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ASME N510 TEST RESULTS FOR SAVANNAH RIVER SITE AACS FILTER COMPARTMENTS

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ASME N510 TEST RESULTS FOR SAVANNAH RIVER SITE AACS FILTER COMPARTMENTS

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Abstract

The K-Reactor at the Savannah River Site recently implemented design improvements for the Airborne Activity Confinement System (AACS) by procuring, installing, and testing new Air Cleaning Units, or filter compartments, to ASME AG-1, N509, and N510 requirements. Specifically, these new units provide documentable seismic resistance to a Design Basis Accident earthquake, provide 2" adsorber beds with 0.25 second residence time, and meet all AG-1, N509, and N510 requirements for testability and maintainability.

This paper presents the results of the Site acceptance testing and discusses an issue associated with sample manifold qualification testing.

I. Introduction

The Savannah River Site (SRS) is located on the Savannah River in South Carolina. The Site is owned by the Department Of Energy, with the Westinghouse Savannah River Company (WSRC), a Subsidiary of Westinghouse Electric Corp., as the primary contractor. The mission of the Savannah River Site was to produce special nuclear materials. Currently, 4 of the 5 production reactors at SRS have been shutdown and the fifth reactor, K-Reactor, is being maintained in a cold standby condition. The reactor never operated with these new filter compartments installed.

The production reactors at the Savannah River Site (SRS) were constructed in the 1950's. These reactors are non-boiling and vented to atmosphere (non-pressurized). The Airborne Activity Confinement System (AACS) for the reactors is designed to collect airborne radioactive particles and halogen vapors that might be released to the atmosphere following a reactor accident. The system is designed for confinement, not containment. Confinement is attained by sweeping outside air through the process areas and exhausting the air through parallel filtration-adsorption units (filter compartments) prior to exhausting to the atmosphere. Five compartments are available with three constantly on-line during reactor operation. Contamination within the reactor building is controlled by flowing air from areas of least expected contamination to areas with a higher potential for airborne contamination. The process areas of the reactor building are sufficiently sealed that they can be maintained at a negative pressure with respect to adjoining areas, including the atmosphere.

Originally, the process area exhaust air was exhausted directly to the atmosphere through a 200' stack. In the 1960's, design changes were implemented to exhaust air from the process areas through the 5 parallel filter compartments prior to exhausting to the atmosphere. Each unit contained a bank of moisture separators, a bank of HEPA filters, and an activated charcoal absorber bed. Typical building total flow rates during reactor operation with the filter compartments installed were 110,000 cfm.

In 1990, a new project was initiated to replace the existing filter compartments with new seismically qualified compartments designed, installed, and tested in accordance with ASME AG-1, N509, and N510 requirements. The new design also incorporated other changes to improve maintainability, operability, and to provide for longer periods of operation between filter replacement (see Figure 1).

The compartments reside on the roof of the building at an elevation 55' above the ground. Because the original AACS design did not include the filter compartments, a uniquely designed compartment was required to retrofit the existing system. Process area exhaust air enters the top of the compartment and makes a 180 degree turn prior to entering the moisture separators. The compartments are locked in place and sealed to the ventilation system using inflatable bladders on the building nozzles.

Neither the new or the old compartments were shielded. Therefore, both were designed for "remote removability" such that if a compartment became highly contaminated, it can be remotely disconnected from the ventilation system, sealed to prevent spread of contamination, and removed by a crane for burial.

The new compartments were constructed of stainless steel to resist corrosion in the acidic process air. Weight constraints were imposed to prevent degrading the building structure's ability to withstand a design basis earthquake (the existing compartments were made of aluminum). The design flow rate through the new compartments ranges from 16,000 to 32,000 cfm each.

II. ASME N510 Acceptance Testing

N510 qualification testing to prove AG-1 and N509 requirements were met was conducted at both an independent laboratory and at the K-Reactor. The test results reported herein were obtained during the Site acceptance testing of Filter Compartment N^o 2 at the K-Reactor, unless otherwise noted.

Structural Capability Test

The filter housing was subjected to both a negative and positive structural capability test. The negative pressure test was performed at -9.25 inches of water gauge (w.g.) and the positive pressure test was performed at 69.5" w.g. Inspection of the filter compartment during pressurization and following test completion showed no evidence of permanent distortion or breach. Therefore the filter compartment met the acceptance as required by ASME N510.

Housing Leak Test

The filter housing was subjected to leak test to demonstrate its leakage integrity under maximum design pressure. The housing was pressurized to 55.9" w.g. Acceptance criteria was 1.0" w.g. decay over a ten minute period. Actual test result, after correction for temperature and barometric pressure changes, showed 0.99" w.g. decay during the ten minute test period.

HEPA And Carbon Adsorber Frame Leak Test

WSRC elected to perform the optional HEPA filter and carbon adsorber frame leak tests. Acceptance criteria per N509/510 is 0.1% of rated flow.

The HEPA frame, after sealing with plastic sheeting, was subjected to $+3.0" \pm 0.1"$ w.g. by pressurizing the housing upstream of the HEPA bank with air. Leakage was measured at the air flow required to maintain pressure. Actual average flow rate measured over a ten minute period was 4.7 cfm or 0.029% of the minimum design air flow.

The adsorber bed, after sealing with plastic sheeting, was subjected to $+1.1 \pm 0.1"$ w.g. by pressurizing the housing upstream of the adsorber bank with air. Leakage was measured as the air flow required to maintain pressure. Actual average flow rate measured over a ten minute period was 8.5 cfm or 0.053% of the minimum design air flow.

This test methodology produced a conservative result by assuming the measured leak rate was completely due to HEPA frame leakage and ignoring the other possible sources of leakage (personnel door seals, light fixtures, inadequate sealing of the plastic sheeting, etc.). Actual frame leakage is most probably less than the measured value. Both tests demonstrated that the sealing of the frames to the housing is adequate and meets all requirements.

Air Capacity Test

An Air Capacity Test was performed to demonstrate that at the maximum housing delta-P of 6" w.g., the process areas remained at a negative pressure with respect to atmosphere and that a minimum flow of 20,000 cfm can be maintained. Actual testing demonstrated that both criteria were met.

Air Flow Distribution Test

An Air Flow Distribution Test for both the HEPA filters and the Adsorber Bed air channels was performed. Both tests were conducted at the maximum design air flow of 32,000 cfm $\pm$ 10%.

HEPA Bank Once the air flow was established, the air velocity was measured at the downstream side of each HEPA filter (filter bank designed as 3 filters wide X 7 filters high). Actual measured velocities, shown in Table 1, demonstrated that the air flow distribution met the N510 criteria of $\pm$ 20% of the average of the individual flows.

Adsorber Bank Once the air flow was established, the air velocity was measured at fourteen approximately equal areas in the plane of the face of the eight inlet air channels. Actual measured velocities, shown in Table 2, demonstrated that the air flow distribution met the N510 criteria of $\pm$ 20% of the average of the individual flows.

Air-Aerosol Mixing Uniformity Test

DOP was introduced into the housing at the maximum design air flow rate ($\pm$ 10%) using the permanently installed injection manifold. The resultant DOP concentration measured one foot upstream of the HEPA filter bank (see Table 3) showed that the air-aerosol distribution at each of the 21 HEPA filters was within $\pm$ 20% of the calculated average concentration.

It should be noted that even though the housing design requires the air to make a 180° turn prior to entering the moisture separators, both the air flow distribution and air-aerosol uniformity were achieved without the use of turning vanes or other mixing devices.

HEPA Filter Bank In-Place Leak Test

Aerosol generators and detectors were connected to the housing for the performance of the HEPA filter bank in-place leak test. System dampers were properly positioned and the maximum design air flow rate ($\pm$ 10%) was established. Upstream and downstream HEPA filter background readings were taken and recorded. Upstream concentration was measured using the single point sample port. This port was proven effective in measuring upstream concentrations during the air-aerosol mixing uniformity test. Downstream concentrations were measured using the permanently installed sample manifold. The aerosol generators were then pressurized, and DOP was injected into the inlet plenum manifold. Four sets of upstream and downstream HEPA filter DOP concentrations were taken and recorded. The final penetration calculated from the data demonstrated that the actual bypass leakage was virtually 0%.

Adsorber Bank In-Place Leak Test

Halide generators and one detector were connected to the filter housing for the performance of the adsorber in-place leak test. System dampers were properly positioned and the maximum design air flow ($\pm 10\%$) was established. Upstream and downstream adsorber background readings were taken to verify stable background conditions for initiation of injection. The halide generators were turned on and halide gas (R-11) was injected into the inlet plenum manifold. Five sets of upstream and downstream readings were taken and recorded. The downstream concentration was measured using the permanently installed sample manifold. The resultant penetration bypass leakage extrapolated to time 0 from the data obtained was less than 0.0016%. However, WSRC questioned the acceptability of the sample manifold to detect bypass of the adsorber bed, even though the manifold satisfactorily passed the manifold qualification test as described in Mandatory Appendix D of N509, Performance Test For Qualification Of Sampling Manifolds. Refer to the following section on Manifold Testing for the basis of WSRC's concerns.

III. Manifold Qualification Testing

Manifold Testing

Testing to demonstrate that the proposed sampling manifold (see Figure 2 & 3) is adequate for sampling during both HEPA filter and adsorber bank bypass testing was conducted at an independent laboratory. Artificial leak sites were introduced in the form of holes in the HEPA frames, tears in the filter medium, and tears in the sealing face gaskets. No attempt was made to introduce artificial leak sites in the adsorber bed or frame.

WSRC questioned the completeness of the testing to show that the manifold is capable of detecting adsorber bypass. WSRC's interpretation of N509 Appendix D, paragraph D4.2(b)(1), which states "the artificial leak paths shall be located, one at a time, to simulate leaks in the filter/adsorbent face, frame-to-wall welds (including floor and ceiling), and gasket-to-frame seals (where applicable), and at structural welds on Type III adsorbers," is that both the HEPA bank and adsorber bank should have artificial leak sites introduced and the sample manifold tested for adequacy. The vendor responsible for the testing interpreted this paragraph as an either/or statement and that testing only the HEPA bank satisfied Appendix D requirements.

WSRC issued a formal inquiry, Inquiry 93-03, to the CONAGT committee to provide the correct code interpretation. The inquiry response indicates that the requirement is an either/or statement and suggests that artificial leak sites need only be introduced at the HEPA bank to satisfy Appendix D requirements. The key assumption, as interpreted by WSRC, must be that the air stream is well

mixed prior to entering the sampler and that adequate bulk air mixing between the adsorber bed and sampler is achieved.

WSRC questioned whether this assumption is correct. It is hypothesized that adequate mixing downstream of the adsorber bed may not be achieved and that the Appendix D methodology is inadequate to demonstrate manifold acceptability. WSRC believes that the mixing experienced by the DOP may not be representative of the mixing that occurs downstream of the adsorber bed.

To prove the hypothesis, prior to receiving the response to the CONAGT inquiry, WSRC developed and initiated scoping tests to simulate point source leaks downstream of the adsorber bank to determine if preferential sampling was occurring at the sample manifold. Halide gas (R-11) was chosen as the challenge gas to be used during the test instead of DOP as required in Appendix D because DOP is not retained by the activated carbon and therefore readily diffuses through the bed. Therefore, the sample manifold cannot distinguish between the DOP flowing through an artificial leak site and the DOP that is passing directly through the bed.

R-11 was injected at 12 discrete points located on the downstream face of the adsorber bed (see Figure 4 & 5) by routing tubing from the halide generator through the housing wall and attaching to the adsorber bank face. Tubing routing was carefully chosen to prevent obstructing air flow. Downstream concentrations were measured at the sample manifold and at a single point downstream of the main exhaust fan. Testing showed the fan adequately mixed the air stream and the single point sample location produced a representative sample of the air stream.

Since two different calibrated Halide detectors were used at the two locations, correlation tests between the two detectors were conducted at the sample manifold prior to the test and at the single point location following the test. While this test is not required per N509, it was felt that this data was an essential for proving the hypothesis. Good agreement between the two detectors was demonstrated, as shown in Table 4.

Comparison between the concentrations measured at the sample manifold and the single point sample locations are shown in Table 5. These results suggest that testing of the HEPA bank only may not sufficiently demonstrate that the sample manifold is adequate for detecting adsorber bypass.

WSRC initiated a test program to retest the sample manifold at the Site to determine if a different configuration is required. Other solutions such as installation of a temporary mixing baffle upstream of the sampler to promote bulk air mixing were also considered. This baffle would be installed prior to performing bypass testing and removed during reactor operation. The baffle

would introduce a more tortuous air flow path to the manifold. However, project funding was canceled following the Department Of Energy decision to place the K-Reactor in a stand-by condition. No actual testing of a new manifold or mixing baffle was conducted.

IV. Summary

The new N^o 2 filter compartment installed at the K-Reactor at the Savannah River Site successfully met all N509 acceptance test requirements, with the possible exception of the adsorber bed in-place leak test. These test results remain suspect pending further testing to demonstrate the acceptability of the sample manifold to detect adsorber bed bypass. Scoping test results suggest that successfully passing Appendix D manifold qualification testing in itself may not ensure that an adequate manifold design is provided. However, the additional testing necessary to prove this hypothesis was canceled following the Department Of Energy's decision to place the K-Reactor in cold stand-by. No further testing is foreseen in the near term.

V. REFERENCES

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2. ASME N510-1989, Testing Of Nuclear Air Treatment Systems.
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4. Reactor Test Procedure WSRC-TR-92-138-007, Duct/Housing Leak And Structural/Frame Test (U), Rev. 0.
5. Reactor Test Procedure WSRC-TR-92-138-008, Airflow Distribution, Air-Aerosol Mixing Uniformity, HEPA And Adsorbers In-Place Tets (U), Rev. 0.
6. Reactor Work Request N^o GWG10, AACS Filter Compartment Manifold.
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Figure 1
Elevation View - New Filter Compartment

Figure 2
Sample Manifold Location

Figure 3
Sample Manifold

Figure 4
Adsorber Bed - Plan View

Figure 5
 Adsorber Bed - Elevation View
 Artificial Leak Site Locations

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