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CONSTRUCTION APPLICATIONS FOR LEAK TESTING

AT THE

SAVANNAH RIVER SITE

PRESENTED AT THE

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The Savannah River Site is a facility of the Department of Energy's Nuclear Weapons complex that is situated in South Carolina on the Georgia border. The site itself covers approximately 315 square miles and is comprised of numerous facilities involved in the production of special nuclear material. There are five reactors which were constructed in the mid-1950's. Of these, three are operable and going through safety upgrades and seismic modifications at the present time. There are two separations facilities which process the nuclear material and also numerous support facilities that are vital to our nation's defense. SRS is also the home of the recently completed Defense Waste Processing Facility (DWPF) and the soon to be completed Replacement Tritium Facility.

Leak testing at the Savannah River Site is performed on a wide variety of piping systems, pressure vessels and gloveboxes. These tests are performed for purposes of ensuring no outward leakage of hazardous materials or products, no inward leakage to systems that are required to operate under vacuum conditions and to proof test a system to ensure that it will withstand the various pressures and/or vacuums that it may be subjected to during its duration of service. These tests include Mass Spectrometer Leak Testing using the Hood and Detector Probe techniques, the Halogen Leak Detection technique, Pressure Change Measurement technique, the Bubble Leak technique, and the Thermal Conductivity method for leak detection. The intended service of the system and the sensitivities required dictate the technique to be used. This determination is usually made by the design agency or the owner of the Facility.

The Defense Waste Processing Facility is a facility that will take highly radioactive sludge and mix it in a slurry form with frit (material from which glass is made). This slurry mixture is then heated to a melting temperature (1050° - 1170° C), poured into canisters and allowed to solidify. The facility is constructed with four foot thick concrete walls which contained over 28,000 feet of embedded piping, much of which required leak tests to be performed. Also, contained within this structure were numerous. Stainless steel lined cells which required vacuum box leak testing of seam welds.

Halogen Detection Leak testing is a widely used method of Leak Detection at the Savannah River Site and in particular at DWPF. It is used to test piping subassemblies, installed systems and pressure vessels. This method of testing is used on a wide variety of pipe system commodities and operating pressures. It is used only for leak detection and not for proof testing as in the case of Mass Spectrometer testing. The proof testing of these systems is usually accomplished by hydrostatic testing.

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Leak testing at Savannah River Site, using the Halogen Detection method is limited to a positive pressure and detector probe type test. The procedure consists of pressurizing a test system with a Freon/air mixture or with 100% Freon to a test pressure of 15 PSIG. This test pressure is held for minimum of 30 minutes prior to performing any scanning. The leak detector sensitivity is verified to be within procedure and specification requirements by the use of a Calibrated Leak Standard. This sensitivity verification is performed prior to and at the completion of the test and at periodic intervals during the test. After sensitivity verification, and a 30 minute "soak" time, all potential leak sites are sniffed with the detector probe.

The sensitivities required for this technique are based on the maximum allowable leak rate. This leak rate is provided in design specifications along with the requirement to scan the test object with a sensitivity capable of detecting a leak 1/10 the amount of the maximum allowable leak rate.

There are several common problems inherent in Halogen Detection leak testing and certain precautions must be taken to ensure valid tests. One such problem is the tendency for the sensing element to "burn out" or show a marked decrease in sensitivity due to repeated exposure to halogens. Another problem is the need to control the background atmosphere to prevent a high level of halogens in the air surrounding the test piece. There is also a safety concern in that the sensing element operates at a temperature of about 1200°F and care must be taken to eliminate any flammable or explosive vapors from the test area.

The Replacement Tritium Facility at the Savannah River Site, completed in 1990 at a cost of \$144 million, processes tritium, a vital component in nuclear weapons technology. At the RTF, tritium, a radioactive isotope of hydrogen, is unloaded from old components, purified and enriched, supplemented by tritium from the SRS reactors, and loaded into new or reclaimed reservoirs. The building itself covers one acre underground. Most of the processing mechanisms of this building are contained within gloveboxes and jacketed piping systems. These systems required extensive degrees of leak testing.

Currently, Mass Spectrometer Leak testing is being used extensively in the construction of the Replacement Tritium Facility. This testing includes Piping Systems within Gloveboxes, Gloveboxes themselves and over 7800 feet of Jacketed Inter-area transfer piping that will transfer tritium from the existing facility to the Replacement Facility. There is a need for extreme degrees of leak tightness at RTF. This facility has numerous systems that operate under vacuum and extremely high pressure conditions. A leak in one of these systems could prove very costly in financial as well as environmental terms.

The Mass Spectrometer Techniques are used primarily for the testing of Tritium process piping. These piping systems, during the lifetime, will be subjected to pressures as high as 35,000 PSI and to vacuums as low as 50 microns. The testing process involves testing of both subassemblies prior to installation and completed, installed systems. The various test methods include, vacuum testing, high pressure testing and pressure change measurement (rate of rise) testing. This process involves testing of both, sub-assemblies prior to installation and completely installed systems.

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The technique for vacuum leak testing in the tracer probe or hood technique involves evacuating a system to a vacuum of 10 microns or less. Then, while this vacuum is held continuously, helium is applied to all potential leak sites. Any detected leaks are located and repaired and the system is retested.

The technique for rate of rise testing involves evacuating a system to a vacuum of 10 microns or less and then completely valving off the system from all vacuum pumps. The rise in pressure is monitored over a specified period of time to determine the rise of microns. The primary purpose for this test is to verify cleanliness and a moisture free system. If there is moisture in the system, the continual offgassing of the moisture will result in the inability to maintain the required vacuum.

The detector probe technique is combined with a proof test. Initially the system to be tested is pressurized to 60,000 PSI and with 100% helium. This pressure is then held for a specified period of time, then reduced to the operating pressure of approximately 35,000 PSIG. The potential leak sites are then probed (sniffed) with the detector probe.

The sensitivities that are obtained by these techniques vary from 1×10^{-9} cc/sec atm. for the hood technique to 1×10^{-6} cc/sec atm. for the detector probe technique.

Problems encountered in Mass Spectrometer Leak testing include the need for extreme cleanliness using this method. The first problem regarding cleanliness is that the tritium process itself cannot withstand any contamination; secondly when performing vacuum leak tests, any oil, dirt, grease, oxidation, etc. will cause substantial off-gassing making it very difficult to achieve the required vacuum. In order to alleviate any cleanliness problems, elaborate cleaning procedures have been instituted. These procedures include a high pressure water blast followed by a flushing of the system with Freon to completely remove any traces of oil or petroleum base contamination. After flushing the system, a small sample of Freon is retained for analysis. This sample is analyzed in a Infrared Spectrophotometer to determine if any oil residue is in the Freon. This process involves the focusing of Infrared light through the Freon sample and determining the amount of transmittance of the light through the sample. The less light transmittance, the higher the oil concentration in the Freon. Transmittance below a specified amount will require recleaning of the system with Freon and retesting of the sample. Only after successful cleaning and testing may Mass Spectrometer Leak tests be performed. Another problem that may be encountered is improper sequencing of required tests. If by chance, the positive pressure helium leak test is performed prior to the vacuum leak tests, significant off-gassing problems can result. This off-gassing results from helium molecules actually being impregnated on the walls and in the joints or any other possible area of the tests system. As the vacuum is drawn continually lower, these molecules continue to off-gass making it extremely difficult if not impossible to achieve the required degree of vacuum.

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The Reactor Facilities at SRS are the primary source of fuel materials for the Separations and RTF facilities. Five reactors were constructed and went operational in the 1950's. Of these reactors, three are operable, one is in a standby mode and one is shut down. Certain alarm systems and process systems at the reactor facilities cannot be exposed to such gases as argon and Freon, and due to the limited mobility of the mass spectrometers, a separate means of leak testing had to be considered. The Thermal Conductivity leak detector solved this problem.

The principle of operation of the thermal conductivity type leak detector is based on different gases having a different thermal conductivity than air. The thermal conductivity difference between helium and air is large, making helium an ideal tracer gas. This technique consists of pressurizing the test system with helium to specified test pressure. The outside of the test object is then sniffed with a hand-held probe to determine if any outward leakage is present. Any leakage is detected by passing the airflow from the probe used to sniff the test object, over a heated filament, while at the same time passing clean air from a reference supply across another heated filament. If helium is present in the supply from the test probe, it will cool the filament at a different rate than the filament being cooled by the reference supply. This cooling differential is measured by a bridge circuit and presented on a digital readout display on the hand-held probe. The sensitivities that can be consistently obtained are in the 10^{-5} to 10^{-7} cc/sec atm. range. One drawback of this technique is that the test must be conducted in very still air. The least amount of air movement can significantly reduce the sensitivity of the test.

PERSONNEL CERTIFICATIONS/QUALIFICATIONS

The Department of Energy has issued an order that the Savannah River Site must comply with the requirements of ANSI/ASME NQA-1. Basic requirement 2 of NQA-1 provides requirements for establishing a Quality Assurance program which will govern all activities affecting Quality. Supplement 2S2 of this document provides supplementary requirements for the Qualification of Nondestructive Examination Personnel. This supplement specifies that the requirements of ASNT's recommended practice SNT-TC-1A, 1980 be applied for the Certification of NDE personnel. MK-Ferguson at the Savannah River Site has developed a Written Practice that complies with the requirements of SNT-TC-1A, and all personnel performing Leak tests are qualified and certified to the requirements of the written practice.

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SUMMARY

Leak testing can be an extremely effective means of detecting and locating even the minutest of leaks if properly performed. When leak testing is performed by properly trained and qualified personnel it can be a very efficient means of ensuring reliability and serviceability of components and to prevent premature failure of systems containing fluids under pressure or vacuum. It takes extensive training and experience to properly qualify individuals to perform leak testing. SNT-TC-1A provides the guidelines for training and experience required for certification in leak testing as well as a recommended training course outline. Experience has shown that many personnel performing leak testing in the construction industry are poorly equipped in regards to training and experience to properly perform and evaluate leak tests. A properly developed and implemented program for the qualification and certification of leak testing personnel, such as that provided by SNT-TC-1A, will result in more accurate and more reliable leak testing being performed industry wide.

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