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Department of Energy
Washington, DC 20585

APR 27 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:

In response to your letter of March 26, 1998, a report of actions being taken to address vulnerabilities from ventilation filter degradation is attached. Additionally, a memorandum tasking field evaluation of safety vulnerabilities, caused by wetting High Efficiency Particulate Air (HEPA) filters, was signed on April 13, 1998. A copy is enclosed for your information.

Efforts to address concerns expressed in your letter of October 30, 1997, have been ongoing. Informal questioning in December 1997, revealed one field office, the Rocky Flats Environmental Technology Site (RFETS), was intentionally wetting HEPA filters by testing of manual fire suppression systems. An Unreviewed Safety Question was declared for three facilities at RFETS, and the contractor has been directed to defer wetting the filters credited by safety analyses, pending resolution of fire suppression system test methods. The occurrence report, cited in the Board's letter of March 26, 1998, related to accidental initiation of the automatic fire suppression subsystem.

I share the Board's belief that protection of the public, workers and the environment is of paramount importance and recognize that HEPA filters are a crucial barrier in protection from release of airborne particulate nuclear materials.

Sincerely,

James M. Owendoff

James M. Owendoff
Acting Assistant Secretary for
Environmental Management

Enclosure
cc: Mark Whitaker, S-3.1

Printed with soy ink on recycled paper

Department of Energy Report of Corrective Action
Nuclear Facility Ventilation High Efficiency Particulate Air (HEPA) Filter Wetting

This report is prepared for response to the Defense Nuclear Facilities Safety Board (Board) as required by their letter of March 26, 1998. The content of this report directly addresses the information requested in the Board letter:

Specific actions by DOE for:

1. Completion of a formal assessment of vulnerabilities associated with ventilation filter degradation from wetting during fire system testing.

A memorandum tasking field review of this concern is attached. The tasking requires a report to headquarters by September 30, 1998, which addresses the scope of vulnerabilities, specifically:

- What nuclear facilities have performed fire suppression testing (or other activities) which wet safety filters,
- Whether such testing and degradation represents potential inadequacies in procedures, configurations, or risk assessments, and
- Completion of a review of fire-fighting strategy.

The tasker requires local review of firefighting guidance and training for emergency response personnel as they relate to vulnerabilities of ventilation confinement systems. This is intended to ensure that they appropriately address coordination of safety concerns for emergency response personnel with concerns for control of fires, and release of radioactive materials to the workplace, the public and environment.

The tasking requires local determination and implementation of appropriate corrective actions. The Department is aware that there is some diversity of thought on the best means to address related concerns. Many facility specific concerns might apply to selection and prioritization of the appropriate corrective actions. Therefore, local DOE authorities are best situated to ascertain appropriate corrective actions.

A discussion below addresses actions at Rocky Flats. There may be no other sites which wets nuclear safety ventilation filters. An informal poll of fire protection personnel from DOE field activities identified no other sites with this vulnerability. A more formal assessment is tasked to provide greater assurance that the response is adequately researched and that managers are aware of the related concerns. Reporting of this assessment will permit DOE Headquarters to determine whether additional inquiry or generic problem analysis is appropriate. If generic problems are identified, further feedback is expected consistent with the Department's implementation of Integrated Safety Management Systems (Board Recommendation 95-2).

Commitments:
1.A. Field activities report results of vulnerability assessment by Sep 30, 1998.
1.B. DOE determine whether there is need for additional generic analysis and action within 30 days of receipt of (all) site reports.

Attachment: (1) DOE (EM, DP, NE) memo of April 13, 1998, to Distribution, "Evaluate Safety Vulnerabilities Relating to High Efficiency Particulate Filter Degradation"

2. Evaluation and correction of the problem by field offices,

The Rocky Flats study on HEPA filter service life concluded that wetting filter media posed potential for significant filter strength degradation, and provided some fundamental quantification of effect. Some degradation due to environmental factors, including moisture, has been understood for decades, and has been considered in development of technical specifications for filter materials. The study suggested that the magnitude of degradation might exceed that for which technical procurement specifications had accounted. Further, it suggested that degraded filter failure modes might involve significant reduction in filtration efficiency. The underlying concern is whether nuclear facility activities adequately account for such considerations in hazard assessments and decisions on related maintenance and controls, such as fire system testing and filter replacement. Whether this concern applies for a given facility, and within a facility for a specific filter (plenum and stage) might not depend solely upon the (uncertain) magnitude of strength degradation, and whether it exceeds the magnitude accounted for in development of technical procurement specifications. It might also depend upon filter safety function, the magnitude of dependence upon filtration in various modes of operation and accident conditions, other configurations or procedures mitigating scenarios of concern, etc.

Whether or not to test plenum deluge systems in a way that wets filters involves both a compliance issue and a safety evaluation judgement. Department of Energy Directives invoke National Fire Protection Association code, which generally requires such testing, both to verify system operability and spray patterns. Directives make provision for federal fire protection engineers to approve equivalencies or exemptions if it serves safety interests. Such determinations involve a balancing the significance of testing to assure system reliability based on design features, operating experience and problems, against the significance of potential filter degradation.

Ventilation system fire suppression configurations typical of the plena of concern at Rocky Flats include three functional components: an automatic sprinkler system which uses heat sensors to initiate sprinkler mist into a heat chamber upstream of the HEPA chamber (and separated from the HEPAs by a demister filter of metal construction), the demister, and a manually initiated sprinkler system which sprays on first stage filters to suppress fire if initiated in them or to extinguish any embers passed by the demister. See the attached schematic figure. The automatic system cools gasses and removes some particulate matter (smoke and water). The demister removes particles, especially larger particles which might be burning, and water droplets.. The manual system is needed to extinguish fire flash over to the filters on which it sprays, and to further cool gasses. It helps preclude need for firefighters to enter plena. The occurrence report cited in the Board's letter of March 26, 1998, related to accidental initiation of the automatic subsystem, which does not significantly wet filter media, and is not expected to cause the degree of wetting evaluated in the testing which initiated this concern (15 minute soak and/or saturation).

As the series of Board letters and DOE responses on ventilation systems have suggested, field determination of appropriate local actions is complemented by expert consensus efforts to revise technical standards and enforce intended manufacturing quality controls. Operational concerns relate to the consensus judgements that are represented in the technical standards for design, procurement and operation of safety significant ventilation systems and components. Industry and Department technical standards for nuclear ventilation HEPA filters are being revised and regenerated in response to these concerns. In the process of revising standards, experts are considering the import of evolving technology, the differing approaches taken within this country and others to the issues, and the diversity of dependence upon confinement systems as facility missions change. Regeneration by DOE of a related (Department of Defense) procurement quality control process which assures that vendors meet the standards, the Quality Products List (QPL) testing requirement, is important and is stipulated in revised standards. The Department's Plutonium Ventilation System Study Report, forwarded to the Board by Secretary of Energy letter of March 15, 1996, identified technical standard revision commitments. Two DOE Technical standards have been revised to date. The Department is also preparing a revision of the Nuclear Air Cleaning Handbook and has provided a draft to the Board staff for comment.

For existing nuclear facilities, if filters have been wet, the most appropriate corrective actions are determined by a confluence of concerns. Action decisions should not be made based on wetting concerns in isolation, but should reflect the related concerns for risks and implications of water or dust/smoke loading of filters during fires, management of ventilation flows and filter differential pressures, risk of degrade of confinement function without active ventilation (negative pressure confinement), ALARA concerns for worker radiation exposures, etc. The interdependence of such related factors cause local DOE authorities to be best suited to determine operational resolutions.

The Rocky Flats disposition of their related Unreviewed Safety Question (USQ) has been informally reviewed by headquarters EM staff, and field office engagement is considered adequate and appropriate to resolve operational concerns. Authority to approve the USQ, and accept related risks, had previously been delegated by the Assistant Secretary for Environmental Management to the Manager, Rocky Flats Field Office. The Rocky Flats process identified USQs for specific filter plena and stages in Buildings 371, 707 and 559. In these facilities, the potential for malfunction of some first stage filtration which had been wet had not previously been considered in evaluating risks from major fire accidents (Building Leak Path Factors accounted for two stages of filtration). Reduction in the analyzed margin of safety was reported for two of the buildings. No compensatory actions were identified, but the Rocky Flats Field Office has directed contractors to defer wetting filters for a period (3 years from last test) sufficient to resolve how best to modify testing requirements for the manually initiated systems which wet filters. Department fire protection engineers have informally concluded that some exemption to the NFPA code test requirements may be appropriate in this case and may be provided to resolve the testing issue. The contractor has been directed to provide their plan for resolution of deluge system testing questions to the field office by June 30, 1998.

The Rocky Flats Field Office has also directed the contractor to include in their resolution a plan for replacement of previously wet filters, or a justification for not replacing them. The evaluated incremental risk from major fires in the affected facilities met site risk acceptance criteria, and

was approved by Manager, Rocky Flats Field Office. Filter performance is periodically verified by efficiency testing in-place to reasonably assure that routine operational exhausts meet safety analysis criteria. Building exhausts are monitored for radioactive particulate contamination as well.

Commitment:

2.A. RFFO approve plans for wetted filter replacement and plenum manual deluge testing procedures by July 31, 1998.

Note: The Department of Energy Plutonium Ventilation System Study Report of February 1996, forwarded to the Board under Secretary of Energy letter of March 15, 1996, identifies commitments for revision of technical standards.

Ref:
a. "Evaluation of HEPA Filter Service Life" , RFP-514, July 14, 1997, J. Fretthold, A. Stithem
b. "Nuclear Facility Plenum and Deluge System Operation During Fires", Nov 12, 1997, Rocky Flats
c. "Potential for HEPA Filter Damage from Fire Protection Systems in Filter Plena", 24 DOE/NRC Nuclear Air Cleaning and Treatment Conference, July 1996, W. Bergman,J. Fretthold, J. Slawski
d. DOE Order 420.1 and Implementation Guide, Fire Safety Program
e. NFPA standard 25, Inspection, Testing and Maintenance of Water-Based Fire Protection Systems
f. DOE-STD-3020-97, Specifications for HEPA Filters used by DOE Contractors
g. DOE-STD-3022-98, DOE HEPA Filter Test Program
h. MIL-F-51079D, Filter Medium, Fire-resistant, High-efficiency
i. Board letters of Feb 1, 1994, June 15, 1995, July 21, 1995, October 3, 1996, December 5, 1996, October 30, 1997, February 9, 1998, and March 26, 1998, all relating to nuclear facility ventilation systems.
j. DOE letters of July 16, 1996, and January 15, 1998, which responded to DNFSB suggestions.
k. Kaiser-Hill L.L.C. memo of February 19, 1998, USQ - Degraded HEPA Filters, Rev. 1 - GMV-065-98.
l. RFFO memo to Kaiser-Hill, L.L.C. of April 24, 1998, RFFO Disposition of HEPA Filter USQ/Issues

Attachment: (2) Figure - Typical Plenum Deluge System

3. Promulgation of the "lessons learned" document,

The lessons learned document was forwarded to the Board with the DOE letter of January 15, 1998. It was sent to all DOE Lessons Learned Coordinators and other interested parties via the DOE Lessons Learned List Server on January 18, 1998. It was placed on the Internet web site for DOE Lessons Learned Information Services in April 1998 (http://tis-hq.eh.doe.gov:80/ll/ll.html). The concern had previously been promulgated in part by Operating

Experience Weekly Summary 97-34, which is also available by Internet (http://tis.eh.doe.gov/web/oeaf/oe-weekly/oe-weekly.html.) The lessons learned was also attached to memo requiring field vulnerability assessment (attached), which went to DOE field managers. Thus, both standard feedback mechanisms and management attention have been invoked in this case.

4. Improvements in the qualification test program for certification of nuclear ventilation filter materials.

Edgewood Laboratories at Aberdeen, MD has informally continued the QPL test program and vendor product certification at vendor request and expense, with DOE encouragement. They have continued to provide this service to support all nuclear filter procurements, but the process must be formalized to assure its intended implementation by both vendors and filter procurement activities. Questions relating to applicability of vendor indemnification under the Price-Anderson Act, and applicability of the Price-Anderson Amendment Quality Assurance Rule (10CFR830.120) may require resolution to complete this action. The QPL program expectations must be formally documented and promulgated to procurement authorities. Included in that documentation is to be an expectation that materials to be tested for vendor certification will be selected by independent test representatives at random, rather than by the vendors as before. Implementing plans and methods are being negotiated by DOE.

Commitment:

4.A. Initiate an improved qualification test program for certification of nuclear ventilation filter materials by December 1998.

DOE F 1325.8
(8-89)
EFG (07-90)

Attachment 1

United States Government **Department of Energy**

memorandum

DATE: APR 13 1998

REPLY TO ATTN OF: EM-64 (K. Juroff, 301-903-4989)

SUBJECT: Evaluate Safety Vulnerabilities Resulting from High Efficiency Particulate Air Filter Degradation

TO: Distribution

Many of the Department's nuclear facilities rely heavily upon the effectiveness of High Efficiency Particulate Air (HEPA) filters in ventilation systems to protect public, workers and environment from routine operational or accidental release of airborne particulate nuclear materials. As indicated in the attached lessons learned document, recent information suggests that such filters could degrade substantially if exposed to wetting.

For each nuclear facility where HEPA filters provide a credited safety function, please determine whether the filters have been subject to wetting. If filters have been wet, please review whether a safety function is impaired and take corrective action. Reviews should include the related guidance and training provided to emergency response personnel and firefighters to ensure that fire fighting strategies reflect the appropriate use of ventilation systems during fire accidents in nuclear facilities. Problems identified in these reviews should be corrected using existing corrective action programs.

By September 30, 1998, please report the results of the reviews for nuclear facilities under your cognizance. Reports should be sent by memorandum to the cognizant headquarters Principal Secretarial Officer, copy to David Huizenga (EM-60). They should describe whether credited safety system filters have been subject to wetting and whether that represents a potential inadequacy in the existing procedures, configuration, or risk assessment.

If you have any questions concerning the review requested by this memorandum, or to receive copies of the documents cited in the attached lessons learned, please contact Mr. James W. Slawski, DP-45 (301-903-5464).

James M. Owendoff
Acting Assistant Secretary for
Environmental Management

Victor H. Reis
Assistant Secretary
for Defense Programs

Terry R. Lash
Director
Office of Nuclear Energy,
Science, and Technology

Attachment

Distribution:
Jessie Roberson, Manager, Rocky Flats Field Office
Greg Rudy, Acting Manager, Savannah River Operations Office
John Wagoner, Manager, Richland Operations Office
James Hall, Manager, Oak Ridge Operations Office
Jack Craig, Director, Fernald Area Office
John Browne, Director, Los Alamos National Laboratory
C. Bruce Tarter, Director, Lawrence Livermore National Laboratory
John Wilcynski, Manager, Idaho Operations Office
John Kennedy, Acting Manager, Chicago Operations Office
Bruce Twining, Manager, Albuquerque Operations Office
Bob Foler, Deputy Manager, Ohio Operations Office
Gerry Johnson, Manager, Nevada Operations Office
James Turner, Acting Manager, Oakland Operations Office

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

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 better judgement in evaluating confinement hazards and in determining appropriate operational controls. DOE Headquarters is assessing mechanisms for institutionalizing these lessons learned in standing guidance.

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) have 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 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 (general) 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 specification 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 specification 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 impact of as-built leakage from system penetrations should rooms in which this equipment is located experience high airborne contamination. Exhaust of this contamination would be diluted to not more than a few percent of the airborne room 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 have 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 Unreviewed Safety Question evaluations of bypass leakage and filtration function effectiveness (accident scenarios not previously considered).

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 function 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 degrade 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.

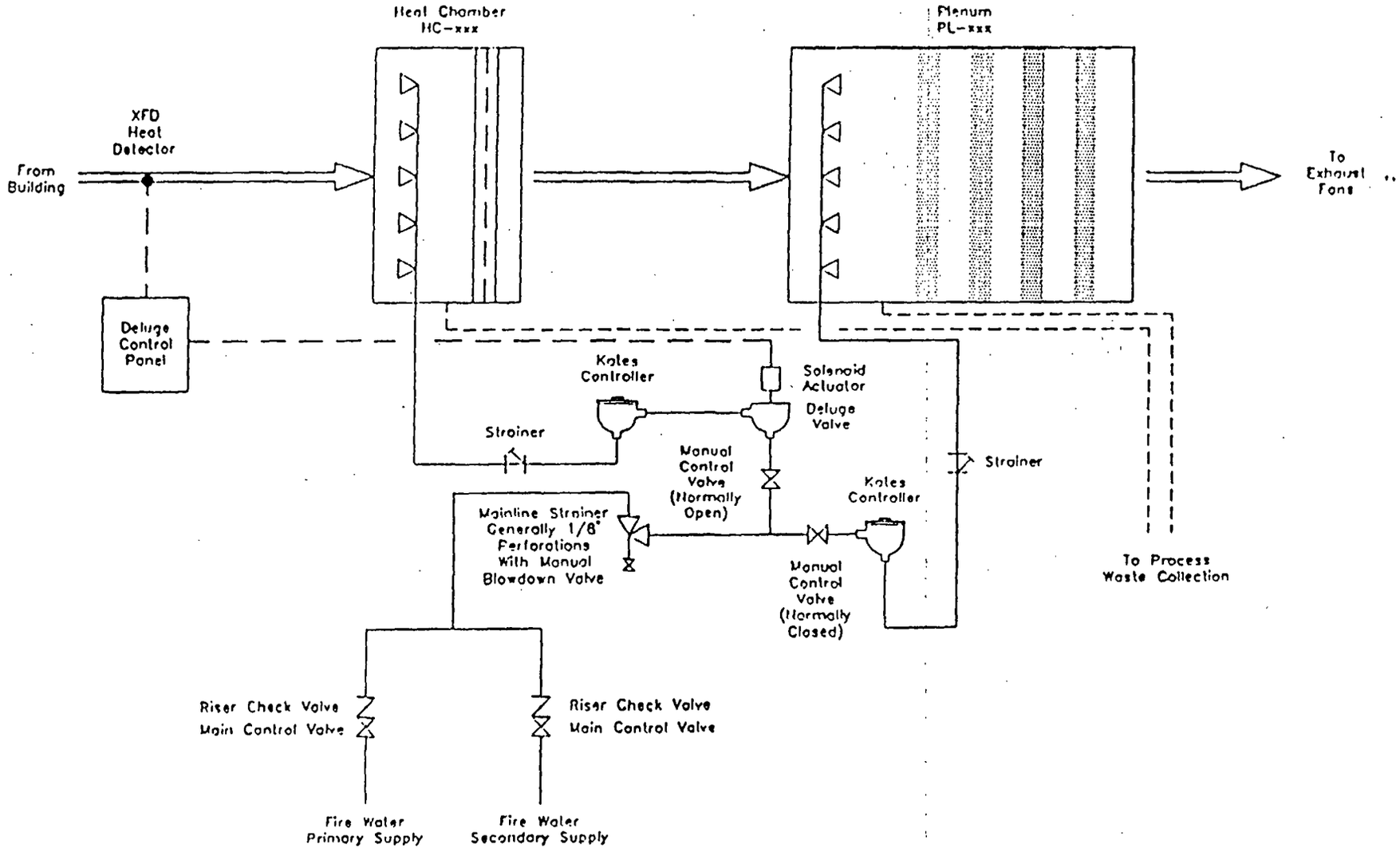

Figure 1

Attachment 2