SESSION 2

NUCLEAR AIR CLEANING CODES AND STANDARDS

Monday:	July 25, 1994
Co-Chairmen:	R. R. Weidler
	J. J. Hayes

OPENING COMMENTS OF SESSION CO-CHAIRMAN HAYES

CHALLENGES OF EQUIPMENT QUALIFICATION USING TODAY'S STANDARDS WITH EMPHASIS ON A CLASS 1E MOTOR PROGRAM
K. Deaton

EVALUATION OF SELF-CONTAINED HEPA FILTER
T. E. Arndt

ASME N510 TEST RESULTS FOR SAVANNAH RIVER SITE AACS FILTER COMPARTMENTS
J. D. Paul, T. M. Punch

AN EVALUATION OF EFFORTS BY NUCLEAR POWER PLANTS TO USE ASTM D3803-89
W. P. Freeman

CLOSING COMMENTS OF SESSION CO-CHAIRMAN WEIDLER

OPENING COMMENTS OF SESSION CO-CHAIRMAN HAYES

This afternoon's session will be dealing with new nuclear air cleaning codes and standards. I think Dr. First's introduction this morning with respect to a synopsis of the past air cleaning conferences is rather appropriate. This afternoon we will be dealing with both the old and the new. We will be dealing with the design of new equipment to new standards. We will be dealing with the application of the existing standards to old equipment. And we will also be seeing how this implementation has taken place for various other systems.

CHALLENGES OF EQUIPMENT QUALIFICATION USING TODAY'S STANDARDS WITH EMPHASIS ON A CLASS 1E MOTOR PROGRAM

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ABSTRACT

This paper describes qualification of new equipment for safety related service in the nuclear power industry in accordance with current industry standards. This topic is presented from the perspective of an original equipment manufacturer (OEM). Equipment qualification is first discussed in a general way then an example is provided of an electric motor qualification. A review of alternative qualification methods including commercial dedication is included. Potential difficulties with alternative / expedited qualification methods are also discussed.

1. Introduction

Fewer companies today are qualifying equipment for the nuclear power industry. The primary reason for this is the fact that no new nuclear power plants are being built in the U.S. Growth in the overseas nuclear power industry has been the primary driving force behind much of the equipment qualification that is being done today.

Given the lack of manufacturers offering pre-qualified equipment, the original equipment manufacturer (OEM) can and often must conduct qualification programs on equipment he intends to use on a particular contract.

This paper describes some of the experiences and challenges in qualifying equipment from the OEM perspective. The Ellis & Watts experience in qualifying our 1E motor design will be used as a typical example of equipment qualification.

In our efforts to qualify equipment we have encountered some alternative qualification methods that will be discussed, including commercial dedication and its role in motor qualification.

2. Qualifying Electrical Equipment

This section can be used in connection with IEEE 323 but is not intended to replace the guidance found in IEEE 323. All references to IEEE 323 are from the 1983 edition.

There are two fundamental reasons to qualify equipment:

1. To provide an adequate level of safety in a nuclear power plant.

2. To meet regulatory requirements in order to keep an operating license.

Successful equipment qualification efforts will satisfy three significant uncertainties of operating equipment:

1. Will the equipment be resistant to common mode failures due to aging degradation?

2. Will non metallic materials survive anticipated environmental stresses?

3. Will equipment and its mountings withstand the seismic forces generated during anticipated earthquakes?

There is a broad range of effort that could be expended in answering these three questions. On one end of the scale is an effort that is insufficient to demonstrate qualification. At the opposite end is an effort that is limited only by time and money. In other words, unlimited time and money could be poured into an equipment qualification program. The goal is an effort that provides reasonable documented evidence that the answers to the three questions above will be yes.

2.1 Generic or Application Specific

One of the first things in qualifying equipment is to establish qualification goals. The program may be conducted as a generic or application specific qualification.

The generic qualification is probably best for the OEM since it opens up the possibility of using the qualified item on a variety of programs in the future. In many cases the generic qualification program is prompted by the need for a qualified item on an existing equipment contract. This type of program requires the determination of realistic test parameters that will probably exceed the needs of the current program but not be so extreme as to reduce the chances of a successful qualification.

Qualification for an application specific program limits use of the component or equipment to programs having the same or reduced environmental stresses.

2.2 Mild or Harsh Environment

A determination must be made regarding mild or harsh environment classification. A mild environment qualification can usually be accomplished without determination of a qualified life (per Section 4 of IEEE 323).

A harsh environment program usually requires testing to verify performance in extreme accident conditions. Simulated aging is necessary to arrive at the end of life condition prior to accident condition testing.

Figure A-1 (see Appendix A) describes the steps to determine if an equipment item is subject to harsh or mild conditions. Even with the direction provided by Figure A-1 there is still some subjectivity involved in making this determination. Only about half of the specifications we encounter make the distinction. Some customer specifications use the absorbed radiation dose as a criteria for distinguishing between mild and harsh. Others use a combination of radiation dose and temperature.

Even if the qualification program is based on a customer specification, there is often insufficient detail to determine what qualification steps are required. The foundation upon which any successful qualification program is built is a complete specification (Paragraph 6.1 of IEEE 323). As an OEM we see many examples of incomplete qualification specifications that must be clarified before the program can proceed.

2.3 Safety or Non-Safety Related Function

It is also necessary to determine if the equipment's function is safety related or non-safety related. Non-safety related items can often be excluded from the qualification process if it can be shown that a failure of that component would have no adverse effect on the safety function of the over all equipment (Paragraph 6.1.4 of IEEE 323). The qualification guidance in IEEE 323 is primarily directed towards equipment performing a safety function.

2.4 Qualification Plan

A qualification plan must also be developed in accordance with IEEE 323. The plan must include a determination of the qualification method, a listing of the environmental service conditions, a description of any required aging program, a prescription of the test sequence, and a definition of the accident test profiles.

An aging program would consist of such things as thermal aging, mechanical/cyclic aging, radiation exposure and mechanical vibration. All of these stressors are designed to simulate the conditions that would be encountered during the expected life of the test specimen prior to accident condition testing (seismic, HELB, LOCA, etc.).

Section 7 of IEEE 323 provides generic time/temperature/ pressure profiles for simulated accident conditions. However, all values are to be provided by the developer of the test program.

Figure A-2 (see Appendix A) summarizes the requirements of EEE 323 in the preparation of a qualification plan.

2.5 Documentation

The final requirement of a typical qualification program is the generation and compiling of program results (per Section 8 of IEEE 323). The documentation must be in a form that would permit confirmation of the results by an independent third party who is knowledgeable in the field of equipment qualification.

3. Ellis & Watts Motor Qualification Program

The qualification of an Ellis & Watts designed and fabricated 1E motor design will be presented as an example of the implementation of the program guidelines described above. IEEE 334-1974 was used as specific guidance for motor qualification in addition to IEEE 323.

This program was conducted in order to establish 1E (safety related) qualification for the Ellis and Watts motor design. The qualification process described herein is in accordance with IEEE Standards 323-1983, 334-1974 and IEEE Recommended Practice 344-1987. Testing performed for this program is for motors serving outside of containment areas.

The motor qualification program was conducted in two phases. The first phase consisted of the thermal aging of motorettes in order to establish a qualified life for the insulation system (as described in IEEE 117). Phase two consisted of prototype motor testing (type tests) (per Section 6 of IEEE 334-1974).

The purpose of the type test program was to demonstrate that the Ellis and Watts motor is capable of surviving a representative design basis event (DBE) after a simulated 40 year life and remaining functional for a specific time period after the DBE. The design basis events considered for this program were seismic and high energy line break (HELB) outside containment. A complete qualification test plan was prepared for the program.

3.1 Applicable Documents

A review of the available guidance for motor qualification revealed that the following documents would be useful and necessary in defining and conducting the motor qualification program:

IEEE 101-1987 Guide For The Statistical Analysis Of Thermal Life Test Data.

IEEE 117-1974 Standard Test Procedure For Evaluation Of Systems Insulating Materials For Random - Wound AC Electric Machinery.

IEEE 323-1983 Standard For Qualifying Class 1E Equipment For Nuclear Power Generating Stations.

IEEE 334-1974	Standard For Type Tests Of Continuous Duty Class 1E Motors For Nuclear Power Generating Stations.
IEEE 344-1987	Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.
UL 1446	Standard For Safety, Systems Of Insulating Materials.
ANSI / ASME NQA1-1989	Quality Assurance Program Requirements For Nuclear Facilities.

3.2 Qualification Test Summary

3.2.1 PHASE 1 Phase 1 of the qualification program established a qualified life for the Ellis and Watts insulation system of 44 years at a 130°C design temperature. Motorette insulation system samples were used and the motorettes were subjected to the battery of simulated aging tests described in IEEE 117. These tests consisted of heat aging, vibration, and moisture (in that sequence). IEEE 117 provides complete detailed instructions for fabrication of motorette insulation system samples.

In addition to IEEE 117 tests, the Ellis and Watts program added the cold shock test described in UL Standard 1446 to the environmental stress sequence. The cold shock was performed just before placing the motorettes into the humidity chamber. In general UL 1446 parallels the requirements of IEEE 117; however, IEEE 117 does not include the cold shock step.

Ten motorettes were taken through repeated cycles of heat, vibration, cold shock and humidity at each test temperature until the motorettes failed. Failure was determined by the voltage test (per Section 2.3 of IEEE 117).

After the motorettes failed, the number of cycles and the total number of hours of heat aging were recorded as test results. This data is provided as an average for each group of motorettes at each temperature. With this information a regression line for the insulation system was obtained using the analytical methods described in IEEE 101-1987. The curve developed from this data allowed the projection of a qualified life at a given motor temperature.

The insulation system was tested against a previously qualified, UL recognized Class H (180°C) control group. The life of the Ellis and Watts system exceeded the minimum life requirements of the Class H control group. A 44 year motor life is established by extrapolating the insulation system regression line to a Class B (130°C) maximum operating temperature. Ellis and

Watts motors are designed for a Class B maximum temperature rise in a 50°C ambient.

3.2.2 PHASE 2 After the 40 year minimum qualified life of the insulation system was established, the next phase of the program was simulated aging and design basis event testing on a prototype motor. The prototype motor (serial number 13703) used in the qualification program was a 7.5 horsepower, 1750 RPM, totally enclosed air over (TEAO) design in a 215T frame.

Phase 2 results are summarized below. The testing was conducted in the sequence listed:

1. THERMAL AGING: The prototype motor was subjected to thermal aging per Section 9 of IEEE 334-1974 to an equivalent of 44 (40 + 10% margin) years at 130°C operating temperature (NEMA Class B temperature rise). Based on the average life characteristic of the insulation system (established in Phase 1) the required number of thermal aging hours needed was determined to be 1698 at a selected aging temperature of 240°C. The prototype motor was thermally aged to an equivalent of 44 years (40 + 10% margin) at an assumed winding temperature of 130°C. The accelerated aging temperature and exposure time for this simulation was determined by use of the Arrenihus curve developed during the insulation system motorette tests conducted in phase 1 of the qualification. IEEE 334-1974 calls this curve the "implied average life characteristic" for the insulation system.

   A line parallel to the insulation system life line was drawn by starting at a point representing the desired life time (y axis) and the maximum operating temperature of the motor (x axis). This second line represents the aging characteristic of the motor. The point on this new line corresponding to an acceptable accelerated time will establish the accelerated aging temperature. This method of establishing the accelerated aging time and temperature is described in Section 9 of IEEE 334-1974.

   Testing showed motor operating temperatures to be below a Class B rise. Therefore, 130°C was used as the expected maximum operating temperature. At this temperature and 44 year life, 1698 hours at 240°C was selected as the accelerated thermal aging condition.

   For this portion of the test only the prototype motor housing and stator were placed in the oven since these were the only parts of the motor subject to the effects of thermal aging. Periodic monitoring of the oven temperature was documented over the 1698 hour time period.

2. MECHANICAL AGING: Mechanical aging was by means of the one hour mechanical vibration test described in paragraph 9.5 of IEEE 334 and paragraph 2.2.3 of IEEE 117. This test consisted of mechanical vibration of the stator for one hour at 1.5 times the acceleration of gravity at a frequency of 60 Hz. with 8 mils double amplitude displacement. This was the same vibration exposure seen by the motorettes during each cycle of phase 1 testing.

   After these first two steps in the test program, the prototype motor was reassembled and the complete motor, including the lubricant, bearing and seal system was subjected to all subsequent testing.

3. ROUTINE PERFORMANCE TEST: A routine performance test was conducted per IEEE 112 Form A1. This test provided baseline functional test data and was conducted with the motor unloaded both prior to and after thermal aging. There was no significant difference in the two sets of data which indicated that the motor was functioning properly after thermal and vibration aging.

4. RADIATION EXPOSURE: The thermally aged motor was exposed to a gamma radiation source to obtain a total accumulated dose of 3×10^7 rads minimum (equivalent air dose). The dose rate was between 250K and 1 megarad per hour. The tolerance of dosimetry instrumentation was taken into account to assure that a minimum dose of 3×10^7 rads gamma was achieved.

   The test lab that performed the radiation exposure provided a certification that the specified minimum dose was received and that the radiation source was Cobalt 60. The motor was rotated during this test to permit more equal radiation exposure to the various motor parts.

5. CYCLIC OPERATION: Additional mechanical aging was simulated by cyclic operation with the motor under load. The prototype motor was started and stopped under full load 520 times which would be equivalent to starting the motor approximately once a month over a 40 year life. In addition to these starts, it was estimated that the prototype motor was stopped and started another 20 to 30 times in the course of the other testing.

Each of the 520 cycles consisted of the following steps:

1) Start and operate motor for 1 minute.

2) Stop motor and keep off for 3 seconds after shaft rotation stops.

3) Stop motor for 10 minutes every seventh repetition of steps 1 and 2.

6. SEISMIC TESTS: The prototype motor was seismic tested in accordance with a generic response spectra created by Ellis & Watts to envelope the peak seismic conditions encountered in typical specifications. The motor under test was operating at full load current during the seismic event simulation.

Seismic tests consisted of 5 operating basis earthquakes (OBE's) and 1 safe shutdown earthquake (SSE) as described in Paragraph 6.1.4 of IEEE 344-1975. A detailed seismic test procedure was prepared by the independent test lab that performed the test. The test procedure contained the following general approach and was submitted to Ellis and Watts for approval.

A resonant frequency search was conducted in each principal axis. Ellis and Watts provided an identical duplicate test specimen for this portion of the seismic testing. The thermally aged motor was not subjected to a resonant frequency search. The input amplitude for the resonance search was the lowest possible that would enable determination of resonant frequencies.

The full level seismic test was performed on a tri-axial random motion vibration table. The test consisted of simultaneous horizontal and vertical inputs of a random motion over a frequency range of 1 to 33 Hz. The amplitude of these input motions were adjusted until the actual test response spectra (TRS) exceeded the Ellis and Watts generic response spectra. A damping value of 2% was used for OBE simulations and 3% was used in SSE simulations.

Acceptance criteria for the full level OBE and SSE simulations is as follows:

1) No observed structural failure is permitted. A thorough visual inspection is conducted after each simulation to locate any structural failures or loose hardware.

2) The motor must continue to operate properly at full load current during all simulations.

Any failure to meet these acceptance criterion will be reported to Ellis and Watts for resolution.

7. ACCIDENT SIMULATION: The high energy line break simulation (HELB) was performed at Wyle Laboratories. The motor operated under load for a period of six hours in the HELB chamber at temperatures which exceeded the required time/ temperature profile. The HELB simulation results were documented in Wyle Test Report Number 43030-1, Revision A .

The high energy line break (HELB) simulation was conducted with the motor operating under load. The test consisted of subjecting the motor to saturated steam to achieve the elevated temperature and high humidity conditions. The simulation ramped up to 212°F in the minimum time possible and held 212°F for 50 seconds minimum. Then the temperature gradually dropped following the generic time / temperature curve compiled by Ellis & Watts for this test. The overall duration of the HELB simulation was one hour minimum.

Ambient pressure was intended to be the prevailing ambient atmospheric pressure at the test laboratory. However, some pressure increase was experienced during the ramp up period. The ambient pressure surrounding the motor was recorded during the test and reported in the test report.

8. POST ACCIDENT ENDURANCE TEST: A post accident endurance test was conducted to simulate operation of the motor for 100 days, under load in an elevated temperature environment.

The post accident endurance test was also intended to address the additional guidelines on aging contained in IEEE 323-1983. The post accident endurance test was performed by Ellis and Watts. This test continued from the point where the HELB test stopped by simulating continuous operation of the motor at maximum design conditions (130°C winding temperature) for 100 days.

In order to reduce the time required to conduct this test a regression analysis was performed using data obtained from the insulation system life test. The regression analysis showed that the 100 days (2400 hours) can be reduced to approximately 500 hours if the winding temperature is increased to 160°C.

A test enclosure was assembled in the Ellis and Watts test lab large enough to house the motor. The motor operated under load within the test enclosure and the ambient temperature was varied as required to maintain a 160°C winding temperature for approximately 500 hours.

A shorter test time could have been used with a corresponding increase in winding temperature in accordance with the regression line slope established in the insulation system life testing. The actual time and temperature used in the test were documented and supporting analysis was provided in the final test report written by Ellis & Watts.

9. FINAL ROUTINE PERFORMANCE TEST: After completion of the post accident endurance test, a second routine performance test was performed on the motor. This routine performance test was conducted in the same manner as all previous routine performance tests for the program so that a comparison of results would be meaningful. The comparison showed that the differences between initial and final routine performance test results is negligible. A discussion of this comparison is provided in the qualification test report prepared by Ellis & Watts.

10. VISUAL INSPECTION: After testing was completed, the motor end bells were removed to permit a visual inspection of the interior of the motor housing. The object of this inspection was to locate obvious signs of damage caused by the stresses of the test program.

    A written description of the visual inspection is included in the test report prepared by Ellis & Watts.

4. Other Considerations

The motor qualification test program also addressed synergistic effects, lubricants, bearings and seal systems as required by IEEE 334.

5. Quality Assurance Provisions

The testing program covered the qualification of a safety related 1E electrical component. For such a program the requirements of 10CFR50 Appendix B and ANSI N45.2 applied. The Ellis and Watts QA program was in compliance with these documents and also met the basic requirements of ASME NQA-1. Ellis and Watts QA manual QC4000N documented the implementation of these requirements at our facility. The reporting requirements of 10CFR PART 21 also applied to the program.

All steps of the above described testing were documented in the Ellis & Watts motor qualification report (ENG 601).

6. COMMERCIAL DEDICATION

The term dedication refers to actions taken to use a commercial grade item in a safety related application within the nuclear power industry.

Commercial dedication is only applicable to parts which are classified as safety related. That is, their failure would prevent the equipment form performing its safety related function.

According to ANSI/ASME NQA-1-1986, a "commercial grade item" must meet all three of the following criterion:

1) It must not be subject to design or specification requirements that are unique to nuclear facilities.

2) It must be used in applications other than nuclear facilities.

3) It must be available from the supplier on the basis of specifications set forth in the manufacturer's literature such as a catalog.

A commercial grade item is said to be dedicated at the point when it is accepted for a safety related application. Deficiency reporting (10 CFR 21) then becomes the responsibility of the party performing the acceptance.

Dedication includes determining if the item performs a safety function and meets the definition of commercial grade. Another requirement is the identification of characteristics which are critical in performance of a safety function and therefore must be verified. Dedication also includes the selection and application of an acceptance method.

The Electric Power Institute (EPRI) Document NP 5652 describes four acceptance methods:

1) Special tests and inspections

2) Commercial grade survey of the supplier

3) Source verification

4) Acceptable supplier / item performance record

Figure A-4 (see Appendix A) is an excerpt from EPRI NP5652 which graphically describes the entire commercial dedication process.

Commercial dedication was first described in 10 CFR 21 in recognition of the fact that not all items used in a nuclear power facility could be obtained from a manufacturer or supplier to nuclear industry design and QA standards.

The evolution of commercial dedication in the nuclear power industry was motivated by the need to justify procurement of commercial parts because items qualified to nuclear industry standards were not available. Dedication was not developed to allow the use of commercial items in lieu of items that were available pre-qualified to nuclear power industry standards.

The use of commercial grade items in lieu of available items qualified to nuclear industry standards does not appear to be prohibited, but there have been difficulties for utilities when this type of procurement is practiced. This is especially true when third party qualifiers are used.

7. Evaluation of Qualification Programs - "Utility Pitfalls"

Procurement of nuclear qualified components can become a very costly and disappointing experience for a utility. Even though the specifying engineer includes all the correct IEEE standards, various interpretations may be taken by equipment and "third party" qualifiers. The NRC's position on qualification is that it is the owner's responsibility to insure compliance. As a result "short cut" qualification methods have been used that may not meet all the requirements of the standards. The "short cut" qualification methods seem to be driven by economic and/or schedule restraints. In many cases, alternative qualification methods do not include all the steps required in the current standards. Utilities must scrutinize these methods to assure compliance.

In relation to motor qualification, three alternative qualification methods that have been observed in the industry are commercial dedication, motor repair-other insulation systems, and expedited test methods. Each are briefly discussed below.

7.1 Commercial Dedication of Class 1E Motors

Commercial dedication of equipment is an acceptable method of equipment qualification. An electric motor, however, is a very questionable candidate for this type of qualification.

The Electric Power Institute (EPRI) Document NP 5652 provides the industry definition for commercial grade dedication and includes the requirement that a commercial grade item not be subject to design or specification requirements that are unique to nuclear facilities. Since there are nuclear industry standards unique for electric motors, commercial dedication is not applicable to Class 1E motors. IEEE 334-1974 is written specifically to address Class 1E motors used in nuclear power plants. IEEE 323 and 344 provide the environmental and seismic requirements respectively. However, utilities have been offered commercially dedicated Class 1E motors on the open market. Without performing all the qualification tests in the sequence described in Section 3.0 of this paper, a commercial dedicator cannot satisfy the requirements to assure all critical attributes are in compliance. As noted previously, the NRC holds the utility responsible for compliance.

7.2 Motor Repair - "Other" Insulation Systems

The qualified design life of a Class 1E motor is normally 40 years. However, utilities have experienced motor failures during normal usage and require motor repair. Ellis & Watts has encountered motor service shops providing this service to the utilities. The motor service shops are not the original supplier of the motors. When the motors are returned to the utility after repair/rewinding, the insulation system has usually been changed from that provided by the motor qualifier. The new insulation system has not endured the stringent qualification of the original insulation and in most cases is not the same material as that originally qualified. Motor manufacturers hold the insulation system used as proprietary because the insulation system is the key to qualification. Little justification is provided to demonstrate qualification of the substitute insulation system, yet the motor is returned to the utility as a "qualified" replacement. It is up to the utility to review and scrutinize to assure compliance.

In addition, one motor service shop claimed that seismic qualification was unnecessary because motors are inherently rugged.

7.3 Expedited Test Methods

Another phenomenon relating to motor qualification is third party qualifiers providing "expedited qualification". In one example, a single motor stator was aged in lieu of motorettes. Use of the motor stator is not, in itself, a problem. However, if motors are used for insulation system qualification instead of motorettes, a quantity of five (5) is required by IEEE 117.

No determination of the insulation system temperature class was performed. The third party qualifier assumed that the commercial motor manufacturer's advertised insulation class was correct. In addition, the statistical analysis of estimated qualified life for the insulation system was not performed. The single sample stator was merely aged and then subjected to accident condition testing. This motor was then offered as a Class 1E qualified motor for harsh environments.

8. CONCLUSION

The true purpose of equipment qualification is to verify design adequacy for assurance of public health and safety. Current IEEE Standards provide the guidance to accomplish this task in a manner that satisfies regulatory documents.

When purchasing equipment for safety related applications, utilities must be aware of potential problems associated with incomplete or abbreviated test methods. Expedient methods of qualification to improve delivery do not always satisfy all requirements of the applicable standards.

The NRC's position is very clear "the licensee has the ultimate responsibility to confirm that a given equipment or component is qualified for a safety related application".

Appendix A. Figures

FIGURE A-1

DETERMINATION OF MILD OR HARSH ENVIRONMENT

If your answers to <u>all</u> of the questions below are "Yes," then the equipment should be treated as mild environment equipment, otherwise, it is covered under the harsh environment qualification program.

1. The environment in the room where the equipment is located is unaffected during and after a DBA, i.e. no significant changes in temperature, radiation, etc.

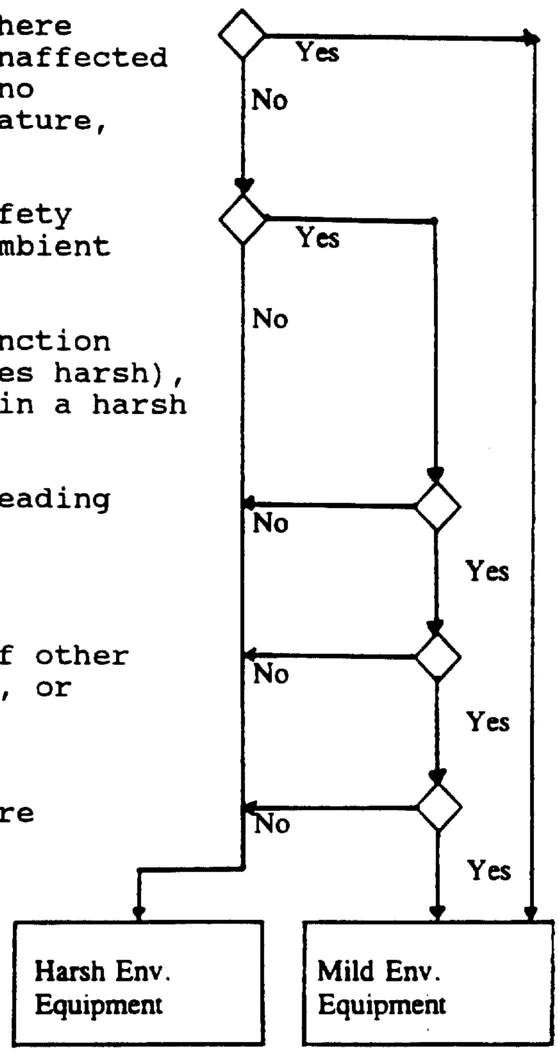
2. The equipment performs its safety related function <u>before</u> the ambient environment becomes harsh?

3. After it has performed its function (before the environment becomes harsh), the failure of the equipment in a harsh environment will **<u>NOT</u>**:

   a) result in providing misleading information, or

   b) affect the functioning of other safety related equipment, or

   c) cause a breach of pressure boundary integrity.



Source credit: EPRI/MOS environmental qualification training course. Used with permission.

FIGURE A-2

METHODS FOR QUALIFYING EQUIPMENT

1. TYPE TESTING

- ACCOUNTS FOR SIGNIFICANT AGING MECHANISMS
- SUBJECTS THE EQUIPMENT TO SPECIFIED SERVICE CONDITIONS
- DEMONSTRATES SUBSEQUENT ABILITY TO PERFORM SAFETY FUNCTION

2. OPERATING EXPERIENCE

- MUST BE COMPARED TO EQUIPMENT HAVING THE SAME GENERIC DESIGN
- VALIDITY DEPENDS ON DOCUMENTATION OF PAST SERVICE CONDITIONS, EQUIPMENT PERFORMANCE, MAINTENANCE AND SIMILARITY

3. ANALYSIS

- REQUIRES LOGICAL ASSESSMENT OR MATHEMATICAL MODEL OF THE EQUIPMENT
- REQUIRES SUPPORT OF TEST DATA, OPERATING EXPERIENCE OR PHYSICAL LAWS OF NATURE
- MUST BE DOCUMENTED IN A WAY THAT PERMITS VERIFICATION BY A COMPETENT THIRD PARTY.

4. COMBINED METHODS

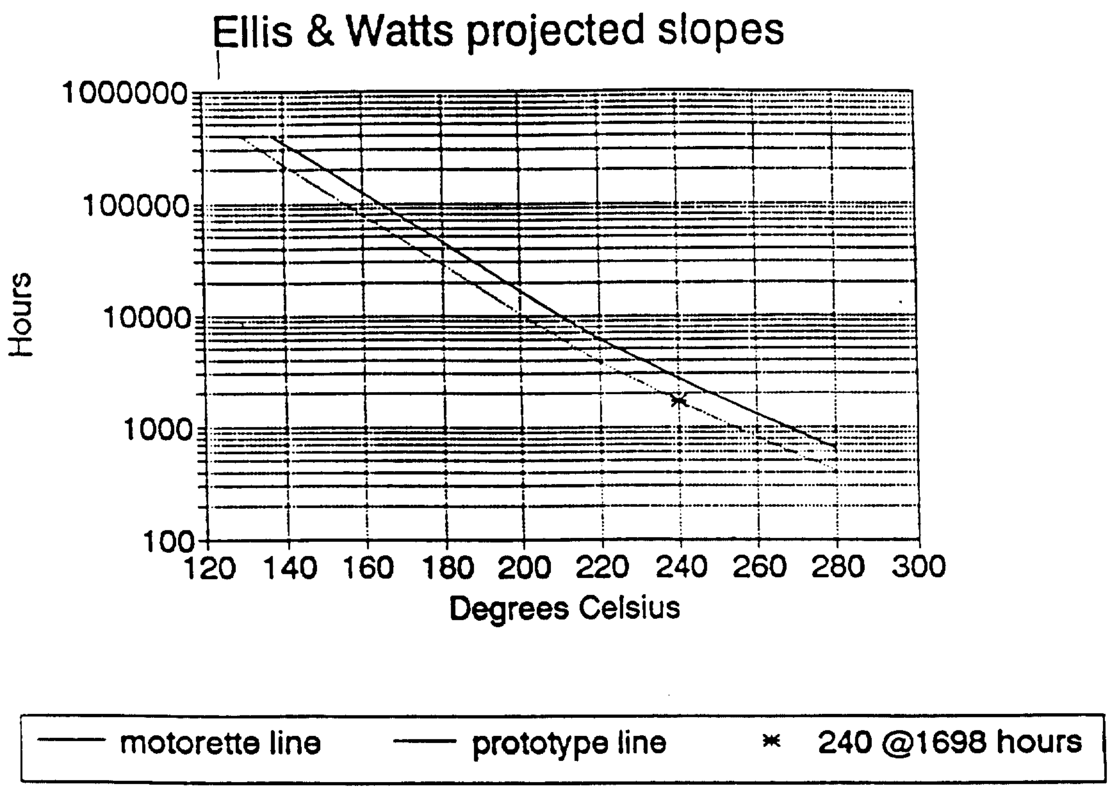
- REPRESENTS A COMBINATION OF ANY OF THE ABOVE QUALIFICATION METHODS

FIGURE A-3

AVERAGE LIFE REGRESSION LINE FOR

ELLIS & WATTS

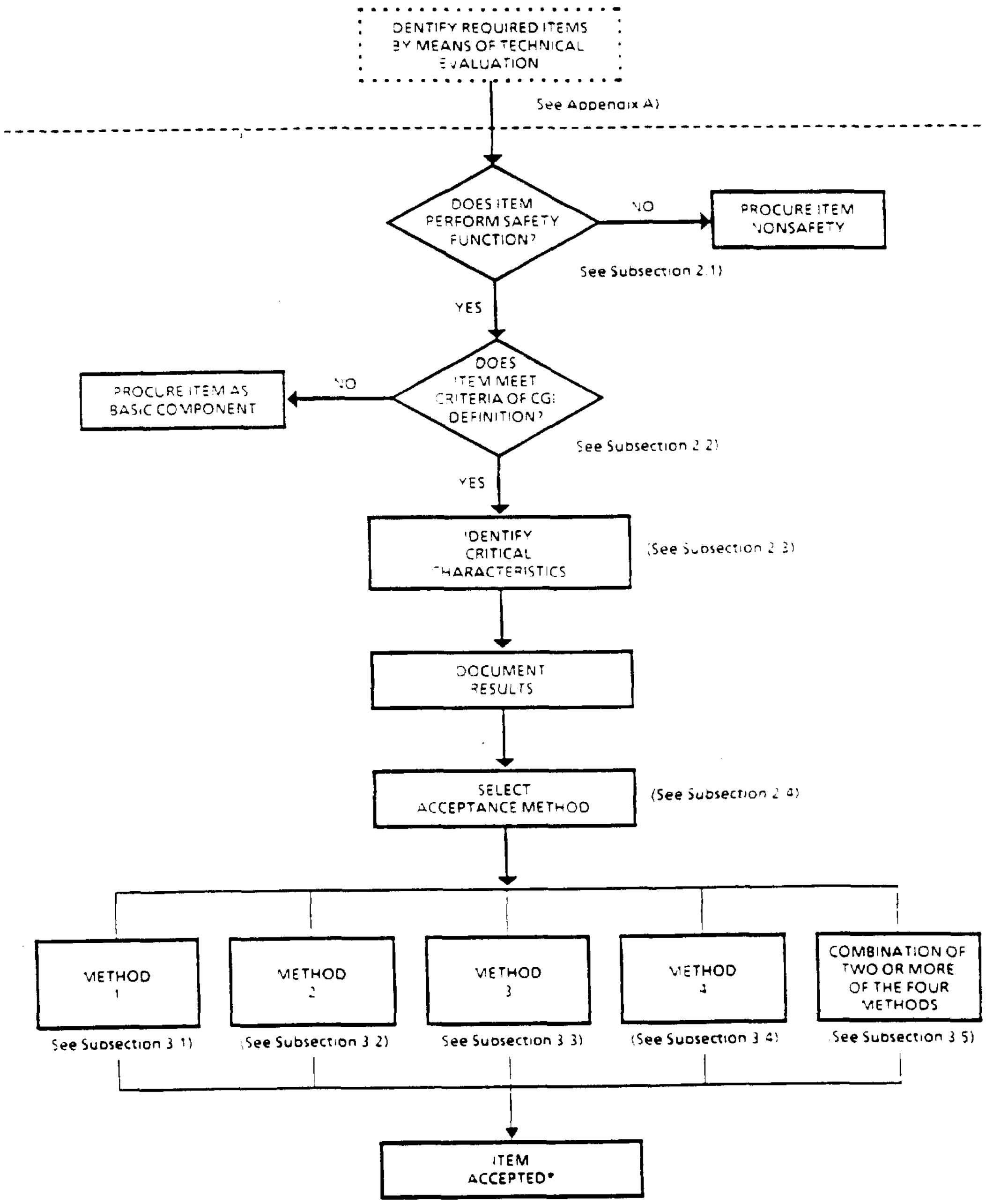
MOTOR INSULATION SYSTEM



This data as of Aug. 31, 1993.

FIGURE A-4

COMMERCIAL DEDICATION SEQUENCE



*Deficiency reporting responsibility accepted.

Source Credit: EPRI NP-5652 Project Q101-7, Final Report, June 1988 *Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Application (NCIG-07)*

DISCUSSION

ADAMS: A concern I have about motor qualification refers to an item on my desk right now. Often, when motors are qualified, they do voltage degradation testing while motors are coupled to a fan or something else. Does your qualification program account for voltage degradation with changes in efficiency and power factor at those degraded voltages? A lot of testing is based on 460 V but you take it up to 560 V and sometimes down to 460 V. A concern I have is that the power factor and the efficiency of a motor does change as voltage goes down, and current response changes drastically. You can actually lose a motor not within specification or covered by a qualification program.

DEATON: I can tell you that our qualification program was based on standard IEEE 334, 1974 edition. In the past, it did not go into much detail on your concerns. However, just in the past month there has been a 1994 revision to IEEE 334, and your concerns about voltage variation and degraded voltage testing are addressed there. Currently, we have another motor test in progress. We will be incorporating test sequences as a part of the program.

BELLAMY: I am from the Nuclear Regulatory Commission, so you have to understand that I am coming at this question from the regulatory side of the house. One of your first slides presented two fundamental reasons to qualify equipment. One was to provide an adequate level of safety, and the second one was to meet regulatory requirements. As a supplier (I think the term you use is, original equipment manufacturer), do you really see a difference between those two goals? Is there a difference between providing an adequate level of safety versus satisfying the regulatory requirements? As a regulator, I hope they are close together. But from a manufacturer's viewpoint, do you see them as significantly different?

DEATON: Not really. I would agree with you that the adequate level of safety is in conjunction with maintaining your license; to satisfy one satisfies the other, also.

EVALUATION OF SELF-CONTAINED HEPA FILTER

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Abstract

This paper presents the results of an evaluation of a self-contained high-efficiency particulate air filter (SCHEPA) used in nuclear applications.

A SCHEPA consists of filter medium encapsulated in a casing that is part of the system boundary. The SCHEPA filter serves as a combination of filter housing and filter. The filter medium is attached directly to the casing using adhesive as a bonding agent. A cylindrical connection in the middle of the end caps connects the filter assembly to adjoining ductwork.

The SCHEPA must perform the functions of a filter housing, filter frame, and filter. It was recognized that the codes and standards do not address the SCHEPA specifically. Therefore, the investigation evaluated the SCHEPA against current codes and standards related to the functional requirements of an air-cleaning system. The specific standards used are required by DOE Order 6430.1A(1) and include ASME N509(3), ASME N510(4), ERDA 76-21(5), MIL-F-51068F(6), NFPA 90A,(7) and NFPA 91(8).

The evaluation does not address whether the SCHEPA as a standard (off-the-shelf) filter could be upgraded to meet the current code requirements for an air-cleaning unit. The evaluation also did not consider how the SCHEPA was used in a system (e.g., whether it was under positive or negative pressure or whether it served as an air inlet filter to prevent contamination releases under system pressurization).

The results of the evaluation show that, the SCHEPA filter does not meet design, fabrication, testing, and documentation requirements of ASME N509(3) and ASME N510(4). The paper will identify these deficiencies.

Specific exhaust system requirements and application should be considered when an evaluation of the SCHEPA filter is being performed in existing systems. When new designs are being contemplated, other types of HEPA filter housings can be used in lieu of the SCHEPA filter.

I. Introduction

Scope of Evaluation

The evaluation examined the self-contained high-efficiency particulate air (SCHEPA) filter for code compliance with DOE Order 6430.IA(1) relative to nuclear-grade HEPA filters. The specific standards in DOE Order 6430.1A(1) used to evaluate the SCHEPA included ASME N509(3), ASME N510(4), ERDA 76-21(5), MIL-F-51068F(6), NFPA 90A(7), and NFPA 91(8).

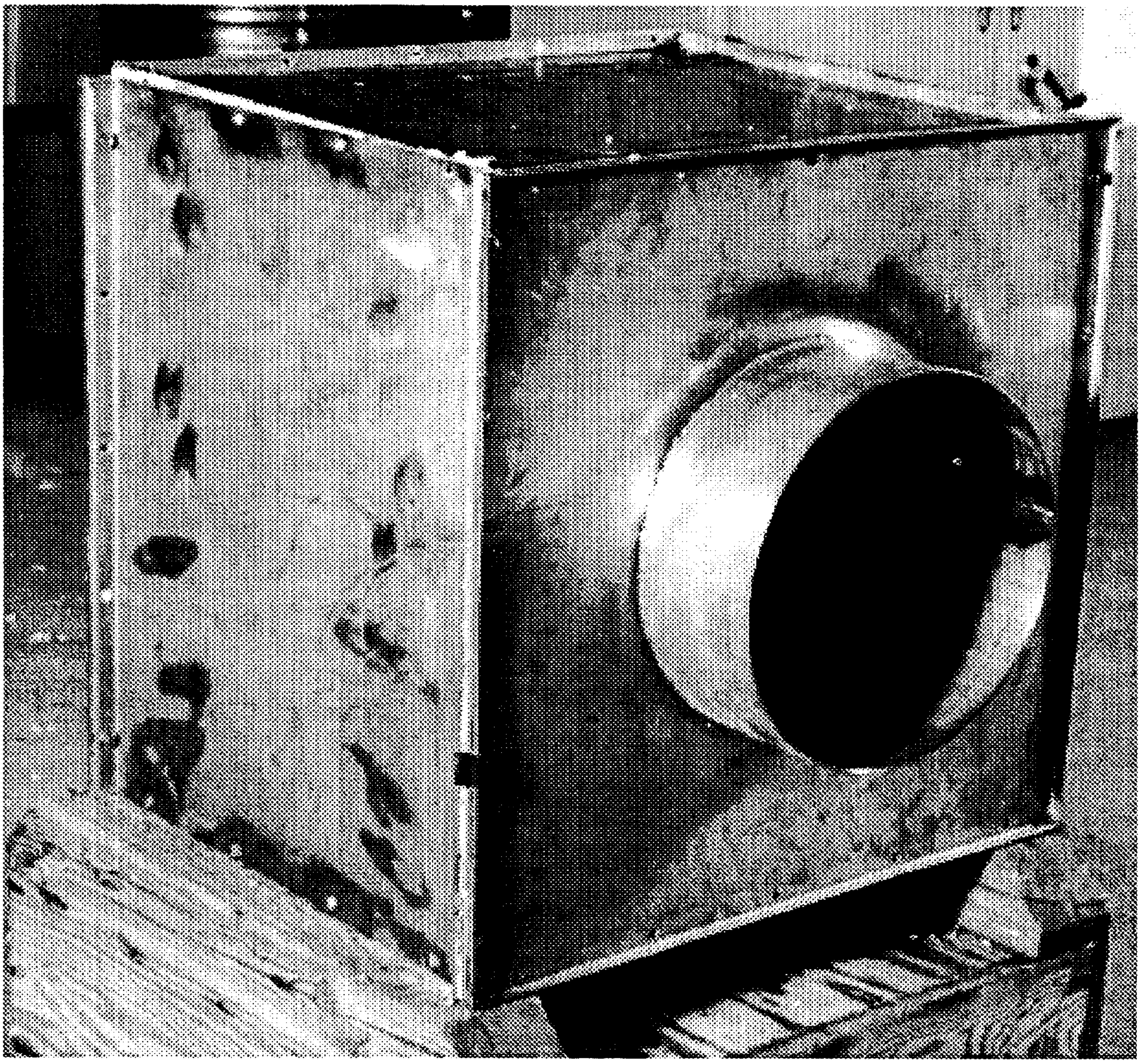

Figure 1. Self-Contained High-Efficiency Particulate Air Filter.

The evaluation took a general approach (i.e, that the SCHEPA filter in a nuclear safety system shall meet all applicable code requirements pertaining to nuclear air-cleaning components). The evaluation did not consider whether the SCHEPA, as a standard (off-the-shelf) filter, could be upgraded to meet the current code requirements for an air-cleaning unit nor did the evaluation consider how the SCHEPA was used in a system (e.g., whether under positive or negative pressure).

II. Description of SCHEPA Filter

The SCHEPA filter is a high-efficiency particulate air (HEPA) filter consisting of filter medium enclosed in a casing that is part of the system boundary. The casing consists of two end caps and four pieces of siding, which form a square frame around the filter media.

The filter media is centered in the casing and is attached directly to the casing with an adhesive used as a bonding agent. End caps cover the medium at the front and back of the frame. A cylindrical connection in the middle of the cap connects the filter assembly to adjacent ductwork. The distance between the filter medium and the caps varies with the type of filter media.

Because SCHEPA filters could be used in safety-related ventilation systems, a better understanding of these filters and their qualification requirements is needed to ensure safe operation of nuclear ventilation systems.

III. Definitions

The SCHEPA filters are not specifically addressed in the ASME Code and DOE Orders. To determine the applicable requirements of the code, the evaluation reviewed definitions of various components provided in the codes and assessed the SCHEPA on the bases of its configuration, design parameters, fabrication, application, and performance requirements.

The following definitions are quoted from ASME N509[3], Section 3.

- **Duct**--An enclosed passage through which air is transferred from point to point; typically will not include air-cleaning components such as HEPA filters or absorber air-cleaning units.

- **Housing**--The portion of an air-cleaning unit that encloses air-cleaning components and provides connections to adjacent ductwork.

- **Components, air-cleaning**--Equipment that is contained in nuclear air treatment systems. Typically components may include dampers, demisters, or moisture separators, heaters, prefilters, HEPA filters, charcoal absorbers, and fans.

- **Air-Cleaning unit**--An assembly of components comprising a self-contained subdivision of a complete air-cleaning system. It includes all the components necessary to achieve a unit air-cleaning function such as removing particulate matter (filter) or iodine vapor. A unit includes a housing plus internal air-cleaning components and may include one or more auxiliary air-treatment components such as prefilters, post-filters, heaters, coils, and moisture separators.

IV. Basis for Code Compliance

The evaluation applied DOE Order 6430.1A[1] as the basis for code compliance. DOE Order 6430.1A[1] states in part that "These criteria apply to any building acquisition, new facility, facility addition and alteration, and leased facility that is required to comply with DOE 4300.1B[2]. This includes on-site constructed buildings, pre-engineered buildings, plant-fabricated modular buildings, and temporary facilities." DOE 6430.1A[1], Section 1550-2.5.5, titled "Air-Cleaning Devices," requires that all HEPA filtration systems comply with ASME N509[3] and be tested in accordance with ASME N510[4].

In addition to the foregoing requirements, RLIP 5480.4C[9], a Hanford Site requirement, titled *Environmental Protection, Safety, and Health Protection Standard*, Section 10, "Nuclear Safety Standards," paragraph b, "Nuclear Facility Safety," also invokes ASME N509[3] and ASME N510[4] as mandatory standards.

A review of ASME N509[3], ASME N510[4], and MIL-F-51068[6], showed that they do not address the SCHEPA nor were they written with the SCHEPA in mind.

On the basis of the definitions given in Section 3.0 of ASME N509[3], the SCHEPA filter was classified for the evaluation as an air-cleaning unit and, therefore, had to meet the applicable requirements identified for a filter housing.

V. Summary of Evaluation

A SCHEPA filter classified as an air-cleaning unit consists of two components, a casing, and a HEPA filter. Unlike the other type of HEPA filters, designed to be attached to the mounting frame within a housing in an exhaust system, the casing of a SCHEPA filter serves as a combination of filter, filter frame, and a filter housing that is a pressure boundary that must satisfy code requirements for a filter housing given in ASME N509[3] and N510[4]. The filter medium and frame must meet the HEPA filter specification given in MIL-F-51086[6].

The evaluation revealed that the SCHEPA filters do not have the documentation required for compliance with design, testing, and fabrication standards in ASME N509[3], ASME N510[4], and MIL-F-51068[6]. Without this documentation, filter adequacy cannot be verified against requirements of DOE Order 6430.1A[1]. The evaluation also revealed that the SCHEPA filter does not meet the airflow distribution requirements of ASME N509[3].

VI. Summary of Noncompliance

Findings of noncompliance with codes and standards are summarized in the following sections. These sections identify the specific paragraph(s) or section(s) with which the filter does not comply and explain why these criteria must be met.

Noncompliance Pertaining to ASME N509, *Nuclear Power Plant Air-Cleaning Units and Components*

Structural Load Requirements Section 4, paragraph 4.5, states, that "The engineered safety feature (ESF) systems and all of their components shall be shown, either by testing or by a mathematical technique, to remain functional under the structural loading specified in Section 4.2(k), 'Structural Loadings,' and described in ASME N509[3], Section 5, paragraph 5.10.3, 'Structural Requirements'." The SCHEPA filter does not have documentation demonstrating that it has met these criteria.

Leak-Test Pressure Section 4, paragraph 4.6.4, states that the leak-test pressures and components (i.e., ducts and housings) must be tested in the shop and field. Furthermore, it states that the test pressure must be documented by the engineer. The SCHEPA filter does not have this documentation.

Negative Pressure Section 4, paragraph 4.6.5.4.(b), states that "Air-cleaning units and components located on the inlet side of fan(s) which can be isolated by closure of an upstream damper, or potentially plugged components shall be designed to withstand a negative internal pressure equal to or more negative than the peak pressure of the fan(s)."

It is a requirement that filters be isolated with dampers for filter removal. If an upstream damper were suddenly closed or the entrance to the filter plugged during normal operation, with the fan peak pressure at a level that surpasses the structural integrity of the casing, the casing could fail and damage the filter medium. The casing of the SCHEPA filter must have test data available to show that it can withstand the structural requirements. The SCHEPA filter does not have this documentation.

HEPA Filters Section 5, paragraph 5.1, states that "HEPA filters shall meet the construction, material, test, and qualification requirements of military specification MIL-F-51068[6], except that listing of manufacturer's HEPA filter qualified products list (QPL) is not required." The SCHEPA is not identified in the MIL-F-51068[6].

Construction Section 5, paragraph 5.1.1, states that "Filters for use in containment or in ESF systems shall be metal case type (Type II frames as defined by MIL-F-51068[6]) and shall be compatible with chemical composition of the air stream. Filter systems exposed to temperatures greater than 200 °F shall have steel sides." A wooden SCHEPA filter in an ESF system does not comply with this requirement.

Documentation Section 5, paragraph 5.1.3, requires that a certificate of conformance be provided to the owner certifying that the filter assembly has been designed in accordance with MIL-F-51068[6]. The SCHEPA does not have the required documentation.

General Requirements Section 5, paragraph 5.6.1, states that the layout of the filter housing shall have uniform airflow within ± 20% of the average through each bank of components. Because a SCHEPA is not designed in accordance with ASME N509[3], it does not meet this requirement.

Housing Doors Section 5, paragraph 5.6.2, (a), requires that a filter housing be equipped with doors. Doors are necessary for inspecting and removing the filter. The SCHEPA filter has no doors. The SCHEPA filter is inspected and replaced by removing the entire SCHEPA filter assembly from the system.

Drains Section 5, paragraph 5.6.2, (c), requires that the housing be equipped with a drain to remove water that may accumulate in the housing. Water may collect in the filter housing if a steam heater develops a leak. Rain or snow may infiltrate the housing through a loosened flanged connection, a crack in the filter housing, an improperly sealed access door, etc.

If the heater fails and the gas stream has high humidity or is saturated, condensation will occur in the housing. Systems that do not normally have high humidity in the air stream and do not have a heater may also experience condensation on the interior of the housing. This phenomenon will occur when the system is in a standby mode and the dew point temperature of the housing surface drops below the dew point temperature of the air inside the duct. The SCHEPA filter does not have a drain.

Housing Connections and Flexible Connections Section 5, paragraph 5.6.2, (e), "Housing Connections" and (f), "Flexible Connections," require that the filter housing connections be flanged and that the flexible connections be qualified for stress and pressure.

The connection between the self-contained filter housings and ducts are made of a light-weight fabric secured to the ductwork by hose-type clamps. This type of connection may not ensure structural stability and must be tested to meet the structural load requirements of ASME N509, Section 4.5.

A standard filter housing is mounted to the duct system by rigid metal flanged connections. The SCHEPA filter is not equipped with flanged connections.

Component Mounting Frame Section 5, paragraph 5.6.3, requires that the HEPA filter be secured within the housing to a mounting frame to ensure rigidity of the filter. One of the major differences between a SCHEPA and a standard 24-in. by 24-in. by 11.5-in. HEPA filter is the mounting arrangement of the HEPA filter.

Standard HEPA filters are bolted directly to a mounting frame or compressed against the mounting frame by a clamping mechanism; the gasket is compressed with a clamping force of at least 20 lb/in^2 of gasket surface or a minimum of 1,400 lb on the HEPA filter frame. The frame must meet the structural requirements of ERDA 76-12, paragraph 4.3, to prevent flexure between the frame and the HEPA filter.

The mounting frame is seal welded to the filter housing to prevent contaminants from bypassing the filter between the housing and mounting frame. The SCHEPA filter medium is attached directly to the casing by an adhesive used as a bonding agent. The SCHEPA filter does not have a mounting frame and does not meet these requirements.

Shop Leak Testing Section 5, paragraph 5.6.5.4, states that "Housings or housing sections shall be leak tested in the shop prior to shipment, in accordance with ASME N510[4], Section 6. Leakage shall be no greater than acceptance criteria provided by the owner. Results of housing leak tests shall be transmitted to the owner for his records." The SCHEPA filter does not have documentation showing that this test has been performed.

Shop Airflow Distribution Test Section 5, paragraph 5.6.5.5, requires that the manufacturer perform an airflow distribution test in the shop in accordance with ASME N510[4], Section 8, before shipment. This test ensures that the manufacturer's design provides uniform air distribution. Again, the SCHEPA filter does not have documentation showing that this test has been performed.

Quality Assurance Required Documentation Section 8, paragraph 8.2 requires that as a minimum the following shall be documented and submitted to the owner:

- Maximum operating pressure
- Test pressure
- Structural capability pressure
- Factory housing leak-test report
- Factory airflow distribution report.

None of the above items have been documented for the SCHEPA filter.

Noncompliance Pertaining to ASME N510,
Testing of Nuclear Air-Treatment Systems

Housing and Ducts Section 5, paragraph 5.5.1.1, (v), states that the system may not contain "sealant or caulking of any type on/in housings or component frames. Caulking on/in ducts may be permissible depending on projects specifications." The SCHEPA filter uses sealant on the end caps that connect the nipples to the filter housing.

Duct and Housing Leak and Structural Capability Tests Section 6 requires that both duct and housing be pressure tested either by the constant-pressure test (positive pressure) of paragraph 6.5.2 or by the pressure-decay method (negative pressure) of paragraph 6.5.3. These tests help ensure that the housing or duct will not release contaminants past the pressure boundary as a result of pressurization.

Standard filter housings are subjected to these tests with the test data documented. The SCHEPA filter casing functions as a housing in an air-cleaning system, but does not have the required documentation of test results.

Airflow Distribution, Air-Aerosol Mixing Uniformity, and In-Place Testing Section 8, paragraph 8.5.2, "Airflow Distribution Test," Section 9, "Air-Aerosol Mixing Uniformity Test," and Section 10, "HEPA Bank In-Place Test," state that the airflow distribution test is a prerequisite for the air-aerosol mixing test and the in-place HEPA filter test.

These tests ensure that a uniform distribution of the test aerosol is received on the entire face area of the HEPA filter bank. Without a uniform distribution of the test aerosol, there can be no assurance that, if a penetration exists in the filter medium, the penetration would be detected during the in-place testing.

The SCHEPA filter, as described in Section 1.2, does not have a smooth transition from ductwork to the filter to allow airflow passing through the filter medium uniformly. For example, the 1,000 ft^3/min SCHEPA filter has a 12-in.-diameter duct inlet. The SCHEPA has no transition from the 12-in-diameter circular cross section to the 24-in. by 24-in. by 11.5-in. filter.

The change in the size of the cross section at the duct inlet of the SCHEPA is abrupt and results in the lack of the nonuniformity in the airflow distribution at the face of the filter medium. Hence, during the filter in-place test, the entire filter face cannot be properly challenged with aerosol.

Further, the layout of the SCHEPA filter does not meet the criteria for even airflow distribution of ASME N509(3), and uniformity in airflow distribution at the face of the filter medium cannot be ensured. The air distribution must be tested to verify the design.

The SCHEPA filter is tested in the factory with the end caps removed to allow an even air/aerosol mixture. The manufacturer does not test the filter with the end caps installed. Therefore, no test data exist to illustrate the aerosol challenge of the filter face after final assembly as the filter is actually installed in the system.

The filter is handled many times before installation and is subject to damage. If the filter is damaged before installation, the adhesive that holds the filter medium in place may be separated from the housing. If in-place aerosol testing does not detect the damaged area, a release of radioactive contaminants could occur. When the entire filter face cannot be properly challenged with aerosol, the result is a false sense of filter integrity.

<u>Noncompliance Pertaining to Military Specification MIL-F-51068</u>

Conformance to Military Specification MIL-F-51068(6), *Filters, Particulate (High-Efficiency Fire Resistance)* is required by ASME N509(3), which states that the HEPA filter must meet the construction and testing of MIL-F-51068(6). The SCHEPA filter does not comply with the following sections of MIL-F-51068(6).

<u>Flatness and Squareness</u> Section 3, paragraph 3.3.2, requires verification that the filter is flat and square when measured diagonally across the corners of both faces. There are no inspection records for the SCHEPA filter.

<u>Resistance to Rough Handling</u> Section 3, paragraph 3.4.3, requires that the filter pass the rough-handling test. This SCHEPA does not have documentation to show that it has passed such a test.

<u>Noncompliance Pertaining to the National Fire Protection Association</u>

This requirement applies only to wooden SCHEPA filters. The DOE Order 6430.1A(1), *General Design Criteria*, Section 1550-2.5.6, states that "Ductwork shall also be designed to comply with NFPA 90A[7]." Exhaust ductwork shall comply with NFPA 91[8].

Noncompliance Pertaining to NFPA 90A, *Installation of Air Conditioning and Ventilation Systems* Section 2.3.1.1 states that ducts shall be constructed from iron, steel, aluminum, copper, concrete, masonry, or clay tile. Some SCHEPA filters are constructed of wood.

Noncompliance Pertaining to NFPA 91, *Blower and Exhaust Systems for Stock and Vapor Removal or Conveying* Section 2.7 also states that the exhaust system shall be constructed entirely of sheet metal or other noncombustible material. The wooden SCHEPA filter cannot meet requirements of either of these sections.

In a fire, the wooden casing would cause the fire to escape to the surrounding area and spread. Therefore, the wooden SCHEPA filter should not be used where the possibility of fire exists.

Noncompliance Pertaining to ERDA 76-21, *Nuclear Air Cleaning Handbook*

The DOE Order 6430.1A(1), *General Design Criteria*, states that "In-place testing design requirements shall meet all the recommendations of UL 586[10], ASME N510[4], and ERDA 76-21[5]." The *Nuclear Air Cleaning Handbook*(5) recommends not using the SCHEPA where high levels of radioactivity are suspected.

Other Code-Related Issues

Visual Inspection ASME N510(4) requires visual inspection of the system, including HEPA filter and ductwork in conjunction with each test series. Direct visual inspection of the SCHEPA is not possible because of the obstruction of the caps and connectors. Because visual inspection must rely on special instruments/tools it becomes impractical; therefore, inspection may not occur.

Airflow Distribution Test for Single Filters As discussed in Section 7 above, the design requires that the layout of the housing shall allow uniform airflow within plus and minus 20% of the average through each bank of components.

Although the ASME N510(4) noted that airflow distribution tests are not required for a filter bank containing a single filter, it does not exempt the design requirement given in ASME N509(3).

Because the SCHEPA is not designed and constructed in accordance with ASME N509(3), the requirement for uniformity in airflow distribution at the filter cannot be assured.

VII. Conclusion

Commercially available SCHEPA filter(s) do not conform to the technical requirements nor have the documentation required to verify conformance to the mandatory codes and standards. The evaluation classified a SCHEPA filter as an "air-cleaning unit," in accordance with the definition given in ASME N509(3). The SCHEPA filters address only the filter medium and casing material aspects and do not stipulate applicable ASME N509(3) air-cleaning unit requirements, such as airflow distribution, structural capability, pressure boundary integrity, seismic capability, and the rough-handling capability test of MIL-F-51068(6).

VIII. Recommendations

The SCHEPA filter should not be used for nuclear applications. When new designs are contemplated, other types of HEPA filter housings can be used in lieu of the SCHEPA filter.

IX. References

1. DOE Order 6430.1A, *General Design Criteria*, U.S. Department of Energy, Washington, D.C.

2. DOE Order 4300.1B, Real Property Management, U.S. Department of Energy, Washington, D.C.

3. ASME N509-1989, *Nuclear Power Plant Air Cleaning Units and Components* American Society of Mechanical Engineers, New York, New York.

4. ASME N510-1989, *Testing of Nuclear Air-Treatment Systems*, American Society of Mechanical Engineers, New York, New York.

5. ERDA 76-21, *Nuclear Air-Cleaning Handbook*, Energy Research and Development Administration, Washington, D.C.

6. MIL-F-51068F, *Military Specifications Filters, Particulate (High-Efficiency Fire Resistance)*, Aberdeen Proving Grounds, Maryland.

7. NFPA 90A, *Air Conditioning and Ventilation Systems*, National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts.

8. NFPA 91, *Blower and Exhaust Systems*, National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts.

9. RLIP 5480.4C, *Environmental Protection Safety and Health Practices Standards*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

10. UL 586, *High-Efficiency Particulate, Air Filter Units*, Underwriters Laboratories, Northbrook, Illinois.

DISCUSSION

TODD: To my knowledge there's no such thing as an off-the-shelf, self-contained HEPA (SCHEPA) filter. I can't speak for my competitors, but in our case the filter would only be built to the customer's specifications. And that brings to mind a question with regard to the reference to MIL-F-51068 for this filter. There are a number of DOD and DOE sites that specifically refer to the self-contained HEPA filter as a part of their individual site specifications. They refer to 51068 as the mother specification and then give size details and a description of the frame; but self-contained filters are not a part of it. This has been a matter of discussion for years. The filter has the components of a 51068 filter, and it is tested like a 51068 filter, but when you add face plates and nipple adapters, the filter is off specification. You are right, the matter does need to be resolved.

ARNDT: Off-the-shelf refers to a specific HEPA filter, or a SCHEPA filter. It has also been called an encapsulated filter or nipple-connected filter. There was a task team that evaluated this, and there was a specific self-contained filter that was addressed. It is in a catalog, and lists the data we used. We went to the vendor, but they did not have any documentation showing that the total assembly met the requirements of the rough handling test for MIL-F-51068.

KOVACH, L.: You were basing your evaluation on the DOE order requiring compliance with ASME N-509 and N-510. Don't you think that common sense HVAC engineering criteria were violated, and that if you were designing an air cleaning system without adding to the DOE order or N-509 requirements, just common sense engineering practice, it would be different from the SCHEPA design? Have you prepared an engineering evaluation, also?

ARNDT: The task we had was to evaluate the filter per the DOE order, and take all the emotion out of it. In other words, we could not put into the report that these filters were used for many years and there is no record of failure. What we had to do was to look at them in light of the DOE order and the documentation we are required to prepare prior to our designs. These filters are used on various applications. Some are used in ESF types of systems and we had to have the required documentation for our QA and for our safety records.

KOVACH, L.: Isn't it possible that the way they are built and the way that you test them in-place, you would not even find out if they leak?

ARNDT: When preliminary tests were performed on the SCHEPA filter, the vacuum pump could not keep up with the leakage. In addition, a rough handling test revealed several loosened bolts which connect the end cap to the casing.

WRIGHT: Considering that the standard is in need of updating, would it be worthwhile to seek an exemption to those specific parts of the order which don't make sense for this application? I can foresee within the environmental remediation effort where having a self-contained filter that you can just plug into an air enclosure would make a whole lot more sense than a permanent installation.

ARNDT: In a report we put out, we recommended that every facility look at their applications and, when technically justified, request a waiver from DOE. Some of these filters are used in systems handling highly radioactive contaminants, so a safety analysis must be performed prior to requesting a waiver from DOE. That is definitely an option. There was an earlier question about the difference between the safety basis and the regulatory basis. Within the DOE community this is a case where they are not necessarily consistent.

LAWTON: First, you can specify a SCHEPA filter to meet most of your specifications but it didn't sound like the one you tested did. Second, DOE order 6431A allows for good engineering practice. Third, if a contamination control specialist uses a SCHEPA filter properly, it can save a lot of work and problems elsewhere. And there are work-arounds. Is the SCHEPA filter really an engineered safety feature, or is it just a prefilter before the effluent stream gets to the building plenum filters, the real engineering safety feature?

ARNDT: It depends entirely on the system function. Using it as a prefilter and not taking credit for it, is one application. But if you are taking credit for it, you have to perform aerosol testing, and a prerequisite is uniform air flow distribution. As I mentioned in the paper, a single filter is not required to meet air flow distribution requirements prior to in-place leak testing but you have to remember we address the enclosure as a filter housing according to N-509. N-509 does not exempt a single filter from uniform air flow. When there is technical justification, it is up to the project engineer, or whoever is responsible for project specifications, to request an exemption if they want to use a SCHEPA filter.

DICK: I question the appropriateness of comparing and basing the adequacy of the self-contained HEPA filter to a standard (ASME-N509) that was not established or considered for SCHEPA filter applications. Many filtration installations made prior to ASME-N509 cannot meet all the design requirements in ASME-N509 whether they are SCHEPA systems or not. However, installations are not inadequate simply because the existing filtration system does not have all the options that a N509 system is required to have.

ARNDT: As stated in the paper, it is recognized that the ASME's codes were not written with the SCHEPA filter in mind. However, if the SCHEPA filter is used in a nuclear application, then it is fair to use the requirements of nuclear filtration to analyze the SCHEPA filter. One of the main goals for nuclear filtration is protection to personnel, equipment, and the environment. Clearly, the SCHEPA filters do not have documentation to support their continued use. However, it is the responsibility of the individual user to make that decision.

BERGMAN: We are concerned that the box (SCHEPA) filters are being used for nuclear applications in several DOE facilities and yet do not meet all of the applicable requirements in ASME N509 and MIL-F-51068. We investigated the problem and discovered that documentation verifying the qualification tests either was not explicitly requested in purchase orders or was not enforced. In other cases, the supplied documentation was for the open-face HEPA filter made with the same materials as the box filter. Discussions with HEPA filter manufacturers confirmed that the box HEPA filters had never been qualified on the heated air, overpressure and rough handling tests. Further investigation also revealed that none of the filter qualification laboratories (Underwriters' Laboratories, the U. S. Army Product Assurance Directorate at Edgewood, MD, and the DOE Rocky Flats Filter Test Station) could even test the box HEPA filters. In addition to lacking the necessary adapters, the test equipment would require an expensive upgrade and relocation to provide additional space.

After the DOE/NRC Nuclear Air Cleaning Conference, we quickly initiated a test program at EG&G Rocky Flats Plant to conduct qualification tests on six box HEPA filters typical of those used at LLNL. Since the test facility at Rocky Flats did not have sufficient space to accommodate the box HEPA filters, we compromised on the design by sealing the test duct to the box frame rather than using inlet and exhaust adapters. The test results for the six, 1,000 cfm box HEPA filters from American Air Filter for the heated air, overpressure, and rough handling tests are given below. We have also tabulated the penetration values allowed by ASME N509 and MIL-F-51068.

Heated Air Test

Serial No.	Percent Penetration at 1,000 cfm Before	After
455566	0.009	0.022
41459567	0.012	0.042
Standard	0.030	3.000

Overpressure Test

Serial No.	Percent Penetration at 200 cfm Before	After
459549	0.012	0.012
41459608	0.012	0.016
459549*	0.010	0.011
Standard	0.030	0.030

* Flanges were cut off the HEPA filter to reach 10 inch pressure drop.

Rough Handling Test

Serial No.	Percent Penetration at 200 cfm Before	After
4159600	0.012	0.014
459560	0.018	0.020
Standard	0.030	0.030

In addition to the problem with adapting the box HEPA filters to the test equipment, we encountered two other problems. The blower on the overpressure test apparatus was not able to generate the required 10 inches of pressure across the filter medium pack because of the added resistance from the reduced entry and exit ports. The filters 459549 and 41459608 had pressure drops of 7.1 and 8.0 inches respectively. We cut off the entry and exit ports on the 459549 filter and repeated the test at the prescribed 10 inch pressure drop. The second problem was the periodic shut down of the rough handling machine due to the high weight of the box filters. The equipment will need extensive modifications for routine tests on the box HEPA filters.

Based on the tabulated test results, the box HEPA filters from American Air Filter passed the required qualification tests. The filters had a plywood frame, deep-pleated medium, aluminum separators, and neoprene sealant. Although box filters from other manufacturers and box filters from American Air Filter made using different materials cannot be automatically qualified based on these tests, they also are expected to pass the tests. This follows because the only difference between a box filter and a standard open face filter is the restricted inlet and exit ports. Since the box HEPA filters from American Air Filter passed the qualification tests, any box HEPA filter made from the same materials and the same manufacturer as an open faced HEPA filter that passed the qualification test is also expected to pass.

ARNDT: A few questions come to mind regarding the testing of the SCHEPA filter for rough-handling, over-pressurization, and the heated air. Did the testing include a hole in the filter media of a known area and location to verify that the testing would detect a flaw in the filter medium during an in-place aerosol test? Due to the configuration and the uneven airflow distribution of the SCHEPA I would suggest, if possible, the filter be tested to failure, *i.e.*, that there be a series of holes of differing diameters in various locations to determine where the filter fails and passes. Also, are there any plans to pressure test the filter housing?

BERGMAN: The qualification tests on heated air, overpressure, and rough handling did not include a hole in the filter media. The qualification tests do not require that, and we see no purpose for artificially introducing such holes. The suggestion to introduce the holes was apparently made to investigate the air-aerosol mixing uniformity in the box HEPA filter. This is neither required by ASME N510, nor does it add to the accuracy of in-place leak tests. Since all box filters can only be used in single filter installations, there are no compelling reasons for doing the uniform air flow and aerosol mixing tests. ASME N510 exempts all single filter installations from such tests. In practice, the aerosols would be measured at some distance upstream and downstream of the entry and exit ducts, not inside the box. At these points, the aerosols would be well mixed. Regarding the final question, we plan to measure the leak rate through the box HEPA filter.

ASME N510 TEST RESULTS FOR SAVANNAH RIVER SITE AACS FILTER COMPARTMENTS

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Abstract

The K-Reactor at the Savannah River Site recently implemented design improvements for the Airborne Activity Confinement System (AACS) by procuring, installing, and testing new Air Cleaning Units, or filter compartments, to ASME AG-1, N509, and N510 requirements. Specifically, these new units provide documentable seismic resistance to a Design Basis Accident earthquake, provide 2" adsorber beds with 0.25 second residence time, and meet all AG-1, N509, and N510 requirements for testability and maintainability.

This paper presents the results of the Site acceptance testing and discusses an issue associated with sample manifold qualification testing.

I. Introduction

The Savannah River Site (SRS) is located on the Savannah River in South Carolina. The Site is owned by the Department Of Energy, with the Westinghouse Savannah River Company (WSRC), a Subsidiary of Westinghouse Electric Corp., as the primary contractor. The mission of the Savannah River Site was to produce special nuclear materials. Currently, 4 of the 5 production reactors at SRS have been shutdown and the fifth reactor, K-Reactor, is being maintained in a cold standby condition. The reactor never operated with these new filter compartments installed.

The production reactors at the Savannah River Site (SRS) were constructed in the 1950's. These reactors are non-boiling and vented to atmosphere (non-pressurized). The Airborne Activity Confinement System (AACS) for the reactors is designed to collect airborne radioactive particles and halogen vapors that might be released to the atmosphere following a reactor accident. The system is designed for confinement, not containment. Confinement is attained by sweeping outside air through the process areas and exhausting the air through parallel filtration-adsorption units (filter compartments) prior to exhausting to the atmosphere. Five compartments are available with three constantly on-line during reactor operation. Contamination within the reactor building is controlled by flowing air from areas of least expected contamination to areas with a higher potential for airborne contamination. The process areas of the reactor building are sufficiently sealed that they can be maintained at a negative pressure with respect to adjoining areas, including the atmosphere.

Originally, the process area exhaust air was exhausted directly to the atmosphere through a 200' stack. In the 1960's, design changes were implemented to exhaust air from the process areas through the 5 parallel filter compartments prior to exhausting to the atmosphere. Each unit contained a bank of moisture separators, a bank of HEPA filters, and an activated charcoal absorber bed. Typical building total flow rate during reactor operation with the filter compartments installed was 110,000 cfm.

In 1990, a new project was initiated to replace the existing filter compartments with new seismically qualified compartments designed, installed, and tested in accordance with ASME AG-1, N509, and N510 requirements. The new design also incorporated other changes to improve maintainability, operability, and to provide for longer periods of operation between filter replacement (see Figure 1).

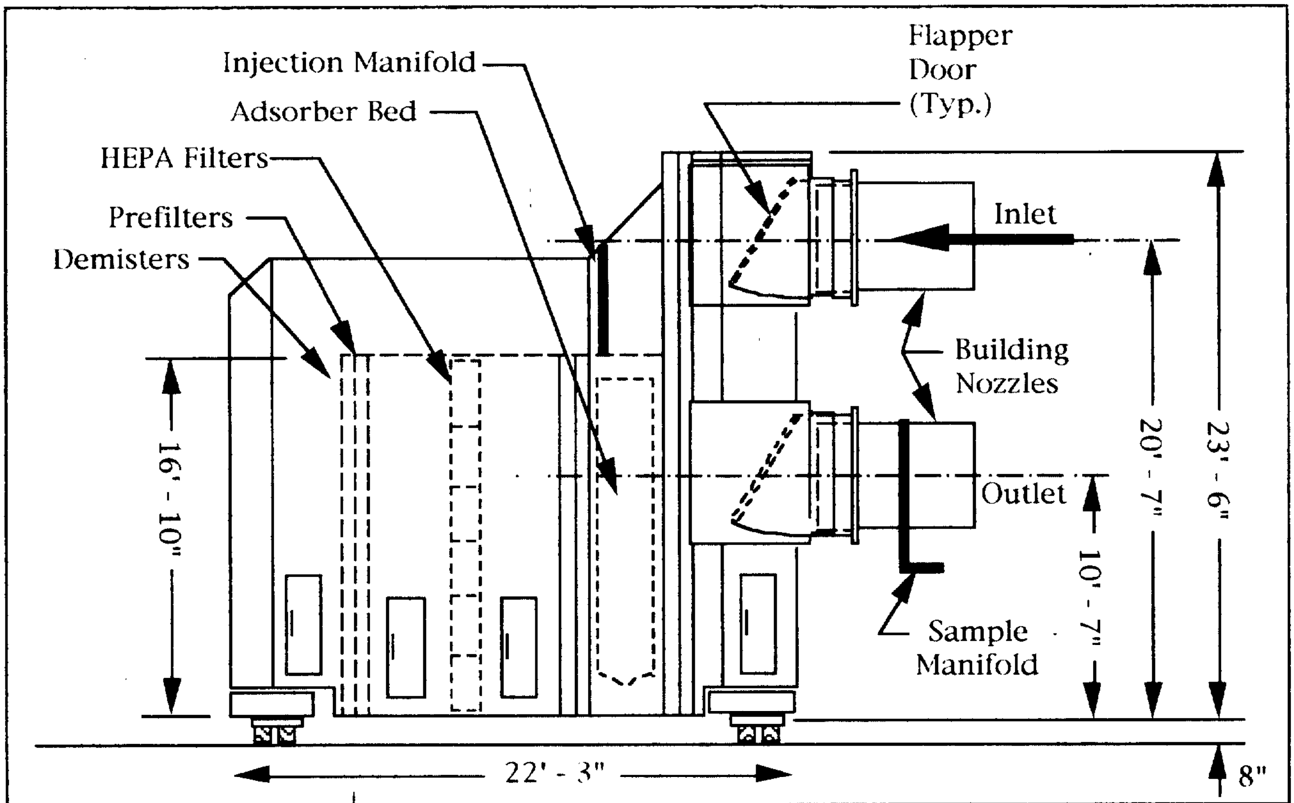


Figure 1
Elevation View - New Filter Compartment

The compartments reside on the roof of the building at an elevation 55' above the ground. Because the original AACS design did not include the filter compartments, a uniquely designed compartment was required to retrofit the existing system. Process area exhaust air enters the top of the compartment and makes a 180 degree turn prior to entering the moisture separators. The compartments are locked in place and sealed to the ventilation system using inflatable bladders on the building nozzles.

Neither the new or the old compartments were shielded. Therefore, both were designed for "remote removability" such that if a compartment became highly contaminated, it can be remotely disconnected from the ventilation system, sealed to prevent spread of contamination, and removed by a crane for burial.

The new compartments were constructed of stainless steel to resist corrosion in the acidic process air. Weight constraints were imposed to prevent degrading the building structure's ability to withstand a design basis earthquake (the existing compartments were made of aluminum). The design flow rate through the new compartments ranges from 16,000 to 32,000 cfm each.

II. ASME N510 Acceptance Testing

N510 qualification testing to prove AG-1 and N509 requirements were met was conducted at both an independent laboratory and at the K-Reactor. The test results reported herein were obtained during the Site acceptance testing of Filter Compartment N° 2 at the K-Reactor, unless otherwise noted.

Structural Capability Test

The filter housing was subjected to both a negative and positive structural capability test. The negative pressure test was performed at -9.25 inches of water gauge (w.g.) and the positive pressure test was performed at 69.5" w.g. Inspection of the filter compartment during pressurization and following test completion showed no evidence of permanent distortion or breach. Therefore the filter compartment met the acceptance as required by ASME N510.

Housing Leak Test

The filter housing was subjected to leak test to demonstrate its leakage integrity under maximum design pressure. The housing was pressurized to 55.9" w.g. Acceptance criteria was 1.0" w.g. decay over a ten minute period. Actual test result, after correction for temperature and barometric pressure changes, showed 0.99" w.g. decay during the ten minute test period.

HEPA And Carbon Adsorber Frame Leak Test

WSRC elected to perform the optional HEPA filter and carbon adsorber frame leak tests. Acceptance criteria per N509/510 is 0.1% of rated flow.

The HEPA frame, after sealing with plastic sheeting, was subjected to +3.0" ± 0.1" w.g. by pressurizing the housing upstream of the HEPA bank with air. Leakage was measured at the air flow required to maintain pressure. Actual average flow rate measured over a ten minute period was 4.7 cfm or 0.029% of the minimum design air flow.

The adsorber bed, after sealing with plastic sheeting, was subjected to +1.1 ± 0.1" w.g. by pressurizing the housing upstream of the adsorber bank with air. Leakage was measured as the air flow required to maintain pressure. Actual average flow rate measured over a ten minute period was 8.5 cfm or 0.053% of the minimum design air flow.

This test methodology produced a conservative result by assuming the measured leak rate was completely due to HEPA frame leakage and ignoring the other possible sources of leakage (personnel door seals, light fixtures, inadequate sealing of the plastic sheeting, etc.). Actual frame leakage is most probably less than the measured value. Both tests demonstrated that the sealing of the frames to the housing is adequate and meets all requirements.

Air Capacity Test

An Air Capacity Test was performed to demonstrate that at the maximum housing delta-P of 6" w.g., the process areas remained at a negative pressure with respect to atmosphere and that a minimum flow of 20,000 cfm can be maintained. Actual testing demonstrated that both criteria were met.

Air Flow Distribution Test

An Air Flow Distribution Test for both the HEPA filters and the Adsorber Bed air channels was performed. Both tests were conducted at the maximum design air flow of 32,000 cfm ± 10%.

HEPA Bank Once the air flow was established, the air velocity was measured at the downstream side of each HEPA filter (filter bank designed as 3 filters wide X 7 filters high). Actual measured velocities, shown in Table 1, demonstrated that the air flow distribution met the N510 criteria of ±20% of the average of the individual flows.

Table 1
Actual HEPA Air Flow (fpm)

	A	B	C
7	686	578	572
6	596	595	620
5	557	569	570
4	589	597	601
3	537	575	489
2	611	631	599
1	570	563	501

(Viewed From Upstream)

Average Air Flow = 581 fpm
Allowable Range: Min. = 465 fpm (-20%)
Max. = 698 fpm (+20%)
Measured Range: Min. = 489 fpm (-16%)
Max. = 686 fpm (+18%)

Table 2
Actual Adsorber Air Channel Air Flow (fpm)

	A	B	C	D	E	F	G	H
14	1870	1944	1842	1902	1929	2011	1895	1781
13	1924	1852	1939	1835	1871	1881	1730	1703
12	1771	1626	1541	1856	1823	1908	1566	1385
11	1514	1667	1831	1963	1859	1709	1646	1796
10	1601	1434	1850	1727	1834	1529	1575	1681
9	1961	1858	1833	1640	1612	1563	1523	1896
8	1872	1691	1785	1604	1671	1572	1535	1845
7	1798	1748	1674	1617	1607	1635	1552	1673
6	1597	1854	1793	1821	1680	1599	1645	1722
5	1898	1762	1660	1626	1684	1487	1580	1688
4	1756	1759	1664	1540	1624	1464	1408	1813
3	1785	1845	1701	1710	1657	1410	1429	1783
2	1872	1813	1909	1804	1786	1519	1445	1841
1	2007	1837	2008	1786	1775	1574	1417	1899

(Viewed From Upstream)

Average Air Flow = 1724 fpm
Allowable Range: Min. = 1379 fpm (-20%)
Max. = 2069 fpm (+20%)
Measured Range: Min. = 1385 fpm (-19.7%)
Max. = 2011 fpm (+16.6%)

Adsorber Bank Once the air flow was established, the air velocity was measured at fourteen approximately equal areas in the plane of the face of the eight inlet air channels. Actual measured velocities, shown in Table 2, demonstrated that the air flow distribution met the N510 criteria of ±20% of the average of the individual flows.

Air-Aerosol Mixing Uniformity Test

DOP was introduced into the housing at the maximum design air flow rate (± 10%) using the permanently installed injection manifold. The resultant DOP concentration measured one foot upstream of the HEPA filter bank (see Table 3) showed that the air-aerosol distribution at each of the 21 HEPA filters was within ±20% of the calculated average concentration.

It should be noted that even though the housing design requires the air to make a 180° turn prior to entering the moisture separators, both the air flow distribution and air-aerosol uniformity were achieved without the use of turning vanes or other mixing devices.

Table 3
Air-Aerosol Mixing - DOP Concentration

	A	B	C
7	86	85	86
6	84	85	83
5	78	70	75
4	78	66	76
3	75	62	75
2	72	62	70
1	68	68	66

(Viewed From Upstream)

Detector Scale Setting = 10%
Initial DOP Concentration = 63
Average DOP Concentration = 74.8
Allowable Range: Min. = 59.8 (-20%)
Max. = 89.8 (+20%)
Measured Range: Min. = 62 (-17%)
Max. = 86 (+15%)

HEPA Filter Bank In-Place Leak Test

Aerosol generators and detectors were connected to the housing for the performance of the HEPA filter bank in-place leak test. System dampers were properly positioned and the maximum design air flow rate (± 10%) was established. Upstream and downstream HEPA filter background readings were taken and recorded. Upstream concentration was measured using the single point sample port. This port was proven effective in measuring upstream concentrations during the air-aerosol mixing uniformity test. Downstream concentrations were measured using the permanently installed sample manifold. The aerosol generators were then pressurized, and DOP was injected into the inlet plenum manifold. Four sets of upstream and downstream HEPA filter DOP concentrations were taken and recorded. The final penetration calculated from the data demonstrated that the actual bypass leakage was virtually 0%.

Adsorber Bank In-Place Leak Test

Halide generators and one detector were connected to the filter housing for the performance of the adsorber in-place leak test. System dampers were properly positioned and the maximum design air flow (± 10%) was established. Upstream and downstream adsorber background readings were taken to verify stable background conditions for initiation of injection. The halide generators were turned on and halide gas (R-11) was injected into the inlet plenum manifold. Five sets of upstream and downstream readings were taken and recorded. The downstream concentration was measured using the permanently installed sample manifold. The resultant penetration bypass leakage extrapolated to time 0 from the data obtained was less than 0.0016%. However, WSRC questioned the acceptability of the sample manifold to detect bypass of the adsorber bed, even though the manifold satisfactorily passed the manifold qualification test as described in Mandatory Appendix D of N509, Performance Test For Qualification Of Sampling Manifolds. Refer to the following section on Manifold Testing for the basis of WSRC's concerns.

III. Manifold Qualification Testing

Manifold Testing

Testing to demonstrate that the proposed sampling manifold (see Figure 2 & 3) is adequate for sampling during both HEPA filter and adsorber bank bypass testing was conducted at an independent laboratory. Artificial leak sites were introduced in the form

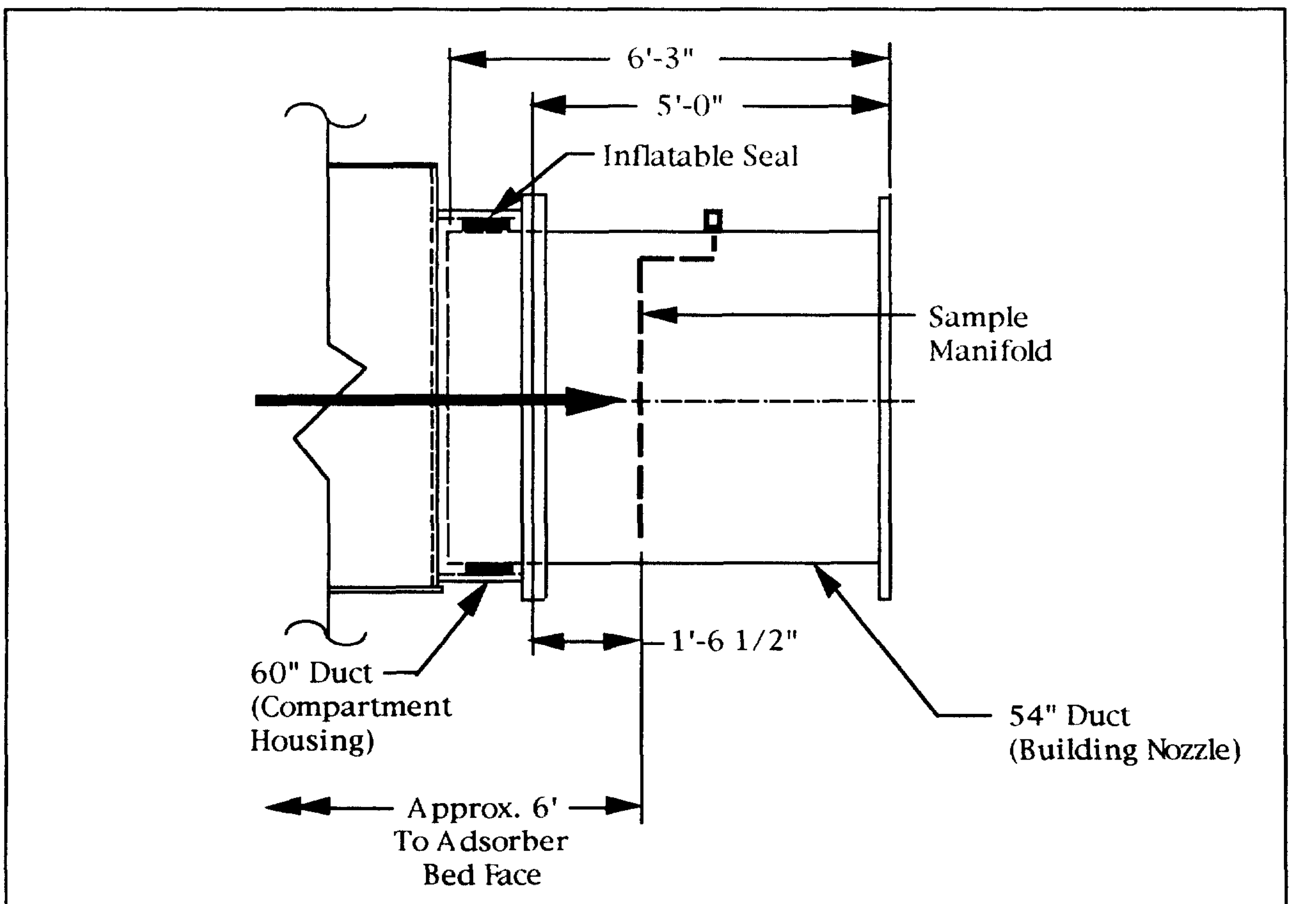


Figure 2
Sample Manifold Location

of holes in the HEPA frames, tears in the filter medium, and tears in the sealing face gaskets. No attempt was made to introduce artificial leak sites in the adsorber bed or frame.

WSRC questioned the completeness of the testing to show that the manifold is capable of detecting adsorber bypass. WSRC's interpretation of N509 Appendix D, paragraph D4.2(b)(1), which states "the artificial leak paths shall be located, one at a time, to simulate leaks in the filter/adsorbent face, frame-to-wall welds (including floor and ceiling), and gasket-to-frame seals (where applicable), and at structural welds on Type III adsorbers," is that both the HEPA bank and adsorber bank should have artificial leak sites introduced and the sample manifold tested for adequacy. The vendor responsible for the testing interpreted this paragraph as an either/or statement and that testing only the HEPA bank satisfied Appendix D requirements.

WSRC issued a formal inquiry, Inquiry 93-03, to the CONAGT committee to provide the correct code interpretation. The inquiry response is pending.

For any downstream sample manifold to work properly, it is essential that the air stream be well mixed prior to entering the sampler and that adequate bulk air mixing between the adsorber bed and sampler is achieved. WSRC hypothesized that adequate mixing downstream of the adsorber bed may not be achieved and that the Appendix D methodology is inadequate to demonstrate manifold acceptability. WSRC believes that the mixing experienced by the DOP may not be representative of the mixing that occurs downstream of the adsorber bed.

To prove the hypothesis, prior to receiving the response to the CONAGT inquiry, WSRC developed and initiated scoping tests to simulate point source leaks downstream of the adsorber bank to determine if preferential sampling was occurring at the sample manifold. DOP was chosen as the challenge gas.

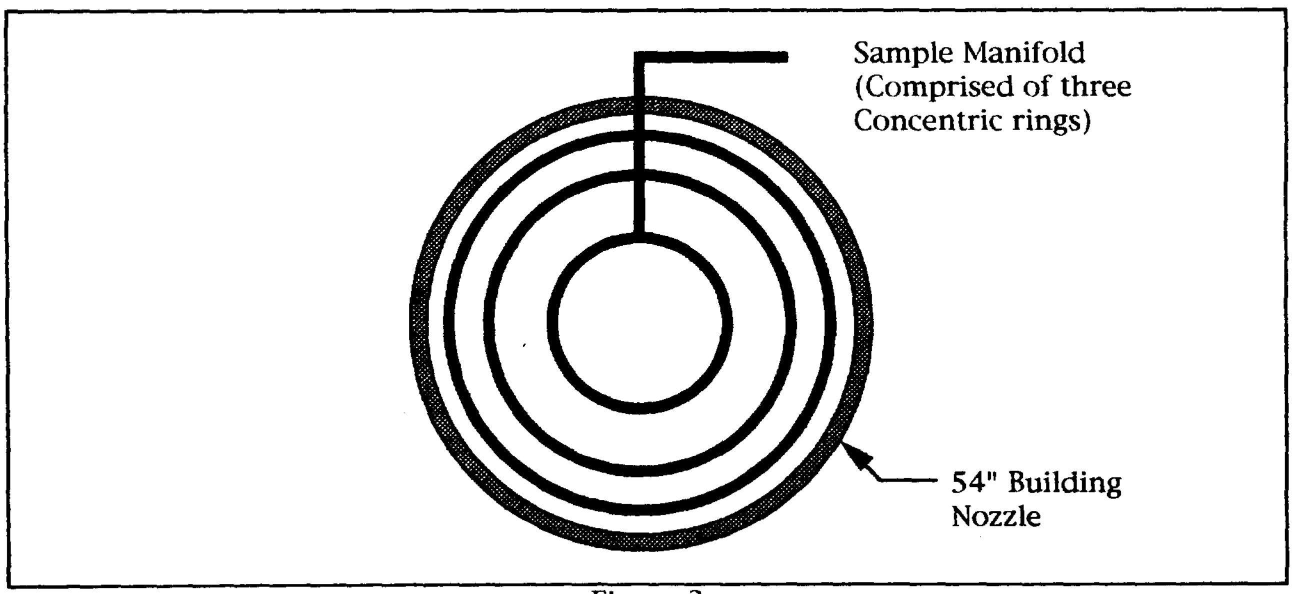


Figure 3
Sample Manifold

DOP was injected at 12 discrete points located on the downstream face of the adsorber bed (see Figure 4 & 5) by routing tubing from the aerosol generator through the housing wall and attaching to the adsorber bank face. Tubing routing was carefully chosen to prevent obstructing air flow. Downstream concentrations were measured at the sample manifold and at a single point downstream of the main exhaust fan. Testing showed the fan adequately mixed the air stream and the single point sample location produced a representative sample of the air stream.

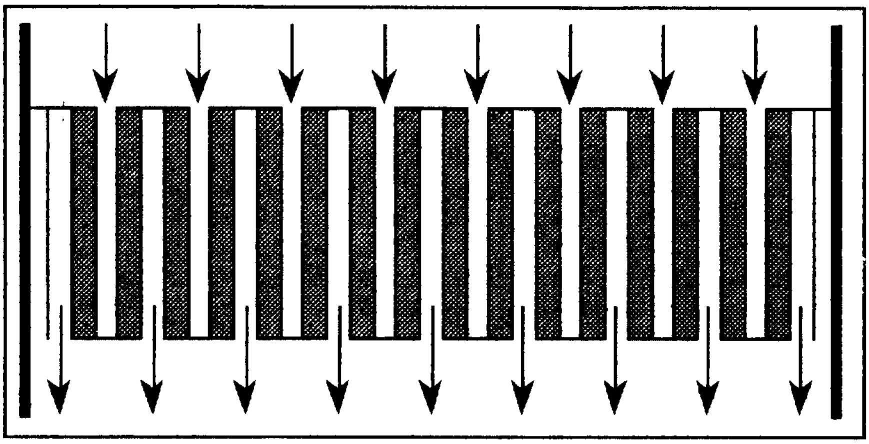
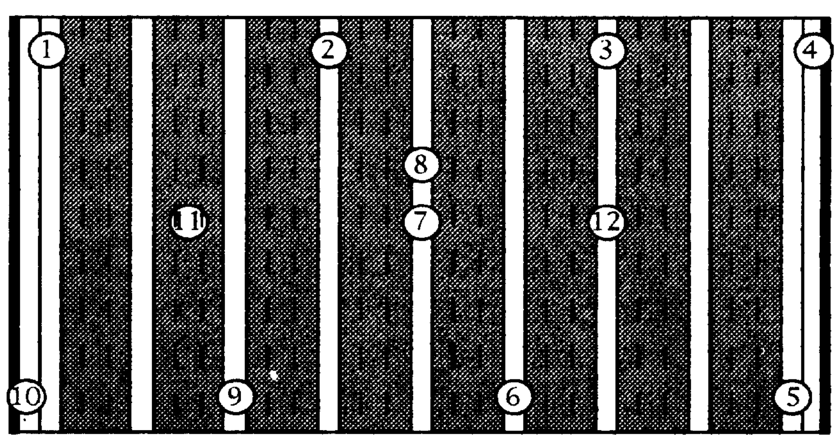


Figure 4
Adsorber Bed - Plan View



Viewed From Downstream

(1)(2)(3) - Located @ top of air channel
(4) - Located @ top of stagnant air gap between housing wall and adsorber bed
(5)(6)(9) - Located @ bottom of air channel
(7)(12) - Located @ middle of air channel
(8) - Located in-line with center of sample manifold
(11) - Located in middle of bed @ a seal weld
(10) - Located @ bottom of stagnant air gap between housing wall and adsorber bed

Figure 5
Adsorber Bed - Elevation View
Artificial Leak Site Locations

Since two different calibrated DOP detectors were used at the two locations, correlation tests between the two detectors were conducted at the sample manifold prior to the test and at the single point location following the test. While this test is not required per N509, it was felt that this data was essential for proving the hypothesis. Good agreement between the two detectors was demonstrated, as shown in Table 4.

Comparison between the concentrations measured at the sample manifold and the single point sample locations are shown in Table 5. These results suggest that testing of the HEPA bank only may not sufficiently demonstrate that the sample manifold is adequate for detecting adsorber bypass.

Table 4
DOP Detector Comparison

Test	Post-Test Comparison (Sample Manifold)			Post-Test Comparison (Single Point Location)		
Point N°	Det. #1 Conc.	Det. #2 Conc.	% Diff.	Det. #1 Conc.	Det. #2 Conc.	% Diff.
1	75	75	0%	49	51	4%
2	54	52	4%	57	61	6%
3	115	105	9%	54	59	8%
4	100	95	5%	63	63	0%
5	125	110	12%	60	66	9%
6	65	64	2%	53	53	0%
7	40	40	0%	69	67	3%
8	54	54	0%	63	63	0%
9	92	94	2%	65	66	2%
10	110	100	9%	66	64	3%
11	88	85	3%	73	70	4%
12	72	75	4%	73	72	1%

WSRC initiated a test program to retest the sample manifold at the Site to determine if a different configuration is required. Other solutions such as installation of a temporary mixing baffle upstream of the sampler to promote bulk air mixing were also considered. This baffle would be installed prior to performing bypass testing and removed during reactor operation. The baffle would introduce a more tortuous air flow path to the manifold. However, project funding was canceled following the Department Of Energy decision to place the K-Reactor in a stand-by condition. No actual testing of a new manifold or mixing baffle was conducted.

Table 5
Sample Manifold Concentration vs.
Single Point Sample Concentration

Test Point N°	Manifold Sample Concentration	Single Point Sample Concentration	% Difference
1	50	47	6%
2	52	55	6%
3	51	80	57%
4	73	75	3%
5	51	52	2%
6	45	35	22%
7	54	25	54%
8	53	30	43%
9	54	49	9%
10	53	53	0%
11	57	56	2%
12	64	46	28%

IV. Summary

The new N° 2 filter compartment installed at the K-Reactor at the Savannah River Site successfully met all N509 acceptance test requirements, with the possible exception of the adsorber bed in-place leak test. These test results remain suspect pending further testing to demonstrate the acceptability of the sample manifold to detect adsorber bed bypass. Scoping test results suggest that successfully passing Appendix D manifold qualification testing in itself may not ensure that an adequate manifold design is provided. However, the additional testing necessary to prove this hypothesis was canceled following the Department Of Energy's decision to place the K-Reactor in cold stand-by. No further testing is foreseen in the near term.

V. REFERENCES

1. ASME N509-1989, Nuclear Power Plant Air-Cleaning Units And Components.
2. ASME N510-1989, Testing Of Nuclear Air Treatment Systems.
3. ASME AG-1-1991, Code On Nuclear Air And Gas Treatment.
4. Reactor Test Procedure WSRC-TR-92-138-007, Duct/Housing Leak And Structural/Frame Test (U), Rev. 0.
5. Reactor Test Procedure WSRC-TR-92-138-008, Airflow Distribution, Air-Aerosol Mixing Uniformity, HEPA And Adsorbers In-Place Test (U), Rev. 0.
6. Reactor Work Request N° GWG10, AACS Filter Compartment Manifold.
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AN EVALUATION OF EFFORTS BY NUCLEAR POWER PLANTS TO USE ASTM D3803-89

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Abstract

A number of nuclear power plants are now using ASTM D3803-89, "Standard Test Method for Nuclear-Grade Activated Carbon" for routine surveillance testing of adsorbents. In order to judge the impact of this change, we have gathered radioiodine removal test results from our data base on a system-by-system basis (i. e. control room, technical support center, and spent fuel pool) and compared test results obtained for the same kind of systems using the new and older test methods. Included in this comparison are systems with and without humidity control.

Results are discussed from the standpoint of what to expect if a change to testing using ASTM D3803-89 is contemplated, especially regarding test results in light of existing acceptance criteria. Additionally, the results are discussed from the standpoint of the sensitivity of the ASTM test method to detect when the performance of the carbon in air cleaning systems has been compromised (compared to the older methods). Finally, we offer some suggestions for how other plants might upgrade their carbon testing to incorporate testing to ASTM D3803-89.

Introduction

It has now been seven years since the publication of NRC Information Notice No. 87-32, "Deficiencies in the Testing of Nuclear Grade-Activated Charcoal." [1] In a previous paper, we discussed the efforts of nuclear power facilities in the U. S. to interpret and apply the new standards for testing adsorbents used in their air cleaning systems and at the same time to address issues raised by the Information Notice.[2] In this paper, we have gathered radioiodine test results obtained from routine testing of particular air cleaning systems (control room, technical support center, and spent fuel pool) using the new and older test methods. Although we find more plants successfully using ASTM D3803-89[3] (or its equivalent), there are still many plants that do not. This situation will not change unless the NRC takes a stronger leadership role by either revising Regulatory Guide 1.52 or applying the available new standards in a consistent fashion.

Methyl Iodide Removal Efficiency Results

Table 1 lists results for testing carbon from Spent Fuel Pool air cleaning systems, Table 2 lists results from testing carbon from Technical Support Center air cleaning systems and Table 3 lists results from testing carbon from Control Room air cleaning systems. Included in the 30°C/95% R. H or 70% R. H. results are results from carbon samples tested at 25-30°C and equilibrated with 95 or 70% R. H. air. We consider this to be testing to ASTM D3803-89. Test results shown under ASTM D3803-79 are results from carbon samples tested at 25-30°C without equilibration at 95 or 70% R. H. For other results listed, no distinction was made between equilibrated or non-equilibrated samples. Results shown in parentheses are for 4" test beds, while single digit numbers in parentheses after test results are bed depths in inches.

TABLE 1
PERCENT METHYL IODIDE REMOVAL EFFICIENCY
FOR SPENT FUEL POOL CARBON SAMPLES
(INCLUDES FUEL HANDLING)

D3803-89	D3803-89	D3803-79	51.7°C / 95° R. H.
30°C / 95% R. H.	30°C / 70% R. H.	30°C / 70% R. H.	99.95
78.14	99.92	99.94	
78.31	99.78	99.95	
96.25	99.31	99.99	66°C / 95% R. H.
96.24	94.89	99.97	82.32
97.71	99.99	98.77	99.66
87.21	99.24	98.81	99.81
93.30	99.66	99.80	91.36
98.00	99.83	99.79	99.88
92.02	99.93	99.98	99.96
99.45		99.99	99.94
84.20		99.81	
93.70		99.99	
98.65		99.96	80°C / 70% R. H.
98.51		99.58	99.40 (99.98)
93.12		99.90	99.45 (99.99)
99.55		99.96	99.89
96.74		99.59	99.88
92.69		98.37	99.97
95.71		99.84	99.92
96.75		99.95	99.43
88.35		99.96	
96.75		99.95	
99.37		99.98	80°C / 95% R. H.
96.49		99.91	95.98
88.89		99.98	88.10
99.09		99.90	99.93
93.80		99.94	
88.89		99.95	
88.82		99.94	130° / 95% R. H.
86.42		99.96	99.92
91.21		99.94	
99.94			
99.70			
99.54			
97.40			
97.95			
99.83			
98.01			
98.93			
99.16			
99.81			
94.05			
99.31			
96.92			
96.25			
98.64			

TABLE 2
PERCENT METHYL IODIDE REMOVAL EFFICIENCY
FOR TSC CARBON SAMPLES

D3803-89	D3803-89	D3803-79	51.7°C / 95% R. H.
30°C / 95% R. H.	30°C / 70% R. H.	30°C / 70% R. H.	99.92
91.47	99.58	99.98 (4)	99.76
93.80	99.89	97.07 (99.89)	96.96
84.70	76.59		87.10
78.73	99.30		99.93
90.54	99.62		90.49
99.37	99.69		
99.51	99.96		
88.58	96.91		66°C / 95% R. H.
90.37	99.88 (99.98)		97.53
98.56	98.48 (99.97)		99.68
99.65	98.61 (99.93)		
94.25	99.96 (99.99)		
92.55	98.61 (99.98)		80°C / 70% R. H.
80.01	99.58 (99.99)		99.96
99.85	99.99+		99.87
93.85	97.29 (99.70)		99.96
99.94			99.98
99.85			99.81
93.87			99.94
98.90 (4)			
99.99 (4)			

TABLE 3
PERCENT METHYL IODIDE REMOVAL EFFICIENCY
FOR CONTROL ROOM SAMPLES

D3803-89 30°C / 95% R. H.
98.73
91.60
97.64
99.83
99.86
96.85
89.59
99.00
99.24
92.81
94.95
92.75
96.64
94.99
90.01
99.31
91.36
83.73
99.31
97.36
97.35
99.06
49.69
47.63
90.56
95.29
96.69
93.58
97.84
99.86
99.83
99.55
83.98
98.78
99.54
86.64
99.30
99.99+(6)
99.56
98.84
98.63
97.36
97.35
97.64

D3803-89 30°C/ 70% R. H.	
99.04	97.88 (99.97)
99.86	99.80
99.50	98.38*
99.42	99.88*
92.35	99.93 (99.99)
90.89	99.55
99.85	99.95 (4)
99.30	99.09 (99.99+)
99.19	99.14*
99.90	84.45 (99.90)
99.86	99.69
99.19	85.95 (99.86)
90.89	99.93
78.90	
97.37	
99.92	
99.09	
84.45	
99.69	
85.95	
99.93	
99.78	
99.93	
99.95	
99.92	
99.45	
99.68	
86.53	
99.96	
82.13	
99.90	
98.39	
99.93	
99.99	
99.97	
99.99	
99.30	
99.99	
99.91	
98.54	
99.03	
99.17	
99.69 (99.94)	
99.81	
99.90	
99.87	
80.30 (99.72)	
83.33 (99.74)	

D3803-79 30°C / 95% R. H.
94.60
96.54

D3803-79 30°C / 70% R. H.
99.99 (4)
99.99 (4)
99.96
99.95
99.96 (4)
99.97 (4)
99.98 (4)
99.99 (4)
99.95
99.95
99.92
99.99 (4)
99.89
99.96 (4)
99.95
99.99 (4)
98.30
99.87
99.98

51.7°C / 95% R. H.
99.90
99.47
99.80
99.90
99.76
96.96
99.67
98.54
98.36
98.44
96.01
79.74
99.47

66°C / 95% R. H.
99.92
99.89
99.87
99.96

80°C / 70% R. H.
99.89 (99.98)
99.66
99.96
99.94
99.72
99.86
99.98
99.79 (99.99)
99.93
99.99
99.52
99.99 (99.99+)
99.99
99.97 (99.99)

80°C / 95% R. H.
99.77
99.67
92.03
84.85
99.98
99.91

130°C / 95% R. H.
99.97
99.93
99.79
99.96
99.91

Discussion of Results and Recommendations

Spent Fuel

It is encouraging to see that most of the test results shown here are obtained from using some version of the D3803 method. This is not too surprising given that the acceptance criterion for this system is usually an efficiency of >90%. The D3803-89 30°C/95% R. H. results of <90% are generally a first time result and represents a need for a carbon change. Thus, a >90% efficiency is a reasonable acceptance criterion for the D3803, 30°C/95% R.H. test. The D3803-89, 30°C/70% R. H. results indicate that an efficiency of >99% can be expected. Thus, we would recommend that systems currently tested at temperatures >30°C and 95% R. H. be tested at 30°C and 95% R.H. according to ASTM D3803-89. All the other systems currently being tested at some temperature and 70% R.H. should be tested at 30°C and 70% R.H. according to ASTM D3803-89. The 30°C/70% R.H. test according to ASTM D3803-79 (without equilibration) is not sensitive enough to the carbon's condition[4] and should be replaced with the 89 version.

TSC

Even though these systems are generally the newest (and best) in the plant, most, if not all, are non-ESF systems. Thus, these systems were designed to be tested at 25°C/70 or 95% R. H. with an efficiency of >90% and the change to D3803-89 at 70 or 95% R. H. has been rather painless. The systems tested using D3803-79 should changed to the 89 version as should the systems tested at the other temperatures >30°C. It was nice to see no 130°C tests in this data (from end of 92 to present), but one wonders why the other temperatures are used.

Control Room

The situation for the control room systems is more complicated. The required efficiency is typically >99% for 2 inch systems and >99.825% for 4 inch systems. This is a difficult requirements for 2 inch systems tested at 30°C and 95% R. H. to D3803-89. A >95% efficiency would be more reasonable, but would require the lowering of the assigned decontamination efficiencies. The results for samples tested at 30°C and 70% R. H. to D3803-89 indicate that an efficiency of >99% for two inch systems and >99.8% for 4 inch systems can be reasonably expected. The lower efficiency test results shown generally are first time results using the newer test methods after historically testing the carbon from these systems at higher temperatures. The high temperature testing of carbon samples from Control Room systems should be replaced with the 30°C/70 or 95% R. H. D3803-89 test. The same holds true for systems tested using D3803-79. It is discouraging to see that some Control Room systems are still tested at 130°C.

Conclusions

The industry must make a decision about testing carbon from air cleaning systems for methyl iodide removal. Do we want to test the carbon with a method that is sensitive to the condition of the carbon or with a test method that allows the carbon to meet the assigned decontamination efficiency for some assigned accident scenario? Systems that can use ASTM D3803-89 at 30°C and 70% R. H. (and hence have humidity control) can do both. But most ESF systems will require a derating of their assigned decontamination efficiency when tested to D3803-89 at 30°C and 95% R. H. Can the NRC provide a uniform, non-litigious means to accomplish this?

References

1. NRC Information Notice No. 87-32: "Deficiencies in the Testing of Nuclear Grade Activated Charcoal"; United States Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, DC 20555, July 10, 1987.

2. Freeman, W. P., "Testing of Adsorbents Used in Nuclear Power Plant Air Cleaning Systems Using the 'New' Standards." 22nd DOE/NRC Nuclear Air Cleaning Conference, CONF-9020823, Vol. 2, pp 661-671.

3. ASTM D3803-79, 86, 89; "Standard Test Methods for Radioiodine Testing of Nuclear-Grade Gas-Phase Adsorbents", ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

4. Scarpellino, C.D. and Sill, C.W.; "Final Technical Evaluation Report for the NRC/INEL Activated Carbon Testing Program," EGG-CS-7653 April 1987, Idaho Falls, Idaho 83415.

DISCUSSION

HAYES: In your conclusion you recommended that the NRC have some definitive guidelines with respect to decontamination efficiencies. Are you recommending that the NRC revise Table 2 of Regulatory Guide 1.52 and, based upon the data you have presented, show an adsorber efficiency credit of 85% or 90%, for the safety analysis with a laboratory testing acceptance criterion of 95%?

FREEMAN: Yes, for carbon samples from systems that have 2-inch beds tested at 30° C and 95% RH according to ASTM standard D3803-89.

KOVACH, L.: In last week's ASME meetings and several discussions that industry groups had with the NRC, the recommendation came out that if the industry knows better than the NRC, they should ask for a technical specification change on an individual plant basis. Not just as an industry representative, but also as a taxpayer, I am upset by this attitude that if there is something stupid in a technical specification (that was put in some time ago and blessed by NRC) and when I want to do something different, I have to go through all these hoops to change it to something that makes engineering common sense on the basis of what we have learned. I think we need and expect a little more leadership from NRC than has been demonstrated in relation to this particular problem. I know it is a political question; and I know it is a legal question, but at the same time I realize that NRC is so busy licensing all these new plants which are being built that they don't have time to work on a problem that they didn't even discover. The industry, at its own expense and endeavor, pointed it out to them as being a problem. It is very frustrating to have this issue under discussion for years without resolution from the NRC. It is clearly defined by current knowledge that a problem exists. Presentations were made to the NRC without even a response. The rest of the world uses common sense test conditions. The U. S., with the most extensive regulatory organization, did not adopt the proper test conditions even after industry pointed at the non-conservative assumptions of the regulated test conditions.

FREEMAN: You are preaching to the choir here. From my standpoint, both as a taxpayer and a Joe Public, what discourages me is that, here we are trying to protect the safety of people that work in power plants, (and people outside power plants if there is an accident), and we are using test methods that are contrary to that endeavor. We can meet a 1% penetration requirement by currently required laboratory tests and yet the system may contain a carbon that would only perform in the low 40% removal efficiency range in a not-so-serious accident. That's really what disturbs me the most.

CLOSING COMMENTS OF SESSION CO-CHAIRMAN WEIDLER

I am going to give a brief summary, and then I'll follow up in a Southern way what Dr. Kovach said. We heard some diverse papers, and I am going to sum them up individually, but the common theme was that we need to continue development and refinement of codes and standards. It is a significant need.

All the presentations were excellent. Ken Deaton's paper on Challenges of Equipment Qualification, and his discussion of the commercial dedication of 1E motors versus the qualification issue point out that the licensee needs to exercise caution in the commercial dedication of items such as motors, because they are extremely complex. From my perspective, it begs a question: are the guidance documents that are currently available to the industry on commercial specifications adequate? I think it is a question we will have to explore down the road a bit.

In Tim Arndt's paper on Evaluation of the Self-Contained HEPA Filter, he talked about the specific design not being recognized by codes and standards, which I consider to be somewhat of a good point, because I don't think codes and standards should restrict specific designs. He pointed out the many areas that are in non-compliance with existing codes and standards for this filter, and the recommendation not to use this filter for nuclear applications. I would like to say that, from my perspective with codes and standards organizations, that when you run into a problem where you are trying to use new technology that doesn't "fit" into the existing standards, such as N-509 and N-510, please, by all means, contact that particular organization and have discussions with them.

The Paul and Punch paper on the new filter system at Savannah River noted that it passed all the acceptance tests in N-510 with the exception of the adsorber in-place leak test. This has not yet been resolved, due to a decision to put the K-reactor on standby. I checked my records on the inquiry to N-510, and they show that CONAGT still has not completed its response. We need to get together and resolve whether our (CONAGT's) records have gone astray or if we have given a wrong impression to Westinghouse Savannah River. I will certainly do that.

Freeman's paper on the Evaluation of Efforts by Nuclear Power Plants to Use ASTM D-3803, shows that a number of plants do use D-3803 for routine surveillance testing. He also pointed out that the adsorbent is being evaluated by different criteria. I conclude by saying that CONAGT took this matter up with the Nuclear Regulatory Commission in April of 1993. To this point, we have not had a response to the issue that we brought before them. We will continue to work for a resolution that is good for all, and we hope that by the next air cleaning conference we can close this issue out.