SESSION 5

STANDARDS AND REGULATIONS

TUESDAY: August 19, 1986
CHAIRMAN: W.H. Miller, Jr.
Sargent & Lundy Co.

OPENING COMMENTS OF SESSION CHAIRMAN MILLER

Since the last Air Cleaning Conference in Baltimore two years ago, we in the nuclear air cleaning business have been experiencing an upsurge of activity, energy, and interest in regulations, codes, and standards. This has come at a time when the nuclear power industry is generally not vigorous, as far as new design goes. The prediction that we would have trouble keeping people involved in standards and regulations has not come to pass. Construction of our third generation of commercial nuclear power plants has progressed through the testing phase of nuclear air cleaning systems, and we now know that we only need to keep the communication lines open to tap the wealth of knowledge that exists in the hands of the users. This session fully opens the communication lines between the standards and regulation writers and the users.

In this session we will hear eight papers, seven by active ASME CONAGT Committee Members. I have to make a statement that will keep four of our presenters from having to make a disclaimer. ASME has a disclaimer that they would like me to read. I will paraphrase it. What it basically says is that this morning you are going to hear papers that concern proposed changes in standards and codes currently under consideration. Because we are involved in an ANSI consensus code process, we will be going through a number of different stages of review. What will be said here is our current intention as a committee, but the final code and standard may be a little different because of the approval processes.

Our first paper concerns workshops that CONAGT held in 1985 to obtain feedback from standards users. Three papers concern CONAGT's efforts to incorporate this effort into our ANSI/ASME N-509,N-510, and Gas Processing standards and codes. Two papers presented by professional nuclear air cleaning field testers will give us a testers' perspective on various issues related to field test methods and misapplications of some of these standards. Lastly, two papers will give us an NRC regional staff perspective on the issues and the potential deficiencies in the literature and various system applications. This is a power packed lineup of practical papers.

REPORT ON THE 1985 CONAGT FIELD TESTING WORKSHOPS

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Abstract

In 1985 the ASME Committee on Nuclear Air and Gas Treatment Equipment (CONAGT) held two workshops on the field testing of nuclear air cleaning systems. The primary goal of the workshops was to provide the users of ANSI/ASME N510 "Testing of Nuclear Air-Cleaning Systems" and ANSI/ASME N509 "Nuclear Power Plant Air Cleaning Units and Components" an opportunity to provide input to the standards writers on changes needed to reduce implementation problems. The result was a forum to discuss the design and testing of nuclear air-cleaning systems that drew a combined attendance of over 100 professionals. CONAGT received valuable input for the revision of ANSI/ASME N510 and N509 as well as input that has been used for the development of other CONAGT codes and standards.

An important by-product of the workshops was the opportunity for the attendees to meet with a cross section of their industry peers to discuss problems and solutions. Previously few opportunities existed for this type of needed communication in the area of nuclear filtration. CONAGT took a bold step in initiating this practical type of interchange in an effort to better understand the needs of the industry it was organized to serve. CONAGT plans to continue this type of direct industry contact and is recommending that the Board on Nuclear Codes and Standards encourage other nuclear code and standard writing committees to follow suit.

The workshops were organized into multiple round table discussions on the following topics: ASMI/ANSE N510 & 509 Revisions, Source Term Implications, Regulatory Concerns, Field Testing of Nuclear Air Cleaning Systems, Operation and Maintenance of Nuclear Air Cleaning Systems and Field Testing Personnel Training. Significant information from each of the round table summaries is discussed with an emphasis on the practical aspects of designing and testing nuclear air-cleaning systems.

I. Introduction

In 1985 ASME's Committee on Nuclear Air and Gas Treatment (CONAGT) established a first in code and standard development. Sensing the changing needs of the utility industry it serves, CONAGT organized two open workshops on the field testing of Nuclear Air Cleaning (NAC) systems. These workshops provided participants an opportunity for face to face dialog with the authors of the codes and standards. The workshops were held on the east and west coast to encourage maximum industry participation at a reasonable cost. Combined attendance totaled 112 people representing design engineers, manufacturers, regulatory agencies, consultants, construction firms, and end users of NAC systems.

II. Workshop History

CONAGT was chartered by ASME in 1975 to "develop, review, maintain, and coordinate codes and standards for design, fabrication, installation, testing and inspection of equipment for nuclear power plant air and gas treatment systems." Before the chartering of CONAGT, the American National Standards Committee N45 had largely completed two standards on the design and testing of air and gas cleaning systems for nuclear facilities. These two standards became the responsibility of CONAGT and were designated N509-1976 "Nuclear Power Plant Air Cleaning Units and Components"(1) and N510-1975 "Testing of Nuclear Air Cleaning Systems"(2). N509 and N510 have since undergone one maintenance revision in 1980 and were due to be reaffirmed or revised in 1985 according to ANSI procedures. CONAGT's original plans were to replace N509 and N510 with the CONAGT code AG-1. The delaying of the complete issue of AG-1 necessitated consideration of the maintenance revisions.

When the possibility for a second revision became known, users in the industry showed considerable interest in contributing. The revision was an opportunity to use the previously unavailable operating experience with N509 systems to refine the two standards. In response to the interest expressed by the industry, the Main Committee of CONAGT proposed that a workshop be used as the mechanism for input. The idea was so well received that two workshops were held yielding benefits well beyond the original intent.

The first workshop was held on the west coast in Los Angeles, California on February 16, 1985. The second was held on the east coast in Charlotte, North Carolina on April 22 & 23, 1985. Both workshops centered around six main topics pertaining to the design, operation, testing, and maintenance of NAC systems. Each topic had one or two moderators that would give an introductory statement on the topic and then host a round table discussion. Round tables were attended by a cross section of the industry where participants had an opportunity to ask questions and provide input. At the end of the round table sessions summaries were given by the table moderators. The conclusion of the workshop was followed by a comprehensive summary that was mailed to all the attendees. As planned this summary became a significant source of input for the maintenance revisions of N510 and N509 which are expected to be issued in 1986 or early 1987.

III. Round Table Results

Some of the more significant information from each of the round table topics were condensed and are listed by round table title in the subheadings below.

ANSI/ASME N509 & N510 Maintenance Revisions

Both of these standards are currently being revised to incorporate new information, provide clarification, and resolve conflicts between N509 & N510. A significant number of comments were received ranging from changing definitions to modifying the basis of the standards. Six of the comments are described below.

Requirement for Downstream HEPA Bank. The need for a second bank of HEPA filters downstream of the carbon filters was questioned. A second HEPA bank was originally intended to catch carbon fines from the carbon adsorber bank and would provide the additional benefit of backup for the primary HEPA bank. The argument was presented that HEPA filters are unnecessary overkill for filtering carbon fines. Carbon fines are typically in the 5 to 10 micrometer range and could be easily be captured by high efficiency dust filters with significantly less pressure drop.

It was also noted that carbon fines have not become the problem they were predicted to be. Activated carbon meeting the specifications outlined in N509 does not generate significant fines. Small quantities of fines result from loading the carbon into the filter housings but are quickly removed by the air flow in the first few minutes of operation.

Fire, Painting, and Chemical Release. Incorporate guidance on the effect of fire (smoke), painting, and chemical release on activated impregnated carbon. Regulatory Guide 1.52 Rev. 2(3) requires in-place testing if any of the above releases occur in any ventilation zone communicating with the filter system. The question remains as to how much fire, painting, or chemical release is required to affect the carbon (e.g. Does smoking a cigarette constitute a fire?).

Through discussion it became clear that most of the participants were convinced that more research needs to be done to quantify the effects of contaminants on carbon. The results of that research and the present knowledge should be incorporated into N510.

Ideal Versus Actual N509 Design. A great deal of concern was expressed over whether the standard for testing (N510) should address only "ideal" N509 design NAC systems; or should guidance be provided for testing systems that don't meet the performance capabilities of "ideal" N509 design systems. It was generally agreed that a majority of NAC systems now in use are not "ideal" N509 systems. Users of N510 desire practical guidance to enable them to perform the necessary testing. CONAGT will attempt to provide this kind of practical guidance in the appendix of N510.

Expand Scope of N509/N510. Attendees not affiliated with nuclear power plants expressed the desire to expand the scope of N509/N510 to include other nuclear facilities such as fuel processing. CONAGT members responded to this suggestion by stating that expanding the scope would require CONAGT charter revisions. There is considerable resistance to expanding the charter to avoid further complicating these standards. It was suggested that other facilities could use N509/N510 to develop their own guidelines.

Clamping/Mounting Requirements. Clamping/mounting devices are not addressed in the current revisions of N509/N510. Clamping/mounting devices need to be added due to the potential of component test failure due to poor design. Inadequate clamping has been a source of failure for in-place leak testing when the clamping devices are unable to provide the proper gasket compression on the filter to frame seal.

Laboratory Testing of Carbon. Used carbon laboratory testing criteria are specified in Regulatory Guide 1.52 Rev. 2 but are not covered in N509. It was recommended that N509 should either directly refer to the Regulatory Guide or state that the requirements are plant specific and are established between the utility and the regulator.

New Source Term Implications

Source Term was included in the workshop because of the potential effects that new source terms could have on the assumptions for radioactive releases and therefore the type and efficiency of filtration required.

Source Term is defined as the amount and type of radioactive materials that would be available for escape to the environment from a reactor which has undergone a severe reactor accident. Current assumptions on source terms used for light water reactor siting evaluations were established during the early sixties. These assumptions were developed using calculations and data from graphite moderated reactors. The effects of reactor design, fission product chemistry, and aerosol behavior were not considered. The key factor that was not considered was the role of water or steam in limiting the release of fission products, especially iodine. Accident records and destructive tests in light water reactors to date show that no more than 0.5% of the available iodine has ever been released to the atmosphere versus the 50% release assumptions used for siting evaluations.

The impact of these finding on nuclear air filtration could mean the elimination of carbon adsorbers on some air filter systems. However, source term reevaluation work is far from complete. Work remains to complete a thorough review of all accident mechanisms. Post accident release of organic iodine was cited as one example where additional work is required.

In some areas the current source term studies have been sufficient to justify regulatory relief. In one case of control room habitability retrofit, relief given for iodine thyroid dose resulted in not having to install two new engineered safety filter trains at an approximate cost savings of $900,000.

It was suggested by one attendee that if carbon adsorbers are removed from a system, the space could be used for an additional HEPA bank if needed.

Regulatory Concerns

Temporary Sealants. The regulatory topic raised by the greatest number of attendees concerned the use of temporary sealants in ductwork on ESF (engineered safety feature) and non-ESF systems. Due to the widespread use of temporary sealants, it was suggested that some of the sealants should be qualified as permanent. No general guidance has been developed on the use of such materials. The NRC is reviewing the use of temporary sealants on a case-by-case basis, taking into account the safety significance of increased leakage resulting from the deterioration of the sealant. It was suggested that periodic leak testing of the ductwork, replacing sealant with welded joints, or partial replacement of the ductwork, are possible options where safety problems are identified.

Isolation/By-pass Damper. Leakage testing of isolation dampers and by-pass dampers seems to be resulting in higher leakage rates than had been assumed. This has been particularly true for dampers associated with high volume recirculating systems where the fan can induce a high differential pressure across the damper. One solution suggested to reduce the high leakage rate is to replace parallel blade type dampers with bubble tight dampers.

Fire Damper Testing. Fire dampers are also presenting problems with testing. The problem occurs when trying to test the damper(s) with the system in operation. This is especially true where sequential testing results in increased velocity or pressure drop across the damper. It was noted that EPRI has been asked to develop guidance on the subject.

Field Testing of Nuclear Air Cleaning Systems

QA Review of Testing. The major item of concern centered around Quality Assurance (QA) personnel reviewing the in-place testing based on the requirements of N510. A majority of NAC systems being tested cannot meet the guidelines of N510 to the letter and are therefore being questioned by QA. The problem has resulted in part because a significant number of systems were designed before N509/N510 were issued. A NAC system not designed to N509 cannot be expected to meet the testing requirements of N510. This is stated in N510 in Section 1.2, "Limitations of the Standard", but still presents problems.

The matter is further complicated by NAC systems that were specified to N509 that still cannot be rigorously tested to N510. Part of this problem is that N510 is not being used as the basis for developing test programs but is being applied in the absolute sense. An example is the visual inspection check list that has items for all types of NAC systems and cannot be applied in its entirety to any one system. It was noted that QA check list or procedures are often too detailed and rigid to allow proper technical judgement to be exercised.

<u>Carbon Aging and Storage</u>. Early purchases of carbon made during plant construction have not been used until five to eight years later. There is no formal guidance on how long carbon can be stored and still meet testing criteria. When should carbon be questioned and therefore retested before be used? In general, the method being used is to retest if there is any doubt. Five years has been suggested as the maximum storage time before retest if the carbon is stored under ideal conditions. Storage conditions will greatly affect carbon life. Most agreed that guidelines are needed and should be based on additional testing of aging under "normal" storage conditions.

<u>Instrument Sensitivity to R-11</u>. Limiting R-11 concentrations to the sensitivity of the detecting instrument is necessary to achieve accurate testing results. It was suggested the upper and lower R-11 challenge concentration limits be established for the specific instrument in use. Instrument linearity or correction for nonlinearity should be taken into account in the evaluation. The limits should also reflect consideration for unstable field environments.

<u>Carbon Adsorber Fire Protection</u>. Fire protection for carbon beds continues to trouble the owners of NAC systems. There have been over 180 reported cases of accidental initiation of fire protection systems. Testing has shown that water spray is not effective in extinguishing a burning carbon bed unless the bed is completely flooded for a period of time. A credible source of ignition has yet to be identified. The only case of a bed fire in a power plant NAC system is where the heaters used to reduce relative humidity were placed directly in contact with the carbon. Defeat of the heater temperature controls led to the ignition of the carbon. Heaters of this type are no longer used.

Wetting the carbon presents numerous problems. Due to the impregnates on the carbon, acids form with the addition of water that are corrosive to stainless steel. Damage to the filter screen will occur unless the carbon is removed quickly and the filters washed. Wet carbon is extremely difficult to remove from any type filter. Disposal of the wet carbon is difficult and expensive. The entire process of putting the NAC system back into service is time consuming and could force the unit off-line due to plant technical specification limitations.

The resistance to removal of water spray fire protection of carbon beds comes primarily from the insurance industry. Insurance concerns are based on experiences in the solvent recovery industry where certain keytones undergo exothermic decomposition which can lead to ignition. This is not a consideration for power plant NAC systems.

Maintenance of Nuclear Air Cleaning Systems

Carbon Sampling. Carbon sampling from Type III carbon adsorber filters can be accomplished using a grain thief (slotted tube) if carbon test canisters are inadequate or unavailable. It was suggested that the sample be taken as close as possible to the air entering side to get the most weathered sample for conservatism. One concern with this method is the possibility of leaving voids in the carbon bed. Most felt that this was highly improbable due to the nature of carbon as evidenced by the settling that occurs when air flow is established through the carbon. To avoid any opportunity of bypass at the top of the filter it was suggested that carbon be added at the top of the bed (above the screen) after removing the sample. The air flow distribution test should be used to locate a representative carbon sample location.

Carbon Loading. Loading carbon in Type III carbon adsorbers has presented several problems. Loading devices provided by manufacturers are often ineffective or too slow. An alternative being used is to pour the carbon in as rapidly as possible and use a pneumatic vibrator to settle the carbon to its maximum density. The carbon should be monitored for excessive settling that could lead to filter bypass. Other carbon loading suggestions include temporarily taping the slots between the bed sections to contain the fines during carbon loading (remove tape after loading), and use a 2 inch roll type filter downstream of the carbon beds during initial start-up to catch carbon fines.

Field Testing Personnel Training

Training opportunities in nuclear air filtration are limited to formal training and apprentice type training. Harvard University and Duke Power Company currently offer the only formal training courses. Some testing consultants are starting to offer on-site training for in-place testing.

A major concern expressed by some individuals is the lack of management priority in the area of NAC systems. Adequate staffing and training of personnel in the testing and maintenance of NAC systems are required to assure that the systems will perform as designed when needed. Even if testing or maintenance services are contracted, supervision needs to be knowledgeable of the testing and maintenance required. Ultimately the licensee is responsible for their NAC system in the event of failure. Ideally all personnel that have contact with NAC systems should have training relevant to their responsibility for the systems.

High turnover rates of testing personnel is a major concern. Trained and motivated personnel tend to move up in the organization making it difficult to keep enough trained and experienced personnel available. No solutions were proposed for this problem which is common in most other technical areas.

Training is one aspect of employee qualification. Experience is also necessary to assure qualification of field testing personnel. It was noted that neither training or experience guarantees that an individual is qualified. A case was discussed where a person was trained and had in excess of seven years experience but was still doing unsatisfactory work. The bottom line is that owner supervision is responsible for the quality of testing and maintenance done on NAC systems to assure their operability.

IV. By-products of the Workshops

Even though the attendees were enthusiastic about the opportunity to provide input into the revisions of N510 and N509, it was obvious that the participants would use the time together for other reasons as well. Surveys were taken after both workshops. In the survey category of "expectations fulfilled", a majority of the participants cited the opportunity for information exchange on their particular concerns. Their concerns included such areas as: testing difficulties, personnel qualification, management support, and regulatory expectations. The workshops were an excellent opportunity to ask questions and share solutions where few opportunities for such exchange exist. Most participants felt they had gained a better perspective of the NAC industry and understanding of the other NAC industry members.

V. Conclusion

Workshops are not a new mechanism for information exchange. What is new is that the CONAGT workshops were used to encourage input into code and standard development. The results of these two workshops should ensure that they will continue in some form for CONAGT activities. CONAGT is also discussing the feasibility of holding NAC short courses under ASME auspices. The people of CONAGT recognize the need to know and address the practical needs of the industry they were chartered to serve. CONAGT is recommending to the Board on Nuclear Codes and Standards that other nuclear code and standard writing committees explore the workshop method for communicating with the industries they serve.

References

1. American National Standard, "Nuclear power plant air cleaning units and components," ANSI/ASME N509-1976, The American Society of Mechanical Engineers (1976).

2. American National Standard, "Testing of nuclear air-cleaning systems," ANSI/ASME N510-1975, The American Society of Mechanical Engineers (1975).

3. USNRC Regulatory Guide 1.52 (Rev. 2), "Design, testing and maintenance criteria for atmoshpere cleanup system air filtration and adsorption untis of light-water-cooled nuclear power plants," (March 1978).

DISCUSSION

HYDER: Mr. Hubbard stated that he felt more work was required in N510 on the effects of organic materials and other insults to carbon beds, and his paper calls for more research on the effect of fumes, solvents, etc. on carbon. A study of the effect of organic materials on carbon performance was made at Savannah River to establish criteria for carbon replacement there. These results should be published within the next year. We did establish requirements for our own carbon beds based on historical studies and analysis of our own carbons.

19th DOE/NRC NUCLEAR AIR CLEANING CONFERENCE

HIGHLIGHTS OF PROPOSED CHANGES
TO
ANSI/ASME N509-80

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Abstract

ANSI/ASME N509 and N510 are undergoing revision based on the results of a required 5-year review and comments received from users of the standards at workshops and through inquiries.(1)(2) This paper discusses the highlights of the significant revisions to ANSI/ASME N509 and explains the reasons for the changes.

I. Introduction

Standards which are approved by the American National Standards Institute (ANSI) are required to undergo a review every 5 years to determine whether they should be reaffirmed as published, withdrawn, or revised.

In 1984, the ASME Committee on Nuclear Air and Gas Treatment (CONAGT) considered whether to perform maintenance revisions of ANSI N509 and N510. CONAGT's original intent was to supersede N509 with the Code on Nuclear Air and Gas Treatment (ANSI/ASME AG-1).(3) However, due to delay in preparation and approval of some code sections, it was apparent that N509 could not be superseded in the near future. In addition, CONAGT committee members noted that many utility Technical Specifications referenced N509-80 and it was apparent that N509 needed clarification based on inquiries received from users.

In order to obtain more industry user input for a possible N509 revision (as well as an N510 revision), CONAGT decided to hold two open workshops in 1985. (For more information on these workshops, refer to D. Hubbard's paper, "Report on the 1985 CONAGT Field Testing Workshops," from these proceedings.) The conclusion reached by CONAGT after these workshops was that N509 needed revision to incorporate comments received from CONAGT members, workshops participants, and technical inquiries; and that N509 needed interface with N510 revisions also presently underway. I was selected by CONAGT to coordinate the resolution of comments and present the revisions at the next DOE/NRC Air Cleaning Conference. These comments have now been incorporated into an N509 draft revision, and an initial CONAGT Main Committee ballot on these changes, as of the writing of this paper, is currently in progress.

At this point, it is necessary to emphasize that these revisions are not yet approved by ASME CONAGT, the Board of Nuclear Codes and Standards, or ANSI. The review of this material is intended as a constructive public service in the hope of spurring interest and comments to improve the final version, and to demonstrate that the consensus standards process is responsive to industry needs. The results of the ASME review process will be made available to the public for comment prior to issuance. It is anticipated that the resolution of Main Committee comments and the ASME Board of Nuclear Codes and Standards (BNCS) approval process will not be completed until the end of 1986. It is expected that N510 revisions will be available for public comment in 1987. (For additional information on the N510 revisions presently being contemplated, refer to D. Whitney's paper, "Highlights of Proposed Changes to ANSI/ASME N510," from these proceedings.)

It is hoped that interested parties will review these revisions and provide constructive comments. The explanation of the revisions contained in this paper will help reviewers to better understand the basis for the changes. Those interested in receiving the revised standard when available for public comment should contact the Secretary for the Committee on Nuclear Air and Gas Treatment through the American Society of Mechanical Engineers in New York.

II. Discussion of Proposed Changes

The following discusses the significant proposed changes and the basis for the changes.

Definitions (Section 3*)

Definitions are often initially overlooked by readers of a standard (and sometimes the preparers as well) until a question of interpretation occurs. Then, definitions are reviewed very carefully, because often they hold the key to the preparer's intent.

System, Unit, Bank. Over the last 5 years, it became apparent that several clarifications were required and several new definitions were needed to better explain the intent of the standard. For example, there has been much discussion on what is an air-cleaning system, what is an air-cleaning unit, and what is a bank of filters. In some cases, where "system" was used, "unit" or "bank" was meant. Definitions are being added or revised to clarify this intent. Figure 1, "Air-cleaning system, unit, component, and filter banks," depicts these terms.

Bypass. Bypass can have many meanings, depending on the situation. For N509 and N510, when bypass is used, it refers to "a path by which contaminated air can escape treatment by the installed HEPA and/or adsorber banks. Examples are leaks in filters, filter frames, defective or inefficient bypass dampers, unintended passage through adjacent plenums or penetrations such as electrical conduits, pipes, or floor drains." This definition is extremely important to proper interpretation of testing

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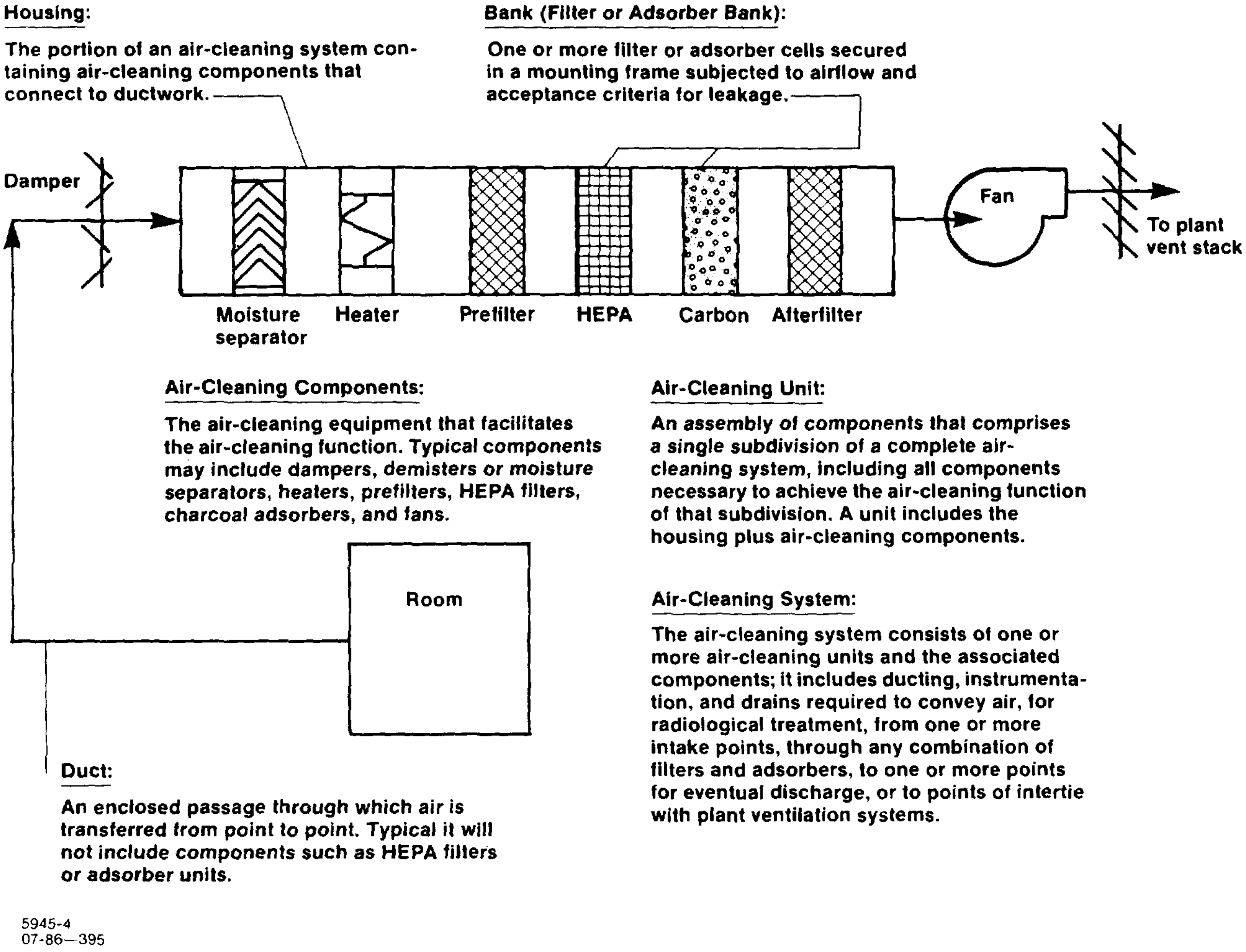
*of ANSI/ASME N509-1980



Housing:

The portion of an air-cleaning system containing air-cleaning components that connect to ductwork.

Bank (Filter or Adsorber Bank):

One or more filter or adsorber cells secured in a mounting frame subjected to airflow and acceptance criteria for leakage.

Air-Cleaning Components:

The air-cleaning equipment that facilitates the air-cleaning function. Typical components may include dampers, demisters or moisture separators, heaters, prefilters, HEPA filters, charcoal adsorbers, and fans.

Air-Cleaning Unit:

An assembly of components that comprises a single subdivision of a complete air-cleaning system, including all components necessary to achieve the air-cleaning function of that subdivision. A unit includes the housing plus air-cleaning components.

Air-Cleaning System:

The air-cleaning system consists of one or more air-cleaning units and the associated components; it includes ducting, instrumentation, and drains required to convey air, for radiological treatment, from one or more intake points, through any combination of filters and adsorbers, to one or more points for eventual discharge, or to points of intertie with plant ventilation systems.

Duct:

An enclosed passage through which air is transferred from point to point. Typical it will not include components such as HEPA filters or adsorber units.

Figure 1. Air-cleaning system, unit, component, and filter banks.

requirements, and therefore, the design must adequately prevent this type of bypassing.

Afterfilter (Paragraph 4.1)

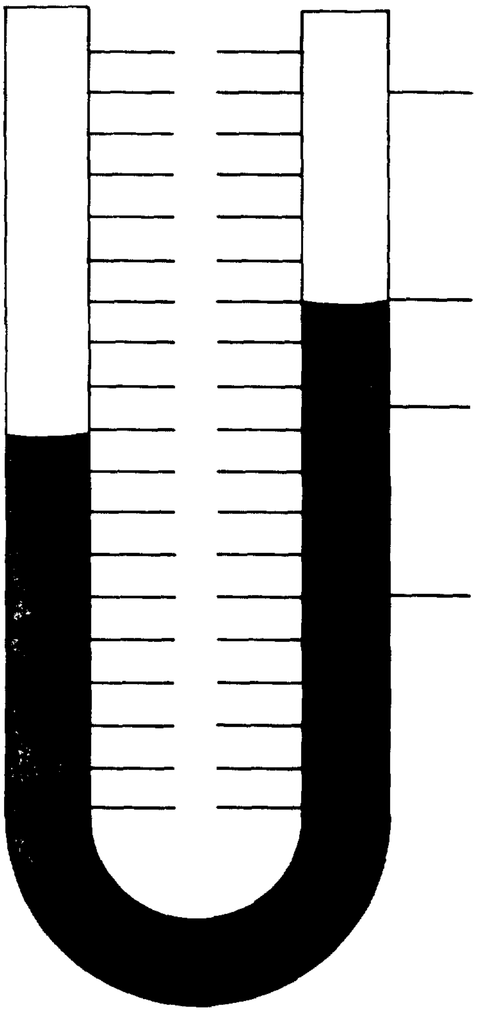
The requirement for an afterfilter was added to Section 4 on Functional Design. An afterfilter is required when adsorbers are used to retain carbon fines. Previously, the standard was silent about this requirement. However, Regulatory Guide 1.52 requires downstream HEPA filters and Regulatory Guide 1.140 suggests they be considered.(4,5) Comments received from the industry indicate that downstream HEPA filters are overly conservative, and since the filters are for retaining carbon fines, a filter with a lower efficiency (85% per ARI 680) is more than acceptable.(6)

The use of an extended media-type filter rather than a HEPA filter simplifies testing and resolves many problems of leak testing series HEPA banks. This is considered a significant, but rather subtle change.

Design Pressures (Paragraph 4.6)

The term design pressure had been used extensively throughout N509 as well as N510, to identify different conditions. Four definitions are being incorporated to properly define the intended pressure and to better interface with N510. These terms are operating pressure, design pressure, structural capability pressure, and test pressure. Figure 2, "Pressure definitions and relationship," identifies the relationship and definitions of these terms. The section on design pressures is being revised to incorporate these terms. For instance:

Units and Components Subject to Only Rated Flow. These requirements are being revised to state that components not required to withstand peak pressure may be designed for maximum operating (static) pressure rather than design pressure. This is especially important for the components at the end of a duct system that may actually experience less than 1 inch Wg, instead of a design pressure of 10 to 15 inches Wg. This also impacts duct leakage analysis and testing as discussed later.



Structural Capability Pressure:

The static pressure to which the designer specifies the component or equipment can be safely loaded. This pressure may exceed the design pressure due to inclusion of a margin.

Design Pressure:

The static pressure that is used for structural design of a unit, component, or system.

Test Pressure:

The static pressure, acting in the direction of the design pressure, used for establishing leakage rates. This pressure is at least 1.25 times the operating pressure of the item being tested but does not exceed structural capability pressure.

Operating Pressure:

The static pressure that corresponds to any single condition of operation of a component. This pressure is less than or equal to the design pressure.

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Figure 2. Pressure definitions and relationship.

Components Exposed to Fan Peak Pressure. The design pressure for components exposed to fan shutoff conditions is still the fan peak pressure. However, if the system design incorporates a provision to trip the associated fan on a static pressure increase, then the components can be designed for this trip pressure, plus margin to allow for rate of pressure rise during the instrument response time.

Location of Fans Relative to Filters (Subparagraph 4.6.4)

This section is being revised to provide general guidance for specific types of air-cleaning systems: once-through, habitability, and recirculating cleanup systems. Previously, habitability systems were not explicitly discussed.

By following these guidelines, as noted in Figure 3, "Guidelines for air-cleaning system configuration and location," the radiological impact of duct or housing leakage may be minimized and the effectiveness of air-cleaning systems improved.

General guidance for various applications are as follows:

1. Once-Through Effluent Air-Cleaning System:
    a. Maintain ducts conveying contaminated air through clean spaces or clean interspaces at a negative pressure with respect to the surrounding areas.
    b. With filter unit located in a clean interspace, locate exhaust fan downstream of filter unit in order to keep filter unit under negative pressure. Any leakage through fan shaft will be from clean interspace.
    c. Filter units located in contaminated spaces or interspaces, fan shall be located upstream of filter unit to prevent infiltration of contaminated air through fan shaft or filter housing from bypassing filters.
    d. Length of positive-pressure discharge ducts from filter units routed through clean spaces or interspaces should be kept as short as practical to minimize impact on in-plant exposure.
2. Habitability System
    a. Outside air ducts conveying radioactive air routed through clean spaces or interspaces should be under a negative pressure.
    b. Recirculating air ducts outside the habitable space under a negative pressure should be avoided or additional filtration provided.
    c. Makeup air filter unit fan shall be located:
        (1) upstream of filter unit if filter unit is in a contaminated space
        (2) downstream of filter unit if filter unit is in a clean space
    d. Positive-pressure duct lengths outside of habitable boundary should be kept as short as possible to reduce effect of duct leakage on ability to pressurize habitable boundary.
    e. Recirculating system housings should be kept at a positive pressure if located outside habitable boundary in a contaminated space or interspace.
3. Recirculating Cleanup Systems
    a. If filter unit located outside space served in a clean space or interspace, fan should be located downstream of filter unit.
    b. Fan may be either upstream or downstream of filter unit if located totally within space served.
    c. Length of ductwork outside space served should be kept to a minimum as much as practical.

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Figure 3. Guidelines for air-cleaning system configuration and location.

Fire Protection (Paragraph 4.10)

The present N509-80 does not include any requirement for fire protection, except that water deluge systems are not acceptable for adsorbent cooling, "although they may be used for fire extinguishment."

Based on recent review of data on frequency and probability of impregnated activated carbon adsorber fires versus the number of spurious activation of automatic or manual fire protection systems, there is a greater need to protect the carbon from the fire protection system rather than from a fire.(7) (A panel discussion on this topic is scheduled for this conference.)

While it is recognized that more data is needed in this area, N509 is being revised to provide for:

- Deluge nozzles inside the housing but not hard piped to a fire protection system. Instead, two isolation valves external to the housing should be provided to allow the plant fire brigade to connect manually to the plant fire protection system if they confirm a carbon adsorber fire exists. Automatic deluge systems are not recommended.
- Automatic shutdown of the fan and isolation of the filter unit based on a first-stage alarm from a two-stage detection system.
- Detection systems chosen based on ability to respond quickly to fire conditions (i.e., product-of-combustion detectors may be faster responding than temperature detectors). In addition, detection system response should be demonstrated.

Monitoring of Operational Variables (Paragraph 4.8)

Several changes are being proposed to the requirements for instrumentation on engineered safety feature (ESF) and non-ESF air-cleaning units.

Recording Function. The requirement for recording inlet flow rates for ESF and non-ESF units is being deleted as is the recording of the ESF upstream HEPA filter pressure drop on the remote manual control panel. These changes are being made based on feedback reporting that the rate of change is so gradual (1 inch Wg over a few years) that it is imperceptible. Recording of filter pressure drops requires a great deal of space in the main control room with little benefit, especially for those plants with many ESF filter systems. Alternately, plants usually keep logs of filter pressure drops for trending and predicting changeout time based on weekly, biweekly, or monthly surveillance. Furthermore, rapid changes in flow or pressure are monitored and alarmed if acceptance values are exceeded.

Unit Pressure Drop. The present N509 standard calls for a high pressure drop alarm in the main control room for each ESF unit. This is now being noted as an optional alarm if each individual air-cleaning unit component, whose pressure drop is subject to change over time, is alarmed in the main control room.

Deluge Valves. The requirement that handswitch and position indicators are only required for power-actuated valves is being added. Manual valves with local position indication at the valve are also acceptable (in fact, preferred).

In-Containment Units. A note is being added to clarify that local controls for non-ESF air-cleaning units located inside the containment should be located outside the containment.

Testability - Test Canisters

The present standard only requires a minimum of six test canisters. The proposed revision changes this to one test canister per 2000 cfm or a minimum of six test canisters dispersed througout the adsorber bank.

Pressure Boundary Leakage (Paragraph 4.12 and Appendix B)

Philosophy. Determination of allowable pressure boundary leakage is undergoing perhaps the most philosophical change from the previous revision. The revised philosophy is a direct outcome of comments received by the N509-80 users and experience with how N509-80 was being interpreted.

N509-80 contained the requirement that pressure boundary leakage be determined based on the minimum allowable leakage of health physics, air-cleaning effectiveness, and duct/housing quality. Consider a specific system design that can withstand 20-cfm leakage to meet health physics requirements, 10-cfm leakage for air-cleaning effectiveness, and 1-cfm leakage for duct/housing quality. By N509-80 criteria, the system would have to be designed to 1-cfm leakage. This could be overly conservative and would require more labor and different construction (or even reconstruction).

The present criteria do not recognize the difference between types of systems, nor can they handle systems with multiple functions (ventilation, air cleaning). Furthermore, they do not allow the designer any decision making authority based on the specific system design requirements.

Because of this, the pressure boundary allowable leakage limits are being revised to be based on health physics requirements and the specific system design. The maximum allowable leakage rates (based on health physics criteria) may be modified by the owner/designer to meet plant specific ALARA (as low as reasonably achievable) programs or, if the owner/designer so chooses, be based on air-cleaning effectiveness and duct/housing quality guidelines, which are contained in nonmandatory Appendix B.

The designer can now choose the appropriate criteria based on the health physics design requirements, the specific system design/function, and plant requirements. The allowable leakage will not exceed the value to meet the health physics requirement, which is the base criterion, just as temperature is one of the base criteria for equipment qualification. This is the true measure of the air-cleaning system's flow effectiveness. An identified margin may then be applied, if so desired.

System Pressure. Another change is that allowable leakage is to be determined at the maximum system operating pressure, rather than design pressure. The designer must also specify the test pressure to be used to perform N510 leak testing.

Examples. Appendix B is being expanded to include suggested procedures and more detailed examples of how to determine allowable leakage to meet health physics criteria. Procedures to determine allowable leakage are being included, based on maintaining MPC (maximum permissible concentration) space levels for:

- ducts under a positive pressure located in a clean interspace (as defined in N509), and
- ducts under a negative pressure located outside the contaminated space they serve.

Also being included in Appendix B are procedures and detailed examples for evaluating iodine protection factor reductions for habitable areas, such as the control room, due to air-cleaning and air-conditioning duct leakage. This material is adapted from previous Air Cleaning Conference papers on this subject.(8,9)

HEPA Filters (Paragraph 5.1)

The qualification requirements previously included in Subparagraph 4.3.1 of N509 are being incorporated in Paragraph 5.1. In addition, it was clarified that listing of a HEPA filter in the U.S. Army Qualified Products List is not required, but that the HEPA filters must be requalified to MIL-F-51068 every 5 years. Qualification documents must be retained by the manufacturer.

Adsorbers (Paragraph 5.2)

Design. The requirements for design of tray-type and deep-bed adsorbers are being revised to reference the imminent issue of ANSI/ASME AG-1, Code Sections FD and FE.(10,11) This supersedes the presently referenced standard AACC-CS 8T.(12)

Adsorbent. New and unused adsorbent must meet the requirements in the newly issued ANSI/ASME AG-1, Code Section FF, "Adsorbent Media."(13)

Testing. The testing requirements presently contained in Table 5-1 are being split into three tables (5-1Q for Qualification Tests, 5-1B for Batch Tests, and 5-1S for Benchmark Surveillance Tests). Tables 5-1Q and 5-1B are in agreement with the previous Table 5-1, as well as with the requirements of Section FF of AG-1. The benchmark surveillance test requirements conform to Regulatory Guide 1.140 requirements, but recognize that Plant Technical Specifications override these requirements.

Unused Carbon. The testing of adsorbent is based on unused carbon (i.e., carbon that has not been placed in service). Carbon that has been originally tested then stored at site for a long period of time has commonly been referred to as "spinster" carbon. Carbon is considered unused if it has not been exposed to process air (or gas) streams. Regulatory agencies require that this carbon be retested to N509.

Reactivation/Reimpregnation. ANSI/ASME AG-1, Code Section FF further prohibits reactivation of activated carbon, but "reimpregnation of carbon that has been in service or outdated impregnated carbon is permitted, but must be qualified in accordance with this Section (FF)."

Housing Design (Paragraph 5.6)

This area is being considerably expanded due to feedback from testing personnel based on their recent experience with air-cleaning units designed and constructed to N509-76 and N509-80.

Many of the design details for smaller components such as housing doors, door lugs and latches, door seals, drains, flexible connections, and manifolds were either only superficially addressed or not addressed at all. Recent experience has shown that these components can be the biggest obstacles to achieving an installation that can be successfully tested to N510. Lack of attention to these details has resulted in systems that are either more difficult to test or unable to meet the test acceptance criteria without extensive, expensive field modifications.

The guidance given in the proposed revision to N509, while intended for new systems, should be reviewed for existing systems that have experienced difficulty in meeting N510 test requireents or acceptance criteria.

Modifications should be thoughtfully considered where economically justified. Reducing test time by 8 hours on a unit may not appear to be a great deal of time, but it adds up when applied to many units over a 40-year life or during a specific outage.

For new equipment designs, or review of existing designs, it is highly recommended that knowledgeable personnel, with N510 test experience, review the manufacturer's drawings and provide recommendations or comments on the testability of a unit. For new designs this will resolve many problems before they get to the field where the best resolutions may not be possible. Some of the specific housing design revisions are:

Housing Doors. Additional requirements are being added to improve the door seals. Door design should protect gaskets and a knife-edge seal should be provided to ensure compression. A means for adjusting compression forces and gasket compression should be included in the door design. The number of gasket joints should be minimized to limit leakage.

More attention needs to be given to door lug design. Human factors need to be considered. Many door designs in use today are not very "user friendly." It is difficult to hold all the lugs in the proper position to close the doors. Therefore, the one or two sentences on lug requirements are being expanded to include the requirements stated in Figure 4, "Housing door latching requirements."

1. Latches must be located on all four sides of any door.
2. There must be six or eight latches minimum, depending on door size (one top, one bottom, four or six on sides). This assumes a standard configuration door, with height two to four times width. Doors with a square shape may need more than one latch on top and bottom.
3. Latches shall seal in less than 270-degree motion.
4. Latches shall not have more than one handle per location. That is, there shall not be a handle to position the inside clamp and a separate handle to tighten the clamping down.
5. Latches shall be configured such that when open, gravity will hold them in the open position.
6. Latches shall indicate (or have permanent indication on the door) which direction to turn to open or close. This shall be for each latch, or if all work the same, then indicated once on each door.
7. Ideally, latches should open and seal with only the torque that can reasonably be applied by an average person while suited up. If additional torque is required, a specific tool to provide the torque shall be supplied for each door, and so attached as to reasonably assure it will be available during the life of the plant.
8. Latch assemblies shall have a minimum number of components and be designed so no loose components can fall apart.
9. Latches shall be designed to operate with no lubricant required within the pressure boundary.

Figure 4. Housing door latching requirements.

Additionally, requirements have been added to submit door design drawings to the purchaser, prior to fabrication, that show:

- location of hinges,
- latch details,
- viewports, and
- gasket installation.

Drains. The requirements for drains are also being expanded to resolve reported problems with recent field installations. Drain systems must be designed to meet the allowable leakage criteria. This requires that drains from individual compartments be valved, sealed, or trapped to prevent bypassing air around filters, inducing air from surrounding contaminated interspaces into the air-cleaning units, or blowing contaminated air from the filter out to a clean interspace.

The number of normally functioning drains should be kept to a minimum; that is, those that are not expected to be required for use during normal operation should be valved or capped off.

Where loop seals are provided in the functioning drains, the seals should be sized based on the highest operating static pressure the unit may experience during system startup, normal operation, or system shutdown. Automatic filling of loop seals should be considered or, if manual filling of the seals is utilized, periodic inspection and fill procedures should be written.

The drain lines should be initially tested to ensure operability. If shutoff valves or check valves are utilized, they should be initially tested for operability and leakage.

In the recent past, two reported problems have been identified with drain lines systems.(14,15) By following the above criteria, the number of reported field problems with drain systems will be reduced.

Housing Connections. No requirements were previously included in N509 for housing connections. The proposed revision includes the following requirements: Housing connections shall be designed with consideration of the air distribution uniformity requirements of N510 to preclude field testing problems. Flexible connections shall be provided between the housing and any prime movers. Flexible connections shall be rated for fan shutoff pressure and a qualified life established based on environmental and operating conditions. Allowable leakage shall be identified and flexible connections shall be tested for fabric and joint leakage following environmental qualification.

As with drains, flexible connections can be a weak link in the air-cleaning system. Degradation or failure of the flexible connection integrity can severely reduce the effectiveness of the air-cleaning system and, depending on fan location, can increase personnel radiation exposure. More attention needs to be given to this component since it, too, is usually a consumable product that requires periodic replacement.

Housing Drawings. Requirements are being added to clarify that manufacturer's housing drawings be submitted to the purchaser depicting the location and size of each door, drain, housing connection/penetration, as well as lights, switches, instrumentation, and other appurtenances. Flexible connection details, door details, and drain valve details shall also be submitted prior to fabrication.

The purchaser should have these drawings reviewed by personnel who are knowledgeable about N509 requirements and by capable filter testing personnel to ensure that housing design can be tested to N510 requirements.

Testing. Another significant addition to the housing design section is the requirements for manifold design. These requirements are being included so that housing designs incorporate provisions for manifolds early in the design phase, prior to shipment to the site. Permanent mounting of manifolds is recommended, although not mandatory, to obtain repeatability of test results. If permanent manifolds are not included, then manifolds shall be provided that can be reassembled in the field with each piece numbered, tagged, and marked for reinstallation. Additional guidance on locating and sizing manifolds is being provided in a new Appendix D. Furthermore, for manifolds located within the housing, manifold design, and location shall be qualified, in the shop prior to shipment, to N510 requirements for airflow distribution and air-aerosol mixing uniformity. Results shall be documented and submitted to the purchaser.

It is expected that early attention to housing testing, and specifically to the design and location of manifolds, will reduce the number of units delivered to the field in the future that are difficult to test adequately.

Fan Selection (Paragraph 5.7)

A clarification is being included to advise the designer that the fan selection should make provision for N510 test conditions. The system designer should identify the maximum allowable differential pressure for each filter bank plus a margin to allow for degradation between surveillance (typically 25%).

Feedback has shown that this requirement (which was in N510-80) has not been incorporated into the design and selection of the fan, and therefore, has caused problems. This clarification is being added to N509 for further emphasis and to assign the responsibility of determining these criteria to the system designer during selection of the fan.

Duct Construction (Paragraph 5.10)

The proposed revision recognizes the use of mechanical lock seams and silicone sealant for air-cleaning ducts and requires that these be qualified for the intended applications.

Testing (Subparagraph 5.10.8)

Leak Testing. Several comments were received concerning inequalities in the present N509 leak testing exemptions and requests for clarifications. Based on these comments, the following changes are proposed to clarify the intent, taking into account the effect of leakage in health physics.

Ducts exempted from quantified leak tests are:

- All ESF and non-ESF ducts serving the protected space, located within the protected space, regardless of length.
- All negative pressure ESF and non-ESF ducts passing through a clean interspace.
- All positive pressure ESF and non-ESF ducts passing through contaminated interspace having an MPC concentration within the duct (Cd), which is no greater than

1.1 times the MPC concentration in the space (Cr), where:

$$Cd \leq 1.1\ Cr. \tag{1}$$

- Non-ESF and ESF positive-pressure duct passes through a clean interspace, and when the effective concentration within the duct is less than 5 MPC.
- Non-ESF and ESF duct under negative pressure passing through a contaminated interspace having an MPC concentration (Cr), which is no greater than 1.1 times the MPC concentration within the duct (Cd), where:

$$Cr \leq 1.1\ Cd. \tag{2}$$

- Plant vent stacks or ducts outside plant buildings when high-level or mixed-mode release credit is not required to meet offsite dose requirements.

Balancing. The requirements for balancing of air-cleaning systems are being modified to allow the owner/designer to set the upper and lower acceptance criteria for system flow rather than the present ±10%. These limits shall be selected such that the design function of the system is maintained and equipment capabilities not exceeded. Furthermore, a statement is being proposed such that the air-cleaning system must be balanced prior to initially declaring it operable. The system need not be balanced prior to air-cleaning unit field testing if the airflow rate through the air-cleaning unit during testing is within the upper and lower acceptance values and the final balanced system flow is within the upper and lower acceptance criteria.

Fan Peak Test. This test requirement is being clarified such that it need only be performed for those housings, ducts, and components that would be subjected to fan peak pressure due to closure of dampers on suction or discharge of fan. Therefore, duct sections far from the fan that will never be subjected to fan peak pressure need not be tested to the fan peak pressure.

III. Summary

The above proposed revisions are currently being balloted by the ASME CONAGT Main Committee. After resolution of ballot comments and Main Committee approval, the revisions are balloted by the ASME Board of Nuclear Codes and Standards. Around the beginning of 1987, the final version of these revisions should be available for public comment. Interested parties should contact the ASME Secretary for information. Constructive input from users of the standard is eagerly sought.

The guidance given in these proposed revisions, while intended for new systems should be reviewed for existing systems that have experienced difficulty in meeting ANSI/ASME N510 testing requirements. In addition, because N509 and N510 are standards which are meant to be used in conjunction with each other, the proposed changes to N510, which are also following the same timetable as N509, should also be reviewed. Potential modifications should be thoughtfully considered where economically justified.

New equipment designed, constructed, and installed to these revised requirements should be better able to meet the intended testing requirements by reducing the number of field-resolved problems.

Acknowledgments

I wish to thank the participants at the 1985 CONAGT Air Cleaning Workshops for their comments and inspiration to initiate this revision. Also, I would like to thank all the many CONAGT members who contributed comments and resolutions.

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HIGHLIGHTS OF PROPOSED CHANGES
TO
ANSI/ASME N510-1980
TESTING OF NUCLEAR AIR-CLEANING SYSTEMS

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Abstract

This paper will review the significant proposed changes to ANSI/ASME N510-1980, "Testing Nuclear Air-Cleaning Systems", which are currently under review by the ASME Committee on Nuclear Air and Gas Treatment (CONAGT). These changes are a result of many sources of input to ASME from users, CONAGT members, and two workshops that were held in 1985 to discuss the proposed revisions to N510-1980 and N509-1980, "Nuclear Power Plant Air Cleaning Units and Components."

The paper discusses the proposed changes and the reasons for the changes.

I. Introduction

All standards which are approved by the American National Standards Institute (ANSI) are required to undergo a review every five years to determine if the standard should be reaffirmed as presently written, withdrawn or revised.

In 1984, the ASME Committee on Nuclear Air and Gas Treatment (CONAGT) considered what course of action to take regarding ANSI/ASME N510-1980(1) as well as N509-1980(2). CONAGT's original intent was to supersede both standards with the Code On Nuclear Air and Gas Treatment (ANSI/ASME AG-1)(3). However, due to the schedule for preparation and approval of the code, and the fact that many utility Technical Specifications refer to N509 and N510, it was apparent that it was appropriate to update and revise these standards to resolve several items needing clarification.

In order to obtain industry wide input to be used in the revisions, it was decided to hold two open workshops. This was done in 1985. (For more information on these workshops, refer to D. Hubbard's paper "Report on the 1985 CONAGT Field Testing Workshops" from these proceedings.)

These workshops provided many helpful comments and questions in addition to those received from CONAGT members and formal technical inquiries relating to both N509 and N510. These comments have been incorporated into N510 and will soon be submitted to the CONAGT Main Committee for balloting.

It is necessary to emphasize that these revisions are not yet approved by CONAGT, the Board of Nuclear Codes and Standards, or ANSI. The presentation of this material is intended as a constructive public service in the hope of spurring interest and comments to improve the final version. The results of these revisions will be available for public comment prior to final issue of the revised standard. It is anticipated that resolution of Main Committee Comments and the ASME Board of Nuclear Codes and Standards (BNCS) approval process will take until the end of 1986. The public comment period will extend into 1987, so actual publication is expected in early 1987.

It is hoped that all interested parties will review these revisions and provide constructive comments. In addition, it is hoped that the explanation of the revisions contained in this paper will help those preparing comments to better understand the basis for the changes. Written comments or suggestions may be submitted to the author. It is doubtful that indivdual responses will be practical, but all received comments will be reviewed by the Subgroup.

II. Discussion of Proposed Changes

The following discussion presents a description of the major changes and their associated background.

Definitions

Field use of N510 has at times been made tedious due to inconsistencies between N509, the NATS design standard, and N510, the NATS inplace testing standard. Furthermore, some fundamental definitions were either missing, contradictory, or simply not useful. A major effort to resolve these concerns has resulted in a consistent set of definitions for the two standards. They are described in the Air Cleaning Conference paper highlighting the changes to N509 by Steve Ornberg(4). One of the most important aspects in these revisions has been to clarify the relationships between Operating Pressure, Test Pressure, Design Pressure, and Structural Capability Pressure.

Application of N510

Although N509 and N510 have been in use since 1976/1975 respectively, field experience has shown that many systems were either built before these standards existed, or the actual installations have not accomplished all that the design standards intended. Simply, there are many systems in-place which do not provide all of the N509 design features, usually with respect to testability. For these reasons, this revision of N510 is specifically structured for the comprehensive testing of N509 designed systems. At the same time, additional test techniques are provided which will assist owners/operators/test personnel in the testing and qualification of those filter systems which do not fully meet N509-1980 requirements. These additional methods and techniques are contained in non-mandatory Appendices of the N510-1986 standard and typically deal with inspection requirements and sampling methods. It is the stated purpose of N510-1986 that the mandatory body shall be rigorously applicable only to N509-1986 systems. It may be used for technical guidance for systems that do not meet the requirements of N509-1986 or N509-1976.

General Changes

A number of general changes are proposed. The proposed revision to the standard is less wordy and does not attempt to provide as much detail in the body as did the 1980 edition. The visual inspection checklist has been expanded and compared line by line with the draft of N509-1986 so all "shall" statements in N509 will be covered in the N510-1986 inspections.

There is consideration being given to require the housing leak test to be repeated at least once each operating cycle. In the 1980 (and 1975) edition this is a one-time test. Experience has shown many leak paths do develop (doors, instruments, conduits, drain lines, etc.) following startup, hense the need for the test.

Where possible, we simply refer to an existing standard that provides a needed method. We feel strongly that there is no need to duplicate an existing standard that provides the required data. (Examples are SMACNA and ASME.)

Reporting requirements are no longer specifically listed, as there were usually too many exceptions General report content guidance is given, but not an item-by-item listing.

It is the committee's intent to provide only minimum functional requirements for test instrumentation and to make the requirements as hardware independent as possible. This will allow new instrument developments to be used without inquiry or special justification.

The Airflow Capacity/Distribution Section has been revised to eliminate confusion as to which part is for Acceptance, and which for Surveillance. An exemption for Airflow Distribution and Air/Aerosol Mixing Uniformity tests for banks having only a single HEPA filter, has been added.

Effect of Inquiries

Since N510-1980 was issued there have been several formal inquiries from field users which have questioned certain of its requirements, methods, and criteria. The number and scope of these inquiries is indicative of the amount of usage N510 receives. The revision to N510 now being proposed incorporates the resolutions of the received inquiries, and has attempted to resolve the underlying cause or concern, which led to the inquiry. The following major issues began as inquiries and are discussed to provide a basis for their treatment in the proposed N510 revision.

a. Requirement for 1 cfm Penetrometer Sample Flowrate

Every effort is being made in the proposed N510 to produce a Standard and not an "operating manual". Requirements such as this are often times historically traceable to a specific piece of once available test equipment, and its requirements, or to some antiquated government test laboratory specification. In this case the "requirement" is that the sample be representative of the air being measured. As such, N510-1986 notes that the upstream and downstream sample line lengths should be similar and that sample delay time needs to be considered when taking and analyzing data. It is left to the specific test procedure to establish flow rates and other related parameters to insure this objective is achieved.

b. Audible Leak Testing

N509 allows for this technique when seeking to identify leaks prior to system qualification testing. As N510-1980 did not provide the associated procedure or method, one has been developed and included. Still, some confusion may exist on the part of quality or regulator inspectors relative to its application. Everyone concerned must recognize that the audible leak test is not quantifiable. Should it be necessary to quantify a leak, then one of the quantitative leak rate test methods in N510-1986 must be used.

c. Testing at "1.25 Times Dirty" Filter Pressure Drop

This issue has been a major problem with field use of N510-1980. With the confusion over definitions, between N510 and N509, and the fact that designers were not required to specify the appropriate field test or surveillance criteria, there are nearly as many interpretations of this requirement as there have been systems to test. Furthermore, given the relatively "flat" fan head/flow characteristics typical of most fans used in air filtration systems, 125% of design pressure drop is often simply not available. The original intent of this requirement was to demonstrate that the system would be able to supply the specified flowrate, even under "dirty filter" conditions. As proposed, N510-1986 will test each system, or filter bank, at both the "clean" and "dirty" pressure drops and demonstrate that the design flow requirements are met. The designer must specify the appropriate "dirty" value. This is important, for it is seldom appropriate to use the sum of the filter manufacturers "maximum dirty pressure drops." This is due to installations where adsorber banks are preceded by HEPA filters, or similarily, downstream or "guard" HEPA's following carbon filters. They usually do not see the particulate material necessary to develop high pressure drops, while the effects of other components in a housing (moisture separators, finned tube heaters, etc.) may significantly effect the system pressure drop and are not always taken into account.

The previous requirement to obtain a flow condition midway between "clean" and "dirty" pressure drop has likewise been eliminated as unnecessary and not meaningful.

d. Use of Flowrate Meter in lieu of Totalizing Gas Meter.

When determining leak rate from an enclosed volume, N510-1980 had specified a method which utilized a totalizing gas meter. As a result of an inquiry, it is being proposed that an acceptable alternate method is to use an appropriate flowrate meter. This is acceptable providing that the necessary changes in the technique and data collection/analysis are made. The SMACNA 15.d(5) test standard is referenced for the direct flow leak test method. Again, this is in an effort to make the standard less of a "handbook" or "procedure" specification.

Multiple Sampling Technique

Air filtration systems and equipment are often large and difficult to test, one of the major reasons for N509 and N510 to exist in the first place. Central to effective testing is the need to obtain representative challenge samples in a timely and repeatable manner. For these reasons, N509 suggested that injection/sample manifolds be installed in filter systems. To date, adoption of this recommended approach has been poorly implemented.

The multiple sampling technique is useful for qualifying air-aerosol mixing uniformity (N510-1980 Section 9, "Air-Aerosol Mixing Uniformity, Upstream of a Filter Bank"), and by comparison, allows qualification of an injection or sample manifold installed ahead of a filter bank.

The proposed revision to N509-1980 aids in this effort by providing design guidelines for these manifolds. Still, field tests are required to "qualify" any installed manifold, and for this reason the Multiple Sampling Technique is presented in the proposed N510-1986, along with a non-mandatory appendix which elaborates on the method and its limitations. Acceptance criteria are unique to each installation, and are to be developed by the system owner.

It must be remembered that Multiple Sampling is intended to show the actual distribution of challenge across a filter bank. If the challenge distribution is non-uniform for any reason, it will be observed during this test. N510 continues to utilize air velocity distribution measurements to qualify the air distribution, while the air-aerosol mixing test is done solely for the purpose of qualifying the location of injection and sample ports. Multiple Sampling is not necessarily meaningful downstream of a filter since there is no assurance that a leak will be aligned with a sample point. A well mixed downstream sample is always needed. The method is useful in situations where non-uniform upstream tracer-air mixing is a concern, or where it is needed to qualify an injection or sample manifold.

Duct-Damper Bypass and System Leakage Tests

Many filtration systems are equipped with ducts and dampers which bypass the filter banks during normal operations. To demonstrate that the filter system is performing at the desired level, it is important to insure that these dampers are such that the filter banks will perform their intended function at the required high efficiency without being bypassed due to damper leakage.

The proposed N510-1986 includes a test of the bypass dampers which is similar to the tests performed on HEPA filter banks. DOP Aerosol provides a quick method for quantifying leak tightness and can usually be used to locate leaks should the leakage exceed acceptance criteria.

Following the testing of the various HEPA filter banks, adsorber banks, and bypass dampers, a NATS "system" test is now specified. For this test, the challenge aerosol is injected far enough upstream, and sampled far enough downstream, to determine the overall effectiveness of the filter system, including ALL bypass and leakage pathways. Acceptance criteria must be carefully developed to consider the systems purpose (as established by the designer in the relevant Design Study) and the effects of any filter banks installed in series. It is this test which demonstrates that the system is performing its intended function. This has resulted in two new sections in the standard to insure there is no ambiguity as to the specific test requirements.

Surveillance Testing

Operating Nuclear Plant Technical Specifications require surveillance testing of those air filtration systems important to safety of plant, its personnel, and the public. N510 provides the test methods to accomplish this testing, although it does not provide acceptance criteria unique to each nuclear facility. That criteria is contained within the facility Technical Specifications. The methods and techniques provided in the proposed revisions to N509-1986 and N510-1986 make available to the nuclear industry the basis for upgrading systems, criteria, and operations to provide a higher standard of performance of these important and expensive systems. Facility owners should review their system designs and operations in light of these revised standards for specific enhancements and improvements within their facility. Experience has shown that these changes will not only improve the filter systems technically, but can provide cost savings too.

Summary

ANSI/ASME N510-1986 "Testing of Nuclear Air-Cleaning Systems" is in the final stages of revision. This is the second revision since original issue in 1975, and should prove to be much more useful to the nuclear industry as a result of the incorporation of the numerous "lessons-learned" during its first eleven years of field use. We equally understand it will not be perfect, and look forward to continued user input.

The coordinated updating, with ANSI/ASME N509 "Nuclear Power Plant Air Cleaning Units and Components," has resolved numerous difficulties faced during the field testing of these filter systems. At the same time, industry participation, through workshops and the inquiry process, has provided impetus and direction to the CONAGT Subcommittees working to develop the most useful and pertinent standards for assuring the quality and performance of nuclear air-cleaning systems.

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(1) ANSI/ASME N510-1980, "Testing of Nuclear Air-Cleaning Systems," published by the American Society of Mechanical Engineers, 345 East 47th Street, New York, N.Y. 10017.

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19th DOE/NRC NUCLEAR AIR CLEANING CONFERENCE

AN ASME CODE FOR FIELD TESTING OF NUCLEAR SAFETY-RELATED GAS PROCESSING SYSTEMS

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Abstract

"Field Testing of Gas Processing Equipment [Nuclear Safety-Related]" is a new test code applicable to equipment designed for processing containment atmospheres in a postaccident condition. This paper provides a discussion of the code section and a perspective of its relationship to the other Nuclear Air and Gas Treatment Code (AG-1) sections. The need for a unified field test code is presented, along with a comparison of existing codes, standards, and regulations. Particular attention is given to providing the potential user with an understanding of the structure of this code section and requirements unique to particular equipment types.

I. Introduction

The ASME Board on Nuclear Codes and Standards (BNCS) originally chartered the Committee on Nuclear Air and Gas Treatment (CONAGT) in 1975 to "develop, review, maintain and coordinate codes and standards for design, fabrication, installation, testing, and inspection of equipment for nuclear power plant air and gas treatment systems."

Under this charter, a draft code section for field testing of nuclear safety-related gas processing systems has been developed and is undergoing the required peer review process.

For the purpose of this code, gas processing equipment either produces a change of state or composition, or alters the concentration of gases. Specifically, equipment designed to stabilize the containment atmosphere or process gasses containing radioactive material during normal or emergency conditions is addressed by this code.

The equipment addressed by the code can generally be distinguished from nuclear air treatment system (NATS) equipment by the following characteristics:

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- Relatively high pressure,
- Relatively low flow, and
- Relatively high radioactivity content.

In the case of "mixed" safety-related air treatment and gas processing systems, this code section applies to gas processing-type equipment (e.g., compressors, piping, and valves) and references other code sections for testing air treatment equipment (e.g., blowers, ductwork, dampers). This code section therefore applies to gas processing equipment such as igniters, hydrogen recombiners, and sampling and analysis equipment. It may also apply to mixing, diluting, inerting and purge equipment, if that equipment is classified as safety-related and contains gas processing-type equipment.

Excluded from the code are gas supply systems and systems not designed to modify the containment atmosphere.

Field acceptance and surveillance tests for identified equipment are included in this code, while manufacturers's acceptance tests are not included. The equipment performance that ultimately matters is functionality under actual intended operating conditions. Therefore, this code section requires equipment to be tested under actual or simulated operating conditions.

In the code section, the term "equipment train" is used synonymously for the term "system." The equipment train is defined as all components between the process gas influx and release point, including associated instrumentation and controls.

II. Need for Testing Code Sections

It is an established practice for codes to address functional testing of equipment important for the protection of plant personnel and the general public. Usually, codes are sets of minimum specific requirements, written in explicit terms, and are often invoked by law.

The concept of including test sections in codes is not new. There are three sections in the ASME Boiler and Pressure Vessel Code (B&PVC) that address testing: Sections VI, VII, and XI. Sections VI and VII of the B&PVC are guidelines for the care and operation of heating and power boilers, respectively. Section XI covers mandatory in-service inspections and tests for nuclear power plant components. All three sections of the code call for functional testing, in addition to pressure boundary tests.

Other ASME test requirements were issued in 1906 as Power Test Codes. These codes are now known as Performance Test Codes (PTCs) and are invoked to verify conformance with design criteria or federal, state, or local laws.

In addition to codes, many standards such as ASME, ANSI, and IEEE standards also address functional equipment testing. These standards are not legally enforceable, except as invoked by a code. One example of this type of cross-reference is the intent of B&PVC

Section VI to reference the ASME Operations and Maintenance (O&M) Standard for in-service testing of valves.

Nuclear Regulatory Guides, Plant Technical Specifications, and Standard Review Plans also require functional testing of equipment. Since these requirements are subject to unannounced change and have no process for industry review, they do not necessarily form the basis for industry consensus standards.

The need for a specific test code for nuclear gas treatment systems was identified by the ASME BNCS for the following reasons:

- Gas processing equipment functionality is important in order to protect plant personnel and the general public;
- General requirements of the B&PVC must be tailored to the specific equipment designed to process gases;
- Minimum test requirements for this type of equipment are currently lacking; and,
- Test recommendations for gas process equipment are scattered among many different documents.

Therefore, this code section was written to augment and consolidate requirements of existing codes and standards, and to provide a viable single-source document.

III. Relationship to Other CONAGT Code Sections

The Code on Nuclear Air and Gas Treatment is organized into four divisions, as shown in figure 1. The code section described in this paper is part of Division IV, Testing Procedures. Definitions and references included in Section AA, Common Articles, are adopted by inference, unless specifically altered or supplemented. Other sections within Division IV are referenced, as applicable.

IV. Generic Examination and Test Requirements

One article of this code section contains generic examinations and test techniques. Also included are general requirements common to all equipment addressed by this code, as well as requirements pertaining to test personnel and test instruments.

Personnel

Because test personnel must have the necessary training to understand the equipment as well as the purpose of the required test, Section TC, Qualifications of Test Personnel (figure 1), was developed and is referenced here.

Test Instruments

General requirements for test instruments are modeled after similar requirements in Section XI of the ASME B&PVC.

Examination Techniques

There are three major types of examination and test techniques:

- Visual examination,
- Pressure integrity examination, and
- Functional examinations.

The generic test requirements of this article and the specific test requirements of subsequent articles are categorized according to these techniques.

The first technique, visual examination, is used in order to assess the general condition of the equipment that may affect its operability and functionality. By conducting visual examinations prior to other examinations and tests, it is intended to discover gross anomalies that may impact the result of a subsequent examination or test.

The second technique verifies the integrity of the pressure boundary. For acceptance testing, if the entire pressure boundary of a new or existing equipment train has been previously verified as acceptable to the rules of Section III or Section XI of the ASME B&PVC, this test need not be repeated. Periodic surveillance tests are required to reverify the pressure boundary integrity of gas processing equipment. As stated before, this code has provisions for utilizing the test results of the B&PVC (Section XI), provided that the entire pressure boundary is subjected to test.

The last technique, functional tests, is used to verify the operability of the entire equipment train. Due to the unique nature of the various types of equipment covered by this code, functional test requirements are specific in nature and are only addressed in subsequent articles.

IV. Specific Examination and Test Requirements

Specific test requirements are addressed by system or component type in two separate articles. The first article addresses field acceptance tests, while the other article addresses periodic surveillance tests. The components/systems addressed are:

- Igniters,
- Recombiners,
- Mixing, Diluting and Purge Equipment,
- Sampling and Analysis Equipment,

- Blowers and Compressors,
- Piping Components, and
- Electrical, Instrumentation and Control Equipment.

Some of the requirements unique to particular types of equipment are discussed in the following paragraphs.

Igniter Equipment

Igniter equipment is an assembly of electrical equipment utilized to burn hydrogen in primary reactor containment prior to the gas reaching critical concentrations. The equipment train usually consists of igniter elements (e.g., glow plugs), power supplies, supports, and instrumentation, controls, cabling, and other interconnections.

The surface temperature of each igniter element must be measured and recorded during operation for the field acceptance test and the periodic surveillance test. The results of periodic surveillance tests must be compared to the field acceptance test results and analyzed for degradation trends.

Recombiners

Recombiners for containment hydrogen control present a particular difficulty for development of a test code. The problem arises because there exist three fundamentally different types of recombiners, two of which involve assemblies of several processing equipment components. The three types of recombiners currently used for this service are:

- Electric
- Catalytic
- Flame

Electric recombiners are of two types. One type of electric recombiner consists of an enclosure containing electrical resistance heaters. The enclosure serves as a duct for funneling the flow of gases past the heating elements. These units are placed in containment and require only electrical connections in order to function. The other type of electric recombiner consists of a furnace external to the containment. Containment-grade piping and a prime mover (e.g., blower) conduct containment atmosphere to and from the furnace.

Catalytic recombiners typically consist of piping, valves, pressure vessels, heat exchangers, a blower, a catalyst bed, and the associated instrumentation and controls required for monitoring and controlling operation of these miniprocess systems.

Flame recombiners typically consist of piping, valves, a blower, fuel injectors, gas supply and lines, an igniter, and the associated instrumentation and controls.

Because of the physical intricacies of all types of recombiners, both internal and external visual examinations are required. The internal examination is necessary to verify the equipment is configured in accordance with design requirements for internal features, and to ensure that no construction debris remains or construction-related damage occurred. Also included are requirements to verify the integrity of support plates after catalyst installation, and to verify the presence of water in loop seals.

Because catalysts are generally adversely affected by contact with water, hydrostatic tests are required to be conducted prior to catalyst installation. If a hydrostatic test of a catalyst vessel is performed, thorough drying is required before catalyst installation. A leak test of affected joint is required after catalyst installation.

Various components, such as liquid level, flow, and spray controls are to be functionally tested with fluids over the entire range of process input conditions. For example, liquid level controls are to be tested by raising and lowering an actual liquid interface past controller setpoints. This testing may be performed during integrated equipment functional tests.

For catalytic recombiners, the integrated flow test is to be followed with a test using a combustible test gas (hydrogen), to ensure recombination functionality at design concentrations and flow rates. After this testing is complete, the equipment is to be internally inspected for migration of catalyst fines.

Because some plant designs allow shared use of a recombiner at more than one operating unit, the situation may occur where the recombiners are kept in a storage location, rather than being permanently installed. To ensure that the recombiner and permanent connections properly join and the soundness of the equipment was not affected by transportation, the code section requires that each shared recombiner be installed at each of its potential use sites and all connections then be leak-tested and/or functionally verified. Integrated flow testing is required at only one of the potential use sites.

Stored units are to be inspected periodically to assure that they have been maintained in accordance with manufacturers' recommendations (or ANSI NQA-2, if no manufacturer's recommendations exist).

A mandatory appendix detailing safety precautions to be taken when handling hydrogen and oxygen has been provided. The appendix references precautions specified in NFPA-50 and NFPR-50A, and includes material found in the Compressed Gas Association pamphlets G-4 and G-5, with only minor modifications.

Mixing, Diluting, Inerting and Purge Equipment

Test requirements for the majority of components in these systems are covered in other articles. Code Section TA, Field Testing of Air Treatment Systems, is referenced for ductwork and damper test requirements.

Sampling and Analysis Equipment

Containment atmosphere sampling and monitoring equipment used to measure hydrogen and oxygen concentration are of two types:

- Out-of-containment analyzers (external system), and
- In-containment sensors (internal system).

The external system consists of a sensor-analyzer unit outside the containment. Tubing and a prime mover (e.g., vacuum pump) transport a continuous sample of containment atmosphere to and from the analyzer. The internal system consists of a sensor(s) mounted inside containment and electrically connected to out-of-containment instrumentation and controls. The sensor must be qualified for postaccident environments.

Prior to pressure and leakage tests, sample lines must be checked for obstructions by blowing dry air or nitrogen through them. This precaution is necessary because the sample lines are usually small (1/4 in.) and the potential for plugging by construction debris is fairly high.

The component test for gas analyzers consists of an operational test using zero and span gases. The span gas mixture is required to be within the upper range of interest for the analyzer. A nonmandatory appendix provides guidance for calibrating analyzers and verifying results. This appendix includes information from ANSI/ASTM D3249-79, with minor modifications.

Certain in-line hydrogen and oxygen analyzers have experienced operational failures due to ingress of water. Because there is a significant potential for condensation of containment atmospheric steam within sample lines with subsequent flow blockage, an integrated flow test under design basis accident conditions (pressure, temperature, relative humidity and time) is required for field acceptance. During this exposure test, the flow rate must be continuously monitored and performance of the analyzer must be verified at least every ten hours. This test is intended to verify that sample line design and installation have precluded the formation of loop seals by condensate and will free-drain back to the containment penetrations.

Condensation and resulting flow blockage could be prevented by maintaining the containment air sample above its dew point temperature along the entire length of sample line. Provision has therefore been made to reduce the required exposure test time to four hours if the sample line is heat-traced. This test will ensure that the heat tracing is capable of maintaining sample temperature during post-accident conditions.

Testing of Individual Components

Test requirements for types of components that are contained in more than one equipment train are detailed in the subarticles following those for equipment train testing. Those components include blowers, compressors, piping components, electrical and instrumentation and control equipment.

Blowers and Compressors. Section TA, Field Testing of Nuclear Air Treatment Systems (figure 1), is referenced for component tests of blowers.

Component tests for compressors consist of vibration amplitude measurements. The compressor test requirements found in ASME B&PVC Section XI, Part IWG, were used as guide for this testing. Acceptance criteria of IWG were modified so that allowable ranges of vibration are not expressed as a function of a reference temperature and pressure, but only of the reference vibration measurements. The tolerances for allowable vibration remain the same as those in IWG.

Piping Components. Valves are the only piping components requiring tests not specified by pressure boundary, electrical or instrumentation and control tests.

ASME B&PVC Section XI, Part IWV, is referenced for component functional testing. The equipment is already under the purview of Section XI; this provides merely a cross-reference, not a new requirement. As previously noted, it is intended that the O&M Standard on valves will eventually be referenced by Section XI. Section TA, by referencing Section XI, will thus also be linked to the O&M Standard.

Electrical and Instrumentation and Control Equipment. Component functional testing required includes:

- Manual and automatic (when applicable) operation of electrical equipment and observation of response,
- Introduction of a test signal to verify equipment trip setpoints, and
- Testing the functionality of any equipment bypass controls and the associated status indicators.

References for continuity, resistance to ground, calibration, and functional performance tests include IEEE-43-1974, NEMA Electrical Standard ICS-1-1978, Part 109, and IEEE-498-1985. In addition, the following component functional tests are required:

- Insulation resistance tests on all electrical drivers,
- Current measurement on each phase of power supplies,
- Polarity of 120 vac, 50-Hz, 3-wire systems,
- Resistance between the neutral side of power supplies and ground, and
- Resistance between the ground connections of all enclosures and earth ground (per IEEE-27-1974).

Acceptable methods for continuity testing are also described.

All instrumentation and controls necessary to operate the equipment train shall be subject to the same test and calibration requirements as for permanently mounted test and calibration equipment.

Annunciator circuits must be tested for functionality by introduction of a test signal, as well as the physical manipulation of process conditions.

VI. Testing Following an Abnormal Incident

Abnormal incidents have the potential for affecting the equipment covered by this code section. An evaluation must be performed and documented to determine the scope of required retesting.

VII. Repair and Retest

Unacceptable equipment conditions must be corrected by replacement, repair, or analysis. The analysis must demonstrate that the condition does not impair equipment performance to design specifications. A simple successful repetition of a test cannot be used to negate a failed test; corrective action must precede the retest.

If the cause of the deviation cannot be determined by inspection or analysis, corrective action may consist of recalibration of test instruments and subsequent retesting. If it is determined that the unacceptable situation is attributable to equipment condition or malfunction, rather than problems with the test equipment or procedure, the equipment must be taken out of service or declared inoperative until corrective action has been taken.

VIII. Documentation

Documentation for the examination, tests, replacements, repairs, corrective actions, analyses, and evaluations must be prepared and maintained for the service lifetime of the nuclear power plant, in accordance with the utility's quality assurance program.

IX. Summary

The code section has received preliminary review from test, operations, and engineering personnel from five utilities, as well as personnel from an equipment manufacturer/supplier, insurers, and an engineering firm. Comments from these sources have been invaluable and all were addressed and resolved by the subgroup. Additional comments received during the ASME review and public comment process will ensure this document is usable, while setting forth minimum test and performance requirements.

Figure 1

Organization of
ASME Code on Nuclear Air and Gas Treatment

Division I - General Requirements

- Section AA - Common Articles

Division II - Ventilation Air Cleaning and Ventilation Air Conditioning

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- Section BA - Fans and blowers
- Section CA - Conditioning equipment
- Section DA - Dampers and louvers
- Section FA - Moisture separators
- Section FB - Prefilters and frames
- Section FC - HEPA filters and frames
- Section FD - Sorbers and frames
- Section FE - Sorbent media
- Section IA - Instrumentation and control
- Section RA - Refrigeration equipment
- Section SA - Ductwork

Division III - Process Gas Treatment

- Section GA - Pressure vessels, piping, heat exchangers, and valves
- Section GB - Noble gas hold-up equipment
- Section GC - Compressors
- Section GD - Other radionuclide equipment
- Section GE - Hydrogen recombiners
- Section GF - Gas sampling

Division IV - Testing Procedures

- Section TA - Field testing of air treatment systems
- Section TB - Field testing of gas processing systems
- Section TC - Personnel qualification
- Section TD - Laboratory qualification

Review Of Current Halide and Aerosol Leak Testing Methods of Nuclear Air Treatment Systems, Components and Banks

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ABSTRACT

All nuclear power plants, and nearly all other types of nuclear facilities, have one or more Nuclear Air Treatment Systems (NATS) to control influent, effluent, or process flow. Many NATS are required to be periodically tested by the facility licensee, and all should be tested per good engineering practice. The basis for this testing in the United States is ANSI/ASME N510-1980 (or -1975), "Testing of Nuclear Air Cleaning Systems."

There are a number of different testing methods, and this paper will discuss the advantages and disadvantages of each method along with ALARA considerations and cost considerations.

With the information and analysis presented in this paper the engineer will have a reasonable basis in both theory and practical experience upon which to help propose the best possible method for testing existing systems and for design of new NATS.

INTRODUCTION AND BACKGROUND

Over the approximately 30 years of the commercial nuclear power industry's history, there has been significant evolution of the Nuclear Air Treatment Systems (NATS) used in these plants. Both the number of systems per plant and system complexity have increased. Concurrently, the requirements (both regulatory and technical standards) for testing the NATS have also increased. Unfortunately the physical provisions in the systems to allow performance of the up-graded testing has not kept pace with the testing requirements. This has led to the development of a number of test methods designed to cope with the problems of attempting to meet testing requirements without the needed physical provisions built in the NATS. This paper will review the historical, technical and standards aspects of this situation.

When the first commercial nuclear electrical power production plants in the United States came on-line in the early 1960's (actually starting with Shippingport in 1957), there were no industry standards on nuclear air filtration systems, no specific regulations on these systems, no specific textbooks or hand books on them, and no formal courses or seminars for training. The only source of specific technical papers was the series of Nuclear Air Cleaning Conferences (1) originally sponsored by the AEC (and now by DOE). The first was held in 1951 and was classified "Secret" (it was never published in the open literature). Later ones in 1952, 1953, 1955, 1957, 1959 and every other year thereafter, were not classified, or if so, were later declassified and proceedings were published. Unfortunately the timing of these early conferences was at, best parallel, for the design of the first plants. Even with the much shorter lead time enjoyed in the early days of the nuclear industry at least 5 years was required so the early plants were contracted for in the mid to late 1950's. This meant that the only basis for NATS design, testing or regulation was the expertise of the technical personnel involved. Fortunately many of these engineers had experience from the Naval Reactors Program, or the earlier Manhattan District Project. This experience, along with good engineering judgement, produced NATS that, perhaps primitive by today's standards, did the required job well enough that there have been no radioactive releases through these systems that have had an adverse effect on the public or the environment.

Two areas that did, and in some cases still do, suffer from a lack of experienced technical personnel, were maintenance and testing. Maintenance is outside the scope of this paper and testing is its substance.

The very first plants had only one or two air filter systems and would hardly be recognized as NATS today. HEPA filters were well known from the Manhattan District Project and follow-on weapons work. Carbon filters for adsorption of gaseous radioactive fission products were even more primitive. The existance of organic forms of Iodine was not considered in those early days. Initially the only actual testing, if any, beyond visual inspection, was an aerosol leak test. The provision for this test was usually the ability to run a sample line into a housing by removing some component and using its pressure boundary penetration. From this we have evolved to NRC Regulatory Guides 1.52 Rev 2 (2) and 1.140 Rev 1 (3), ANSI/ASME N509-1980 and N510-1980, (4)(5)(6)(7) (with 1986 revisions in-process) and detailed NRC Inspection and Enforcement Procedures for HVAC in the "Inspection and Enforcement Manual" section 50100 (8).

The earliest generally available guidance for Halide leak testing of adsorbers was from the Savannah River Production facility of the AEC in publication DP 1082 (9,11). This was published in 1967. ANSI N101.1-1972 (10) was the first industry standard for DOP aerosol leak testing of HEPA filters. It was published in 1972. These early standards and technical reports were of great assistance to the industry, and were the basis for later documents. They were, however, limited in scope and not written for broad nuclear power plant use. The need for broader standards was recognized and an ad-hoc group was formed in July of 1971 under the American National Standards Institute (ANSI) N45 Committee on Reactor Plants. The American Society of Mechanical Engineers (ASME) was the direct sponsor. This group authored the original issue of N509 "Nuclear Power Plant Air Cleaning Units and Components" in 1976, and N510 "Testing of Nuclear Air Cleaning Systems" in 1975. Need for continuing development and ongoing revision was immediately recognized, and the permanent ASME Code "Committee on Nuclear Air and Gas Treatment" was accredited in January, 1976. CONAGT has produced the 1980 editions of N509 and N510, and is working on the 1986 editions. CONAGT is also writing an expanded Code including both NATS and Gas Processing systems for future use.

In addition to the overall and unavoidable problem of a learning curve there is the very real problem created by the long lead time between design of a NATS and its Acceptance Testing. Today this is unfortunately on the order of 10 years. This means the testing requirements may be more demanding than the equipment design anticipated even when the letter and intent of the requirements at the time of design were fully implemented. Unfortunately this full implementation of the intent of the standards is less common than it should be so the overall problem is further complicated.

The most common NATS consists of a series of component banks in a filter housing. The simplest would be a prefilter and HEPA bank with the most complex a Standby Gas Treatment or Control Room Emergency Makeup with a Moisture Separator, Heater, Prefilter, HEPA filter, Adsorber and Final HEPA filter (Figures 1, 2 and 3). Many variations and combinations exist including multiple adsorber banks in series. It is the series aspect of component banks that is the most common source of testing problems. By regulation and good engineering practice, each bank must be leak tested individually for credit to be taken for that bank. This requires each bank to be individually challenged and sampled. How to introduce an aerosol challenge between two HEPA banks, and how to sample between them in a manner that evenly challenges and samples the entire bank equally is a significant problem. The same problem exists for series adsorbers further complicated by the time dependency of a halide leak test. Fortunately series adsorbers are very unusual, and therefore will not be treated as a separate item in this paper. Most comments on series HEPA banks will apply to series adsorbers.

Over the years a number of common, de facto, procedures were developed to allow a bank leak test of some type to be performed. Some of these procedures provide reasonably accurate indications of bank leak tightness but at a great cost in time and effort. Others have significant technical flaws. That is not to say they are worthless. Simply, that as the sophistication of the industry has evolved, better methods have been developed, so older methods can no longer be justified. One method stands out as the most technically correct, and also the most cost efficient in the long run. It adds slightly to the upfront capital cost (which is the most visible), and therefore is often resisted. The analysis in this paper will call attention to the significant costs, as well as the purely technical aspects of each method.

The most common methods in use today to perform ANSI/ASME N510 Leak Testing can be summarized as:

1. Shroud Test Method (STM)
2. Component Removal Method (CRM)
3. Selective Insertion Method (SIM)
4. Multiple Sampling Method (MSM)
5. Test Manifold Method (TMM)
6. Single Point Sampling (SPS)

DEFINITIONS

For consistancy and to reduce possible confusion the following definitions are used in this paper:

1. Aerosol - A suspension of small particles, solid or liquid, in air. The diameter or major dimension of the particles may vary from 100 microns down to 0.1 micron or less (a micron is 1/1,000,000 meter or about 1/25,000 inch.

2. Challenge Agent - Either DOP or Halide used to measure leakage through a component bank.

3. Component Removal Method (CRM) - The removal of one or more components from a component bank to allow challenge agent to flow through said component bank without filtration, delay, or reduction of the challenge agent concentration.

4. DOP - Dioctyl Phthalate (di-2-ethyl hexyl phthalate) an oily, clear, noncorrosive liquid that forms an aerosol of repeatable dimensions under given parameters of temperature, pressure, flow, etc.

5. DOP Aerosol - By N510-1980 definition, the polydispersed aerosol shall have:

"an approximate light-scattering mean droplet size distribution as follows: 99+% less than 3.0 microns
50+% less than 0.7 micron
10+% less than 0.4 micron"

6 Halide (per ANSI B79.1) (11)
2.6.1 R-11; Tricholoro (mono) fluormethane
2.6.2 R-112; 1,1,2,2-Tetrachlorodifloroethane

7. Multiple Sampling Method (MSM) - The taking of many individual samples in a defined cross section or housing area over a period of time to be averaged by calculation per Section 11 of N510-1980. (Note: "Section" references are to N510-1980 unless otherwise specified.)

8. Selective Insertion Method (SIM) - The selective insertion or installation of components during bank loading to allow passage of challenge agent through said bank before all components are installed.

9. Shroud Test Method (STM) - The use of a device (shroud) to limit flow from a generator, or to a detector, through a subset of the entire bank under test. See Section 10.6 of N510-1975.

10. Test Manifold Method (TMM) - The use of devices (manifolds) to inject or sample challenge agents over a defined area or housing cross section with the concentrations averaged by physical mixing to provide the equivalent of a single point sample to a detector or even distribution from an injection position.

11. Single Point Sampling (SPS) - The taking of a single sample as representative of the Challenge Agent concentration over a defined area or housing cross section. For a SPS to be used, test data must have been obtained to verify the sample is representative (Section 9).

Each of the listed methods will be described and discussed as to their strengths and weaknesses.

DISCUSSION

SHROUD TEST METHOD (STM)

The STM is one of the oldest methods, and while very useful in the past, it has been superseded by better methods. It was deleted as an acceptable integrated leak test method by N510-1980. The only current application of this method would be to assist in scanning for locating leaks (Section 10.1).

A shroud is a device to enclose a portion of a filter or adsorber bank to limit the challenge injection and sampling to this restricted section (Figures 4,5). The original basis of need was very real. It was the limited output of DOP Aerosol Generators. Laskin nozzle air operated generators were usually limited to an output sufficient for about 15,000 SCFM. Even at this output, they were being pushed to their limits. High output DOP Aerosol Generators for 80,000 SCFM systems have been commercial units since 1975.

For the bank, other than the perimeter, shroud design was not too difficult. It would enclose one or more filters in a box form on both upstream and downstream faces of a bank. There is the immediate and obvious trade off of size/weight with attendant handling and problems vs. the number of setups and tests made. At best handling any object in a housing with installed components is difficult and time consuming. Such handling often causes damage to the installed components. Once the shrouds were installed, a local leak test was performed. The total leakage was then obtained by calculation when all locations had been tested.

The perimeter filters are very difficult to test with a shroud. Since the frame to housing seal must be included as a part of any leak bank test, the shroud must seal to the wall, floor, or ceiling depending on the filters being tested. This usually means three shroud sets, or at least three setups or configurations of a single, more complex shroud set. Obviously complexity, weight, expense, and delay are increased by these different configurations.

An additional problem with shrouds is the inherent probability of both Type I and/or Type II errors. That is, failing an acceptable bank or passing an unacceptable one. The basis for this problem is the need to ensure total coverage of all possible leak paths. This is usually done by overlap of the area covered by different shroud locations/setups. Double counting the same leak will occur when the shroud overlaps to include the entire bank. Certainly this is the conservative and safe approach.

If the shroud does not cover all possible leak paths, then leaks could obviously be missed. The housing to frame seal welds were the most commonly missed potential leaks as many shrouds were never designed to seal to the wall.

As mentioned, damage to HEPA filters and other NATS components was a serious problem when using a shroud even with faceguards on the HEPA filters.

Uniform air flow distribution is a question universally (in this author's experience) neglected when using shrouds. To meet the requirements of N510-1975, an Air Flow Distribution Test must be performed for each Shroud Setup.

ADVANTAGES

1. In the past it allowed testing of large systems when there were no alternate options due to DOP Aerosol generator limitations.

2. If leaks must be found on a bank that failed some other form of integrated leak test, it could assist in scanning by DOP, loading only a portion of the bank at a time.

DISADVANTAGES

1. The requirement of fabricating, handling, mounting, and moving the shrouds. Inside a housing handling is time consuming and a potentially serious problem. If the system has any contamination, it also becomes an ALARA problem. The frame requires

provision to hold the shroud in place.

2. Missing frame to housing seals and potential leaks.

3. Type I and Type II errors.

4. Damage to HEPA filters (and other components).

5. Much longer time required for test.

6. Requirement to perform an Air Flow Distribution Test for each Shroud Setup.

7. It has been deleted as an acceptable test in N510-1980 (and draft-1986).

8. The need for shrouds no longer exists as high output DOP Aerosol generators have long been commercially available.

COMPONENT REMOVAL METHOD (CRM)

The CRM method is also a long used method. The method is exactly as the title suggests. One or more HEPA filters in the first (upstream) bank are removed to allow DOP challenge to pass through to test the second (downstream) bank. (Figures 7,8). The DOP flow is also through the adsorbent when such a bank exists between the HEPA banks.

This can provide an acceptable test of the second HEPA bank but the problem remains of how to test the first bank. After the removed filters are reinstalled in the first bank it must be leak tested. Obviously HEPA filters cannot be removed from the second bank, or it would need to be retested, and you would be in an endless loop of testing. The usual method of downstream sampling for the first HEPA bank is the MSM.

The CRM has been used on high efficiency prefilters to provide sufficient challenge to the first HEPA bank. This is more acceptable than removing HEPA's since prefilters do not need testing, but it is still a less than ideal process. Airflow Distribution will change when some prefilters are removed. Again, the question of Air Flow Distribution arises. To meet the requirements of N510, an Air Flow Distribution Test is required prior to a Bank Leak Test if any modifications are made. Upstream filter removal is certainly a modification. Even if the same filters are always removed, the dirt loading, and, therefore, the pressure drops will be different, so the test is always required. By the same reasoning, the Air/Aerosol Test is also always required.

At times, Type II carbon trays are removed along with the selected HEPA filters in the first bank. Such removal is a good practice since it keeps the DOP from passing through the actual adsorbent. It is, however, a labor intensive process and adds additional possibilities for damage and resealing problems. This practice also further compounds the Air Flow Distribution and Air/Aerosol Mixing situation.

In any CRM approach, the units removed must be carefully chosen to provide uniform air flow and challenge/air mixing for the bank to be tested.

ADVANTAGES

1. It allows testing of series systems that would not be otherwise (except by some method discussed here) testable.

2. It does not require any fixtures or extra test apparatus.

3. Depending on the system, it is usually reasonably rapid compared to a shroud method.

4. Properly performed it challenges the entire bank so the Type I/Type II error problem is eliminated.

DISADVANTAGES

1. It requires considerable time inside a housing which can be an ALARA problem.

2. It requires removal and reinstallation of a number of HEPA filters which will usually result in some damage. It also presents the problem of reseating a filter with a deformed gasket. Leaks often result from re-using a HEPA filter that has been clamped in place since the gaskets take on a permanent deformation. The same problem exists for removal and replacement of Type II Trays.

3. For the method to provide uniform challenge, the position and number of filters removed requires careful analysis. Both an Air Flow Distribution test and an Air/Aerosol Mixing Uniformity test per N510 is required to confirm that proper air flow and challenge is obtained at the bankface.

4. Unless the entire bank of Type II Trays is removed, DOP will go through the adsorbent. On a two inch Type II tray, this is not a serious problem, but equally, not good practice.

5. If a Type III deep bed adsorber is in the flow path, a problem exists with DOP flow through the adsorbent. At 4 inches or greater, a significant quantity of DOP will be removed by the carbon. As the bed depth increases so does the problem. Additionally, DOP appears to be a potential poison to the impregnated carbon. Unfortunately there is <u>very</u> little data on DOP as a

poison in the quantities used for leak tests, but we know most hydrocarbons have a negative effect on the impregnated carbon.

6. Much longer time required for test.

7. The test is not specifically recognized by N510

SELECTIVE INSERTION METHOD (SIM)

The SIM approach is very similar to the CRM except that by definition it applies only at startup (or in some cases filter changeout). Filters and adsorbent are installed in an order such that the various tests may be performed the same as they are in the CRM. One advantage is that the DOP testing can (if a deviation is taken on the Airflow Distribution test, Section 8.2) be completed before the carbon is installed. (Figures 9,10)

The problem of Airflow Distribution testing is critical to the use of this method. N510-1980 requires the Airflow Distribution Test as a prerequisite to the DOP leak test. An Airflow Distribution Test requires all the actual filters and carbon be installed. If all components are installed, the situation is that of using the CRM not the SIM. In either case if the Airflow Distribution test is not performed and passed, then N510-1980 has been violated.

Most significant in an analysis of the SIM is the impact on plant operation. It may allow a valid leak test if the Airflow Distribution problem is somehow addressed during Startup but except in exceptional circumstances, it CANNOT BE REPEATED AS A SURVEILLANCE TEST during plant operation. This point is often "neglected" to be mentioned when the SIM is used for Acceptance Tests.

ADVANTAGES

1. It allows a test to be performed that would not otherwise (except by some other method discussed here) be possible.

2. It does not require any fixtures or extra test apparatus.

3. Depending on the system, it is usually reasonably rapid compared to a shroud method.

4. Properly performed, it challenges the entire bank so the Type I/Type II errors are eliminated.

DISADVANTAGES

1. It is essentially a Startup/Acceptance test only, and leaves the problem of life of plant Surveillance Tests to the plant operating staff. This is seldom acknowledged at the time of the test.

2. The problem of Airflow Distribution testing is critical and often simply overlooked. This will make the Test invalid on procedural grounds. Further, when the test is performed, if it does not meet the N510 requirement of all components installed, an Air/Aerosol Mixing Test is performed under conditions contrary to the requirements of N510.

3. The problem of downstream sampling of the first HEPA bank is left open as in the CRM. Multiple sampling is the usual approach for this requirement.

MULTIPLE SAMPLING METHOD (MSM)

The MSM is performed as the name implies. A number of samples (usually large) are taken over the subject cross section, and the average concentration is calculated along with the standard error, and the 95% confidence level of the concentration per Section 11 of N510-1980. (Figures 11, 12)

While the first formal step in the procedure (11.4) is to define a set of sample points, the <u>prerequisite preliminary step</u> is to scan the entire bank including the frame to housing interface, locate, and have all leaks repaired. The immediate problem is that leak is not defined. How small or large an indication of increased DOP concentration constitutes a leak? At best, this is a very time consuming step, and loads considerable DOP on a large bank. It will also be a significant ALARA problem in a contaminated system. The question of what level of DOP concentration is acceptable without being defined as a leak is not addressed in N510-1980. It is not an easy question. If the level is set too high, then too much leakage may be accepted. If set too low, it will take an unreasonable length of time to eliminate all these indications. This prerequisite is a major undertaking, and again is usualy ignored when a case is being made for the MSM.

After the scanning repair and rescanning, the formal sample areas must be chosen. The guidance given is theoretically correct, but could lead to missing frame to housing leaks unless executed with great care. If the prescanning was well executed, then the formal data taking is essentially instrument noise or random particles that always penetrate or come off the actual media. Further the scanning in step 11.4.2 does not take into quantitative account the area of the maximum reading. It could be a point or an area equal to (or even larger than) the traverse area selected. This reduces the quantitative confidence of the method regardless of mathematical calculations based on statistics. It is also very time consuming.

Note that the MSM does not in any way address the problem of injection of a challenge for a down stream component bank. In a HEPA-carbon-HEPA system, DOP must be injected after the carbon to challenge the down stream HEPA. While the MSM can provide concentration data, it simply ignores this injection problem.

N510-1980 in 11.1 discusses penetration, but in 11.4 defines "Cu" as the upstream concentration. For upstream it would be an Air/Aerosol Mixing Uniformity Test per Section 9. When used for penetration, it could make sense as providing necessary data per discussion in other methods.

When the MSM is used, the samples should be taken where there is the best mixing provided by the system itself. For example in a Type III adsorber, the inlet slots provide good mixing for the downstream sample of a first HEPA bank.

ADVANTAGES

1. For upstream readings of a system where the ±20% challenge uniformity cannot be met (and modification is not made to bring the NATS up to standard), this is a reasonable method.

2. In general, it can always be used to take readings, IF there is any physical access, either for man entry or for remote traverses.

3. It does not require any component removal, or matter in what order components are installed. There is usually no problem of Airflow Distribution. If a person is inside a small system, some air flow disruption obviously takes place, but does not seem to constitute a problem.

DISADVANTAGES

1. Long exposure of HEPA filters to DOP loading.

2. NO possible application to Halide leak testing due to strict time dependency of a Halide leak test.

3. Serious potential ALARA problems due to long duration of work required inside the housing.

4. Limited confidence in the value of downstream readings when there are no leaks. The value should be low and provides good indication that the bank integrity is leak free, but the actual calculated penetration values are very shaky.

5. Based on the prerequisite scanning, it is more of a qualitative exercise that there are no leaks over some arbitrary

value. This may be all that is needed, but the MSM must be recognized for what it is in relation to a real integrated leak test penetration (or efficiency) value.

6. The problem of injection for challenge of a down stream component bank remains totally unaddressed by the MSM. This is a critical flaw that is usually not discussed in relation to the MSM.

7. Access to the entire bank face is required.

TEST MANIFOLD METHOD (TMM)

A Test Manifold (TM) is a device that takes a number of representative samples over a defined cross section of a housing, all at the same time, and averages them by physical mixing for a single sample representative of the entire cross section (Figures 13,14 and 15). The TM may be a permanent part of the housing (greatly preferred), or temporary and installed only for the test. Usually temporary TM's are only used if they are added after the housing is installed, and were not designed and built in as a part of the original system.

Since a TM is operating "real time" (less a very short delay due to sample transmit time), it can be used for Halide tests as well as DOP tests. This "real time" sample also allows a very efficient and rapid test. With permanently installed TMs (or after temporary TMs have been installed), the actual leak test is performed in a few minutes; the same as for the ideal Single Point Sampling Method.

The design of the TM should use the inherent mixing of the housing. The previously mentioned slots of a Type III adsorber are excellent locations for manifolds.

Based on the N509 and N510 (all editions) requirements for testability, TMs should be designed and built in systems to allow leak testing as necessary. As discussed in this paper, many NATS did not have them included so they have been added as backfits. This presents the problems of seismic analysis, possible interference for maintenance, and component changeout, as well as "after the fact" design in the field. These backfit TMs are usually designed for temporary use to avoid the seismic and interference problems. While far better than no manifolds, temporary TMs are not as desirable as permanent TMs. The increased initial cost of a permanent TM is quickly paid back in plant operational use. With a permanent TM, a leak test can be conducted without otherwise disturbing an operating (or operational) system. That is, it is a leak test that is possible without any intrusion into the system housing.

ADVANTAGES

1. It can be used for both Halide and DOP Leak Tests.

2. It provides the same convenience and accuracy as Single Point Sampling.

3. It will allow a test to be performed without entry into the housing (for permanently installed TMs).

4. Usually, a shorter time is required in a housing to install a TM (designed for temporary use) than for the MSM, STM, CRM, or SIM.

5. It provides greater repeatability since a fixed sample configuration is used for each test based on the fixed physical construction of the TM. This applies to both permanent or temporary TMs.

6. It can be used with generally less requirements for training and skill of the test engineers than any of the other methods (except SPS, of course).

DISADVANTAGES

1. Some increase in initial cost.

2. If temporary, controlled storage is critical so the TM will be available when needed.

3. The TM takes up some space in the housing where space is usually in short supply.

CONCLUSION

Given the noted and obvious disadvantages of the CRM, MSM, SIM, and STM, the conclusion is firm that the TMM is the method of choice when SPS is not possible for series components. Further, it is specifically required (or at least such was the intent) in N509, N510, R.G 1.52, and R.G. 1.140. From a "life of plant" cost standpoint, the TMM is clearly the least costly based only on simple test time. Unfortunately the "life of plant" cost does not seem to be used in most design analyses, or bid evaluations for NATS. When ALARA considerations are added, the TTM advantage is greatly reinforced. Adding the significant technical deficiencies discussed makes this conclusion even more obvious.

Certainly in some NATS configurations such as a HEPA-HEPA system, a manifold may be difficult to design, and end up with rather complex baffles added to provide mixing. (An excellent reference on basic mixing baffles and related testing topics is

"A Comparison of the Methods Used in the Nuclear Industry to Test High Efficiency Filters") (12). However, the same type of problems will exist for any alternate method, and be repeated each time the system is tested.

The problems of Airflow Distribution and Air/Aerosol Mixing as required prerequisite tests each time an alternate Leak Test method is performed have historically been ignored. This brings to question many leak tests performed in the past.

TMs are often argued to be unnecessary added cost, but when there is any real analysis of the technical merits and life of plant costs; rather simply the cost of a day's time for a test team on a "one shot" basis vs. the one time cost of TMs, the answer always is the same on paper. It is not clear why all plants have not upgraded existing systems to the required standards, and to good engineering practice.

Whatever the specifications, regulations, or industry standards require, or are interpreted to require, the real design objective should be for a NATS that will operate, and be testable and maintainable; at a maximum technical level and at minimum cost for the life of the plant. TMs clearly are required to meet these criteria if Single Point Sampling and Injection is not possible.

REFERENCES

[1] AEC/ERDA/DOE-Harvard Nuclear Air Cleaning Conferences, (1951 to present)

[2] US NRC Regulatory Guide 1.52, Rev 2, "Design, Testing, And Maintenance Criteria For Post Accident Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration And Adsorption Units Of Light-Water-Cooled Nuclear Power Plants"

[3] US NRC Regulatory Guide 1.140, Rev 1, "Design, Testing, And Maintenance Criteria For Normal Ventilation Exhaust System Air Filtration And Adsorption Units Of Light-Water-Cooled Nuclear Power Plants"

[4] ANSI/ASME N509-1976, "Nuclear Power Plant Air Cleaning Units and Components"

[5] ANSI/ASME N509-1980, "Nuclear Power Plant Air Cleaning Units and Components"

[6] ANSI/ASME N510-1975, "Testing of Nuclear Air Cleaning Systems"

[7] ANSI/ASME N510-1980, "Testing of Nuclear Air Cleaning Systems"

[8] US NRC "Inspection and Enforcement Manual," 17 October 1975

[9] USAEC DP-1082, July 1967, "Standardized Nondestructive Test of Carbon Beds for Reactor Confinement Applications" *

[10] ANSI N101.1-72, "Efficiency Testing of Air Cleaning Systems Containing Devices for Removal of Particulates"

[11] ANSI B79.1, "Number Designation of Refrigerants"

[12] "A Comparison Of The Methods Used In The Nuclear Industry To Test High Efficiency Filters," R.G. Dorman, Commission Of European Communities, June 1981

*NOTE: A series of DP reports in the mid-sixties were written on the technical area of leak testing of adsorbent beds. DP-1082 is the one most commonly referenced.

PUBLICATIONS SOURCES

[1] U.S. Nuclear Regulatory Commission Documents

A) U.S. Government Printion Office
P.O. Box 27982
Washington, DC 20013-7082
(202) 275-2060 (202) 275-2171

B) Publication Service
U.S. NRC
Washington, DC 20555
(301) 492-7914

C) NRC Public Document Room
(202) 634-3273

D) National Technical Information Service (NTIS)
U.S. Department Of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

[2] ANSI/ASME Standards

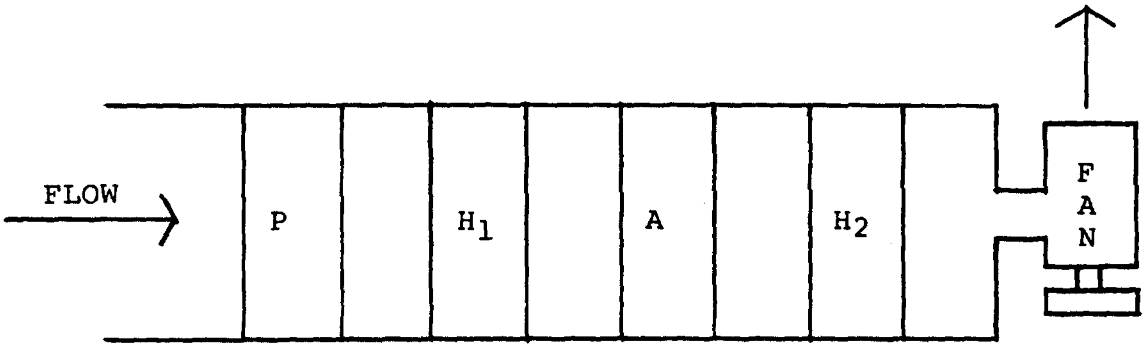
A) The AMerican Society Of Mechanical Engineers (ASME)
345 East 47th Street
New York, NY 10017
(212) 705-7801, Nuclear Department

B) American National Standards Institute (ANSI)
Sales Department
1430 Broadway
New York, NY 10018
(212) 642-4900

[3] Organization for Economic Co-operation and Development (OECD)

A) Nuclear Energy Agency
Organization for Economic Co-operation and Development
Director of Information, OECD
2, rue Andre-Pascal
75775 PARIS CEDEX 16
FRANCE

B) OECD (USA Address)
OECD Publications and Information Center
1750 Pennsylvania Avenue N.W.
Washington, DC 20006-4582
(202) 724-1857



Typical NATS configuration with Prefilter, HEPA filter, Adsorber and HEPA filter banks in series. This will be used for all examples

CONFIGURATION:

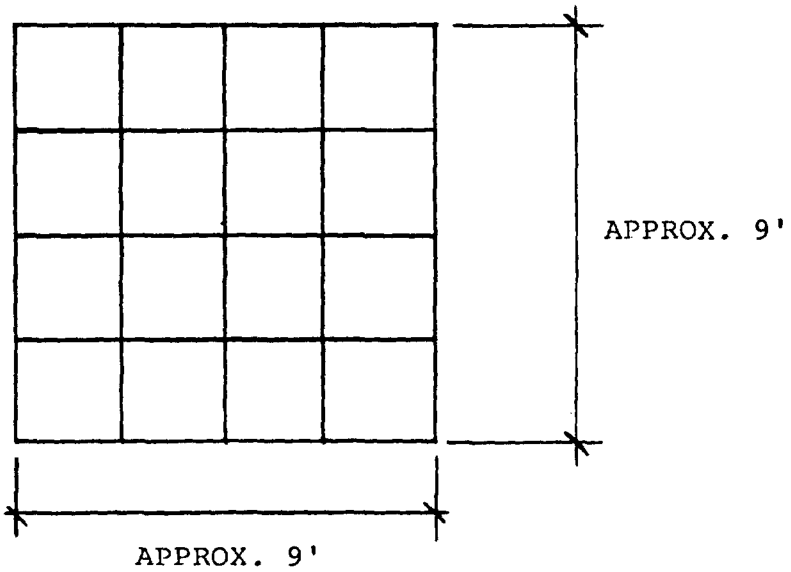
P = Prefilter Bank

A = Adsorber Bank

H_1= First HEPA Bank

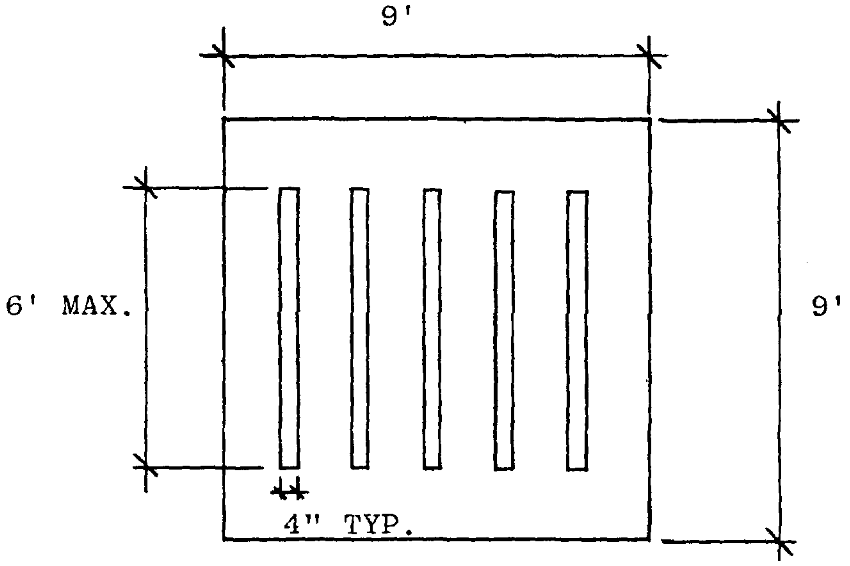
H_2= Second HEPA Bank

FIGURE 1



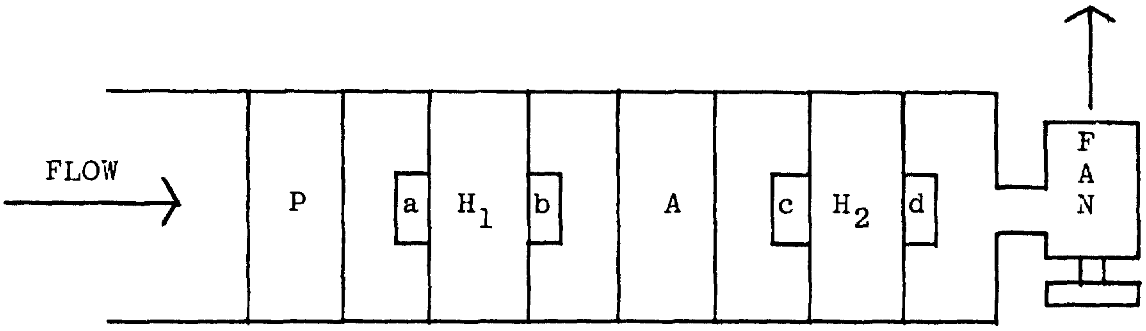
Typical 4 x 4 HEPA Filter Bank. This configuration will be used for all examples.

FIGURE 2



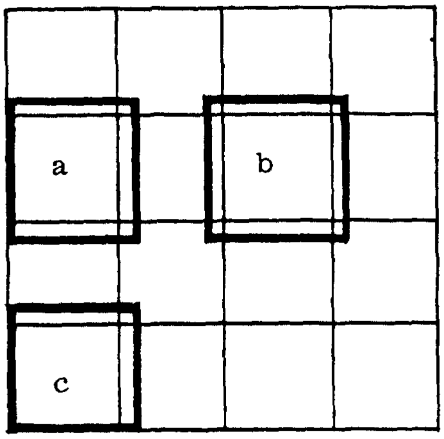
Typical Type III Deep Bed Adsorber showing flow slot configuration. Note small face area of slots vs. that of HEPA Banks. Slot area is typically 10% to 15% of HEPA face area.

FIGURE 3



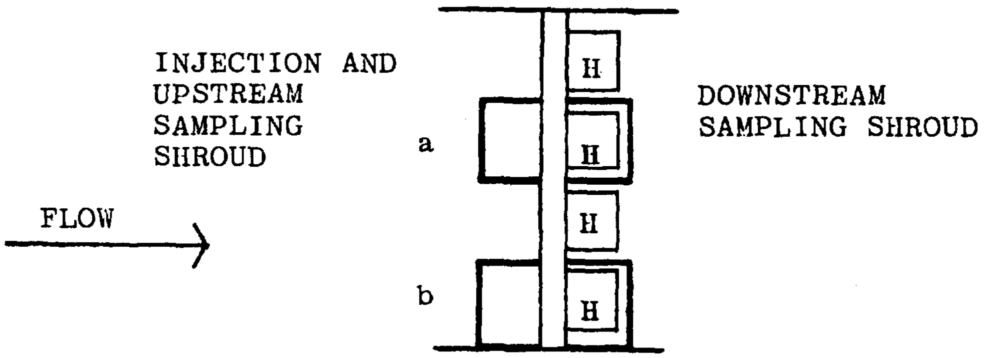
Typical placement of Shrouds to test the HEPA Banks. Shrouds a/b and c/d must be moved in pairs to perform the test. There is usually only one pair and the tests done sequentially.

FIGURE 4



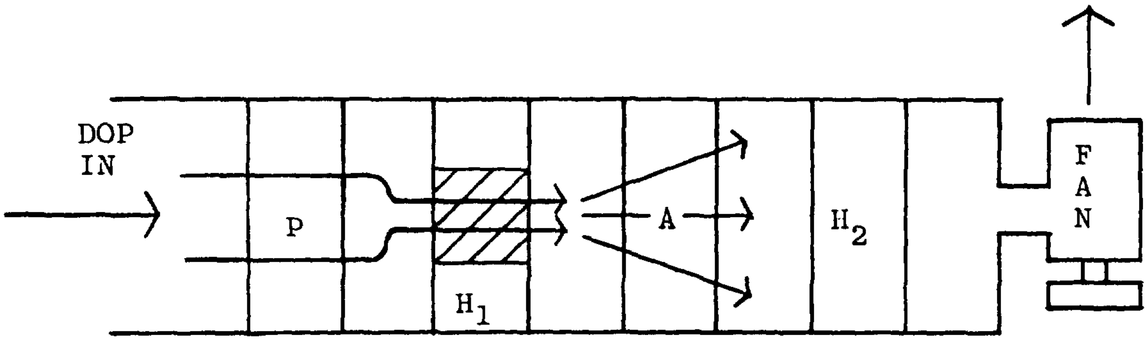
Example of the three configurations that shroud design must address--a is filter plus filter bank seal to side (or top or bottom) wall, b is filter(s) only and c is the corner. All three exist on all NATS.

FIGURE 5



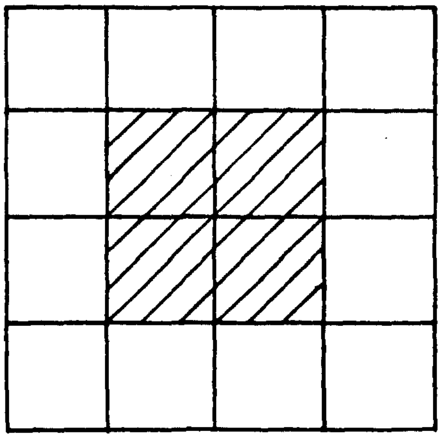
Side view of typical shroud used on a 4 high HEPA bank. Two shroud sets are shown in place but usually only one set at a time is used. Note the different design required to test a center filter vs. a perimeter filter where the housing wall must be included.

FIGURE 6



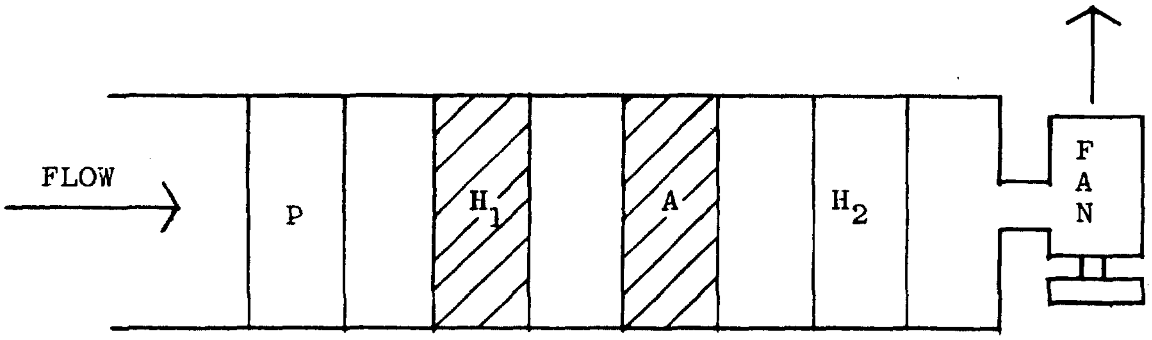
Example of CRM configuration to test HEPA Bank H_2 by removing filters from Bank H_1. Injection is in the up stream duct. Shaded area in H_1 shows removed filters. DOP is injected through the Adsorbent.

FIGURE 7



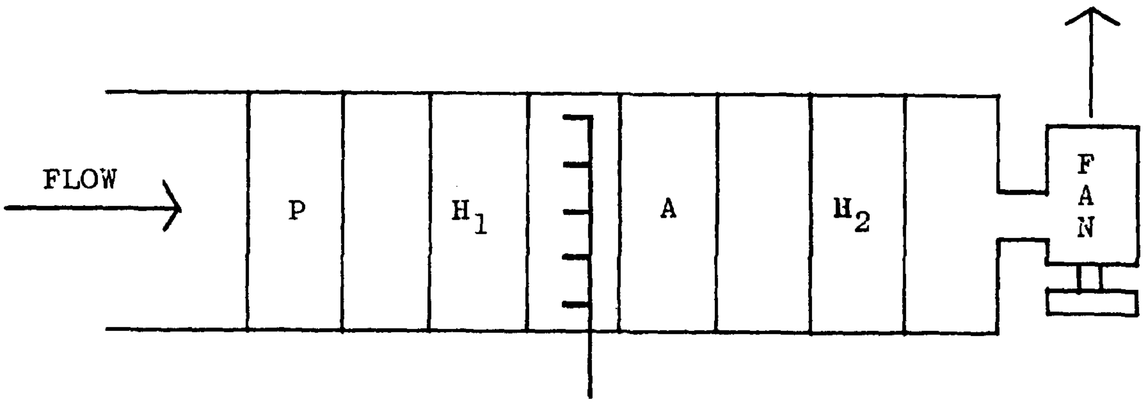
Example of CRM with shaded areas showing a possible set of filters removed.

FIGURE 8



Example of SIM with H_2 under test and H_1 and A not yet installed.

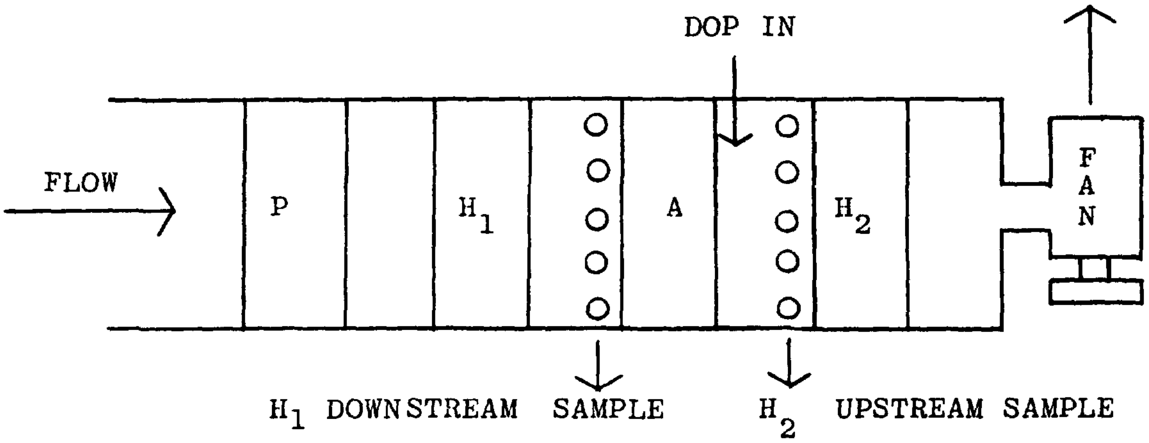
FIGURE 9



H_1 Down Stream Sample

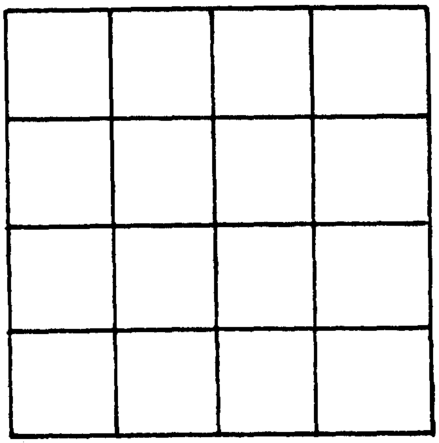
Example of SIM with H_1 under test after H_2 has been tested and accepted. Note sampling for downstream sample must be taken between H_1 and H_2.

FIGURE 10



Example of MSM required downstream of H_1. Note need for DOP injection for H_2 test. A second MSM may be required upstream of H_2 depending on Air/Aerosol Mixing.

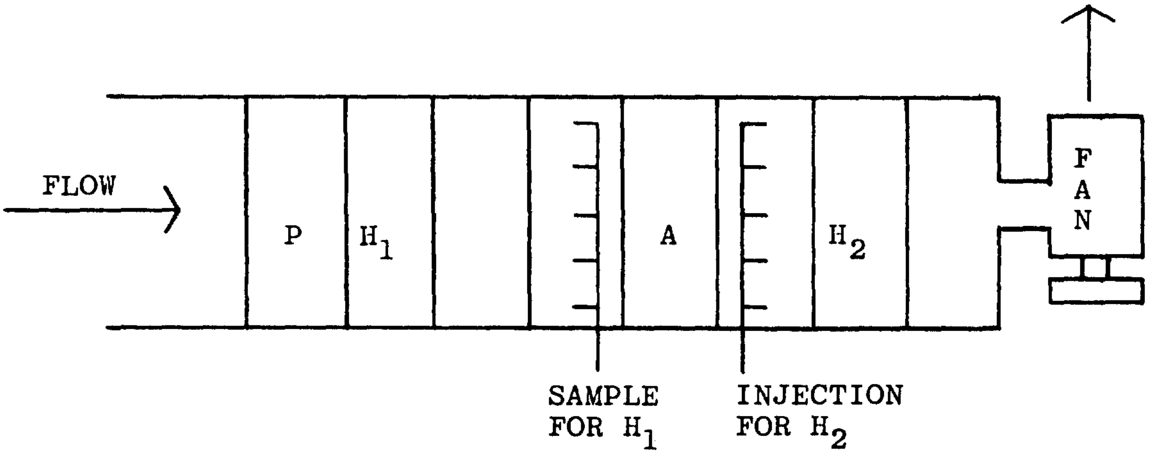
FIGURE 11



AREA APPROXIMATELY
80+ ft^2, HOUSING
PERIMETER 36 ft AND
HEPA GASKET
PERIMETER 128 ft.

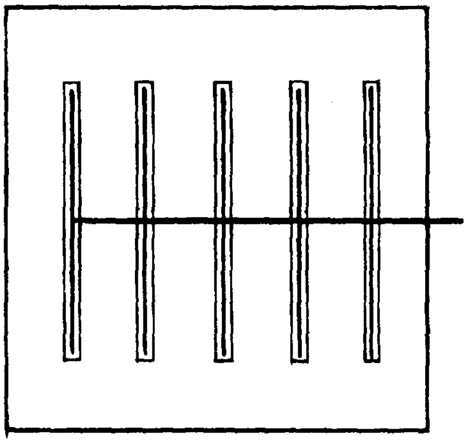
Face of HEPA Bank for MSM. Both the face area and listed perimeters are critical and must be included in MSM test point selection. Laminar flow leaks are easily missed.

FIGURE 12



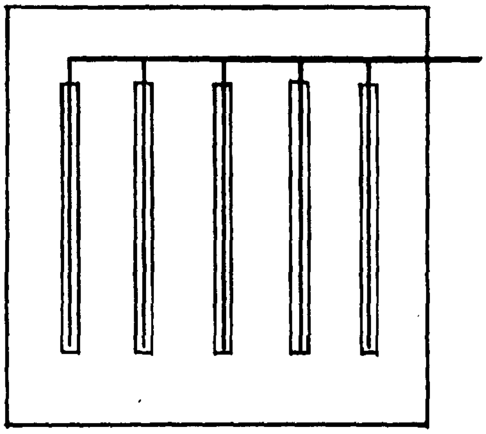
Typical placements of Manifolds. Sample Manifold for downstream sample of H_1 and Injection Manifold for H_2.

FIGURE 13



Typical example of a Manifold used in relation to a Type III Adsorber. Basic configuration is the same for sampling and injection to take advantage of reduced flow area and turbulence.

FIGURE 14



Common alternate Manifold configuration. Usually found on Manifolds added in the field. They may be permanent or removable.

FIGURE 15

DISCUSSION

ORNBERG: I think your examples of selective removal of upstream filters show how the downstream HEPA complicates testing. I strongly urge people to discuss this with their regulatory people to find out if, indeed, they can eliminate testing requirements for the downstream HEPA. It would make it a lot easier to test the upstream HEPA and result in a better system all around.

JACOX: An additional problem with the downstream HEPA is that even when you do have carbon dusting, a HEPA is the worst possible filter to use because it blinds very quickly on the particle sizes of carbon you usually get during dusting. When you have severe carbon dusting, rather than helping, the filter will simply blind, your pressure drop will go out of sight, and you will end up with little or no flow. When there is a carbon dusting problem, a HEPA is the worst filter to use. You should use an 95% NBS filter, instead.

BURWINKEL: Has anybody gone to the black box approach by challenging the entire package as a unit regardless of the number of HEPAs or carbon filters installed?

JACOX: What I interpret you to be referring to is an overall system test. A plant I have been working with is doing that. I am aware by NRC participation in two workshops that it is the intent of the NRC that you shall test the entire system as a blackbox. And that is a good approach.

MILLER: I think he is saying that you can take one sample of the upstream and one sample on the downstream at the very end. Is that what you are agreeing to, Jack?

JACOX: When you have carbon and HEPA filters, you have to use both an aerosol and an halide. From a strictly procedural standpoint, it is definitely the intent and the requirement of N-510 and NRC Regulatory Guides that you have bank tests first to prove integrity on an individual bank basis and then work your way up to the bypass ducts and the system as a whole. The analogy I use is that when you have a primary loop, you don't turn it on to see if it works. You check your valves, check your pumps, check your electricals, check your cutouts. You don't just turn a system on and say "Does it work or not."

ANON: If we eliminate the individual HEPA challenge, what we are left with is a system test.

JACOX: How are you going to show that both a HEPA and an absorber bank are leak tight if you use a single test?

EDWARDS: I think what is being said is that in lieu of testing each bank separately, one might test an entire system with DOP and if it passes, no matter how many filters are in it, it is an acceptable system. Then, one would test the overall system with Freon and if the carbon adsorbers remove the Freon, no matter how many there are in series, the system is acceptable.

JACOX: The Nuclear Regulatory Commission and the CONAGT standard say very clearly that you get no credit for a bank unless it is challenged individually.

EDWARDS: In one of your drawings, you showed that if you remove some filters to challenge the carbon beds you have to do an aerosol uniformity test. You also say that you have to do an air distribution test if the system does not have carbon filters in it. Is an air distribution test a technically reasonable requirement for HEPA filters only?

JACOX: I feel it is technically reasonable and the standards, as well as the NRC, state that it is procedurally required because the justification of residence time on carbon is easier to measure. Some systems that I have seen, at least when they were first tested and before there were modifications made, would have an order of magnitude difference in the flow distribution. I think you would agree that even for HEPA filters, if you have such a flow distribution, you have a pretty poor system, one that is not going to function as intended. You could disagree with the tolerance figure, perhaps, but I don't think you could argue that it is an unnecessary test.

EDWARDS: I disagree technically that a uniform air distribution system is a requirement on a HEPA bank for several reasons. One involves your order of magnitude. If you have 200 fpm in one place and 2,000 fpm in another, very soon the 2,000 fpm filter is going to load up and you will tend to have a fairly even flow distribution. In other words, the HEPA filters are going to correct themselves. When you don't have carbon in the system, it really doesn't make any difference.

CONFLICTS AND MISAPPLICATIONS OF ANSI N509, N510 USNRC REGULATORY GUIDE 1.52 AND 1.140

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I. Abstract

The nuclear industry in the early 1970's attempted to standardize air cleaning system design and testing by the development of ANSI N509, "Nuclear Power Air Cleaning Units and Components" and ANSI N510, "Testing of Nuclear Air Cleaning Systems". Parallel to these and leaning somewhat on the same information, the USNRC has prepared first, Regulatory Guide 1.52, "Design, Testing, and Maintenance Criteria for Atmosphere Clean Up of System Air Filtration and Adsorption Units of Light Water Cooled Nuclear Reactor Plants", and Regulatory Guide 1.140, "Design, Testing, and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light Water Cooled Nuclear Power Plants".

These documents were a good starting point and should have been the basis for the evolution of sound engineering practices. Instead of that path, the subsequent revisions were narrow in scope, uncoordinated, rarely based on experience and became nearly unworkable.

Starting with the scope statement (or equivalent for the regulatory guides) the problems began to occur.

ANSI N509

"This standard covers requirements for the design construction, and testing of the units and components which make up Engineered Safety Feature (ESF) and other high efficiency air and gas cleaning systems used in nuclear power plants".

Thus, there is no system design specification, only air cleaning component and unit design requirements. Requirements are not standards, and as further review of N509 demonstrate may items are "recommendations" and some critical system related specifications are missing.

ANSI N510

"This standard covers field testing of ESF (Engineered Safety Feature) and other high efficiency air cleaning systems for nuclear power Plants and other high efficiency air cleaning systems for nuclear power plants and other nuclear applications." The standard provides a basis for the development of test programs and detailed acceptance and surveillance test procedures, and specifies minimum requirements for the reporting of test results. The standard does not include acceptance criteria except where the results of one test influences the performance of other tests.

Here we are talking about testing systems which are not designed to any standard. N509 requirements are for units and components, but in fact, further review of N510 does not indicate a single "system" test. At best, sections of units are tested instead of systems. Additionally, N510 is taken by both regulatory personnel and utilities as a test specification. Section are copies verbatim, instead of realizing that the scope states that "it is a basis for developing detailed procedures for the testing". As a result, test procedures are applied incorrectly to system testing and the actual application suitability of the particular system is not determined.

Regulatory Guide 1.52

"This Guide presents methods acceptable to the NRC staff...with regard to design, testing and maintenance criteria for air filtration and adsorption units of engineered safety feature (ESF) atmosphere cleanup systems in light-water-cooled nuclear power plants.... It addresses the ESF atmosphere cleanup system, including the various components and ductwork, in the postulated DBA environment".

This is accomplished mainly by referring to ANSI N509, N510 and ORNL-NSIC-65 (ERDA 76-21) the latter being not a standard but a collection of good practices, not a standard.

An example of this type of reference is the following: "Duct and Housing leak tests should be performed in accordance with the provisions of Section 6 of ANSI N510-1975". Unfortunately, there is no duct testing procedure in ANSI N510. Only a housing test is described. A detailed analysis of the Reg Guide shows numerous other conflicts.

Currently the omissions, mistakes, and inconsistencies of these basic documents make any procedure and work subject to various individual interpretations and did not result in good standardized design and/or design verification. As many of these problems as possible will be pointed out to assist those laboring on future revisions of these documents, or preparing test procedures for start-up and surveillance of air cleaning units and systems.

II. Environmental Design Parameters

Regulatory Guide 1.52, Section B, Paragraph A, requires design to DBA conditions as specified in Table 1 where pressure surge is specified for in containment systems as a "result of initial blowdown" and for outside containment as "generally less than primary". This pressure rating resulted in systems being built ranging from ASME Section III to flimsy sheet metal construction as the two extremes. Even the two classifications are inadequate. The pressure surge on a Standby Gas Treatment System can be significantly higher than the pressure surge on a Control Room Recirculation Clean Up System.

In the same section Reg Guide 1.52 specifies maximum pressure for outside of the containment systems as "near-atmospheric" and the inlet relative humidity for all systems of 100%.

ANSI N509 simply states that "design parameters shall be specified when invoking this standard..." The net result is that the environmental design conditions are highly subjective and generally not consistent from plant to plant.

The same Table 1 of Reg Guide 1.52 specifies (for outside of containment systems) elemental iodine inlet concentrations as 10 mg/m^3 and both methyl iodide and particulate iodine as 1 mg/m^3. Aside from the lack of reality in the source term on which these values are based (particularly as ratios of the various forms) the values do not correspond to ANSI N509, RDT M16 or ASTM D3803 loading requirements. Furthermore, Reg Guide 1.52 Section 3.C.i specifies a minimum loading of 2.5 mg total iodine (radioactive & stable) per gram of activated carbon. This value again does not correspond to either ANSI N509, RDT M16 or ASTM D3803 loading conditions. The same paragraph of Reg Guide 1.52 requires that "the radiation stability of the type carbon specified should be demonstrated and certified". There is no standardized test method for this requirement. Many carbons currently sold have never been tested and certified for this requirement and, in fact, the requirement is being ignored by the NRC, the Architect Engineers, the Utilities and many of the carbon suppliers.

Regulatory Guide 1.52, Section B, paragraph 6 states "Average temperature and relative humidity also vary from site to site, and the potential buildup of moisture in the adsorber should also be given design consideration. The effects of these environmental factors on the ESF atmosphere cleanup systems can be determined by scheduled testing during operation". Unfortunately, there are no standard test procedures for the "effects" of "these environmental factors" in ANSI N510 or any site specific "scheduled testing".

Summarizing the Environmental Design Conditions for which the engineered safety feature(ESF) atmosphere clean-up units are supposed to be designed, it can be said that they are inadequately specified in Regulatory Guide 1.52, left to individual design selection in ANSI N509 and not covered adequately (or at all) in ANSI N510. Where certain requirements are specified, the appropriate test methods do not match the requirements.

III. Inter-relation of Test Conditions

Regulatory Guide 1.52 requires "periodic testing during operation to verify the efficiency of the components..." and "the adsorber system should be designed for an average residence time of 0.25 seconds per two inches of bed depth".

The ANSI N510 airflow capacity test acceptance criteria is +/-10%. This is normally performed by pitot tube measurements in ducts which measurement has an error limit of +/-5% to +/-10%. The ANSI N510 Airflow distribution test acceptance criterion within a single bank is +/-20%.

Thus there can be a significant velocity variation within a single air cleaning unit from the design assumption. Airflow will be always highest through the thinnest part of the adsorber and the efficiency of the unit for a contaminent will not follow flow averages. In the Three Mile Island 2 accident, the iodine activity within a single adsorber bank varied by approximately one order of magnitude from top to bottom.

At the same time, the performance of the radioiodine test of samples removed from adsorbers being in use, is performed within +/-4% velocity tolerance and currently the test condition is being restricted to even lower tolerances.

Where is the correlation between the various standards? Or is it assumed that if the laboratory test for the adsorbent is performed under the best controllable conditions, that the obtained test result will, in fact, resemble the performance of an air cleaning unit where the aggregate contaminant flow is variable by +/-30% at any point?

IV. Representative Samples

Regulatory Guide 1.52 states "The efficiency of the activated carbon adsorber section (presumably bank) should be determined by laboratory testing of representative samples of the activated carbon exposed simultaneously to the same service conditions as the adsorber section. Each representative sample should not be less than two inches in both length and diameter and each sample should have the same qualification and batch test characteristics as the system adsorbent... . The design of the samplers should be in accordance with the provisions of Appendix A of ANSI N509-1976..."

ANSI N509-76 states "The superficial velocity of any test canisters shall be shown by calculation or direct measurement to be within +/-20% of the superficial velocity of the adsorber bed." (Same value is permitted in the 1980 version)

This +/-20% is apparently on top of the possible +/-30% variation discussed above, and review of the illustrations attached to ANSI N509-76 shows methods which almost guarantee that the flow through the canisters will be, if anything, -20% compared to bank flow.

The Type 1 test canisters show elbows, reductions and extensive velocity loss in lines. No aerodynamic analysis is required to realize that the velocity will be less than the velocity across the main adsorbent bed. The Type 2 test canister shown in the illustration, was tested by the author and had more than double the pressure drop at the same flow rate of an equivalent size standard adsorber tray.

This type of sampling is being performed on approximately 80% of the currently operating nuclear air cleaning units.

However, ANSI N509-1980 in Table 9-1 Acceptance Test, requires that Adsorber Residence Time is a Field Determination and the "Avg = minimum, design value specified". Typically the residence time is not evaluated on the basis of all of the tolerances permitted.

While Reg Guide 1.52 requires correctly, that the same Batch of adsorbent be used to fill the test canisters, both 1976 and 1980 versions of ANSI N509 requires only that the same Lot be used. Thus the loading of the canisters is not specified, particularly for cases where more than a single batch (approximately 12,000 lbs) is required to load the adsorbent bank.

In this case, Regulatory Guide 1.52, by specifying the illustrated ANSI N509-1976 methodology promotes the use of incorrect engineering.

It is estimated that even if interlaboratory carbon sample testing agreement is reached, the laboratory test results will rarely predict the actual performance of the adsorber unit if designed to ANSI N509 and Regulatory Guide 1.52 conditions.

V. Unenforced and Unenforcable Sections of Reg Guide 1.52

Section C.2.d

"Each component should be protected with such devices as pressure relief valves so that the overall system will perform its intended function during and after the passage of a pressure surge..."

If there is a relief valve, how can the system perform its function while it is venting? If designs exist meeting this criterion verbatim, what detail requirements are they designed to, there is no discussion of this subject in ANSI N509 and no test method in ANSI N510.

Section C.2.j

"Each train should be designed and installed in a manner that permits replacement of the train as an intact unit or as a minimum number of segmented sections without removal of individual components".

The author is not aware of a single unit at any US power reactor which could satisfy this criterion.

Section C.2.1

"ESF atmosphere cleanup system housings and ductwork should be designed to exhibit on test a maximum total leakage rate as defined in Section 4.12 of ANSI N509-1976".

Why should anyone design to exhibit a "maximum" leakage? Furthermore, ANSI N509-1980 states in Table 9-1 that housing test is performed per paragraph 4.12, which states that "The test pressure shall be equal to the design pressure as defined in Par. 4.6.". Par. 4.6.3 states "Design pressure shall be determined by summing the losses in total pressure of all air path components between the open atmosphere and the point in the system under consideration. Losses shall be based on the most severe condition of resistance to rated air flow.". Which pressure is obviously that with dirty filter pressure drop. However, ANSI N510 does not agree that the test pressure is the design pressure because in Section 6.4.2.3 it states that "Start blower and run until pressure in the enclosed space is equal to 1.25 times the system design pressure.".

Section C.3.j

"Adsorber cells should be designed, constructed and tested in accordance with the requirements of Section 5.2 of ANSI N509-1976".

ANSI N509-76 in turn states in Paragraph 5.2.1 "Pleated bed and tray type adsorber cells shall meet the requirements of Type I or Type II cells respectively of AACC CS-8...and in paragraph 5.2.5.1 "A report giving the information specified in Par. C.4 of AACC CS-8...shall be furnished to the purchaser".

In spite of these requirements, tray units are supplied which do not meet the size requirements of the AACC CS-8 and are not interchangeable with standard adsorbers. Filling methods and construction methods are often not qualified according to the AACC CS-8 procedures. As a matter of fact, several types do not even meet the structural test requirements of the CS-8 specification (or its current replacement standard IES-RP-CC-008-83-T).

Section C.3.k

"The design of the adsorber section should consider possible iodine desorption and adsorbent autoignition that may result from radioactively-induced heat in the adsorbent and concomitant temperature rise. Acceptable designs include a low airflow air bleed system, cooling coils, water sprays for the adsorber section, or other cooling mechanism..."

The low flow air bleed presents a significantly higher hazard (that of ignition) than no flow at all.

Cooling coils would increase relative humidity and lower the organic iodide removal efficiency.

Water deluge systems remove the adsorbed iodine, and can cause extensive corrosion if free iodine containing carbon is used.

Therefore, none of the three listed methods would prevent iodine desorption. Fortunately, it is unlikely that the massive amounts of radioiodine would be present to cause overheating of the adsorbent bed.

Section C.3.o

"Straightening vanes should be installed where required to ensure representative air flow measurement and uniform flow distribution through the cleanup component."

Very few systems are in existence where this method is used to ensure uniform flow distribution either with clean or with dirty filters.

Section C.4.c

"The system design should provide for permanent test probes with external connections in accordance with the provisions of Section 4.11 of ANSI N509-1976."

ANSI N509 4.11 states "Where required for proper challenge agent mixing and/or sampling, multiple inlet or outlet distribution manifolds shall be provided to allow injection and sampling per ANSI N510".

Neither of these sections allow shroud testing, removing filters to perform testing or using internal multiple sampling techniques. In spite of that there are many systems installed without required manifolds and, therefore, violating Regulatory Guide 1.52, without any enforcement action.

The performance of test with pre or HEPA filters removed obviously voids any air flow distribution or air aerosol mixing uniformity test, which was performed prior to the removal of those components. Therefore, it generates only numbers instead of meaningful results.

Section C.5.c

"The use of silicone sealants or any other temporary patching material on filters, housing, mounting frames, or ducts should not be allowed."

This is spottily enforced, without complete review and results in great inconsistency in system quality.

VI. Iodine Removal Efficiency Credits

Table 2 of Regulatory Guide 1.52 assumes that all systems are either inside the containment or have humidity control installed in the unit which is not always the case.

A credit of 95% removal is given if adsorbent from a test cartridge (which needs to be equalized only to within +/-20% of the main system velocity) results in less than 1.0% penetration. The velocity effect on the penetration is well known and such latitude is not realistic, particularly when most sampling cartridges have lower velocities than the main adsorber banks (more likely -20% rather than the +20% side).

The same problem exists with Table 2 of Regulatory Guide 1.14 also.

Why tests should be performed at 70% RH for any system sample if there is no humidity control component is not explained.

The exact test conditions for used samples are currently completely non uniform. Earlier issues of the Reg. Guide 1.52 required running tests under DBA temperature, velocity, etc., conditions and early ORNL work stated that worst test conditions were to be 130°C, 95% RH. It is well known now that low temperature at high humidity is a more stringent test conditions, but industry practice has not followed this change in knowledge.

Many plants also miss the somewhat hidden requirement of Reg Guide 1.52 which states that "Similar (to Table 2) laboratory tests should be performed on an adsorbent sample before loading into the adsorbers to establish an initial point for comparison of future test results". This requirement should be clearly listed on requirements to be performed at the time of loading which can be significantly later than when the carbon is purchased.

The wide variety of test conditions - often under unrealistic test parameters - does not permit a comprehensive evaluation of adsorbent performance in the US.

VII. Recommendations

1) Review the overall system requirements and expectations before codifying obsolete or incorrect designs.
2) Evaluate tolerances of design conditions and operation to assure that tolerances are realistic for each step and commensurate with the tolerances of the safety analysis. Require justification of all tolerances.
3) Require proof testing of representativeness of any test canister.
4) Establish correlation between requirements and test methods used to meet the requirements.
5) Write design and test specifications sequentially rather than simultaneously.
6) Both Regulatory Guides 1.52 and 1.14 should be revised to eliminate unnecessary requirements and to contain only critical uniformly enforceable and enforced items.
7) Establish adsorbent test parameters commensurate with adsorbent use conditions.
8) Quantify chemical release effects, requiring retesting.
9) Develop actual system design requirements and overall system tests for air cleaning systems.
10) Eliminate personal interpretation possibilities by clear wording in all standards and Regulatory Guides.

DISCUSSION

GUEST: Given the discussion you just gave us on the impossibility of getting representative samples in these canisters, and the discussions we have heard this week and previously on no laboratories being able to agree on what the chemical analysis of the efficiency of the charcoal is, is it not, perhaps, time to rethink the entire process. Perhaps we shouldn't be testing samples. Perhaps we should be performing in situ tests within the station i.e, the blackbox approach suggested earlier, testing the entire system with radioiodine.

KOVACH: I agree that the entire approach has to be reviewed to make sure that what we are doing matches the safety requirements for the system. Just because we can test in the laboratory to the second decimal, if the sample is 50% non-representative, we are not going to have an adequate evaluation of our system.

Controversial Issues with Air Cleaning at Nuclear Power Stations

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Abstract

The guidance documents available for design, installation, and testing of air cleaning systems at commercial nuclear power stations are quite numerous. They have been written and subsequently revised to provide sufficient specificity, yet at the same time allow flexibility to the plant operator. These documents have received continual review and updating by recognized experts in nuclear air cleaning. Nonetheless, issues continually arise that are subject to interpretation, and discussion on these issues sometimes becomes quite controversial. The 18th DOE Nuclear Airborne Waste Management and Air Cleaning Conference discussed a number of these concerns that were long-standing. Even with the discussion at that time taking place in an open, public forum, questions still remain on those issues. In addition, new questions continually surface with respect to the applicable guidance.

This paper will provide a forum to attempt to resolve long-standing issues, such as the definition of "significant", with new input and ideas discussed since the 18th Air Cleaning Conference. It will also discuss new issues, to include time between sampling and testing activated carbon, definition and timing of an air cleaning system being out-of-service, best available guidance for laboratory testing of used carbon and resultant technical specification conflicts, and installation of sub-standard HEPA filters.

I. The Definition of Significant

The interpretation of the phrase "significant painting, fire, or chemical release in any ventilation zone communicating with the filter system" is an issue that is still subject to considerable controversy. Although discussed in great detail at the 18th Air Cleaning Conference (1), it is clear that confusion continues to exist. It is important to recognize that the plant technical specifications, and their interpretation by the regulatory authorities, are the controlling documents. There is no question that the performance of activated carbon will be severely degraded for iodine removal by the adsorption of the products of paint or fire, or by chemicals. Therefore, if there are any concerns about how well the carbon might perform, the best guidance would be to run a laboratory radioiodine test. Any decisions made by nuclear power plant staff should be documented with approval by station management.

A better approach, and one many licensees have asked about in the last two years, is to protect the carbon so that the question of whether a laboratory radioiodine test should be run does not arise. Ways to accomplish this include:

1. Turn off the filter system during any painting, and leaving it turned off for days after the termination of painting.
2. Use a scavenger carbon system during the painting that will be discarded after use.
3. Schedule painting just before a test or changeout of the carbon is required for other reasons.

Significant should be interpreted as implying any release that could affect the performance of the filter system. Thus, filter system operation should be planned so that painting does not affect its performance, and if this is not possible, any decision pertaining to whether to run a laboratory radioiodine test should be documented, including the applicable reasoning.

II. Laboratory Testing Criteria

Whenever activated carbon is tested in the laboratory for radioiodine removal, the resultant penetration depends very heavily on the test conditions used: temperature, relative humidity, equilibration, loadings. Of equal if not greater importance is the procedure followed in performing the test. Recent round robin testing is reported in the Panel Session "Nuclear Carbon Test Protocols" as part of this Conference.

Until the results of these recent studies and round robins are complete and additional consensus guidance issued to the industry, licensees should follow their plant technical specifications. This can, however, cause difficulties when it is obvious that the results for the laboratory radioiodine testing are inconclusive, not representative, or misleading. In these cases it is important to realize that the purpose of this test is to verify that the carbon has not degraded to a level where it would not perform satisfactorily in the event of an accident. Therefore, it is incumbent on the licensee to identify such inadequacies, and pursue resolution with the appropriate regulatory authorities.

III. Reactivation and Re-impregnation

Spinster carbon has previously been defined as qualified carbon that has not seen service but has been stored at a site for a number of years. Prior to being put in service, this carbon should be tested to verify that it has not degraded. Inquiries have been made concerning whether this carbon can be re-treated in any fashion to improve its performance, even temporarily. All guidance published to date (specifically ASME Code Sections on Sorbent Media) do not allow reactivation of carbon, irrespective of what filter system will use the carbon. However, these same code sections very clearly allow re-impregnation of carbon that has been in service or of outdated impregnated carbon, so long as the carbon is qualified in accordance with the applicable requirements.

IV. Heating of Service Carbon

Lengthy discussions were held with a licensee in June 1986 concerning the heating of air for purging carbon prior to an in-place freon test. The system in question does not have installed heaters, but the licensee was using a portable heater to heat the air, thus removing atmospheric contaminants and greatly improving the chances of passing the in-place freon test. At first glance this approach sounds like adding a bias to the system and testing the system under conditions that would not approximate those expected during an accident. However, it must be remembered that the in-place test is only for leaks; it is not designed to check the capacity, efficiency, or retentivity of the carbon. The licensee was removing representative carbon samples at the specified frequency to verify the condition of the carbon. In addition, freon testing was being performed at all other specified intervals - maintenance, replacement of trays. Therefore, it was concluded that although the idea of "cleaning" carbon prior to a freon test may not sound logical, it is within the guidelines of plant technical specifications, and is improving the performance characteristics of the carbon.

V. Sub-standard HEPA Filters

Industry consensus over the last 10 years has shown that, although not required by regulation, the use of a DOE operated Quality Assurance Filter Testing Station to visually inspect and dioctyl-phthalate (DOP) test every HEPA filter prior to installation is an excellent industrial practice (2,3). An incident discovered in late 1984 by an NRC licensee and subsequently indicted by a federal grand jury shows the wisdom of using Quality Assurance Filter Testing Stations.

During a routine audit of a vendor by the NRC licensee, it became apparent that non-nuclear (commercial grade) HEPA filters were reported to be nuclear-grade (safety-related). A total of 250 filters were supplied to the licensee and certified as nuclear grade by a local distributor and supplier of HEPA filters. Contrary to this certification, the audit at the vendor's manufacturing plant revealed that these 250 HEPA filters supplied to the distributor by the vendor were not nuclear grade, but had been purchased by the distributor as commercial grade. However, the filters were received by the NRC licensee bearing labels indicating that they were nuclear grade. Documentation supporting the nuclear grade labeling was furnished by the distributor. Ninety-seven (97) of these filters were installed in operating air cleanup systems in the nuclear power plant where nuclear grade filters are required.

Once reported to the NRC by the licensee, in accordance with 10 CFR 21.3(e) as a potential for non-conformance by a supplier of nuclear grade material, the NRC referred the matter to the Department of Justice for possible prosecution against the supplier/distributor. It was clear that the supplier had simply re-labeled the commercial grade HEPAs as nuclear safety-grade. After testimony supplied to a federal grand jury, the supplier/distributor pleaded guilty and was fined.

It is important to emphasize three facts. First, the vendor/manufacturer of the HEPA filters was not involved in any way, and his performance was never questioned. He was asked by the supplier/distributor to provide commercial grade filters, and he did just that. During the investigation the manufacturer/vendor very easily traced the serial numbers for all 250 HEPAs, and readily acknowledged they were commercial grade. Second, no substantial safety concern was created by this deviation. All releases from the plant were controlled, filtered, and monitored at all times, and were always within applicable release limits. Third, the concern was identified and corrected by the "self-police" results of the licensee's audit program at the vendor/-manufacturer.

VI. Out-of-Service Air Cleaning Systems

Plant technical specifications are very clear and specific concerning what constitutes operability of an air cleaning system. The surveillance requirements list specific tests to be performed, the acceptance criteria, and surveillance frequency. If any parameter is out-of-specification, the filter system is defined as inoperable, and a time limit is given within which corrections to the system must be made.

The importance of having operable engineered-safety-feature air cleaning systems was emphasized after an inspection of a Portland General Electric facility (4). Serious concerns arose over the failure to maintain the control room emergency ventilation systems in an operable status over an extended period of time. Inleakage pathways through a condensate drain and housing opening existed, and excessive makeup flow was measured, that would have resulted, under design bases accident conditions, in doses significantly exceeding those specified in General Design Criterion 19 of Appendix A to 10 CFR 50 to the control room operator. The limits specified in these regulations are 5 Rem whole body, 30 Rem thyroid, and 30 Rem skin dose for the duration of the accident. In addition, the two control room emergency ventilation systems were not independent in that a cross connection (common drain line) existed which allowed air flow between each system. To emphasize the importance of maintaining these ventilation systems in an operable status, a Severity Level II violation (Level I being the most severe, Level V being the least severe) was issued, along with a Civil Penalty.

VII. Recent Operating Event

Perry, Unit No. 1, a BWR in Ohio, had a recent malfunction leading to a charcoal fire (5). Since the malfunction occurred during pre-operational testing, no radioactive materials were involved, and the charcoal did not contain any radioactive materials.

The plant's main condensor offgas system consists of two trains connected for series flow, with four tanks in each train. Each tank is approximately 20 feet tall by 4 feet in diameter, containing 6 tons of charcoal. The licensee was heating the rooms containing the charcoal tanks with space heaters on June 20, 1986, for a startup test of the HVAC system for the rooms. This test required an initial air temperature of 150°F. Although the offgas charcoal was not in service during the HVAC system test, thermocouples in the center of the charcoal in two tanks (one in each train) measured between 1100°F and 1400°F. The tank surface temperature remained below 150°F.

Room air returned to normal temperature as the HVAC test was stopped. Nitrogen (25 cfm) was used to purge the tanks of free oxygen, however, residual oxygen kept the charcoal burning (smoldering) for days, and although the temperatures decreased, the maximum measured charcoal temperature on June 23, 1986 was 324°F. The tanks have been opened and the charcoal is being analyzed.

The source of heat leading to the high charcoal temperatures appears to be the placement of the space heaters too close to the charcoal tanks. Once the charcoal began smoldering, it was difficult to extinguish the charcoal. An attempt at a retest on July 6, 1986, resulted in further elevated temperatures (700°F) being observed in the charcoal tanks, simply by blowing 80°F instrument air over the charcoal.

VIII. Summary

This presentation has discussed those air cleaning issues that have led to some confusion, discussion, and even disagreements since a similar presentation at the 18th Air Cleaning Conference. Its purpose was not to give definitive guidance, but to allow the opportunity for discussion and input from all interested parties. Consensus standards are the best source of guidance, but even these are subject to interpretation. It is clear that nuclear air cleaning is still an evolving art, and concerns that arise need to be discussed to achieve the best possible guidance and clarification.

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DISCUSSION

ORNBERG: What are your comments regarding requirements for a downstream HEPA, since it is mentioned in the Regulatory Guide 1.52? 2) Comment also on the substandard filters. I think the biggest potential problem exists with the non-ESF units because those filters are required to be just like the ESF filters, yet many purchasing agents, when they see they are non-ESF systems, figure that they don't need any quality assurance at all. I think there is more potential there for getting the commercial-grade filters. The last question is, whether you or any other NRC member has any comments to make about when, or if, Regulatory Guides 1.52 and 1.140 are going to be revised?

BELLAMY: I will start with your second comment and say, I agree with it. Addressing your question on the downstream HEPAs, I would say that the basis for the Regulatory Guide was a perceived lack of confidence in some of the installers in the field and the fact that I, personally, viewed maintenance individuals having lunch inside the housings. After testing was done, they would walk around inside with wrenches in their back pockets and put holes in the HEPA filters. They didn't know what a HEAP was. Because the filters have fragile components, we figured it made sense to have a redundant downstream bank of HEPA filters. Is it still necessary today? You can make a good case that it is not. The recommendation that it be taken out of N509 and all future codes is one I can agree with. I think that is the statement you were looking for. Getting back to the previous blackbox discussion on testing an entire system, it is important to realize that, to the NRC, it doesn't matter how many banks of HEPA filters you have, one or many, the credit given for particulate removal during an accident will be the same.

ORNBERG: For people with downstream HEPAs installed now, what do you suggest they do regarding discussions with the NRC about continuing to test them.

BELLAMY: I suggest that the filters be left in, but that a case be made to treat the system as a blackbox and test the two banks simultaneously.

Regarding your third question, I have been pushing to get the Regulatory Guides revised. I am not going to stand up here and tell you the 1978 issues are perfect. Obviously they are not perfect and they are not even adequate in a lot of cases. We have figured how much it would cost us to revise one of the Regulatory Guides. The point I am going to make is that the money to do this is not in the NRC's budget. There are no plans that I know of to initiate a revision to the Regulatory Guides. What I am looking for is someone or some group willing to volunteer their time to revise the Regulatory Guides for us.

JACOX: The comment you made about a blackbox test seems to be a fairly radical change from the previous NRC/DOE position. When you have a system where you have one HEPA bank only, I can see some technical basis for it, but I know there are a number of systems, one in a plant that is still to be started up, where they have charcoal banks in series. Would you also apply the blackbox test to charcoal in series. You could have one that is leak tight when the other leaks grossly.

BELLAMY: The answer is, yes, I would.

JACOX: Well then, how can you justify the need or the existence of the second bank? If one leaks and one doesn't, the one that leaks doesn't exist for practical purposes, so how do you justify having it in?

BELLAMY: I would think that the visual test would point out a lot of the potential gross leakages. Certainly, a molecule that has passed through the first bank of carbon doesn't know that there is a space between the first bank and the second bank. So, for this purposes two two-inch banks would be the same as a four-inch bank. There could be some inconsistences with gross bypass, but that is the purpose of the visual test, to catch such a defect.

JACOX: I agree that a good visual inspection catches most of the defects. I disagree with the blackbox approach. Will you cite specific technical data that constitute a basis for allowing reimpregnation, but not allowing reactivation, I find this a highly difficult differentiation to understand.

BELLAMY: We have had a lot of discussions on reactivation versus reimpregnation in the code work that we have done. For ESF systems, in particular, I have taken the position that it is a nickel/dime item whether you reactivate the carbon or not. It doesn't make any sense to me to reactivate the carbon. I think, in the overall operating and maintenance cost of the filter system, the cost of new carbon versus the cost of possibly reactivating and reimpregnating it just doesn't make enough sense to go ahead with the reactivation process. I know there are some of my learned colleagues here today who do not agree with that point. In the interest of publishing an adsorber code section, we negotiated and compromised. We agreed that the reactivation would not be allowed in the present code section but that we would very actively and quickly try to come to some happy medium on exactly what might be allowable for reactivation. Reimpregnation, I think, has a basis in the fact that it is permitted for spinster carbon (a term that you really should take credit for, Jack.) This means that if a carbon has never been used, but its impregnation has deteriorated, you can come to the conclusion that it is financially beneficial to go ahead and put a second impregnant on it and then run the whole gamut of tests. If it then passes all the tests, as a regulator, I cannot tell you it is not allowable to use that carbon in the filter system. You might say I am talking out of both sides of my mouth because you could use a similar argument to permit reactivation. I think it is just a philosophical point, reimpregnation is one step, reactivation is a second step. This is where we draw the line for the present. I know that is not going to give you a warm feeling but that is the best I can do.

RIGBY: My question relates to the last question. I think that, quite frankly, reimpregnation is full of dangers. You are into the stage of what is a spinster carbon and how that can be developed and changed. I am sure that one would think that, in the industry that we are talking about, the utilities, we are not really in the secondhand car market.

BELLAMY: My answer to the original question was more from a regulatory NRC concern. Now, I have to agree with you 100%. As an engineer, I would say that reimpregnation is not a recommended thing to do. If I worked for a utility, I would very strongly push to prevent reimpregnated carbon being used on my site. I personally would not recommend it.

REACTIVE INSPECTION RESPONSE OF NRC REGION III TO POTENTIAL TECHNICAL DEFICIENCIES IDENTIFIED IN RECENT NUCLEAR AIR CLEANING CONFERENCE PAPERS

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ABSTRACT

In order to effectively meet its responsibility to protect the public health and safety, the Nuclear Regulatory Commission (NRC) nuclear power plant licensing and inspection programs respond to potential technical deficiencies identified by conference and professional society meeting papers when deemed appropriate. The NRC staff's response mechanisms for such technical deficiencies include: generic letters, Bulletins, Information Notices, Standard Review Plan (NUREG-0800) revisions, docketed Final Safety Analysis Report (FSAR) questions, special studies, special (reactive) inspection, and inspection program revisions. This paper describes reactive inspection efforts by Region III in response to potential technical deficiencies identified in recent air cleaning conference papers, including: post-accident effluent sample line deposition losses; failure to implement good engineering practices in the design, construction, and testing of Nuclear Air Treatment Systems (NATS); filter bypass via filter housing drain lines; spinster carbon degradation; use of silicone sealants and other temporary patching material in NATS; filter housing fire protection deluge system problems; lack of charcoal batch traceability; Quality Assurance records problems involving equipment, vendor, filter, and personnel qualifications; inadequate ANSI/ASME N510 acceptance criteria and tests; and failure to adequately demonstrate control room habitability per 10 CFR 50, Appendix A, General Design Criterion-19. Region III inspections indicate that many of these deficiencies appear to be prevalent. Inspection findings and utility responses to the findings are discussed. NRC Region III and Headquarters programmatic reactions to the identified generic problem areas are also discussed.

I. INTRODUCTION

Each year potentially generic technical deficiencies of significance to the nuclear industry are identified in technical journal articles and conference and professional society meeting papers. Once the NRC becomes aware of these reported deficiencies, the staff reviews each item and responds as deemed appropriate by management. The NRC staff's response mechanisms include: generic letters, IE Bulletins and Information Notices, Standard Review Plan (NUREG-0800) revisions, docketed Final Safety Analysis Report (FSAR) questions, special studies, special (reactive) inspections, and inspection program revisions. This paper deals specifically with the reactive inspection response of the NRC Region III to potential technical deficiencies identified in recent Nuclear Air Cleaning Conference papers.

The 17th (1982) and 18th (1984) Nuclear Air Cleaning Conference proceedings published a number of papers which the NRC Region III and the Office of Nuclear Reactor Regulations (NRR) felt might represent potentially generic technical deficiencies. The areas of concern included post-accident effluent sample line deposition losses; failure to implement good engineering practices in the design, construction, and testing of Nuclear Air Treatment Systems (NATS); filter bypass via filter housing drain lines; spinster carbon degradation; use of silicone sealants and other temporary patching material in NATS; filter housing fire protection deluge system problems; lack of charcoal batch traceability; Quality Assurance records problems involving equipment, vendor, filter, and personnel qualifications; inadequate ANSI/ASME N510 acceptance criteria and tests; and failure to adequately demonstrate control room habitability per 10 CFR 50, Appendix A, General Design Criterion-19. In order to determine the extent of these problems, the Chief, Meteorology and Effluent Treatment Branch, NRR, and the Chief, Emergency Preparedness and Radiological Protection Branch, Region III agreed that Region III should conduct regional directed (reactive) inspections at two Near Term Operating License (NTOL) commercial nuclear power plants. Based on the inspection findings at the first two NTOLs, this special inspection program was extended to include the other three Region III NTOLs and several operating plants. These inspection findings were shared with other NRC regional offices, the Office of Inspection and Enforcement (IE), and NRR.

NTOL HVAC acceptance test programs receive review by several groups of regional inspectors, including: Test, Quality Assurance (QA), Resident, Fire Protection, and Facilities Radiation Protection Section (FRPS) inspectors. Although each of these inspection groups reviews a portion of each NTOL applicant's HVAC preoperational program for compliance with regulations and commitments in accordance with existing standard inspection procedures (modules), none of these procedures specifically addresses the potential deficiencies discussed in recent Nuclear Air Cleaning Conference papers. Therefore, in addition to the completion of the scheduled inspection modules, the FRPS was assigned to conduct special (reactive) inspections of Region III NTOL's to determine the extent to which the reported deficiencies existed at these facilities.

Region III generally encouraged the applicants to conduct a compliance review to identify and correct any potential regulatory violations before the NRC inspectors formally began the inspections. The FRPS inspectors initially met with applicant representatives to: (1) determine the status of the ANSI/ASME N510 acceptance test program; (2) inform them of the types of documents which should be available onsite for NRC inspector review; (3) discuss programmatic deficiencies discovered at other NTOL plants; and (4) request that spinster carbon be laboratory retested, an ANSI/ASME N510 acceptance test compliance analysis be prepared, and the use of silicone sealant on HVAC ductwork and filter housings be evaluated.

The types of documents which were reviewed during these special inspections included: (1) acceptance test inspector qualification records; (2) applicant quality assurance vendor audits; (3) HEPA filter and charcoal adsorber qualification documents; (4) applicant ANSI/ASME N510 test acceptance criteria; (5) acceptance test procedures and reports; (6) HVAC and ANSI/ASME N510 acceptance test program commitment and compliance documentation; (7) deficiency tracking system documentation; and (8) applicable HVAC surveillance and operational procedures. The inspectors also interviewed applicant and contractor personnel to assure that proper use was being made of the applicant's deficiency tracking systems and that all identified design, test, and procedural discrepancies were satisfactorily resolved. The review of the HVAC systems also included physical inspections of ductwork, filter housings, housing drainage systems, and fire protection water deluge systems to assure compliance with design and construction commitments to regulatory guidance and industry standards.

Although an applicant's ANSI/ASME N510 acceptance test program was not usually developed sufficiently to warrant detailed NRC inspector review during the first site visit, the inspectors met with applicant representatives to discuss programmatic deficiencies discovered at other NTOLs. Potential deficiencies discussed included: (1) performance of tests by uncertified personnel; (2) unresolved vendor audit findings and observations; (3) inadequate HEPA filter and carbon adsorber qualification records; (4) lack of carbon adsorber batch traceability; (5) lack of a deficiency formal reporting and resolution tracking system; (6) misuse or lack of adequate test acceptance criteria; (7) inadequate timing of visual inspections; (8) significantly degraded "spinster" carbon; (9) lack of detailed compliance with N510 test procedure and report specifications; and (10) improper use of silicone sealants. Subsequent NRC inspections were conducted to review applicant documentation, interview personnel, and inspect installed HVAC systems to assure compliance with regulations and commitments.

In response to Region III requests, applicants for operating licenses generally prepared two documents to track compliance of their ANSI/ASME N510 acceptance test programs. These documents were internal reports made available for NRC review. The first report was a commitment and compliance analysis which provides a detailed (line-by-line) identification of each commitment associated with ANSI/ASME N510, addressed reviews of QA qualification documentation and specific potential HVAC system or acceptance test deficiencies, ascertained compliance with regulations and commitments, identified corrective measures needed or variance requests required, and identified actions needed to document compliance. The second report was a detailed action plan providing a tracking system for actions needed to comply with commitments and regulations, for design deficiencies and other discrepancies and their resolution, and to document compliance. This report was usually detailed enough to include specific tasks, individuals assigned to each task, a schedule for completion, and a periodically updated status for each action item.

All of the Region III NTOL applicants identified a number of apparent violations of regulations and deviations from commitments. Under the provisions of 10 CFR 2, Appendix C, the NRC does not usually issue notices of violation when the violation is licensee or applicant identified and the corrective actions are deemed adequate, if the other criteria of Appendix C are also met. The following example is typical of the results of an applicant's ANSI/ASME N510 commitment and compliance analysis. The applicant's ANSI/ASME N510-1980[1] line-by-line commitment and compliance analysis was divided into 55 Engineered Safety Feature (ESF) commitments (Regulatory Guide 1.52[2]) and 55 non-ESF commitments (Regulatory Guide 1.140[3]). The applicant also reviewed QA qualification documentation and specific potential deficiencies based on discussions with NRC Region III personnel. Approximately 180 action plan tasks were assigned, 35 variances from ANSI/ASME N510 specifications were noted, acceptance test criteria and procedures were modified, FSAR amendments were issued, operational and surveillance procedures were revised, HVAC and fire protection deluge systems were modified, and some technical specifications were redrafted. Technical deficiencies discovered included lack of QA documentation on charcoal adsorber batches and HEPA filters, improper vendor charcoal adsorber qualification tests, lack of carbon adsorber batch traceability, lack of detailed compliance with ANSI/ASME N510 acceptance test specifics, improper use of silicone sealants, and filter bypass via filter housing drainage systems. The applicant initiated adequate corrective actions for the delineated deficiencies by use of existing deficiency reporting and resolution tracking systems.

II. FINDINGS

Based on the reactive inspection of four of the five Region III NTOLs and a partial review of several operating nuclear power plants, it appears that at least some of the potential technical deficiencies identified in recent Nuclear Air Cleaning Conference papers are prevalent. The findings for each identified potential deficiency will be presented separately.

Post Accident Effluent Sample Line Deposition Losses

In 1982 Kabat[4] reported deposition velocities for various species of iodine for a variety of sample line materials. These deposition velocities were used by the NRC to obtain the concentration reduction factor results in Table 1 for a certain station's auxiliary building vent stack post-accident effluent monitoring system. Because the high range sample line losses were found to be excessive by NRR, the licensee has agreed to modify the system (before startup after the first refueling outage) to greatly reduce the iodine deposition potential. NUREG-0737[5], Item II.F.1, Attachment 2 specifies that representative samples are to be obtained from post-accident effluent sampling systems. As stated in Footnote 14 of Table 3 of Regulatory Guide 1.97. Revision 3[6], "collection of representative samples" means obtaining the best samples practicable given the exigencies that attend the accident environment; line losses or line deposition should be empirically predetermined and appropriate loss correction factors should be applied. This statement from the regulatory guide is utilized as further clarification of the NUREG-0737 requirement by the NRC. As a result of this interpretation, Region III NTOL applicants had their operating licenses conditioned by the requirement to empirically predetermine post-accident effluent sample line losses when supplied by NRR with the criteria for an acceptable methodology. NRR has contracted Battelle Pacific Northwest Laboratories and the Idaho National Engineering Laboratory (INEL) to aid in the development of guidance for iodine sample line loss determination. It is noted that INEL and NRC representatives will be presenting a paper at this conference regarding this matter[7].

Table 1. Calculated iodine deposition factors for a certain station's auxiliary building vent stack low and high range sampling lines.

EXPOSURE CONDITIONS			EXPERIMENTAL PARAMETER	LOW RANGE SAMPLING LINE CALCULATED IODINE LOSS			HIGH RANGE SAMPLING LINE CALCULATED IODINE LOSS		
Iodine Form	Relative Humidity % (±3%)	Surface	Deposition Velocity Vg (m/s)	Deposition per length Du (m^{-1})	Total Conc. Reduction Factor	D_L, Total Deposition Fraction	Deposition per length Du (m^{-1})	Total Conc. Reduction Factor	D_L, Total Deposition Fraction
I_2	5	N.Cl.	1.8(-4)	1.367(-2)	1.72	.418	1.268(-1)	1.52(+2)	.993
		Ch.Cl.	8.7(-4)	6.606(-2)	1.37(+1)	.927	6.129(-1)	3.53(+10)	1.00
	97	N.Cl.	1.6(-3)	1.215(-1)	1.23(+2)	.992	1.127	2.50(+19)	1.00
		Ch.Cl.	2.0(-3)	1.519(-1)	4.11(+2)	.998	1.409	1.76(+24)	1.00
HOI	5	N.Cl.	4.0(-6)	3.037(-4)	1.01	.0120	2.818(-3)	1.12	.106
		Ch.Cl.	3.3(-5)	2.506(-3)	1.10	.0945	2.325(-2)	2.51	.602
	97	N.Cl.	1.8(-5)	1.367(-3)	1.06	.0527	1.268(-2)	1.65	.395
		Ch.Cl.	4.4(-5)	3.341(-3)	1.14	.124	3.100(-2)	3.42	.707
CH_3I	5	N.Cl.	1(-7)	7.593(-6)	1.0003	.0003	7.045(-5)	1.003	.003
		Ch.Cl.	7(-8)	5.315(-6)	1.0002	.0002	4.931(-5)	1.002	.002
	97	N.Cl.	8(-8)	6.075(-6)	1.0002	.0002	5.636(-5)	1.002	.002
		Ch.Cl.	8(-8)	6.075(-6)	1.0002	.0002	5.636(-5)	1.002	.002

Where:
N.Cl. = non-cleaned surface
Ch.Cl. = chemically cleaned surface
Vg = deposition Velocity of Stainless Steel (exp)
Du = deposition of iodine per unit length (exp) = $\frac{(\pi d)\ Vg}{F_s}$
e^{Du*L} = total iodine concentration reduction factor
d = inside diameter of sample tubing = 1/4" and 3/4" for High and Low range, respectively
Fs = sample line volumetric flow rate = .06 and 1.67 cfm for High and Low range, respectively
L = length of sample line = 130 feet
D_L = $1 - e^{-Du*L}$ = total iodine deposition fraction

In 1984, the methodology for experimental determination of the transmission of radioiodine through sample lines was apparently advanced as reported by Unrein, Pettetier, Cline, and Voilleque[8]. Although the deposition velocities determined earlier by Kabat[4] are reaffirmed by this paper, the more recent experimental program also investigated the effects of resuspension. It was found that over a period of time the radioiodine transmission factors improve significantly over that predicted by deposition velocity alone. Although this more recent data indicates that equilibrium iodine transmission may be much higher than originally predicted, it also indicates that the transmission factor changes over a period of time (until equilibrium is reached) and the transmitted iodine may have changed chemical species and undergone significant radiodecay. This variation of transmission characteristics and chemical species with time will make the development of regulatory guidance for post-accident empirical predetermination methodology even more difficult.

Failure to Implement Good Engineering Practices

At the 17th DOE Nuclear Air Cleaning Conference, Moeller and Casper Sun[10] presented a paper which analyzed failures in air-cleaning, air-monitoring, and ventilation systems in commercial nuclear power plants based on data gleaned from Licensee Event Reports (LERs) submitted from 1978 through 1981. It was concluded by the authors that although information needed to prevent and/or correct such failures is available, it is not being effectively utilized. The authors also concluded that the primary reason for the failures is a shortage of personnel who are knowledgeable about HVAC systems, in general, and about nuclear air cleaning technology, in particular. To correct this situation, the authors recommended an increase in the training of both nuclear power plant personnel and members of the NRC staff in the subject areas. The NRC Region III special inspection effort regarding potential HVAC deficiencies is, in part, in response to this paper. The NRC Region I training efforts in response to nuclear air cleaning concerns were well expressed by Dr. R. R. Bellamy in the discussion portion of Panel 13, "Nuclear Air Cleaning Field Experiences," of the 18th DOE Nuclear Airborne Waste Management and Air Cleaning Conference (see Pages 923-934 of the proceedings).

The lack of adequately trained personnel seems, however, to account for only part of the nuclear air cleaning system failures. As pointed out by Moeller and Casper Sun[9], LERs are written to address mostly problems which represent violations of Technical Specifications. In order for the NRC staff to properly assess problems associated with air cleaning systems, data supplemental to information contained in LERs must be obtained. The papers presented at the Nuclear Air-Cleaning Conferences is a good source of that supplemental data. Additional information of this type was suppled by Jacox[10,11] who indicated that although lack of sufficient training and knowledge concerning Nuclear Air Treatment Systems (NATS) is a generic industry problem, failure to implement good engineering practices in the design, construction, and testing of NATS is also prevalent. The effect of poor engineering practices on HVAC system and equipment reliability is well documented by conference papers including those by Kovach[12] and Graves, Hunt, Jacox, and Kovach[13] from the proceedings of the 13th and 15th Nuclear Air Cleaning Conferences, respectively.

During the NRC inspector review of the Region III NTOL ANSI/ASME N510 acceptance test programs, many of the examples of poor engineering practices described by Moeller and Casper Sun[9], Jacox[10,11], Kovach[12], and Graves[13] were noted. These examples included: damper failure or excessive leakage; other HVAC system ductwork under positive pressure which passes through the Control Room gas control envelope; use of silicone sealant and other temporary patching material on ductwork and filter housings; hydrogen explosions and fires in BWR offgas systems; poor cooperation between design engineering, system engineering, startup test engineering, and operations; significant difficulty of low quality ductwork and filter housings to pass ANSI/ASME N510 acceptance test criteria; improper interpretation of regulations and standards; improper QA documentation and qualification tests of charcoal adsorbers and HEPA filters; lack of adequate provision of testing manifolds for series filter banks; floor drain check valves installed so that the filter housing doors cannot be opened far enough to change out filters; and other examples of poor engineering practice which appear elsewhere in this paper.

Regional NRC inspectors are, in general, restricted to assuring that an applicant for an operating license complies with regulations and commitments. The regional inspector, however, is aided by technical and regulatory guidance from NRR and inspection program guidance from I&E. If an applicant meets the requirements of the relevant regulations and commitments, it is difficult for the NRC inspector to additionally require that generically recognized good engineering practices be followed. Thus, although nuclear standards, codes, and regulations are meant to be additional requirements over and above the use of good engineering practices, all too often it appears that NATS are designed, constructed, tested, and operated by applicants and licensees who take full advantage of their minimal commitments to standards, codes, and regulatory guidance. Although not readily able to directly require the application of good engineering practices, NRC inspectors do assure that the applicants' deficiency reporting systems are properly utilized, management controls are adequate, and all allegations are thoroughly reviewed and resolved.

Filter Bypass Via Housing Drains

Regulatory Guide 1.52, Revision 2, March 1978[2], (Regulatory Position 3.h) and Regulatory Guide 1.140, Revision 0, March 1978[3], and Revision 1, October 1979[14], (Regulatory Position 3.e) state that the filter housing water drains should be designed and constructed in accordance with the recommendations of Section 4.5.8 of ERDA 76-21[15] and Section 5.6 of ANSI N509-1976[16], respectively. These recommendations include individually valving, sealing, or otherwise protecting drain lines from individual chambers of the housing to prevent bypassing of contaminated air around filters or adsorbers through the drain system. At the 17th Nuclear Air Cleaning Conference, Bellamy[17] described how filter and system bypass via housing drains was discovered at the TMI Station in early 1982. He considered this incident a problem of potential generic applicability.

During the special Region III reactive inspection program regarding potential generic HVAC deficiencies, filter bypass pathways via housing drain systems were found at all five NTOLs and many of the operating plants which were reviewed for this deficiency. As an example, a recent inspection at an operating plant revealed that out of 19 filter housings inspected, only two had drainage systems which precluded filter bypass. The most common deficiencies at this plant were drain lines connected to a common header without isolation valves in each drain line and uncapped drain lines left open to room atmosphere. Even for those housings which had valves or loop seals in each uncapped drain line, in general, applicants and licensees usually did not have adequate administrative controls on use of isolation valves and loop seals, air leak-tightness of isolation valves had never been verified, either water check valves had not been a design consideration or installed water check valves were of inadequate design, loop seals were also often of inadequate design, and significant potential existed for either allowing loop seals to dry-out or to inadvertently flood the housing by overfilling or by drawing water out of the loop seal during system startup. The Region III licensees and applicants for operating licenses all initiated adequate corrective actions when informed by NRC inspectors that filter housing drain systems or administrative controls are not adequate.

Spinster Carbon

Partly because of significant delays in the startup dates for many reactors, qualified carbon has been in storage at some sites for five years or more. This unused carbon is commonly referred to as "spinster" carbon. Due to the lengthy storage times, spinster carbon may be significantly degraded by the time it is used and therefore may have to be retested to verify adequate retention of performance characteristics. The amount of degradation depends on many factors, including: storage period; damage due to handling, moving, and storage techniques; packaging methods; and exposure to contaminants. Hubbard[18] states that unused carbon is generally expected to have a shelf life (when properly sealed in storage) of three to five years when it can meet the specifications of new carbon. Jacox[11] points out that although carbon may be several years old before it is used in a system, it should meet all the requirements of new carbon, but this is nowhere stated in standards or regulatory guidance. Bellamy[19] recommends, as a rule of thumb, if the carbon was stored properly, it probably need not be retested if the storage time is one or two years or less. He also states that if storage approaches five years, retesting should be performed.

All the Region III NTOLs were asked to voluntarily test spinster carbon using the following guidelines.

- If the carbon has been properly stored, it probably need not be retested if the storage time is 18 months or less. Retesting should be considered for longer storage times and if storage approaches five years, retesting should definitely be performed.
- Batch samples should be tested with methyl iodide to Regulatory Guide 1.52, Table 2 or Regulatory Guide 1.140, Table 2 (as appropriate) acceptance criteria. The carbon should be replaced if it fails the prescribed test.

All Region III NTOLs agreed to test spinster carbon which had been stored for longer than 18 months. For the four NTOLs which have completed this test, about one-half of the carbon stored longer than five years and less than 10% of the carbon stored less than five years failed the laboratory tests. Although given the poor quality of the recent roundrobin carbon adsorber test results, as reported by Miller[20], First[21], Kovach[22], and Bellamy[23], the significance of these spinster carbon tests is uncertain. It should also be noted that the Region III spinster carbon which had been stored greater than five years was all at one NTOL and was purchased approximately ten years before the laboratory retest. Region III NTOL applicants who failed spinster carbon tests have discarded the failed charcoal adsorber batches except for one batch for which special permission for use was granted by NRR.

Use of Silicone Sealants

Regulatory Guide 1.52, Revision 2 (March 1978[2]), Regulatory Position 3.n states that ESF ductwork should be designed, constructed, and tested in accordance with the Section 5.10 of ANSI N509-1976[16]. ANSI N509-1976, Subsection 5.10.4 states that longitudinal seams shall be either all welded, seal welded mechanical, or in accordance with SMACNA - High Velocity Duct Construction Standards (Pittsburgh Lock or Acme Lock Seam) as required to meet structural and leak-tightness requirements of Pars. 5.10.3 and 4.12, respectively. ANSI N509-1976, Subsection 4.12 states that the allowable leakage will, by reference to Par. 4.12.3, indicate the required type of duct construction; i.e., welded or nonwelded; however, ducts for ESF systems and all housings shall be welded. It should, however, be noted that Subsection 4.12 of ANSI/ASME N509-1980[29] allows welded or flanged transverse joints and mechanical lock type longitudinal seams for ESF ductwork.

Regulatory Guide 1.52, Revision 2 (March 1978), Regulatory Position 5.c states that the use of silicone sealants or any other temporary patching material on ESF filters, housings, mounting frames, or ducts should not be allowed. Regulatory Guide 1.140, Revision 0 (March 1978[3]), and Revision 1 (October 1979[14]) Regulatory Positions 3.f and 5.c have the same wording as Regulatory Guide 1.52, Revision 2 (March 1978), Regulatory Positions 3.n and 5.c, respectively (which are discussed above).

Contrary to the above regulatory positions and to the applicants' commitments to the regulatory guides, Region III inspectors have identified the use of silicone sealant at all five NTOL's and one operating plant. Common uses of silicone sealant to pass ANSI/ASME N510 leakage tests includes application on ESF and non-ESF mechanical lock longitudinal seams inside sheetmetal ductwork, external longitudinal and transverse ductwork seams, between stitch welds on companion angle flanges, companion angle flange gaskets, installation of instruments into ductwork, and on non-ESF housings. After the use of silicone sealant was identified at each plant, the matter was referred to NRR for resolution.

The responses of NRR to the use of silicone sealants and other temporary patching material at Zion[24] and Clinton[25] are a matter of public record. In both cases, NRR issued general guidance on the use of temporary sealants and patching materials in air cleaning systems. This guidance states that while the quality of some of these sealants has improved in recent years, the NRR staff has not yet accepted such material as being good for the life of the plant; thus it is the staff's position that these materials can be expected to degrade over a period of years and may result in unacceptably high leakage in ductwork or filter housings. The guidance also states negative pressure ductwork outside the Control Room gas control envelope is of particular concern. Several alternatives are available if an applicant for an operating license has used temporary sealant on this ductwork including replacement of the sealant with welded joints or a leakage testing program which would establish the long-term integrity of the sealant or patching material used. Other ESF and non-ESF air cleaning systems which incorporate these sealants in construction or leakage repair are evaluated on a case-by-case basis. The NRR resolution of each plant's use of sealants on air cleaning systems has resulted in license conditions or technical specification modification.

Fire Protection Deluge System Problems

During their review of LERs submitted from 1981 through 1983, Moeller and Kotra[26] noted that unintentional actuation of fire suppression systems was reported at several nuclear power plants during the three-year study period. This rendered the filters and adsorbers inoperable and they had to be replaced. IE Information Notice No. 83-41[27] also addresses this topic. Perhaps the most serious incident of this type occurred on May 15, 1985 at Hatch, Unit 1 (LER 85-018-00, INPO SER 34-85, and IE Information Notice No. 85-85[28]) where inadvertently flooded ductwork leaked water onto an Analog Transmitter Trip System (ATTS) panel. This introduced moisture into the ATTS panel which, in turn, resulted in the malfunction of a safety relief valve and the High Pressure Coolant Injection System (HPCI). For approximately 15 minutes a safety relief valve could not be closed and the HPCI system could not initiate.

As part of the special (reactive) inspection of potentially generic HVAC deficiencies, FRPS inspectors discussed the Hatch incident with applicant and licensee representatives, reviewed applicant and licensee internal responses to INPO SER 34-85 and IE Information Notices No. 83-41 and 85-85, and inspected the physical configuration of filter housing drains and the fire protection water deluge systems at Region III commercial nuclear power plants. Although response to this concern was initially inadequate at some facilities, licensee meetings with NRC Region III personnel led to acceptable resolutions. Some of the modifications Region III NTOLs and operating plants made to fire protection deluge systems included: changing from automatic to manual activation (with NRC concurrence); modifying the valving arrangement from one valve under pressure (which when opened initiates deluge flow) to a system with two closed valves in series with an open low-point drain line isolation valve between them (which requires the operation of the three valves to initiate deluge flow), and an actuation sequence which required two permanently installed fire hoses to be connected and two valves to be opened.

Although the final design of the installed deluge systems and the applicants' and licensees' internal responses to INPO SER 34-85 and IE Information Notices No. 83-41 and 85-85 indicated that there was little likelihood of the fire protection systems inadvertently actuating, it often appeared that the applicants and licensees had not instituted administrative controls beyond those needed for the initiation of the deluge systems. The administrative controls which were initially lacking, included: (1) assurance that the filter housing will not overfill to the extent that water backs up into the ductwork, housing integrity is jeopardized, or seismic and static loading become concerns; (2) training or procedural cautions to warn the fire brigade that the water in the housing is contaminated and radwaste (or radiation protection) personnel should be notified; (3) assurance that the housing will be drained in a timely manner without overloading the radwaste system, with procedural steps to ensure that the proper isolation valves are correctly manipulated; (4) addition of the filter housing drain line isolation valves to the valve check list of the ventilation system startup procedure; and (5) assurance that the filter housing drain line isolation valves are verified closed as part of the (monthly) fire protection surveillance program. Region III FRPS inspectors assured that proper administrative controls were eventually established.

In addition to assuring that Region III licensees and applicants for operating licenses had properly designed systems and administrative controls to significantly reduce the probability of inadvertently actuating filter housing fire protection water deluge systems and to ensure proper recovery from deluge system operation, the FRPS inspectors also assured that potential for wetting of charcoal adsorbers during HVAC system operations due to leaky fire protection water deluge systems was minimized. Several conference papers discuss the effects of wetted carbon beds in detail including those by Kovach[12] and Graves, Hunt, Jacox, and Kovach[13] from the proceedings of the 13th and 15th Nuclear Air Cleaning Conferences, respectively. Fortunately, system modifications and administrative controls taken in response to inspector concerns and IE Information Notices 83-41 and 85-85 also usually reduced the probability of charcoal adsorber wetting during normal plant operations. However for several plants additional corrective actions were required, as the following example illustrates.

In March 1985 a Region III licensee noticed during surveillance that the an ESF filter housing was leaking onto the charcoal adsorbers in several trays. The problem was traced to a plugged check valve in the deluge valve drain line which was quickly corrected; however, a condition report for this incident was not prepared. In part because a condition report was not written for this incident, deluge valve drains apparently were not checked for the other HVAC filter housing deluge systems. During a plant tour by NRC inspectors in September 1985 it was noted that many of the deluge valve drain line sight glasses were partly filled with residue, indicating a significant potential for plugged drain lines or check valves. Apparently a small leakrate into the deluge line can produce significant wetting of the charcoal adsorbers because the high negative pressure in the filter housing atomizes the water and sprays it directly onto the charcoal. With the fan turned off, the deluge water would instead drip to the floor of the housing. The five filter housings that were opened for visual inspection during the

September 1985 plant tour indicated water had pooled in each, which may indicate a chronic problem with the deluge systems. The pooled water had evaporated, leaving residue (dirt, scale, and/or rust) on the floor of each filter housing. The licensee's subsequent investigation found corrosion and evidence of water damage on some charcoal trays. Licensee corrective actions included: (1) replacing damaged charcoal and trays (some had split seams); (2) cleaning filter housings of all dirt, scale, rust, or other material which might damage filters, (3) repainting corroded filter housing areas; (4) replacing all deluge valve drain line check valves by more reliable stainless steel check valves, and (5) providing adequate maintenance of the deluge systems and sight glass surveillances.

Lack of Charcoal Batch Traceability

Each original or replacement batch of impregnated activated carbon used in the adsorber section of air-cleaning systems is required to meet the qualification and batch test results specified by Regulatory Position 3.i of Regulatory Guide 1.52[2] or Regulatory Position 3.g of Regulatory Guide 1.140[3,14], as appropriate. NRC inspectors reviewed the Region III NTOLs regarding charcoal batch traceability; all five facilities had significant difficulty demonstrating batch traceability. Examples include: (1) 32 out of 35 drums had lost their batch identification labels; (2) several barrels in each of four batches in a given lot did not have the stenciled batch number designation; (3) a lot of a size great enough to constitute several batches was procured by a purchase order which did not require the charcoal vendor to designate batches; (4) at two facilities the charcoal vendor filled all the batch test canisters with charcoal from the same batch to represent all batches in the lot; and (5) during the NRC inspection at one NTOL, it was noted that most of the charcoal drum batch designation labels were poorly affixed due to insufficient adhesive properties. In all cases the applicants either restored batch traceability or discarded the charcoal.

Quality Assurance Records Problems

As part of the NRC Region III special HVAC inspection program, Quality Assurance (QA) records of equipment, vendor, filter, and personnel qualifications were reviewed at NTOLs. Since these inspections revealed only minor problems regarding the applicants' QA audit records of HVAC equipment and vendor qualifications, only filter (HEPA and charcoal adsorber) and personnel qualifications are discussed in this paper. It should be noted that the FRPS inspectors did not conduct full QA reviews of the above delineated areas. The purpose of the special inspection program was the potential verification of specific HVAC deficiencies. The comprehensive reviews of NTOL QA programs are conducted by Region III Quality Assurance Program Section (QAPS) inspectors with assistance from the resident inspectors.

At the 18th DOE Nuclear Airborne Waste Management and Air Cleaning Conference, Jacox[11] gave an example of applicant QA personnel, "who admit that they have no idea of the technologies involved (and no need to learn it), down-grading experienced test personnel from Level III to a Level II based on a utility decision to use the N45.2.6 recommended experience periods as an absolute minimum." He also points out the delays some utilities inflict on the N510 acceptance test program while personnel are qualified to the utilities interpretations of ANSI N45.2.6[30,31]. Regional inspectors review the applicants' QA and training records to ascertain whether commitments made to the NRC regarding personnel qualifications are met. Region III FRPS inspectors identified no significant problems with the ANSI/ASME N510 acceptance test personnel qualification records at NTOLs. CONAGT's efforts concerning the development of a specific qualification standard for field-test personnel was discussed by Miller[21] at the last air-cleaning conference.

Major QA problems at two Region III NTOLs resulted in all the charcoal adsorbers being disqualified for use in commercial nuclear power plants. At the first facility, half of the charcoal failed the spinster carbon laboratory test and the other half was without new charcoal qualification test records. The utility discarded their entire charcoal inventory. The second facility also discovered that all of its charcoal was unqualified for various reasons, including: (1) lack of batch traceability; (2) purchase orders did not require qualification documentation; and (3) improper new charcoal qualification tests. With the concurrence of NRR, the utility successfully requalified the ESF charcoal (four batches, 40,000 pounds) according to the new charcoal acceptance criteria of ASNI N509-1980. The non-ESF charcoal (three batches, 7,000 pounds) was discarded. The applicant also found a number of HEPA filters, designated for use in non-ESF, N510 filter systems, which did not have adequate qualification documentation.

Inadequate N510 Acceptance Criteria and Tests

A primary goal of the NRC Region III reactive inspection response to concerns raised by certain Nuclear Air Cleaning Conference papers is to assure that NTOL ANSI/ASME N510 acceptance test programs comply with regulations and applicant commitments. During the preparation of the commitment and analysis reports, the applicants found numerous failures to meet regulations and commitments. The inspectors reviewed the corrective actions for adequacy. Usually the corrective actions were adequate; however, controversy often developed between the NRC and the applicants in several key areas. The disputed areas were mostly detailed specifics involving adequacy of N510 test acceptance criteria and apparent lack of detailed compliance with N510 test procedure and report specifications. Although these disagreements reached satisfactory conclusions for all but one NTOL, it is important that utilities pay close attention to these sorts of details. One Region III NTOL received notices of violation when similar failures were discovered by the NRC, rather than the licensee. It is imperative that applicants for licenses state in their FSAR commitments to Regulatory Guides 1.52 and 1.140 any exceptions they wish to the specific requirements/recommendations given in ANSI/ASME N509 and N510.

Control Room Habitability

At the 18th DOE Nuclear Airborne Waste Management and Air Cleaning Conference, several papers were presented which discussed control room habitability potential deficiencies, including papers by Moeller and Kotra[26] and Hayes, Muller, and Gammill[32]. The first paper discussed deficiencies reported by licensees in LERs and the second paper discussed the NRC working group study of control room habitability. It is noted that interim findings of the NRC study concerning operating plant reviews will be presented at this conference by Driscoll[33]. Because the generic NRC study group was conducting a thorough review of control room habitability, the Region III special HVAC inspection program concentrated inspector efforts toward assuring that the calculated dose guidelines of 10 CFR 50, Appendix A, General Design Criteria (GDC)-19[34] were met at Region III NTOLs.

Section 4.12 of ANSI/ASME N509[16,29] states that the criteria for leakage across the pressure boundary of any portion of an air cleaning system are: (a) air cleaning effectiveness requirements; (b) health physics requirements; and (c) duct and housing quality requirements. The standards also states that the lowest value as determined by items (a), (b), or (c) shall be used as the allowable leakage for design and testing. Based on the review of Region III NTOLs, it appears common for applicants to base the value of allowable unfiltered inleakage into the control room gas envelope on the health physics requirements without doing the required evaluation to choose the lowest value derived from the three methods. It should be noted that the applicants also have the option of requesting NRR concurrence such that they need consider only the allowable inleakage value obtained from the health physics requirements evaluation.

Section 6.4, "Control Room Habitability System," of the Standard Review Plan (NUREG-0800[35]) provides NRC personnel with guidance on the review of applicants' control room design, including the requirements of 10 CFR 50, Appendix A, GDC-19. The Standard Review Plan references a Nuclear Air Cleaning Conference paper by Murphy and Campe[36] for further guidance concerning GDC-19 compliance. Further guidance on the mathematical modeling of control room ventilation systems, which might aid in the calculation of post-accident doses to control room operators, is contained in several other Nuclear Air Cleaning Conference papers, including those by Miller, Ornberg, and Rooney[37] and Almerico, Michaels, Ornberg, and Lahti[38]. The Region III FRPS inspectors reviewed the calculational basis for each NTOL's control room allowable unfiltered inleakage and assured that this N510 acceptance test parameter agreed with the applicant's regulatory commitments. All Region III NTOL reviews of the documentation of this parameter and the acceptance test programs for the control room ventilation systems have led to several rounds of negotiations between Region III, NRR, and the applicant before final resolution.

Although Standard Review Plan Section 6.4 states that applicants for licenses should determine the control room unfiltered inleakage flowrate (infiltration) conservatively and include such infiltration sources as leaking dampers, none of the approximately 20 FSAR control room dose evaluations reviewed by the inspectors assumed infiltration except for a few cases where lack of acceptable two-door vestibules resulted in the standard assumption of 10 cfm inleakage for post-accident control room ingress and egress. Inspector reviews of N510 acceptance test criteria and test results revealed that control room infiltration rates of several hundred cfm are apparently common. Much of this infiltration is due to high leakage ductwork which has mechanical lock longitudinal seams and gasketed flanged transverse joints. Addition leakage at some plants is also due to the use of opposing blade isolation dampers rather than Class I bubble-tight dampers required by ANSI/ASME N509[16,29]. Despite the poor quality of HVAC construction at some facilities, all plants are required to comply with the same regulations and to their FSAR commitments. Three of five Region III NTOLs have passed these criteria to date, although some system modifications were necessary.

By not including the actual control room infiltration values in the FSAR evaluation of control room operator post-accident doses, the nuclear industry is left with the impression that these HVAC systems are of considerably higher quality than field experience indicates. This concept is illustrated by the following example. Acceptance Criterion 2.a of Standard Review Plan Section 6.4 states that dampers used to isolate the control zone from adjacent zones or the outside should be leak-tight and the degree of leak-tightness should be documented in the FSAR. The example utility purchased an opposing blade isolation damper which was specified to leak at no more than 2 cfm at 10 in. wg. When tested in-situ, the damper leaked at 670 cfm at 4 in. wg. It should be recognized that vendor idealized laboratory tests may not reflect the conditions imposed on an installed and cycled nuclear power plant HVAC damper. The total allowable infiltration for the example control room was 650 cfm. This plant's mechanically connected thin-gauge sheet metal control room ductwork also had significant leakage problems.

The inspectors noted that all Region III NTOLs reviewed to date had significant difficulty passing the acceptance criteria imposed by GDC-19 and indeed usually failed the initial control room habitability acceptance tests. It should be noted that although ANSI/ASME N510[1,39] does not specifically require in-situ damper leakage tests, these tests are required for some control room HVAC isolation dampers to satisfy the conditions of ANSI/ASME N509[16,29] and GDC-19[34]. In fact, the measurements of all control room infiltration pathways, including other systems' ductwork under positive pressure which passes through the control room gas control envelope, are required when the health physics requirements option of N509 is used.

III. SUMMARY

During the last two years, the NRC Region III has conducted a reactive inspection program partially in response to potential technical deficiencies identified in recent Nuclear Air Cleaning Conference papers. The technical concerns reviewed at Region III NTOLs were in several areas, including: post-accident effluent sample line deposition losses; failure to implement good NATS engineering practices; filter bypass via filter housing drain lines; silicone sealant; fire protection water deluge systems; charcoal batch traceability; QA records; ANSI/ASME N510 acceptance criteria and tests; and control room habitability per GDC-19 of Appendix A to 10 CFR 50. Without exception, these concerns were identified as apparently prevalent technical deficiencies in the Region III NTOLs and operating plants reviewed. Based on Region III inspector discussions with numerous industry experts in the past two years, deficiencies in the above delineated technical areas may be common in the nuclear industry. Other NRC regions, NRR, and IE headquarters have been kept informed of the findings of the special Region III HVAC inspection program.

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DISCUSSION

JACOX: This is more of a comment and commendation than a question. Initially, you made a point about good engineering practice. This is something that many of the people here know I have harped on for years and will again at a later panel session. I find it very difficult to understand why people will take a minimum regulatory approach rather than apply good engineering practice, when in the long run, just fighting about it often costs more than the perceived savings that you anticipate. I particularly commend your citing specific examples in previous papers presented by many of us at these Conferences. In the long run, good engineering practice will, in my experience, generally meet all the NRC requirements. That should be the place to start.

MILLER: A comment I would like to add is that I saw my own name and your name (Jack) in the specific example table too many times. I hope that in the next few Conferences, we will see some fresh authors because we need to hear from everyone having relevant experiences.

CLOSING COMMENTS OF SESSION   CHAIRMAN MILLER

We have come a long way in terms of finding out what is bothering users of the Nuclear Codes and Standards that apply to air and gas cleaning systems, and changes for the better are well along. We still have a lot of inconsistences between regulations and corresponding codes standards. We still have some practices and some systems in the field that need additional work to bring them into compliance. Let us conduct a little examinations of conscience when we get back home to see if there is anything we can do to improve the situation.