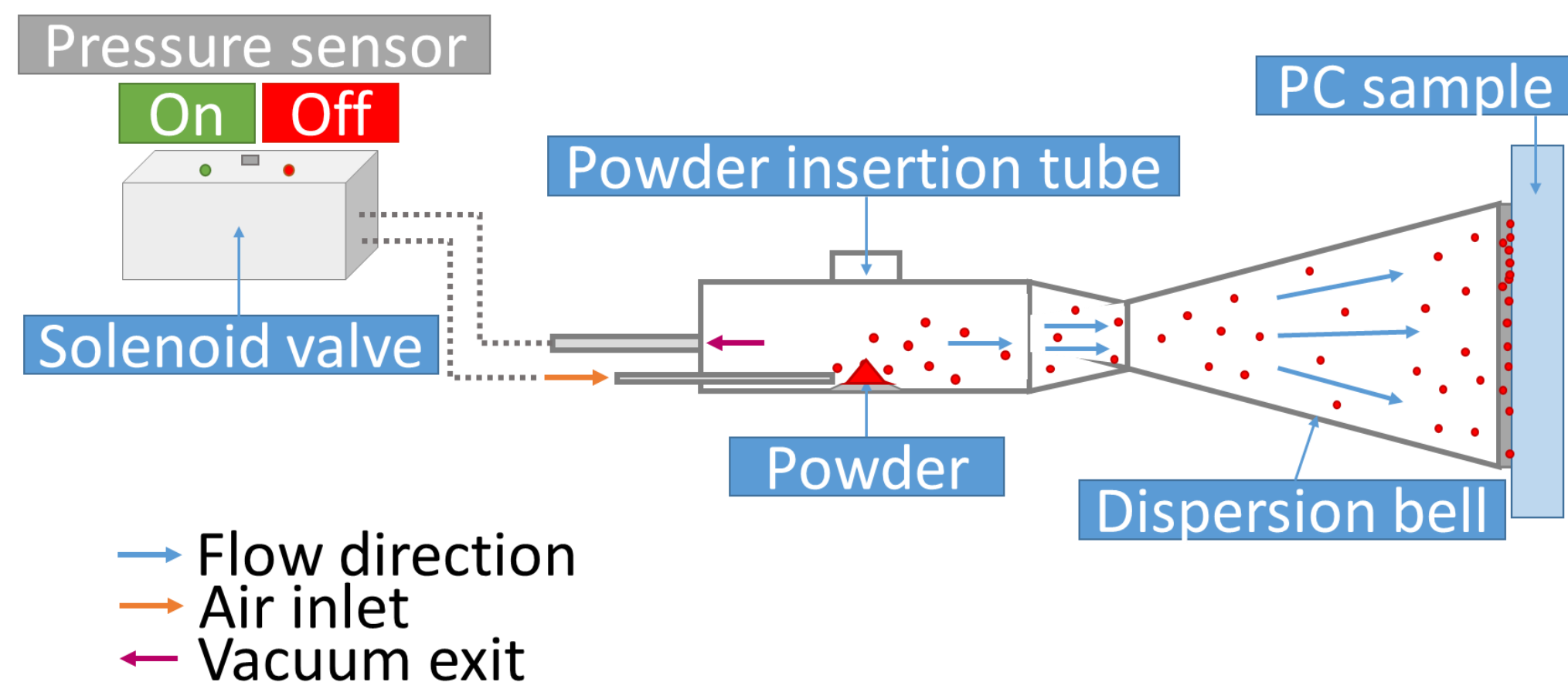
Quantifying the airborne release fraction of plutonium oxide surrogate in a small-scale fire experimental facility

Introduction

Fire events in nuclear fuel fabrication and reprocessing plants can lead to radiological consequences due to airborne release of contaminants, like PuO_2 and UO_2 .

The airborne release fraction (ARF) is used to assess the **source term in case of fire event in glovebox and currently estimated at between 1 and 50%**. Small-scale experiments were performed in ARTEMIS facility described here. Medium-scale (see companion paper by Sow *et al.*) and full-scale experiments were also carried out in the framework of the FIGARO project (Zavaleta *et al.*, 2024).

Contamination process



Surrogate and sample preparation

We identified:

- Suited PuO_2 surrogate $\rightarrow \text{HfO}_2$
 - Density, chemical proximity, thermal stability
 - Median aerodynamic diameter = $14.3 \mu\text{m}$
- Suited tracer $\rightarrow \text{Al}_2\text{O}_3$
 - Density, aerodynamic behavior.

$9 \times 9 \text{ cm}^2$ polycarbonate samples were contaminated with a surface concentration of $0.4 \pm 0.03 \text{ mg/cm}^2$.

Thermal degradation of polycarbonate samples took place in a dedicated facility, named ARTEMIS, thanks to the radiant panel set to 750°C .

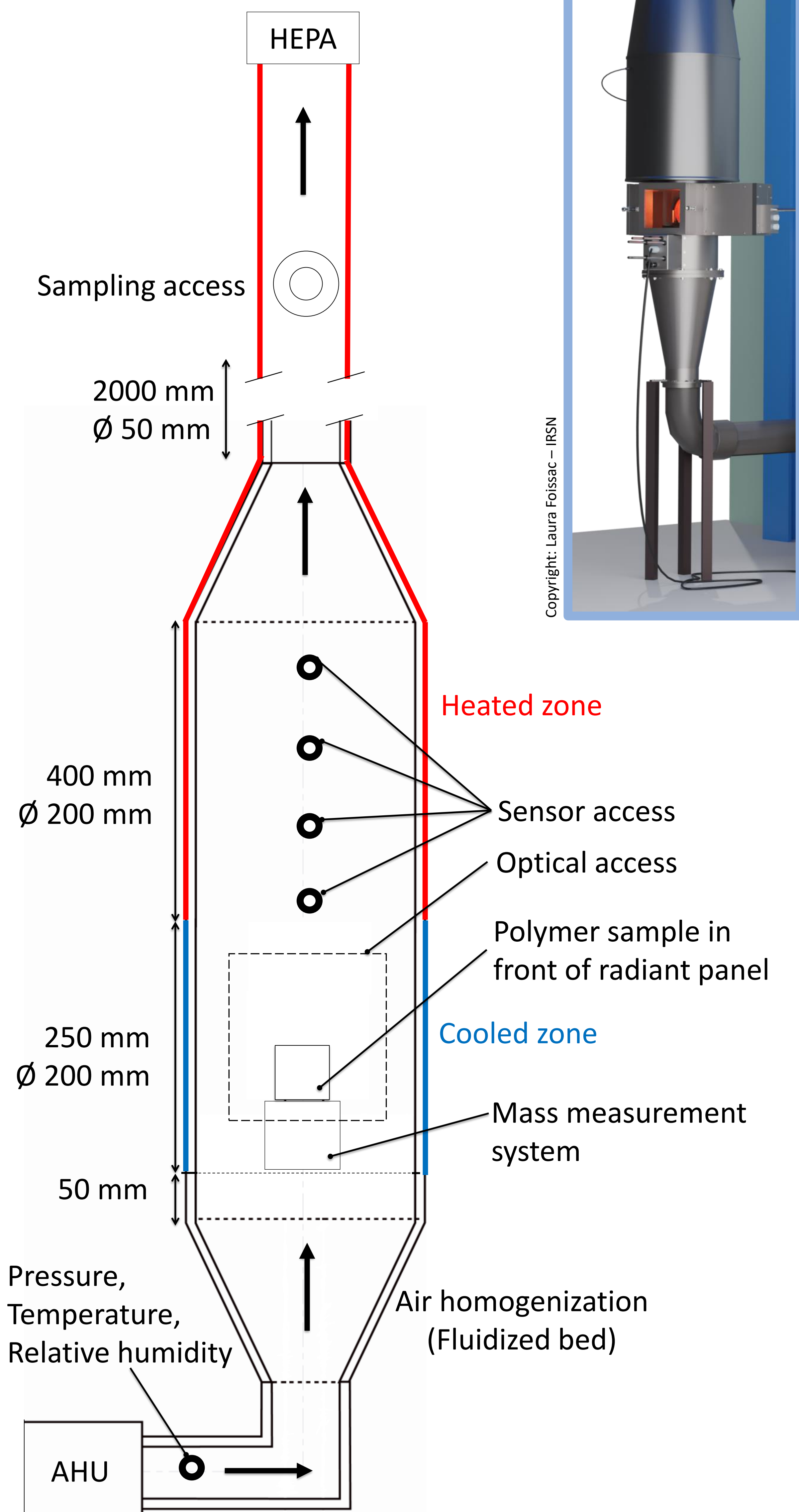
The line was heated at 150°C and at the top, particles were collected on 2 membrane filters made of cellulose acetate and with a diameter of 47 mm diameter. The sampling was of 5 l/min for each filter.

The sampling filters were analyzed with ICP-MS technique.

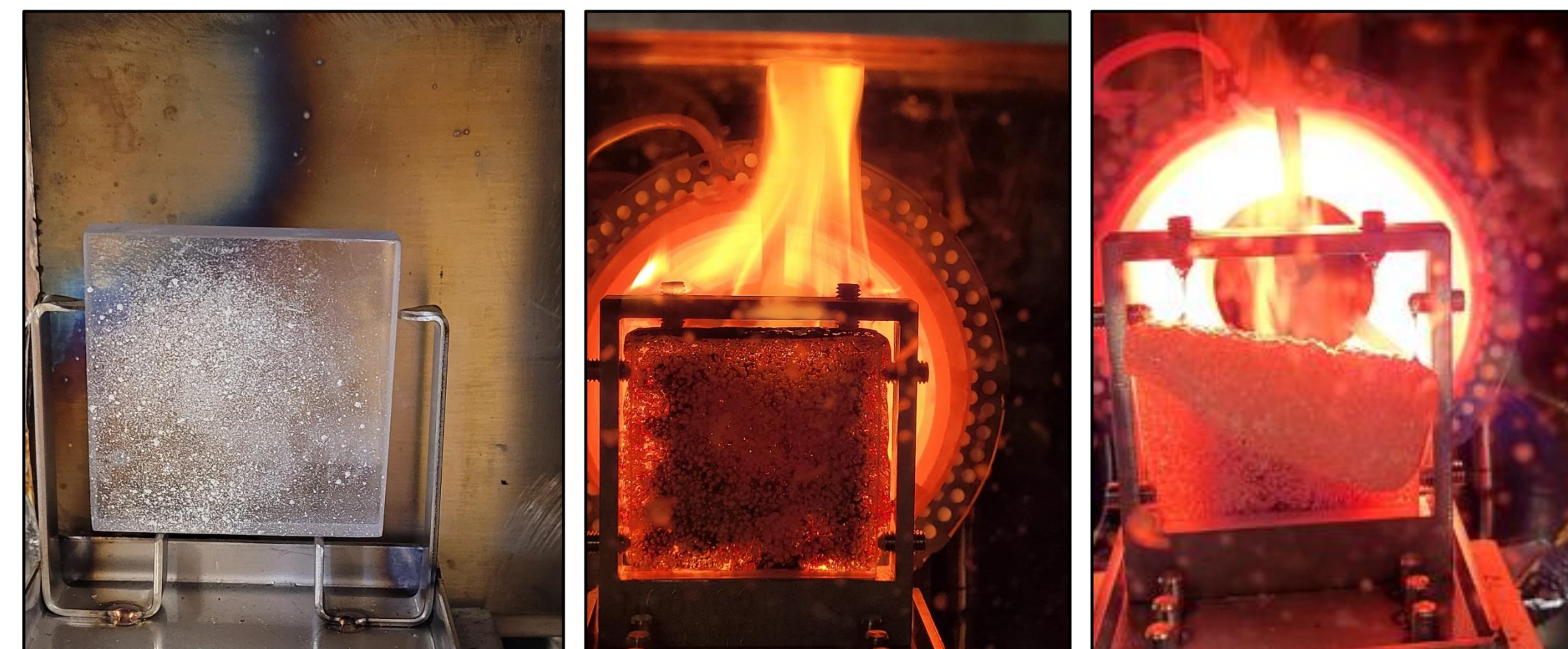
$$ARF = \frac{m_{\text{HfO}_2 \text{ on the filters}} \times \frac{Q_{\text{bulk}}}{Q_{\text{sampling line}}}}{m_{\text{HfO}_2 \text{ initial, on the PC sample}}}$$

ARTEMIS

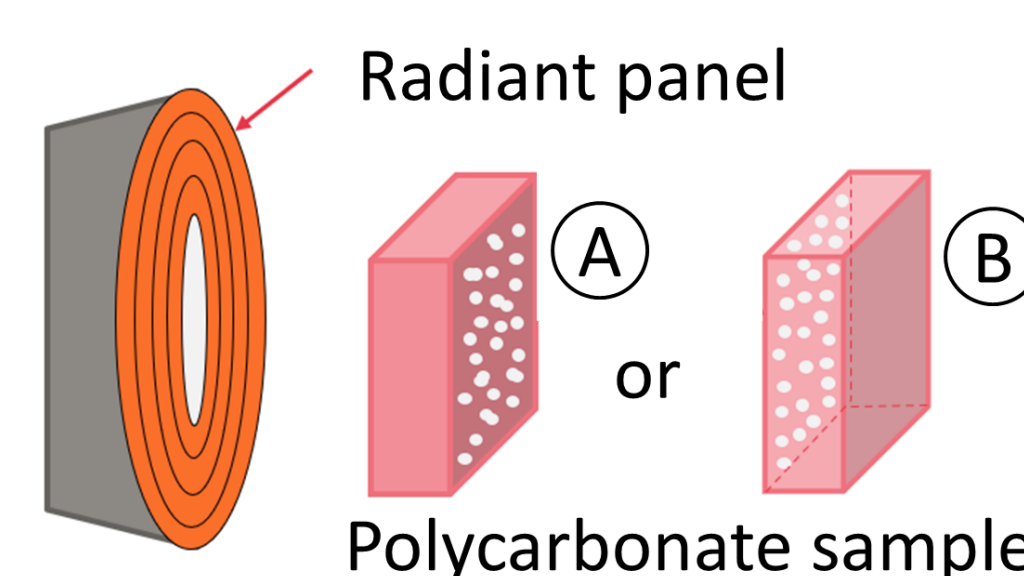
Thermal degradation facility for the study of airborne resuspension by fire



Fire dynamic and results



Bubbles appear on the surface of the polymer during the first phase of the fire. Then, the sample ignites. The sample ultimately collapses due to its deformation and loss of mechanical integrity after reaching its glass transition temperature. It is followed by the formation of a carbonaceous residue.



The mean ARF for three experiments is:

A: $0.167\% \pm 0.031\%$

B: $0.213\% \pm 0.029\%$

Conclusion

Blank measurements showed no hafnium particles.

Calculated ARF based on the filter measurements are of the order of a tenth of a percent for super-micronic particles.

The position of the particles regarding the radiant panel is affecting the ARF, but this remains of the same order of magnitude.

Literature cited

Sow *et al.* (2024) Quantifying the airborne release fraction of plutonium oxide surrogate in a medium-scale fire experimental facility. Companion paper for EAC2024 Zavaleta *et al.* (2024) Presentation and first outcomes of the FIGARO research program that aims at assessing the airborne release fraction of plutonium dioxide during glove box fires in nuclear fuel fabrication and reprocessing plants. Mechanical Engineering Journal. 10.1299/mej.23-00463

Acknowledgments

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