SESSION 4

CODES AND STANDARDS

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REVIEW OF HEPA FILTRATION TEST STANDARDS AND THEIR APPLICATION TO NUCLEAR APPLICATIONS

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Abstract

This paper is a review of HEPA filtration test standards as they relate to nuclear applications. It includes both nuclear and "non-nuclear" standards and references for completeness and since they are closely related and overlap.

The intent of this paper is provide some guidance for those involved with HEPA filters in the nuclear industry as to which standards apply specifically to nuclear applications. Since HEPA filtration related standards exist for all aspects of the technology, from basic components through in-place testing, the possibilities for misunderstanding are considerable.

I. Introduction

The development and history of HEPA filters is a long and interesting one. Even the name "HEPA" has two alternate possible basis that are lost in the early days of development. Whether HEPA stands for "High Efficiency Particulate Air" or "High Efficiency Particulate Aerosol" is open for debate. When even the derivation of the name is in doubt it is not surprising that there is confusion in the more complex area of construction, specification and testing. I recommend a paper given at the tenth Air Cleaning Conference in 1968 by Dr. Melvin First and Humphrey Gilbert.[1] to explore HEPA filter history.

Before any discussion of "HEPA" filters is possible we must define what one is. Unfortunately that is not as easy as it should be. To many a HEPA filter is essentially a commodity. To others more intimately involved with the technology of high efficiency filtration the question has a more complex answer. In fact the definition in many ways depends on the industry and use to which the filter will be put.

By the common definition and industry use a HEPA filter is a filter that has a removal efficiency of at least 99.97% on a 0.3 micrometer aerosol, has medium meeting a government requirement and has folded medium to provide extended surface area. This is a start, but the aerosol test must be to a rigorous standard, the filter medium requirement must be specified and the details of construction must be specified for standardization and commonality. The oldest and most basic document is the test method. MIL-STD-282[2] which describes the test method but is a test not a filter specification. Today the actual test methods used on the filter medium are specified by defining the physical testing apparatus. The U. S. Army does this through the Edgewood Arsenal at Aberdeen, Maryland. Because of this, all HEPA filters used in the nuclear industry are still functionally based on a Military Specification. The technical and commercial specification of HEPA filters for nuclear application will be discussed in detail in this paper.

As a further complication, while HEPA filters are in general industry use, the exact parameters of how they work and the fine points of their performance is still being investigated. Even though we are approaching the fiftieth anniversary of what we know as HEPA filters, new work is continually coming out as to exactly how they work, and why they perform. A current paper on "Alpha Migration Through Air Filters: A Numerical Simulation"[3] is an example.

Historical Development of Nuclear Standards for HEPA Filters

Over the years the standards for HEPA filers used in AEC, ERDA, NRC, DOE licensed nuclear facilities have evolved a great deal. The filter was developed from WWI technology used in making gas mask filter cartridges for use in the nuclear weapons program during WWII the earliest years of the history are lost in the mists of security classification. The Military Standards of the medium were the first to be in unrestricted use. One of the first references for the nuclear industry was a document published in 1965, "Health and Safety Information" Notice 212 dated 25 June 1965 (4). The title was "Minimal Specification for the Fire-Resistant High-Efficiency Filter Unit". The Basic reference was MIL-F-50168 "Filter, Particulate, High-Efficiency, Fire Resistant(5). MIL-F-50168 referenced MIL-F-51079 "Filter Medium, Fire-Resistant, High-Efficiency (6) which is still the basis for specifying HEPA filters. Health and Safety Information Notice 212 was revised by Health and Safety Notice 306 in 1971. These were superseded by industry standards for the civilian power industry about this time but were in use by government facilities much longer.

In this same period an industry organization was writing tentative standards for both particulate and gas phase filters. These were not formally accredited American National Standards but were written by a broad range of industry experts. The American Association for Contamination Control (AACC) published the first HEPA filter standard outside the government in 1968, AACC CS-1T ("T" for tentative) "HEPA Filters"(7). CS-1T did not mention Military standards directly but relied on an Edgewood Arsenal testing document "Instruction Manual for installation, operation and maintenance of Penetrometer, filter testing, DOP, Q107"(8). Even the most current industry specifying documents (ASME AG-1(9) for example) still ultimately rely on such a testing instruction from Edgewood Arsenal. The test equipment has changed with time but not the ultimate reliance on the Edgewood Arsenal expertise in defining what test equipment and procedure is necessary to prove filter medium worthy of being called "HEPA medium" and used in HEPA filters.

The late 60s and early 70s were a busy time for HEPA filter standards, nuclear filtration standards and guidance in general. In 1970 the first so called "Air Cleaning Handbook" was published by the Atomic Energy Commission. More formally ORNL- NSIC-65 "Design, Construction and Testing of High-Efficiency Air Filtration Systems for Nuclear Applications"(10). ORNL NSIC-65 was substantially revised in 1976 by the second edition ERDA 76- 21 now called simply the "Nuclear Air Cleaning Handbook"(11) Both of these editions, and a third in preparation, were guides and text books not standards or specifications. Unfortunately they were often used as standards and specifications with nearly uniformly poor results. Guides are not sufficiently proscriptive to be blindly used to define critical systems and much unnecessary extra work and conflict arose from the misuse of these otherwise very valuable sources of information. Almost unbelievably the 1976 edition is still being used today as a system specification. I had a call for help from an Owner in July of this year asking for help resolving a conflict since an Architect & Engineer had used (Incorrectly) ERDA 76-21 as a specification.

In 1974 the AEC replaced, or supplemented the Health and Safety Information Notices, with publications from the "Division of Reactor Research and Development" with new documents; RDT M-16-3T "HEPA Filter Medium, Glass Fiber (MIL-F-51079 with Modifications and Additional Requirements")(12) and RDT E-9-1T "HEPA Filters (AACC CS-1 With Additional Requirements)"(13). In both cases the additions and modifications were mainly in QA, testing and minor changes in the filter frame. The basic filter was not changed.

For decades there have been increasingly formal meetings between government and industry personnel who attend the Nuclear Air Cleaning Conferences. These meetings have been held during the Conferences and cover all aspects of HEPA filters, testing, specification and media. The most comprehensive coverage is a group of papers in he 19th Conferences(14). These meetings have had major impact on HEPA filter standards through information exchange and education for those of us who have attended.

RDT Standards are now obsolete and have evolved into USDOE "Nuclear Standards (NE)" some of which are still active. Actually most NE Standards are also obsolete. The governments objective is to withdraw them after they are either unnecessary or have been transformed into industry consensus standards. A list of NE Standards can be obtained from the USDOE Office of Scientific and Technical Information, Oak Ridge, TN 37831 as the "Nuclear Standards MASTER INDEX". A number of NE HEPA related Standards have been discontinued or withdrawn and internally replaced by other NE Standards. M-16-3T as discontinued and replaced by F-3-45T "Specifications for HEPA Filters Used By DOE Contractors"[15]. NE E-3-46 "Round-Robin Verification of Filter Test Facility Operations and Procedures" was withdrawn and replaced by NE E-3-43 "Quality Assurance Testing of HEPA Filters"[16]. NE F-3-49 "Auditing of HEPA Filter Manufacturing Procedures and Materials" was withdrawn and replaced by NE E-3-42 "Operating Policy of DOE Filter Test Program"[17]. NE E-3-48 "Recommended Minimum Specification Requirements for HEPA Filters" was withdrawn and also replaced by NE E-3-45. NE E-3-47 "Standardized Reporting of Filter Test Facility Operations was withdrawn and replaced by NE E-3-44 "DOE Filter Test Facilities Quality Program Plan"[18]. These NE Standards E-3-42, E-3-43, E-3-44, and E-3-45 generally are the current DOE documents for HEPA Filter specification and testing. There are an excellent series of conference papers reviewing the operations of the DOE Filter Test Facilities. The latest is in the 21st Conference[19] and includes references to the previous reviews.

The government has always required redundant testing of HEPA filters used in AEC/ERDA/DOE facilities. That is, first at the manufacturers plant as all HEPA filters must be 100% tested but then again at one of the government test stations as defined in the above series of NE standards. This has caused some long term confusion since NRC licensed facilities do not automatically require this second test. It is always an option the owner may chose but is not an NRC requirement. Another similar area of confusion is the "QPL" list. The US Army has a Qualified Products List. For a HEPA filter manufacturer to be qualified to be on the QPL requires considerable effort and expense. The Army and most DOE facilities require that filters used by them be on the QPL while the NRC does not.

One additional NE standard is applicable to HEPA filters. NE E-3-41T "In-Place Testing of HEPA Filter Systems by the Single Particle, Particle-Size Spectrometer Method"[20]. This is not a standard for testing individual HEPA filters but installed HEPA filters as a filter bank test. It is in the process of becoming an ASTM standard. There is considerable rewriting but the technical content is basically unchanged. This standard is aimed primarily at multiple series banks of HEPA filters for Plutonium and other fissile material facilities.

Current Nuclear Standards for HEPA Filters

For NRC licensed facilities there are basically two reasonably consistent specifications that define a HEPA filter acceptable for use in systems designed to control radioactively contaminated air flows. These specifications are contained in two ASME documents; ASME N509-89[21] and ASME AG-1-91. N509 is a Standard that has evolved from a 1976 first edition. AG-1-1991 is a Code that is in its second edition, the first being issued in 1985. Both specify essentially the same final HEPA filter functionally but with different degrees of proscription and via different routes. Since these are the most commonly referenced documents for HEPA filters we will discuss them in some detail.

N509 uses the same two ubiquitous Military Standards as the basis for specifying HEPA filters. MIL-F-51068, "Filter, Particulate, High Efficiency, Fire-Resistant" and MIL-F-51079, Filter Medium, Fire-Resistant, High Efficiency. AG-1 also uses MIL-F-51079 but provides much more detail as to materials and methods of construction and testing directly in the Code section. This eliminates the need to reference MIL-F-51068. AG-1 includes direct reference to UL 586-1985, "High Efficiency, Particulate Air Filter Units"[22] for fire resistance. MIL-F-51068 makes reference to ANSI B132.1 "High Efficiency Air Filter Units"[23] which is UL 586. UL 586-1990 (And earlier editions.) states on page 1 "Approved as ANSI B132.1-1971, July 14. 1971". AG-1 also directly references other documents that are covered in MIL-F 51068 as well as ASME NQA-2-1986 "Quality Assurance Requirements For Nuclear Facility Applications"[24].

The changes between N509 and AG-1 are considerable, and for the novice confusing, but that is consistent with the history of HEPA filter standards. As a founding member of the ASME "Committee On Nuclear Air and Gas Treatment" (CONAGT) I can state that the objectives on the Committee did not change and that there was considerable continuity of membership during the period that the simple N509 HEPA Standard evolved into the more complex AG-1 Code. The rational for the change was to try to rely on industry consensus standards rather than Military Standards. Unfortunately, this has lead to two HEPA filter specifications which are seemingly quite different and not obviously the same technically. The intent of the two is identical. It is the bureaucratic approach and philosophy that makes them so complicated. Of course the earlier editions of N509 (1976 & 1980) and AG-1 (1985) further complicate the situation.

The most important thing to understand is that the physical filter is the same which ever of these documents (N509 or AG-1) or editions is used to order them. It is the route the specifications take, the QA requirements and bureaucratic details that change. And even these change only slightly. Unfortunately if you need HEPA filters for an NRC licensed nuclear facility these slight differences are of critical importance. For plant safety systems many Plant Technical Specifications define the documents very specifically so only components that meet these exact standards are legal to use.

For DOE facilities the NE Standards are usually the standards that must be used. In recent years some DOE facilities have started to use the "NRC" standards. That is, the ASME Codes and Standards. Since the DOE facilities still require the retesting of all HEPA filters this brings a new mix of standards. Filters may be ordered as part of N509 or AG-1 and retested to NE E-3-42, E-3-43 and E-3-44.

Non-nuclear HEPA Filter Standards

The single industrial HEPA Standard is published by the Institute for Environmental Sciences (IES). It is an outgrowth of the old American Association for Contamination Control. When the AACC disappeared the IES took on the responsibility for developing a HEPA filter standard. At first they simply supplied the old AACC CS-1T. After many years IES introduced a tentative HEPA Standard "HEPA FILTERS", IES-RP-CC-001-83-T[(25)] in 1983. In 1986 the standard was released as "HEPA FILTER", IES-RP-CC-01-86[(26)].

IES-RP-CC-001-86 is an interesting document. To define and specify a HEPA filter it refers to Both MIL-F-51068 and MIL-STD- 282 as well as MIL-F-51477 "Military Specification, Filters, Particulate, High -efficiency, Fire Resistant, Biological Use, General Specification For"[(27)]. MIL-F-51477 double references many specifications such as ANSI B132.1 as well as UL 586. It also references nuclear standards for Quality Assurance via NQA-1 and ASME N-510 "Testing of Nuclear Air Treatment Systems"[(28)]. This standard unfortunately lists an incorrect title for N-510 in the reference section of the standard. Incorrectly it calls N-510 "Nuclear Air Cleaning Systems" when there is no such title. This standard also directly refers to many other ASTM, UL, Military and Federal Standards. Such profligate references to overlapping standards provides great potential for confusion and misapplication.

The single most obvious physical change in HEPA filter design, other than size, allowed by the IES standard is that "mini-pleats" are acceptable in it. Military and nuclear HEPA filters are required to have the filter medium folded over corrugated separators that control the spacing and air flow. The corrugated construction also has a major impact on the overall filter pack strength. A "mini- pleat" design uses a "string" to space the medium. The folds are also much smaller and tighter than the full length folds of the Military and nuclear type. There is an ongoing debate as to the relative strength of these two approaches. A catastrophic failure of a clean room filter (Other than in medical or biological applications which are usually separately specified.) has no health or safety considerations so industrial filter pack strength requirements are based on different (economic) criteria.

The main difference between IES-RP-CC-001-86 and the nuclear standards, other than the significant ones of style and approach, is that it covers more sizes and efficiencies. IES-RP-CC- 001-86 includes a list of filter sizes for clean room and clean bench applications. They range in size for 8x8 inches to 36x72 inches. The depth of HEPA filters specified in IES-RP-CC-001-86 is only 5 1/2 inches rather than the 11 1/2 depth of "Nuclear" HEPA filters. IES-RP-CC-001-86 includes a specification for a so called ULPA filter. This comes from Ultra Low Penetration Air which is defined as at least 99.999% efficient on the usual 0.3 micrometer aerosol challenge. These extremely high efficiency filters are needed for improved yield in micro-chip manufacturing. The standard also includes overlapping requirements for scanning filters for pin hole leaks which are not usually of significance in nuclear applications. A pin hole is of significance for micro chip production as artifact sizes have become less than a micrometer.

There are a number of in-place testing standards for clean rooms, clean hands and biohazard cabinets, but they are outside the scope of this paper.

As a point of information The American Society of Heating, Ventilating and Air-conditioning Engineers (ASHRAE) is developing a totally new test standard for mid and high efficiency filters. The objective is a test standard and procedure that will produce efficiency vs. particle size data. They have placed a contract with a commercial laboratory to perform the work upon which to base this new standard. The range of particle size under consideration is from hundreds of micrometers to perhaps as low as sub-micrometer. Since the basic work is still in progress this note is included as something to look for in the near future.

General Areas of Special Concern For HEPA Filter Users

In fact there are a number of commercially created names in use for high efficiency filters that are not based on any industry standards. One of the worst examples is a "95% HEPA filter". The manufacturer states that this filter is 95% efficient when tested with DOP aerosol. Unfortunately the incorrect use of the "HEPA" designation can lead the novice and unwary badly astray. Trade names that are versions of the word "HEPA" and/or have the word "HEPA" in them can also cause confusion. Sadly there are some filter manufacturers that simply are not honest about their "HEPA" filters. Some sell filters as "HEPA's" but do not even have the specified DOP aerosol test instrument required to perform the aerosol leak test. A few of these filters have even found their way into nuclear facilities before the industry became aware of the situation and education solved the problem. Or at least as far as is known it has been solved.

The problem of unethical producers and resellers is not a new one. A study was performed in 1982 and reported in the 17th Conference[(29)]. Perhaps a similar study would be a valuable project at least every decade or so to hopefully confirm what we specify and purchase is what we are actually getting.

As this is being written IES has published a new standard for ULPA filters. Unfortunately the timing of the availability of the standard and the submission of this paper for the Conference has not allowed acquisition and analysis of this standard. The title is "Recommended Practice For Testing ULPA Filters"[(30)].

Conclusion

With all the possible Codes and Standards that can be used to specify a HEPA filter a few simple concepts may help the user.

First - no matter which document (Of those discussed here.) is used to specify a HEPA filter, it will be physically the same basic construction and efficiency as any other.

Second - all the different documents, Codes and Standards ultimately rely on MIL-F-51079 for the filter medium.

Third - all the current documents end up providing the same over all physical design, fabrication, tolerance and test requirements. The main difference is if the DOE retest is required and if the filter must be on the US Army QPL list.

Fourth - the fine points of the exact QA documentation for materials and testing do vary somewhat. These differences are not physically significant but critically significant form a legal point of view.

Our nuclear industry, commercial or government, requires that the documentation be complete and exact. The consequences of failing to rigorously meet the paperwork requirements are severe. Therefore it is necessary for everyone who orders, installs, uses, maintains; inspects or tests a HEPA filter, or HEPA filter bank, know precisely what the appropriate documents are that apply to the filters on filter bank in question. This is not always a simple task given the multiplicity of documents described. For NRC licensed facilities the Plant Technical Specifications should define the controlling Codes and Standards. For DOE facilities it is less well defined but there should always be an original specification for any system that provides the requirements. As shown it is even more complicated using the one non-nuclear standard. When a new filter system is being specified the most prudent approach will be to use AG-1 since it is the latest and most complete specification. It also has the great virtue of allowing formal inquires through ASME. As an ASME Code it will be updated every five years as a minimum and maintained by an accredited formal Committee for continuity. The ASME Code organization is over a century old and is recognized around the world and should provide a measure of confidence for users.

Given the complexity of the current multiplicity of HEPA filter standards, let alone system and facility specific requirements, the proper understanding of this area requires considerable study and experience. With new personnel always entering the field we all have an obligation to pass on our experience and provide the necessary education to our new colleagues.

References

1. First, M. W, Gilbert, H.; "Octennial History of the Development and Quality of High Efficiency Filters for the US Atomic Energy Program", STI-PUB-195, 1968, International Atomic Energy Agency, National Agency for International Publications, 317 East 37th Street, New York, NY 10016

2. MIL-STD-282; "Military Standard Filter Units, Protective Clothing, Gas Mask Components and Related Products: Performance Test Methods; Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

3. Biermann, A.H.; Roza, R.A.; Chang, Y; "Alpha Migration Through Air Filters: A Numerical Simulation", UCRL-LR-109866, Lawrence Livermore National Laboratory, December 1991

4. Health and Safety Information Issue 212; "Minimal Specification For The High Efficiency Particulate Air Filter", @5 June 1965, USAEC, Division of Operational Safety, Washington, DC 20545.

4. MIL-F-51068; "Filter, Particulate, High Efficiency, Fire Resistant", Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120

5. MIL-F-51079, "Filter Medium, Fire Resistant, High Efficiency", Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120

6. AACC CS-1T, "HEPA Filters; American Association for Contamination Control, Now defunct.

7. Document Number 136-300-175A, "Instruction Manual for the installation, operation nd maintenance of Penetrometer, filter testing, DOP, Q107", U. S. Army, Edgewood Arsenal, Aberdeen, Maryland.

8. ASME AG-1-1991; Code on Nuclear Air and Gas Treatment", American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017

9. Burchsted, C. A., Fuller, A. B., "Design, Construction, and Testing of High-Efficiency Air Filtration Systems for Nuclear Applications", January 1970, ORNL-NSIC-65, National Technical Information Center, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

10. Burchsted, C. A., Fuller, A. B., Kahn, J. E., "Nuclear Air Cleaning Handbook", 1976, National Technical Information Center, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161

11. RDT M-16-3T; "HEPA Filter Medium, Glass Fiber (MIL-F-51079 with Modification and Additional Requirements)", March 1974 USAEC, Division of Reactor Research and Development, Now USDOE Office of Scientific and Technical Information, Oak Ridge, TN 37831

12. RDT E-9-1T; "HEPA Filters (AACC CS-1 with Additional Requirements)", August 1974 USAEC Division of Reactor Research and Development, Now USDOE Office of Scientific and Technical Information, Oak Ridge, TN 37831

13. NE E-3-45; "Specifications for HEPA Filters Used By DOE Contractors", October 1988, USDOE Office of Scientific and Technical Information, Oak Ridge, TN 37831.

14. NE E-3-43; "Quality Assurance Testing of HEPA Filters", February, 1990, USDOE Office of Scientific and Technical Information, Oak Ridge, TN 37831.

15. First, M. W., Gilbert, H.; "Government and Industry Meeting On Filter, Media and Media Testing", 19th NACC, 1986, CONF- 860820, Superintendent of Documents, USGPO, P.O.Box 37082, Washington, DC 22013-7082.

16. NE E-3-42: "Operating Policy of DOE Filter Test Program", October 1988, USDOE Office of Scientific and Technical Information, Oak Ridge, TN 37831

17. NE E-3-44; "DOE Filter Test Facilities Quality Program Plan", July 1986, USDOE Office of Scientific and Technical Information, Oak Ridge, TN 37831.

18 McIntyre, J. A.; "Review of DOE Filter Test Facility and Filter Test Facility Support Group Activities, FY 1986 - FY 1989", 21st NACC, 1990, CONF-900813, Superintendent of Documents, USGPO, P.O.Box 37082, Washington, DC 20013-7082.

19. NE E-3-41T; "In-Place Testing of HEPA Filter Systems by the Single-Particle, Particle-Size Spectrometer Method", December 1981, USDOE Office of Scientific and Technical Information, Oak Ridge, TN 37831.

20. ASME N509-1989; "Nuclear Power Plant Air Cleaning Units And Components", American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017

21. UL 586; "High Efficiency, Particulate Air Filter Units", Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062,

22. ANSI B132.1-1971; "High Efficiency Air Filter Units", American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018

23. ASME NQA-2; "Quality Assurance Requirements For Nuclear Facility Applications", American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017

24. IES-RP-CC-001-83-T, "HEPA Filters", Institute of Environmental Sciences, 940 East Northwest Highway, Mount Prospect, IL 60056.

25. IES-RP-CC-011-86, "HEPA Filters", Institute of Environmental Sciences, 940 East Northwest Highway, Mount Prospect, IL 60056.

26. ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Power Plants", American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

27. MIL-F-51477, "Filters, Particulate, High-Efficiency, Fire Resistant, Biological Use, General Specification For", Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

28. ASME N510-89, "Testing of Nuclear Air Treatment Systems", American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

29. Allen, T.T., Cramer, R.V.; "Evaluation of HEPA Filters Meeting MIL-F-51068 Purchased On The Open Market. Are They Nuclear Grade?", 17th NACC, 1982, CONF-8020833, Superintendent of Documents, USGPO, P.O.Box 37082, Washington, DC 22013-7082.

30. IES-RP-CC007.1; "Recommended Practice For Testing ULPA Filters", IES, 940 East Northwest Highway, Mount Prospect, IL 60056.

DISCUSSION

PORCO: My first comment is on the courses available. You failed to mention the ASME N509/N510/AG-1 short course. Which is a very good course series.

JACOX: Thank you. A serious omission, I am sorry.

PORCO: The second comment concerns the qualification of HEPA filters. You said that people are making filters to the correct specifications but that they are not on the QPL. To my knowledge, there is not a filter manufacturer that has gone through all the qualifications that is not on the QPL. In other words, if you are going to comply with all the qualification tests, you might as well be on the QPL.

JACOX: I agree with the statement, you certainly should. I was under the impression there were people who simply have not gone through the Edgewood bureaucracy to do it.

PORCO: Edgewood is the only facility that has the authority to designate entries to the Government's QPL for HEPA filters and has all the test equipment needed to go through the entire qualification test protocol.

EDWARDS, Jim: Duke Power at McGuire Training Center also has a comprehensive 3-day HEPA and carbon testing course.

JACOX: Is that on testing only, Or is that on the design specification?

EDWARDS: It is a comprehensive review of HEPA filter design, specifications, testing, and working characteristics. The same coverage is given to carbon adsorber units.

APPLICATION OF ASME CODE AG-1 TO YGN 3 & 4 PLANTS, SOUTH KOREA

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Abstract

Yonggwang Nuclear Power Plant Units 3 & 4 are located on the southwestern coast of South Korea on the Yellow Sea. The plant is owned by Korea Electric Power Corp.(KEPCO), with the engineering being performed by Korea Power Engineering Co. Inc. (KOPEC) and Sargent and Lundy under a technology transfer agreement. The plants are both 950 Megawatt (electric) pressurized water reactors of U.S. design.

Under contract to KEPCO, Korea Heavy Industries and Construction Co., LTD. and Ellis and Watts, Division of Dynamics Corporation of America, Batavia, Ohio, supplied major components to the YGN plants in compliance to ASME AG-1. These components included safety related Air Cleaning Units, Reactor Containment Fan Cooler Units, Air Handling Units, Cubicle Coolers, Duct Electric Heaters, and fans. This paper details the extent of applicability of ASME Code AG-1 to the specific equipment, description of the equipment, conformance, testing, and design required. The paper also discusses the problems encountered in implementing ASME AG-1, working around Code sections that were not complete at contract inception, conflicts in project documents and related problems. Also discussed are the logistics problems, material availability, and quality assurance aspects complicating the application of ASME AG-1, due to the required Korean content for some components.

Based on successfully supplying the equipment referenced above, it has been concluded that AG-1 is a working document and can be successfully implemented. It provides the requirements necessary for performance, design, construction, acceptance testing, and quality assurance of equipment used as components in nuclear air and gas treatment systems in nuclear facilities.

The paper also addresses lessons learned and aspects of mixing U.S. design and U.S. built components in Korean built assemblies.

Introduction

Yonggwang Nuclear Power Plant Units 3 & 4 (YGN 3 & 4) are identical 950 Megawatts (electrical) (MWe) units using steam generated by pressurized water reactors. The Yonggwang site is located on the southwest coast of the Republic of South Korea on the Yellow Sea. The plant site is situated to use seawater for primary cooling. Korea Electric Power Corporation (KEPCO) is the owner. Korea Power Engineering Company (KOPEC) is the engineering agency of KEPCO.

The overall plant design was the product of a technology transfer agreement between KOPEC and Sargent and Lundy, a U.S. based major engineering consultant firm. Technical specifications for all of the YGN 3 & 4 designs were based on U.S. technology.

Safety-Related Heating, Ventilating, and Air Conditioning (HVAC) equipment was awarded to Korea Heavy Industries and Construction Company, LTD (KHIC) under a separate contract. Within this Safety-Related HVAC contract, three (3) specifications were prepared by the owner to consolidate similar items in common specifications. These specifications were as follows:

Specification M862

Reactor Containment Fan Coolers (RCFC) providing reactor building cooling using water coils and vaneaxial fans.

Air Cleaning Units (ACU) providing air cleanup for Control Room Emergency Makeup, ECCS Equipment Room Exhaust, and Fuel Building Emergency Exhaust. These systems all used moisture separators, electric heaters, prefilters, high efficiency particulate air (HEPA) filters, activated impregnated carbon, and fans.

Duct Electric Heaters (DEH) providing air heating for control, electric equipment, battery, diesel/generator, and diesel oil storage tank rooms using resistance heating elements.

Specification M863

Cubicle Coolers (CC) providing cooling for LPSI pump, containment spray, HPSI pump, general access, shut down cooling heat exchanger, valve, charging pump, safety injection recirculation, auxiliary feed water pump, penetration, mechanical penetration, component cooling water pump, access aisle, electrical penetration, emergency core cooling spray ACU, spent fuel cooling pump rooms (areas). The Cubicle Coolers consist of chilled water cooling coils, centrifugal fans, and Class 1E motors.

Specification M876

Air Handling Units (AHU) providing air movement, cooling and heating for control room supply, engineered safety features switchgear and equipment, and emergency service water pump room supply.

Fans providing air movement for control room return, component cooling water heat exchanger room supply, diesel/generator room high volume supply/exhaust, engineered safety feature switchgear room return, battery room exhaust, and diesel oil storage tank supply.

ASME AG-1 Application

The Korea Electric Power Procurement Specifications for the safety related equipment invoked ASME Code AG-1-1985 as a requirement. Since the 1985 Edition of the Code was not complete, ASME N509 was utilized where Code sections were not available. For example, Section FC, HEPA Filters was not added till 1988, Section FE, Type III Absorbers was added in the 1989 Adenda. Section FG Filter Frames and IA Instruments and Control are still in the course of preparation. The Code was also limited by the applicability to the equipment as defined in the specification. Additional complications resulted after the issue of the 1989 Revision to N509.

Specific Equipment

1. Safety Related Reactor Containment Fan Coolers (RCFC)

The total weight of each RCFC approaches 80,000 pounds (36,300 kg) in operating status. Nine (9) component cooling water (CCW) coils, nine (9) chilled water (CW) coils, and their separate piping manifolds occupy three (3) open sides of the square cooler assembly. The fan is suspended inside below the floor, exhausting downwards into a duct system in the containment. These coolers are located high in the containment building and are above the missile shielding walls. They must, therefore, be locally reinforced to be resistant to jet impingement loads in some quarters.

The design specification for RCFC invoked AG-1 in a general reference. It also drew particular AG-1 articles into the detailed specification text for (CCW) coils and coil supports as well as inspection and testing requirements. These CCW coils, being ASME Section III, Class 2 components responsible for post-accident heat transfer, were required to conform to AG-1 , Section CA. CW coils, located in series in the same cooler housings, were specified as ASME Section III, Subsection NF and AG-1 Article CA-4130 components. These two criteria dictated a very detailed seismic analysis for the supporting frames and connected piping.

The coils, piping manifolds, and fans were supplied by E & W as U. S. manufactured items. The housing, piping manifold supports, structure, and drain pans were of Korean manufacture using KS materials. The KS materials were selected during the design phase on the basis of equivalent chemical and physical properties to ASME materials and availability of Certified Material Test Reports (CMTR). In this respect the use of KS steel presented no problems, just another detail in the manufacturing sequence.

One unique test was specified beyond AG-1 requirements for the post-accident service by the CCW coils. A prototype CCW coil test was required to demonstrate the performance and functionality of the CCW coil design at Design Basis Accident (DBA) conditions. This test which had been performed a few times in the 1960's and 1970's in the U. S., was set-up and run to document that computer-selected coils could meet the design conditions.

At the time of final assembly of the RCFC at the Korean manufacturing plant, an air flow test, fan balance, and sound pressure level measurements for the assembly were made. Again, these tests were not AG-1 requirements for the assembly but were specification measures showing compliance of the large assembly to design goals. Test procedures were prepared following AG-1 guidelines where possible to give the most consistency to the final results.

2. Safety Related Air Cleaning Units (ACU)

The ACU design specification required the ACU's to be in compliance with AG-1-1985. In order to use the later completed articles of AG-1, a deviation request for use of AG-1-1988 was submitted and received A/E approval. ASME N509 was used where AG-1 sections were not available.

Ellis and Watts designed the ACU in compliance with the structural design requirements of AG-1, Article AA-4000. Drawings and procedures were prepared to be in compliance with the fabrication, welding, brazing, coating and packaging requirements of Article AA-6000 of AG-1. Drawings were dual-dimensioned, CAD-prepared and indicated assembly, subassembly and piecepart requirements. Bills of materials on drawings indicated major components, threaded fasteners, and other items supplied by E&W. Structural materials were of Korean supply. Seismic qualification was accomplished by a combination of analysis and testing. Environmental qualification was also accomplished by a combination of testing and analysis based on previous testing.

Each ACU has a seismically-qualified, pressure-rated welded steel housing. The housing section of AG-1 has not been published, therefore, N509 was followed without problem. As each housing was completed in the assembly plant in Korea, a structural integrity pressure test and housing leak rate test per ASME-N510 were performed in accordance with ASME N510. This demonstrated that the E&W design had been satisfactorily assembled.

Ellis and Watts provided detailed shop drawings and procedures to KHIC and the Korean manufacturing plant selected for fabrication, assembly, and shop testing of the ACU's. KHIC coordinated the procurement schedules to insure materials were received in time with the desired site delivery dates. KHIC also verified all the quality requirements of AG-1 were met.

For material compliance to AG-1, Ellis and Watts specified material on the drawings and bills of material as required by Article 3000 of the applicable code sections. When Korean source materials were to be used, comparisons were made between available KS/ASTM/ASME standard materials to insure that physical and chemical property requirements were met.

E&W fabricated the HEPA filter frames due to the criticality of the HEPA filter-frame interface. Fit and function of each filter frame was verified in E&W's plant prior to shipment to the Korean assembly plant.

Dimensional interface between E&W-supplied HEPA filter frames and Korea-supplied ACU housings proved to be no problem. Welded joint design, sensible drawing tolerances, and prior planning lead to good fitup for these critical items.

On occasions there were drawing interpretation or sequence of operation problems. A controlled Engineering Change Notice (ECN) procedure was provided so that drawing interpretations, minor dimensional adjustments, and material substitutions could be evaluated prior to or concurrent with shop work.

ASME AG-1 Section FA, Moisture Separators, had not been issued when the specification was released, therefore the requirements of ASME N509 were specified. The pre-qualified MSA moisture separator was selected. The qualification is detailed in Atomic Energy Commission (AEC) Report MSAR 71-45. E&W supplied the moisture separators and designed the supporting frames and individual drain pans for fabrication in Korea. The filter supporting frames were designed in accordance with N509, since AG-1 Section FG is also in the course of preparation.

HEPA filters were specified to meet the requirements of ANSI/ASME N509-1980 and AG-1 Section FC. E&W supplied 1000 CFM nuclear grade metal frame HEPA filters meeting the specification and the intent of N509 and AG-1, Section FC. Differences between the specification, N509 and AG-1, caused some interpretation problems which were resolved with the specification taking precedence.

Prefilters were specified to meet ANSI/ASME N509-1980, Article 5.3 as AG-1's Section FB, Prefilters, had not been published. Support frames were designed by E&W for fabrication in Korea. No problems of compliance to AG-1 were experienced other than the ambiguity of ASME N509-1989 concerning prefilter efficiency (<u>minimum</u> required ASHRAE (average) efficiency) and minor dimensional adjustments required at the Korean assembly plant to ease maintenance access around the DOP test manifolds.

Carbon Adsorbers were specified to meet ANSI/ASME N509-1980, Article 5.2 as AG-1's Section FE, Type III Adsorbers, had not been published in 1985. E&W requested a deviation to permit AG-1-1989 Addenda, Section FE to be used. The deviation was granted by KOPEC. Four (4) inch (102 mm) thick adsorber beds were required with a residence time of 0.5 sec. No compliance problems were encountered. Test canisters were specified and provided; the number specified exceeded Section FE minimum quantity.

Carbon adsorbent was specified to meet AG-1-1985. When Section FF, Adsorbent Media, was published, E&W requested and received approval for a deviation to permit AG-1-1988, Section FF, to be used. The carbon supplied by E&W was scheduled for shipment so that the production of it was as late as possible to preserve shelf life and minimize accidental contamination in site storage. No problems of compliance to AG-1 were experienced for the adsorbent.

Instrumentation and Controls were specified in considerable detail and was based on ANSI/ASME N509-1980 Tables 4-1 and 4-2, as AG-1 Section IA, Instrumentation and Control, had not been published. The specification was tailored by the A/E to meet the special requirements of the Korean utility. Mounting, electrical interface, and wiring connection standards for YGN 3&4 were influenced strongly by the other plant designs already in the KEPCO System. No compliance problems specific to AG-1 were experienced.

Fans and motors for ACU's were specified to be in compliance with N509-1980, Articles 5.7 and 5.8, instead of AG-1, Section BA. This presented no problem; the specification was compatible with AG-1 requirements. Fans were selected as heavy duty direct drive pressure blowers with metallic disc couplings. Flexible connections were installed at each fan discharge. The entire fan was inside the ACU housing. It was necessary to have actual AMCA 210 performance tests on the fan since the addition of fixed inlet screens adversely effected the fans' performances. These new tests were made a part of the quality assurance documentation. Motors were qualified in accordance with IEEE-323 and IEEE-344.

3. <u>Safety Related Duct Electric Heaters (DEH)</u>

Duct Electric Heaters (DEH) are intended to provide heat to airstreams on an as-needed basis. All of the 28 assemblies, with individual control and instrumentation packages were required to conform to AG-1 Section CA. Control of the heaters was accomplished with Silicon Controlled Rectifier (SCR) or step controllers. All have overheat cutouts and airflow switches for thermal protection.

To meet seismic and environmental requirements of IEEE 323 and 344, it was necessary to perform testing on a representative heater assembly. Control panels and instrumentation were tested and qualified to IEEE-323 and 344. All of the DEH's were shipped fully assembled from E & W's plant after shop (functional) testing per N509, N510, and AG-1.

4. <u>Safety Related Cubicle Coolers (CC)</u>

There are 86 Cubicle Coolers of 20 designs ranging from 1,000 SCFM (1,700 SCMH) to 30,870 SCFM (52448 SCMH). The units vary from floor-mounted, ceiling-mounted, horizontal, and vertical. All have ASME Section III, Class 3 cooling coils and a Class 1E motor-driven centrifugal fan, direct coupled. Each has a prefilter. All are seismically analyzed for their plant locations, principly pump and penetration rooms, in which they remove heat released locally. Environmental qualification varied from mild to harsh environment depending on equipment location.

All coils, fans and motors for Cubicle Coolers are of U. S. manufacture. The housings were fabricated and final assembled in the Korean shop. KS materials equivalent to ASTM materials were used.

AG-1 Sections CA (Cooling coils), BA (Fans), and DA (Backdraft Dampers) are invoked by the specification. Numerous articles are restated for emphasis of details selected by the Engineer. Examples of this are coolant tube velocities being restricted per CA-4122, vibration limits for fans defined per BA-4211, and damper seal leakage limitation per Article DA-4140.

The Cubicle Coolers were designed, tested, inspected and qualified to ASME Code Section III and AG-1 requirements. AMCA Fan Test Standards 210 and 300, and IEEE environmental test standards 323 and 334 were also met.

5. Safety Related Air Handling Units (AHU)

AHU designs vary to meet different system requirements. Each of the three (3) designs is unique. The Control Room Supply AHU is a multizone unit consisting of housing, mixing box section, high efficiency filter bank, enclosed direct drive fan, cold deck and bypass dampers. At the outlet of the housing are six (6) flow control dampers of different sizes, each with an electrohydraulic actuator, Class 1E qualified. For this design, fans, motors, cooling coils, flow control dampers and actuators were supplied by Ellis & Watts. The balance of the fabrication and assembly was completed in Korea.

The ESF Switchgear and Equipment Room AHU consists of housing, mixing box section, high efficiency filter bank, electric heating coil, chilled water cooling coils, two (2) 100% capacity fans direct driven by Class 1E motors, and isolation dampers. The isolation dampers permit service of a fan while the unit continues to operate with the other fan. Fans, motors, electric heating elements, cooling coils, and isolation dampers were supplied by Ellis & Watts. The balance of the equipment was fabricated and assembled in Korea.

The ESW Pump Room Supply AHU consists of a down flow filter bank closely coupled to a vaneaxial fan. This entire assemble was fabricated and shipped as a single unit from E & W's plant.

The specification governing AHU's, like the Cubicle Cooler specification, invoked AG-1 in general and had many direct references to AG-1 articles for definition of details. Cooling coils were ASME Section III, Class 3 and had connecting manifolds to the same Code. Cooling coil details were from both Codes. Damper design and leakage criteria were specified from both AG-1 Section DA and N509. Slight differences were resolved and accepted by KOPEC.

The AHU's had to undergo shop testing to verify leak tightness and functionality. Electric heating coil assemblies, had to be tested in the Korean assembly shop for resistance, continuity, dielectric and functionality in accordance with AG-1, Article CA-5000. Installed dampers were demonstrated by test to perform as specified.

6. Safety Related Fans and Motors.

Both centrifugal and vaneaxial fans were supplied, all were direct driven by Class 1E motors. They ranged in airflows from 2,300 SCFM (3,900 SCMH) to 48,000 SCFM (81,500 SCMH).

All of the fans were of U. S. manufacture. Each was fitted with a non-safety related local static pressure indicator.

Testing per AMCA 210 was performed in accordance with AG-1. The manufacturer or independent laboratories were used to perform the tests.

Problems Encountered

The specification had some areas where the use of historical documents, without an order of precedence, created confusion. ASME AG-1, N509 and N510, NRC Regulatory Guides, the Nuclear Air Cleaning Handbook, RDT Standards, etc., all have subtle differences. Many of the differences are the result of improvements to testing methods, product developments, or evolutionary clarifications necessitated by application and interpretation problems encountered over the years. Usually, compliance with the latest standard resolves any conflicts, but not always.

Typical examples of problems encountered are as follows:

1. Charcoal performance testing with conflicting test requirements, RDT vs. ASTM.

2. Reference to Article BA-4300 of ASME AG-1 for lifting lugs for the AHU; BA-4300 addresses lifting lugs for fans, housing lifting lugs are described in Article AA-6610 of AG-1.

3. Slight differences in leakage criteria for dampers between ASME AG-1 and N509.

4. Fan AMCA test requirement differences such as N509 requirement to test "one fan of each size and type" vs AG-1 requirement to test "a full size fan or smaller geometrically similar fan".

In each case, there was a workable solution for the apparent conflicts. Common sense approach and documented justification of resolutions avoided any quality assurance issues.

An area where ASME AG-1 guidance would have prevented confusion is in the instrumentation and controls. This area required more clarification and precipitated more differences in requirement interpretations than any other. Publication of Section IA, Instrumentation and Control, should be a priority for the AG-1 Committee.

LESSONS LEARNED

With any contract of this magnitude, it is imperative to minimize specification reference conflicts prior to issuing the procurement specification. Common sense and good communications are essential to the execution of a project that includes offshore fabrication and construction. The cooperation, communication, and understanding between KOPEC, KHIC, and E&W were essential in bringing this project to a successful conclusion.

The application of ASME AG-1 to the design, fabrication, and testing of the equipment described above is possible with careful consideration to the equipment not presently addressed in published sections of AG-1. A complete AG-1 Code is necessary to eliminate historical reference document conflicts.

CONCLUSIONS

Based on the successful design, fabrication, testing, and installation of the equipment discussed above, ASME AG-1 Code can be succesfully implemented to supply safety-related equipment to commercial nuclear power plants. ASME AG-1 is a working document that contains the design, performance, testing, construction, and quality requirements necessary for equipment and components in nuclear air and gas treatment systems. ASME AG-1 has also proven to be a workable code in the scenerio involving the added complexity of multi-national procurements and fabrication.

DISCUSSION

JENKINS: I am curious why an incomplete specification would have been used? I think you said that AG-1 was not complete at the time.

YORK: Yes, the basic specifications that were prepared by KEPCO, with technical input by Sargent & Lundy, used some Byron and Braidwood Nuclear Station specifications, plus AG-1, 1985. As you know, AG-1, 1985 did not (then) have a number of the sections that have since been added. In order for us to work with AG-1, one of the things we had to do was to go to KEPCO and ask them if we could use the 1988 Code (or, in the case of the carbon unit, the 1989 Addendum) of AG-1 in order to use a more complete AG-1 specification. There are still pieces of AG-1 that have not been published. So, it was incomplete in the sense that the end goal of AG-1 had not been reached at the time.

JENKINS: Perhaps it is just a contractual issue. I was trying to understand why you would have accepted a contract to build something to what was apparently an incomplete specification. I guess there was more involved.

BELLAMY: We have the Chairman of the ASME Committee here, so why don't we let him address the question.

MILLER, William: When the AG-1 Code was originally planned, it was understood that all the parts of the Code would be completed over the span of about 10 years. Therefore, the Code was designed with common sections that would support each one of the completed modules. As the modules were issued, they could be used on a stand alone basis with the common sections, so that the architect-engineer selected those portions of the Code that were complete and supplemented them with requirements from N509 and from other specifications. I am happy to report that both the I&C, and ductwork sections of the Code are rapidly proceeding toward publication. They both have reached the Board of Nuclear Codes and Standards for approval and are undergoing second ballots. We expect both to be issued later this year. We are in much better shape now than we were back in 1989 or 1990 when the specifications were being put together for YGN. The follow-on units for Korea, the Ulgin Project, will more than likely reference the entire Code. But that is up to the KOPEC.

FLIS: Section FG (Mounting Frames) of AG-1 will be published with AG-1 addenda by October 1992.

YORK: Another thing I can add, Mr. Jenkins, is that there were several places in the paper where it reports that the specifications said do it according to AG-1, period. There were other places where extracts from AG-1 were used and, sometimes, pieces of AG-1 and pieces of N509 were put together to make a specification. So, there were differences between the specifications we worked with. Some were brief, inasmuch as that they merely cited an AG-1 requirement, whereas others were rewrites of AG-1 and N-509 material, editor's choice.

FRANKLIN: I am interested as a follow-on to Mr. Paul's paper. Can you describe any problems, successes, etc. with testing for air distribution in the air cleaning units?

YORK: The requirement to do airflow distribution tests on air cleaning units of every size was followed. We would simulate inlet conditions, turn on the fan, and measure velocity at the prefilter and again at the HEPA filter inlet face. We were able to come well within the ±20% requirements, after we added the resistance of the upstream mist eliminator pads. In other words, we used the upstream mist eliminator pads as natural flow distribution devices. When we got to the prefilter and the HEPA filter, we got distribution within acceptance criteria. That was demonstrated for each filter size and for charcoal.

BARCT: A CONSERVATIVE APPROACH TO REGULATING RADIONUCLIDE EMISSIONS

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Abstract

The State of Washington, Department of Health, is responsible for the enforcement of regulations for the emissions of radionuclides to the air. Our regulatory standards include a health-based ambient standard of 25 mrem/yr to the maximally exposed member of the public and engineering standards at the source. The Department (of Health) also enforces more stringent state or federal regulations, that, in effect, limit the emissions of radionuclides to the environment.

A reasonably available control technology (RACT) engineering standard, based on the principle of "as low as reasonably achievable" (ALARA), applies to existing facilities and minor modifications. The more stringent best available radionuclide control technology (BARCT) engineering standard applies to new construction and significant modifications. The BARCT standard is modeled after EPA "top-down" best available control technology (BACT).

The conservative approach to regulation of radionuclide emissions is the result of public demand for accountability. This has resulted in the introduction and passage of the BARCT standard and by the authority granted to the Department of Health to enforce the standard.

The recently proposed revision to the state's Washington Administrative Code (WAC) 246-247[1], includes a BARCT determination procedure. The concise procedure includes a purpose, scope, engineering standards, an application procedure and documentation requirements. Final adoption of WAC 246-247 is expected later this year.

This paper provides a description of the BARCT determination procedure and gives several examples of BARCT determinations.

I. Introduction

The BARCT engineering standard for control of radionuclide emissions at the source was first adopted in the State of Washington in WAC 173-480[2] in 1986. The enforcement of this standard was specified in WAC 246-247 and became effective August standard was specified in WAC 246-247 and became effective August 10, 1988. The Department of Health administers this program. The regulatory definition of BARCT and guidance from the Department (of Health) constitutes the present BARCT determination requirement. The EPA "top-down" BACT guidance[3] was adapted to the emission of radionuclides. The procedure has been used successfully in several construction applications.

II. BARCT Standard and Definition

Standard

The BARCT engineering standard, as set forth in WAC 173-480-060, states that: "(1) Whenever the construction, installation or establishment of a new emission unit subject to this chapter is contemplated, the project shall utilize best available radionuclide control technology (BARCT). (2) Addition to, enlargement, modification, replacement, alteration of any process or emission unit or replacement of air pollution control equipment which will significantly change potential radionuclide emissions or significantly change the dose equivalent will require the proposed project to utilize best available radionuclide control technology (BARCT) for emission control."

Definition

The BARCT definition is contained in WAC 173-480-030, as: "(1) Best available radionuclide control technology 'BARCT' means technology which will result in a radionuclide emission limitation based on the maximum degree of reduction for radionuclides which would be emitted from any proposed new or modified emission units which the permitting authority on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such emission unit or modification through application of production processes or available methods, systems, and techniques. In no event shall application of best available radionuclide control technology result in emissions of radionuclides which would exceed the ambient annual standard limitation specified in this chapter."

III. BARCT Determination Procedure

Purpose

A BARCT determination is the conclusion of an evaluation process which results in the selection of the most effective control technology from all available, feasible alternatives, applicable to the specific emissions unit.

The BARCT standard and definition are the basis of the BARCT determination procedure. The Department has reserved the right to adjust this procedure, on a case-by-case basis, in order to ensure compliance. The extent of the evaluation is dependent upon the source's "potential to emit" (emissions without controls).

Scope

The BARCT determination includes the abatement technology, control features (administrative or automatic) and indication devices that control the emissions of radionuclides. Applicability extends from entry of radionuclides into the ventilation vapor space to release to the environment.

Engineering Standards

A listing of applicable engineering standards are provided in the regulations. These include standards for abatement equipment and testing, quality assurance, sampling and monitoring, and ventilation.

Application Procedure

A 5-step evaluation is used to determine compliance to the BARCT engineering standard.

Step 1 Define facility process variables. The physical and chemical process upstream of the emissions abatement control technology is evaluated. The "potential to emit" is estimated, as if no control technology is present. Radionuclides are selected for control technology evaluations. Those that contribute more than 10% of the unabated dose, or that exceed 0.1 mrem/yr (to the maximally exposed member of the public (MEI)), or any others which the Department indicates are necessary are used to evaluate potential abatement technology.

Step 2 Gather information on all available control technologies. A selective search is made of "available" control technologies. This list is prepared by review of literature, database searches and compendiums of air emission control technologies. Available technologies include any technology that may be procured.

Step 3 Determine technical feasibility. A control technology may be eliminated if it is found to have poor safety, reliability, control effectiveness, or applicability to the emissions unit. The BARCT evaluation will include combinations of abatement equipment, indication devices and control features. Both the ventilation system and its components are evaluated.

Step 4 List all feasible control technologies in order of effectiveness. The remaining control technologies are listed in order of effectiveness (efficiency) in reducing the dose to the MEI. This produces a "top-down" list. If the "top" control technology is selected, the BARCT determination is complete.

Step 5 Evaluate the environmental, energy, and economic impacts. Each control technology is evaluated in succession from the "top-down." An objective evaluation considers both beneficial and adverse impacts.

Health-Based Benefit - The reduction in dose equivalent to the population , or at least to the MEI, and to the radiation worker is a beneficial impact.

Environmental Impact - Generation and disposal of waste (all types), construction activities, and threats to the public health and the environment are potential environmental impacts.

Energy Impacts - Energy use, both for construction and operation, is an energy impact. Supply services (e.g., power lines) are included.

Economic Impacts - Financial impacts include: design and development, construction, operations and maintenance, and the cost of environmental and energy impacts.

The adverse economic impact versus the reduction in dose equivalent is a measure for the cost/benefit analysis of the control technology evaluated.

Documentation Requirements

The evaluator reports the conclusions of the BARCT determination. The Department reviews the report and approves or disapproves the evaluation.

IV. Examples of BARCT Determinations

(1). Grout Disposal Facility - The Grout disposal facility receives large volumes of liquid low level waste from the Hanford tank farms. This waste is mixed with grouting materials and formed into large grout vaults. The potential for release of radioactive air emissions was evaluated for this project. The evaluation identified HEPA filtration and zone control as BARCT. The use of condensers to control small amounts of tritium was found to exceed BARCT requirements. This conclusion was based on estimates that electric power requirements (energy impacts), if from a nuclear power source, would produce a much greater radioactive waste source-term than it would mitigate. The cost of condensers and the need to dispose of large volumes of slightly contaminated water influenced this decision. Forty four grout vaults, each containing 1.4 million gallons of grouted waste, have been permitted to date.

(2). Waste Water Treatment - The BARCT determination considered the facility as new construction, the source-term as small and the radionuclide emissions in particulate form. The obvious need for HEPA filtration was determined to be BARCT. This is an example of a determination not entailing a cumbersome evaluation.

(3). DAW Gasifier - Dry activated waste (DAW) from commercial reactor operations is separated into a cellulosic portion and gasified. This high temperature process utilizes a heated, slow feed-rate auger and a non-oxidizing atmosphere to accomplish volume reduction. The residue is mixed with grouting material and solidified in preparation for low level solid waste disposal.

The BARCT evaluation included the potential for a large unabated dose due to the close proximity of public access to the facility. This produced a requirement for significant control technology to obtain a large reduction in emissions.

The BARCT evaluation required the use of several control technologies. A scrubber was required for emissions abatement and off-gas cooling. An optional mist eliminator was required if liquid water is present in the scrubber off-gas. A heater was required to reduce the maximum humidity of the off-gas through the filters. A redundant set of pre-filters, HEPAs, and two stages of charcoal absorbers followed. Indication and control devices were specified. Compliance with ASME N509 and N510 was required. Fire suppression and zone control at the input and output of the process was defined.

Disposal of the liquid waste from the scrubber by mixing with the residue and grouting material was an added benefit.

The BARCT determination evaluation was based on cost and control technology efficiency estimates, and the resulting MEI and population dose reduction estimates. Measures were cost per dose reduced and estimated emissions (dose with BARCT controls).

(4). HWVP (Hanford Waste Vitrification Plant) - The HWVP will receive small volumes of high level liquid radioactive waste from Hanford tank farms for vitrification. This waste will be pre-treated and mixed with frit (glass forming material). A liquid-fed, joule-heated melter will produce bora-silicate glass. Joule-heating is produced by application of a voltage across the resistivity of the liquid. The melted glass is poured into large stainless steel cylinders, weighing approximately 2000 kg. (4800 lb.) when full. After cooling, the cylinders are decontaminated and a closure is welded into the top opening. Glass logs, as they are called, will be placed in interim storage at Hanford and ultimately disposed of at the high level waste repository.

The BARCT determination must consider the melter off-gas (MOG) and the pre-treatment process vessel vents (PVV). The MOG consists of volatile and semi-volatile compounds (mostly steam) evolving from the melter. The 1100 C. (2000 F.) melt temperature produces condensable and non-condensable surges in gas flow that must be controlled. The turbulent nature of the off-gas causes entrainment of large particles. A film cooler at the exit from the melter causes the solidification of entrained glass particles and reduces the likelihood of plugging.

The PVV collects the volatile off-gas from the pre-treatment process vessel vents. The chemical process in these vessels produces hydrogen. Addition of air dilutes the concentration of hydrogen in the off-gas below the lower flammable limit. There is also a large volume of steam evolved during pre-treatment. Other non-radioactive chemical components may be present in quantities that could influence the selection of abatement technology.

Construction of the HWVP is to begin in February, 1993. Operation is expected in December, 1999. A phased application process is planned. Each phase of construction will be permitted successively. The initial BARCT determination is expected by the Department later this year. The BARCT determination will be revised prior to each construction phase.

(5). Cancer Research Facility - This research and clinical facility is expected to have a low potential to emit. Radio-iodine is the principle source-term. Proposed treatment protocols include the use of charcoal absorbers at the source. Final evaluation is pending receipt of a BARCT determination application. A streamlined evaluation for BARCT is planned.

V. The Future for BARCT

The State of Washington will enforce the most stringent engineering standards at the source. BARCT is the current "best" or most stringent standard. As other regulations and standards are developed, the state will evaluate and adopt these standards, as appropriate. The revision of WAC 246-247 with the codification of the BARCT determination procedure, is expected to enhance the Department's ability to enforce the BARCT standard. The enforcement of BARCT helps assure the public that the state is taking a conservative approach to radionuclide air emissions.

REFERENCES

1. Washington Administrative Code 246-247, "Monitoring and Enforcement of Air Quality and Emission Standards for Radionuclides," (1988), Department of Health, Olympia, WA.

2. Washington Administrative Code 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," (1986), Department of Ecology, Olympia, WA.

3. "'Top-Down' Best Available Control Technology, Guidance Document (Draft)," March, 15, 1990, U.S. Environmental Protection Agency, Washington, DC.

DISCUSSION

HAYES, J.: Does BARCT apply to nuclear power plants?

BLACKLAW: I believe it will when it is adopted.

HAYES, J.: Will it only apply to normal effluents or will it apply to all effluents?

BLACKLAW: I think it will apply to any vapor effluent. Generally speaking, we have NRC facilities such as power plants and they are quite well regulated. We can enforce the NRC regulations, I expect, but we don't see that our regulations are more stringent at this point (except for the BARCT and RACT engineering standards).

HAYES, J.: The reason I asked that particular question is because, in some of the advanced reactors, there has been a tendency to remove charcoal adsorbers from both ESF systems and from normal effluent systems. I think this would have an impact upon advanced reactor designs if you could enforce this type of regulation in the State of Washington, and possibly, in other states.

Another question: it seems you have something equivalent to a cost-benefit ratio. Do you use a dollar value, so many dollars per person rem, to put you over the edge? In other words, if the ratio is over $100 per person rem would the equipment not be installed?

BLACKLAW: We researched that topic and we have some internal guidelines that we use. We don't like to use them because, a lot of times, what in the end makes the difference is the actual expected dose, rather than the dollar-per-man-rem-reduced. We have numbers like that, but they are only one part of what we end up using.

HAYES, J.: In other words, guidelines versus a fixed, definitive rate?

BLACKLAW: Yes.

HAYES, J.: For your 25 millirem per year, is that a particular organ dose or is it a whole body?

PETERSON: It is a whole body dose. Organ doses are limited to 75 millirem per year.

BLACKLAW: Also, it might be noted that EPA NESHAPS (40 CFR 61, Subpart H) calls for a 10 millirem ambient standard. When it is in effect (DOE facilities), we expect to regulate to that limit. When it is not in effect, we will use the 25 millirem standard (e.g., NRC Licen.).

CLOSING COMMENTS OF SESSION CO-CHAIRMAN SOFFER

In this session, four papers were scheduled. We actually heard three. The first paper by Mr. Jacox, reviewed HEPA filtration test standards. He began with an interesting discussion about the development and history of HEPA filters. He pointed out that the key attribute is efficiency. However, he pointed out that HEPAs are often looked upon as a commodity and that users, when ordering or specifying HEPA filters, have to be very careful that they comply with the legal requirements of the authorities, either DOE or NRC, that they are being licensed under. He pointed out the plethora of standards and codes that have been issued and the fact that people have used textbooks as specifications when they should not have done so. There was a considerable amount of discussion that there are courses, workshops, and ample instructional materials in this somewhat confusing area. One of the more important points that was made was that DOE requires all its HEPA filters to be double-tested, whereas NRC leaves this up to the individual user.

The second paper was on the application of ASME Code AG-1 to the construction of the Yonggwang Plant in South Korea. This was presented by Mr. J.D. York of Ellis and Watts. He pointed out that AG-1 can be successfully implemented and it has proven to be a workable code despite the fact that there are still missing sections. However, these were supplemented by existing portions of N509 and N510. He also pointed out some of the interesting problems that resulted from working in a cross-cultural environment, including the blessing of ATRAC components, which I don't think is in any of the U.S. standards. He pointed out an interesting test that was performed on the component cooling water coils where it was really necessary to demonstrate that they could be operated at design basis accident conditions.

The final paper was a presentation by Mr. Blacklaw of the State of Washington, Department of Health, on BARCT: A Conservative Approach to Regulating Radionuclide Emissions. Mr. Blacklaw pointed out that the Federal Clean Air Act gives states authority to set standards. He described the standards of the State of Washington. They use an ambient standard of 25 mrem/yr and require RACT, or reasonably available control technology, which is basically a ALARA-type standard. Much more stringent BARCT, or best available radionuclide control technology, adopted in 1988, is required whenever there are changes or modifications that will significantly change potential radionuclide emissions. He described the 5-step determination procedure that goes into this procedure. He also described the control strategies to be applied in a top-down order of approach and he discussed a number of examples, particularly around the Hanford area but not necessarily confined to that.