Department of Energy
Washington, DC 20585

15 January 1998

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W., Suite 700
Washington, D.C. 20004

Dear Mr. Chairman:

This is in response to your letter to Secretary Peña dated October 30, 1997, which focused our attention on vulnerabilities associated with nuclear facility ventilation confinement systems. We acknowledge the need to complete a formal assessment of the safety vulnerabilities associated with ventilation filter degradation from wetting during fire system testing. Field Offices have been asked to evaluate and correct related problems. The enclosed "lessons learned" document is being promulgated to convey related lessons from the "Evaluation of High Efficiency Particulate Air Filter Service Life" study, the various bypass leakage studies, and considerations of firefighting strategies and system test strategies. An improved qualification test program for certification of nuclear ventilation filter materials will be initiated by promulgation of a technical standard and establishment of a test laboratory. Each of these actions will be tracked as commitments with projected completion dates in the Department's Safety Issues Management System, which is managed by the Department Representative to the Defense Nuclear Facilities Safety Board.

Sincerely,

Alvin L. Alm
Assistant Secretary for
Environmental Management

Enclosure

cc: Mark Whitaker, S-3.1

NUCLEAR VENTILATION HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTER LESSONS LEARNED

January 14, 1998

The following lessons relate to non-reactor nuclear facilities that use HEPA filters for confinement of particulate radioactive materials. This notice is intended to stimulate application of judgement in evaluating confinement hazards and in determining appropriate operational controls.

1. **The fiberglass "paper" media that provides filtration in ventilation filters is subject to embrittlement with age.**

   This is of concern because many old filters remain in service in DOE Nuclear facilities where they provide an important filtration safety function under normal operating and accident conditions.

   Even pinhole leaks in these filters can reduce their filtration of the small particles of greatest health concern (plutonium and uranium oxides). Filters are expected to remove no less than 99.97% of respirable particles, and are sometimes credited with accident effectiveness approaching that efficiency. Cracking of old filters has been observed at the accordion folds where fibers are most stressed after the media was removed on disassembly. (This implies embrittlement, but not necessarily that the cracks existed before disassembly while the filters were in service.)

   Efforts to quantify the filter media strength reduction with age were frustrated because other factors had potentially greater effects. Limited evidence suggests that filter media tensile strength and water repellency may reduce with age. The uncertainty associated with filter reliability under accident conditions that might stress both strength and filtration performance is a matter of concern because of the relatively great reliance upon these potentially fragile safety components. Existing filter plena designs typically have multiple stages of filtration, which may provide redundancy for both filtration and strength performance of the safety function. Still, there is concern over the potential for common mode failures or undetected single stage failures of filtration.

2. **It is not apparent what service or manufacture age merits replacement of HEPA filters.**

   Several factors affect need for filter replacement, including dust loading (differential pressure), weakening from exposure to water or acid, physical damage, etc. Conservatively early replacement based on age alone may not be merited because of cost, replacement activity personnel radiation exposure, and waste generation concerns. However, degradation of filter strength with age remains a concern, although age may not be limiting and age effects have not been adequately quantified.

3. **Study and test evidence shows that service life or aging effects are masked by other factors affecting filter performance.**

Clearer effects result from exposing filter media to water, and variability in the quality (manufacture) of filter materials.

4. **Thoroughly wetting HEPA filter media, even once, substantially degrades filter strength** and could reduce resistance to media breach. This is a special concern under fire or explosion accident conditions.

One-time thorough wetting (15 minute soak) and drying of filter materials can reduce filter strength by as much as 60%. Additional wetting further reduces material strength.

Dust loading of filters also contributes to strength reduction, and combined dust and wetting are a still more serious cause of degradation.

Each of three serious fires in plutonium facilities at Rocky Flats (1957, 1969, 1980) resulted in significant damage to filter systems, either from media pack blowout, media burn (in 1957, filters were made of cellulose media, since replaced with fiberglass that resists ignition), media pack glue or filter housing gasket melting, fire water sprayed on filters, smoke clogging of filters, or a combination. One fire presented visual evidence of confinement breach and release of smoke to the environment.

Two fires resulted in plenum explosions/deflagrations of combustible gasses, damaging and igniting filters. One explosion occurred after the main fire was extinguished.

Two fires melted the glue holding the filter media pack to the filter frame, and resulted in a filter media pack blowout.

Securing fans while fighting fires resulted in loss of negative differential pressure confinement and significant facility contamination in two fires.

5. **Testing of filter plenum fire suppression systems should be performed in a way that does not directly expose filter media to wetting.**

Direct water spray on filter surfaces can contribute to filter clogging, increased differential pressure, and media breach, as well as reducing media strength.

Wetting of filters has resulted from periodic testing of fire suppression systems that directly spray on filters. Test methods should be reviewed and revised as appropriate to assure that filter reliability and functionality requirements for accidents are met.

Common plenum configurations at Rocky Flats include automatically (heat) initiated water sprays which are separated from filters by a demister, and manually initiated deluge which sprays directly on a first bank of filters. Both spray systems have been periodically tested by spray actuation to assure that nozzles are not clogged and spray patterns are properly directed, per the National Fire Protection Association code requirements. Testing of the manual deluge system has resulted in periodic wetting and consequent strength degradation of the first stage of filtration. This stage is not credited for public protection in some cases, but it is still considered for defense-in-depth.

6. **Local emergency response planning should consider employment of ventilation confinement systems in fire prevention and fire-fighting within non-reactor nuclear facilities, especially if wet fire suppression systems are used in filter plena.**

Fire-fighting strategies should be thought through, and fire brigade and emergency management personnel should be trained in them.

Preplanned guidance and training for fire-fighting should include consideration of:

a. Whether to secure ventilation fans to reduce potential for facility emissions, or to preserve filtration or rather to keep them running to eliminate combustion gasses and reduce facility contamination,
b. Whether to manually initiate plenum deluge flows to cool gasses and scrub smoke or to avoid deluge to minimize filter damage,
c. How (on what information basis) to control ventilation flow and plenum entry,
d. Relative priority for extinguishing fire, preventing explosions, preventing release or spread of contamination, and removing smoke as a personnel hazard or encumbrance to firefighting.

7. **The DOE should institute improved filter material and vendor qualification testing to improve vendor quality control of filter materials.** Changing some filter material specifications may also be merited.

Non-compliance with technical specifications for filter materials, and large variations in materials provided, have been observed. Quality control and assurance of filter materials are inadequate for the DOE nuclear confinement application, and technical specifications for materials may need revision.

Filter vendor qualification program effectiveness has been questioned, and no qualification testing has been performed for two years.

DOE Headquarters is taking steps to restart an improved vendor material qualification program. Revision of technical standards is being considered.

8. **Evaluation of existing ventilation systems revealed that even minor leakage paths (such as seal leakage on fan seals or damper linkages) into the systems between filters and fan suctions have potential to measurably increase exhaust emissions.**

One site assessed the impact of as-built leakage from system penetrations should rooms in which the ventilation equipment is located experience high airborne contamination. Exhaust of this contamination would be diluted to not more than a few percent of the room airborne levels. No public health effects are expected. One preventive action has been to limit storage of material that could result in room contamination. Accident analysis should determine whether operational limitations on storing materials in the rooms containing these components may be necessary.

Testing and inspection has been used to identify bypass leakage paths around exhaust filtration systems. One test method used to identify potentially significant leak paths has been visual observation of smoke generated near such components for evidence the smoke is being sucked into the ventilation exhaust. While this method is not quantifiable, it seems to be more practical and sensitive than alternatives.

Some significant plutonium facilities have conducted determinations whether bypass leakage and filtration function effectiveness (potentially scenarios or conditions not previously analyzed) represent unreviewed safety questions.

9. **Safety analysis for facilities relying upon filters for confinement function should consider accident scenarios and failure modes that account for filter stage or cascade effects on entire plena caused by major fire accidents** wherein:

a. Smoke clogs filters and increases differential pressures.
b. Filter media are weakened and subject to breach under elevated differential pressures.
c. Heat in filter plena causes failure of adhesive which binds filter media pack to frame. Media pack blows out, potentially resulting in debris damage to downstream filter stages.
d. Fire scenarios could release combustible gasses that could explode or deflagrate in ventilation ducts or plena, as from mixing with oxygen from other ventilation paths.
e. Evaluation of even small leakage paths may be appropriate for material release scenarios resulting in airborne radioactivity surrounding ventilation components/ducts under reduced (negative) pressure and downstream of filtration.

Safety analysis of facility fire scenarios may not have considered the potential reliability of filtration functions under major fire accident conditions that might cause filter function degradation. Sensitivity of accident consequences to the effectiveness of filtration is significant; often six or more orders of magnitude reduction in release are credited for

filtration. Filtration degradation or failure mechanisms may not be known or understood by analysts.

Where fire suppression plenum deluge wets only a first stage of a plenum, even if wetted filters are not credited with a filtration safety function they may have a function of protecting downstream credited stages of filtration by limiting their dust/smoke loading and water exposure, e.g., enhancing credited stage reliability.

Consideration should be given in accident analysis to the potential for cascading effects of major fires on stages of filtration, e.g., breach of a weakened first stage could enable clogging or ember carryover to a next stage. Such consideration is equivalent to evaluating the reliability of the credited filtration function.

These lessons were derived from multiple sources:

A recent study of effects of service applications on HEPA filter performance, including results of destructive and nondestructive filter testing. ("Evaluation of HEPA Filter Service Life," July 14, 1997, J. K. Fretthold, A. R. Stithem, R. M. Suyama, at Rocky Flats.)

The related lessons learned from three serious fires in plutonium facilities at Rocky Flats over past decades. ("Nuclear Facility Ventilation and Plenum Deluge System Operation During Fires," November 12, 1997, Rocky Flats, and "Potential for HEPA filter damage from water spray systems in filter plenums," Bergman, Fretthold, Slawski, presented at the 24th DOE/NRC Nuclear Air Cleaning Conference.)

The results of filter bypass leakage inspections and analyses performed at several DOE plutonium sites.

Expert consensus conclusions regarding vulnerabilities of confinement filter plena to media rupture in fire accidents.

This document was prepared by K. Juroff, 301-903-4989, with the collaboration of J. Slawski, 301-903-5464, and numerous inputs from the community of related experts.