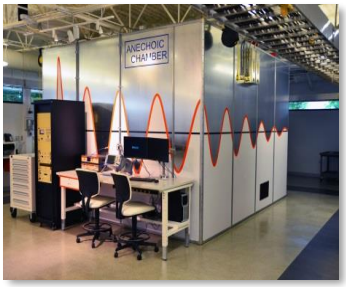
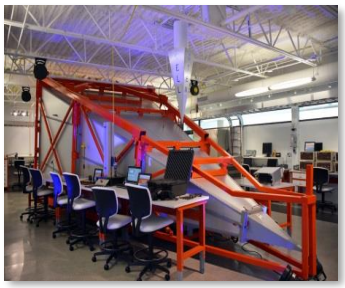
# Qualifications of AMS: Wireless and EMC


***Figure 1. AMS EMC Laboratory***




***Anechoic Chamber***



***GTEM Cell***

***New EMC Expansion (3-Meter Chamber)***

AMS has served the nuclear power industry for over 40 years in instrumentation and control (I&C) system testing, diagnostics and prognostics, electromagnetic capability (EMC) measurements, EMI/RFI troubleshooting, wireless technology deployment, cable and connector testing, predictive maintenance of equipment and processes, and automated test equipment development.

AMS has been a major supplier of EMC qualification testing, EMI/RFI troubleshooting, and cable condition monitoring for over 20 years. Our infrastructure, employees, procedures, and quality assurance (QA) program are all tailored to meet the unique needs of the nuclear power industry. In fact, AMS has just completed the construction of a third building, representing a major expansion to its main technology campus. This new $5 million testing and research and development (R&D) facility adds 15,000 square feet of new office and laboratory space to AMS' existing headquarters, including a $1 million 3-meter EMC chamber. The new chamber contains nearly 10,000 cubic feet for MIL-STD and IEC testing to meet the EMC requirements of the NRC and EPRI and is designed to accommodate equipment with weights up to 5,000 pounds. As such, AMS is familiar with and regularly employs the use of the relevant standards for nuclear EMC qualification testing such as EPRI TR-102323, "Guidelines for Electromagnetic Interference Testing of Power Plant Equipment," U.S. NRC Regulatory Guide

1.180, “Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems,” Department of Defense Interface Standard MIL-STD 461, “Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment,” IEC Standard and European Norm (EN) 61000, EMC – Part 4, “Testing and Measurement Techniques,” and others.

***Field Testing in Diablo Canyon***

AMS’ infrastructure for EMC testing in the nuclear power industry also includes a 1-meter semi-anechoic RF chamber and a Gigahertz Transverse Electromagnetic (GTEM) cell. AMS boasts one of the finest laboratories for EMC qualification and research in the United States (Figure 1) and provides a significant amount of EMC qualification testing of analog and digital I&C components for nuclear power plants. The laboratory allows for EMC testing and research from 30 Hz to 18 GHz. Our state-of-the-art EMC test facility is accredited to ISO/IEC 17025, “General requirements for the competence of testing and calibration laboratories,” by the American Association for Laboratory Accreditation (A2LA) under AMS’ A2LA certificate number 3483.01.

In addition to performing EMC qualification testing of nuclear plant equipment and wireless devices in the laboratory, AMS has also been involved in mapping the electromagnetic environment at dozens of nuclear power plants in the U.S., performing passive site surveys as well as specialized on-site immunity testing to provide objective data regarding the potential impact of wireless signals on existing plant equipment. We have also developed and deployed wireless condition monitoring systems in nuclear power plants.

For example, AMS has completed a project with the Diablo Canyon Nuclear Power Plant consisting of plant walkdowns, site surveys, laboratory testing, and on-site immunity testing of plant equipment to verify that cell phones, tablets, and other wireless devices will not pose a significant impact to the operation of existing plant equipment. AMS performed a similar project at the Nine Mile Point Nuclear Power Station as they implement cellular devices on a site-wide Distributed Antenna System (DAS). The project with Nine Mile Point has also involved the laboratory testing of a Samsung Galaxy S8+ cell phone using AT&T service and an Apple iPad Pro tablet using Verizon service to quantify its near-field and far-field emissions and establish their associated exclusion distances. In 2018, AMS also performed a comprehensive EMI/RFI evaluation and testing project at the Krško Nuclear Power Plant in Slovenia to support the widespread use of wireless technologies and to facilitate future digital upgrades at the plant.

***Testing Performed in AMS' Anechoic Chamber***

Examples of installations of AMS wireless condition monitoring equipment in nuclear facilities include the High Flux Isotope Reactor at Oak Ridge National Laboratory, Comanche Peak Nuclear Power Plant in Texas, and Arkansas Nuclear One (ANO). These implementations culminated in the installation of a wireless system in the containment building of ANO Units 1 and 2 to monitor the vibration of containment cooling fan motors and control element drive mechanisms (CEDMs). The ANO system has provided reliable and consistent data daily since October 2011.

## AMS Participation in National and International Guidance and Standards

The following listing provides examples of the different areas where AMS is involved in helping to develop national and international standards and guidance on the use of wireless technologies in the nuclear power industry.

1. In May 2009, the IEC SC 45A Technical Working Group on Nuclear Power Plant Control and Instrumentation held a meeting which resulted in the recommendation to develop a technical report addressing the applicability of incorporating wireless technology throughout nuclear power plant systems. The focus of the report was on non-safety applications with future work and investigations identified as necessary to overcome the barriers of using wireless for control and safety applications. The report was issued in July 2014 as IEC/TR 62918 ed. 1.0. The technical report was meant as a precursor to an IEC standard on the same topic. The IEC 62988 standard, "Nuclear Power Plants – Instrumentation and Control Important to Safety – Selection and Use of Wireless Devices," was published in 2018. AMS was one of the principal authors of the report and is serving as a co-chair for the standard development.

   In addition to the wireless standard, AMS is also the chair of the revision to IEC 62003, "Nuclear Power Plants – Instrumentation, Control, and Electrical Systems Important to Safety - Requirements for Electromagnetic Compatibility Testing." A major emphasis on the revision of this standard is to address the implementation of wireless devices in nuclear power plants. This standard is expected to be released in 2020.

2. In 2014, the Nuclear Power Engineering Section of the Division of Nuclear Power at the International Atomic Energy Agency (IAEA) conducted a project on, "Application of Wireless Technologies in Nuclear Power Plant Instrumentation and Control Systems." The goal of the project was to develop and demonstrate techniques for advanced wireless communication in instrumentation and control systems at nuclear power plants that can be applied for transferring process and diagnostic information as alternatives to wired technologies. AMS participated as a Chief Scientific Investigator (CSI) for the project and a technical report was published in 2019.

3. In June 2016, the IEEE Standards Association approved the development of an RF Site Survey Standard, “Recommended Practice for an Electromagnetic Site Survey (10kHz to 40GHz).” AMS is serving as the chair of the Working Group that is developing the standard through the IEEE EMC society. In conjunction with the IEEE site survey standard, AMS is also participating in the development of an “In-situ EMC Immunity Test Standard” being developed by the American National Standards Institute, ANSI C63.24.

   IEEE is also developing their own nuclear EMC standard, P2425, “Standard for Electromagnetic Compatibility Testing of Electrical and Instrumentation and Control Equipment at Nuclear Power Generating Stations and Other Nuclear Facilities”. AMS serves as a working group member on this standard which is expected to take several years to complete.

4. The EMC Working Group of the Electric Power Research Institute (EPRI) is developing guidance on the use of wireless technologies as it relates to EMI/RFI. For example, this group developed a new appendix on the use of wireless technologies for the guidance stipulated in EPRI TR-102323 Revision 4. AMS, through its CHAR Services division, has participated in the working group since the mid-1990s and was one of the principal authors of EPRI TR-102323.

5. AMS has been the major contributing author on a number of EPRI Technical Reports related to the use of wireless technologies including:

   a. *Implementation Guideline for Wireless Networks and Wireless Equipment Condition Monitoring,* EPRI, Palo Alto, CA: 2009. 1019186. This report includes guidance for the implementation of a wireless network within a nuclear power plant and also covers the use of wireless sensors for asset condition monitoring.

   b. *Wireless Sensor Survey and General Specification*, EPRI, Palo Alto, CA: 2018. 3002011818. This report presents the various wireless sensor technologies that are commercially available; an overview of EMI/RFI concerns for wireless sensor technology, including laboratory test results for numerous sensors; guidance for specifying and procuring wireless sensor technology to meet a particular equipment condition monitoring application; and the suggested responsibilities of various departments within the power plant during the implementation of wireless technology. The results of this report can be used by a utility to assist in the deployment of wireless technology within a nuclear power plant environment.

   c. *Wireless Technology Assessment*, EPRI, Palo Alto, CA: 2018. 3002012707. The purpose of this project was to perform laboratory EMI/RFI testing of modern and currently prevalent wireless devices to identify the typical distances that smartphones, tablets, and laptop devices exceed recommend EMI/RFI emissions and susceptibility limits. The results of the work were used to support the fifth revision to EPRI TR-102323 that includes license guidance for the use of portable wireless communications devices in commercial nuclear facilities. The fifth revision was published in December 2019.

6. Since 2009, AMS has been awarded over $6M in R&D projects by the U.S. Department of Energy that focus on the use of wireless technologies in the nuclear power industry. The project titles are as follows:

    - *Wireless Sensors for Equipment Health and Condition Monitoring in Nuclear Power Plants.* Major developments include deployment of wireless sensor networks for use in nuclear power plants. This included installation of a new, first-of-a-kind wireless system to monitor cooling fan vibration inside the containment of a nuclear power plant.

    - *Wireless Sensors for Predictive Maintenance of Rotating Equipment in DOE's Research Reactors.* Major developments include wireless sensor networks for process measurements in DOE's research reactors.

    - *Strategy for Implementation of Fixed and Mobile Wireless Technologies in Crowded and Confined EMI Environments of Nuclear Power Plants.* This project focuses on development of new equipment and techniques to resolve wireless EMC and coexistence issues and facilitate widespread use of wireless technology in nuclear facilities. The result of the work has allowed nuclear power plants to use on-site immunity testing to reduce or eliminate exclusion zones for wireless transmitters.

    - *Distributed Antenna System for Wireless Data Communication in Nuclear Power Plants*. The goals of this project are to build upon industry experience with the Distributed Antenna Systems for voice and data communications in nuclear power plants by identifying and addressing implementation concerns as well as identifying/developing sensors capable of using the new communication capabilities.