

15th DOE NUCLEAR AIR CLEANING CONFERENCE

SESSION XIII

OPEN-END

Wednesday, August 9, 1978

CHAIRMAN: M. W. First

USE OF INSTALLED TEST CANNISTERS FOR REPRESENTATIVE SAMPLING OF VENTILATION SYSTEMS
CHARCOAL ABSORBERS C. A. Moore

A REMOTE SAMPLING SYSTEM FOR HEPA (1500 CFM) IN-PLACE FILTERS WITH A FLUORIDE
(CHANNEL) SEAL SYSTEM L. G. Musen

RADIOACTIVE WASTE MANAGEMENT: THE NEED FOR MULTIPLE BARRIERS
J. Sokol, M. Cooper

CSL ENGINEERING DESIGNER HANDBOOK A. Shacter

CPP EXPERIMENTAL HEPA FILTER MEDIA W. D. Hanson

OPENING REMARKS OF SESSION CHAIRMAN:

The Open-End Session will be devoted to brief technical notes, to short presentations of new work that is in progress but not yet far enough along to justify a full formal report, to descriptions of puzzling observations that the audience will have an opportunity to respond to from their own experiences, and to statements of a policy or other nature that would not easily fit into any other part of the program.

The first speaker on the program is J. P. Olivier from the Organization for Economic Cooperation and Development. A formal presentation of his remarks is contained in the last paper of Session 12, entitled "New Air Cleaning Technology from Europe." Regrettably, the authors of this paper were unable to attend the Conference. Mr. Olivier has some items he would like to bring to our attention on sampling and measurement techniques for gaseous wastes and the testing of HEPA filters.

OLIVIER: I come from the Nuclear Energy Agency of OECD which is an inter-governmental organization. We are interested in and have been active in nuclear safety and waste management. Our interest in air cleaning technology started only two years ago. We are working to prepare a study on effluent releases from the nuclear fuel cycle and trying, on the basis of new ICRP Publication 26, to look at all the impacts in such a way that we can determine cost-benefit trade-offs for retention of radionuclides such as krypton-85, tritium, carbon-14, and iodine-129.

FIRST: Thank you for bringing this information to our attention. I am sure we will all be interested in reading the details in the paper by Dubé and Zabaluev. Your suggestion of an international agency to do testing is an interesting one. I don't think it would be valuable to repeat what is being done in each of the several countries, but I can think of at least a couple of areas where an international body could have an important impact. For example, they could pos-

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sibly resolve the several different test methods used for HEPA filters. We in the U.S. have the DOP method. U.K. has the sodium chloride method. France has the dye method. All of these are familiar to you. It would be useful if an international agency would study all these methods and tell us how they relate to one another. Another area for international action would be in HEPA filter design. We are trying to decide whether the European small pleat design is better or worse than the U.S. and U.K. wide pleat design. Certainly this is an important area for standardization.

Our next speaker is Mr. Charles Moore who is with the Florida Power and Light Co. He would like to tell us a bit about the use of installed test canisters for representative sampling of ventilation systems employing charcoal adsorbers.

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USE OF INSTALLED TEST CANNISTERS FOR REPRESENTATIVE SAMPLING OF VENTILATION SYSTEMS CHARCOAL ABSORBERS

Charles A. Moore
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INTRODUCTION

In Nuclear Power Plants, activated charcoal is routinely installed in the Emergency Safeguards Ventilation Systems for reduction of iodine releases under postulated post-accident clean-up conditions. Since charcoal is subject to several types of degradation; representative sampling methods must be utilized in order to perform analyses to ensure these systems are maintained at a proper level of iodine removal efficiency.

A common method of sampling currently in use is to install small test canisters containing charcoal from batches used to fill the main absorber beds. These are usually placed so that the samples are exposed to the same general environmental conditions as the absorbers, i.e., temperature, humidity, etc.

CONCERN

While current standards recommend that the flow conditions of the test canisters be the same as the main absorbers, limited testing has been performed to verify such conditions do exist in field installations.

CRITERIA

- 1) Typical Technical Specifications issued on ESF Ventilation Systems in the last few years require that--a laboratory analysis of a carbon sample from at least one test canister--demonstrates a removal efficiency of $\geq 90\%$ for radioactive methyl iodide when the sample is tested in accordance with ANSI N 510-1975--etc.
- 2) Regulatory Guide 1.52, Rev. 2 (March 1978) "Design, Testing, and Maintenance Criteria for Post Accident Engineered Safety Feature Atmosphere Clean-Up System Air Filtration and Absorber Units of Light Water Cooled Nuclear Power Plants" states in Section 6, paragraph b that---The efficiency of the Activated Carbon Absorbers Section should be determined by laboratory testing of representative samples of the activated carbon exposed simultaneously to the same service conditions as the absorber section.
- 3) ANSI N 509-1976 "Nuclear Power Plant Air Cleaning Units and Components" Appendix "A" Paragraph A.2.1 states that--The superficial face velocity of any test canister shall be shown by calculation or direct measurement to be within ± 20 per cent of the superficial face velocity of the absorber bed.

LOCATION OF TESTING

The St. Lucie Nuclear Plant is an 853 MWE, Combustion Engineering Pressurized Water Reactor Plant of the Florida Power and Light Company System, located on the Atlantic Coast of Florida approximately 100 miles north of Miami. The plant was

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licensed in March, 1976 and commenced power operation in April, 1976.

The ventilation charcoal filtration devices were supplied by Mine Safety Appliance Company of Evans City, Pennsylvania. The plant systems were designed and installed by Ebasco Services, Inc., New York, New York, the Architect-Engineer on the St. Lucie Project.

CHARCOAL SYSTEM GENERAL DESCRIPTION

The St. Lucie Plant has four (4) major emergency safeguards ventilation systems containing activated charcoal which are addressed in the Plant Technical Specifications:

- 1) ECCS Area Exhaust System--Two (2) trains--30,000 CFM each
- 2) Shield Building Ventilation System--Two (2) trains--6,000 CFM each
- 3) Control Room Emergency Recirculation System--One (1) train--2,000 CFM
- 4) Fuel Handling Building Exhaust System--One (1) train--9,800 CFM

These systems contain the Mine Safety Appliances (MSA) tray-type absorber beds. The charcoal beds are two (2) inches in depth and each tray has a surface area of approximately eight (8) square feet. The beds are designed for a flow of approximately 333 CFM per bed, which gives a face velocity of approximately 42 feet per minute. St. Lucie Plant Technical Specifications allow a flow variation of ± 10 per cent from design.

The Test Cannisters have two (2) inches charcoal depth also and are $2\frac{1}{2}$ inches in diameter. The cannisters are mounted between absorber racks with $\frac{1}{4}$ inch, Schedule 40 pipe, which has a total length of $33\frac{1}{2}$ inches. The cannisters are located on the upstream side of the absorber racks.

TEST PROGRAM

During the Spring, 1978 refueling outage of the St. Lucie Plant, while conducting the routine Ventilation System surveillance, a test was performed to determine if the flow conditions of the test cannisters were representative of the actual flow conditions of the Main Absorber Trays.

The Shield Building Ventilation System operating at design flow of 6000 CFM, was selected as the test system. Measurements were taken with an Alnor Type 8500 Thermo-Anemometer outside the trays with flow through to the center and on the screen face of the carbon test cannisters. Measurements were repeated several times on different trays and different cannisters.

RESULTS

Measurements on the trays and cannisters showed a nominal face velocity of 45 feet per minute. (MSA in house testing has shown similar results.)

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CONCLUSION

Both the cannisters and carbon trays have a bed depth of two (2) inches and measurements in each case showed a nominal face velocity of 45 feet per minute; therefore, the cannisters in addition to environmental conditions are also representative of flow conditions at the St. Lucie Plant.

BENEFITS

Cannisters provide a convenient means of sampling charcoal without disturbing the main absorber installations. Alternate methods of acquiring such samples involve disassembling expensive trays and in some cases would involve additional in-place testing.

PERSONNEL PARTICIPATING IN THE TEST PROGRAM

- 1) Mr. Fred D. Leckie, Nuclear Containment Systems, Contractor for Ventilation Systems Testing at St. Lucie Plant.
- 2) Mr. Charles A. Moore, Chemistry Supervisor, St. Lucie Plant, Florida Power and Light Company.
- 3) Mr. Robert J. Frechette, Senior Plant Technician, Chemistry Department, St. Lucie Plant, Florida Power and Light Company.

ACKNOWLEDGEMENTS

- 1) Mr. Roger Zavodoski, Nuclear Regulatory Commission, Region II, Atlanta, Georgia and
- 2) Mr. Ron Bellamy, Nuclear Regulatory Commission, Washington, D.C. for providing incentive for this effort.

DISCUSSION

FIRST: After some of the other papers we've heard at this meeting, this seems like a very simple way to do it. Do other people complicate the problem?

HULL: Did you find comparable results for filters in steady and routine use? I assume the loadings are quite different for charcoals that are not on stream all the time.

MOORE: The systems that we have are all stand-by systems with the exception of the fuel ventilating system which is operated in conjunction with fuel movement for a period of time. We have just done measurements on our shield building ventilation system; we haven't done a complete set of measurements on all of the systems.

HULL: At 6,000 cfm, I would guess that the shield building is a recirculating clean-up unit within the building, isn't it?

MOORE: It exhausts out of the stack.

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A REMOTE SAMPLING SYSTEM FOR HEPA (1500 cfm) IN-PLACE FILTERS WITH A FLUID (CHANNEL) SEAL SYSTEM*

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"ABSTRACT"

High efficiency particulate aerosol (HEPA) filters are used extensively for air cleaning systems at the Idaho National Engineering Laboratory (INEL). These filters are occasionally located in inaccessible areas, in high radiation or toxic areas, or where design does not permit correct sampling distances. This paper describes certain advantages in using a specially designed multihole sampling probe in conjunction with a separatorless, fluid (channel) seal, filter and crab trap system. All work utilizing this system is conducted from outside the area, thus reducing personnel exposure and testing time, and providing accurate sampling. This system has enabled the INEL to meet the requirements for testing filter systems that otherwise could not have been tested.

1.0

Introduction

High efficiency particulate aerosol (HEPA) filters are used extensively for air cleaning systems at the Idaho National Engineering Laboratory (INEL). The Department of Energy (DOE) and the American National Standard (ANSI) Institute standard N-101.1 and N-510 require evaluation prior to placing a HEPA filter system in service and at regular intervals thereafter. These filters are occasionally difficult to evaluate because they can be located in banks, stages, series, inaccessible locations, and high level radiation or toxic areas (Figures 1,2,3,4,). This paper describes both the current method, and the remote sampling system for HEPA filters located in areas where accessibility is difficult.

2.0

Methodology

"CURRENT IN-PLACE TEST METHOD"

The current in-place method for evaluating HEPA air cleaning filter systems consist of introducing a challenge aerosol agent of dioctyl-phthalate (DOP), 0.3 micron partical size, in the air stream at 10 duct diameters upstream from the filter face. This distance ensures a thorough mixing of DOP in air. The sample ports are 5 to 7 duct diameters upstream, and 7 to 10 duct diameters downstream from the filter face.

* Work supported by the Idaho National Engineering Laboratory operated under the auspices of the U. S. Department of Energy, Idaho Operations Office, under contract No. EY-76-C-07-1570.



Fig. 1 Operating hot cell.

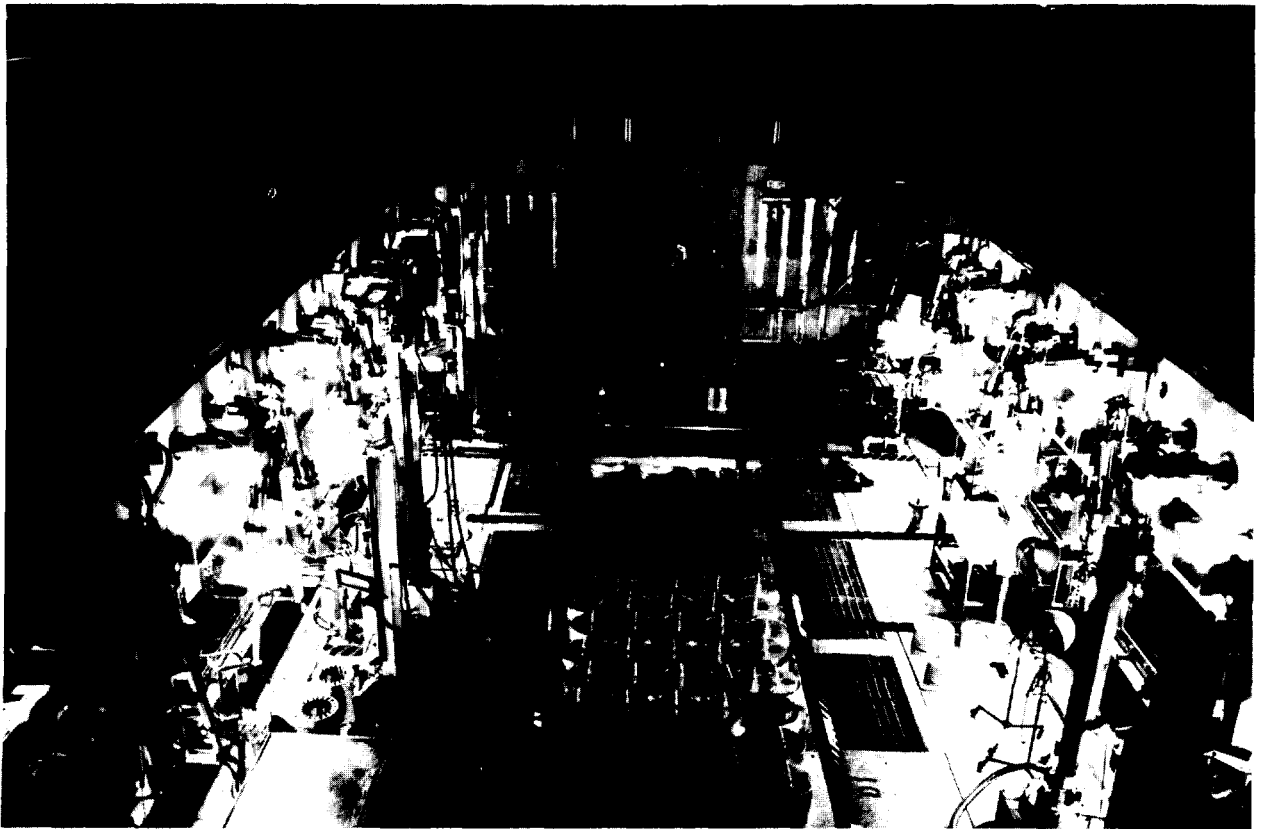


Fig. 2 Oxygen deficient or toxic area.

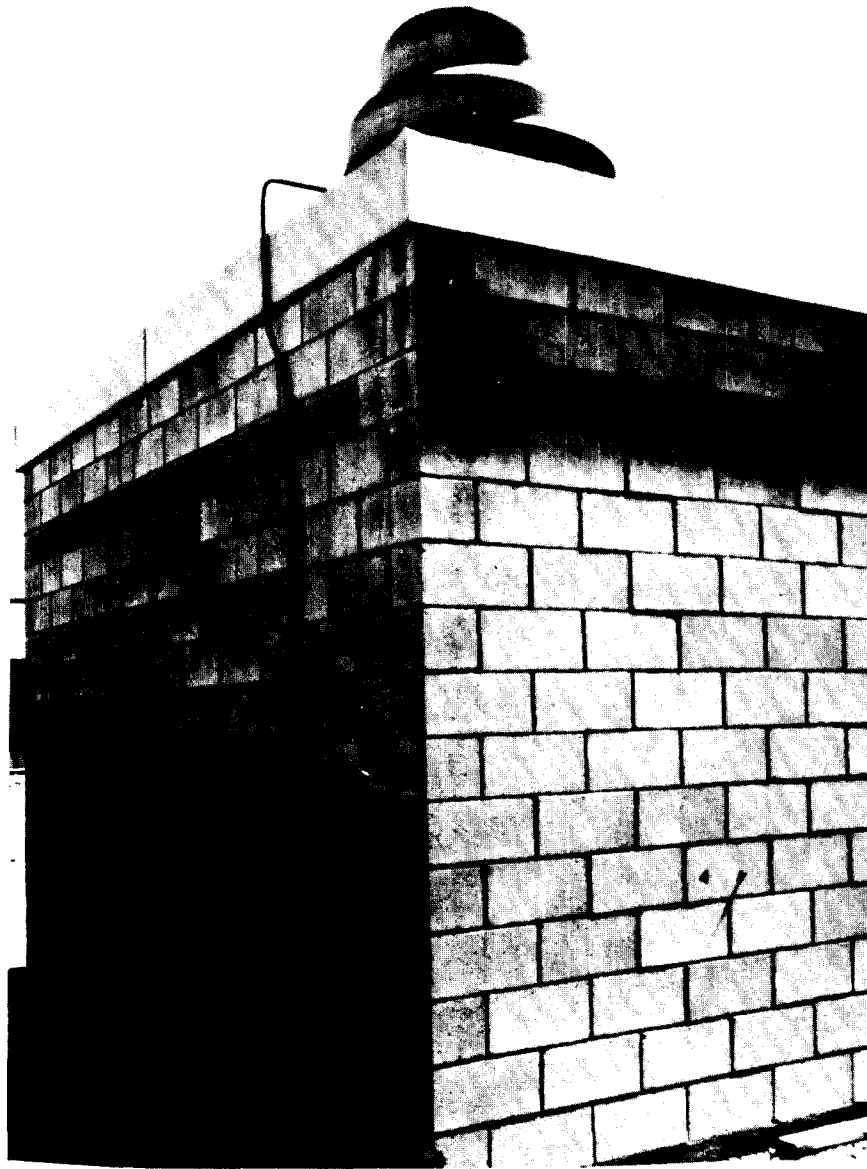


Fig. 3 Remote area.

A probe connected to a light scattering photometer is then inserted into the sample ports to determine the DOP concentration upstream and downstream of the filter face. The above method requires personnel to be in the immediate vicinity of the HEPA filter during testing.

The accuracy of the test is reduced whenever the filter system is located in inaccessible areas, high radiation areas, or where design does not permit correct sampling distances. Some of the problems encountered are:

- (1) Personnel are exposed to excessive toxic material or radiation during testing of filters.
- (2) A challenge agent of DOP aerosol cannot be introduced at the proper distance from the filter face. This will result in an uneven distribution of DOP across the filter face.
- (3) DOP samples cannot be collected at the proper distance downwind of the HEPA filter.
- (4) Testing time is increased.



Fig. 4 High radiation area, bank of filters.

D. O. P. INJECTORS

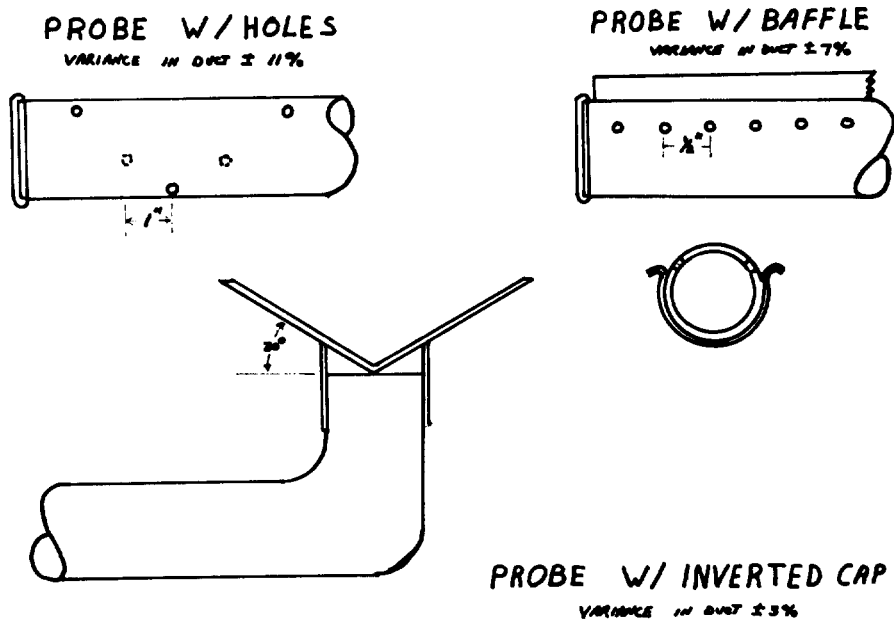


Fig. 5 DOP injectors.

1. INJECT DOP WITH INVERTED CAP,
2. USE CRAB TRAP,
3. USE SPECIAL PROBE.

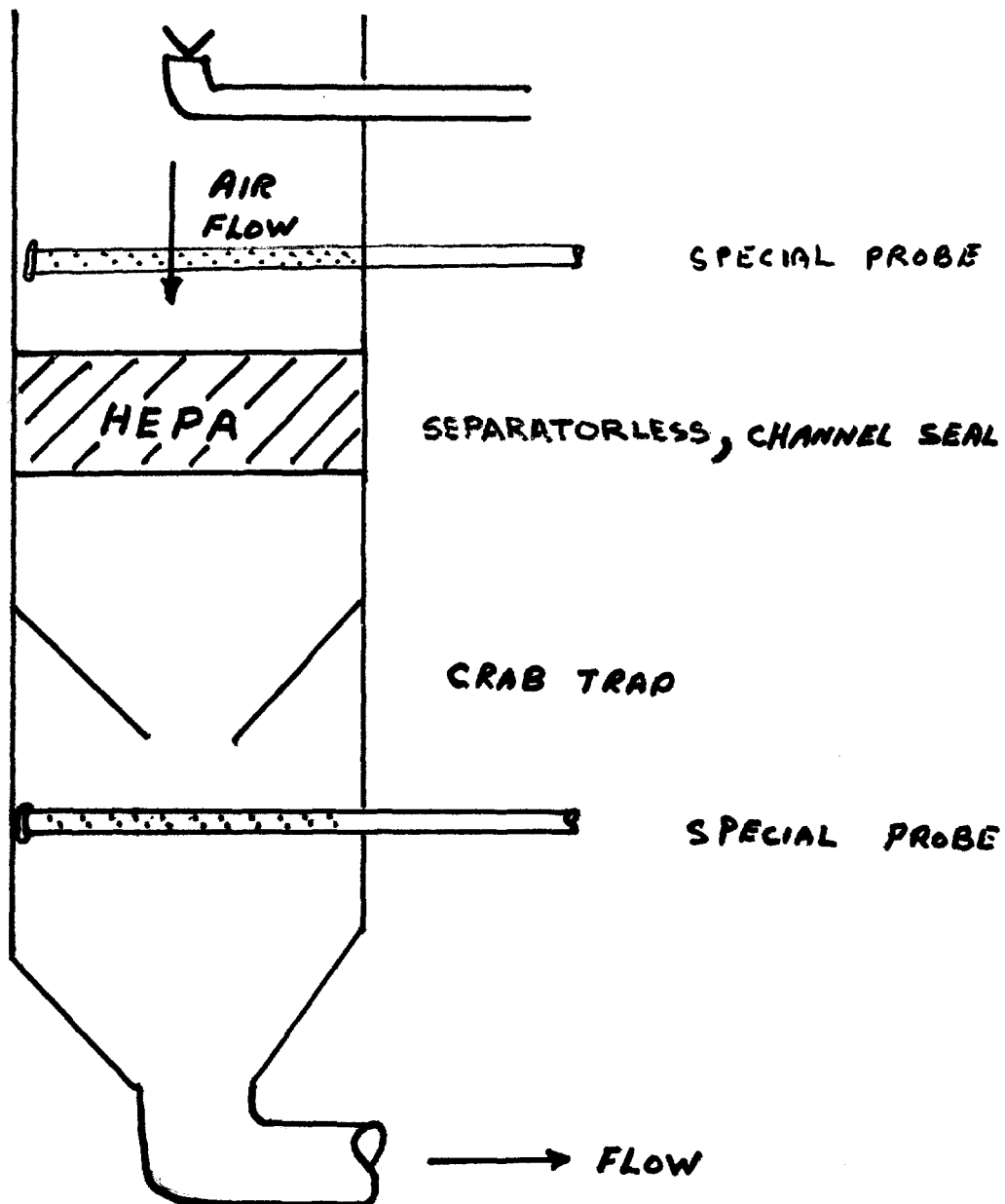


Fig. 6 Sample method for filter in series or small sample distance.

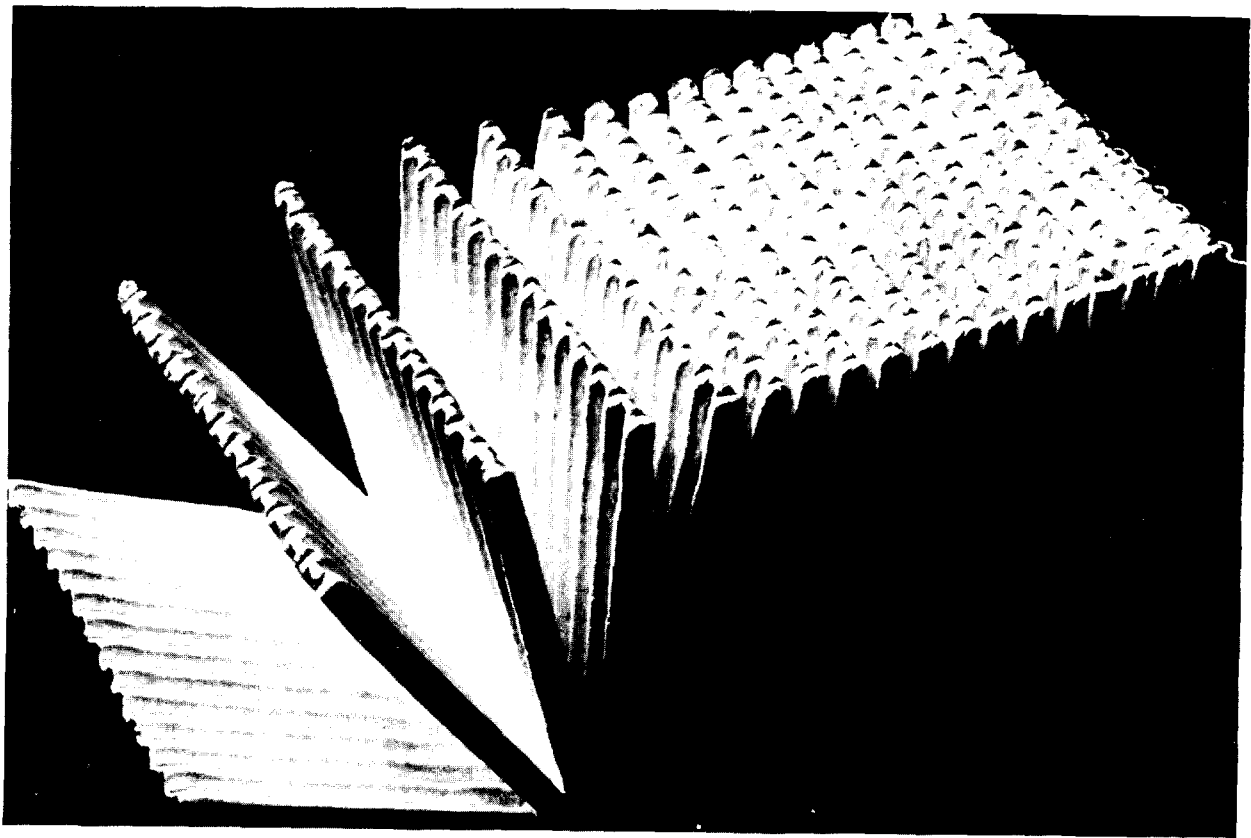
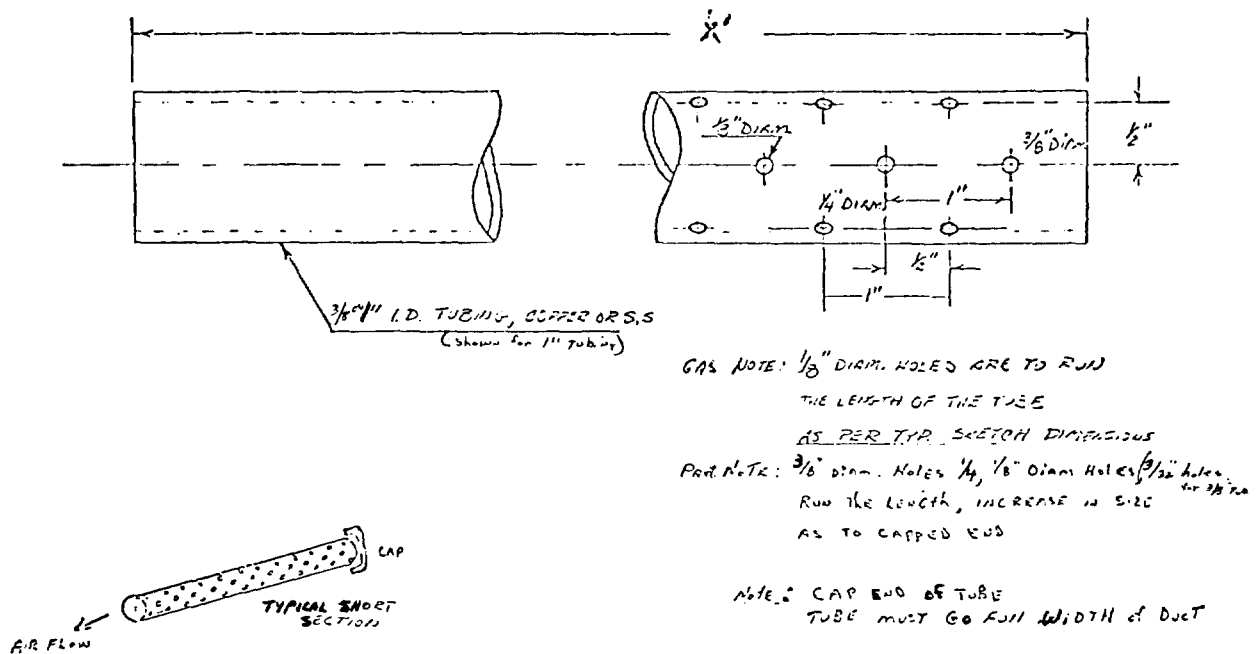


Fig. 7 Separatorless filter.



PROBE FOR HEPA EXHAUST DUCT

Fig. 8 Sample probe with multiholes.

"REMOTE TEST METHOD"

The remote test method equipment consists of the following:

- (a) DOP injector probe (Figure 5).
- (b) Crab trap (Figure 6).
- (c) Separatorless filter with fluid "channel" seal system (Figure 7).
- (d) DOP multihole sample probe (Figure 8).

DOP is injected into the system by using the inverted cap injector probe (Figure 5). A "100%" DOP concentration is obtained upstream of the filter face. Downstream from the injector probe is a nuclear grade separatorless HEPA filter. A fluid "channel" seal system is used with these filters. This reduces gasket seal problems on installation by about 80 per cent. This type of filter system is used almost exclusively at the INEL for remote sampling.

Located downstream from the filter system is a "crab trap" designed by Flanders Filters, Inc. It is designed to ensure a turbulent mixture of DOP in air, and can be moved out of the way for normal air flow operations. The "crab trap" is located downstream from the filter at a distance equal to the width of the filter.

The multihole sample probe is located downstream from the "crab trap" $1\frac{1}{2}$ times the width of the "crab trap" opening. The initial test utilized a variety of sample probes. These probes were isokinetic, straight pipe, bent pipe, pipe with holes on the side, and a "U" pipe. The probe determined to be the best overall was the multihole probe (Table I).

Tubing with an inside diameter of 0.375 inches is connected from the permanently installed multihole duct sample probe to a remotely located light scattering photometer (Figure 9). The DOP injection line is also connected from the injector probe to the DOP generator. The DOP generator is located in the same area as the light scattering photometer (Figure 9). All lines should be kept as short as practical to reduce lag time, to increase efficiency, and reduce the possibility of DOP plating out on the lines.

3.0

Discussion

HEPA filters are occasionally located in inaccessible areas, high radiation areas, or where design does not permit correct sampling distances. This remote test method was developed to reduce possible employee exposures, improve testing efficiencies, and reduce testing time. The remote sampling system, in one instance, has enabled testing of 26 individual filters in a hot cell, by one person, in less than one hour with no measurable personnel exposure.

"ADVANTAGES OF THE SYSTEM"

- (a) The DOP filter test is conducted from outside the immediate area, thus reducing personnel risk.
- (b) The DOP sample injection can be used to test one or more units either

individually or as a system.

- (c) The DOP sample injection is evenly distributed over the filter face.
- (d) An accurate DOP test can be obtained when filters are in close space arrangements of a bank.
- (e) The remote system reduces personnel exposures.
- (f) The remote system reduces personhours required for the test and enables one person to perform an accurate test.
- (g) The separatorless filters have a 2 to 3 times longer life expectancy with virtually no sealant problems.

"SUGGESTED TEST PROCEDURES"

Installation

- (1) Install a dispersion cap in the center of the duct and install a fall-away "crab trap"
- (2) Install a channel system knife edge and a separatorless channel (fluid) system HEPA filter
- (3) Install a circular drilled multihole sample probe in the correct location across the entire duct as indicated by a traverse.

Procedure

- (1) Check out and set up for operation the photometer and the generator (ensure proper warmup of the generator)
- (2) Blow a small amount of gas or air through the sample tube to ensure a relatively clean line
- (3) Connect the aerosol generator to the injection pipe
- (4) Connect the photometer to the upstream sample tube
- (5) Swing "crab trap" into the sample position
- (6) Obtain the upstream sample
- (7) Move the photometer sample tube to the downstream sample tube and obtain a sample
- (8) Disconnect the photometer and swing "crab trap" into the stored (manual) position
- (9) Record and evaluate the sample data

Conclusion

The remote test system has proven very successful when HEPA filters are located in inaccessible areas, high radiation or toxic areas, or where design does not permit correct sampling distances. This system has enabled the INEL to meet the requirements for testing HEPA filter systems that otherwise could not have been tested

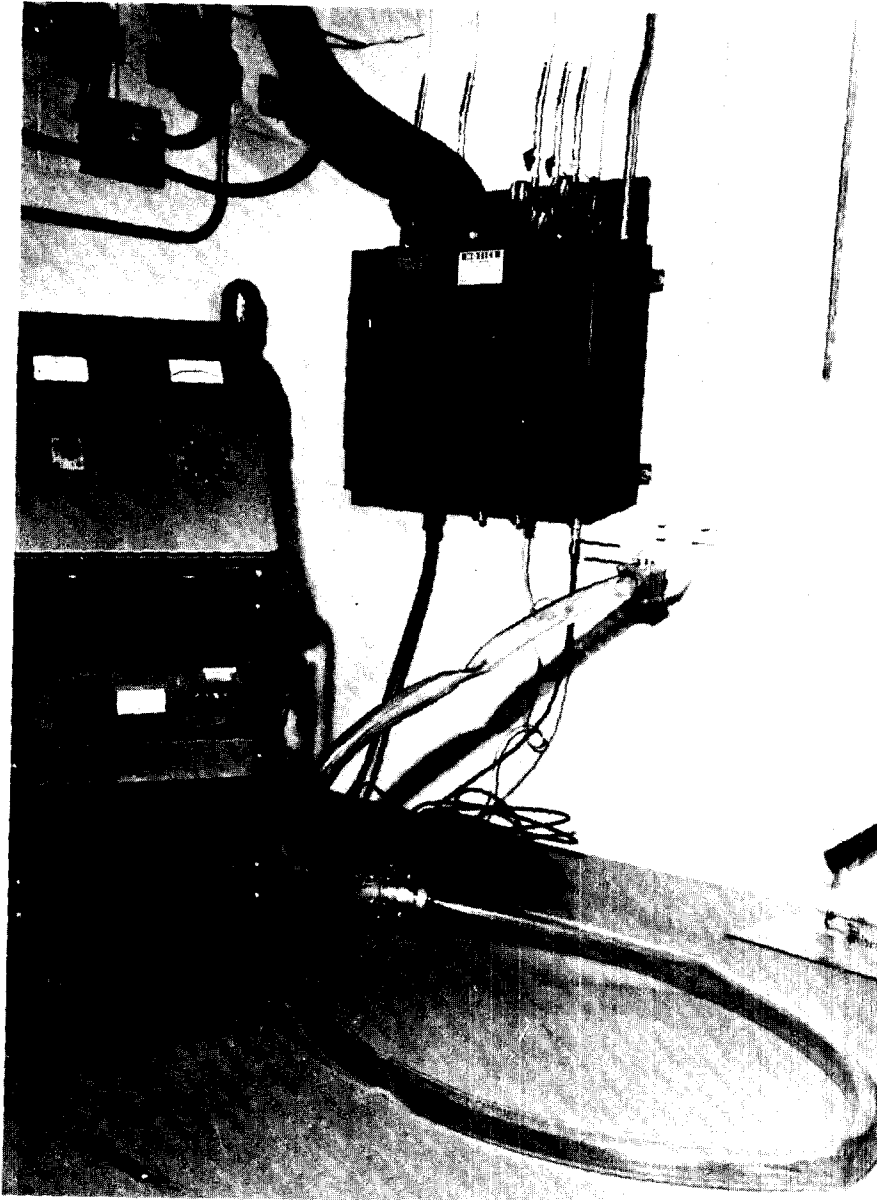


Fig. 9 Remote sample by one person.

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DETECTOR TDA-2D

(flow rate 25 and 50 f/m)

Test Number	Upstream Concentra- tion	Type of Probe (downstream of filter)					
		Probe with Holes (3/8 in.)	Straight Pipe (3/8 in.)	Isokinetic (1/8 in.)	Isokinetic (1/4 in.)	Bent Pipe (3/8 in.)	"U" Bent Pipe
1	100	0.013	0.011	0.011	0.011	0.012	0.015
2	100	0.013	0.011	0.012	0.012	0.013	0.016
3	100	0.014	0.011	0.012	0.012	0.013	0.015
4	100	0.013	0.011	0.012	0.012	0.002	0.016
5	100	0.014	0.012	0.012	0.012	0.013	0.017
6	100	0.013	0.012	0.012	0.012	0.012	0.016
7 ^[a]	100	3.1	2.6	2.8	2.8	2.7	4.0
8 ^[a]	100	3.4	2.8	2.7	2.8	2.4	3.2
9 ^[a]	50	3.2	2.7	2.8	2.8	2.5	3.9
10 ^[a]	25	3.2	3.1	2.9	3.0	2.8	4.0
11 ^[a]	100	3.3	2.6	2.8	3.0	3.0	6.4
12 ^[a]	100	3.2	2.5	2.7	2.6	2.3	4.0

[a] Hole in filter unit. The ratio was best on the special probe and compared very well to isokinetic.

Table I Sample Probe Test Comparison

DISCUSSION

FIRST: We have heard other papers in this Conference on testing. This is a little different variation. Mr. Musen, could you tell me why you thought it was worthwhile to do your studies to see if isokinetic or nonisokinetic sampling had an effect when the particle size is well below one micrometer?

MUSEN: The main reason is that we wanted to look at all the different types of sample probes. We considered isokinetic sampling to be the state of the art.

FIRST: I would be very skeptical of a multiple port probe if you did have particles that were larger than one micrometer because then inertial effects would be present. Even though the holes were distributed uniformly over your probe, there is no guarantee that the particles would be uniformly distributed over the duct into which the probe was placed so you might get some false results for this reason.

MUSEN: This was considered but since the filter would not otherwise be capable of being tested, it was better to use it than not to test the filters at all. A loss of only $\pm 4-6\%$ in efficiency resulted.

FIRST: Dr. Sokol's subject matter is a review of the current technical status of high level waste disposal with emphasis on the recommended use of multiple barriers.

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RADIOACTIVE WASTE MANAGEMENT THE NEED FOR MULTIPLE BARRIERS

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Abstract

Isolation criteria for the disposal of high-level radioactive waste are critically examined. The results indicate that the essential period for isolation of high-level waste is about 1,000 years. Multiple barriers, such as a solidified, leach-resistant waste form (i.e. fixation in glass), a corrosion-resistant outer container, and a stable geological formation, which limit the transport of radioactivity into the human food-chain are recommended. The multiplicity of barriers allows for the unlikely event of failure in one or two of the barriers while still providing adequate isolation of the waste.

I. Introduction

The essential period for the containment of high-level waste is about 1,000 years (Figure 1). This is based on a comparison of the hazard using the federally allowed Maximum Permissible Concentrations (MPCs) in water, of the fission product and actinides in the waste produced from the reprocessing of a ton of nuclear fuel to the hazard of the naturally occurring, radioactive uranium ore which was mined to produce this ton of fuel.^(1,2) The MPCs take into account the biological effects produced by individual radionuclides and the use of MPCs in water reflect the fact that flowing water is the most likely mechanism for transporting the radionuclides in the water to the human food chain.

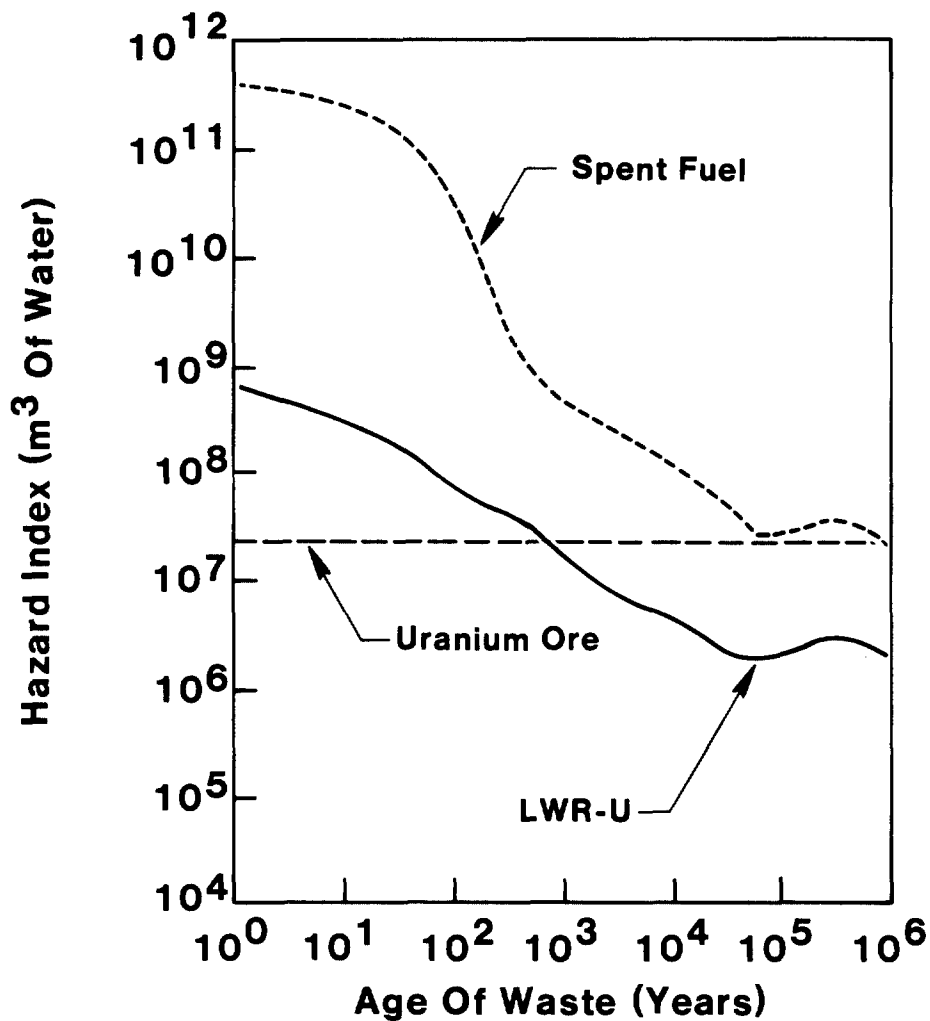
Since the first 1,000 years are the essential period for containment of the waste and considering the advances which have been made on waste management technology, a waste management system which includes an engineered barrier, as well as geological barriers, has the best chance of meeting the technical and public acceptance requirements for a waste management system. Having a multiplicity of barriers allows for the imperfect knowledge which will exist about the integrity of any one of these barriers. Such an approach for the disposal of high-level radioactive waste would involve consideration of the solid form of the waste, the engineered outer container, and the geological medium for disposal.

II. Solid Waste Forms

For all practical geological disposal modes, the leach rate of the ultimate product is an important factor in determining potential hazards from buried waste. Borosilicate glass waste forms have been produced in the U.S. with initial leach rates of 10^{-6} g/cm²/day. Battelle Laboratories has estimated that the leach time for such a 1-ft. dia. x 10-ft. long glass monolith is approximately 150,000 years.

Similar borosilicate glass forms have been produced in France with initial leach rates in the range of 10^{-7} to 10^{-8} g/cm²/day. Nepheline syenite glass waste forms from Canada show a leach rate of 4×10^{-11} g/cm²/day in ground water after remaining in situ for 18 years.⁽³⁾

SUMMARY OF HAZARD-INDEX COMPONENTS



Reference: NUREG 0216,1977

Figure 1

III. Engineered Containment

Historically, the U.S. Program has not emphasized the concept of a well-engineered outer container for high-level waste. For example, in bedded salt the stainless steel canister was assumed to be corroded by the salt in a few years.⁽⁴⁾ One of the objections to Project Salt Vault in Lyons, Kansas was the lack of retrievability for the waste.⁽⁵⁾ In a waste disposal system developed in Sweden, a containment system, which uses a layer of lead 100 mm thick surrounded by 6 mm of titanium, has been devised to provide 500 to 1000 years of retrievability.⁽⁶⁾ To add to the integrity of their high-level waste disposal system, the Swedish plan includes a packing of bentonite and quartz-sand around the canisters which decreases the flow rate of the water by a factor of 200 or more and therefore reduces the release rates of radionuclides in the unlikely event that water enters the repository.

IV. Geological Disposal Mediums

For two decades, disposal in bedded salt has been the leading high-level waste disposal medium in the U.S. The advantages of bedded salt are its high thermal conductivity, resistance to radiation damage, and the ability to flow plastically under moderate pressure and "heal" breaks in the formation.⁽⁷⁾

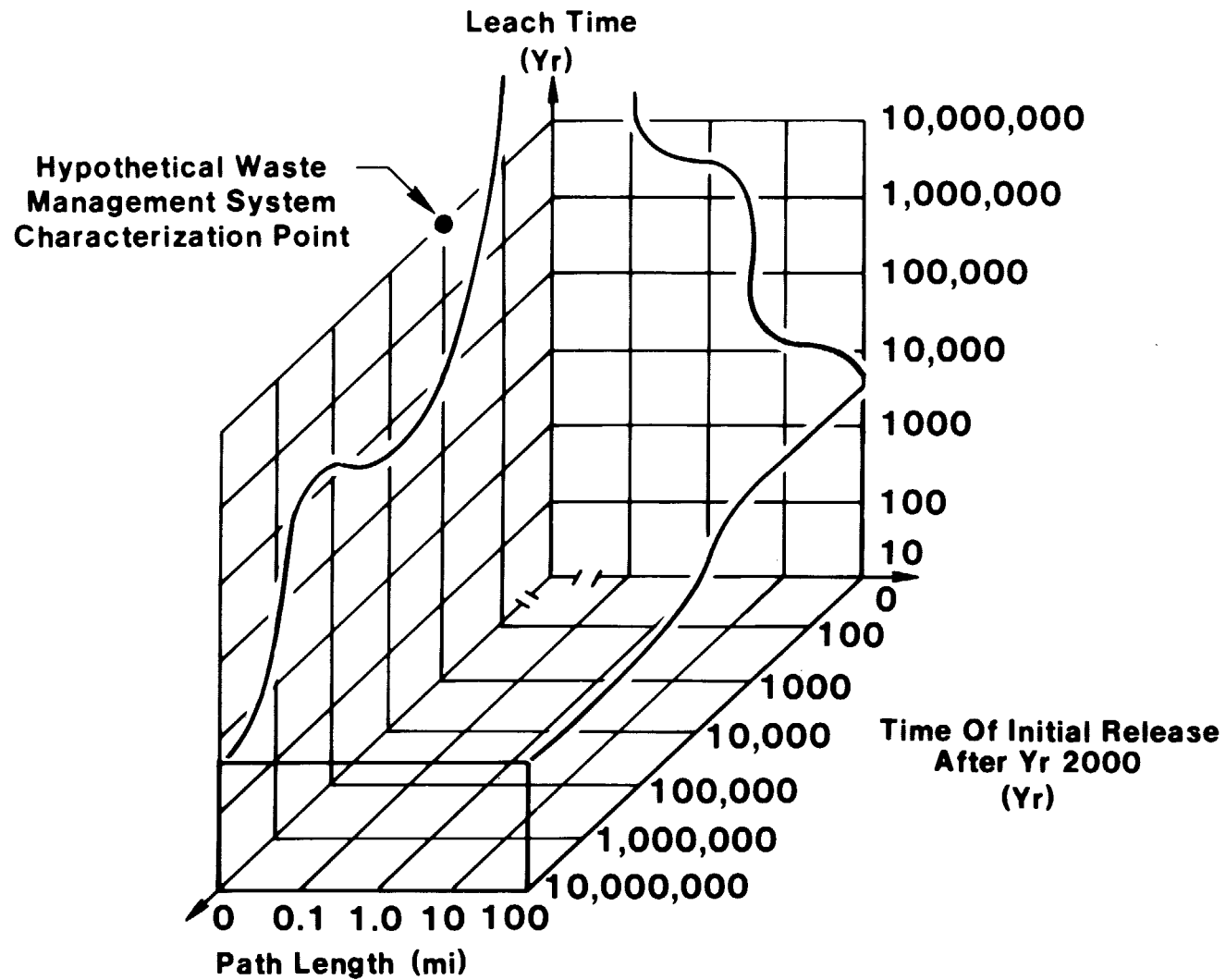
The crystalline rocks, such as the granites and basalts, under investigation in both the U.S. and Sweden, lack some of salt's desirable thermal and mechanical properties but represent a less corrosive environment. Also, the public image of this type of material is better ("hard as a rock"). Since the number of disposal sites in bedded salt which meet all the requirements for disposal of radioactive waste may be limited, other geological mediums are under investigation in the U.S. and overseas which appear to also offer the potential as an acceptable medium for geological disposal of radioactive waste.⁽⁸⁾

V. Hazard Assessment

A realistic assessment of the waste disposal hazards must include considerations of the leach-resistance of the waste form, the engineered containment, and the absorption of the waste in the surrounding geological medium. Recent studies in both the U.S. and Sweden have considered the effects of these various barriers.

Studies by Battelle Pacific-Northwest Laboratory considered all the solidified high-level waste produced by commercial nuclear power plant operations by the year 2000 placed in a repository in typical western U.S. desert soil. These calculations considered variations in the leach-resistance of the solidified waste form, the time before containment is breached, and the path length between the repository and a body of water at the surface. The results were in terms of a radiation dose to an individual who obtained all his food and water from water which has been contaminated.⁽³⁾ The results of these studies (Figure 2) indicated that using realistic assumptions, the maximum dose to this individual would be a fraction of the normal dose due to background radiation. In fact, using this analysis and assuming a well engineered container (1000 years of containment) and a high leach-resistance glass (10^{-8} g/cm²/day), the high-level waste would not pose a serious environmental hazard even if buried in near surface storage in a dry area.

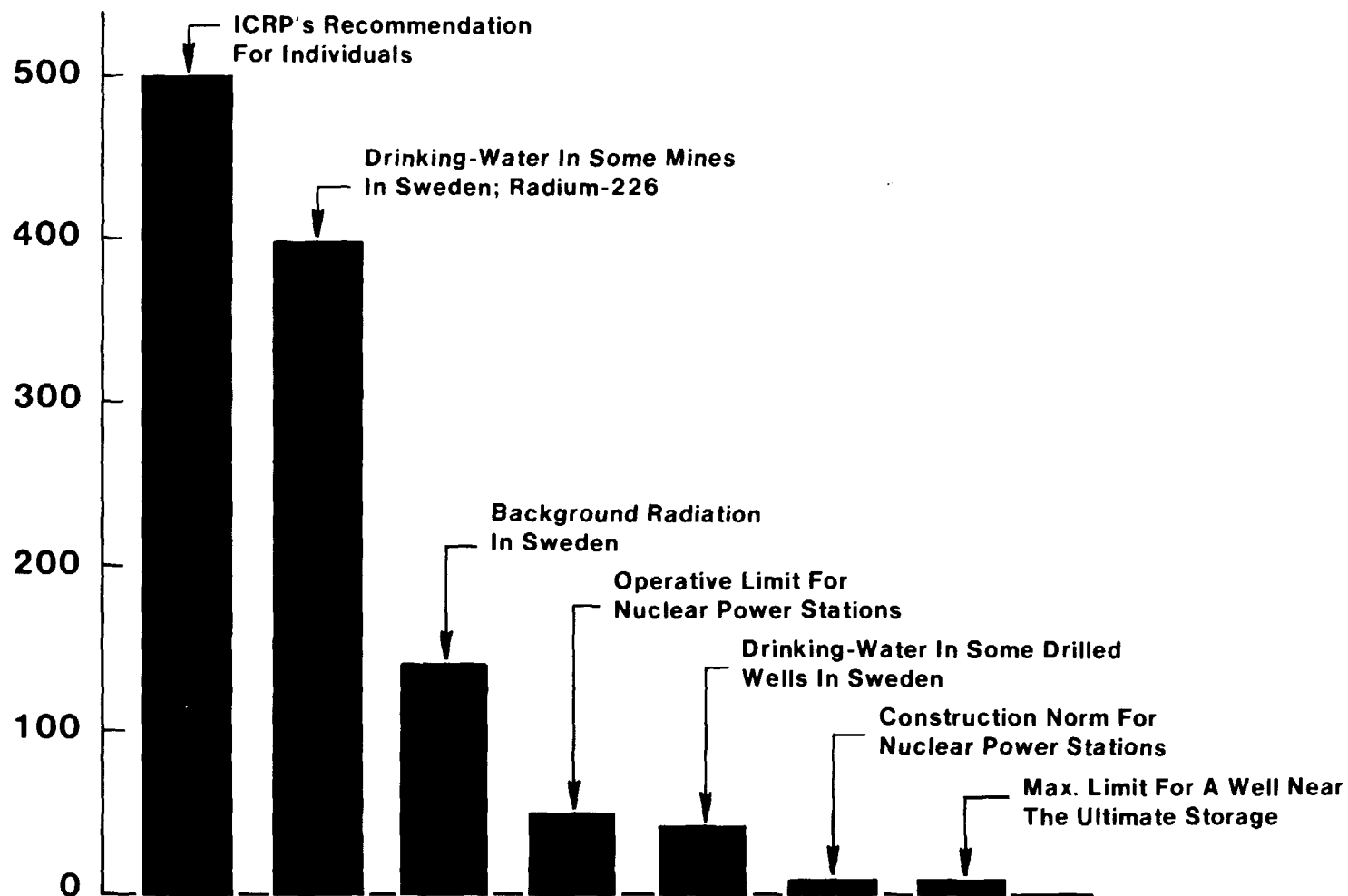
WASTE MANAGEMENT CONTROL SURFACE FOR INCREMENTAL BACKGROUND DOSE



Reference: BNWL-1927, 1975

Figure 2

Radiation Dose mrem/year



Reference: KBS, Report No. 1, 1978

Figure 3

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A similar study done in Sweden (Figure 3) for solidified high-level waste disposed in granite showed that the maximum dose to an individual would not be more than 13 mrem (about 10% of background radiation) and is below the dose some people in Sweden receive from naturally occurring minerals in drinking water (about 40 mrems).⁽⁹⁾ Of course, if the engineered barrier were still intact, then no radioactivity would be released and a small defect in the engineered barrier, such as a crack or hole, would only allow a small fraction of the radioactivity (the 13 mrem) to reach the critical group.

By combining a series of engineered barriers, which can be qualified by accelerated life testing, and geological barriers, a disposal system can be developed using current technology which can meet the current political/public acceptance, as well as technical requirements for the safe disposal of high-level waste.

DISCUSSION

HULL: From the health physics standpoint, there is a lot of radioactivity in nature, but nobody worries about it because it is dispersed. Since the long run problem of high-level wastes is not so much the amount as the concentration, doesn't this make deep ocean sediment disposal, that the British are looking at, attractive? If the containers leak from there, the effluent would be widely dispersed. Also, it would be far removed from manmade intrusions. Nobody is going to sink into it unless they're looking for oil at 10,000 or 20,000 foot depths some time in the future.

SOKOL: There has been some work done on this by Nuclear Safety Associates. You're talking about human intrusion which is apart from general public health. If you say that after 1,000 years the container is going to go and the material is going to spread out somewhat, it turns out that it doesn't have to spread out very much before you are down to the same concentrations of uranium ore you started with. In other words, you would only have to go 30 feet to the side of these 1 x 10 ft. canisters before you would be down to concentrations similar to the uranium ores people are finding in places like Canada and early parts of the Grant's Belt mineral district. Therefore, it requires a system of container design that optimizes for containment, which is important for the general public, and isolation, which is related to the fear that some idiot will dig 3,000 feet down into salt or granite for something that he can find easier elsewhere. One of the advantages of granite is you can mine it deeper and this may make it easier to optimize for containment and isolation from human intrusion. But you can do the same if you adopt more than a single barrier.

HULL: Maybe we have to do this in order to obtain public acceptance of nuclear power, but I'm a health physicist and a member of the American Public Health Association and I keep thinking, "If only we could transfer this money that we're spending for all this redundancy plus redundancy into real public health issues, we could really improve the public health." I think we ought to keep saying to the public that it could be much better spent. This will create a perception of sensible options on risk prevention.

SOKOL: I will reiterate what I said about containment buildings. Early European reactors did not have large concrete and steel containment structures. They now have to have them. Your point is well taken, but we have to deal with the political realities of our times.

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DUGGAN: Would you comment on the cost of using a three containment system for disposal of nuclear wastes? It seems that it is political to some extent; that we are trying to make the public feel more safe about the way we plan to dispose of our wastes. Yet, at the same time, we can't make disposal of the waste more expensive than producing the power in the first place. How do you balance cost-effectiveness against gains in assurance of containment?

SOKOL: Most of the figures that I have seen from the Department of Energy show that very elaborate schemes, such as separating out parts of the waste and putting it in outer space shift power cost 5% at the most. When you consider that waste disposal represents a small fraction of the total fuel cycle cost, you have tremendous freedom in designing the system. The Swedes have said that economics--at least initially--is not a factor. We want a system that will be safe without a lot of dickering over cost-effectiveness. You may find a system 15, 20, or 30 years from now that lets you eliminate or reduce some of your dependence on one of the barriers, but right now you're talking about being penny-wise in terms of saving money on one of these barriers and pound foolish because you won't have the generating stations that you need and you won't have the lowest price form of generating system that you need. People have talked about a tenth of a mil per kilowatt hour for some of these disposal schemes, and there is tremendous leeway in that economic area, so it's silly to get hung up on that part of it; at least at this stage of the game. I have my own reasons for not being keen on disposal in outer space, but that's another topic.

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CSL ENGINEERING DESIGN HANDBOOK

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Abstract

An engineering design handbook recently published describes a high efficiency air cleaning filtration system. This system, modified from the basic nuclear concept, was designed to meet the criteria for a chemical demilitarization facility. Topics covered in the book include both basic and detailed filtration and ventilation design considerations.

Presentation

I am here today to discuss a recently released Chemical Systems Laboratory document entitled "Engineering Design Handbook for Air Cleaning for Chemical Demilitarization." (Figure 1).

Why prepare an Engineering Design Handbook? The answer is simple. There is a lack of published information available on this subject and the information is relevant to both government and industry.

In late 1973, the Chemical Systems Laboratory located at Aberdeen Proving Ground, Md., was assigned the task of designing an air cleaning system for a facility located at the Tooele Army Depot, Utah. This facility, called Chemical Agent Munitions Disposal System (CAMDS), (Figure 2), was to dispose of obsolete chemical munitions containing toxic agents. To meet the stringent requirements imposed by Public Law and other regulations relating to safeguarding the health and safety of workers and the environmental quality of air discharged to the atmosphere, a high efficiency air cleaning system was required. By high efficiency air cleaning system, I do not mean a general industrial or air pollution control system, but a system equivalent to a nuclear air cleaning system, capable of handling the extremely hazardous material to be contained.

During the initial design effort, an extensive search for published literature on filtration systems was conducted. The typical chemical filtration system at that time was the chemical-biological-radiological (CBR) unit which consisted of a roughing filter, a HEPA filter and a specially made wood encased adsorber. When this design was compared to the basic nuclear concept, the nuclear concept had more potential advantages. The information that was incorporated into the various designs came mainly from ORNL-NSIC-65 (the predecessor of the current nuclear air cleaning handbook) and "Industrial Ventilation" (a manual prepared by the American Conference of Government Industrial Hygienists).

Over the next four years the CAMDS system was completed and successfully tested. Since this system was judged to be a significant improvement over previous air cleaning systems built by the US Army, it was desirable that the experience gained as a result of the effort be suitably documented to provide baseline data for designers of future systems of this type. Thus, this handbook was prepared.

The information contained in the handbook is shown in Figures 3 - 5. Figure

AD

CONTRACTOR REPORT ARCSL-CR-78022

ENGINEERING DESIGN HANDBOOK
FOR
AIR CLEANING FOR CHEMICAL
DEMILITARIZATION

by

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March 1978

Contract No. DAAA15-75-C-0154

Task No. 52-7US4001M-1E200

Project No. 655



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
Chemical Systems Laboratory
Aberdeen Proving Ground, Maryland 21010

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FIGURE 1

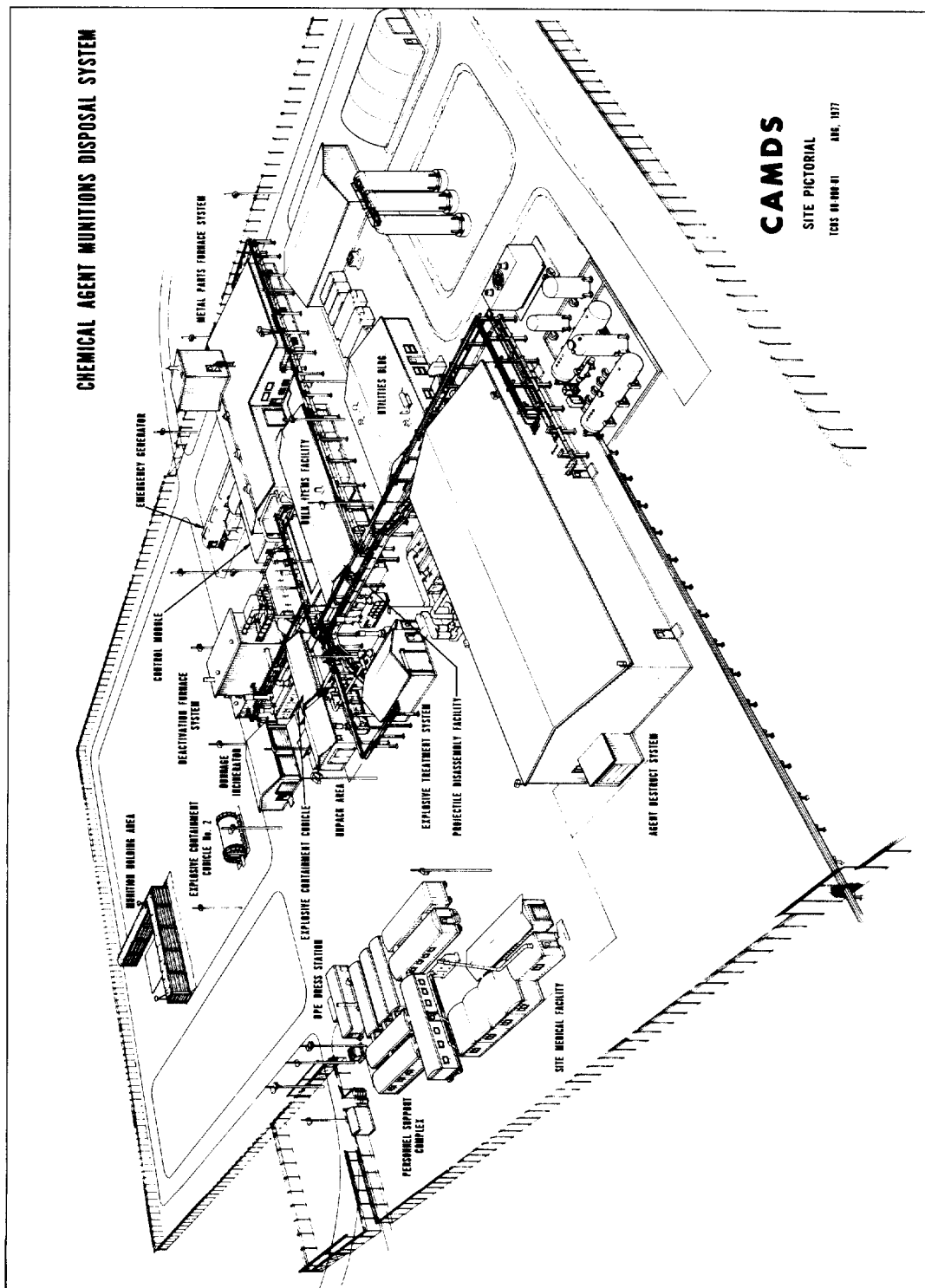


FIGURE 2

TABLE OF CONTENTS

1. INTRODUCTION
2. REQUIREMENTS FOR AIR CLEANING FILTRATION SYSTEMS
3. BASIC DESIGN CONSIDERATIONS FOR EXHAUST SYSTEM
4. DETAILED DESIGN CONSIDERATIONS
5. OPERATIONAL CONSIDERATIONS
6. BASIC MAINTENANCE AND STORAGE CONSIDERATIONS
7. TESTING
8. APPLICATION OF AIR CLEANING CONCEPTS TO DATS
9. LITERATURE CITED
10. GLOSSARY OF TERMS

APPENDIXES

- A. PROPOSED MAXIMUM ALLOWABLE LIMITS FOR EMISSIONS OF GB, VX, AND MUSTARD FOR CHEMICAL DEMILITARIZATION
- B. SPECIFICATION FOR CAMDS AIR CLEANING SYSTEM
- C. DETAILED ADSORBER BED CONSIDERATIONS
- D. GENERAL CHARACTERISTICS OF ACTIVATED CARBON

FIGURE 3: HANDBOOK CHAPTER HEADINGS AND APPENDIXES

- 3. BASIC DESIGN CONSIDERATIONS FOR EXHAUST SYSTEM
 - 3.1 AGENT VAPOR REMOVAL METHODS
 - 3.2 CRITERIA FOR DETERMINING VENTILATION RATES
 - 3.3 FILTER CAPACITY
 - 3.4 SAFETY
 - 3.5 OPERATION AND DESCRIPTION OF KEY COMPONENTS
 - 3.6 EXTERNAL COMPONENTS
 - 3.7 EXTREME ENVIRONMENTAL CONDITIONS

FIGURE 4: CHAPTER 3 - SUBHEADINGS

- 4. DETAILED DESIGN CONSIDERATIONS
 - 4.1 FILTRATION SYSTEM
 - 4.1.1 CONFIGURATION
 - 4.1.2 FILTER HOUSING DETAILS
 - 4.1.3 FILTERS AND ADSORBERS
 - 4.2 VENTILATION SYSTEM DESIGN CRITERIA
 - 4.2.1 HOODS
 - 4.2.2 DUCT DESIGN
 - 4.2.3 AIRLOCK DESIGN
 - 4.2.4 FAN SELECTION
 - 4.2.5 DAMPERS
 - 4.2.6 AUTOMATIC CONTROLS
 - 4.2.7 MAKEUP AIR
 - 4.2.8 HEAT CONTROL
 - 4.2.9 REDUNDANCY AND SAFETY FEATURES

FIGURE 5: CHAPTER 4 SUBHEADINGS

3 lists the 10 chapter headings and the appendixes. Note Appendixes C and D. These were written by Dr. Leonard Jonas of the Research Division of Chemical Systems Laboratory. Appendix C is a mathematical description on how the adsorptive process works and Appendix D explains how various factors effect the adsorptive capability of carbon.

The major portion of the design information is contained in Chapters 3 and 4 as shown in Figures 4 and 5.

These next figures are typical of the information contained in this handbook. Figure 6 is an isometric of a walk-in type filter housing. The handbook discusses in detail, three different types of filter housing designs: The walk-in, the bag-in, bag-out, and the walk-in with stationary absorber. Five separate banks of cells (prefilter, HEPA, adsorber, adsorber and HEPA) can be seen in the filter housing. All of the CAMDS filter housings have this same bank arrangement. The handbook also explains the function of each bank, discusses mounting frame configurations, clamping techniques for the cells, instrumentation, testing, etc.

Figure 7 shows one of the bag-in-bag-out filter housings as it is installed at the CAMDS site. You will note that this filter housing is located outdoors. The notes in the picture are pointing out two butterfly dampers in the ductwork and an inter-connecting duct to another filter, which enables a partial parallel redundancy to be achieved between the filter housing shown in the foreground and one in the background.

Figure 8 shows the overall CAMDS filter system layout. Each solid black rectangle represents one filter housing and each dark black line represents the ductwork. There are 10 separate filter units. The filter units vary in capacity from 333 CFM to 30,000 CFM. (Filter housings #9 and #10 with a capacity of 15,000 CFMs each are in parallel. You will note that most of the air cleaning systems are connected to one and in some cases, two other air cleaning systems. This provides a partial parallel redundancy without requiring additional filter housings. The handbook discusses in both general and specific terms, series and parallel redundancy, sizing of filter unit, exhaust stack requirement, access requirements, power requirements, etc.

As you may have noted from these last three slides, the CAMDS system is an extrapolation of the basic nuclear air cleaning concept, modified to meet the specific requirements of ventilating a chemical demilitarization facility, and the filter housings are similar to some nuclear units.

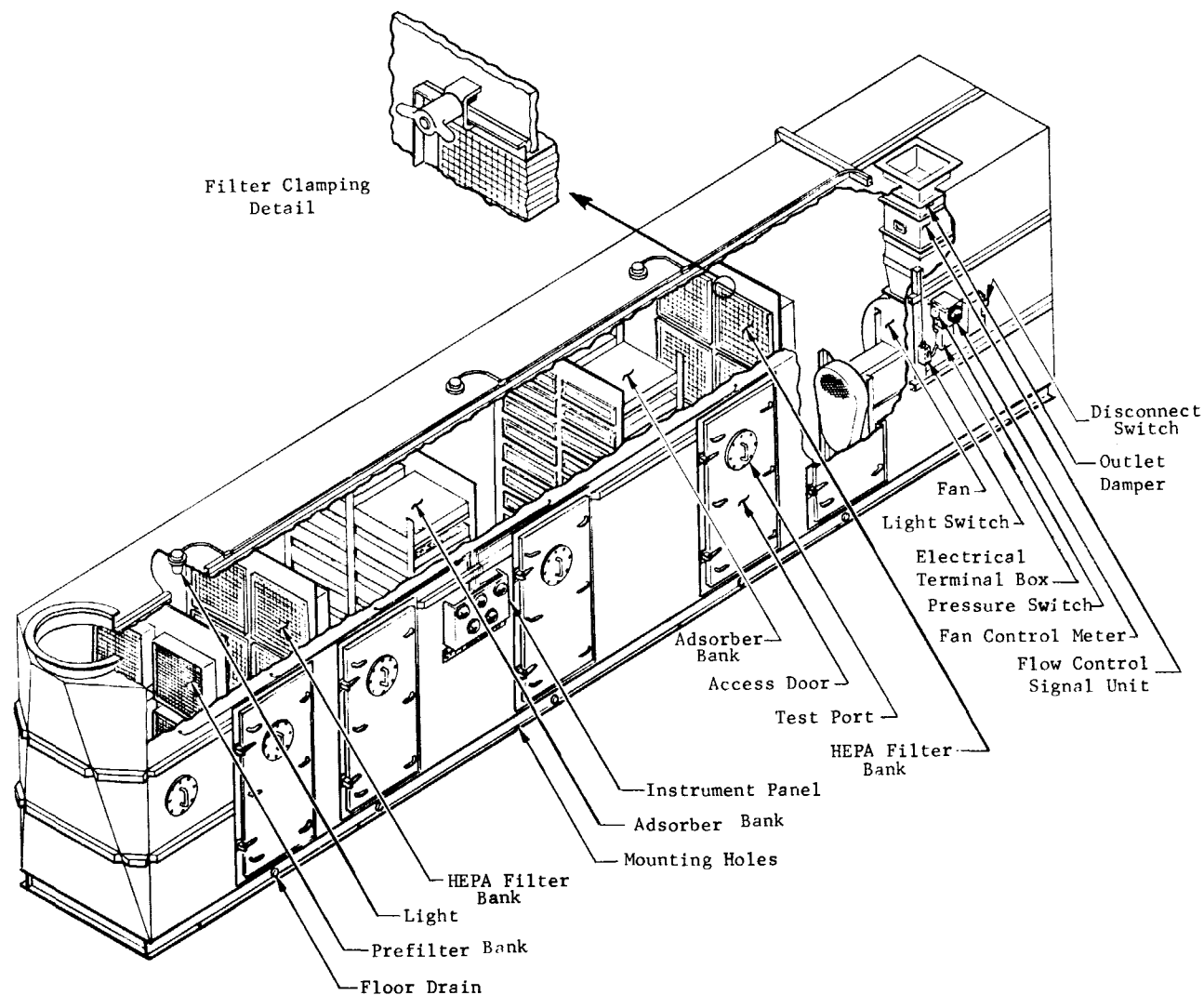
The major differences between this system and the typical nuclear system are:

(1) Adsorbent - The CAMDS adsorber cells contain an unimpregnated activated carbon whereas the nuclear field uses an iodine impregnated carbon.

(2) Location - All CAMDS filter housings are located outdoors whereas most nuclear units are located indoors.

(3) Adsorber Bank Arrangement Requirement - CAMDS has two series - redundant adsorber banks (2" bed depth) with agent monitoring equipment between, whereas this is not a requirement in the nuclear field.

(4) Maximum temperature of (110°F) and maximum pressure requirements of 24" H₂O are lower than for nuclear systems.



Type II Filter System (6,000 Cfm), Walk-In
(Courtesy Of CTI-Nuclear, Inc.)

FIGURE 6

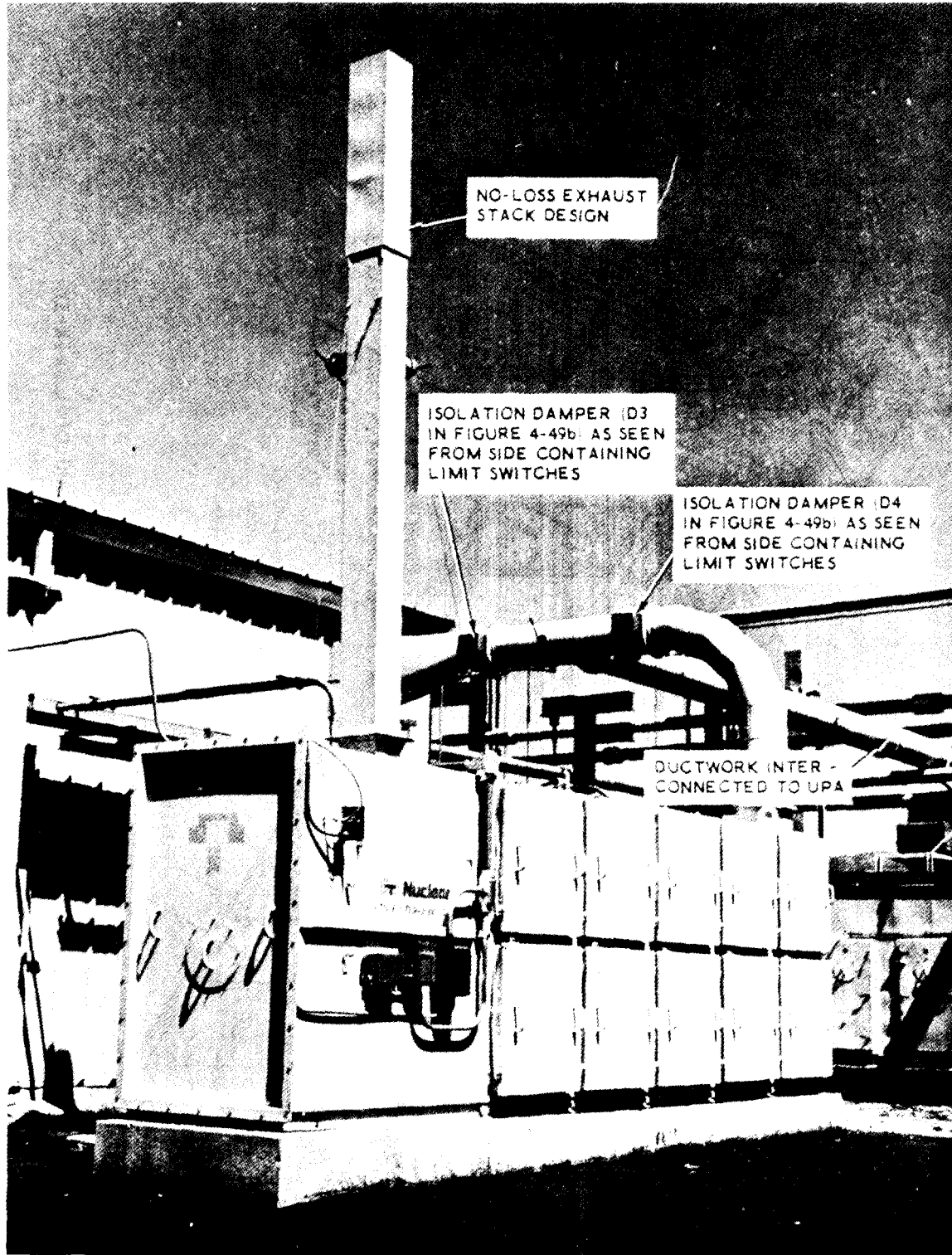


Figure 7 Type I Filter System (2,000 Cfm) For Explosive Treatment System At CAMDS Showing Isolation Dampers And Interconnecting Ductwork

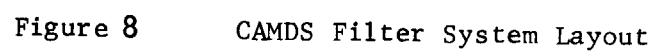


Figure 8 CAMDS Filter System Layout

(5) No sprinkler system requirement for CAMDS.

As more stringent environmental and personnel safety requirements are continually being imposed, there may be a corresponding demand for high efficiency air cleaning systems in certain industrial situations. This handbook has been prepared primarily for those designing air-cleaning systems in the chemical demilitarization operations as the nuclear air cleaning handbook was prepared for those in the nuclear field. As Chemical Systems Laboratory was able to extrapolate extensive information from the nuclear air cleaning handbook, personnel working in various air cleaning areas of the chemical or industrial field may be able to obtain information from this handbook which will make their task easier and their end product more technically sound.

This handbook has been assigned a #ADA-056-389 by Defense Document Center and is currently being processed through normal channels. When processing is complete, this handbook will be available from the National Technical Information Service at 5285 Port Royal Road, Springfield, VA 22161, area code 703-557-4650.

DISCUSSION

DENNISON: Would you comment on your instrumentation regarding the efficiency of your untreated charcoal beds in dealing with heavy hydrocarbons or other hydrocarbons for that matter?

SHACTER: The instrumentation to be used for the CAMDS high efficiency air cleaning systems will consist of two bubbler systems and an M8 Alarm. One bubbler system will sample between the two adsorber banks and the other bubbler system will sample at the exhaust stack. The M8 Alarm will sample between the two adsorber banks with provisions to have the sample source switched to the exhaust stack should a breakthrough of the first adsorber bank occur. The chemical analysis of the bubbler solutions will achieve sensitivities of 3×10^{-5} mg/m³, 3×10^{-6} mg/m³, and 3×10^{-3} mg/m³ for the three toxic agents to be contained. The M8 Alarm is an electrochemical detector with an immediate response, but only a 102 mg/m³ sensitivity. The only suggestion I could offer would be to use a gas chromatograph in series with a detector selected for your specific requirement. An example of this is, the Chemical Systems Laboratory uses a Hydrogen Flame Emission Detector (HYFED) to detect phosphorous-bearing toxic agents.

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CPP EXPERIMENTAL HEPA FILTER MEDIA

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At the Waste Calcining Facility located at the INEL, we have some rather challenging problems to overcome in the various filtration systems. Some have already been mentioned in other papers by Schindler, Loo, and Murphy.

One of the problems we are currently trying to overcome is that of having a filter media withstand the high NO_x concentrations, the high relative humidity and radioactivity. One of the major problems is that the present filter media has the organic binder destroyed after several days in the system due to the high (10,000 to 15,000 ppm) of NO_x and high Moisture loading on the filters, forming nitric acid.

We have asked Flanders Filters to develop a different binder in the filter media which would be more NO_x and moisture resistant. We have since tested three of such filters in the off-gas system of the Atmospheric Protection System (A.P.S.). Our first observation indicated that we had also achieved a further reduction in the Decontamination Factor (DF) of approximately 30. Before the filters were changed efforts were made to intentionally breach the filters by lowering the superheater temperature from approximately 170° F to 125° F for approximately twenty five minutes. There was no increase in the ΔP noted. These tests were duplicated and varied within system constraints, with little effect. No increase was seen on the stack monitor. Although we cannot be certain that moisture actually formed on the filter during these tests, it was felt by all concerned that it should have. Previous filters have been breached by too much moisture forming on the filters. Upon removal from the system a brief visual examination showed no apparent damage to the filters, and no sagging of the media. These filters are of the super-flow design - not having separators. Samples of the used filter media were taken to compare with new media and were to be remotely tested for the tensile strength using an Instron machine. However, personnel operating the Instron testing felt that the "hot" filter sample was too fragile. It had been an additional 6-7 weeks since removal and it was felt that further deterioration had likely taken place.

We are planning on experimenting with some additional filters in the A.P.S. off-gas system as well as the primary Waste Calcining Facility (WCF) off-gas filter systems.

One question arises that we have been unable to answer satisfactorily is that of the type and size of particles passing through or around the two HEPA filters in series at the WCF and collecting on the HEPA filters at the A.P.S. off-gas system. Are these particles formed by recondensing downstream of the WCF HEPA system or is it a wicking effect or what have you?

DISCUSSION

FIRST: At the meeting that was held in Aix-en-Provence a year and a half ago we had a presentation from Argonne showing migration of plutonium through many filters in series.

COWAN: Digester offgas from acid digestion of combustible waste also caused failed filters due to condensate. The temperature was increased to 250-300°C so that the gas was dry and no problems are now found. Also, another filter on an HNO₃ concentrator is operated at 125-135°C without a problem. Increasing the temperature may solve your problem.

HANSON: On filter change, we noticed that we had liquid in the third set of filters downstream and it was at 170°. They tried to maintain the temperature in the 170-180°F range.

CALAN: We are operating in the 250°C range. We have another set of filters off the top of our fractionator where we're filtering nitric acid off the concentrator. We run these around 125-130°C and we are not experiencing difficulty there, either. But, if you look at the vapor pressure of nitric acid, a fairly small concentration of NO₂ can result in a rather high concentration of nitric acid forming in the filter itself. In the 40% range it condenses around 125°C.

BURCHSTED: Your problem suggests that the NO_x passed through the double bank of filters as a gas, then combined with moisture which condensed in those filters or in the duct downstream of them. These droplets then were trapped in the third stage filter. Condensation between filters in the first two stages did not occur because they were too close together; that is, they may have acted as a single filter in this respect.

HANSON: They are in the same housing and they are essentially one filter.

BURCHSTED: The first two?

HANSON: Yes.

BURCHSTED: There's apparently some condensation taking place between your double bank and your final bank down below.

HANSON: There could be. The gases go through superheaters but maybe this isn't sufficient.

FIRST: Our time for the Open-End has come to a conclusion. I think it was a very interesting session in terms of the variety of topics that we covered and the speakers were very kind and held their discussions to a very short time which was the intent. So, to all you gentlemen and to those who commented many thanks.