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A SURVEY OF MIXED-WASTE HEPA FILTERS IN THE DOE COMPLEX

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ABSTRACT

A brief investigation was made to determine the quantities of spent, mixed-waste HEPA filters within the DOE Complex. The quantities of both the mixed-waste filters that are currently being generated, as well as the legacy mixed-waste filters being stored and awaiting disposition were evaluated. Seven DOE sites representing over 89% of the recent HEPA filter usage were identified. These sites were then contacted to determine the number of these filters that were likely destined to become mixed waste and to survey the legacy-filter quantities. Inquiries into the disposition plans for the filters were also made. It was determined that the seven sites surveyed possess approximately 500 m^3 of legacy mixed-waste HEPA filters that will require processing, with an annual generation rate of approximately 25 m^3. No attempt was made to extrapolate the results of this survey to the entire DOE Complex. These results were simply considered to be the lower bound of the totality of mixed-waste HEPA filters throughout the Complex. The quantities determined encourage the development of new treatment technologies for these filters, and provide initial data on which an appropriate capacity for a treatment process may be based.

INTRODUCTION

Mixed-waste, high efficiency particulate absorber (HEPA) filters are a troublesome waste stream in that they are bulky, non-homogeneous, and prevalent. Mixed wastes contain both radioactive contaminants and materials identified as being hazardous per the Environmental Protection Agency (EPA). Although various sites have formulated individual disposition paths for their mixed-waste HEPA filters, there appears to be a need for better treatment technologies. Current practice is to send mixed-waste filters to a Subtitle-C disposal landfill such as Envirocare. If treated to the extent that the hazardous components are either destroyed or sufficiently bound, the waste may be disposed of much less expensively as radioactive (only) waste material in a Subtitle-D low-level radioactive landfill. Furthermore, since the bulk density of filters is quite low, it would be advantageous to have a treatment technology that can greatly reduce the volume. Treatment processes are currently being developed at Argonne National Laboratory-West and other organizations.

The purpose of this study was to quantify the mixed-waste HEPA filter waste stream within the Department of Energy (DOE) Complex to support an overall assessment of the magnitude of the

problem. The waste stream of interest includes filters that are currently being generated at DOE-operated facilities, as well as legacy spent filters being stored at these facilities and awaiting disposition. The results of this survey can be used to justify the capacity of any proposed filter-treatment installation.

This investigation considered only filters generated at DOE facilities. Commercial nuclear power plants and certain health-services facilities that administer nuclear-medicines are other potential sources of mixed-waste HEPA filters. Inclusion of these relatively diffuse sources was not possible in this limited study. Waste streams originating from these generators would only add to the volume of wastes reported here and would thereby increase the benefits of a viable treatment program.

FILTER TYPES

Ventilation System HEPA Filters

HEPA filters used for air-pollution control in ventilation systems comprise the main source of HEPA filters. These filters come in a variety of sizes, with either plywood or steel frames, with or without pleat separators, and with or without face guards. Standard sizes are square, with dimensions of 203 x 203 mm (8 x 8 in), 305 x 305 mm (12 x 12 in), or 610 x 610 mm (24 x 24 in). The smallest standard-size filters are available with filter depths of 78 mm (3-1/16 in) or 150 mm (5-7/8 in). The larger frame sizes come in depths of either 150 mm (5-7/8 in) or 292 mm (11-1/2 in). Variations in the number and configuration of pleats allows flow ratings of from 42 m^3/hr (25 cfm) on the smallest standard size up to 3400 m^3/hr (2000 cfm) on the largest frames. The majority of ventilation-duct HEPA filters used are in the standard sizes.

Prefilters

The literal objective of this study, to determine the number of mixed-waste HEPA filters, leads to a much smaller population for treatment than is potentially the case. Virtually all HEPA installations incorporate a “roughing” filter upstream. These so-called prefilters prolong the life of the HEPA filters by collecting relatively large particulate materials that do not require the fine filtration capability of HEPA filters. Often the prefilters may, themselves, be HEPA rated, but are non-nuclear-grade filters. Since no credit is taken for the air-pollution-control benefits of the prefilters, these are typically just commercial procurements without the added independent testing and examination controls associated with nuclear-grade HEPA filters. No in-use periodic testing, e.g., dioctyl-pthalate (DOP) testing, is required. As may be expected, such commercial-grade prefilters are considerably less expensive to acquire, store, and use than are HEPA filters. Prefilters are typically simply changed out when the pressure differential across the filter reaches some facility-designated threshold.

The implications to the waste-stream treatment program is significant. Prefilters are typically changed out on a ratio of 3:1 to 10:1 versus the frequency of HEPA change out. In many installations, the prefilters are so effective that the actual air-pollution-control HEPA filters have never been changed out. [a] The prefilters themselves, however, become contaminated waste, so they will require the same waste-steam considerations as the HEPA filters. Following discharge from the facility, they will surely be handled as contaminated waste, although they may not be identified in waste databases as "HEPA" filters. Similarly, as new inventory, the situation is equally uncertain; they may or may not be tracked as HEPA filters. In some cases, however, actual nuclear-grade HEPA filters are used as prefilters. This all adds a measure of uncertainty to the data collected.

Respirator Filters

Hands-on activities at many nuclear facilities require respiratory protection that is achieved by the use of cartridge-type, HEPA-filtered respirators. Very large numbers (but relatively small physical volumes) of these are used throughout the DOE facilities and in commercial nuclear power plants.

HEPA respirator cartridges are discarded into contaminated waste streams. The air flow through these devices is quite low, however. Because regulations require supplied-air breathing equipment when airborne levels of contaminants exceed certain levels, cartridge-type respirators rarely experience enough deposition of listed hazardous wastes or toxic metals to qualify as mixed wastes. Since the concern in this report is only for mixed-waste, cartridge-type HEPA filters are not considered any further.

Special-Purpose HEPA Filters

Special-purpose HEPA filters are used for tank vents, protection against accidental backflow on inlets of purged vessels or gloveboxes, etc. These filters are frequently of non-standard configuration, such as rectangular, round, radial-flow, etc. These are referred to as "Special" HEPA filters. These may or may not have been installed in applications where they might become mixed waste.

SURVEY APPROACH

Since the early 1950's, all nuclear-grade HEPA filters destined for deployment at DOE (and predecessor agency) facilities have been required to be independently tested at designated government-operated filter-test facilities. Although all of the HEPA vendors are required to have an extensive, American Society of Mechanical Engineers (ASME) NQA-1 quality-assurance program, the DOE filter-test facilities are charged with the final approval for use. Testing at these DOE facilities includes receipt inspection for shipping damage, conformance to procurement requirements, and conformance to the requirements for usage at DOE facilities

stated in DOE-STD-3027-97, which specifies physical dimensions and tolerances, construction details, material requirements, particle-penetration testing, and pressure-drop performance. Three other tests, comprising the Quality Products List (QPL) are currently required by the DOE. To satisfy the requirements for a QPL listing, the filters are subjected to rough-handling testing, over-pressure resistance to failure testing, and moisture and heated-air performance testing.

Filter-testing facilities were established at Oak Ridge National Laboratory, the Rocky Flats Plant, and the Hanford Works. In 1996 the latter two test facilities were shut down because of low testing demand, leaving the Oak Ridge Filter Test Facility (ORFTF) alone to perform this service. Since all nuclear-grade HEPA filters used at DOE facilities are literally passed through the ORFTF, this organization has been an invaluable and authoritative source of information for this report.

Table I shows the numbers of HEPA filters tested at ORFTF over the past 5-1/2 years, not including respirator filters. With only minor exceptions, these filters were manufactured by either Flanders Filter, Inc. or American Air Filter Co. Testing for fiscal year (FY) 2001 is projected at 4500 filters. A total of 1947 filters had been tested through the first six months ending March 31, 2001. As a point of interest, nearly 8% of all filters tested at ORFTF over the past 5-1/2 years have been rejected, having failed one or more of the ORFTF acceptance criteria.

Aside from the issue of prefilters vs. nuclear-grade HEPA filters alluded to earlier, the ORFTF reports provide excellent summaries of nuclear-grade HEPA filters currently being supplied to the DOE Complex. The question remains, however, as to what fraction of these filters is destined to become mixed waste, and what is the magnitude of the legacy mixed-waste spent HEPA filters that are already in service or have been accumulated. To address these questions, direct contact with the users was necessary.

Table I. Oak Ridge Filter Test Facility Testing Activities From 1996 Through Mid-2001

	1996	1997	1998	1999	2000	1st Half 2001	Totals	Data Period Annual Averages
Filters Tested	2643	2916	2305	2362	3597	1947	15770	2867
Filters Accepted	2150	2814	2237	2325	3243	1776	14545	2645
Filters Rejected	493	102	102	37	354	171	1225	223
Percentage Rejected	18.7	3.5	3.0	1.6	9.8	8.8	na	7.8

ORFTF reports its filter-testing activities biannually. HEPA filters tested at ORFTF for each of the past 5-1/2 years (eleven half-year reporting periods), beginning in FY-1996, have been compiled in Table II by customer name (as tracked by ORFTF) from information provided by ORFTF. Totals for each customer and percentage of the grand total over this period are also

shown in this table. This enables a quick identification of the major users, which are shown shaded in the table. There is a plethora of nuclear-grade HEPA users. The current top ten customers are, in descending order, as follows:

1. Westinghouse Savannah River Co.,
2. Argonne National Laboratory (East),
3. Los Alamos National Laboratory,
4. Lawrence Livermore National Laboratory,
5. Y-12 Plant,
6. X-10 Plant,
7. Rocky Flats Closure Site Services, L.L.C.,
8. Kaiser-Hill Co., L.L.C.,
9. Lockheed-Martin Idaho Technologies Co., and
10. Fernald Environmental Restoration Management Co.

As is indicated in Table II, these top ten customers represent over 84% of all HEPA filters tested at ORFTF over the past 5-1/2 years. However, many sites within the DOE Complex have multiple contractors involved with their operations. These contractors often procure the materials that they require for their operation, but wastes that are generated typically become part of the host site waste streams. Furthermore, information acquired from waste operations, which may be handled by yet another contractor, e.g., WASTREN, Inc. at Rocky Flats, is not normally tracked separately by the procuring contractor. Therefore, where recognizable, contractors have been grouped together under the heading of the host site in the right-hand side of Table II. For example, Kaiser-Hill Co., Rocky Flats Closure Site Services, DynCorp of Colorado, Dykes/RFETS etc. all support the same site, the Rocky Flats Environmental Technology Site. The Y-12 Plant, the X-10 Plant, the K-25 Plant, Bechtel-Jacobs, and UT-Battelle are all supporting Oak Ridge National Laboratory operations. Bechtel Babcox & Wilcox, Inc. and Lockheed-Martin Idaho Technologies Co. represent only a change of contractors for the same operations at the Idaho National Engineering and Environmental Laboratory.

The top seven sites, when grouped by host site in descending order, are

1. Savannah River Site (SRS),
2. Oak Ridge National Laboratory (ORNL),
3. Rocky Flats Environmental Technology Site (RFETS),
4. Argonne National Laboratory-East (ANL-E),
5. Los Alamos National Laboratory (LANL),
6. Lawrence Livermore National Laboratory (LLNL), and
7. Idaho National Engineering and Environmental Laboratory (INEEL).

Table II. Oak Ridge Filter Test Facility HEPA-Filter-Testing Customers - 1996 through Mid-2001

Customer	Numbers of Filters Tested, Each Customer											Customer 5.5-year Total	% of Grand Total	% By Major Users	Number of Filters Tested							
	FY1996		FY1997		FY1998		FY1999		FY2000		FY2001				Major DOE-Complex Sites							Non-DOE Complex
	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half				ANL-E	INEEL	LANL	LLNL	ORNL	RFETS	SRS	
Air-Maze Corp				10	7			1				18	0.1									18
American Technologies, Inc									2			2	0.0									2
Argonne National Lab - E	154	85	249	165	78	186	43	76	220	47	211	1514	9.6	9.6	1514							
Argonne National Lab - W									6	13	10	29	0.2									
BBWI										207	162	369	2.3			369						
Bechtel Jacobs										3	65	68	0.4						68			
Bechtel Nevada										19	2	21	0.1									
Boeing-Rocketdyne						21						21	0.1									21
Brookhaven National Lab	10	6	28	5	3	10	8	3			5	78	0.5									
Donaldson Filter Co								5				5	0.0									5
DynCorp of Colorado/RFETS					1	120	45	3				169	1.1							169		
DynCorp Tri-Cities Services											12	12	0.1									
Dykes/Westinghouse Savannah Riv. Co.		2										2	0.0								2	
EG&G Mound Applied Technologies		90	3	90								183	1.2									
Eltek/Westinghouse Savannah Riv. Co.		3										3	0.0								3	
Fernald Environ. Restoration Mgmt. Co.	140	111	85	35								371	2.4	2.4								
Flanders Filters, Inc									3			3	0.0									3
Fluor Hanford										17	6	23	0.1									
Keiser Hill - RF					100				3	70	543	716	4.5	4.5						716		
Knolls Atomic Power Lab				6	21	4		4				35	0.2									
Lawrence Livermore National Lab			63	71	41	92	77	384	68	126	60	982	6.2	6.2				982				
K-25		5		6								11	0.1						11			
X-10		173	94	38	12	365	6	204	7	8	14	921	5.8	5.8					921			
Y-12	93	103	9	27	19	114	144	282	8	5	119	923	5.8	5.8					923			
Lockheed-Martin Idaho Technology Co.			33	181	40	25		60	157	113		609	3.9	3.9		609						
Lockheed-Martin Utility Services-Piketon			26									26	0.2									26
Los Alamos National Lab			53	41	24	41	16	83	798	267	134	1457	9.2	9.2			1457					
National Institute of Standards		11							5		7	23	0.1									23
Nuclear Filter Technology, Inc									2			2	0.0									2
Nuclear Utility Products							1					1	0.0									1
Oak Ridge National Lab	73											73	0.5						73			
Pall Aeropower Corp.		10	3					5	3	1		22	0.1									22
Pall Trinity Micro		4	56	11	1				16			88	0.6									88
Pantex Plant			24	17	19				4	20	8	92	0.6									
Pennsylvania Power & Light										27		27	0.2									27
Portsmouth Gaseous Diffusion Plant	23											23	0.1									
Power Products, Inc				10	10		10			10		40	0.3									40
RMI Environmental Service					36	18	1		45			100	0.6							100		
Rockwell Aerospace Corp.			10									10	0.1									10
Rocky Flats Closure Site Services, LLC							28		81	274	421	804	5.1	5.1						804		
Round Robins				12								12	0.1									12
Sandia National Lab				8				18		6	22	54	0.3									
Thompson Mechanical-Hanford						19						19	0.1									
UT Battelle										2	94	96	0.6						96			
West Valley Nuclear Services	131	90	8	9	25	19		27	4		27	340	2.2									
Westinghouse Electric Co.	16	27	80	3	69	44	33					272	1.7									
Westinghouse Waste Isolation Div				96							16	112	0.7									
Westinghouse Savannah River Co.	902	381	320	931	337	384	352	453	324	608	9	5001	31.7	31.7							5001	
Totals	**1542**	**1101**	**1144**	**1772**	**843**	**1462**	**764**	**1608**	**1756**	**1843**	**1947**	**15782**	**100.0**	**84.3**	**1514**	**978**	**1457**	**982**	**2092**	**1789**	**5006**	**300**
															Total, Major DOE Sites:						**13818**	
															Ratio, Major DOE Sites / All DOE						**0.89**	

Shown in the right-most column of Table II are the quantities from the few ORFTF customers whose filters do not appear to be destined for a DOE Complex site, e.g., National Institute of Standards, Pennsylvania Power and Light, Boeing-Rocketdyne, etc. After deleting these customers, HEPA filter usage at the seven highest DOE sites actually comprise over 89% of the total filters shipped to sites within the Complex.[b] So a survey of these seven sites should provide a meaningful lower bound for the mixed-waste HEPA filters throughout the DOE Complex. Surprisingly, it appears that the Hanford site has not been a substantial customer for HEPA filters over the past 5-1/2 years, a period subsequent to the closing of the Hanford filter test facility.

RESULTS

Meaningful information was eventually obtained from all seven of the major sites. Table III provides a summary of the numerical data obtained. The upper portion of the table refers to currently generated mixed HEPA filters, while the lower portion refers to stored mixed-waste filters. Data for stored waste may be more reliable, since stored wastes are usually tracked in some type of database. Currently generated waste is tracked by individual facilities at the sites, but does not get compiled until it is transferred to some type of central waste area. It should also be noted that there are a large number (thousands) of HEPA filters that are currently installed. If these are not regularly changed out, they will not be reflected in the current procurements, and therefore will not have been included in either category shown in Table III.

Some sites reported their data in terms of the numbers and types of waste packages while others simply reported volumes. To maintain commonality with the individual sites, the data are listed in Table III as provided by the sites, except that volumes have been converted to cubic meters for ease of comparison. The volumes of all mixed HEPA filters at the sites were then totaled. An average value is shown in the table for sites that reported some range of values, e.g., ANL-E reported a stored volume of 10-16 m^3, which is shown as 13 m^3 in Table III.

The mixed HEPA filters stored at the Savannah River Site are the largest component, followed by Lawrence Livermore National Laboratory and Los Alamos National Laboratory. Overall, it appears that there are two-to-three hundred mixed-waste HEPA filters currently being generated throughout the DOE Complex annually.

Table III. Mixed-Waste HEPA Filters at the Seven Highest-Usage DOE Sites

	Vol. (m^3)	Totals for Highest-Usage DOE Sites							Totals, All Seven Sites
		ANL-E	INEEL	LANL	LLNL	ORNL	RFETS	SRS	
Current Annual Generation									
Volume (not in other categories)	--	5			11				16
Filters, 610x610x305 mm (2x2x1 ft)	0.114			8					8
Drums, 208 l (55-gal)	0.208					2			2
B-12 Box - 610x1220x1830 mm (2x4x6 ft)	1.36								0
Box - 610x1220x2135 mm (2x4x7 ft)	1.59								0
B-25 Box - 1220x1220x1830 mm (4x4x6 ft)	2.72					3			3
Box - 1220x1220x2135 mm (4x4x7 ft)	3.17								0
Standard Waste Box (SWB)	1.93								0
Total Volumes	m^3	5	0	1	11	9	0	0	26
Previously Generated (Stored)									
Volume (not in other categories)	--	13		4.7	115				133
Filters, 610x610x305 mm (2x2x1 ft)	0.114		150						150
Drums, 208 l (55-gal)	0.208			112		391	13		516
B-12 Box - 610x1220x1830 mm (2x4x6 ft)	1.36								0
Box - 610x1220x2135 mm (2x4x7 ft)	1.59						5		5
B-25 Box - 1220x1220x1830 mm (4x4x6 ft)	2.72					5		73	78
Box - 1220x1220x2135 mm (4x4x7 ft)	3.17						5		5
Standard Waste Box (SWB)	1.93			10					10
Total Volumes	m^3	13	17	47	115	95	27	199	513

Specific supplementary information collected from each of these sites is given below.

Savannah River Site

Only the Consolidated Incineration Facility (CIF) produced mixed-waste spent HEPA filters. CIF is now shut down, and in stand-by status. SRS currently has 73 B-25 Waste Boxes of spent mixed-waste HEPA filters from CIF. Each box contains an average of about nine HEPA filters, giving a total of approximately 650 filters.

These filters are to be sent to the Permafix Environmental Services, Inc. treatment facility in Oak Ridge later this year for treatment and eventual disposition at Envirocare, UT.

Permafix recently purchased East Tennessee Materials & Energy Corp (M&EC). M&EC operated a process for low-level mixed waste based on macro-encapsulation. Waste materials were compacted into 322-l (85-gal) drums which were then loaded, end-to-end, into approximately 15-m-long engineered overpack containers called Aero-Paks. This was the basis for handling the mixed waste in the SRS Site Treatment Plan (STP). Permafix is now putting into place a *micro*-encapsulation capability. This will involve separating and shredding the filter media and frames using jaw-type crushers and stabilizing with a cementitious type of material. The STP is currently being modified to reflect this new approach, and SRS believes that they will get it approved. Permafix expects to have the micro process on-line toward the end of calendar-year 2001.

Oak Ridge National Laboratory

Operations at ORNL have recently been split into numerous separate contractors, making it difficult to obtain definitive information. The Y-12 Plant is operated by Bechtel Babcox & Wilcox Inc. They currently have 468 containers that carry "filter" in the content codes in their database. All but 72 of these are cataloged as mixed waste. These are mostly drums, but about 5 containers are B-25 boxes. Last year 2 drums and 3 boxes of mixed HEPA filters were generated.

ORNL mixed-waste HEPA filters carry a plethora of EPA waste codes: D004-D011, D016, D018-D043, F001-F008, F039, P003-P004, P022, P037, P050-P051, P059, P105, P123, U001-U012, U018-U020, U022, U028-U029, U031, U033, U035-U037, U039, U044-U045, U050, U052, U055-U058, U060, U070, U078, and U080.

Approximately 0.5 m^3 of these filters are TRU-mixed, the remainder are mixed low-level wastes.

Rocky Flats Environmental Technology Site

Ventilation systems at RFETS have several stages of HEPA filters. The first stage usually becomes contaminated at TRU levels. The last stage(s) usually are low-level. Occasionally, intermediate stages are sometimes in the 10-to-100 nCi/g range. Rocky Flats has several waste streams. One major group is from their aqueous waste treatment operations that produced nitrate-salts-contaminated spent HEPA filters - EPA Code D001 (these also carry EPA Codes F001, F002, F005, F006, F007, and F009 based on materials used in the processes, but the low levels of the organic contaminants might not exceed the Land Disposal Restrictions limits; a final determination has not yet been made). Waste types are both alpha low-level mixed and TRU mixed. Filters from this process comprise approximately 22 m^3, currently packaged as

(7) 208-l (55-gal) drums,
(3) 610 x 1220 x 2135-mm (2 x 4 x 7-ft) boxes, and
(5) 1220 x 1220 x 2135-mm (4 x 4 x 7-ft) boxes.

Two of the drums are TRU mixed, the remainder of these wastes are alpha low-level mixed. This process has recently re-started. It is estimated that an additional 3-to-5 boxes and 3-to-5 drums of waste filters will be generated in the near term.
The RFETS organic liquid waste treatment operations produces filters contaminated with organic sludges carrying EPA Codes F001 and F002 (and contaminated at levels unlikely to meet LDR requirements). Stored filters from the process comprise approximately 1.3 m^3, in six 208-l (55-gal) drums, two of which are transuranic (TRU) mixed waste. The process is currently shutdown, but may resume operations, producing 3-to-5 additional drums of TRU-mixed waste filters.

In addition to these, there is one 1.6-m^3 box of large filters of alpha low-level mixed with EPA Codes F001, F002, F005, F006, F007, and F009 from the pond-water processing facility. There is another 1.6-m^3 box of large filters with P- and U-listed EPA Codes.

Argonne National Laboratory

Argonne National Laboratory - East (ANL-E) currently generates 2.8-5.6 m^3/yr of mixed-waste HEPA filters. Radioisotopes are virtually all low-level beta/gamma; some low-level alpha, hardly ever any at TRU levels. There are 11-14 m^3 of mixed-waste HEPA filters currently stored on-site. (These volumes refer to characterized, mixed-waste filters in their normal configuration.) Prior to shipment to Envirocare for macro-encapsulation and burial, the media are removed and compacted into drums, which are then loaded into B-12 boxes, along with the frames, for shipment. Shipments vary from 2 to 4 times per year.

Hazardous contaminants are almost exclusively heavy metals. Occasionally polychlorinated biphenol compounds (PCBs) or organic contaminants are found.

Los Alamos National Laboratory

Candidate facilities at Los Alamos National Laboratory (LANL) for generating any significant mixed-waste filters are the Chemistry and Metallurgy Research (CMR) Laboratory and the Plutonium Facility at Technical Area (TA)-55. These two facilities probably account for 90% of the mixed-waste streams at LANL. There was an entire ventilation system HEPA change out at the CMR Laboratory last year involving 720 filters. These were thoroughly (100%) characterized. Contamination on about 160 resulted in a transuranic (TRU) classification, but no filters were found to be mixed waste. There was considerable contamination by perchlorate salts that raised concerns for explosion potential. A safety review concluded that the perchloric concentration was about a factor of five below the minimum required for detonation.

TA-55 generates virtually no mixed HEPA filters. Los Alamos uses waste "profiles" that describe the waste for all handling activities. There are currently no waste profiles for mixed-waste HEPA's from TA-55, suggesting that none are being generated.

Apparently there is currently only a very low generation rate of mixed-waste HEPA filters throughout LANL, estimated by LANL personnel to be perhaps only 5 - 10 filters per year. The environmental stewardship organization that tracks waste around the entire site has no knowledge of recent mixed-waste HEPA filters.

Legacy mixed waste at LANL is tracked separately by type. The mixed-waste TRU category consists of 17 208-l (55-gal) drums of Pu-238 contaminated filters, mostly 203 x 203-mm (8 x 8-in) size, and 39 m^3 of Pu-239 contaminated filters. The latter are stored in 95 drums, 10 Standard Waste Boxes (SWB), plus approximately 0.5 m^3 of miscellaneous packages.

Low-level and alpha low-level mixed-waste legacy HEPA filters consist of 4.2 m^3 stored in 11 containers of various types. This waste was "profiled" by the generator as being mixed waste, but has not yet been formally characterized. This information was gleaned from the low-level waste database. However, entries are only made to this database when the waste is transferred from the individual facility to Hazardous Waste Operations. Although TA-55 has its own satellite accumulation areas, there are no known mixed-waste HEPA filters currently stored.

Lawrence Livermore National Laboratory

Current inventory of stored, spent HEPA filters at LLNL is about 115 m^3 (container volumes). These are stored in one cargo-type container, several B-25 boxes, and drums. These filters are not yet characterized, so the fraction of these that are mixed-waste is unknown at present. Over the past 3 years, LLNL has generated an average of 10-12 m^3/yr of mixed-waste HEPA filters. These are virtually all contact-handled, low-level, and primarily metal-contaminated, but also contain some organics. Most of the LLNL filters are the 610 x 610 x 305-mm (2 x 2 x 1-ft) size. LLNL is in the process of gradually replacing all of its approximately 2000 wood-framed HEPA filters with metal-frame types. There are likely to be mixed-waste filters within this group.

Current plans and activities involve stabilizing the mixed-waste filters on-site using a resin-encapsulation process developed by LLNL called IS*SAFE. This process encapsulates the filter media (only) in a solid resin material. The development work is on-going. This is a rather expensive process, with costs of nearly $3000 per filter reported. LLNL believes that the encapsulated filters will then be eligible for burial at a non-Subtitle-C disposal site, based on some Toxicity Characteristic Leaching Procedure (TCLP) and California WET-Extraction testing completed on surrogate materials formulated from filter media, resins, and representative quantities of Resource Conservation and Recycle Act (RCRA) hazard-characteristic metals. The encapsulated filters would then be sent to Nevada Test Site for burial.

LLNL also continues to work with a Russian group on the development of a paint-stabilization treatment, in which some paint-like surface-coating material is drawn through the filter media to provide an impermeable seal coating. This work is reported to be going very slowly.

Idaho National Engineering and Environmental Laboratory

Current generation rate from the Idaho National Engineering and Environmental Laboratory (INEEL) Idaho Nuclear Technology Engineering Center (INTEC) is about 3.5 m^3/yr, and is projected to remain at this level for the next five years. EPA waste codes are D004, D006 - D009, D011, F001 - F002, F005, and U134.

A leaching process is currently being used to treat mixed-waste, spent HEPA filters. This involves three cycles of submerging the filters in a bath of nitric acid, heating and air sparging the filters, rinsing in water, and a short drip dry, followed by blow drying in 300 F air for 5 - 6 hours. These filters nearly always pass TCLP, but the occasional failures are usually due to residual mercury. The operating permit requires sampling every 20th filter for leach testing, but normally testing is performed every 9-to-10 filters treated. Filters are each put into an individual, stainless-steel, clam-shell-type container for fiber retention during washing, and the treated filters are sent to the landfill. Some 50 stored, mixed-waste filters were treated in this process in 2000, and "a few years" of HEPA filters remain to be treated for disposal.

The leachate is collected, sampled, and then either fully or partially evaporated. The vapor is condensed and sent through another evaporation cycle, from which the vapor is vented. The evaporator residuals, or bottoms, from both steps are sent to the high-level-waste tank farm for eventual disposition along with the tank waste stream.

Fernald Plant

Although Fernald Environmental Restoration Management Co. is the Number-10 individual customer in Table I, as a site Fernald's filter procurements over the last 5-1/2 years put the site at only about one-half of the Number-7 site. Therefore, Fernald was not intended to be surveyed, but during the course of surveying ORNL, some useful information on this site was obtained from a former employee that was worth noting in this report.

The treatment involved approximately 40 boxes of mixed-waste HEPA filters at Fernald. The characteristic-type, mixed-waste filters were treated with the same process that Permafix is now installing at ORNL (see SRS writeup, above). The filter media was separated from the frames, shredded using jaw-type crushers, and stabilized. Frames, both wood and metal, were shredded and put into containers with the stabilized media. The volume of the final product was about 2/3 of the original volume. The treatment reportedly passed the TCLP, which allowed burial at the Subtitle-D landfill at the Nevada Test Site (NTS). Disposal costs at NTS were about \$130/m^3 versus about \$1400/m^3 at Envirocare. The only mixed waste that was sent to the Subtitle-C landfill was that contaminated with EPA-listed hazardous wastes. These wastes were macro-encapsulated.

The treatment process was said to have worked very well, albeit with only limited volume reduction. Treatment costs with this process were between $88/m^3$ ($2.50/ft^3$) and $230/m^3$ ($6.50/ft^3$), depending on the quantity of waste processed, $140/m^3$ being an average target cost. The actual components of this cost figure are not known, and any comparisons to other processes can, therefore, be very misleading. Nonetheless, contrasted to the nearly $3000 cost for treating a 114-l filter at LLNL (see LLNL, above), it is clear that this is very economical.[c]

Disposition of the entire waste filter inventory was reported to have been completed by 1998. This is consistent with Table I, which shows that the last filters tested for Fernald by ORFTF were in 1997. Since the generation of mixed-waste HEPA filters at Fernald appears complete, the 371 filters tested by ORFTF for Fernald shown in Table I can be deducted from the total in gaging the current HEPA filter usage at DOE facilities. This suggests that the present survey actually accounts for at least 91% of all of the filters used within the DOE Complex.

CLOSING REMARKS

Information from the various sites is difficult to acquire. Identifying knowledgeable individuals at a given site is a drawn-out process involving making an initial contact and following up, serially, on numerous suggested leads once an entry into the site has been established. At each step in this process, actually making contact with the indicated individual is often tedious; and when contact was finally made, the information may not be readily accessible or may be incomplete. In a few cases, the responses were guarded.

Conflicting reports were occasionally detected among the contacts. For example, one source reported that up to 50% of the filters at a specific facility were likely mixed waste, but another, more knowledgeable individual reported that a detailed characterization of several hundred filters from this same facility found that none was mixed waste. In another case, it was reported that although a large quantity of HEPA filters were used at a particular site, most of the filters used were the small, glovebox-type filters. However, the ORFTF records clearly showed that all but 30 out of nearly 1500 HEPA filters procured by this site over the past 5-1/2 years were 610 x 610 x 302-mm (2 x 2 x 1-ft) filters. Information offered might also be inaccurate, even when provided by an authoritative source. Much of both the recent and legacy stored waste has not yet been characterized. The waste categories into which non-characterized wastes are assigned is often based on limited process knowledge, and therefore may not be correct. "Non-mixed-waste" spent HEPA filters may turn out to be mixed waste, and vice-versa. So while there was considerable success in gaining the desired information, many uncertainties still remain.

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The authors are grateful to all of the contacts who provided whatever help they were able to offer. There were typically many individuals who were contacted at each site. Although many were unable to directly provide the information, they were helpful in suggesting other contacts. Several of the contacts went so far as to canvass their sites for the information, collected what could be obtained from their colleagues, and then relayed the information. Particular thanks go to Dave Crosby and Julie McIntyre of the ORFTF for the extensive information on their filter testing they provided.

FOOTNOTES

a. A new DOE directive has been discussed that calls for more frequent change-outs of HEPA filters to ensure that the structural integrity is maintained to better meet unforeseen challenges, even though DOP testing and pressure-drop measurements are passed. Many HEPA filters have been in place for a long time, and when changed out on age, many of these are likely to be found mixed waste.

b. A few customers could not be readily identified as to whether they serviced a DOE site or some other application, e.g., "Westinghouse Electric Co." Only customers readily identifiable as being *non*-DOE were deleted from the total count, i.e., the top seven DOE Sites may represent an even higher percentage of the total HEPA filter usage within the DOE Complex.

c. LLNL had a previous process that involved shredding of the filters by respirator-equipped workers. This process was stopped by DOE after a large actinide uptake by one of the workers. This may have been a low-tech implementation of a treatment process similar to the Permafix-type process. This led to the LLNL development of the macro-encapsulation process.