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Detailed Basis for Assumptions Used to Determine Radionuclide Process Removal Efficiencies

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Detailed Basis for Assumptions Used to Determine Radionuclide Process Removal Efficiencies

1 Introduction

This document provides additional details about the basis for the assumptions used to determine radionuclide removal efficiencies in high-level waste treatment processes (WSRCa, 2005). The additional basis information is provided in a cross-reference table where the assumption in the original evaluation is identified with specific location reference. References are provided to support the assumption including reference to data that demonstrate validity of the assumption where available.

2 Tables

Table 1: Assumption Basis and References for Radionuclide Removal Efficiencies (WSRCa, 2005)

Assumption	Basis	Reference
DDA – Deliquification: Nominal: remove 50% of the supernatant solution, Lower bound: 30% removed Upper bound: 70% removed.	The nominal case represents the experience from the deliquification of one tank, Tank 41. The analysis by Flach on this draining experience establishes that the operation removed about 50% of the interstitial liquid. A detailed discussion of the basis of the liquid remaining in the saltcake is provided in the response to NRC comment 12 (see CBU-PIT-2005-00131, Rev. 1, pages 55 – 59). The limited amount variability analysis using the known variability in physical properties of the saltcake and interstitial supernate shows that the percent of liquid removed can have a very large variance from the nominal estimate. The values for the upper and lower bound approximate this variance.	Shah and Hopkins, 2004, page 3 Flach, 2003, pages iii - iv Flach, 2004, page 3 WSRCb, 2005, pages 55 – 59
DDA – Gravity Settling: Nominal: thirty day period - two-thirds of the suspended solids removed Lower bound: 50% Upper bound: 80%	A detailed discussion of the basis of the solids removal by gravity settling is provided in the response to NRC comment 12 (see CBU-PIT-2005-00131, Rev. 1, pages 63 – 64). The amount removed depends on the time allowed to settle and the height of the liquid layer. For the planned cases, there is very little variability from nominal. The variability estimates are based on general experience with operating the high-level waste facilities to produce a batch of the size planned and the length of time allowed beyond the 30 days planned. In addition, the settling properties are based on sludge settling properties gained from sludge processing experience. The suspended solids might behave somewhat differently from the sludge material previously known and measured, which could reduce or increase the settling rates. Therefore, the values for the upper and lower bound represent the range typically experienced with similar operations.	WSRCb, 2005, pages 63 – 64 Gillam, 2005

Table 1: Assumption Basis and References for Radionuclide Removal Efficiencies (WSRCa, 2005)

Assumption	Basis	Reference
Cross-flow filtration for all processes Nominal: 100% removal of the suspended solids Lower bound: 99.5% removal	ARP design basis uses 100% efficiency as noted by stream 14 in the material balance, filtrate to Tank 50, showing no solids content. SWPF Design basis is under development and equivalent documentation is not available. The pre-conceptual design basis for SWPF used 100% efficiency. Startup testing at ARP shows the filter feed solutions with turbidity measurements of 20,800, 42,600, and 86,700 NTUs were reduced to less than 0.5 NTUs in the filtrate, which indicates practically 100% of the insoluble solids were removed. The lower bound is based on industrial filtration experience as demonstrated by literature for sintered metal filters equivalent to the filters used in ARP/SWPF designs to separate insoluble solids. Examples from the references show a random sintered-metal filter cartridge manufacturer that rates a 0.1-micron filter at 100% efficiency for particles above about 0.4 microns. Sinter metal filters have been tested for use as HEPA filter media, which requires 99.95% minimum efficiency. The tests show a minimum 99.97% efficiency for 0.3-micron particles. Since the filter media could be used for HEPA filters, the lower bound is estimated to be 99.5%.	Subosits, 2004, Appendix A, page 5. Dimenna, et. el., 1999, Appendix A, C, and E. Harrison and Seufert, 2002, page 8. Mott HEPA filter replacement: http://www.netl.doe.gov/products/em/IndUnivProg/pdf/2405.pdf, page 48 (Appendix A) GKN Sintered Metal Filter Cartridge brochure: http://www.pyramidfilters.com/html/metalfiltermedia.html#membrane, page 5 (Appendix B)

Table 1: Assumption Basis and References for Radionuclide Removal Efficiencies (WSRCa, 2005)

Assumption	Basis	Reference
ARP – Duration of the MST strike: 24 hours	Residence time for the MST strike is part of the ARP design basis.	Subosits, 2004, page 5 Le, 2005, page 4
ARP – decontamination factors (DFs) of the MST strike: See Table 2 shown below.	Nominal DFs are those used in the ARP design basis for a twenty-four hour duration strike as reported by Le. This report compiles the DFs used in ARP and the SWPF design basis and compares them to the available test data for some alternate process options. The references that document latest laboratory test data demonstrating DFs for several simulants and few actual waste tests are as follows: D. T. Hobbs et al., "Phase V Simulant Testing of Monosodium Titanate (MST) Adsorption Kinetics," WSRC-TR-2000-00142, Rev. 0, May 2000 D. T. Hobbs and T. B. Peters, "Estimate Decontamination Factors for Americium and Curium upon Contact of Concentrated Alkaline Waste Solution with Monosodium Titanate," SRT-LWP-20003-00013, January 2003 D. T. Hobbs and F. Fondeur, "Decontamination Factors for Strontium, Plutonium, Neptunium, and Uranium upon Contact of Concentrated Alkaline Waste Solutions with Monosodium Titanate", SRT LWP 2004 00076, Rev. 0, May, 2004 M. J. Barnes, F. F. Fondeur, D. T. Hobbs, and S. D. Fink, "Monosodium Titanate Multi-Strike Testing," WSRC-TR-2004-00145, Rev 0, April 2004	Le, 2005

Table 1: Assumption Basis and References for Radionuclide Removal Efficiencies (WSRCa, 2005)

Assumption	Basis	Reference
	Lower and upper bounding DFs represent the extremes of the available data as compiled by Le from these references under conditions of four to twenty four hour duration strikes.	
MCU – radionuclide DF: Nominal: 12 for soluble phase cesium; 0 for Sr-90 and alpha-emitting TRU nuclides	The DF is based on the minimum design specification for the MCU as identified by d'Entremont in the process planning reference. The real waste demonstration of CSSX shows that overall DFs varied during the test from 40,000 to 802,000. For the 15 extraction stages in the test, single stage DF would average from 3.9 to 5.0. Parsons reports the single stage DF from a simulated waste test of 1.97. Using these average stage DFs and the current MCU conceptual design showing 7 contactors for the extraction stage, the overall DF could range from 46 to 17,000. Since the compositions tested so far are intended to test the range of compositions sent to the SWPF, the actual composition sent to the MCU may vary considerably from those tested, thus, the low end of performance is used to set the design parameter. Until the exact composition of the salt solution is known and the actual contactors designed and tested, the actual performance remains unknown. Without additional performance data on actual waste, the design basis DF of 12 is used to project the facility performance.	d'Entremont and Drumm, 2005, page 26 Campbell, et. el., 2001, pages 57 - 58 Parsons, 2004, page 23
SWPF – Duration of the MST strike: 12 hours	Residence time for the MST strike is part of the SWPF design basis. Note that the design basis is still under development and the process has not been optimized. As such, the residence time baseline value may change in the future.	Parsons, 2004, pages 21-22

Table 1: Assumption Basis and References for Radionuclide Removal Efficiencies (WSRCa, 2005)

Assumption	Basis	Reference
SWPF – decontamination factors (DFs) of the MST strike: See Table 3 shown below.	Nominal DFs are those used in the SWPF design basis for a twelve hour duration strike as reported by d'Entremont. Le compiles the DFs used in ARP and the SWPF design basis and compares them to the available test data for some alternate process options. The references that document latest laboratory test data demonstrating DFs for several simulants and few actual waste tests are as follows: D. T. Hobbs et al., "Phase V Simulant Testing of Monosodium Titanate (MST) Adsorption Kinetics," WSRC-TR-2000-00142, Rev. 0, May 2000 D. T. Hobbs and T. B. Peters, "Estimate Decontamination Factors for Americium and Curium upon Contact of Concentrated Alkaline Waste Solution with Monosodium Titanate," SRT-LWP-20003-00013, January 2003 D. T. Hobbs and F. Fondeur, "Decontamination Factors for Strontium, Plutonium, Neptunium, and Uranium upon Contact of Concentrated Alkaline Waste Solutions with Monosodium Titanate", SRT LWP 2004 00076, Rev. 0, May, 2004 M. J. Barnes, F. F. Fondeur, D. T. Hobbs, and S. D. Fink, "Monosodium Titanate Multi-Strike Testing," WSRC-TR-2004-00145, Rev 0, April 2004 Lower and upper bounding DFs represent the extremes of the available data as compiled by Le from these references under conditions of four to twenty four hour duration strikes.	d'Entremont and Drumm, 2005, page 32 Le, 2005

Table 1: Assumption Basis and References for Radionuclide Removal Efficiencies (WSRCa, 2005)

Assumption	Basis	Reference
SWPF – the CSSX DF for soluble phase cesium: Nominal: 40,000	The DF is based on the minimum design specification for the SWPF as used by d'Entremont in process planning. The SWPF design basis is still under development. The real waste demonstration of CSSX shows that overall DFs varied during the test from 40,000 to 802,000. For the 15 extraction stages in the test, single stage DF would average from 3.9 to 5.0. Parsons reports the single stage DF from a simulated waste test of 1.97. The current design shows 16, 2, 16, and 2 contactors for the extraction, wash, stripe, and scrub stages, which results in an overall DF of 33,000.	d'Entremont and Drumm, 2005, page 32 Campbell, et. el., 2001, pages 57 - 58 Parsons, 2004, page 23

Table 2: ARP MST Soluble Phase Decontamination Factor

Constituent	ARP MST Soluble Phase Decontamination Factor		
	Nominal	Lower Bound	Upper Bound
Strontium	130	20	130
Cesium	0	0	0
Plutonium	13	5.5	13
Americium	1.7	1.0	4.6
Curium	1.7	1.0	1.7

Table 3: SWPF MST Soluble Phase Decontamination Factor

Constituent	SWPF MST Soluble Phase Decontamination Factor		
	Nominal	Lower Bound	Upper Bound
Strontium	20	20	130
Cesium	0	0	0
Plutonium	5.5	5.5	13
Americium	4.6	1.0	4.6
Curium	1.0	1.0	1.7

3 References

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Appendix A

Mott HEPA filter replacement: http://www.netl.doe.gov/products/em/IndUnivProg/pdf/2405.pdf, page 48 (Appendix A)

Mott Corporation

Sintered Metal HEPA Filter

Technology Need:

Conventional disposable glass-fiber high-efficiency particulate air (HEPA) filters are used throughout the Department of Energy (DOE) complex in various systems. For instance, high level waste (HLW) tanks which are located outdoors are equipped with a ventilation system to maintain the tank contents at negative pressure (-1.0" water column), which prevents the release of radioactive material to the environment. These systems are equipped with conventional disposable glass-fiber HEPA filter cartridges. HEPA filters are critical elements for the prevention of the release of material to the atmosphere and thereby serve to protect workers, the public, and the environment.

However, these filters require routine removal, replacement, and disposal. This process is not only expensive, but also subjects personnel to radiation exposure and adds to an ever growing waste disposal problem. Conventional HEPA filters also create safety concerns in the areas of filter media strength, water damage, and operation in environments with elevated temperatures. There is a need for high quality, durable, moisture tolerant HEPA filters which can be regenerated or cleaned in situ as an alternative to conventional disposable HEPA filters.

Technology Description:

Alternatives to glass fiber filter media hold great promise for use in HEPA filters. The Mott Corporation is developing a sintered metal HEPA filter to replace the conventional glass filters. These filters have the potential for a long life and can be regenerated in situ. In addition to eliminating the costs associated with conventional filter replacement and disposal, the strong filter media will reduce the potential for a catastrophic HEPA filter failure due to high moisture content or fire.

Mott Sintered Metal Filter

For cleaning, one or more spray nozzles contact the media the full length of the cylinder. Reverse flow of clean air during the cleaning will assist in dirt and sludge removal by creating a turbulence at the surface and flow out of the pore structure. This air flow will not change the pressure of the tank relative to the atmosphere. Scale-up is simply the multiplication of one element, each element operates independently of the others.

Benefits:

- Filters can be regenerated without being removed from the ventilation system
- Eliminates personnel radiation exposure associated with removal of plugged filters
- Eliminates high costs of filter replacement & disposal
- Discharges from the system are compatible with the HLW tank contents (e.g., no organics or chlorides), therefore preventing generation of a waste stream that would require separate treatment

TMS Tech ID: 2405 September 2002

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- Filter systems are moisture tolerant both to minimize the possibility of soluble cesium releases and to meet the other performance requirements

- Sintered metal filters are stronger structurally, thus reducing the potential of a filter failure due to media breakthrough, moisture, or fire in the process ventilation system

- In situ regenerative system may also be suitable to recover nuclear materials, such as Plutonium collected on HEPA filters from glove box ventilation systems

Status and Accomplishments:

Mott developed several prototype, regenerable, HEPA filter elements for performance testing at the Savannah River Technology Center (SRTC) in the HEPA Filter Test Assembly (HFTA). The filters were tested to determine the feasibility of regenerating or washing them in situ with a liquid after becoming plugged with simulated HLW sludge, simulated HLW salt, and atmospheric dust. They were tested in a hostile environment, where they would plug rapidly, in order to maximize the number of filter cleaning cycles that would occur in a specified period of time.

The Mott filters passed the standard in-place Di-Octylphthalate (DOP) leak test of HEPA filters with an efficiency of 99.97% removal of 0.3 micron particles or better at the start, middle, and end of the test campaign. The Mott filter was found to be insensitive to high humidity or moisture conditions. The filters were easily cleaned in situ and recovered to approximately the original differential pressure and airflow, even after numerous plugging and cleaning cycles. Test data indicates promising results and shows that the sintered metal filter is suitable as an in situ cleanable HEPA filter for ventilation systems.

Mott fabricated full-scale prototype filters for testing. Five full-scale prototype filters underwent DOP testing by Air Techniques, Incorporated (ATI) at the Oak Ridge National Laboratory (ORNL). Three of the five Mott full-scale filters tested passed the Di-Octylphthalate (DOP) retention test with a greater than 99.97% efficiency. The two elements that failed at ATI were returned to Mott for examination. It was confirmed that the failure was due to the epoxy seal cracking, not the quality of the porous media.

HLW personnel provided operational performance requirements to allow detailed design of regenerative HEPA filter systems for cold and hot demonstration and deployment at SRS. Prior to proceeding with detailed design, NETL determined that lack of near-term commitment for demonstration and deployment would jeopardize future success. Therefore, this project is currently undergoing closeout.

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E-mail: jagdish.malhotra@netl.doe.gov

Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 2405
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov

For additional information, please visit the Mott Corporation website at http://www.mottcorp.com/

Appendix B

GKN Sintered Metal Filter Cartridge brochure:
http://www.pyramidfilters.com/html/metalfiltermedia.html#membrane, page 5

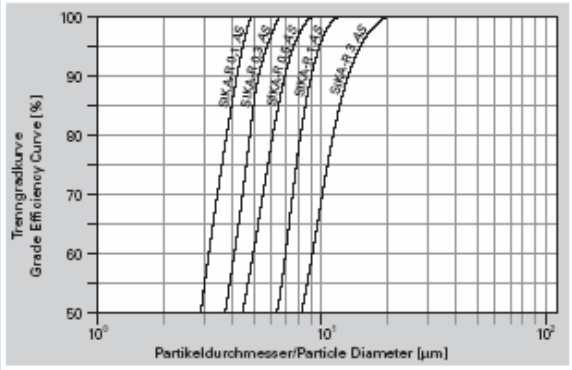
GKN Sinter Metals

Durchgang
Partikelverteilung des Filtrats.
Ermittelt analog ASTM F 795
im **„Single-Pass"**,
Test ohne Kuchenbildung.

Teststaub: SiC
Vorlaufkonzentration: 50 mg/l H2O

Through put
Particle size distribution of filtrate.
Established in accordance with
ASTM F 795 in **"Single-Pass"**,
test without cake formation.

Testing dust: SiC
Dust concentration: 50 mg/l H2O

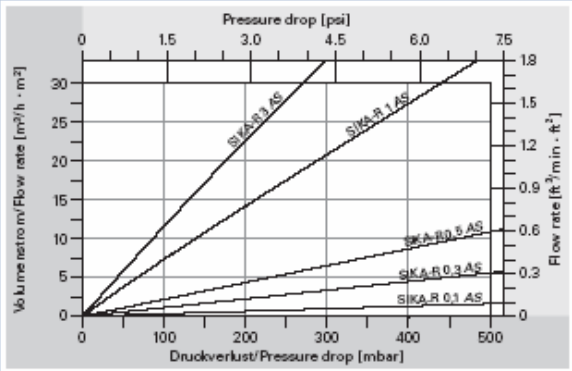


Wasserdurchströmbarkeit
Ermittelt analog ISO 4022

Medium: Wasser, 20 °C
Filterdicke gesamt: s = 3 mm

Water permeability
Established in accordance with
ISO 4022

Medium: water, 20 °C
Filter thickness total: s = 3 mm

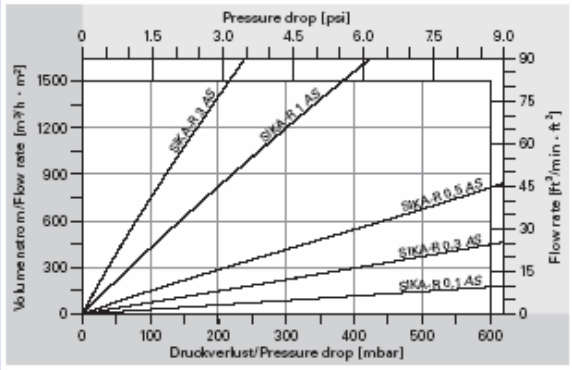


Luftdurchströmbarkeit
Ermittelt analog ISO 4022

Medium: Luft, 20°C
Filterdicke gesamt: s = 3 mm

Air permeability
Established in accordance with
ISO 4022

Medium: air, 20°C
Filter thickness total: s = 3 mm



Alle angegebenen Daten sind „Typische Messwerte"
All given data are "Typical measurements"

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