



## Requirements for Filters and Filter Testing

The radionuclide segment of the IMS is required to achieve a minimum of 95% data availability while maintaining high sensitivity for detection of nuclear explosions. These consistent levels of performance can only be achieved with the continued use of high-quality and reliable equipment and consumables. To manage and ensure the future supply of filter media needed to sustain longer-term IMS radionuclide particulate sampling, the PTS is preparing for the testing and qualification of the future supply of IMS filter materials. This project aims to define a testing regime for product acceptance testing and batch testing for quality assurance.

CTBT/WGB/TL-11,17/18 OPERATIONAL MANUAL FOR RADIONUCLIDE MONITORING AND THE INTERNATIONAL EXCHANGE OF RADIONUCLIDE DATA

Minimum Requirements for Particulate Monitoring Station Specifications:

- Airflow > 500 m<sup>3</sup>/h
- Filter Adequate composition for compaction, dissolution and analysis
- Collection efficiency
  - Collection efficiency > 80% for particle size of 0.2 μm
  - Global collection efficiency > 60% for particle size 10 μm
- Baseline Sensitivity 10 to 30 μBq/m<sup>3</sup> for Ba-140

### Measurement of collection efficiency:

Filter collection efficiency is a function of particle size, face velocity of air flow through the filter and loading of the filter. Past tests have shown that the collection efficiency increases monotonously with size and plateaus after 1 μm. Collection efficiency decreases with increasing speed of air flow. RASA aspiration efficiency (worst case) at 10 μm particle size was measured as 65%.

### Implications for testing regime:

Collection efficiency test should be undertaken at maximum face velocity. This is approx. 1.4 m/s for TGD sample (smallest filter size) and at 1000 m<sup>3</sup>/h air flow. Proposed conservative testing parameter therefore is face velocity of 1.5 m/s. Global collection efficiency is met if filter collection efficiency is > 92 % for 10 μm particle size. Test for collection efficiency for 10 μm is therefore only required if collection efficiency at 0.2 μm is above 80% and less than 92%. Test for collection efficiency at one particle size between 1 μm and 10 μm may be used to estimate collection efficiency at 10 μm.

### Filter material composition

Material composition testing is required for evaluation of new material.

**Requirements:**  
Elemental composition is needed for modelling purposes  
Filter needs to be suitable for use at IMS stations, e.g. be useable at RASA stations and meet requirements for compression at manual stations.

### Proposed testing regime for evaluation:

Mechanical test to confirm usability for manual and RASA stations  
Fourier-Transform Infrared Spectroscopy (FTIR) or CHNO test to determine bulk composition  
Inductively Coupled Plasma Mass Spectrometry (ICPMS) for trace elements

### Radioactivity content

**Requirements:**  
No anthropogenic radio-isotopes detectable in IMS measurement (HPGe, 24 hours counting time)  
MDC for Ba-140 < 10 mBq/m<sup>3</sup>

### Proposed testing regime for evaluation:

Gamma spectrometry at certified CTBT laboratory, 7 day counting time

## Acceptance Test and QA test procedure

### Proposed testing regime for Acceptance Testing:

- Test of collection efficiency for whole filter for particle size 0.2 μm (or distribution including 0.2 μm) at face velocity 1.5 m/s.
- Test of collection efficiency for scrim for particle size 0.2 μm (or distribution including 0.2 μm) at face velocity 1.5 m/s.
- If collection efficiency (0.2 μm) is between 80-92% then:
  - test of collection efficiency at a particle size between 1 μm and 10 μm (or distribution) at 1.5 m/s face velocity.
- Measurement of elemental composition and trace elements (as above)
- Radioactivity measurement by gamma spectrometry

### Proposed testing regime for QC (for production batch testing):

- Test of collection efficiency for whole filter for particle size 0.2 μm (or distribution including 0.2 μm) at face velocity 1.5 m/s.
- If collection efficiency (0.2 μm) is between 80-92% then
  - Test of collection efficiency at a particle size between 1 μm and 10 μm (or distribution) at 1.5 m/s face velocity.
- Radioactivity content of blank filters measured by gamma spectrometry

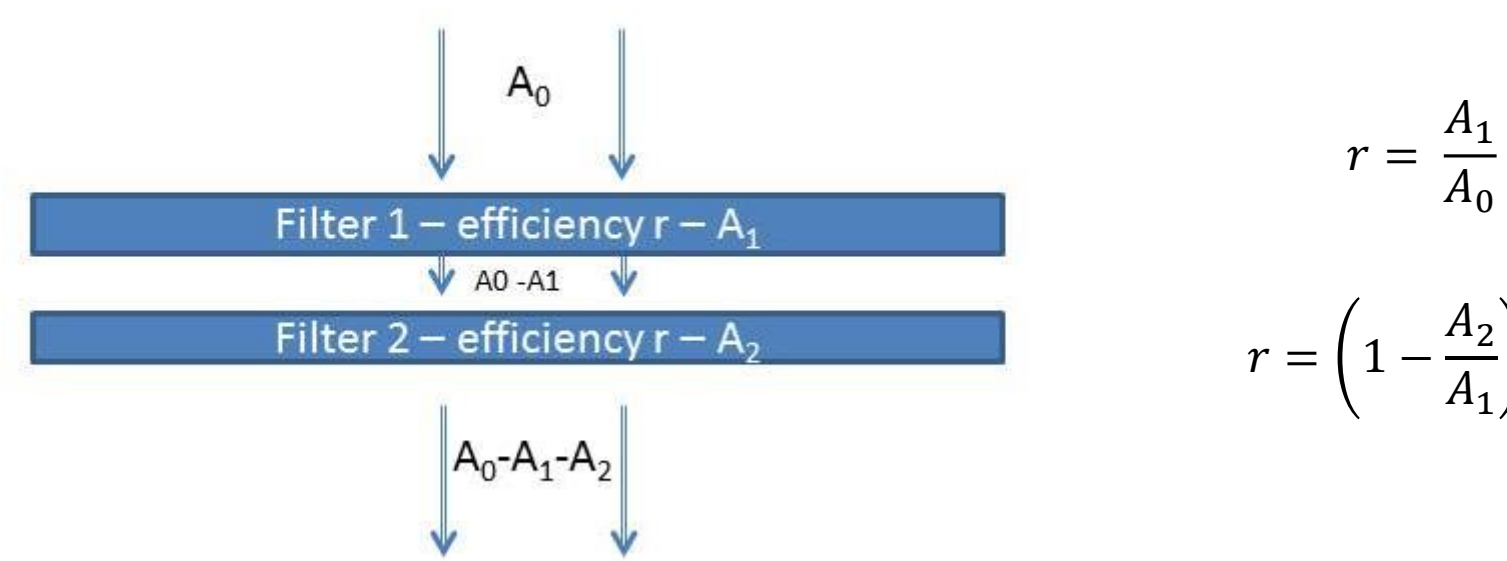
## Initial Testing at the CTBTO test facility VIP00 And filter collection efficiency test results

VIP00 is a fully functional particulate station which is used for testing of equipment, software and procedures before adoption into the IMS. The following tests can be undertaken at VIP00 as part of acceptance testing of filter material.

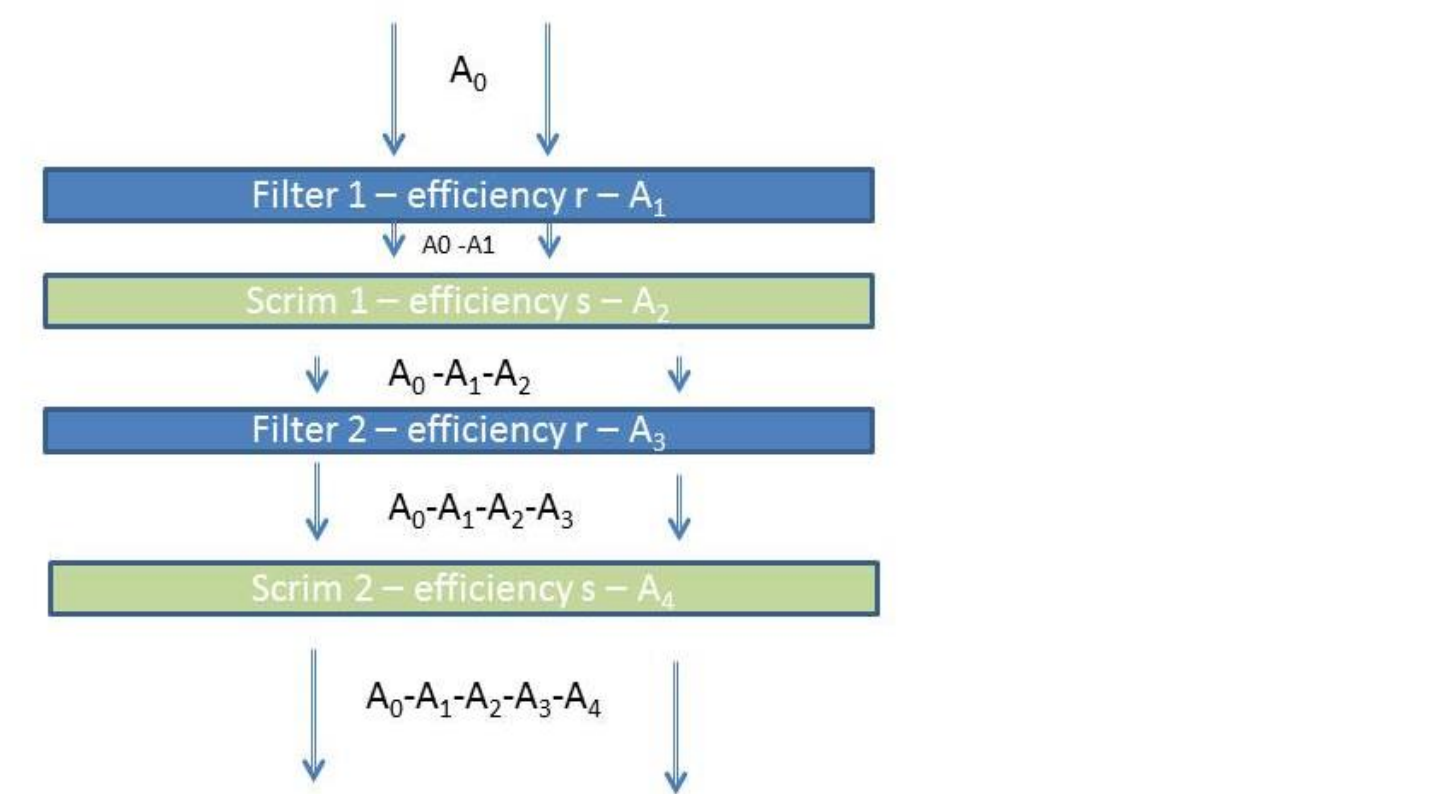
- Visual inspection, weight measurement and compression test.
- Filter efficiency test under realistic operating conditions using naturally occurring nuclides (Be-7, Pb-210, ..) present in ambient air.
- Radioactivity measurement of blank material.

### Collection efficiency determination using Be-7

Collection efficiency of filters can be measured by sampling air through a stack of filters (2 or more) and subsequent analysis of the nuclide activity on each individual filter in the stack. Be-7 has been shown to have a size distribution centered around 0.5-1 μm and can therefore be used for preliminary measurements against IMS requirements.



The manual filters used at IMS stations consist of a thin filter and a support layer (scrim). While the collection efficiency of the scrim should be small, a full test should include the contribution.



$$A_1 = rA_0$$

$$A_2 = s(1-r)A_0$$

$$A_3 = r(1-s)(1-r)A_0$$

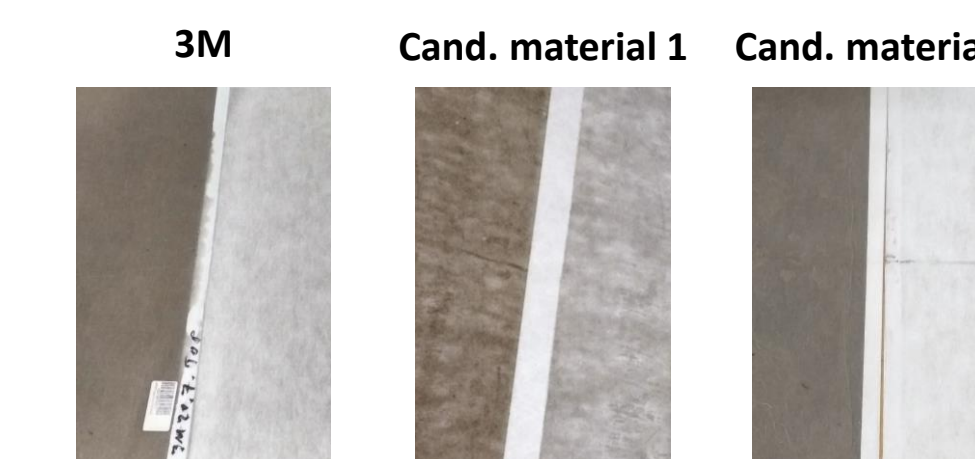
$$A_4 = s(1-s)(1-r)^2A_0$$

$$r = \frac{1 - \frac{A_3}{A_1}}{1 + \frac{A_2}{A_1}}$$

### Assumptions and limitations:

- Filter elements have identical collection efficiencies
- Collection efficiency is constant over the size distribution (Be-7)

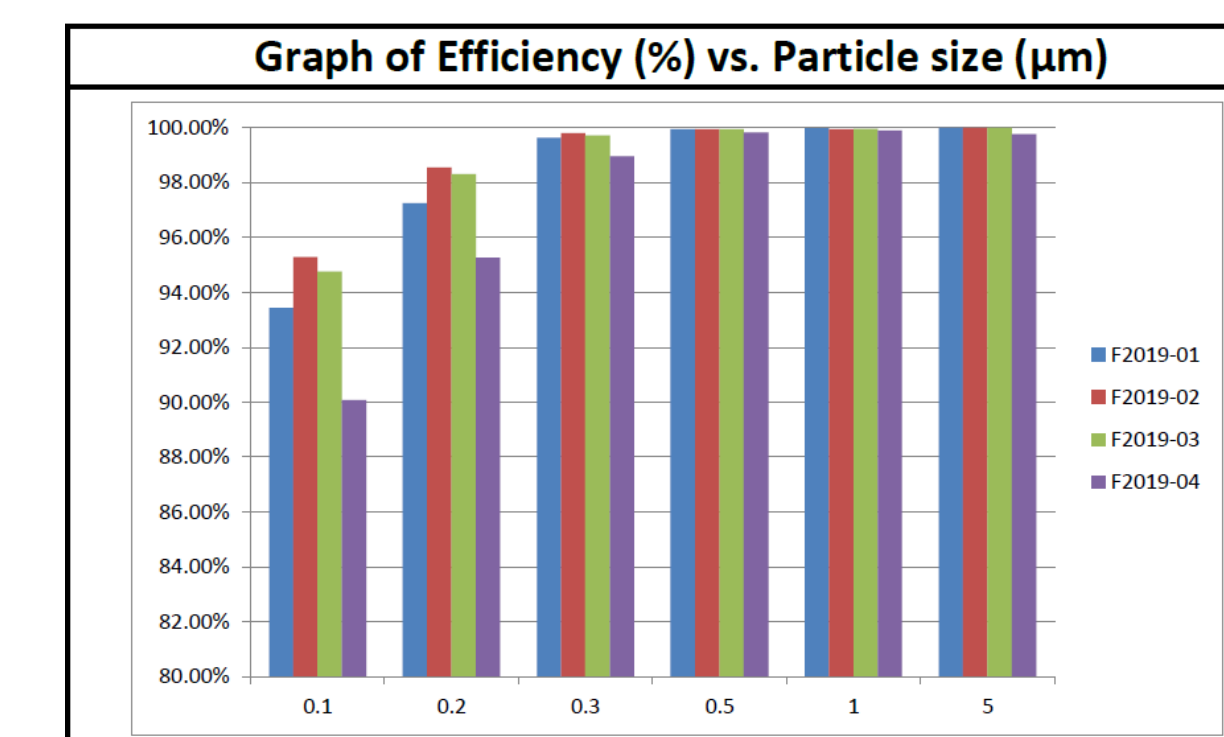
### Initial testing at VIP00



Be-7 test			
Filter	3M	CM 1	CM2
Coll eff	0.93	0.60	0.96

### Collection efficiency measurements

Testing of filter media for collection efficiency was performed by APC Filtration Inc. (except CM2). The tests were undertaken according to IEST-RP-CC021.3 using KCl as an aerosol. Tests with face velocity of 1.5 m/s



Test results for four different filters, binned for 6 different particle sizes (0.1 – 5 μm).



Filter collection efficiency (0.2 μm) results. Note: candidate material 2 result is based on Be-7 test

## Test Results 3M filters and candidate materials

### Physical properties:

- 3M - good handling and compression properties.
- Candidate material 1 - filter residue remains on compression dye, compressed disk good.
- Candidate material 2 - good handling, compressed disk too thick (-15% in detection eff.).

**Long term stability:** 3M filters taken from depot from different batches produced 2011-2017 were all meeting requirements without measurable deterioration.

**VIP00 test:** Useful for prescreening of filter material and for testing under normal operating conditions. Be-7 collection efficiency is good indicator of collection efficiency at 0.2 μm.

### Collection Efficiency:

- 3M: All filters tested 88% or higher.
- Candidate material 1 - collection efficiency too low, scrim collection efficiency high
- Candidate material 2 - collection efficiency comparable to 3M

## Conclusions and outlook

- Acceptance Test Criteria and test plan have been developed.
- Initial Testing at VIP00 shown to be valuable screening test
- High efficiency filter material is only available from a small number of suppliers.
- IMS stations can continue using 3M filters until a new supply contract is in place.
- Testing of new candidate material will continue.
- QC testing for batch acceptance will be implemented.