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Savannah River
NUCLEAR SOLUTIONS℠

# Initial Testing of a Small Gamma Detector (GR1+) for Detection of Holdup in HEPA Filters

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Summer Work Testing for Andy

Measuring and assessing holdup is a key component of proper inventorying of a Material Balance Area (MBA). The Nuclear Material Control and Accountability (NMC&A) group at the Savannah River Site is responsible for ensuring that the methods used to determine holdup in the MBAs are valid for the conditions of that MBA. Holdup can be contained inside processing equipment or inside ventilation systems that that pulls air out of the glovebox through HEPA filters and stainless steel piping.

Typically, a liquid nitrogen cooled, commercially available germanium semi-conductor crystal detector is used to measure and determine the quantity of holdup in different areas of these two regions. For the glovebox region, the detector is quite close to the target which significantly increases the accuracy of the measurement. However, the ventilation measurements are much more challenging to do because of their further target to detector distance as well as additional shielding material between the detector and target that significantly increases gamma attenuation. While this is currently the standard for the facility, new methods are being looked at to increase the quality and decrease the uncertainty in these measurements.

One of these new methods is using a commercially available Cadmium Zinc Telluride (CZT) crystal detector which can be directly against the target in the ventilation system. These detectors can be placed along pipes and, more importantly, against the outside housing of HEPA filters which usually are at the inlet to the above ventilation system from the glovebox. These HEPAs typically represent most of the holdup attributed to the ventilation. This detector is powered over USB and does not need any liquid cooling since it operates at room temperature. A currently produced model, the GR1+ by Mirion/Kromek, was obtained and set up to perform calibration measurements of a setup similar to what would be expected in a nuclear processing facility.

The GR1+ detector was attached to the outside of the filter in one of the possible locations the detector could be placed along the side of the HEPA filter housing in the facility. In order to access the transport of gamma rays through the HEPA filter and housing, a multi-energy certified gamma ray source (Ho-166m) was used for the testing of the GR1+.

This detector is ISOCS characterized meaning that the detector was calibrated at the commercial company Mirion, and a detector file was created for this exact detector. That file can be uploaded into the ISOCS Geometry Composer software which can model the measurement conditions and be used to determine the measurement efficiency of the detector at different source locations in the HEPA filter.

On August, 12$^{th}$ 2024, the GR1+ detector was attached to the side of a commercially available HEPA filter housing (Figure 1). The Ho-166m source (Figure 4) was placed at 21 different locations in the HEPA filter at 7 different locations at 3 different heights (Figures 2 and 3) in the HEPA filter to attempt to cover the entire range of source locations. Those results were then compared against the model created in the ISOCS software and adjustments were made to improve the agreement between the two. This was an iterative process until a consensus was reached.

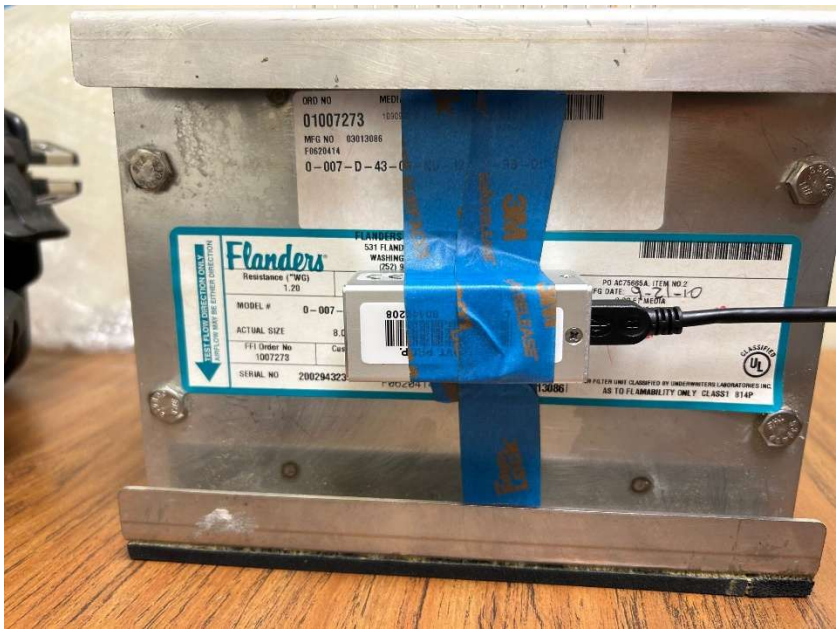


Figure 1

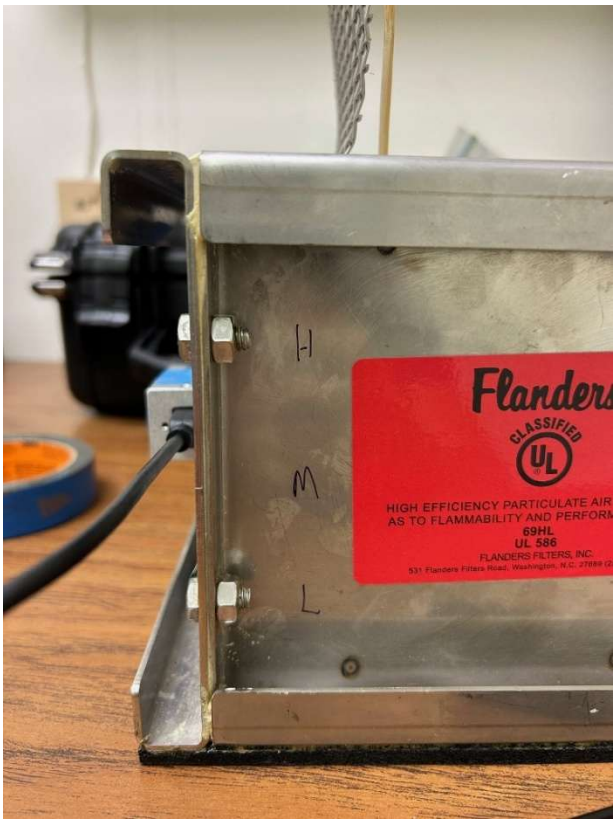


Figure 2

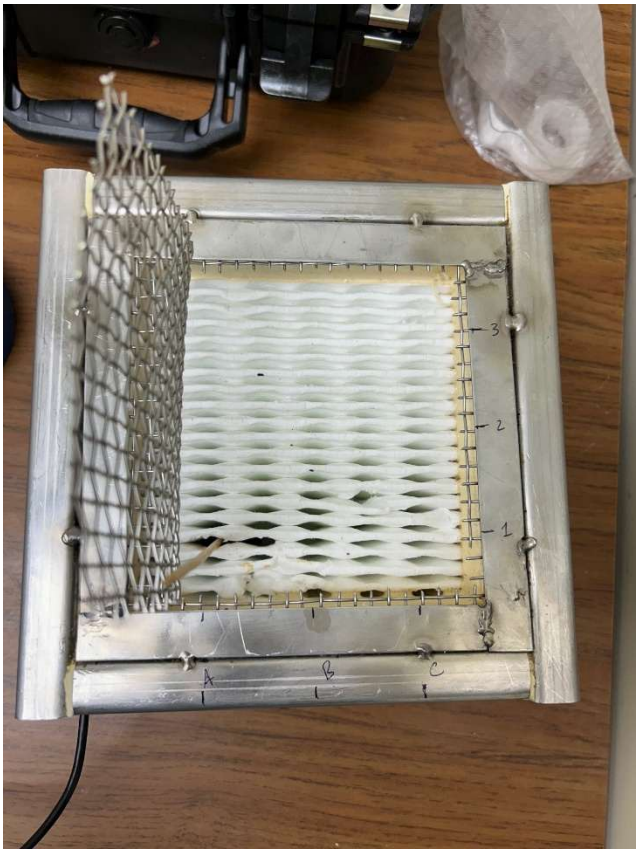


Figure 3


Figure 4

The measured results were compared to the ISOCS results to yield the following:

| | A | B | C | | | |
|---|---|---|---|---|---|---|
| **High** | -34.74% | | 0.92% | **3** | Average | STD DEV |
| | 3.66% | 20.76% | 5.98% | **2** | 14.25% | 37.83% |
| | 90.30% | | 12.86% | **1** | | |
| | | | | | | |
| **Mid** | -28.46% | | -1.69% | **3** | | |
| | 19.17% | 10.24% | 26.11% | **2** | 28.75% | 58.17% |
| | 153.73% | | 22.16% | **1** | | |
| | | | | | | |
| **Low** | -37.35% | | -8.89% | **3** | | |
| | -9.63% | 4.30% | 6.94% | **2** | 11.34% | 46.14% |
| | 108.65% | | 15.38% | **1** | | |

Table 1

Where the percentage is the difference between the ISOCS and measured result (positive value indicates a larger result in the model than the actual measurement).

The average difference was below the 28% uncertainty currently assigned to the HEPA measurement points for holdup measurements for 2 of the 3 heights with the Mid location being approximately the same value.

After looking at this data, it was determined that the A1 position was much more significantly different than between the model and actual measurement than at any of the other 8 locations. This indicates that there is probably additional shielding between the detector and source at this location. The ISOCS model software cannot be fine-tuned enough to assess this difference. Therefore, a further study will be done using a more robust gamma transport code, a Monte Carlo n-transport Code (MCNP), to investigate this discrepancy.

When the A1 position is removed from the data set, the following results:

| | A | B | C | | | |
|---|---|---|---|---|---|---|
| **High** | -34.74% | | 0.92% | **3** | Average | STD DEV |
| | 3.66% | 20.76% | 5.98% | **2** | 1.57% | 19.17% |
| | | | 12.86% | **1** | | |
| | | | | | | |
| **Mid** | -28.46% | | -1.69% | **3** | | |
| | 19.17% | 10.24% | 26.11% | **2** | 7.92% | 20.40% |
| | | | 22.16% | **1** | | |
| | | | | | | |
| **Low** | -37.35% | | -8.89% | **3** | | |
| | -9.63% | 4.30% | 6.94% | **2** | -4.88% | 18.59% |
| | | | 15.38% | **1** | | |

Table 2

The average difference for all 3 heights, averaged across all 6 locations at each height, is below 10%, well below the 28% uncertainty that is currently applied to the HEPA measurement results.

Therefore, the GR1+ detector system tested in this experiment would be more than adequate as a remote holdup measurement system that could be applied to ventilation holdup applications as long as an initial model characterization and testing are done.