Greenhouse Gas Technology Verification Center

A USEPA Sponsored Environmental Technology Verification Organization

Testing and Quality Assurance QA Plan for the France Compressor Products Emissions Packing

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☒ indicates comments are integrated into Plan

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1.0 BACKGROUND AND INTRODUCTION

The Environmental Technology Verification (ETV) program was established by the United States Environmental Protection Agency (EPA) in response to the belief that there are many viable environmental technologies which are not being used for the lack of credible third-party performance testing. With the performance data developed under the program, technology buyers and permitters in the United States and abroad will be better equipped to make informed environmental technology purchase decisions. In late 1997, EPA selected the Southern Research Institute to manage one of twelve ETV verification entities: The Greenhouse Gas Technology Verification Center (the Center). Eleven other ETV entities are currently operating throughout the United States conducting third-party verification in a wide range of environmental media and industries.

In March of 1997, the Center met with members of the Executive Stakeholder Group. In that meeting, it was decided that the oil and gas industries were good candidates for third-party verification of methane mitigation and monitoring technologies. As a consequence, in June 1998, the Center hosted a meeting in Houston, Texas with operators and vendors in the oil and natural gas industries. The objectives of the meeting were to: (1) gauge the need for verification testing in these industries, (2) identify specific technology testing priorities, (3) identify broadly acceptable verification and testing strategies, and (4) recruit industry stakeholders. Industry participants voiced support for the Center's mission, identified a need for independent third-party verification, and prioritized specific technologies and verification strategies. Since the Houston meeting, a 19 member Oil and Gas Industry Stakeholder Group was formed, vendors of GHG mitigation devices were solicited in several top-rated technology areas, and verification testing of several compressor leak mitigation and other devices has begun.

France Compressor Products (Coltec Industries, Inc.) has committed to participate in a long-term independent verification of their static sealing technology. The France Emissions Packing is designed to reduce methane leaking from compressor rod seals during periods of compressor shutdown without full depressurization. There are over 13,000 natural gas compressors operating in the United States alone, a significant number of them experiencing frequent shutdowns. When the compressor remains pressurized during these periods, rod leaks continue at rates similar to or higher than those that occur during normal operation. According to the Gas Research Institute/Environmental Protection Agency study "Methane Emissions from the Natural Gas

Industry ("GRI Study"), compressor rod seal leaks during periods of shutdown represent a major source of methane emissions, and a significant loss of economic and natural resources.

A test of the Emissions Packing will be carried out at a compressor station operated by ANR Pipeline Company (ANR) of Detroit, Michigan. This Test Plan describes the technology to be tested, and outlines the Center's plans to conduct the verification in a field setting.

Field testing of the Emissions Packing is scheduled to begin at the ANR site in July 1999, and will continue for up to 4 months. After initial installation and testing is complete, the Center will issue a Phase I Report, containing installation and initial verification measurements data (October 1999). After all testing is complete, a Phase II Report will be issued which contains longer-term technical and economic performance verification data (2 months after–completion of the field evaluation). The specific verification parameters associated with the Phase I and Phase II efforts are listed below. Determination of each parameter is discussed in Section 2.2.

Phase I Emissions Packing Evaluation:

- Document initial gas savings for primary baseline operating conditions (Case 1 and Case 2 see Section 2.2)
- Document capital, installation, and shakedown requirements and costs

Phase II Emissions Packing Evaluation:

- Document annualized gas savings for primary baseline conditions
- Document methane emission reduction
- Calculate and document Emissions Packing payback period

Phase I goals will be achieved through observation, collection and analysis of direct gas measurements, and use of site operator logs and vendor supplied cost information.

A primary goal of Phase II is determination of the Emissions Packing payback period. As a practical matter, the Center cannot conduct direct testing for the several years that would be required to determine payback. Thus, several Phase II goals will be accomplished through a combination of medium-term measurements (several months), data extrapolation, and collecting and presenting data adequate to calculate payback for various operating/shutdown scenarios.

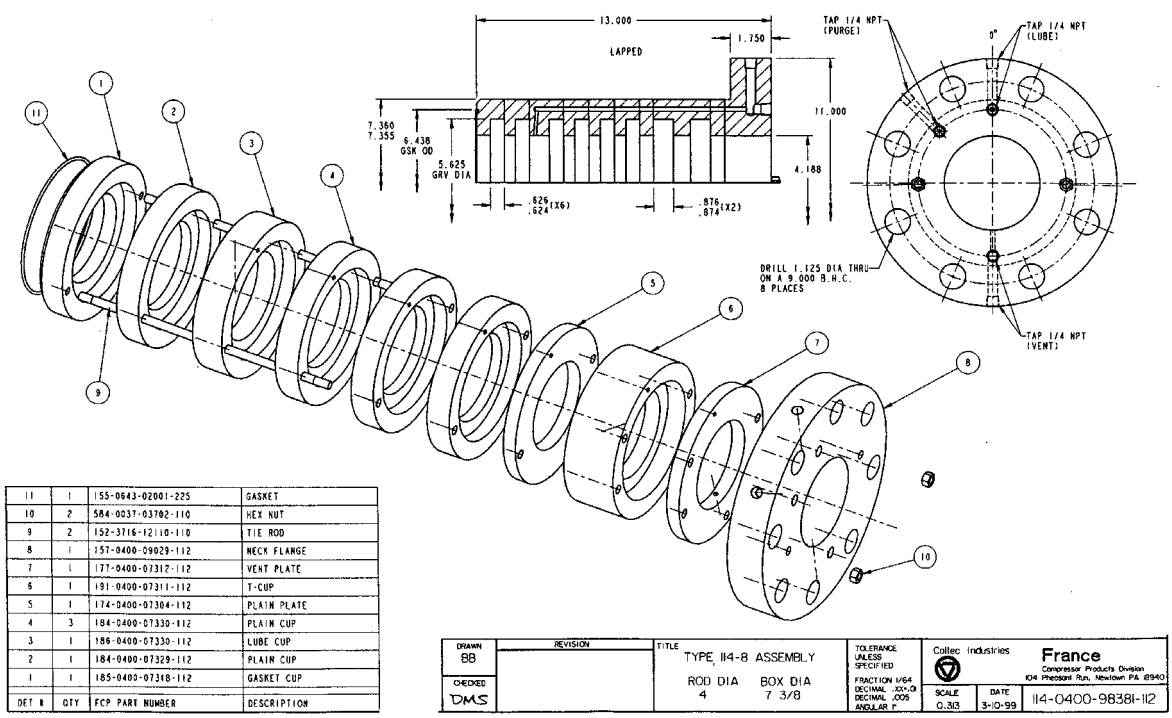
Extrapolation and other assumptions will be transparent in the final report, allowing readers to make alternate assumptions and assessments as needed.

2.0 TECHNOLOGY DESCRIPTION AND VERIFICATION APPROACH

2.1. EMISSIONS PACKING SYSTEM DESCRIPTION

The France Emissions Packing is a modification of a conventional rod packing which has the result of reducing or eliminating emissions during idle periods. It is a simple design. A spring-loaded plate is added to the final packing cups in a conventional rod packing case. This plate keeps the sealing surfaces of the conventional sealing rings in contact during idle periods – reducing or eliminating leaks.

The emissions packing for the ANR test site is a common type and contains 8 cups (see Figure 1). The first cup or groove is occupied by the breaker ring (Figure 1a) whose function is to reduce the pressure on the packing rings by providing an orifice restriction to flow. A second function is to regulate the reverse flow of gas from the packing case into the cylinder. This reverse flow occurs as the piston begins the intake stroke, and the pressure is rapidly reduced in the cylinder.



DET #	QTY	FCP PART NUMBER	DESCRIPTION
11	1	155-0643-02001-225	GASKET
10	2	584-0037-03702-110	HEX NUT
9	2	152-3716-12110-110	TIE ROD
8	1	157-0400-09029-112	NECK FLANGE
7	1	177-0400-07312-112	VENT PLATE
6	1	191-0400-07311-112	T-CUP
5	1	174-0400-07304-112	PLAIN PLATE
4	3	184-0400-07330-112	PLAIN CUP
3	1	186-0400-07330-112	LUBE CUP
2	1	184-0400-07329-112	PLAIN CUP
1	1	185-0400-07318-112	GASKET CUP

Figure 1. France Emissions Packing

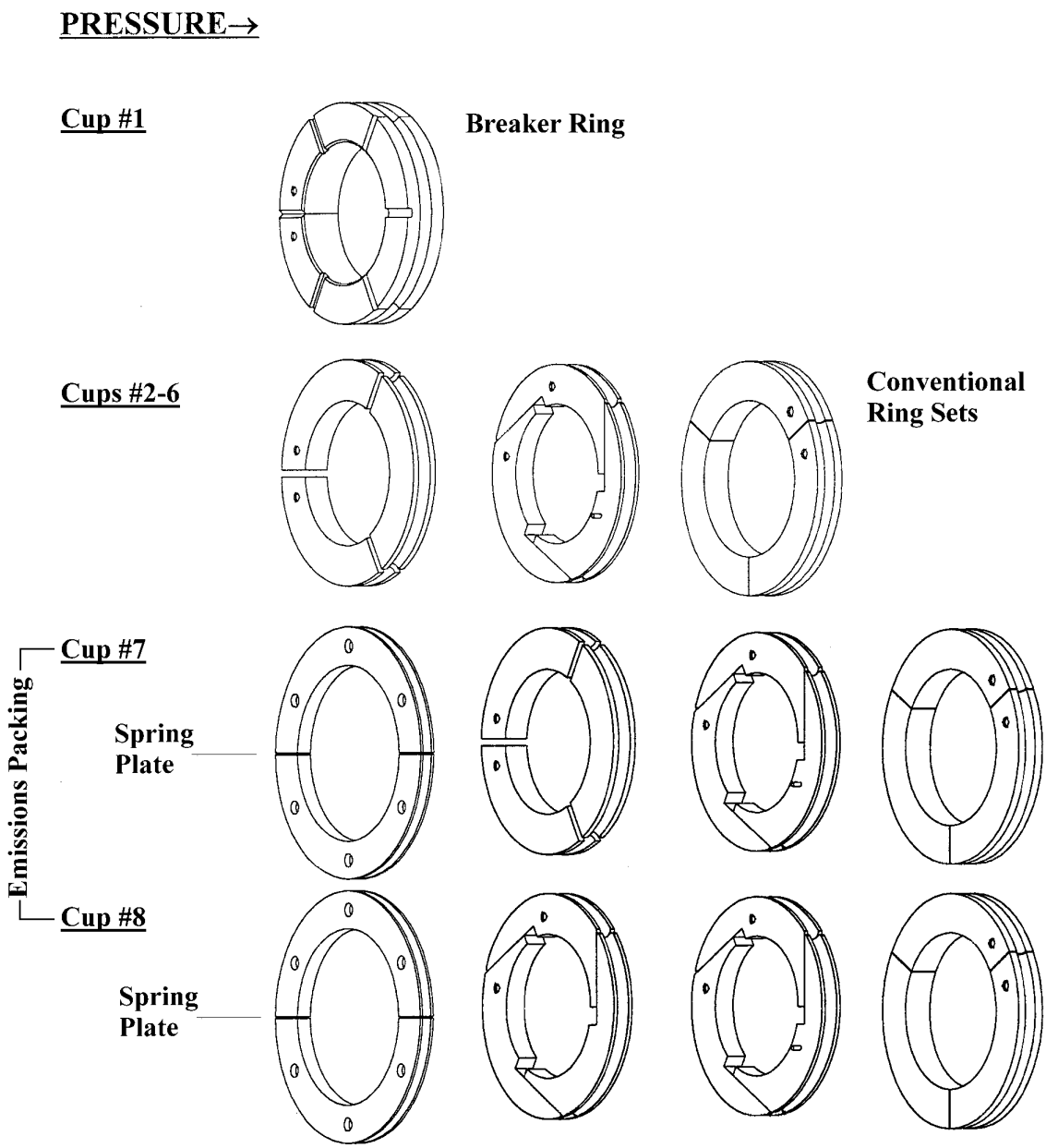


Figure 1a. France Emissions Packing – Ring Detail

Cups 2 through 6 are occupied by conventional three-ring packing sets consisting of a radial cut, a tangent cut ring, and a backup ring (see Figure 1a). A more detailed description of this and other common sealing arrangements is given in GRI's report documenting existing compressor rod packing technology and emissions (GRI 1997). During the discharge stroke, pressure is exerted on the seals which (1) forces the mating faces together and (2) constricts the tangent cut seal against the rod. During the intake stroke, the pressure is rapidly reduced in the cylinder and gas flows

from around the sealing rings back toward the cylinder. During this cycle, the rings are free to move back and forth within the cups (more or less so depending on how much differential pressure they experience and the movement of the rod). Most rings seal only on the compression faces, but some rings seal on both faces. The tangent cut ring is pressed against the rod once each cycle at the start of the compression stroke, and can move away during the intake stroke. During idle periods (with the unit remaining pressurized at station suction pressure), the pressure equalizes around the rings and they can float within the cups - potentially compromising the seal.

With the France emissions packing, a spring-loaded pressure plate is added to the ring assemblies in the final cups (7 and 8). This plate keeps pressure on the sealing faces of the rings, maintaining the seal when the unit is idle. France currently has over 30 installations where pressure plates have been added to the final cups to effect static sealing. Sealing performance is claimed to be very good. In these cases, to fit the pressure plates into a conventional packing case, the backup ring was removed. In a few instances, there has been some extrusion of the ring material due to the absence of the backup plate. For the ANR test, the packing case was modified to allow room for both the pressure plate and the backing ring. This modified system should provide static sealing and prevent extrusion. The modification was accomplished by removing the final three sealing cups and replacing them with a France "T-cup" which contains the pressure plate and the ring assembly. The Emissions Packing contains one less ring set than the packing being replaced in order to allow room for the addition of the pressure plates. France does not expect this modification to influence running or idle emissions; however, both of these will factors be quantified as part of the test.

2.2. VERIFICATION PARAMETERS AND THEIR DETERMINATION

2.2.1. Approach

The Emissions Packing is designed to provide sealing during shutdown periods. Therefore, the gas savings depend on the number and duration of shutdown periods. In addition, changes in operating procedures associated with installation of the static seal must be considered in determining net gas savings.

Normal compressor shutdown procedures vary from station to station. In general, the following procedures are used:

- Depressurize/blow-down all pressure (except a small residual pressure to prevent air in leakage) and vent the gas, either partially or completely, to the atmosphere,
- Maintain pressure, either with or without the unit isolation valves open,
- Depressurize to a lower pressure, either venting the gas to the atmosphere or to the station fuel system, or
- A combination of these procedures.

Adding an Emissions Packing to a compressor will result in varying levels of net gas savings and emission reductions depending on the current shutdown procedure. Evaluation of net emission reductions for Emissions Packing operation requires quantifying any significant leak rate changes resulting from normal Emissions Packing operation and related changes in operating procedures.

A station that currently leaves compressors pressurized during shutdown will realize net savings simply from the decrease in the rod packing leak rate due to the action of the static seal. If a station that currently blows down its compressors during shutdown were to add static seals, it is presumed that the station would change to a pressurized shutdown condition. In this case, the savings result from the eliminated blow-down and the unit valve leak (the unit valves are prevented from leaking because the unit now remains pressurized). There is also the potential for increases in emissions at components now exposed to pressure during shutdown.

Table 1 shows the relationship between operating procedures and emission changes at other leak sources in the compressor system for common shutdown scenarios.

Table 1. Common Shutdown Scenarios and Emissions Changes with Static Seals

CH_4 SOURCE	CASE #1	CASE #2	CASE #3	CASE #4	CASE #5
Current shutdown procedure	Pressurized shutdown with unit valves open	Blow-down/ 100% vent to atmosphere	Pressurized shutdown with unit valves closed	Depressurize to a lower pressure a. Vent to atmosphere b. Vent to fuel system	Depressurize/ vent to fuel system, then vent to the atmosphere
Procedure with static seal	n/c	Pressurized shutdown	n/c	Pressurized shutdown	Pressurized shutdown
Emissions Changes with Static Seal					
Rod seals	decrease	small increase?	decrease	small increase?	small increase?
Blow-down volume	n/c	decrease	n/c	a. decrease b. decrease	Decrease
Unit valves	n/c	decrease	n/c	a. decrease b. n/c	decrease
Blow-down valve (fugitive leaks)	n/c	increase	n/c	a. increase b. increase	increase
Pressure relief valve (fugitive leaks)	n/c	increase	n/c	a. increase b. increase	increase
Misc. valves, fittings, flanges, etc. (fugitive leaks)	n/c	increase	n/c	a. increase b. increase	increase

NOTES: n/c - no change/effectively no change

The evaluation of the Emissions Packing performance at ANR Pipeline Company will focus on two shutdown scenarios, (1) pressurized when idle (Case 1) and (2) de-pressurized (blow-down) when idle (Case 2). These two operating procedures represent the most common approaches to compressor shutdown. Based on data contained in the GRI methane study (GRI 1996), about 57 percent of idle transmission compressors are maintained at operating pressure and 38 percent are blown-down to atmospheric. A smaller percentage (less than 5 percent) are blown-down to a lower pressure (in some cases venting to the fuel system). The following discussion highlights the verification issues for each case and outlines measurements and data collection activities needed to implement the verification test.

Case 1: The baseline for this case is a compressor that normally maintains full operating pressure during idle periods. The addition of the Emissions Packing should reduce or eliminate leaks that occur during idle periods and cause little or no change in the leak rate while the compressor is operating.

Emissions reductions will be determined by comparing uncontrolled emissions with emissions controlled by the Emissions Packing. It is not possible to obtain a direct measurement of uncontrolled emissions since the Emissions Packing cannot be disabled. Therefore, uncontrolled emissions will be characterized based on measurements of emissions during idle periods from a second rod (the control rod) on the same engine using a new conventional packing. This arrangement will be repeated on two separate engines in order to provide a more reliable and robust data set.

Leak rate measurements on the control rods during idle and operation periods will be used as a baseline for verifying the emissions reductions during idle periods, and any change in running emissions that may occur due to the Emissions Packing.

Because the unit pressure is essentially unchanged during both operating and idle periods, all other component leak rates (pressure relief valve, blow-down valve, unit valves, and miscellaneous flanges, valves, and fittings) can be anticipated to remain constant after installation of the Emissions Packing. This will be verified by manual measurements before and after installation.

Case 2: The baseline for this condition is a compressor that normally blows down from operating pressure to a minimum pressure level during idle periods. At such times, the pressure on compressor components is reduced to near zero and any rod packing, pressure relief valve and blow-down valve leaks cease. However, any leaking gas from the unit valves isolating the compressor is lost. The gas leaks into the compressor system, and passes to the atmosphere through the open blow-down valve to the open-ended blow-down line. Based on available data, the loss from the unit valves can be substantial (see Table 2). To address this, unit valve leak rates will be measured. This gas will be considered a savings associated with the use of the Emissions Packing.

In addition, the compressed gas contained in the compressor lines is lost during the blow-down. This gas will also be considered a savings associated with the Emissions Packing. This will be calculated based on known volumes of compressor components and operating pressure.

In order to determine net gas savings, any increase in leaks from the pressure relief valve, blow-down valve, and various flanges, connectors, and valves due to leaving the unit pressurized must be measured. The sum of any increase in leaks from these components offsets the gas savings described above.

Components that require quantification of gas leak rate during the evaluation are identified in Table 2. The table also presents estimates of the leak rate for each component based on GRI studies (GRI 1996) and indicates gas savings or loss associated with each component for each test scenario.

Table 2. Leak Sources, Emissions, and Gas Savings

Emissions Sources	Notes	Gas Savings/Loss Associated with Emissions Packing (Mcf/yr)			Gas Savings/Loss
		High	Low	Avg.	
Compressor Seal	**Unit Idle, Pressurized**	2,212	84	670	Case 1 Savings
Compressor Seal	**Unit Operating**	(0)	(0)	(0)	Case 1 Loss
		2,212	**84**	**670**	**Case 1 Net Gas Savings**
Blow-down Volume	**Loss eliminated due to change in operating procedure associated with static seal**	2,750	220	825	Case 2 Savings
Unit Valves	**Loss eliminated due to change in operating procedure associated with static seal**	2,916	67	1,491	Case 2 Savings
Blow-down Valve	**Unit Idle, Pressurized**	(587)	(235)	(436)	Case 2 Loss
Pressure Relief Valve	**Unit Idle, Pressurized**	(256)	(0)	(149)	Case 2 Loss
Misc. Components	**Unit Idle, Pressurized**	(75)	(52)	(64)	Case 2 Loss
Compressor Seal	**Unit Idle, Pressurized**	(0)	(0)	(0)	Case 2 Loss
Compressor Seal	**Unit Operating**	(0)	(0)	(0)	Case 2 Loss
		4,748	**0**	**1,668**	**Case 2 Net Gas Savings**

2.2.2. Phase I Emissions Packing Evaluation

Document Initial Gas Savings for Baseline Operating Conditions (Case 1, Case 2)

Initial gas savings will be determined and reported in the Phase I Report based on three sets of manual measurements conducted at roughly equal intervals (beginning, middle, and end) over a 4 week period of operation. Table 2 (above) lists the components for which emissions measurements will be made. Net gas savings will be determined separately for Case 1 and Case 2 as discussed above.

For Case 1, the savings consist solely of the gas prevented from leaking from the rod packing during idle periods. This is the difference between the leak rate without the Emissions Packing (measured on the control rods) and the leak rate (if any) with the Emissions Packing. In addition, if it is determined that the Emissions Packing causes any increase in emissions during operation, these emissions must be subtracted from the gas savings. The following formulas (Equations 1 and 1a) state how gas savings will be calculated.

$$G1_i = [Q_u - Q_s] * t \qquad \text{(Eqn. 1)}$$

Where,
$G1_i$ = Gas savings for each idle period (Case 1), cf
Q_u = uncontrolled leak rate (control rod), scfm
Q_s = leak rate during shutdown, scfm
t = shutdown period, minutes

The total gas savings for the test period is

$$G1 = \Sigma\, G1_i - V_m \qquad \text{(Eqn. 1a)}$$

where V_m is the increase in operating emissions (if any) over the test period due to the Emissions Packing. V_m is the difference between emissions for the test and control rods.

For the Phase I evaluation, cumulative gas savings during idle periods will be calculated and reported as Case 1 gas savings. Details of the measurement methods, tests to be conducted, QA/QC and schedule are given in Section 5.

For Case 2, gas savings consists of the blow-down volume (times the number of idle periods) and the unit valve leak rate (times the duration of idle periods). In addition, there are gas losses due to leakage from the blow-down valve, pressure relief valves and miscellaneous components (see Table 2). An additional loss is any gas that escapes past the Emissions Packing (since the baseline for this case is a blown-down compressor, rod packing leakage would be zero). For Case 2, the gas savings for each idle period will be calculated as follows.

$$G2_i = BDV + Q_{uv} * t - [Q_{prv} + Q_{bdv} + Q_{misc} + Q_s] * t \quad \text{(Eqn. 2)}$$

Where,
G2 = gas savings for each idle period (Case 2), cf
BDV = blow-down volume, cf
Q_{uv} = unit valve leak rate, cfm
Q_{prv} = pressure relief valve leak rate, cfm
Q_{bdv} = blow-down valve leak rate, cfm
Q_{misc} = aggregate leak rate for miscellaneous components, cfm
Q_s = rod leak rate (cfm)
t =shutdown period, minutes

The total gas savings for the test period is

$$G2 = \Sigma\, G2_i - V_m \qquad \text{(Eqn. 1b)}$$

where V_m is (once again) the total increase in operating emissions (if any) over the test period due to the Emissions Packing.

Note that these calculations (for both Case 1 and Case 2) are for each idle period that occurs during the test period. Since results will be based on periodic manual measurements, there will likely be idle periods for which there are no direct measurements. To account for this, a trend line will be developed for emissions results spanning the direct measurement periods, and values from this trend line will be applied to corresponding idle periods to calculate gas savings. Information on start/stop times for the test engines will be obtained from the ANR site data acquisition system.

The blow-down volume for the test unit has been calculated by ANR personnel to be 200 cf at 800 psi or roughly 55,000 scf. For the other components, manual leak rate measurements will be needed. These measurements will be made during intensive measurement periods at the start,

middle and end of the Phase I evaluation. Details of the measurement methods, tests to be conducted, QA/QC and schedule are given in Section 5.

Document Capital, Installation, and Shakedown Requirements and Costs

The Emissions Packing will be installed by ANR site personnel, with supervision and guidance provided by a France engineer. Center personnel will be on-site throughout the installation and shakedown process, and will document any modifications made or difficulties encountered. The Center will also document key decisions made regarding placement of equipment or adjustments made for site-specific conditions.

France will provide written instructions as needed on start-up activities and routine monitoring and maintenance requirements. The Center will document any problems encountered or changes made to the start-up and shakedown activities, and report the final procedures in the Verification Report.

To determine the payback period, it will be necessary to document Emissions Packing capital and installation costs. The cost for a new packing case for the ANR test compressor is $1,972.77 and the packing ring set is $1,390.31, for a total cost of $3,363.80. A customer could modify their existing packing cases, if they had spares, and effectively reduce the cost of buying a new case by as much as 50 percent. Labor for installation is expected to be about 2 hours per rod (two mechanics). This is a preliminary estimate. France may add or delete items necessary to accommodate site specific conditions. ANR site personnel will provide information on labor and other costs associated with the installation, operation and maintenance of the emissions packing.

The Center will obtain the "as-built" equipment list from France after installation is complete, and will document total equipment and installation costs based on invoices and labor logs. The Center will multiply the logged hours by the hourly rates charged by all participating contractors and ANR staff to calculate total installation cost. The sum of the capital equipment costs and installation costs will represent the net Emissions Packing initial cost. This cost will not include the capital or installation costs associated with the flow monitors and other devices required for the verification test.

2.2.3. Phase II Emissions Packing Evaluation

The Phase II evaluation represents an extended period of performance testing and includes trends analysis to project emissions beyond the period of the field test. Calculation of the payback period based on these measurements and analysis is another key element of Phase II. Phase II will represent up to 4 months operation with the emissions packing and include a total of 5 intensive periods of manual measurements. A discussion of verification issues and actions for each Phase II verification parameter are given in the following sections.

<u>Document Annualized Gas Savings for Primary Baseline Operating Conditions</u>

Case 1 and Case 2 gas savings for each idle period during the entire field test will be computed in the same manner as for the Phase I testing (see Equations 1 and 2). Since the test may not span the entire payback period, it will be necessary to project gas savings over this longer period. The most direct method would be to simply compute an average gas savings over the study period (for Case 1 and Case 2) and multiply by the number of expected idle hours during a year. However, this approach could yield an overly conservative estimate of annual gas savings - especially for Case 1 (see the "Average Gas Savings" in Figure 2).

It is expected that rod packing emissions (and possibly the leak rates for other components) will increase over time. Since Case 1 gas savings are due entirely to eliminating rod packing leaks during idle periods, neglecting an increasing leak trend would lead to an underestimate of gas savings over an extended period of time. It is also possible that leak rates for components contributing to Case 2 gas savings and losses could change over time. Thus, it is necessary to consider any trend in emissions from all the components of interest that is revealed by the test data.

To determine annual gas savings, an increasing trend in gas savings in the test data will be projected in two straightforward ways: a conservative case, and a likely case. The conservative case assumes that the gas savings rate after the test will not be lower than the gas savings rate at the end of the test (unless a component is repaired or replaced). The likely case attempts, based on available data, to project future increases in emissions, and take this into account in calculating gas savings (see Figure 2).

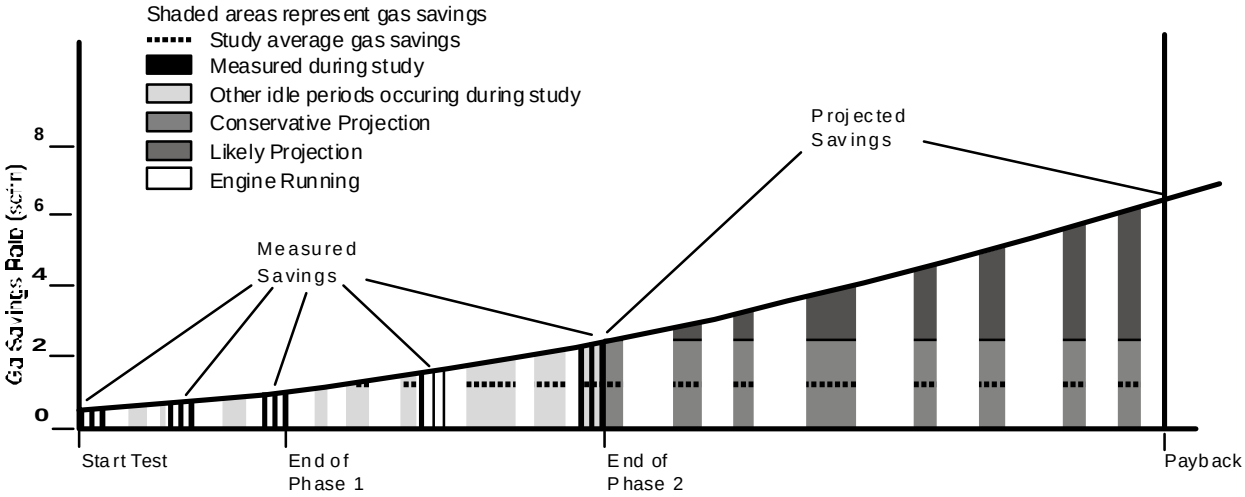


Figure 2. Methods of Projecting Gas Savings

Document Methane Emission Reduction

The net methane emission reduction is simply the cumulative gas savings calculated as described in the previous sections. The measured leak rates for the major components will be reported to allow users to assess the trends observed, use alternate assumptions and data interpretations, and apply results of this evaluation to differing operating conditions as needed.

Calculate and Document Emissions Packing Payback Period

Payback occurs when the capital and operating costs (including cost of money) of the Emissions Packing are balanced by the value of the gas saved. The operating and maintenance costs for the Emissions Packing system are expected to be minimal, but will be documented and included in payback calculations.

Complete O&M logs on both the Emissions Packing and the compressor will be maintained. This will include selected monitored parameters for the engine/compressor system, and manual logs of key O&M activities. Table 3 lists the operational and maintenance parameters that will be collected.

Table 3. Operational and Maintenance Data to be Collected During Testing

Description	Source of Data
Compressor, and Engine Operating Parameters Logged:	
Engine rpm	Operating Station Data
Time	
Rod temperature (both rods)	
Unit discharge pressure	
Unit discharge temperature	
Unit suction pressure	
Maintenance Requirements Logged:	
Labor required to start/stop the system, conduct routine leak checking on the entire Emissions Packing assembly, repair leaks, respond to malfunctions, and perform Emissions Packing adjustments	Operator logs
Equipment replacement or repair costs for failed units	
Labor required to replace or repair failed units	
Compressor/Engine downtime costs caused by failures in the Emissions Packing apparatus	

In the event that any of the Emissions Packing components fail and need repair or replacement, ANR site personnel will log the purchase cost of each component, and the time and materials expended in installing and checking the new components. Although unlikely, if failure in the Emissions Packing system causes malfunctioning of the compressor or the engine, ANR site operators will be consulted to help quantify the costs associated with the failure.

The procedure for calculating payback is outlined below.

1. Total cost will be determined by adding the Emissions Packing capital costs, installation costs, and O&M costs determined as outlined above. Capital costs will be amortized over the payback period assuming a discount rate of return of 10 percent. Payback is achieved when the total amortized cost = the value of the gas saved.

$$\textbf{Total Cost} = (\textbf{Gas Savings}) * (\textbf{GP}) \qquad \text{(Eqn. 3)}$$

Where: Total Costs = sum of capital, installation, O&M costs and cost of money
Total Gas Saved = net volume of methane (SCF) required to achieve payback
GP = gas price ($2/MCF)

2. Total gas savings over the payback period will necessarily include measured and projected values. Savings will be projected in the same manner as described for determining annual gas savings. For each case,

$$\textbf{Total Gas Saved} = \textbf{Gas Saved}_{\textbf{Test}} + \textbf{Gas Saved}_{\textbf{Est}} \qquad \text{(Eqn 4)}$$

Where: Gas Saved_{Test} = total measured net volume of gas saved during the test period.
Gas Saved_{Est} = total estimated net volume of gas to be saved after the test period.

The payback projections will include a conservative and a likely case. These will be calculated just as described for projecting annual emissions reductions - except over the payback period.

2.2.4. Generalization of Results

The results of this test will be specific to the host site. In an effort to generalize the results to a broader segment of the industry, the data collected during this verification will be used to estimate the payback period for sites with emissions rates that differ from those encountered at the host site. This will also provide a framework that others can use to determine Emissions Packing performance for their site conditions.

To accomplish this, the Center will compile data from several studies of compressor emission measurements including the GRI/EPA study discussed earlier (GRI, 1997), ongoing compressor emissions characterizations being conducted by the Center, and more recent studies conducted by Radian corporation and others. These data will be used to determine a range of emissions characteristics for compressor rods, both running and idle, and other components examined in the study. These data, along with the sealing performance measured at the host site (i.e., percent reduction), will be used to determine payback estimates for 2 to 3 cases which span the range of emissions observed in the industry.

2.3. SITE SELECTION, DESCRIPTION, AND EMISSIONS PACKING INSTALLATION

2.3.1. Site Selection and Description

The natural gas transmission engine/compressor selected to host this evaluation is operated by ANR Pipeline Company. This station operates six Cooper-Bessemer engines (8 cylinder, 2000 Hp), each equipped with two reciprocating compressors operating in series (4,275 cubic inch displacement, 4-inch rods). Geographic location was not seen as a significant factor in the evaluation, but extremes of environment, very hot or very cold, were avoided.

The low speed engines at the test site are typical of many used in the industry, but may not be typical of newer high-speed engines in use. The rods and packing cases have the same basic design and functionality as most reciprocating compressors used now and planned for use in the future within the transmission sector. Reciprocating compressors are the dominant types in use, although newer compressor designs, such as screw-type, are beginning to be placed into service. The rod packing system used at this station is typical of those being built or retrofitted within the industry. The rod packing is essentially a dry seal system, using only a few ounces of lubricant per day. Traditionally, wet seals, which use high-pressure oil to form a barrier against escaping gas, have been employed. According to the natural Gas STAR partners, dry seal systems have come into favor recently because of lower power requirements, improved compressor and pipeline operating efficiency and performance, enhanced compressor reliability, and reduced maintenance. The STAR industry partners report that about 50 percent of new seal replacements consist of dry seals.

In order to provide necessary experimental controls (see Section 2.2), the Emissions Packing will be installed on one compressor on each of two engines. The packing on the second rod on each engine will be replaced with a new packing at the same time that the Emissions Packing is installed. The two engines are the same age and have similar operating hours (this is part of ANR's operating practice). Actual operating hours on each engine will be logged at installation. ANR's operation and maintenance practices are the same for each of the units.

2.3.2. Emissions Packing Installation and Operation

The host site presents a typical installation for the Emissions Packing system and no application specific engineering is required. The Emissions Packing system is designed to accommodate the

conditions (rod size, pressure, existing sealing system) at the test site. The Emissions Packing will be installed in a modified packing case with new seals. A representative of France has confirmed all necessary requirements. Once the Emissions Packing is installed, it should operate without further attention. During the test, continuous monitors should indicate any change in capture efficiency.

2.4. FIELD TEST OVERVIEW

The field testing will consist of periodic intensive periods of manual measurements which will be correlated with idle periods that occur during the test period. Measurements of the rod leak rate on the test and control rods will be used to quantify the gas savings from the rod packing leaks due to the action of the Emissions Packing. These measurements allow quantification of the Case 1 gas savings (for a compressor that remains pressurized while shut down). Additional manual measurements are necessary to quantify leak rates for the unit valves, blow-down valve, pressure relief valve and miscellaneous components that make up additional data needed to quantify Case 2 gas savings (for a compressor that would normally blow-down prior to installing the Emissions Packing).

2.4.1. Rod Packing Leak Rate Measurements

At the test compressor, emissions from the packing case vent and fugitive emissions from around the rod are both vented into the distance piece or doghouse and then vented to atmosphere through the doghouse vent. The doghouse vent and oil drain are the only paths by which the leaking gas can leave the doghouse. For the test, the doghouse drain will be sealed using a liquid trap so that all emissions will be forced out the doghouse vent.

To measure these emissions, flow meters will be installed on the doghouse vent lines for each of the compressors to be tested. The meters must present a minimal restriction to flow in order not to influence the leak rate. They must also have a wide range, and be resistant to oil vapor present in the emissions. The meters selected for the test are a type of rate meter (similar to a rotameter) designed for measuring methane emissions from sludge digesters, landfills, and other low pressure applications. They have wide range (25:1 turndown), a very low pressure drop (2 inches water) and should not be affected by oil mist present in the emissions. The meters are factory calibrated

and scaled to provide a direct reading in cfm methane. The Center will check the calibration of the meters against a certified laminar flow element standard before and after each intensive measurement period. The meter reading will require correction to standard conditions (scfm). This will be based on ambient pressure and gas temperature readings obtained concurrent with the measurements. During installation and during periodic intensive measurement periods, the methane concentration of the gas leaking from the doghouse will be measured with a portable hydrocarbon analyzer.

2.4.2. Component Leak Rate Measurements

Manual measurements will be made of leak rates for the unit valves, blow-down valve, pressure relief valve and miscellaneous components.

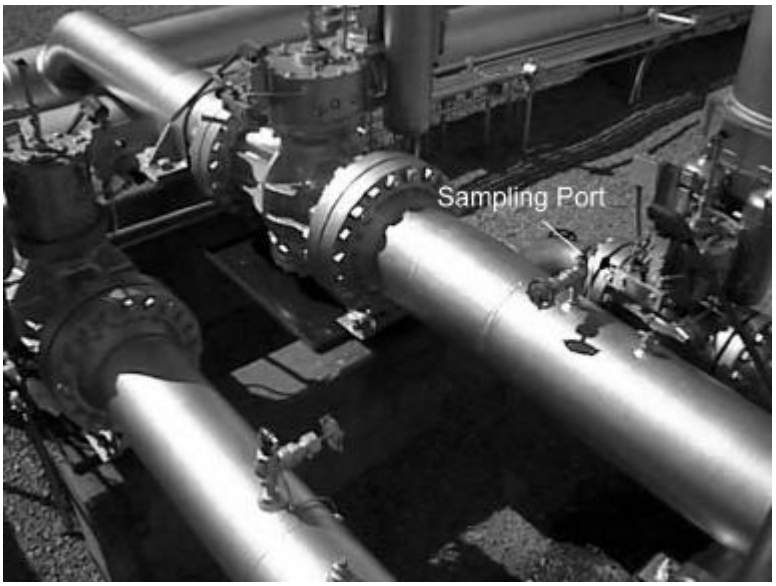


Figure 3. Unit Valve Sampling Port

The leak rate for the unit valves will be measured at an existing port located immediately downstream of the unit valve in the suction line to the compressor (see Figure 3). With the compressor shutdown and blown-down, any unit valve leak will exit through the opened port. The

leak rate will be measured using a standard pitot mounted in a flow tube (see Section 5 for details of operation and calibration).

The leak rates for the blow-down valve and pressure relief valve will be made with the unit shut down and pressurized. The leak rate for the blow-down valve will be measured at the flange located at the exit of the valve (see Figure 4). To make this measurement, it will be necessary to unbolt the flange. The flange will then be separated about 1 inch, and a disk will be inserted and clamped into place. The disk will capture the leak and direct it outward. The disk will be made of high-density polyethylene about 1 inch thick and machined to fit the flange. A borehole will be provided radially into the disk that will allow any leaking gas to escape for measurement using the flow tube.

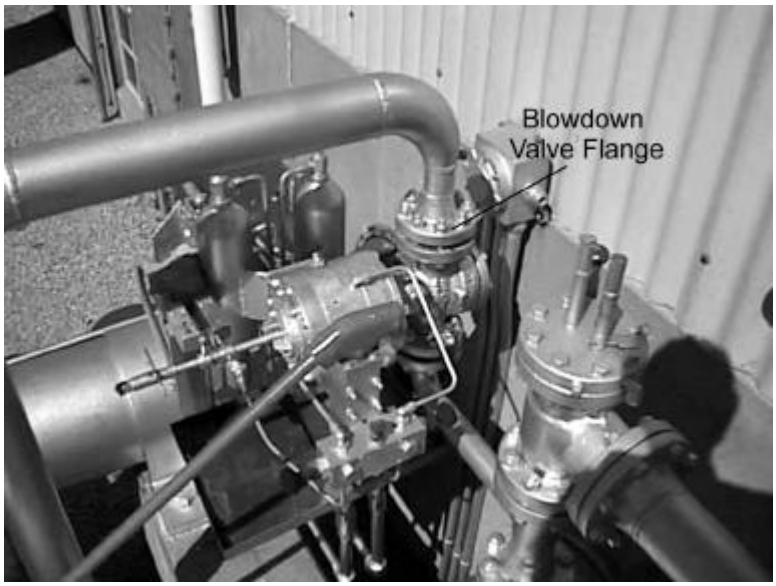


Figure 4. Blow-down Valve Sampling Location

The pressure relief valve normally vents through a 4 inch standpipe extending to the roof of the compressor building. The simplest way to measure the leak rate is to cap the standpipe, allowing a port to channel emissions for measurement using a flow tube.

The miscellaneous components at the test site consist of metering ports and valves used to recover gas to the fuel system during shutdowns (the host station normally vents to the fuel system during shutdowns). Significant leaks are not expected at these locations; however, all components will be soap screened and any leaks identified will be quantified using the EPA protocol tent/bag method.

The manual leak rate measurements will require scheduled shutdowns that proceed as follows:

- Unit shutdown - remains pressurized, leak rates for the pressure relief valve, blow-down valve and miscellaneous components will be measured (several hours)
- Measure rod packing leak rates on test and control rods
- Unit blown-down, unit valve leak rate measured (about one hour)
- Unit brought back on line

Nearly one full day will be needed to conduct this suite of measurements.

The station has agreed to a limited number of scheduled shutdowns for the purpose of conducting the measurements described above. These will only be used to characterize the quantities as discussed above, and will not contribute to the gas savings – which will be based on idle periods during normal operation. It is proposed to conduct 3 such scheduled shutdowns during the first week of the test, after installation of the Emissions Packing and after the packing has had time to stabilize (approximately 48 hours). In order to address changes over time, this series of measurements will be repeated on four other occasions at approximately 2 weeks, 1 month, 2 months, and 4 months after installation. Thus, the manual measurements will be repeated a total of 9 times in Phase I, and a total of 15 times for Phase I and Phase II combined in order to capture the magnitude and variability of the various quantities involved.

2.5. SCHEDULE OF ACTIVITIES

A site survey visit has been completed and preliminary emissions measurements have been obtained. Field testing is scheduled to begin in June of 1999. Allowing time for data analysis to be completed, a draft Phase I Report should be available for review in late August, 1999. All field activity should be completed by October of 1999. A draft Phase II Report should be available no later than December 31, 1999. A final Phase I Report should be available for distribution in November, 1999 and a final Phase II Report should be available for distribution in February, 2000.

3.0 DATA QUALITY OBJECTIVES

Data quality objectives state the values of key data quality indicators for each measured quantity. These objectives must be achieved in order to draw conclusions from the measurements with the desired level of confidence. The process of establishing data quality objectives for measurements starts with determining the desired level of confidence in the primary verification parameters (e.g., confidence level in the verified payback period).

The next step is to identify all measured values impacting the primary verification parameters, and determine the error allowed. Formal error propagation techniques can help to systematize these determinations. With error propagation, the cumulative effect of all measured variables on the primary data quality objective can be estimated. This allows individual measurement methods to be chosen which perform well enough to satisfy the data quality objective for the primary verification parameter.

A primary quantitative objective for this study is to establish the payback period associated with installation and use of the France emissions packing. Based on meetings with the Stakeholders, a payback period of three years would represent acceptable performance. An error in this value of about $\pm$ 3 to 4 months, or about 10 percent, is used as a basis in determining the data quality requirements.

Payback occurs when the total cost of the Emissions Packing (amortized capital and installation costs, and operation and maintenance costs) equals the savings that the system provides (net gas loss prevented). For the field test, the costs will be based on actual costs and the errors are zero. Gas loss reduction will be measured directly during the study, then projected for the periods immediately before and after the test is done. Specific data quality objectives address the error in

the direct measurements only; however, a discussion of the errors in the projections is also provided below.

3.1. ROD LEAK MEASUREMENTS

For a three year payback to occur for Case 1, the gas savings rate would have to average about 3.8 cfm - or 1.9 cfm per rod (assuming $4,000 total cost for two rods, gas value of $2/MCF, and 33 percent downtime). This implies a minimum gas savings rate of interest of about 0.2 cfm per rod (~10 percent of 1.9 cfm). However, based on survey measurements, the running leak rates could be as low as 0.1 scfm or less. In order to adequately quantify these baseline emissions, more sensitive meters are required. To span the full range of interest (up to at least 2 scfm per rod), dual sets of meters (high range and low range) will be required.

The low range meters span 0.75 to 22.5 scfh (0.01 to 0.375 scfm) methane. The high range meters span 7.5 to 187.5 scfh (0.125 to 3.125 scfm) methane. The maximum error in both meters is $\pm$ 2 percent. As discussed above (see Equation 1), the gas savings for each idle period will be taken as the difference between the leak rate on the test and control rods. By error propagation, the total error in the difference is the sum of the absolute error in each measurement (in measured units). Thus, the total error in low range differences is 0.9 scfh (0.015 scfm) methane. The total error in high range differences is 7.5 scfh (0.12 scfm) methane. For comparisons between high range and low range measurements, the total error is 4.05 scfh (0.07 scfm) methane.

These errors are all below the minimum leak rate of interest and meet the 10 percent data quality objective for a three year payback. The low range measurements provide additional capability to meter very small emissions.

3.2. COMPONENT LEAK RATE MEASUREMENTS

Measurements of the leak rate for the blow-down valve, pressure relief valve and unit valves will be made using a calibrated flow tube. For the miscellaneous components, it may not be possible to effectively channel the leaking gas to the flow tube. In such cases, EPA’s protocol tent/bag method will be used to quantify the leak rate.

The flow tube consists of a 0.125 inch standard pitot (Dwyer model 166-12) mounted in the center of a 1 inch diameter straight run of pipe. The differential pressure across the pitot is proportional to velocity and is metered by a precision digital manometer. The minimum flow velocity that can be measured is 25 fpm. This corresponds to a flow of about 0.15 cfm in the 1 inch pipe. The entire apparatus will be calibrated specific to methane against a certified laminar flow element transfer standard (traceable to NIST). The calibration curve thus generated will be used to obtain flow values from the raw pressure differential readings. The precision and accuracy of the flow tube will be based on the calibrations. Estimated accuracy (based on nominal values) is $\pm$ 2 percent of reading.

EPA's tent/bag method is nominally accurate to within $\pm$ 20 percent (EPA 1993), but has been shown to be capable of better than $\pm$ 10 percent when carefully applied (SRI 1996). Thus, the methods should be capable of producing data at or near the desired level of confidence.

As a practical matter, the real limitation on the accuracy and the representativeness of the manual measurements is their relative infrequency. To counteract this, the manual measurements will be repeated in triplicate during each of the three intensive measurement periods planned for the overall test (Phase I and Phase II).

The other quantity to be considered for Case 2 is the blow-down volume. This will be quantified based on the volume of piping and manifolds in the compressor system and will be accurate within the piping specifications and pressure sensor accuracy. Unit pressure (measured at the station) will be used to convert the volume to scfm.

3.3. PROJECTIONS

As discussed above (Section 2.2), projections beyond the test period will include a conservative case and a likely case. In both cases, estimates for the number and duration of idle periods will be based on the previous year's operation for the test unit. In the conservative case, emissions projections are straight lined from the end of the test period and the uncertainties are small - no more than uncertainty in the final set of measurements used for the projected value. In the likely case, projections will be based on the trends in the measured data. In this case, the uncertainty may be estimated based on the fit of the projected curve to the measured data.

4.0 DATA QUALITY INDICATORS

This section specifies data quality indicators that will be used as measures of data quality for the test data and states how values for each indicator will be determined through calibrations, QC checks, and other appropriate measures. This is presented in Table 6.

Table 6. Data Quality Indicators

Measurement	Method	Range	Completeness/ Frequency	Precision/ Accuracy	How Verified/ Determined
Doghouse Vent Emissions (Rod leaks)	Variable area rate meters (MEM Rangemaster)	0.01 to 0.375 scfm (low range) 0.125 to 3.125 scfm (high range)	15 total measurements (5 sets of 3)	2 % FS	Calibration check against NIST traceable LFE
Unit Valve Leak Rate	Flow Tube	0.1 to 4 scfm methane	15 total measurements (5 sets of 3)	5 %	Calibration against NIST traceable LFE
Blow-down valve leak rate	Flow Tube	0.1 to 4 scfm methane	15 total measurements (5 sets of 3)	5 %	Calibration against NIST traceable LFE
Pressure relief valve leak rate	Flow Tube	0.1 to 4 scfm methane	15 total measurements (5 sets of 3)	5 %	Calibration against NIST traceable LFE
Misc. components leak rate	EPA Tent/Bag	0.1 to 4 scfm methane	15 total measurements (5 sets of 3)	10 to 20 %	Repeat measurements

5.0 SAMPLING/ANALYTICAL AND QA/QC PROCEDURES

5.1. ROD LEAK MEASUREMENTS

Emissions Packing leak prevention is determined using a flow meter on each doghouse vent to measure any leaks. The meters selected for the test are a type of rate meter (similar to a rotameter) designed for measuring methane emissions from sludge digesters, landfills, and other low-pressure applications. Since they are rate meters, they will require external temperature and pressure correction to obtain flow readings at standard conditions. Since the meters will be vented to atmosphere, local barometric pressure data will be used to correct for pressure. The temperature of the sampled gas will be checked during each measurement and used to correct for temperature.

The flow meters will be factory calibrated against a primary volume standard (spirometer). Calibration certificates will be supplied. The meters are rugged and reliable and should not require re-calibration over the duration of the study In addition. The calibrations will be checked before each intensive measurement period.

5.2. COMPONENT LEAK RATE MEASUREMENTS

A general description of the manual measurements of the leak rates for the unit valves, blow-down valve, pressure relief valve, and miscellaneous components is given in Section 2.4. The manual leak rate measurements will require scheduled shutdowns that proceed as follows:

- Unit shutdown - remains pressurized. Leak rates for the pressure relief valve, blow-down valve and miscellaneous components will be measured (several hours). The gas recovery system will be disabled for the testing.
- Measure rod packing leak rates on test and control rods (one hour)
- Unit blown-down, unit valve leak rate measured (about one hour)
- Unit brought back on line

Nearly one full day will be needed to complete this suite of measurements. The station has agreed to a limited number of scheduled shutdowns. It is proposed to conduct three such scheduled shutdowns during the first week of the test, after installation of the Emissions Packing and after the new packings have had time to stabilize (approximately 48 hours). In order to address changes over time, this series of measurements will be repeated on two other occasions in Phase I (at 2 weeks and 4 weeks), and 2 additional occasions during Phase II (at 2 months and 3 months). The manual measurements will be repeated a total of 15 times in order to capture the magnitude and variability of the various quantities involved.

Detailed procedures for each type of measurement follow.

5.2.1. Blow-down Valve, and Pressure Relief Valve

The leak rates for the blow-down valve and pressure relief valve will be made with the unit shut down and pressurized. The leak rate for the blow-down valve will be measured at the flange

located at the exit of the valve (see Figure 3). To make this measurement it will be necessary to unbolt the flange. The flange will then be separated about 1 inch and a disk will be inserted and clamped into place. The disk will capture the leak and direct it outward radially. The disk will be made of high-density polyethylene about 1 inch thick and machined to fit the flange. A borehole will be provided radially into the disk that will allow any leaking gas to escape for measurement using the Flow Tube. The procedure is as follows:

- Shutdown the unit, leaving pressurized. Vent gas recovery system should be disabled.
- Record suction and discharge line pressures (obtain from station operator).
- Unbolt the flange and jack up the blow-down vent pipe approximately 1-2 inches.
- Insert the leak capture disk and clamp into place.
- Complete measurement of leak rate.
- Log all results in the field data log.

The pressure relief valve normally vents through a standpipe extending to the roof of the compressor building. The simplest way to measure the leak rate is to cap the standpipe, allowing a port to channel emissions for measurement using the Flow Tube. The procedure is as follows:

- The unit should still be shut down and pressurized.
- Record suction and discharge line pressures (obtain from station operator).
- Ascend to the roof of the compressor building - observing station safety rules (tie offs).
- Cap vent pipe with ported sampling cap.
- Complete measurement of leak rate.
- Log all results in the field data log.

Quality control for the blow-down and pressure relief valve measurements consists of calibrating the flow tube prior to each series of measurements. The flow tube calibration is a direct comparison against a NIST traceable laminar flow element, specific to methane, conducted at no fewer than 5 points spanning the flow range of interest (0.15 scfm to 5 scfm methane). Documentation of all calibrations will be maintained on file.

5.2.2. Miscellaneous Components

The miscellaneous components at the test site consist of metering ports, the bypass valve and the vent gas recovery system used to recover gas to the fuel system during shutdowns (the host station normally vents to the fuel system during shutdowns). These tests will be conducted with the unit shut down and fully pressurized. Significant leaks are not expected at these locations; however, all components will be soap screened and any leaks identified will be quantified using the EPA protocol tent/bag method (EPA 1993). Sampling/analytical and QA/QC procedures for this method are published elsewhere (EPA 1993). The basic principle is to measure the methane concentration in a known volume of clean air and compute the leak rate as the product of the methane concentration and the sampling rate.

A Bascom-Turner CGI-201 methane analyzer will be used to determine methane concentration. The CGI-201 is very stable and need only be calibrated prior to each set of intensive measurements. Calibration will be done in the Center's Research Triangle Park, NC laboratory facility using certified methane standards at 2.5, 25, 50, and 100 percent methane. Field checks consist of an automated zero cycle conducted prior to each set of measurements.

5.2.3. Unit Valves

After the leak rates for the blow-down valve, pressure relief valve, and miscellaneous components have been measured, the unit will be blown-down to measure the combined leak rate from both unit valves. Whenever the unit is shut down, the suction and discharge lines are connected via a bypass valve and line. The combined leak rate for the unit valves will be measured at an existing port located immediately downstream of the suction side unit valve. With the compressor blown-down, the combined leak from both unit valves will exit through the sampling port. The leak rate will be measured with the flow tube. The procedure is as follows.

- Blow-down the unit (station operator).
- Open the sampling port.
- Complete measurements of the leak rate.
- Log all results in the field data log.

Quality control for the unit valve measurements is the same as for the other manual measurements using the flow tube for quantification.

5.3. DATA ACQUISITION

Direct field measurements will be conducted manually and results will be logged on field data forms (see Table 7).

In addition to the direct measurements, data on engine and compressor operation that relate to the test are stored in the station computer and will be retrieved and transmitted to the Center periodically. Table 8 lists all parameters that will be collected and stored and their purpose.

Table 7. Field Data Form

Field Data Form - France Emissions Packing Measurements

Rod Packing Leaks - MEM Rangemaster	Engine 1		Engine 2	
	Test Rod	Control Rod	Test Rod	Control Rod
Range Low/High				
Gas Temp (C)				
Bar. Pressure (mmHg)				
Leak Rate (cfm)				
Leak Rate (scfm)				
	Measure with Unit Pressurized - Running			

Rod Packing Leaks - MEM Rangemaster	Engine 1		Engine 2	
	Test Rod	Control Rod	Test Rod	Control Rod
Range Low/High				
Gas Temp (C)				
Bar. Pressure (mmHg)				
Leak Rate (cfm)				
Leak Rate (scfm)				
	Measure with Unit Pressurized - Idle			

Component Leaks - Flow Tube	Blow Down Valve		Pressure Relief Valve		Unit Valves (combined)	
	Engine 1	Engine 2	Engine 1	Engine 2	Engine 1	Engine 2
Gas Temp (C)						
Bar. Pressure (mmHg)						
Velocity (fpm)						
Leak Rate (scfm)						
	Measure with Unit Pressurized - Idle				*Unit De-pressurized - Idle*	

Misc. Components - Tent/Bag						
Component Desc./ Engine No.	Amb. Temp (C)	Press. (mmHg)	Bag flow (lpm)	Conc. (% methane)	Leak Rate (lpm)	Leak Rate (scfm)
	Measure with Unit Pressurized - Idle					

Table 8. Data Record Contents and Significance

PARAMETER	SIGNIFICANCE
Date	
Time	
Rod Seal #1 Leak Rate	Leak rate
Rod Seal #1 Gas Temperature	Temp. Correction for #1 leak rate
Rod Seal #2 Leak Rate	Leak rate
Rod Seal #1 Gas Temperature	Temp. Correction for #2 leak rate
Barometric pressure	Pressure correction for #1/#2 leak rates
Engine RPM	Unit on/off status
Unit Suction Pressure	Unit operating status
Unit Discharge Pressure	Unit operating status

6.0 DATA REDUCTION, VALIDATION, AND REPORTING

6.1. DATA REDUCTION

This section documents calculations that will be used to obtain final results from raw measurements.

6.1.1. Rod Leak Measurements

The flow meters used to measure rod emissions will be calibrated specific to methane at 70 degrees F. and 1 atmosphere pressure. To adjust for variations in gas temperature and pressure and correct to standard conditions.

scfm = cfm * (P/760 * 294.26/T)^0.5

where P is the absolute barometric pressure (torr) at the site and T is the gas temperature (in Kelvins). The exponent of 0.5 (square root) is necessary due to the physics of rate meters.

6.1.2. Component Measurements

Leak rates for the blow-down valve, pressure relief valve, and unit valves are determined using the flow tube which measures sample flow and concentration. The flow will be calibrated specific to methane in the laboratory and the calibration parameters (slope and intercept) will be used to convert directly from the output (fpm) to flow rate (in scfm) as follows.

$$scfm = v * m + b$$

where v is the pitot output, m is the slope of the calibration curve, and b is the intercept.

If miscellaneous components are found to be leaking (using soap solution), then the leak rates will be quantified using EPA protocol (Method 21) tent/bag method. The leak rate is found as the product of the methane concentration and the sampled flow rate. The methane concentration will be read directly from a Bascom-Turner CGI-201 analyzer calibrated specific to methane.

6.1.3. Gas Savings and Payback period

Formulae for calculating gas savings (Case 1 and Case 2) and for determining the payback period are given in Section 2.2 of this plan.

6.1.4. Unit Conversions

Engineering units in common use at the test site and within the host industry will be used for reporting and summarizing results. For pressure, the units are psi or inches water column. For flow, the units are cfm and scfm (1 atmosphere, 70 degrees F or 294.26 K). For gas velocity, the units are fpm. For concentration, percentage by volume or ppm are used.

6.2. DATA REVIEW AND VALIDATION

Calibrations and quality control checks for each measurement are described in Section 5 - Sampling and Analytical Procedures. Table 9 summarizes the calibrations and quality control checks to be performed. Upon review, all data collected will be classified as either valid, suspect,

or invalid. In general, valid results are based on measurements meeting data quality objectives. All data are considered valid unless a specific performance limit is exceeded or operational check is failed.

It is often the case that anomalous data are identified in the process of data review. All outlying or unusual values will be investigated as fully as possible using test records and logs. Anomalous data may be considered suspect if no specific operational cause to invalidate the data are found. All data - valid, invalid, and suspect will be included in the final report. Report conclusions will be based on valid data only. The reasons for excluding any data will be justified in the report. Suspect data may be included in the analyses, but may be given special treatment as specifically indicated. All continuous sensor data will be reviewed on a daily basis. All anomalous or outlying values will be identified and investigated to find a cause for the unusual condition. Manual measurements data will be reviewed in the field as they are collected and any anomalous conditions will be documented in field log book and, if possible, corrected.

Table 8. Summary of Calibrations and QC Checks

Measurement	Cal/QC Check	When Performed/ frequency	Expected or Allowable Result	Response to Check Failure or Out of Control Condition
Rod Leak Rate	MEM Meter Calibration Check	Prior to each measurement period	$\pm$ 5 %	Identify cause of discrepancy and correct
	MEM Meter Calibration	Prior to shipping	Initial calibration	Replace meter
Component Leak Rates	Flow Tube Calibration	Prior to each measurement period	Obtain calibration slope and intercept	Identify cause of any problem and correct
EPA Method 21	Methane Analyzer Calibration	Prior to each measurement period	Set to standard	N/A
	Flow System Calibration	Prior to each measurement period	Obtain calibration slope and intercept	N/A
	Flow System Leak Check	Each measurement	No leak	Identify cause of any problem and correct

6.3. DATA ANALYSIS AND REPORTING

After data reduction, review and validation, the primary Phase I data analyses will include the following:

- Document initial gas savings (methane emission reduction) for primary baseline operating conditions

  The gas savings and methane emission reduction is the amount of gas that is prevented from leaking to the atmosphere either by the static seals themselves (Case I) or by the seals and changes in shut down procedure associated with installation of the seals (Case II).

- Document capital, installation, and shakedown requirements and costs

  This is a broad assessment of effort and costs required to install the Emissions Packing and ensure that it is operating properly. Any problems encountered during installation and shakedown - and their resolutions will be described. Capital and installation costs will be based on the actual installed cost for the system. For the test, flow sensors are being installed that might not be installed in a normal situation. Once the system is operational, host site personnel will be interviewed to determine whether flow sensors to document gas savings would be considered necessary in a permanent installation.

The following is a preliminary outline of the content of the Phase I Verification Report.

Preliminary Outline
France Emissions Packing Seal System
Phase I Verification Report

Verification Statement

Section 1 Verification Test Design and Description

- Emissions Packing Description
- Site Selection, Description, and Emissions Packing Installation
- Verification Parameters and Their Determination
  - Initial gas savings (methane emission reduction) for primary baseline operating conditions
  - Installation and Shakedown Requirements
  - Initial Capital and Installation Costs
- Sampling and Analytical Procedures
  - Continuous Measurements
  - Manual Measurements
  - Data Acquisition System
- Quality Assurance and Quality Control Measures
  - Calibration Procedures
  - Quality Control Checks, Audits, and Corrective Actions
  - Data Reduction
  - Data Validation
  - Data Analysis and Reporting

Section 2 Phase I Verification Results and Evaluation

Initial gas savings (methane emission reduction) for primary baseline operating conditions
Installation and Shakedown Requirements
Initial Capital and Installation Costs
Data Quality Assessment

Section 3 Additional Technical and Performance Data From France

References

The Phase II report will include key data from the Phase I report. The Phase II report will incorporate the results from the entire evaluation process, and will focus on longer-term performance of the system and the payback period. Phase II verification parameters include:

- Annualized gas savings for primary baseline conditions
- Methane emission reduction
- Calculate Emissions Packing payback period

7.0 AUDITS

An internal systems audit is planned for this test. The audit will be conducted by SRI's independently managed QA staff. This will include field verification, procedural, and documentation components using this plan as the basis for the audit. An external audit may be performed at EPA's discretion by EPA QA staff or a qualified contractor. A performance audit on sensors used in the study is not considered necessary since all devices will be laboratory certified before each intensive measurement period. An internal audit of data quality will be conducted once data collection and analyses are complete. The final report will contain a summary of results from all audits.

8.0 CORRECTIVE ACTION

Table 9 in Section 6.2 lists allowable values for each of the calibrations and quality control checks and also indicates actions to be taken in response to an out of control condition. Other issues may arise that require corrective actions or plan changes to ensure that data quality objectives are met. SRI's quality management plan provides general procedures for corrective action that will be followed in such instances.

9.0 PROJECT ORGANIZATION

Southern Research Institute's Greenhouse Gas Technology Verification Center has overall responsibility for planning and ensuring successful implementation of the verification test. France is providing the Emissions Packing technology, equipment, and engineering for the test installation. ANR Pipeline is providing access to the host site, and logistical and manpower assistance in the installation and operation of the Emissions Packing. Good working relationships have been established between the Center, France, and ANR which have proved valuable in the planning up to this stage. All parties have signed a formal agreement (documented in the Letter of Commitment and associated documents) specifying details of financial, technical, and managerial responsibilities.

EPA's APPCD is the sponsor of the ETV Greenhouse Gas Pilot and is providing broad oversight and QA support for the project. The project organization is presented in Figure 5.

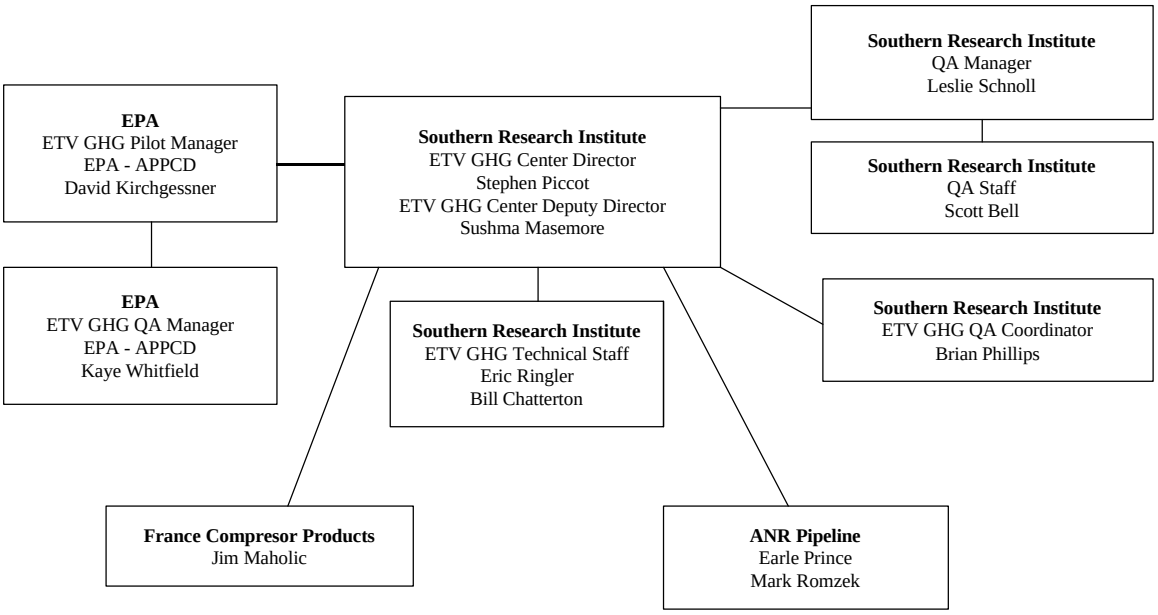


Figure 5. Project Organization

10.0 TEST PROGRAM HEALTH AND SAFETY

This section applies to Center personnel only. Other organizations involved in the project have their own health and safety plans - specific to their roles in the project.

SRI staff will comply with all known ANR, state, local, and Federal regulations relating to safety at ANR's Celestine compressor station. This includes use of personal protective gear (flame resistant clothing, safety glasses, hearing protection, safety toe shoes) as required and completion of site safety orientation (site hazard awareness, alarms and signals, etc.).

Other than normal industrial hazards, the most significant hazard at the Station is the potential for explosive concentrations of natural gas. SRI plans to use only intrinsically safe apparatus in the compressor building. Should use of any equipment not so rated be required, SRI will not use this equipment until advised by site personnel that it is safe to do so.

Some test procedures will require that special safety precautions be observed. In particular, when conducting manual sampling of the blow-down valve leak rate, the automated blow-down valve control should be disabled to prevent a blow-down during sampling.

11.0 REFERENCES

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