# GHG Emission Factor Development Project for Selected Sources in the Natural Gas Industry

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Quarterly Progress Report

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Submitted to

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**Project Overview**

Methane ($CH_4$) is the primary component of natural gas and is also a potent greenhouse gas (GHG). Emissions of $CH_4$ from natural gas production, processing, and distribution are among the top ten source categories of greenhouse gas emissions in the United States, expressed on a $CO_2$ equivalent basis. The overall goal of the project is to update default $CH_4$ emission factors for selected processes and equipment used in the natural gas industry. The default emission factors will be updated by compiling and synthesizing existing data for a variety of source categories and by acquiring new emission rate measurement data for selected sources where existing data have unacceptably large uncertainties or are insufficiently representative of current practices or equipment.

The project is organized into four tasks:

- *Task 1, Data Synthesis and Gap Analysis:* The purposes of this task are to: (1) identify, compile, and synthesize existing $CH_4$ emission factor and activity factor data; (2) critically review the quality and representativeness of the existing data; (3) recommend and prioritize emission source characteristics for new data collection efforts under Task 3.
- *Task 2, Technical Plan Development:* The purpose of this task is to develop technical work plans and detailed cost estimates for conducting data collection and measurement studies aimed at filling the emission data gaps identified in Task 1. In doing so, we will consider the range of potential activity data metrics that could be used for updating default emission factors and gather preliminary data on relevant metrics to ensure that all the major subgroups of equipment or processes are taken into account.
- *Task 3, Measurements and Analysis:* The purposes of this task are to: (1) execute the technical plans developed in Task 2, contingent on authorization by EPA; and (2) analyze the resulting data to develop new default emission factors and uncertainty estimates for the measured sources.
- *Task 4, Reporting and Dissemination:* The purpose of this task is to report on the default emission factors developed in Tasks 1 and 3 of this study, including the methods used in the process. Reporting and communication with stakeholders will be integrated into all of the tasks and a final reporting will disseminate project results.

**Progress on Tasks**

***Task 1***

A draft review of sources of emission factor and/or activity factor data that may have relevance to the natural gas sources of interest was prepared at the end of 2008. A series of stakeholder conference calls to solicit input on the report were organized (calls were held beginning in January, 2009) and an updated literature review was prepared. The updated review, dated March 31, 3009, was posted to the project web site:
(***http://www.utexas.edu/research/ceer/GHG/tasks.htm*** )

On a subsequent conference call (May 12, 2009), stakeholders identified additional reports and reports that, while not currently available, would likely become available during the lifetime of the project. These reports will be incorporated into the Task 1 report as they emerge, so the report will continue to be updated throughout the project.

***Task 2***
During the first quarter of 2009 a work plan specifying methods and procedures for gathering additional data needed for updating factors used for estimating methane emissions from centrifugal and reciprocating compressors used in natural gas transmission and processing was drafted. A series of stakeholder conference calls to solicit input on the plan were organized (calls were held beginning in January, 2009). A second draft of the work plan was added to the project web site: (***http://www.utexas.edu/research/ceer/GHG/tasks.htm*** ). During the third quarter, final updates were made to the Quality Assurance Project Plan (QAPP) for compressor sampling, in anticipation of sampling beginning in the fourth quarter of 2009 and the first quarter of 2010. The QAPP for compressor sampling was approved in late October, prior to sampling in November.

***Task 3***
During the second and third quarters of 2009, the focus was on identifying compressor sampling sites. At least 4 different companies considered opening multiple sites to the study team. During the third quarter, negotiations for site access reached the final stages with 2 of the companies. These discussions were finalized and full execution of the site access agreements occurred during the fourth quarter of 2009 (October 2009). Both of these companies made multiple sites available for sampling, with multiple compressors at each site. The University has also procured additional liability insurance through November 2010, with an option to extend coverage, if necessary.

The compressor station sampling techniques were as follows:

- Station Fugitive screening by FLIR camera (non-quantitative)
- Fugitive measurement on found leakers by High Volume Sampler device
- Vent Measurement by alternate methods (pitot tube, anemometer, or calibrated bag)

Sampling at the first group of sites in east Texas, all belonging to a single company, occurred for a week in November, 2009. A second week of sampling occurred in February, 2010, at a group of sites belonging to a different company in west Texas. The strategy in conducting the sampling has been to collect as much data as possible at the sites, using three different types of instruments, and to perform a detailed cost analysis of the sampling program. Measurements included compressor related fugitive components (flanges, valves, open-ended-lines, pressure relief valves) as well as blowdown vent lines and compressor seal and rod packing emissions, the latter which were measured by anemometer and calibrated bag techniques. Table 1 describes the instruments that were deployed at the sites.

Table 1. Summary of sampling done to date

| Ownership of site | Type/Number of Compressors | Date sampled | IR Screening | Hi Flow on Component leaks | Vent pipes measured |
|---|---|---|---|---|---|
| Company 1 | Recip./6 | 11/3/09 | √ | √ | √ |
| Company 1 | Recip./5 | 11/4/09 | √ | √ | √ |
| Company 1 | Centrif./3 | 11/3/09 | √ | √ | √ |
| Company 2 | Recip. | 2/23/10 | √ | √ | √ |
| Company 2 | Recip. | 2/24/10 | √ | √ | √ |

The most significant findings in this first round of sampling were high emission rates for some compressor vent pipes and emission rate variability in the vent pipes, summarized in Table 2.

Table 2. Emissions from compressor vents

| | scfm* | Mscfy** | GRI/EPA Data Mscf/compressor/year |
|---|---|---|---|
| Company 1 (3 sites) | | | |
| Average blowdown vent for compressors at idle | 1.33 | 699 | 3683 |
| Average blowdown vent for compressors running and idle | 30.03 | 15,787 | |
| Average packing vent | 15.94 | 8,379 | 396 |
| Company 2 (2 sites) | | | |
| Average blowdown vent for compressors at idle | 27.30 | 14,347 | 3683 |
| Average blowdown vent for compressors running | 16.76 | 8,807 | |
| Average packing vent | 26.25 | 13,798 | 396 |

*standard cubic feet per minute
**thousand standard cubic feet per year

The overall emissions from fugitive emissions from valves, flanges, and other sources are reported as an average over all five sites in Table 3.

Table 3. Fugitive emissions from valves, flanges and other components

| | scfm* | Mscfy** | GRI/EPA Data Mscf/recip. compressor/year |
|---|---|---|---|
| Pressurized idle | 0.114 | 60 | 180 per Recip compr; |
| Operating | 0.091 | 48 | |
| Average | 0.099 | 52 | |

*standard cubic feet per minute
**thousand standard cubic feet per year

As was found in the previous GRI/EPA study, the largest single emission sources at a compressor station site are the compressor blowdown (BD) vent lines and the compressor seal vents. These remain the largest sources in the sampling for this project. For compressor vent lines, measurements at the Company 2 stations exceeded the values previously reported for the GRI/EPA study. However, measurements at the Company 1 stations had lower values for idle reciprocating compressors. One potential reason for the variability in compressor vent emissions at idle is differences in practices for pressurizing compressors at idle. Figure 1 shows a representation of a typical compressor blowdown line configuration. When compressors are idle and pressurized, the small (often 2 inch size) valve to the open vent is the only open-ended line (OEL) leak point. However, if the compressor is isolated from the suction and discharge lines and blown-down, the OEL leak points are the very large suction and discharge block vales, which can leak at a much higher rate.

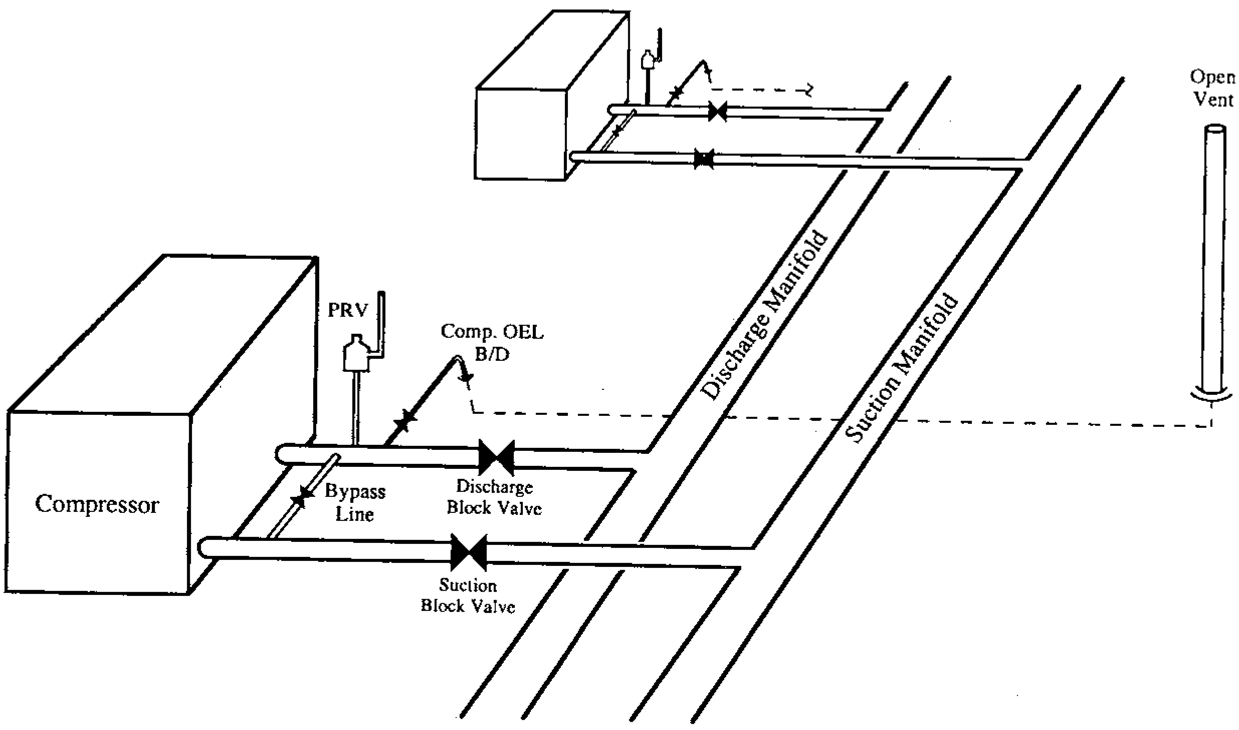


Figure 1. Compressor blowdown line configuration

At the Company 1 stations, the practice for idle compressors was to leave the compressor pressurized. This reduces leakage through the compressor BD line versus other practices.

While no statistical analysis have yet been made, it is unlikely that the data collected to date are statistically sufficient to replace the previous GRI/EPA data, which made direct measurements of the high emission components at 15 stations, and which gathered other activity data on a much larger sample set. Specifically, the values are the result of an average of zeros and a few high values, which would lead to high uncertainty limits. More stations would have to be visited across a broader geographic area to cover a representative sample of US transmission compressor stations and their operating practices. Also, data on operating practices for compressors might be gathered from a larger sample than visited for direct measurements; volunteer companies could participate in a survey that would gather the needed data.

**Plans for Next Quarter**

***Task 1***

The literature review will be updated, as appropriate, on an on-going basis.

***Task 3***

The ultimate goal for the project is to develop new emission factors for these sources that could be used to replace the existing emission factors, most of which were developed in the mid-1990's under the GRI/EPA program.

This study may be of special interest now, since the measurement techniques used were nearly identical to those that the EPA recently outlined in the April 12, 2010 proposed Subpart W of the greenhouse gas (GHG) Mandatory Reporting Rule (MRR). This rule also required measurements by natural gas industry for many of the same sources that were targeted by this project.

The EPA proposed Subpart W rule is due to be issued as a final rule by September or October of 2010. While EPA may make changes to the version proposed in April 2010, the currently proposed version of the rule would require measurement of all these individual sources by practically every US operator. In that scenario, the data collected in this project would likely serve as benchmark values. Industry associations and individual companies have commented on the proposed rule, and it is possible that EPA will make changes to eliminate the regulatory measurements, and rely upon emission factors. In that scenario, this University of Texas research project to update the emission factors becomes more important.

Given this uncertainty, it is clear that the project team must closely monitor the outcome of the final published MRR Subpart W. There is benefit to additional compressor station work under any outcome of the rule, however, either as a more complete benchmarking or in establishing updated emission factors..

If the project continues with compressor stations, more sampling is needed to establish a statistically significant number of measurements. The specific recommendations of the study team to the EPA and the stakeholder group are:

- Continue work on compressor stations, based on large estimated emissions (see Table 4) and significant emission variability among stations sampled to date
- Gather more direct measurement data (Measure more compressor station sites and gas plant sites) Target: 6-10 more stations, geographically diverse.
- Survey INGAA members for company practices on compressor operating practices that affect leak rate
- Produce and publish updated compressor emission factors

Alternately, the project could address the other emission source items on the initial list, as shown in Table 4. It should be noted that all of the items under consideration for this project are also being addressed by the US EPA GHG MRR proposed Subpart W.

Table 4. Background on Previous Source Measurements

| Topic<br><br>(GRI/EPA total CH4 emissions in U.S.) | GRI/EPA Previous Reports | | | MRR Subpart W, proposed | Possible New Measurements |
|---|---|---|---|---|---|
| | **CH4 EF** | **Basis**<br>*Note: (assumed mol fraction methane is 78.8%)* | **Sample Size** | | |
| **Well Completion Flaring/Venting**<br><br>(0.000619 Bscf $CH_4$) | 0.733 Mscf/well completion (± 200 %)<br><br>844 completed wells (± 10 %) | 1) Sites did not track flared volumes<br>2) Assumed that amount flared was equal to half the amount directly vented in production.<br>3) Used flare efficiencies from literature search (98% in production).<br>4) Assumed that flow rate was equal to average gas well flow rate (maximum was not available); rate from Gas Facts<br>5) Assumed that each completion lasted 24 hours<br><br>6) Number of exploratory wells completed from EIA | 2 production fields (421 gas wells) | "Gas well venting during unconventional well completions and workovers"<br><br>Measure for one and apply to all ***or*** calculate by pressure difference and apply to all<br><br>"Conventional" calculate | No new technologies since 1990s<br><br>Use MRR approach with Volunteer companies (target: 6) |
| **Well Workovers**<br><br>(0.0229 Bscf $CH_4$) | 2.454 Mscf/workover (± 459 %)<br><br>9329 workovers (± 258 %) | 1) Pipeline Systems Inc reported well workover emissions from 2 sites (report for Radian in 1990)<br><br>2) Ratio of wells worked over to all wells from 2 sites visited by | 2 sites | | |

| | | | | | |
|---|---|---|---|---|---|
| | | PSI | | | |
| **LP Gas Well Unloading / Clean up**<br><br>(5.65 Bscf $CH_4$) | 49.57 Mscf/event (± 344 %)<br><br>114,139 wells unloaded (± 45 %) | 1) Volume and frequency from 12 sites visited by GRI/EPA that had LP gas wells<br><br>2) 25 sites visited by GRI/EPA wherein 41.4% of the gas wells required periodic "unloading" operations. This percentage was applied to all wells in the US | 12 sites<br><br>25 sites (6387 gas wells) | "Well Venting For Liquid Unloading"<br><br>Directly Measured for unique tubing diameter and applied to all in field ***or*** calculated by event log and site data. | No new technologies since 1990s<br><br>A) Use MRR approach with volunteer companies (more than 12)<br><br>B) Bring portable measurement equipment |
| **Production Pipeline Leaks**<br><br>(0.2 Bscf $CH_4$) | – | – | – | – | – |
| **Transmission Compressor Stations**<br><br>(50.7 Bscf $CH_4$) | Recip compr BD OEL =3683 Mscfy; Recip PRV = 372; Recip Comp Seal = 396; Recip misc = 180<br><br>Centrif compr BD OEL = 9652; Centrif starter OEL = 1440; Centrif seal = 165 Centrif misc = 18 | 1) Compressor EF's based on 15 stations measured by High Flow in 1994<br>2) Compressor operating hours based on FERC and GRI TRANSDAT database<br>3) Component counts based on 24 sites visited in 1993-1994 | 15 measured stations | On 3 compressor components (rod packing, blowdown, wet seals, etc) measure. Station: Screen with FLIR camera, quantify with High Flow or Calibrated Bags. | UT EPA Technique is nearly identical to MRR requirements except that other direct measurement techniques (i.e. anemometer) allowed for vent lines. |
| **Transmission Compressor Stations** | Non Compressor components:<br><br>Valve= 0.87 Mscfy | 1) Other station component EF based on 6 transmission stations visited for emissions | 6 stations | Station: Screen with FLIR camera, quantify with High Flow or Calibrated | UT EPA Technique is nearly identical to MRR requirements except that other |

| | | | | | |
|---|---|---|---|---|---|
| | Connection = 0.15;<br>Control Valve = 8.0;<br>PRV = 6.2;<br>Site BD OEL = 264 | measurements by Indaco in 1994<br>2) Component counts based on 24 sites visited in 1993-1994 | | Bags. | direct measurement techniques (i.e. anemometer) allowed for vent lines. |