THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

SOUTHERN RESEARCH INSTITUTE

ETV Joint Verification Statement - Phase II

TECHNOLOGY TYPE:	**EMISSION CONTAINMENT AND UTILIZATION SYSTEM**	
APPLICATION:	**SECONDARY SEALING SYSTEM FOR RECIPROCATING COMPRESSOR ROD SEALS**	
TECHNOLOGY NAME:	**SEAL ASSIST SYSTEM**	
COMPANY:	**A&A Environmental Seals, Inc.**	
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The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by substantially accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups that consist of buyers, vendor organizations, and regulators, and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests, collecting and analyzing data, and preparing peer reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Greenhouse Gas (GHG) Technology Verification Center (the Center), one of 12 technology areas under ETV, is operated by Southern Research Institute, in cooperation with EPA's National Risk Management Research Laboratory. The Center has recently completed the Phase II evaluation of the performance of the Seal Assist System. This verification statement provides a summary of the Phase II test results for the A&A Environmental Seals, Inc. Seal Assist System (SAS).

TECHNOLOGY DESCRIPTION

The Seal Assist System (SAS) is a secondary emission containment device designed for natural gas compressor stations to prevent compressor rod packing leaks from escaping into the atmosphere. The SAS allows existing rod packing leaks to continue, but the leaking gas is contained within a secondary containment gland. The contained gas is then collected, recompressed, and routed into the compressor engine fuel line for use.

The SAS consists of four primary components: the Emission Containment Gland (ECG), the Jets, the Recycle stream, and an Eductor/Compressor system that pressurizes the collected gas. The ECG acts like a secondary seal when attached to an existing compressor packing case, and prevents rod emissions from entering the atmosphere by maintaining a slightly negative operating pressure. The ECG also includes a floating face seal, called the tertiary seal. The primary role of the tertiary seal is to prevent air from entering the fuel line.

The gas isolated in the ECG is brought into the SAS piping system by a series of jets. The jets contain a specially designed nozzle that creates a near-sonic velocity jet stream. This induces gas flow from the ECG, and transports the collected gas into the low-pressure side of the jets, where it mixes with the motive gas. A small portion of the jet discharge stream is recirculated to the ECG. The recycle system provides a continuous supply of gas at slightly positive pressure to move the captured emissions from the ECG to the jets.

The gas exiting the Jet discharge stream is pressurized and transported to the engine fuel header by an eductor/compressor. The eductor/compressor unit is designed to boost clean, dry methane from a 2- to 4-psig suction pressure to a 90-psig discharge pressure. It requires a motive gas flow (350 scfm natural gas at 550 psig) to recompress the captured gas and inject it into the engine fuel header system. The motive gas is supplied by the station's main transmission pipeline.

The SAS reduces greenhouse gas emissions by capturing compressor methane emissions and directing them back to the fuel header. Because the SAS has no effect on engine fuel consumption, the benefits are obtained with no increase in carbon dioxide emissions.

VERIFICATION DESCRIPTION

The SAS was verified at a natural gas compressor station operated by Transwestern Pipeline Company - Enron Gas Pipeline Group. The station operates three 4500 horsepower Clark gas-fired engines and moves approximately 360 x 10^6 cubic feet of natural gas per day per engine. Each engine is equipped with three integral cylinder-type compressors operating in series. Three ECG glands were installed on the three compressor rods on Engine 1. Phase I of the verification was conducted between March 10 and 31, 1999 and reported capital and installation costs and initial SAS leak tightness, gas recovery, and methane emission reduction performance. The Phase I Verification Statement was issued in September 1999. Details of the Phase I verification test results may be found in the report titled *Environmental Technology Verification Report, A&A Environmental Seals, Inc., Seal Assist System, Phase I.* This verification statement summarizes Phase II test results using data collected from the start of the project in March 1999, to the end of Phase II in March 2000. Conclusions presented in this Verification Statement are based on direct measurements, industry average compressor rod leak rates, equipment logs and cost data submitted by installation contractors, and interviews with site operators.

Details on Phase II verification test design, measurement test procedures, and quality assurance/quality control (QA/QC) procedures can be found in the following Test Report: *Test/QA Plan for A&A Environmental Seals' Seal Assist System (SAS), December 18, 1998.* Details of the Phase II verification test results may be found in the report titled *Environmental Technology Verification Report, A&A Environmental Seals, Inc., Seal Assist System, Phase II*. Both reports have been reviewed by A&A ESI personnel, Transwestern Pipeline Company personnel, selected members of the Center's Oil and Gas Industry Stakeholder Group, and the EPA QA Team. Copies of the reports may be downloaded from the Center Web site (www.sri-rtp.com) or through the link on the ETV Program Web site (www.epa.gov/etv).

The primary goal of the Phase II testing was to determine the SAS payback period. The original verification plans called for the extrapolation of medium-term continuous measurements (8 months) conducted at the host site to be used to estimate the payback period. However, due to compressor/engine problems, extrapolation of measured data wasn't feasible. Instead, SAS payback is estimated for an "average" compressor system with operating parameters based on national data sets, and SAS performance as measured during this verification. Other Phase II verification goals were to determine medium term and estimate long term SAS leak tightness, gas recovery performance, and annual emission reductions.

The engine/compressor unit selected for this and the other units at the site have normally had excellent dependability with normal run times in excess of 90 percent. Unfortunately the test unit experienced significantly greater wear and breakdowns during the test than normally encountered. Investigations since the test period have indicated that a section of pipeline feeding the suction side of the station was cleaned about the time the test started. This station, being the first station downstream of the cleaning operation, experienced higher than normal particulate levels in the gas because of this. This condition would be expected to reduce seal and rod life to levels well below normal.

VERIFICATION OF PERFORMANCE

Leak Tightness and Gas Recovery Performance:

- SAS Leak Tightness: SAS leak tightness was determined by quantifying any SAS components that were emitting gas to the atmosphere including the ECG seals, piping, valves and fittings, jet assemblies, and all other SAS components. The following conclusions were reached:
  - The SAS assembly was found to be leak tight with the exception of the ECGs.
  - The average leak rates for the ECGs installed on Rods 1, 2, and 3 were 1.18, 0.90, and 1.05 scfm natural gas, respectively.
  - Total leak rates for all ECGs ranged from 0.07 to 3.45 scfm, and were determined over a relatively wide range of rod packing emission rates: 0.43 to 6.28 scfm of natural gas.

  ECG leak rates tended to be lowest when ECG suction pressures were very low or negative (approximately –0.7 to 0.2 psig). However, this was not always the case; moderately high leak rates occurred even when SAS operated near design ECG suction pressure.

- Gas Recovery Performance: Gas recovery is defined as the volume of gas collected by the SAS and injected into the fuel header. During the Phase II verification period, the test engine operated in an unusual manner, although other engines at the site did not experience the same level of rod and packing case failures. The operating conditions encountered on the test engine significantly impacted SAS performance throughout most of the verification period. Given this, the continuous in-line data collected by the Center represent SAS performance under unrepresentative or extreme compressor operation, and modifications in the methods were required to facilitate the estimation of more representative SAS performance results. Manual measurements collected during stable engine/compressor operations were used to quantify emission reduction and gas recovery performance in lieu of the continuous measurements originally planned. Using the manual measurement data, the following conclusions were reached:
  - Emission capture performance varied widely from -34 (a net emission increase) to 95 percent.
  - Negative emission reductions were possible because, at times, the SAS leaked both rod packing emissions and motive gas introduced into the SAS from the station's pipeline.
  - The overall average emission capture is estimated to be 50 percent.

- Annual Methane Emission Reduction: Given the engine operational problems experienced throughout the verification period and the abnormally high rod packing emissions, annual methane emission reduction was determined for the SAS based on the emission and operational characteristics of a generic engine/compressor system representing the natural gas transmission industry. Annual emission reduction was also determined for the test engine, but only using reduction rates selected from the manual measurements that were conducted during representative engine/compressor operating regimes.

Based on gas industry studies, average leak rates for reciprocating compressors vary between 0.98 and 1.86 scfm of natural gas per rod, and the average engine is equipped with three compressors. Emission reductions were estimated for compressors that liberate emissions at both of these rates using the average gas recovery observed at the test site (50 percent):

- The annual methane emission reductions for the two industry average emission rates were 84 and 159 tons (76 and 145 metric tons) of carbon equivalents per year, respectively (these figures assume the engines are operated at 8,232 hours per year).
- The annual methane emission reduction at the test site was 131 tons (120 metric tons) of carbon equivalents per year based on data collected during representative engine operations.

SAS Payback Period:

- Payback Period: To determine payback, SAS capital and installation costs were verified during Phase I, and annual gas savings were determined in Phase II. The capital and installation cost for the SAS was $42,774. Using the annual gas savings rates measured during the verification, or the industry average rates, SAS payback is not achievable because the gas savings rate observed on the test engine (average of 50 percent) was not sufficient to overcome the investment cost of money.

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