GHG Mitigation Technology Performance Evaluations Underway at the GHG Technology Verification Center

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Abstract:

The Greenhouse Gas (GHG) Technology Verification Center is one of 12 independent verification entities operating under the U.S. EPA-sponsored Environmental Technology Verification (ETV) program. The ETV program tries to accelerate the acceptance and use of improved technologies through the development of third-party technology performance data. The Center focuses on GHG mitigation and monitoring technologies and has completed performance verification testing on one technology and initiated testing on six others. Technologies applicable to the natural gas industry, electricity generation industry, and GHG monitoring industry have been the primary focus of the Center's initial efforts. This paper outlines the Center's verification approach and activities. Final results are presented on a fuel cell technology for which testing has been completed, and preliminary results are presented for two additional types of technologies that have completed the first phase of a two-phase verification test.

1. THE GHG VERIFICATION CENTER

The U.S. Environmental Protection Agency's (EPA's) Office of Research and Development has created a program to facilitate the deployment of innovative technologies through performance verification and information dissemination. The goal of the Environmental Technology Verification (ETV) program is to further environmental protection by substantially accelerating the acceptance and use of improved and more cost-effective technologies[1]. With the performance data developed under the program, technology buyers and permitters will be better equipped to make informed environmental technology purchase decisions.

The Greenhouse Gas (GHG) Technology Verification Center (the Center) is one of 12 independent verification entities operating under EPA's ETV program. The Center is managed by EPA's partner verification organization, Southern Research Institute, and focuses on GHG mitigation and monitoring technologies. The Center is guided by volunteer groups of Stakeholders who help identify appropriate technology areas to test. The groups also help develop widely acceptable verification protocols, and assist in disseminating and reviewing the results. The Center has three Stakeholders groups, one executive group and two technology-area-specific groups. Together, the groups include about 40 individuals from a range of different backgrounds including private industry (technology sellers and buyers), government bodies (local, national, and international), research organizations, technology finance organizations (private finance firms and the World Bank), and industry trade organizations.

2. VERIFICATION ACTIVITIES

The verification process consists of: 1) inviting vendors to submit pre-test applications; 2) conducting engineering evaluations of those applications to determine their readiness for testing; 3) locating host test sites and preparing test plans based on input from the Stakeholders, vendors, and host; 4) negotiating and signing verification testing commitment letters; 5) preparing verification protocols; 6) performing verification tests; and 7) reporting and distributing results. The Stakeholders role in developing broadly acceptable verification protocols is central to the Center's approach, and external peer review of Verification Test Plans and Verification Reports enhances the independence and relevance of each verification.

The Center has completed verification testing on one technology, and initiated testing on six others. Figure 1 illustrates where testing has been completed or is currently underway. As the figure indicates, technologies

applicable to the natural gas industry, electricity generation industry (i.e., fuel cells and microturbines), and GHG monitoring industry have comprised the primary focus of the Center's initial performance verification efforts.

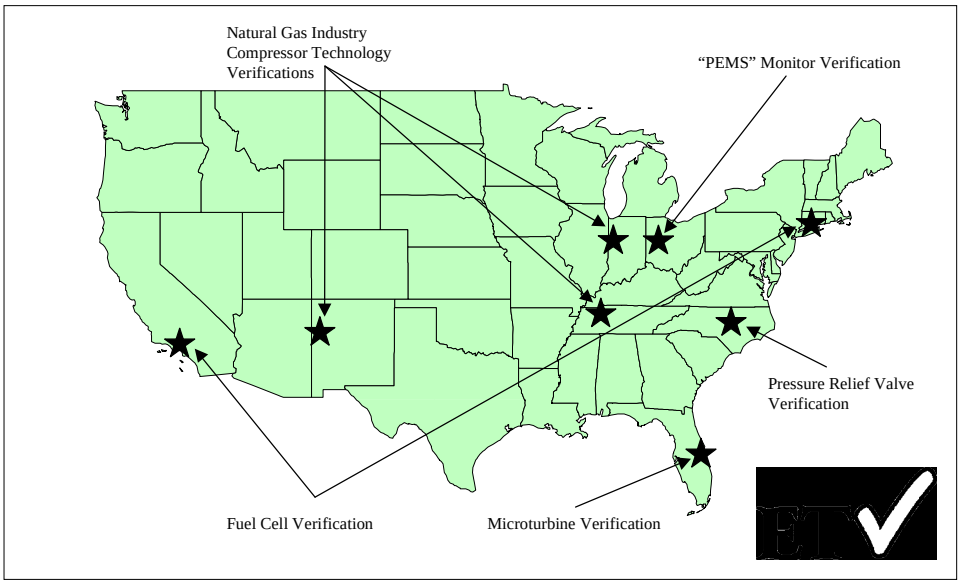

Figure 1. Tests completed or underway.

3. VERIFICATIONS COMPLETED OR UNDERWAY

Currently, one electricity generation technology (two fuel cell sites) has been completed and one gas industry technology has completed Phase I testing. Phase II testing will add long-term technical and economic performance data. Preliminary results were available for two other natural gas industry technologies. The performance evaluation strategies and results for these four technologies are summarized in the two subsections that follow.

Although not described below, performance testing of a computer-model-based emission monitoring system, referred to as a Parametric Emission Monitoring System (PEMS), has also been completed. This potentially low cost monitoring system is applicable to large gas-fired internal combustion

engines, and independent performance test results were collected which show the PEMS ability to produce representative emission rate predictions. Phase I testing of Allied Signal's 75-kW microturbine will begin in the Fall of 1999, and emissions and energy efficiency performance results will be made available in early 2000. Phase II microturbine testing will continue into 2000, after which long-term technical and economic performance results will be published. Verification testing of a new pressure relief valve for use on large organic liquid storage vessels has been completed, and the results for this performance evaluation will be available in late 1999. Additional information, including available verification test plans for all evaluations described here, can be obtained from the Center's web site www.sri-rtp.com.

3.1 Natural Gas Industry Technologies – Phase I Evaluation

Two different types of gas industry technologies have been evaluated which reduce methane emissions from leaking natural gas compressor seals (specifically, rod seals). Natural gas compressors are one of the most significant methane emission sources in the natural gas industry. With over 13,000 compressors operating in the U.S. alone, compressor rod seal leaks represent a major source of methane emissions, and a significant loss of economic and natural resources. Natural gas compressors are used to move high-pressure natural gas through the national transmission pipeline network to its final point of distribution.

The first type of technology evaluated was offered by A&A Environmental Seals of La Marque, Texas. The device, referred to as the Seal Assist System (SAS), allows compressor rod seal leaks to be captured and used to fuel internal combustion (IC) engines at the compressor station. A Phase I evaluation of SAS was conducted at an operating transmission line compressor station in eastern Arizona. The following indicators of performance were evaluated independently by the Center at this station: (1) the installation process and cost, (2) the system's leak capture efficiency (what fraction of the gas leaking from the compressor rod seals is captured by SAS), and (3) the initial methane emission reduction. In an on-going Phase II evaluation, the performance indicators above will be characterized over time, and the system's economic payback period will be estimated.

Results from the Phase I evaluation indicate that SAS leak capture efficiency ranged between 43 and 100 percent over the 3-week Phase I evaluation period[2]. The average leak capture efficiency and methane emission reduction were found to be 72 ±10 percent. This average is based on a running average of the 15-minute values reported over the 3-week sampling period (excluding engine shutdown periods). It was concluded

that, when the system operates under SAS design conditions, high leak capture efficiencies occur. It was observed that, when fuel system pressure increased on the IC engine, SAS was sometimes unable to maintain design operational pressures and, as a result, leaks to the atmosphere increased. For the host site, the SAS mechanical components required 297 hours to install. The total installation costs for a "standard" system was $11,841 and the total capital and installation cost was $42,774 (1999 U.S. $).

The second type of technology evaluated reduces emissions from compressors when they are placed in the standby mode. Two different vendors' technologies were submitted for evaluation: the Static Pac, offered by the C. Lee Cook Company of Louisville, Kentucky, and the Emissions Packing System, offered by France Compressor Products of Newtown, Pennsylvania. At the time this paper was written, the Center had completed a portion of the Phase I testing on both vendors' technologies to verify installation requirements and gas savings. The goals of the Phase I effort are to verify methane emissions and emission reductions which occur during compressor standby after initial installation has occurred, and to verify installation and shakedown requirements and costs. In an ongoing Phase II study, longer-term technical and economic performance is being verified.

Each vendor's technology is being evaluated at separate natural gas compressor stations located in the midwestern part of the U.S. The Phase I results obtained so far are preliminary and subject to change pending final data collection and quality assurance. Initial emissions testing has been performed on both systems and, based on these data, rod seal emissions during compressor standby operations were found to range from <0.071 to 0.420 liters per second (L/s) for both vendors' technologies. Rod seal emissions measured during compressor operation ranged from 0.42 to 1.04 L/s. Both systems reduced emissions during shutdown operations, although not at the same level. Conclusions about the efficacy of each will be withheld pending a review of the final data.

3.2 Electricity Generation Technology – Completed Evaluation

In 1998, the Center published the results of performance verification conducted on a phosphoric acid fuel cell system offered by ONSI Corporation of Connecticut[3]. The ability of the fuel cell system to produce electricity from raw landfill gas (LFG) was evaluated. Prior to the fuel cell, a Gas Pretreatment Unit (GPU) is used to clean raw LFG to remove contaminants that harm the fuel cell's performance. The PC25^{TM} fuel cell itself consists of a fuel processing system power section, a fuel cell stack, an

electrical conversion system (power conditioner), and a thermal management system. The PC25™ is designed to produce 200 kW of AC power.

Tests on the GPU and PC25™ were conducted at two sites. The performance of the GPU was evaluated by comparing the sulfur and halogen concentrations in the GPU outlet gas with the levels required to effectively operate the fuel cell. The GPU operating availability was determined by dividing the length of time the unit was available by the total operating time of the GPU. The emissions characteristics of the GPU flare, which is used to combust the contaminants collected by the GPU, were measured to evaluate hazardous air pollutants emitted to the atmosphere. Performance of the fuel cell was evaluated by determining the LFG-to-energy conversion efficiency, quantifying power output, and measuring fuel cell exhaust emissions.

At both host sites, the GPU provided LFG purification that was a factor of about 10 better than its design specifications required. The GPU availability was 87 percent at the first site and, after initial startup problems were resolved at the second site, availability was 70 percent. The availability for the fuel cell was over 96 percent at both test sites. The fuel cell system energy conversion efficiency, based on lower heating values for the LFG, was determined to be between 37 and 38 percent. The electricity produced at both sites was directed to the grid and sold to utility companies. The average emissions from the fuel cell exhaust were (dry gas, corrected to 15 percent oxygen): nitrogen oxides = 0.12 ppmv or 0.29 g/hr, sulfur dioxide = nondetectable (0.23 ppmv detection limit) or <0.78 g/hr, and carbon monoxide = 0.77 ppmv or 1.15 g/hr. Details of the verification have been published[3], and a Verification Statement may be downloaded from the Web site mentioned earlier.

4. REFERENCES

1. U.S. Environmental Protection Agency. Environmental Technology Verification Program: Verification Strategy, Report No. EPA/600/K-96/003 (NTIS PB97-160006), 22 pp., Office of Research and Development, Washington, DC, February 1997
2. Southern Research Institute, Performance Test Results For The A&A Environmental Seals' Seal Assist System (SAS) Phase I Technology Verification Report. July 1999 (draft final).
3. Masemore, S.; Piccot, S. Electric Power Generation Using a Phosphoric Acid Fuel Cell on a Municipal Solid Waste Landfill Gas Stream, Report No. EPA-600/R-98-105 (NTIS PB99-118333), 63 pp., U.S. Environmental Protection Agency, National Risk Management Research Laboratory, Research Triangle Park, NC, August 1998.