PNNL-13754 Ver. 1.2

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Filter Media Recommendation Review

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January 2002

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

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(9/2003)

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Executive Summary

The original filter recommended by PNNL for the RASA is somewhat difficult to dissolve and has been discontinued by the manufacturer, 3M. The manufacturing process for substrate blown micro-fiber (SBMF) media has been superceded by a substrate-free process known as blown micro-fiber (BMF). Several new potential filters have been evaluated by PNNL and by an independent commercial lab. A superior product has been identified which provides higher trapping efficiency, higher air flow, is easier to dissolve, and is physically thinner resulting in more filters per RASA roll. This filter is recommended for all ground-based sampling, and with additional mechanical support, may be useful for airborne sampling.

Introduction

The original filter specified for the RASA, SBMF-40VF (3M part number R122), met the original needs of high volume sampling with adequate dissolution chemistry. A recent test, funded by the Comprehensive Test Ban Treaty Organization and carried out by STUK, but performed at VTT (Aimo Taipale, VTT Automation, PO Box 13001, Tampere, Finland) demonstrated the superior characteristics of the media.

For the past two years, efforts have been underway at PNNL and 3M Filtration Products to identify and select a filtration media for the RASA that would be free from titanium, meet particle collection requirements, be cost effective and available long-term from the 3M company. In light of the recent discontinuation of 3M R122 media this effort has become more important as the available stock of the R122 media is limited.

As a review, virtually all of the titanium contained in media R122 was in the cover web of the material. The cover web provides the mechanical stability necessary for the filter to transit the RASA sample head effectively. A new web was identified in mid-2000 that was titanium free. This cover web, trade named Typar, was evaluated on two different occasions at PNNL. Trace element analysis showed Typar to be essentially free of titanium, which should make dissolution easier and more successful. In addition, trace analysis of actinides (below detection limits) showed that this filter would give excellent results. (See Appendix 1.)

Recent Testing

In late 2000, 3M joined Typar with the recently developed blown micro fiber filtration material to create a new RASA media named 3M F734. Difficulty surrounding the identification of an independent filter testing laboratory that could challenge the filter at the face velocities used in the RASA prevented the formal adoption of this media. Finally, in May of 2001, VTT Automation was contracted to provide a third-party evaluation of F734. The results of this test are shown in Figure 1. Note that efficiency is shown at several face velocities. Depending on the pressure drop attainable by a sampling system, the sample volume changes. Given that the face area of the RASA is about 0.24 m^2, the daily volume attainable for a RASA that can attain a differential pressure of 2,100 Pa would be:

$$\text{Volume} = 86{,}400 \text{ seconds/day} * 2.50 \text{ m/s} * 0.24 \text{ m}^2 = 51{,}400 \text{ m}^3\text{/day.}$$

Note: A RASA that has been modified for CTBT certification can attain a pressure drop of ~2100 Pa. The PNNL prototype RASA can attain ~1200 Pa and collect about 22,000 m^3/day.

The collection efficiency results for F734 were disappointing, as the minimum CTBT requirement is 80% trapping efficiency for 0.2 micron particles. Clearly, a more efficient filter media was needed for the RASA.

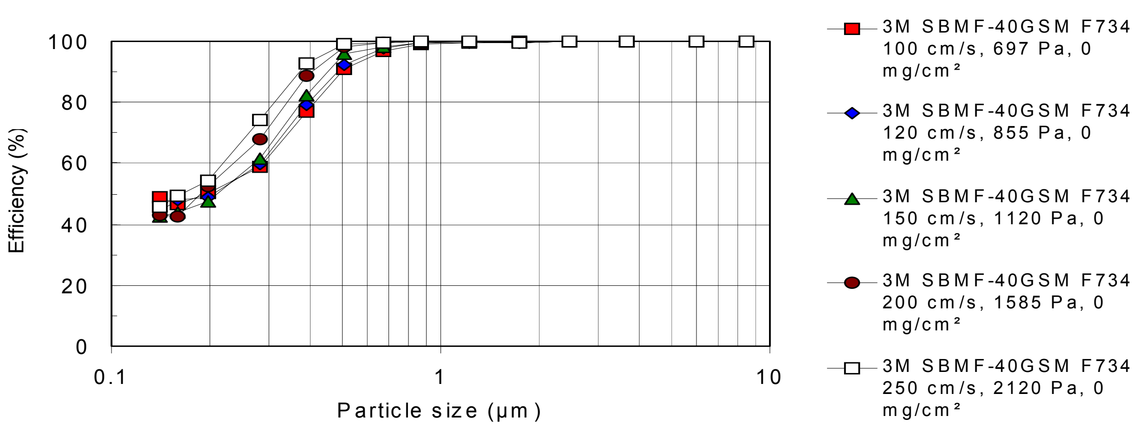

Figure 1. VTT results for 3M F734 (one layer)

Consultation with filtration experts at 3M produced a list of five other candidate filtration media, see Table 1. All of these candidate media require a higher differential pressure from the RASA blower than the F734 media (the F734 media had a pressure drop of 67%-70% of R122). Of the five media recommended to PNNL by 3M, two were selected for testing. These media are BMF40C (a.k.a.

Filter	Flow	DP ("H20)	Penetration	Particle Size
BMF40C-1 layer	103 lpm	5.4	19.1	0.28 micron
BMF40C-2 layers	103 lpm	11.0	2.7	0.28 micron
BMF30F	103 lpm	13.2	1.3	0.28 micron
BMF20F	103 lpm	8.2	13.4	0.28 micron
BMF-VB-1 layer	103 lpm	7.3	26.6	0.28 micron
BMF-VB-2 layers	103 lpm	14.4	6.5	0.28 micron
BMF-VB-3 layers	103 lpm	23.0	1.25	0.28 micron
F734	103 lpm	5.3	32.5	0.28 micron

Table 1. Filter information provided by 3M Corporation. Filters were challenged with 0.28-micron DOP particles.

3M 5379 40 gr. coarse) using a two layer construction and BMF20F (a.k.a. 3M 5379 20 gr. fine). PNNL has received a complete load of filtration media from 3M constructed from Typar and 5379 20 fine and has operated this media in RASA USX03 for several months without incident.

At PNNL's request, 3M shipped samples of BMF40C-2 layer and BMF20F to VTT in June 2001. VTT performed the same suite of tests on these media as on the F734 media (a subset of the tests provided to the CTBTO). The results of these tests are presented in Figures 2 and 3, respectively. In addition to these media, PNNL also requested that VTT repeat the filter testing regimen on two-layer construction of F743 media. Results of this examination are presented in Figure 4.

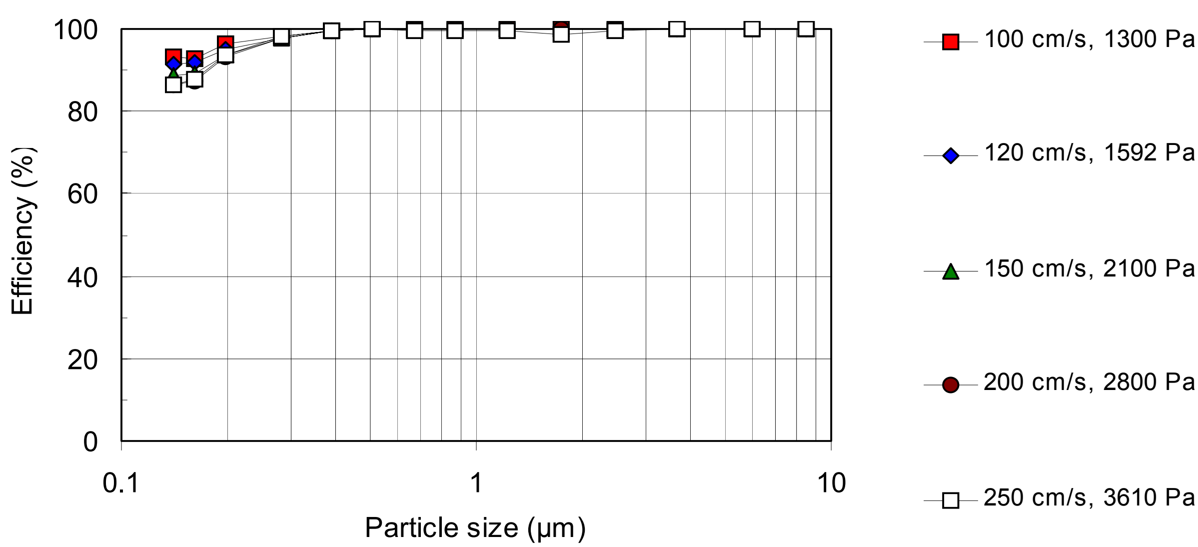

Figure 2. VTT results for 3M 5379 20 gr. fine.

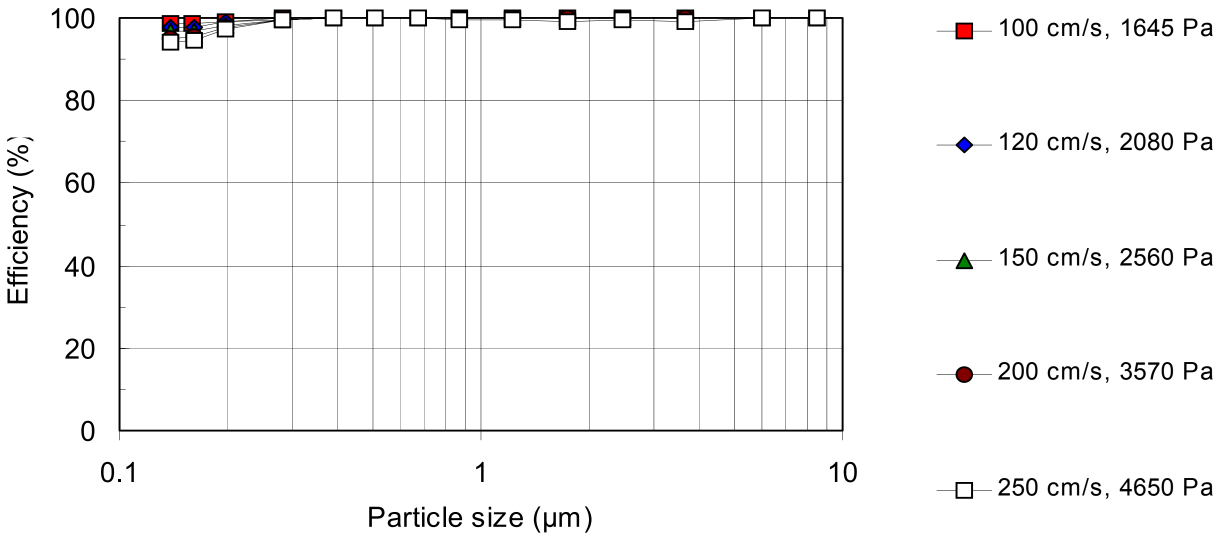

Figure 3. VTT results for 3M 5379 40 gr. coarse-2 layer.

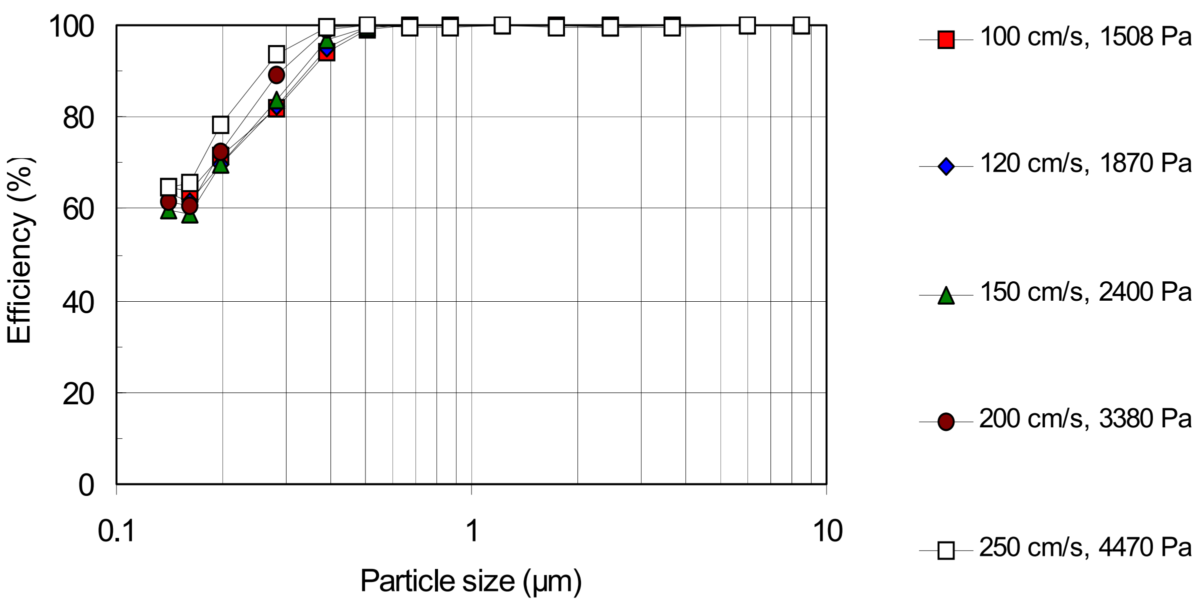

Figure 4: VTT results for F734 2-layer.

In reviewing this data, it is clear that either the BMF20F or BMF40C-2 layer will meet the >80% @ 0.2 micron collection requirements. The primary selection criteria must now shift to the available differential pressure at various face velocities in the RASA systems.

Applicability to the RASA

Tests of 3M 5379 20 gr. fine media carried out on RASA USX03 suggest the airflow is greater than when the RASA is loaded with the original R122 media. Currently, several blower options are available for the RASA. Figure 5 presents the relevant known data.

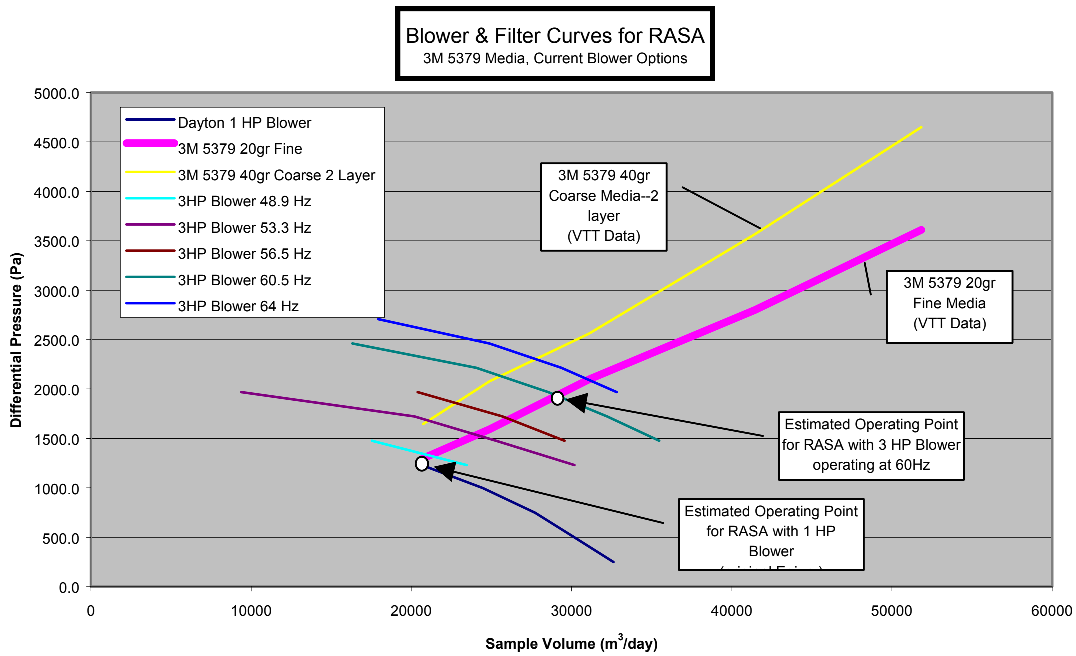

Figure 5: RASA Performance Curves

From these data, an estimated sample volume of roughly 20,000 m^3/day is obtainable with the original Dayton 1 HP blower. This estimate excludes the differential pressure of the RASA itself (measured in the prototype-RASA to be ~240Pa), which has been considered irrelevant to these calculations. Using the 3 HP blower engineered by DME/Veridian and operating this blower at 60 Hz, a sample volume approaching 30,000 m^3/day may be achievable.

Conclusions and future actions

Small, visual samples of BMF20F and BMF40C were obtained by PNNL on 19 July 2001. An inspection of these media did not reveal any concerns with respect to manufacturing long rolls of filter for use in the RASA. PNNL will continue to operate the USX03 prototype with a test run of filter media for a real-world test, although F734 on Typar has been in continuous test at PNNL for some time (>1 year) with no severe transport problems. There is the likelihood that the sealing rollers and drive rollers may need to be replaced to accommodate the thinner filter, but this requirement has been known for some time by the RASA community. Currently, by reasonable adjustment of the tensioning mechanism on the plastic tape rolls (the bar code roll and the sticky roll), F734 seals with minimal effectiveness.

An additional concern, given the single cover web now in use on the filter media, is based on the opportunity for the BMF fibers to collect on rollers and sliders in the RASA unit. All previous filtration media have had a cover web exposed on both sides of the media. This was a trivial accomplishment due to the fact these media were multi-layered. The single layer construction of 5379 20 fine media does not necessitate the use of multiple cover webs. Evaluation will need to be done in order to determine the potential severity of this problem.

Ultimately, a second cover web may need to be added to the media design. Tests conducted on the prototype-RASA with a Dayton 1-HP Blower demonstrated a 4-5% drop in differential pressure when a second layer of Typar was added to the BMF20F as a protective facing material.

Given the impetus surrounding the desire to begin the procurement of new filter media for the RASA, it is the conclusion of this report that efforts should begin as soon as possible to manufacture RASA filtration media based on a single layer of 3M 5379 gram/m^2 fine media and a single Typar cover web. Of course, the other criteria remain the same with respect to the construction methods for RASA filter.

These criteria are:

- Filter Media: 3M 5379 BMF 20 gram/m^2 fine, 1 layer
- Cover Web: Typar, one layer (bottom)
- Inner Core: Plastic Spool, 3.00” ID
- Outer Filter Roll Diameter: 18” maximum
- No Splices of the filter or cover web are allowed
- Filter width: 4.875” nominal +/- 0.125”

In addition to tests designed to evaluate the mechanical reliability of the media, filter loading tests should also be done to determine if the single layer of media will be subject to premature occlusion in some operational environments. Given the ‘loft’ of this material is very small, it may be more prone to occlusion than previous RASA media.

An evaluation of the differential pressure after considerable (~1 year) operation should also be executed to determine if the pressure drop varies significantly from sample to sample or from roll beginning to roll end. Presumably, the quality control measures in place at 3M would prevent significant deviations from the average, but to date, no data has been presented on this possibility.

Appendix 1. Trace element analysis

Alpha Backgrounds

Isotope	d/m/gram ash*
^{232}U	<0.00024
^{233}U	<0.00010
^{234}U	<0.00012
^{235}U	<0.00004
^{236}U	<0.00002
^{238}U	<0.00010
^{237}Np	<0.00037
^{236}Pu	<0.00004
^{238}Pu	<0.00008
$^{239-40}$Pu	<0.00004
^{242}Pu	<0.00006
^{242}Am	<0.00044
^{242}Cm	<0.00006
^{244}Cm	<0.00002

* "Less-than" value is based on a detection limit of 4 times background, but does not include interferences from other isotopes of the same element.

Filter ash composition of 0.25 m^2 filter of similar type

Element	Ash mg
Ag	0.01
Ba	0.005
Be	<1 E-6
Cd	0.0001
Ce	0.0006
Fe	0.126
Mo	<0.001
Nd	0.0016
Sm	<0.001
Sr	0.0012
Ti	0.0758
Y	<0.0001
Zr	0.0003
Ca	0.966
SUM:	1.189 mg