Technology Development

HEPA Filter Service Life Test Plan

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Introduction

Rocky Flats Environmental Technology Site (the Site) has approximately 10,000 High Efficiency Particulate Air (HEPA) Filters installed in a variety of filter plenums. These ventilation/filtration plenum systems are used to control the release of airborne particulate contaminates to the environment during normal operations and also during potential design-based accidents. The operational integrity of the HEPA filter plenums is essential to maintaining the margins of safety as required by building specific Final Safety Analysis Reports (FSARs) for protection of the public and environment. An Unreviewed Safety Question Determination (USQD), USDQ-RFP-94.0615-ARS, was conducted in 1994 addressing the potential inadequacy of the safety envelope for Protected Area building HEPA plenums. While conducting this USQD, questions were raised concerning the maximum service life criteria for HEPA filters. Accident scenarios in existing FSARs identify conditions that could potentially cause plugging or damage of down stream HEPA filters as a result of impaction from failed filters. Additionally, available data indicates that HEPA filters experience structural degradation due to the effects of age. The Unresolved Safety Question (USQ) compensatory measures thus require testing and analysis of used HEPA filters in order to determine and implement service life criteria.

Background

The current Site criteria for replacement of in-service HEPA filters is based on 1) pressure drop, 2) filter degradation over short time intervals, 3) stack sampling results, and (4) failed dioctylphthalate aerosol efficiency testing. This practice results in some filters remaining in place for unlimited periods of time. However, sufficient data does not exist presently on the Site or within the nuclear industry to support quantitative criteria for maximum HEPA filter service life. The Site has several plenums with filters that have been in service greater than five years. Some individual filters have been in service ten to fourteen years. M. W. First in his July 1990 report on filter systems at Rocky Flats recommended only a five year service life interval to preclude the effects of age degradation on the filtration system efficiency. Alternatively, First also advised that more frequent in-place testing could serve to certify the plenums for continuous service and potentially predict the point of failure. Unfortunately, both these solutions require Air Filter Technicians to enter potentially contaminated areas and therefore are labor intensive and costly. More frequent manual testing and replacement operations also conflict with Site waste minimization and radiological As Low As Reasonable Achievable (ALARA) goals. Gilbert [1] et al., have estimated the total cost for replacement, testing, and low level waste disposal for a failed filter at $3,000 per filter. The total cost for 40 filter-sized plenum stages is estimated at $240K for those buildings whose Operational Safety Requirements (OSRs) require efficiency testing of two stages. Therefore, any service life extension would have a significant realized cost saving along with the benefits of reduced worker risk and waste generation. This test plan will provide the technical basis for maximum service life criteria. The expected outcome is validation of the extended service life of HEPA filters well past five years.

A separate proposal has been written, but not funded, to evaluate remote testing apparatus for HEPA filters for implementation of a new test standard, ASTM F 1471-93. This proposal was also presented to the DOE Health and Safety organization. The remote testing apparatus would provide the capability for more frequent filter testing for validation of service life extension while at the same time reducing costs, employee radiological risk, contamination risk and waste.

Previous Work on HEPA Aging Effects

Components of a HEPA filter such as the binder that holds the glass fibers together in a sheet, separators, the organic sealant that glues the filter pack into the frame and forms a seal, the polymer gaskets, the frame, and the glass fibers themselves are subject to aging. Previous work by K. S. Robinson[2], et al., has examined aging effects on HEPA filters in-service for up to ten years. In their tests, HEPA filters were disassembled and the media tested. According to this report, the main cause of deterioration of the frames, separators, and sealant was due to chemical action. There was also evidence suggesting that the filtration efficiency of the glass fiber paper decreases with age due to deformation, vibration, and flexing experienced through normal use. Johnson and Beason [3] have performed some pressure testing using a tornado pressure pulse. This is a rapid pulse of air at a given pressure. HEPA filters that were in service for 13 to 14 years showed no loss in efficiency, but a significant decrease in filter tensile strength and water repellency. Neither of these studies attempted to define maximum service life criteria.

HEPA Filter Testing Plan

Approximately 40 filters of assorted service life and manufacturers will be removed from the supply plenums of Rocky Flats buildings. Eight filters from a plenum for Building 886 that was partially flooded will also be tested to establish the effects of water on HEPA filters. Finally, approximately five new filters will be tested for a baseline comparison. The above filters will be pressure tested to destruction. Unlike the Johnson and Robinson tests , the filters will be pressure tested as a whole unit utilizing a gradual increase in the pressure applied to the filter media until the point of rupture. This technique was selected to simulate the normal operating changes in pressure. This destructive test process will be video taped for future reference. While the filters are being destructively tested, controlled test parameters such as flow and pressure will be recorded along with pertinent environmental parameters. A laser particle size spectrometer utilizing diotcylphthalate aerosol challenge will be employed to determine filtration efficiency via measurement of the size and distribution of particles penetrating the filter media at each logged pressure. In addition, materials property testing will be performed on filter components. This includes evaluation of the filter media for water repellency and tensile strength as well as examining gasket material, adhesive, media binder and glass fiber structure for degradation. Tensile testing and burst testing requirements will be extracted from Military Specifications MIL-F-51068F Filters, Particulate (High Efficiency Fire Resistant) [4] and MIL-F-51079D Filter, Medium, Fire-Resistant, High-Efficiency [5].

A filter pressure testing apparatus will be designed and purchased. This apparatus will be configured to pressurize the test filter to the point of rupture. Provisions will be designed into the pressure testing apparatus to provide for efficiency testing through challenge aerosol injection and incorporation of upstream and down stream particle monitoring probes. Visual documentation will be accomplished by camera mounts for viewing the tested filter both upstream and down stream. Further monitoring will be accomplished by ports for temperature, relative humidity, flow, absolute pressure and differential pressure measurement. Also, measurement of downstream penetrating particles will be used as an indication of the exact applied pressure value at the rupture point.

Acceptance of the pressure testing apparatus will include verification of uniform test aerosol mixing and uniform air flow distribution across the face of the filter. A background particle test will be performed to verify the absence of leaks and proper seating of the filter in the test apparatus.

Appropriate hardware will be required for data acquisition and instrument control. A small amount of software may need to be developed to acquire the data and control the instruments.

Tentatively, testing of filters removed from operation will be performed in Building 371 or 559 due to the possible radiological contamination. New filters will be efficiency and pressure tested in the Building 442 Filter Test Facility. Portions of these tested filters will be removed for further laboratory materials property and degradation testing. The tested filters will be disposed of in compliance with applicable regulatory requirements.

<u>**Test Outline**</u>

The following steps will be performed on both used and new filters:

1. Record filter information.
    a) Serial number
    b) Manufacturer

c) Date of Manufacture

d) Service Life History (date of installation, service environment, etc.)

2. Visually inspect filter components using Section 3.3 of MIL-F-51068F as guidance and record condition.
   a) Gasket material
   b) Media
   c) Separators
   d) Adhesive

3. Perform pressure tests.
   a) Place filter in pressure testing apparatus
   b) Set air flow through filter at 1000 CFM
   c) Record environmental parameters
      i) Temperature
      ii) Relative humidity
      iii) Pressure
      iv) Flow
4. Measure initial filter efficiency via aerosol laser spectrometry
   a) Record environmental parameters
   b) Record penetrating particle counts
   c) Calculate filtering efficiency
5. Start video camera(s)
6. Perform pressure gradient tests
   a) Increase differential pressure on the filter in 1 inch increments over a chosen time interval step
   b) Record environmental parameters at each pressure step
   c) Track particle counts distribution for penetrating particles
   d) Continue graded pressure increase until filter ruptures
7. Remove burst filter and clean debris from test unit.
8. Remove samples for materials property testing
   a) Filter media
      i) Tensile strength
      ii) Water repellence
      iii) Media degradation, condition of binder material and glass fibers
   b) Gasket material
      i) Compression/Resilience

c) Adhesive/Sealant

d) Separators

9. Dispose of filter

The acquired data will be analyzed and presented in a final report to provide the technical basis supporting a maximum service life criteria for in-place HEPA filters at the Rocky Flats Environmental Technology Site.

References

1. H. Gilbert, et al., "Preliminary Studies to Determine the Shelf Life of HEPA Filters," Proceedings of the 23rd DOE/NRC Nuclear Air Cleaning Conference, July 25, 1994, CONF-940738, NTIS.
2. K. S. Robinson, et al., "In-Service Aging Effects on HEPA Filters," Proceedings of the Gaseous Effluent Treatment in Nuclear Installations, October 14, 1985, Graham & Trotman.
3. J. S. Johnson and D. G. Beason, "The Effect of Age on the Structural Integrity of HEPA Filters," Proceedings of the 20th DOE/NRC Nuclear Air Cleaning Conference, August 22, 1988, CONF-880815, NTIS.
4. "Military Specification, Filters, Particulate (High-Efficiency Fire Resistant)," MIL-F-51068F, Edgewood Arsenal, April 1988.
5. "Military Specification, Filter, Medium, Fire-Resistant, High-Efficiency," MIL-F-51079D, Edgewood Arsenal, February 1988.