APPENDIX A

MEMORANDUM

To: Sandra Snyder, INGAA

From: Innovative Environmental Solutions, Inc.

Date: December 14, 2018

Subject: Review of EPA Memo “EPA Analysis of Fugitive Emissions Data Provided by INGAA” (Docket Document EPA-HQ-OAR-2017-0483-0038)

In June 2018, INGAA provided several documents to EPA regarding fugitive emissions data to substantiate its position that fugitive emissions monitoring at compressor stations should be less frequent than quarterly. EPA’s review of that material is provided in an EPA memo titled “EPA Analysis of Fugitive Emissions Data Provided by INGAA” (docket document EPA-HQ-OAR-2017-0483-0038).

This memo is an attachment to INGAA’s comments on Subpart OOOOa proposed amendments. Several clarifications are warranted to INGAA’s earlier submittals. This memo is intended to continue the dialogue with EPA regarding the data and information that are “best available science” for developing cost-effective mitigation of fugitive gas leaks.

For ease of review, this memo provides the text from the EPA memo in blue Arial font below and INGAA’s feedback/responses in black Times New Roman font.

Summary of INGAA Comments

This memo provides INGAA’s feedback and comments on the EPA memo “EPA Analysis of Fugitive Emissions Data Provided by INGAA”:

1. EPA’s memo cited three data sources to support the optical gas imaging leak detection and repair (LDAR) leak emission reduction estimates of 40% for annual monitoring, 60% for semi-annual, and 80% for quarterly. These data were not based on measured gas leak emission reductions and the sources have major deficiencies, as explained further below:
   - A Colorado Air Quality Control Commission (CAQCC) cost-benefit analysis for LDAR is based on uncited EPA information. Using this undocumented source means that Subpart OOOOa is in part based on a circular reference with no actual supporting data.
   - EPA also referenced example calculations for an EPA Leak Protocol LDAR Control Efficiency Model. These example calculations do not support EPA’s assumptions regarding the LDAR control efficiency for natural gas compressor stations because they are based a very limited data set collected approximately 40 years ago from the synthetic organic chemical manufacturing industry; and

- EPA referenced an ICF study that is another a model-based estimate driven by inputs and assumptions. The ICF study does not present *measured* leak emission reductions. The docket only provides a copy of PowerPoint slides summarizing this study. The PowerPoint slides do not present detailed results and the assumptions used for the modeling alternative survey frequencies are not discussed or defined, nor was a detailed report provided for further explanation. INGAA is concerned about a PowerPoint being part of the basis for regulatory change because regulatory requirements should be based on substantive and detailed reports rather than high level PowerPoint slides.

Due to these flaws, INGAA provided information to EPA about more reliable leak measurement data from implementation of a recent multi-year program conducted in the oil and natural gas industry. The data from this program showed about 75% leak emissions reduction is using annual leak monitoring.

2. The EPA memo noted that some emission factors provided in the INGAA White Paper do not match the emission factors reported in the PRCI report. First, INGAA would like to clarify that the "PRCI report" that INGAA is referencing is an analysis of Subpart W data that were reported to EPA to inform future rulemaking and regulatory decisions making. The PRCI report analyzed the Subpart W data consistent with historical methods and emission factors (e.g., the 1996 GRI/EPA Study[1]). This memo provides additional detail to explain the component parts that comprise compressor emission factors, related Subpart W measurement data, and use of historical (e.g., EPA/GRI Study) or current (e.g., Subpart W) data (e.g., different time-in-factors for compressors, missing compressor measurements for Subpart W).
3. This memo provides further explanation regarding several issues related to the Subpart W leak emission measurement and estimation methodologies and how these measurements correspond to the 1996 GRI/EPA study and emission sources regulated by Subpart OOOOa, including:
   - The optical gas imaging leak survey procedures for Subpart W and Subpart OOOOa are very similar. Both are based on the alternative work practice in the 40 C.F.R. Part 60 general provisions that require a pre-survey screening of a defined flow rate (60 grams per hour or lower) and procedures to ensure the viewing distance considers onsite weather conditions. Optical gas imaging leak survey pre-test procedures basically confirm instrument functionality under site conditions – i.e., this technology does not require frequent calibrations, etc. that are required for many other test methods. Subpart W leak survey results are therefore comparable to Subpart OOOOa leak survey results.
   - Subpart W requires direct measurement of natural gas leakage emissions from major compressor components (i.e., blowdown valves, isolation valves, reciprocating compressor rod packings, centrifugal compressor wet seals) rather than use of emission factors.
   - How the GRI/EPA study accounts for leak emissions from non-major compressor components and non-compressor components, and the corresponding development of

[1] Gas Research Institute (GRI)/U.S. EPA. Research and Development, *Methane Emissions from the Natural Gas Industry, Volume 8: Equipment Leaks*. June 1996 (EPA-600/R-96-080h).

"complete" compressor emission factors that are a composite of emissions data from all pertinent leak sources.

4. The EPA memo notes that the California Air Resources Board (CARB) study "Enhanced Inspection & Maintenance for GHG & VOCs at Upstream Facilities – Final (Revised)," which presents gas leak rate versus Method 21 screening value correlations based on recent leak rate measurements, had a small number of measurements including many from upstream oil and natural gas operations (i.e., not natural gas transmission and storage), and was conducted solely in California (where the natural gas composition may not represent U.S. average). INGAA acknowledges that the CARB study was a limited study, but it still provides a basis for two key points: (1) gas leaks detected with leak screening values on the order of regulatory leak definitions/repair thresholds (e.g., order of 500 or 10,000 ppmv) are generally very small, and (2) these leaks are very minor compared to emissions from major compressor component leaks.

5. EPA's LDAR cost-effectiveness analysis for natural gas transmission in the Technical Support Document is based on uncontrolled (i.e., pre-LDAR) gas leak emissions from a Model Plant compressor station that replicates 1996 GRI/EPA Study gas leak emissions from non-compressor components at transmission compressor stations. EPA should use data from Subpart W leak surveys and leaker emission factors rather than the 1996 GRI/EPA data for its LDAR cost-effectiveness analysis.[2] The Subpart W data set is much larger (hundreds of stations were surveyed) and it was collected more recently, meaning that it is more representative of modern operations. In addition, as EPA explained when it promulgated Subpart W in 2010, the purpose of gathering and reporting the Subpart W data was to inform future decision-making and potential regulations.[3] Where feasible, EPA should use Subpart W data for Subpart OOOOa decision-making.

   An additional consideration is that the 1996 GRI/EPA Study data indicate that the Technical Support Document Model Plant represents only about 13% of transmission compressor station leak emissions subject to the LDAR provisions. Using the Subpart W data would provide the model with uncontrolled gas leak emissions from more than just the non-compressor components; it would also be able to include emissions from blowdown valves, isolation valves, and other non-major compressor components.

6. Subpart W and state or local LDAR regulatory reporting may be better sources of data that could be used for inputs in the EPA Leak Protocol LDAR control efficiency model. The input data should be accurate and representative of present-day operations. The data EPA used was limited in scope, several decades old, and from a different industrial sector. Ideally, LDAR control efficiency model input data, including the initial leak rate, leak occurrence rate, and unable to repair rate should be from the same or comparable data sets.

[2] Subpart W data might be best characterized as "somewhat controlled" emissions because some leaks may be repaired after the Subpart W surveys are conducted, but leak repair is not mandated.

[3] 75 Fed. Reg. 74,458, 74,460 (Nov. 30, 2010).

The blue Arial font text below is directly from EPA's memo. INGAA's comments are provided in black Times New Roman font.

1.0 INTRODUCTION

On June 8, 2018 and June 20, 2018, the Interstate Natural Gas Association of America (INGAA) submitted reports to EPA regarding "Methane Emissions from Natural Gas Transmission and Storage Facilities: Review of Available Data on Leak Emission Estimates and Mitigation Using Leak Detection and Repair." Attachments 1 and 2 to this memo contain the reports provided by INGAA. This memo discusses our analysis of the information and conclusions presented by INGAA.

> INGAA believes that its June 28, 2018 memorandum "Supplement to INGAA White Paper on Subpart OOOOa TSD Estimates of Leak Emissions and LDAR Performance – Revision 1"[4] ("INGAA White Paper Supplement") should be cited rather than its June 20, 2018 memorandum "Supplement to INGAA White Paper on Subpart OOOOa TSD Estimates of Leak Emissions and LDAR Performance."[5] The June 28 memo corrected a data entry error and removed text that mis-identified an anomaly in an analysis in the June 20 memo.

2.0 SUMMARY OF INFORMATION

As stated in the June 8, 2018 INGAA White Paper[6] (herein referred to as "INGAA White Paper") results for three recent studies were presented related to fugitive emissions from natural gas systems: (1) a Canadian Association of Petroleum Producers (CAPP) study[7] that updated emissions factors for upstream oil and gas fugitive emissions sources, (2) a Pipeline Research Council International (PRCI) report[8] that examined emissions reported under Subpart W of the Greenhouse Gas Reporting Program (GHGRP, see 40 CFR part 98, subpart W – Petroleum and Natural Gas Systems) (herein referred to as "Subpart W"), and (3) a California Air Resources Board (CARB) study[9] that utilized Method 21 of appendix A-7 of 40 CFR part 60 ("Method 21") to develop correlation equations for different fugitive emissions components based on Method 21 screening values. INGAA performed an analysis of the results of these studies, and concluded that fugitive emissions from fugitive emissions components located at compressor stations were overestimated in EPA's model plant analysis. Further, INGAA states that annual monitoring is more appropriate for compressor stations, instead of the currently required quarterly monitoring.

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[4] EPA-HQ-OAR-2017-0483-0038 Attachment 3 "Supplement to INGAA White Paper on Subpart OOOOa TSD Estimates of Leak Emissions and LDAR Performance - rev 1."

[5] EPA-HQ-OAR-2017-0483-0038 Attachment 2 "Supplement to INGAA White Paper on Subpart OOOOa TSD Estimates of Leak Emissions and LDAR Performance."

[6] EPA-HQ-OAR-2017-0483-0038 Attachment 1 "Methane Emissions from Natural Gas Transmission and Storage Facilities: Review of Available Data on Leak Emission Estimates and Mitigation Using Leak Detection and Repair."

[7] *Update of Fugitive Equipment Leak Emission Factors*", Canadian Association of Petroleum Producers (CAPP), February 2014, available at EPA-HQ-OAR-2017-0483.

[8] *GHG Emission Factor Development for Natural Gas Compressors*, PRCI Catalog No. PR-312-1602-R02, April 18, 2018.

[9] CARB (California Air Resources Board). 2016. *Air Resources Board RFP No. 13-414: Enhanced Inspection & Maintenance for GHG & VOCs at Upstream Facilities – Final (Revised).* Prepared by Sage ATC Environmental Consulting, LLC, available at Docket ID No. EPA-HQ-OAR-2017-0483.

Note: It should be noted that the authors of the INGAA White Paper were also listed as authors of the PRCI Report.

INGAA does not have any comments on section 2.

3.0 DISCUSSION OF WHITE PAPER CONCLUSIONS

INGAA has provided detailed comments below each section that follows. For convenience, INGAA has included the following summary of key issues discussed in the White Papers and has also presented a comparison between the CAPP study and Leak Protocol model in Table 1, *infra*. INGAA acknowledges that the CAPP Study data is not perfect, and EPA's memo raises concerns regarding that study. However, in rebuttal, INGAA provides several points that each independently support using the CAPP Study; when these points are considered collectively, the CAPP Study is clearly a superior resource.

The CAPP Study:

- presents data from a leak mitigation program for upstream operations in the natural gas industry, rather than relying on data from a different industrial sector;
- includes a much larger data set than EPA used in its analysis;
- includes a broader and more complete list of leaking components and does not solely present leak information on valves; and
- is based on data that is much more current – i.e., data from 2007, as compared to data from the late 1970s or early 1980s.

3.1 Canadian Association of Petroleum Producers (CAPP) Emissions Factors

Section 2 of the INGAA White Paper discusses the control efficiencies used by EPA in our model plant analysis. First, INGAA asserts that "EPA's leak emissions reduction estimates are based on a LDAR control efficiency model with high uncertainty and biased by flawed and unrepresentative data and assumptions. These reduction estimates were not supported by actual measurements of gas leak emission reductions." (See Attachment 1 at page 4). In this discussion, INGAA appears to have focused on one data source that EPA used to estimate OGI control efficiency – Method 21 control efficiency at 500 ppm and 10,000 ppm. While it is true that EPA estimated the control efficiency of the alternative standard (i.e., Method 21 monitoring at a repair threshold of 500 ppm), it is incorrect to assert this as the only data source.

INGAA agrees that EPA did not estimate the LDAR control efficiencies based on one data source. In the September 2018 Technical Support Document ("TSD") for Subpart OOOOa[10,11] (pages 24 – 26), EPA cited three data sources to support the optical gas imaging (OGI) LDAR leak emission reduction estimates of 40% for annual monitoring, 60% for semiannual monitoring, and 80% for quarterly monitoring: (1) A Colorado Air Quality

[10] EPA-HQ-OAR-2017-0483-0040.

[11] In the three Technical Support Documents for Subpart OOOOa – August 2015 (EPA-HQ-OAR-2010-0505-5120), May 2016 (EPA-HQ-OAR-2010-0505-7631), and September 2018 – the assumptions and data (e.g., LDAR control efficiency, Model Plant emissions, costs) used to develop the LDAR cost-effectiveness estimates are essentially the same. Thus, discussion regarding the September 2018 TSD generally apply to the previous versions.

Control Commission cost-benefit analysis for LDAR ("CAQCC analysis"),[12] (2) data from the 1995 EPA Leak Protocol document ("EPA Leak Protocol"),[13] and (3) an ICF study ("ICF study").[14] INGAA previously identified major deficiencies in each of these data sources.[15] A brief summary is provided below:

(1) Relying on the CAQCC analysis creates a circular reference. The CAQCC report simply states:

> "Based on EPA reported information, the Division calculated a 40% reduction for annual inspections, a 60% reduction for quarterly inspections, and an 80% reduction for monthly inspections."

No citation is provided for the "EPA reported information" and there is no evidence that these estimates are based on actual measurements of gas leak emission reductions. While relying on the CAQCC analysis for support, EPA also assumed a different and significantly more optimistic LDAR control efficiency/survey frequency correlation without providing any explanation for these differences. Please refer to page 23 in EPA-HQ-OAR-2010-0505-6872 for further discussion.

(2) The EPA Leak Protocol LDAR Control Efficiency (CE) Model leak emissions reduction estimates are based on an "example application"[16] for a LDAR program control efficiency estimation model. These reduction estimates were not supported by actual measurements of gas leak emission reductions and the data used contained high uncertainty and were biased due to flawed and unrepresentative data and assumptions. Please refer to pages 3 – 7 of the INGAA White Paper and Table 1 below for further discussion.

(3) The ICF study is a model-based estimate driven by inputs and assumptions and it does not present *measured* leak emission reductions. This "study" should not be given much weight because it is not presented in the docket as a transparent report; rather, only PowerPoint slides are available for review. Regulatory requirements should be based on substantive and detailed reports rather than high level PowerPoint slides. The public and regulated community needs to be provided with the opportunity to review the detailed report in order to evaluate the underlying model data, assumptions, and calculations. Pages 8 and 9 of INGAA's June 28 Supplement addressed this issue.

As stated in the Background Technical Support Document (TSD),[17] OGI equipment meeting the requirements of 40 CFR 60.5397a(c)(7)(i) are capable of viewing fugitive emissions located at oil and natural gas well sites and compressor stations. The sensitivity (i.e., detection limit) of the currently available OGI equipment varies based on changes in the fugitive compound(s) being

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[12] EPA-HQ-OAR-2010-0505-7573. Colorado Air Quality Control Commission, *Cost-Benefit Analysis for Proposed Revisions to Regulation Number 3 and 7 (5 CCR 1001-5 and 5 CCR 1001-9),* February 7, 2014.

[13] EPA-453/R-95-017. *Protocol for Equipment Leak Emission Estimates, November 1995*, *available at* Docket ID No. EPA-HQ-OAR-2017-0483.

[14] ICF International, Leak Detection and Repair Cost-Effectiveness Analysis, Prepared for Environmental Defense Fund, December 4, 2015, Revised May 2, 2016, *available at* https://www.edf.org/sites/default/files/content/edf_ldar_analysis_120415_v7.pdf.

[15] EPA-HQ-OAR-2010-0505-6872.

[16] EPA Leak Protocol at 5-7.

[17] See *Background Technical Support Document for the Proposed Reconsideration of the New Source Performance Standards 40 CFR part 60, subpart OOOOa*, May 2018, available at Docket ID No. EPA-HQ-OAR-2017-0483.

imaged, ambient conditions (i.e., sky condition, wind speed, and background temperature), distance of the operator from the fugitive emissions source, and the visual acuity of the operator. Because of the subjectivity of the measurement and variability in typical field ambient conditions, it is not possible to correlate OGI detection capabilities with a Method 21 instrument reading, provided in ppm. However, based on our current understanding of OGI technology and the types of hydrocarbons found at oil and natural gas well sites and compressor stations, the emission reductions from an OGI monitoring and repair program likely correlate to a Method 21 monitoring and repair program with a fugitive emissions definition somewhere between 2,000 to 10,000 ppm. Therefore, while the effectiveness of the alternative Method 21 program was evaluated, it was not the sole basis of our assumptions for OGI.

> As explained above, INGAA acknowledges that EPA cited three sources of information to support its assumptions regarding OGI-based LDAR control efficiency. The CAQCC document references EPA data but no citation is given to verify these results.[18] The ICF study PowerPoint slides present results from a model-based estimate driven by inputs and assumptions. The May 2016 TSD[19] heavily relied on the EPA Leak Protocol LDAR CE model example calculations to estimate OGI-based LDAR control efficiencies[20] and the calculations and supporting data are transparent and could be evaluated. INGAA did not mean to imply that this LDAR control efficiency estimate was the focus of its analysis.

INGAA further states that EPA's estimate of 40% control efficiency at annual monitoring is too low, and instead states that "more reliable actual leak measurement data from implementation of a multi-year O&G systems DI&M program indicates that about 75-80% reduction is achieved using annual monitoring." (See Attachment 1 at page 6). Here, INGAA refers to a report from the Canadian Association of Petroleum Producers (CAPP)[21] as evidence that annual monitoring using OGI will achieve 80% emission reductions, a value twice that which EPA uses in the model plant analysis. Based on our review of the information presented in the CAPP report, we are unable to conclude that annual OGI monitoring will achieve 80% emission reductions.

The 2014 CAPP study was conducted to determine if updates were needed for the emissions factors that were originally developed using data collected from the mid-1990s to early 2000s. In 2007, CAPP issued Best Management Practices (BMPs) for fugitive emissions at oil and gas sites.[22] These BMPs were not an enforceable regulation, and did not specify a leak definition monitoring frequency, repair timeline, the components to monitor, or require a specific technology or method of detection. Instead, the BMPs provided an outline of suggestions to help a facility design a program to target identifying and repairing fugitive emissions from components more likely to leak.

> The CAPP BMPs are based on a direct inspection and maintenance (DI&M) approach to gas leak control. DI&M programs directly measure or estimate the mass emission rate of detected leaks. Repair decisions are based on a safety- and cost-effectiveness-based analysis. Although there is not a specific leak definition, all detected leaks are investigated. The

[18] Although INGAA does not have any means to verify, it suspects that the "EPA reported information" cited in the CAQCC document may be these example LDAR control efficiency calculations from the EPA Leak Protocol.
[19] EPA-HQ-OAR-2010-0505-7631.
[20] Please refer to the TSD text quoted on page 3 of the INGAA White Paper.
[21] *Update of Fugitive Equipment Leak Emission Factors*", Canadian Association of Petroleum Producers (CAPP), February 2014, available at EPA-HQ-OAR-2017-0483.
[22] *Management of Fugitive Emissions at Upstream Oil and Gas Facilities*, Canadian Association of Petroleum Producers (CAPP), January 2007, available at EPA-HQ-OAR-2017-0483.

guidelines for monitoring frequency and components to measure are discussed in the INGAA White Paper,[23] and it is reasonable to assume that OGI and Method 21 were used to detect the leaks.

EPA questions the veracity of the CAPP data in part because the BMPs are not enforceable regulations; however, it is not clear whether the example LDAR control efficiency estimates from the CAQCC analysis and EPA Leak Protocol example calculations were based on enforceable regulations. Regardless, the EPA Leak Protocol data are limited in scope, from another industry, and are decades old.

Emissions data should be evaluated based on its representativeness and the dataset size and quality, and not solely on whether or not it is regulatory based. If EPA believes the CAPP data (which are more current and are comprised of a larger sample than the data used by EPA, and from oil and natural gas operations) need to be disregarded based on certain criteria, then a similar level of scrutiny should be applied to the data used by EPA.

In 2014, CAPP evaluated the information submitted from eight companies, for a total of 120 facilities to determine if the emissions factors should be updated and concluded there was a net component-weighted reduction of 75% of the emissions across all component categories. However, EPA is noting this is not reflective of a 75% reduction in emissions from an annual fugitive emissions monitoring program, as suggested by INGAA.

INGAA respectfully disagrees with EPA's conclusion that "this is not reflective of a 75% reduction in emissions from an annual fugitive emissions monitoring program." The fundamentals of the CAPP DI&M program are discussed on pages 6 and 7 of the INGAA White Paper, and the CAPP data and report do support the conclusion of a gas leak emissions reduction on the order of 75% for annual LDAR. As discussed below, the CAPP data are not perfect for calculating LDAR control efficiencies, but perfect data are not known to exist. The CAPP report was the most reliable and best supported estimate of leak emissions reductions that IES found in its research. The 75% LDAR control efficiency estimate is based on *measured* emission reductions from a large population of oil and natural gas equipment, whereas none of the three data sources referenced by EPA to support its LDAR control efficiency versus leak survey frequency estimates are based on LDAR control efficiency measurements.

Given that the BMPs were not regulatory actions and no information is provided in the 2014 study to demonstrate the exact monitoring method/instrument, monitoring frequency, or repair schedule for the facilities represented, EPA is not able to conclude any details about the specific monitoring programs implemented at the individual facilities. Additionally, we have concerns regarding the comparison of the emissions factors because only one company provided actual measurements of identified fugitive emissions for the 2014 CAPP study. Information from the other seven companies was based on estimated component counts and "leak/no leak" emissions Factors.

EPA notes that the information provided in the 2014 CAPP study and the CAPP DI&M BMPs lack specific and exact information regarding the leak reduction program. INGAA acknowledges that the CAPP data are not perfect for calculating LDAR control efficiencies, but perfect data are not known to exist. Rather, EPA should analyze all of the available information to determine what LDAR control efficiency data are most representative of

[23] INGAA White Paper at 6.

current oil and natural gas systems and can be used to provide the most reliable and robust estimates of LDAR control efficiencies. An objective comparison shows that the CAPP information is superior to the information used by EPA. To illustrate, Table 1 compares the CAPP data to the data that are the basis for the EPA Leak Protocol LDAR CE model example calculations.

Table 1. Comparison of Data Used to Estimate LDAR Control Efficiency for the CAPP Study and for the EPA Leak Protocol LDAR CE Model Example Calculations

Parameter	CAPP Study	EPA Leak Protocol Model Example Calculations
Annual LDAR CE	75 – 80%	42 – 68% (40% assumed for OGI)
LDAR CE basis	Emissions directly measured and calculated from M21 surveys & M21 Screening Value-based emission factors (EFs)	Example calculations based on a theoretical model
Components controlled	Valves, emergency vents, pressure relief valves, open-ended lines, flanges, connectors, compressor seals, blowdown systems.	Valves only
Years data collected	2007 +	Data reports published 1980 -1982
Process streams	Oil and natural gas	Synthetic organic chemical manufacturing industry (SOCMI), which includes corrosive streams atypical of oil and natural gas
Data set size	120 facilities over multiple years; ~ *250,000* components	Leak occurrence rate based on *71* gas service valves

The CAPP Study data are more representative of current natural gas compressor station operations for several reasons. First, the CAPP Study data are from the oil and natural gas sector – not a chemical plant. Data from chemical plants are not representative because corrosive process streams at chemical plants can corrode component gaskets and seals, causing leaks that are not typical in the oil and natural gas sector. Second, the CAPP study data are much more current and thus more representative of equipment (e.g., valve technology) and maintenance advancements and improvements since the late 1970s and early 1980s when the data that are the basis for the EPA Leak Protocol example calculations were collected. Third, the CAPP Study represents the typical wide array of potentially leaking components – not just valves, as in the EPA example calculation data. Fourth, the CAPP Study reflects a much larger data set – several orders of magnitude larger than the EPA example calculation data.

In comparison, the EPA LDAR control efficiency estimates are from example calculations, using decades old chemical plant data regarding leaks from valves. Alone, any one of these issues with EPA's data should raise concerns about the resulting analysis; however, together these four flaws in the EPA analysis raises significant concerns about whether EPA has developed a record to support regulatory requirements for natural gas industry operations.

Overall, the CAPP Study dataset is more robust, current, and representative of natural gas operations than the data used for the example calculations for the EPA Leak Protocol LDAR CE model.

Example calculations based on the limited chemical plant data from the 1970s are not reliable estimates of LDAR control efficiencies for present-day oil and natural gas systems. If EPA would like to use the EPA Leak Protocol LDAR CE model to estimate LDAR control efficiencies, then EPA should collect current generation data for model input parameters (e.g., leak occurrence rate, initial leak rate (i.e., "uncontrolled/pre-Subpart OOOOa" leak rate)) from an array of components in natural gas operations and then conduct the appropriate calculations.

The preamble to the proposed rule quotes 2011 Executive Order 13563: "our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the *best available science*."[24] As discussed above, the CAPP LDAR control efficiencies are based on the most representative and reliable data available and should be considered the "best available science" for estimating LDAR control efficiencies. An objective comparison should conclude that the CAPP data are superior to the antiquated data used for the EPA Leak Protocol LDAR CE Model example calculations.

3.2 Pipeline Research Council International (PRCI) and Subpart W Leak Data.

INGAA cites a PRCI report[25] summarizing emission measurement data for compressor sources reported under Subpart W. The PRCI report summarizes data from 11-member companies for six reporting years (2011 through 2016). Thus, while the PRCI study does not use all the transmission and storage data available, it does include a significant portion (approximately 50%) of the available data for these segments.

The PRCI report provides two sets of emission factors related to Subpart W data; one set of emissions factors including all "reliable" data and a second set of emissions factors which excludes any leak over 2,000 standard cubic feet of natural gas per hour (scf NG/hr). PRCI mentions that acoustic measurements were generally lower than measurements made using other methods and did not include these data to develop their emission factors. They also note that there are some emissions for compressor sources not required to be measured and accounted for in Subpart W (e.g., rod packing emissions in standby pressurized mode or emissions from centrifugal compressors while in standby-pressurized mode).

The primary conclusion of the INGAA/PRCI analysis is that the Subpart W data are more recent and robust than the 1996 GRI/EPA study data. Based on our initial review, it appears that the INGAA White Paper uses a draft data set from the PRCI study.

The data and emission factors presented in the INGAA White Paper are based on the final PRCI study data set based on Subpart W reporting. Draft data were not used. These data are a valuable resource based on years of compliance with Subpart W reporting requirements. PRCI analyzed these data consistent with their intended use, as stated during GHGRP development – i.e., to help inform policy decisions related to GHG emissions, such as methane emissions. PRCI has continued this project by evolving its analysis of data from Subpart W reporting.

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[24] 83 Fed. Reg. at 52,088 (emphasis added).

[25] *GHG Emission Factor Development for Natural Gas Compressors*, PRCI Catalog No. PR-312-1602-R02, April 18, 2018.

First, INGAA reports using 10,637 reliable leak rate measurements, while the PRCI report cites this number as 10,595 measurements.[26]

10,595 is the correct number of reliable measurements and is the value used for all calculations. 10,637 is a typo in the text of the White Paper.

Second, the emissions factors provided in Table 3-1 of the INGAA White Paper generally do not match the emissions factors reported in the PRCI report.[27]

In footnote 24 of the White Paper, INGAA explained the difference between the emission factors (EFs) in the White Paper and in the PRCI report. INGAA can provide additional explanation, as needed, to clarify the component parts of the compressor emission factors. The emission source components that comprise the emission factors (see Table 2 below) are based on the historical analysis in the GRI/EPA study. This approach was used to provide "complete" compressor emission factors and to facilitate comparison of historical emissions to more recent operations:

> "Compressor EFs are calculated by summing average measured leak rates for each major (compressor) component/compressor mode combination weighted by the annual time fraction for each mode. To provide comparability with the US GHG Inventory EFs, the time-in-mode fractions from the 1996 GRI/EPA report (Volume 8) were used. In addition, Subpart W does not require rod packing emission measurements when reciprocating compressors are in the pressurized and standby mode, and the US GHG Inventory EFs do include emissions from this mode. Thus, for comparability with the US GHG Inventory EFs, rod packing emissions in the pressurized and standby mode from the US GHG Inventory (2013-) EFs were added to the Subpart W emissions data used to develop the analogous Subpart W compressor EFs."[28]

Overall, the difference between the emission factors in the White Paper (Table 3-1) and in the PRCI report (Table 9) are emissions from the component sources that are not measured for Subpart W (i.e., the PRCI report focuses on the measured data) – e.g., emissions associated with reciprocating compressor rod packing during standby-pressurized (i.e., not-operating pressurized) mode. *See also* the footnotes associated with Table 9 of the PRCI report. PRCI anticipates publishing a White Paper in early 2019 that will explain the "development" of updated reciprocating and centrifugal compressor emission factors in great detail and will present emission factors based on available data (e.g., Subpart W measured data when available, historical data for smaller source contributions that are not measured for Subpart W).

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[26] The value of 10,637 reliable leak rate measurements is provided on page 8 of the INGAA White Paper; the value of 10,595 reliable measurements used is provided on page 2 and in Table 8 (page 11) of the PRCI report.

[27] The values for reciprocating compressors for transmission and storage facilities do not match values presented in either Tables 9 or 10 of the PRCI report. Values for centrifugal compressors at transmission facilities generally match the values in Table 9 (except for 2015), but the PRCI report recommends using the emission factors based on Subpart W time-in-mode fractions reported in Table 10.

[28] INGAA White Paper at 8 n.24.

Third, INGAA reports compressor source-specific emissions factors in Figure 3-7, which are not directly presented in the PRCI report. Therefore, while relying on the data collected during the PRCI study analysis, it appears that INGAA has done some of their own analyses.

> The INGAA White Paper includes a more detailed presentation of the Subpart W data than was presented in the PRCI report (i.e., EFs in units of scf/component-hr for each major compressor component rather then rolled up compressor level EFs in units of scf/compressor-day). The component parts used to develop the rolled-up emission factor are provided in the White Paper. This level of detail will be included in a forthcoming PRCI White Paper that will detail alternative compressor EFs based on the Subpart W data.

We also note that the compressor component-specific emissions factors presented in Figure 3-7 of the INGAA White Paper do not correspond to the compressor emissions factors as used in Subpart W.

> To clarify, the emission factors in Figure 3-7 are for major compressor components (i.e., reciprocating compressor rod packings, centrifugal compressor wet seals, blowdown valves, and isolation valves) developed by PRCI from Subpart W direct emission measurements data from 2011 to 2016. The EFs were constructed using the methodology from the GRI/EPA Study to allow a direct comparison between the data. Emission factors in Tables W-3 and W-4 of Subpart W apply to other components that are not directly measured – i.e., non-compressor components and other non-major compressor components (*see* 40 C.F.R. § 98.233(q)) where a leak survey and "leaker emission factors" are used to estimate emissions. Subpart W methodology does not include emission factors for major compressor components because direct measurement of emissions is required (*see* 40 C.F.R. §§ 98.233(o) for centrifugal compressor major components and 98.233(p) for reciprocating compressor major components).

The factors in Figure 3-7 appear to have been reduced by the time the compressor is in a given mode and are not equivalent to the emissions factors as used in Subpart W.

> The factors in Figure 3-7 are based on compressor time-in-mode fractions; this is consistent with the GRI/EPA Study approach for constructing compressor emission factors and show the contribution of a particular leak source to the composite emission factor. As noted above, Subpart W does not use emission factors to estimate emissions from major compressor components; thus, the factors in Figure 3-7 do not correspond to "emissions factors as used in Subpart W."

This is evidenced by the fact that the maximum emissions for transmission reciprocating compressors would appear to be approximately 160 scf methane (CH_4)/hr or 3,840 scf CH_4/day during operating mode (i.e., rod packing plus blowdown valve emissions). However, the average compressor emissions factor for transmission reciprocating compressors as provided in the INGAA White Paper (Table 3-1) is 9,165 scf CH_4/day. The sum of emissions factors in Figure 3-7 (assuming the time component is already attributed in the factors) would be 290 scf CH_4/hr or 6,960 scf CH_4/day, which is still 25% lower than the compressor emissions factor presented in Table 3-1 of the INGAA White Paper.

> The EPA calculations are mathematically correct; however, EPA did not have all the necessary information to calculate the average compressor emissions factor (sum of major compressor component emission factors, which does not include non-major compressor component emissions) for transmission reciprocating compressors provided in Table 3-1 of

the INGAA White Paper (9,165 scf CH4/day). For example, the major compressor component emission factors in Figure 3-7 of the INGAA White Paper are based on time-in-mode fractions from the Subpart W dataset, whereas the Table 3-1 emission factors are based on GRI/EPA Study time-in-mode fractions to facilitate a more direct comparison of historical (i.e., GRI/EPA Study) and present-day (i.e., Subpart W) leak emissions. The PRCI project analysis of Subpart W data is an on-going effort. A revised INGAA White Paper Figure 3-7, based on the current Subpart W data set analysis and the GRI/EPA Study time-in-mode fractions, is presented below. In addition, Subpart W does not require the measurement of reciprocating compressor rod packing emissions in the standby pressurized (SP) mode. To address this data gap and calculate "complete" compressor emission factors that are comparable to the GRI/EPA Study emission factors, INGAA calculated an estimate of the rod packing emissions in the standby pressurized mode using GRI/EPA Study data. Table 2 provides emission factors for the major compressor components at a transmission compressor station. Table 2 calculates the emission factors for transmission reciprocating compressors and the major components using the Subpart W measurement data in Figure 3-7, Revision 1 and the rod packing emissions in the standby pressurized mode calculated using GRI/EPA Study data. The calculated value of 8,813 scf CH4/day differs slightly from the INGAA White Paper Table 3-1 value of 9,165 scf CH4/day due to the evolving data set analysis. This relative difference is small in comparison to major discrepancies associated with using outdated data as in the EPA analysis. The key takeaways from INGAA's analysis are the same.

Table 2. Transmission Reciprocating Compressor Major Component Emission Factors Calculated from Subpart W Measurements and GRI/EPA Study Time-in-Mode Fractions

Emission Source	scf CH4/hr	scf CH4/day
Rod Packing (OP)	122.7	2,945
Rod Packing (SP)[I]	55.8[II]	1,339
BD Valve (OP)	54.0	1,296
BD Valve (SP)	62.1	1,490
Iso Valve (NOD)	72.6	1,742
TOTAL[III]	**367**	**8,813**

OP = Operating Pressurized mode; SP = Standby Pressurized mode (also Not Operating Pressurized or Pressurized Idle); NOD = Not Operating Depressurized mode (also Standby Depressurized or Depressurized Idle)

I. Subpart W does not require the measurement of rod packing emissions in the standby pressurized mode; thus, these emissions are estimated using data from Volume 8 of the 1996 GRI/EPA Study

II. 55.8 scf CH4/hr = [3.3 seals/compressor[A] * [531,000 scf/seal-yr[B] * 0.339[C] * (1 - 0.05[D]) *(1 - 0.0842[E]) + 116,000 scf/seal-yr[F] * 0.339[C] * 0.05[D]] * 0.934[G]]/8,760 hr/yr

A - Table 4-17

B - uncontrolled emission rate, Table 4-21

C- time-in-mode fraction, Table 4-20

D - page 59, about 5% of reciprocating compressors in Transmission have a Fuel-Saver system that reduces compressor pressure and leak rate in standby pressurized mode

E - page 60, about 8% of reciprocating compressors are equipped with Static-Pac and have negligible emission rates during standby pressurized mode. It is assumed reciprocating compressors with a Fuel-Saver system do not have Static-Pac; thus, 8.42% of reciprocating compressors without a Fuel-Saver system assumed to be equipped with Static-Pac (i.e., 0.0842 = 0.08/0.95)

F – Fuel-Saver emission rate, Table 4-21

G - scf CH4/scf NG

III. Total does not include emissions from non-major compressor components

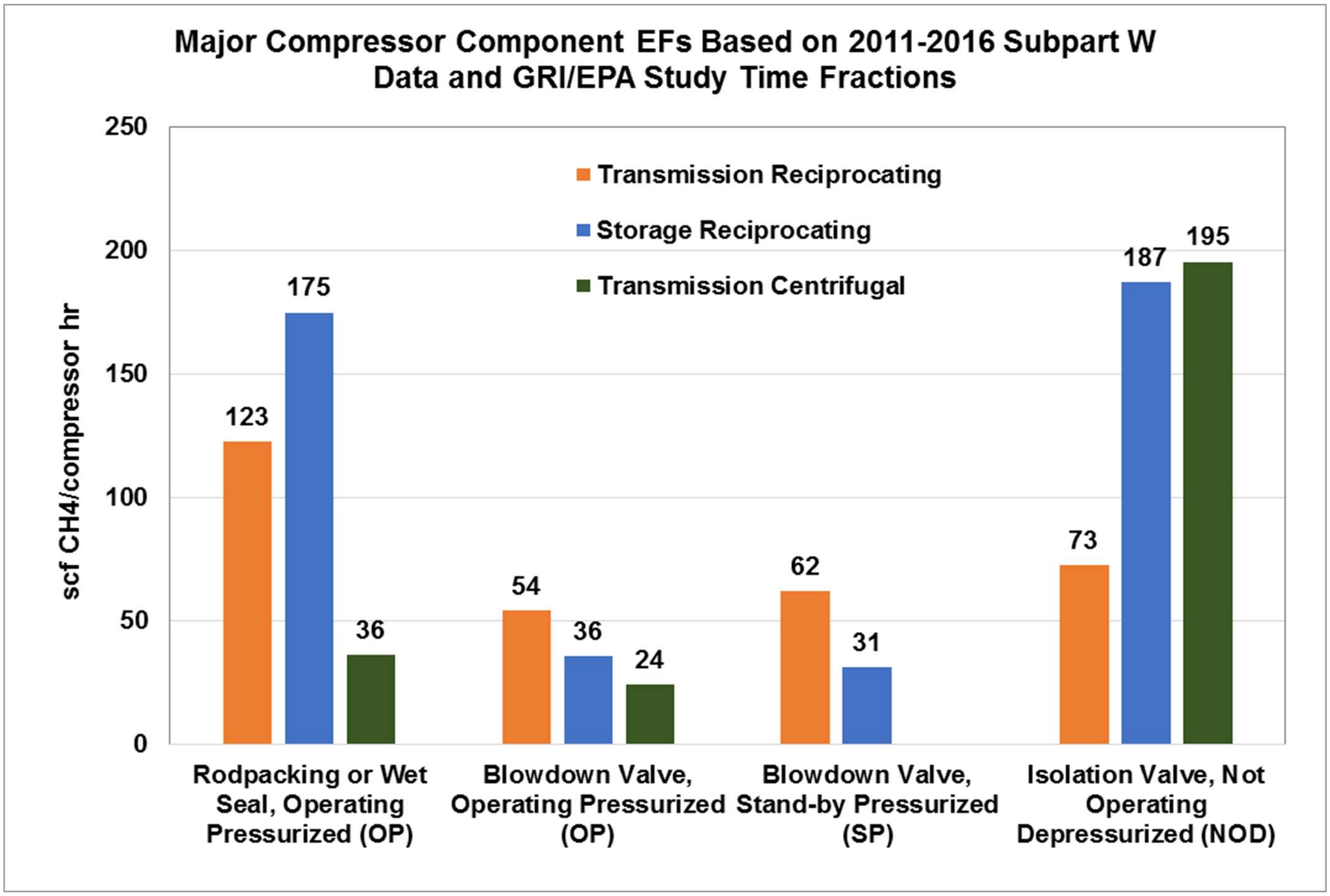

Figure 3-7, Revision 1. Major compressor component emission factors for Transmission and Storage based on GRI/EPA Study time-in-mode fractions.

A second conclusion from INGAA's analysis of the PRCI data is that compressor source emissions, predominately seal emissions (either rod packing or wet seals) and isolation valve leakage, are large and account for 80% to 90% of CH4 emissions (considering compressor source emissions plus equipment leak emissions reported under Subpart W). However, it is important to note that isolation and blowdown valve emissions, which are accounted as compressor source emissions under Subpart W, are considered to be fugitive emissions components under NSPS OOOOa when these valves are not used for venting (e.g., leakage past a closed blowdown valve). Consequently, the proportion of transmission and storage station emissions subject to the fugitive emissions requirements in NSPS OOOOa is greater than the 10% to 20% suggested by INGAA.

INGAA understands that leakage past closed isolation valves and blowdown valves are fugitive emissions. However, the Model Plant compressor stations in the TSD, which were used to estimate the cost-effectiveness of the proposed LDAR provisions, *only include non-compressor components*. For example, the component counts and component emission factors used in Table 2-5 and Table 2-7 of the TSD for the natural gas transmission and storage Model Plants are the same component counts and component emission factors for "non-compressor related components" in Table 4-17 and Table 4-24 of Volume 8 of the GRI/EPA study.

Table 3 below summarizes methane leak emissions for transmission compressor stations from the GRI/EPA study data. About 11% of the emissions are from non-compressor components that are represented by the TSD Model Plant. If the compressor seals (which are not covered by the fugitive emissions provisions in Subpart OOOOa) are removed from the Table 3 inventory, then about 13% of the emissions are from the non-compressor components that are represented by the TSD Model Plant.

As shown in Table 3, isolation valves, blowdown valves, and reciprocating compressor rod packing are the largest gas leak emission sources for transmission compressor stations. Similar trends are seen for the GRI/EPA study storage station data and compressor station data for other GHG inventories such as the U.S. GHG Inventory.[29]

The TSD Model Plant analysis does not consider emissions from leakage past closed isolation valves and blowdown valves or leakage from other non-major compressor related components, nor does the TSD Model Plant LDAR cost-effectiveness analysis consider repair costs associated with these components.

[29] *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2016, available at* https://www.epa.gov/sites/production/files/2018-01/documents/2018_complete_report.pdf.

Table 3. Transmission Compressor Station (CS) Leak Emissions (Data from GRI/EPA Study Volume 8, Table 4-17)

Leak Source	Source Leak Rate (Mscf CH4/yr)	Sources per CS[A]	Leak per CS (Mscf CH4/yr)		Percent of Total
Recip Compressor Rod Packing - OP[B]	834.5[C]	4.00	3,337.5	5,299.2	17.7%
Recip Compressor Rod Packing - SP[B]	490.5[D]	4.00	1,961.7		
Cent Compressor Seal - OP[B]	203.1[E]	0.40	81.4	98.6	0.3%
Cent Compressor Seal - SP[B]	43.1[F]	0.40	17.3		
Recip Compressor BD Valve - OP[B]	574.6[G]	4.00	2,297.9	4,174.2	14.0%
Recip Compressor BD Valve - SP[B]	430.9[H]	4.00	1,723.5		
Cent Compressor BD Valve - OP[B]	307.6[I]	0.40	123.2		
Cent Compressor BD Valve - SP[B]	73.7[J]	0.40	29.5		
Recip Compressor Isolation Valve - NOD[B]	2,680.0[K]	4.00	10,718.4	14,314.0	47.9%
Cent Compressor Isolation Valve - NOD[B]	8,976.0[L]	0.40	3,595.7		
Other Recip Compressor Components	552.0[M]	4.00	2,207.7	2,791.7	9.3%
Other Cent Compressor Components	1,458.0[N]	0.40	584.1		
Non-Compressor Station Components	3,200.0[O]	1.00	3,200.0	3,200.0	10.7%
			29,877.8	**29,877.8**	**100.0%**

Notes – all Tables and pages referenced in these footnotes are from Volume 8 of the GRI/EPA Study

- TF = Time Fraction compressor is in indicated mode
- 0.934 = default concentration of CH4 in natural gas for Transmission (scf CH4/scf NG, Table 4-17)

A. Reciprocating and Centrifugal compressors per compressor station calculated from equipment population data on page B-19 of Volume 8: Recips/CS = 6,799/1,700 = 4.00, Cents/CS = 681/1,700 = 0.40

B. OP = Operating Pressurized mode; SP = Standby Pressurized mode (also Not Operating Pressurized or Pressurized Idle); NOD = Not Operating Depressurized mode (also Standby Depressurized or Depressurized Idle)

C. = 3.3 (seals/compressor, Table 4-17) * 599 (Mscf NG/seal-yr, Table 4-21) * 0.452 (OP TF, Table 4-20) * 0.934

D. = 3.3 (seals/comp, Table 4-17) * 0.92 (fraction of compressors without Static-Pac®, pg 60) * [531 (Mscf NG/seal-yr, Table 4-21) * 0.339 (SP TF, Table 4-20) * 0.95 (fraction of compressors w/out Fuel Saver system, pg 59) + 116 (Mscf NG/ seal-yr, Table 4-21) * 0.339 (SP TF, Table 4-20) * 0.05 (fraction of compressors with Fuel Saver system, pg 59)] * 0.934

E. = 1.5 (seals/compressor, Table 4-17) * 599 (Mscf NG/seal-yr, Table 4-21) * 0.242 (OP TF, Table 4-20) * 0.934

F. = 1.5 (seals/compressor, Table 4-17) * 531 (Mscf NG/seal-yr, Table 4-21) * 0.058 (SP TF, Table 4-20) * 0.934

G. = 1 (BD valve/compressor, Table 4-17) * 1,361 (Mscf NG/BD valve-yr, Table 4-19) * 0.452 (OP TF, Table 4-20) * 0.934

H. = 1 (BD valve/compressor, Table 4-17) * 1,361 (Mscf NG/BD valve-yr, Table 4-19) * 0.339 (SP TF, Table 4-20) * 0.934

K. = 1 (Iso valve/compressor, Table 4-17) * 13,729 (Mscf NG/Iso valve-yr, Table 4-19) * 0.209 (NOD TF, Table 4-20) * 0.934

L. = 1 (Iso valve/compressor, Table 4-17) * 13,729 (Mscf NG/BD valve-yr, Table 4-19) * 0.700 (SP TF, Table 4-20) * 0.934

M. = 372 (Mscf CH4/PRV-yr, Table 4-17) + 180 (Mscf CH4/Miscellaneous-yr, Table 4-17). Miscellaneous = cylinder valve covers, fuel valves, other compressor components. (page 53)

N. = 1,440 (Mscf CH4/Compressor Starter OEL-yr, Table 4-17) + 18 (Mscf CH4/Miscellaneous-yr, Table 4-17). Miscellaneous = cylinder valve covers, fuel valves, other compressor components. (page 53)

O. = 3,200 (Mscf CH4/CS (non-compressor related components)-yr, Table 4-17)

A third conclusion is that significant emission reductions can be made by focusing on large leaks (e.g., those exceeding 2,000 scf NG/hr). This leak rate is approximately 3,500 grams CH4/hr,

> Assuming 95% methane in natural gas and 24 scf/lb of methane, 2,000 scf natural gas per hour is about 38,000 grams per hour. Note that this analysis in the PRCI Report is intended to illustrate the significant contribution of a small number of leaks to total leak emissions. It is not otherwise pertinent to the Subpart OOOOa discussion in INGAA material and the large leak data are included in the analysis regarding compressor emissions, compressor emission factors, etc.

which is significantly higher than the 60 g/hr fugitive emission detection threshold for the OGI equipment specified in NSPS OOOOa. While we agree that a significant portion of mass emissions result from these large fugitive emissions, the effectiveness of a fugitive emissions program is dependent on multiple factors. First, the procedures that are followed to conduct monitoring is an important factor that affects the effectiveness of a fugitive emissions program, and little information is available. However, at the time of the PRCI study, NSPS OOOOa had not been promulgated, therefore it is reasonable to assume that some of the OGI monitoring would not meet the procedures required for NSPS OOOOa.

> The reference to "PRCI study" here implies that there may be some confusion regarding the source of the data being discussed. The data analyzed in the PRCI Report are direct measurements of natural gas leak rates from major compressor components (i.e., compressor seals, isolation valves, and blowdown valves) reported under Subpart W. OGI monitoring conducted to detect leaks pursuant to Subpart W is very similar to the procedures required for NSPS OOOOa OGI monitoring where pre-test screening confirms OGI instrument functionality. PRCI selected the large leak threshold based on that data distribution from the dataset of over 10,000 measurements of major compressor components. The threshold was primarily used to illustrate the point that a small number of leaks contribute the majority of leak emissions. This point has been documented in many studies (e.g., Clearstone I[30] and Clearstone II[31]) and EPA's Natural Gas STAR program documentation related to directed inspection and maintenance.
>
> Subpart W provides a valuable dataset for assessing leak emissions, and a 2019 PRCI White Paper will further review this issue and present a sensitivity analysis that reviews the implications of different large leak thresholds on facility leak emissions distribution (i.e., "X" percent of the leaks contribute "Y" percent of the leak emissions for different leak size thresholds). As noted above, the PRCI Report illustration does not have any direct implications on the INGAA material commenting on the EPA TSD analysis.

Another factor is the frequency of monitoring, which affects how long fugitive emissions may exist prior to detection. As the frequency of monitoring increases, the amount of time a large fugitive emission exists prior to detection decreases. A second factor is the repair threshold, which prescribes the level of fugitive emissions that require repair. NSPS OOOOa requires repair of any fugitive emissions identified with OGI, or an alternative repair threshold of 500 ppm if Method 21 is used to detect fugitive emissions. We note that 60 g/hr is not a small fugitive

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[30] Clearstone Engineering Ltd. *Identification and Evaluation of Opportunities to Reduce Methane Losses at Four Gas Plants*. Calgary, Alberta: 2002.

[31] Clearstone Engineering LTD. *Cost-Effective Directed Inspection and Maintenance Control Opportunities at Five Gas Processing Plants and Upstream Gathering Compressor Stations and Well Sites.* (Draft): 2006.

emission. This would equate to 0.5 metric tons of CH4 emissions (or 13 metric tons of CO2e emissions) over the course of 1 year for each component identified as having fugitive emissions. INGAA focuses on estimating emissions based on detection using Method 21, but use of Method 21 is an alternative that achieves better, or at least equivalent, levels of emissions reduction to OGI.[32] Monitoring with OGI is considered the best system of emissions reduction (BSER) for NSPS OOOOa, and therefore impacts of the fugitive emissions requirements should be based on the use of OGI for monitoring. Because NSPS OOOOa considers monitoring with OGI BSER and the detection threshold for OGI in NSPS OOOOa is 60 g/hr,

> As EPA noted in Section 3.1 of its memo, the detection limit of OGI gas leak monitoring is impacted by many parameters:
>
> > "currently available OGI equipment varies based on changes in the fugitive compound(s) being imaged, ambient conditions (i.e., sky condition, wind speed, and background temperature), distance of the operator from the fugitive emissions source, and the visual acuity of the operator."
>
> INGAA agrees with this assessment, which leads to the conclusion that, in practice, it is likely that the OGI detection limit will vary for different sources during a leak survey. However, that detection limit will remain commensurate with a level that constitutes a relatively small leak.

we consider that the fugitive emissions requirements in NSPS OOOOa already allow facilities to focus on repairing relatively large sources of fugitive emissions, thus providing significant emission reductions in a cost-effective manner for the transmission and storage segment.

The following information provides context to the EPA's statement above and the PRCI analysis of large leak data.

- The Subpart W data indicate significant emission reductions could be made by focusing on large leaks (e.g., those exceeding 2,000 scf NG/hr are presented in Section 3.1 of the White Paper). Section 3.1 of the White Paper presents leak rate data from direct measurement of leak rates from major compressor components (compressor seals, compressor blowdown valves, and compressor unit isolation valves). These direct leak rate measurements were required by 40 C.F.R §§ 98.233(o) and 98.233(p) of Subpart W.
- Because the data PRCI analyzed were from Subpart W, all of the natural gas leak rate measurements were conducted in accordance with the methods listed in 40 C.F.R. § 98.234.
- OGI monitoring can be used to screen the major compressor components for emissions.[33] If emissions are not detected, volumetric emissions are assumed to be zero. If emissions are detected, then direct measurement of the emission rate is required. OGI must be conducted as specified by 40 C.F.R. §§ 98.234(a)(1) or 98.234(a)(6). 40 C.F.R. § 98.234(a)(6) references the OGI procedures specified in Subpart OOOOa (i.e., 40 C.F.R. § 60.5397a) and the OGI procedures specified by 40 C.F.R. § 98.234(a)(1) have similar requirements to the Subpart OOOOa OGI procedures (e.g., both are based on the EPA alternative work practice in 40 C.F.R. Part 60 general provisions and use the same technology, require a detection sensitivity of 60 grams per hour or less, daily

[32] 81 FR 35857 (June 3, 2016).
[33] *See, e.g.*, 40 C.F.R. § 98.233(o)(2)(i)(D).

performance checks to establish a maximum viewing distance based on site conditions (e.g., weather), and adherence to manufacturer instructions. Thus, OGI monitoring conducted to detect leaks required to be measured for Subpart W would be expected to produce similar results as OGI monitoring for NSPS OOOOa.

- INGAA agrees that leak monitoring procedures, frequency, and repair threshold will impact the control efficiency of a LDAR program. The key point of the analysis presented in Section 3.1 of the White Paper was that a small percentage of the detected leaks (i.e., ~ 3%) from compressor seals, isolation valves, and blowdown valves are the source of a majority of the gas emissions (i.e., ~ 63%). Thus, an LDAR program that focuses on the detection and repair of the largest leaks (i.e., repair threshold that includes the largest leaks) would be much more cost-effective than an LDAR program that requires any detected leak to be repaired according to a prescribed schedule, no matter how small (i.e., regardless of the actual gas leak rate).

In Section 3.2, INGAA presents the average number of equipment leak components found to be leaking at transmission stations and storage stations. They conclude in Section 3.2 that approximately 25 components are found leaking per station based on Subpart W data; however, they use this data in Section 5.1 of the White Paper to suggest that emissions from non-compressor components are small compared to compressor components.

Based on available information, including Subpart W data (which uses direct measurement for major compressor components and a leak survey with leaker emission factors for other facility components), total facility emissions from non-compressor components are typically very small compared to total emissions from compressor components (i.e., major compressor components and other non-major compressor components). The GRI/EPA Study transmission compressor station data presented in Table 3 show emissions from non-compressor components are about 11% of facility leak emissions and emissions from the compressor components are about 89% of facility emissions. Subpart W data are similar in magnitude.

We disagree with the assessments provided when excluding leaks greater than 2,000 scf NG/hr. INGAA states that these large leaks represent only about 3% of the measured leaks and represent 63% of the total compressor emissions. INGAA does not address the difference in how the OGI measurements are performed under Subpart W and NSPS OOOOa, which are a key factor in the number of fugitive emissions detected.

Please refer to the discussion above regarding OGI measurement methodology consistent with the current state of the art and OOOOa requirements, and the general illustrative purpose of reviewing the emissions contributions from larger leaks. The major compressor components data in the White Paper are from Subpart W-mandated leak rate measurements of specified sources. These data are not from an LDAR program detecting leaks from all components at a facility.

Furthermore, these data have been certified by facilities to be true, accurate and complete.[34] Therefore, we see no valid reason to remove the data exceeding 2,000 scf/hr from the analysis.

[34] 40 CFR 98.4(e).

The major compressor components emissions data presented in the White Paper with the data exceeding 2,000 scf/hr removed (e.g., Figure 3-4) are presented to illustrate the impact of larger leaks on the emissions inventory and to evaluate the impact of a leak mitigation program that primarily addresses large leaks. INGAA does not suggest that those data should be excluded from emission factors used to estimate compressor leak emissions.

The next paragraph in the EPA memo reviews and analyzes the data presented in Figure 5-1 of the White Paper. For Transmission, the TSD Model Plant compressor station uses the component counts and population emission factors for "Compressor Station (non-compressor related components)" in Table 4-17 of Volume 8 of the GRI/EPA Study ("Volume 8"). This Model Plant is used in the TSD to estimate the cost-effectiveness of various LDAR programs (e.g., different leak definitions, leak survey frequencies). White Paper Figure 5-1 compares the Model Plant emissions estimate to corresponding (i.e., non-compressor components) Transmission compressor station leak rate data collected for Subpart W. The Volume 8 Table 4-17 non-compressor components data are from a study conducted at five facilities[35] in 1994. The Subpart W leak data were collected from 2011 to 2016 during hundreds of leak surveys, and thus are much more likely to be representative of gas leak emissions from non-compressor components at present-day transmission compressor stations than the Volume 8 Table 4-17 data. The following paragraph reflects confusion about how non-major compressor components (i.e., all compressor service valves, connectors, etc.) that are not major compressor components (i.e., isolation valves, blowdown valves, and compressor seals) are accounted for in Volume 8 Table 4-17. EPA also compared the Subpart W compressor component plus non-compressor component leaks emissions to the Model Plant non-compressor component leaks emissions, which is an "apples and oranges" comparison, and does not consider that a comparable Model Plant (i.e., one with compressor components) would have many more components that would need to be considered in the cost-effectiveness analysis (e.g., component repair costs would likely be much higher). These two issues are discussed further below.

Further, we disagree with INGAA's analysis regarding the average number of components found to be leaking at transmission stations and storage stations. INGAA highlights their use of the non-compressor component emissions factors from Subpart W because the model plants used in the EPA model plant analysis in the TSD were based on 1996 GRI/EPA counts and emissions factors for non-compressor components. This is an erroneous analysis because of the differences in what is considered "compressor components" between the GRI/EPA study and the Subpart W equipment leak provisions. The only items considered to be compressor components in the GRI/EPA study are the compressor seal, the blowdown open ended line (through which both blowdown and isolation valve leakage emission are released), and starter open-ended lines.

EPA's conclusions in this paragraph regarding compressor components in the GRI/EPA study are not supported by information in the GRI/EPA report and in referenced documents.

[35] Refer to Reference number 12 in Volume 8 of the GRI/EPA Study "Indaco Air Quality Services, Inc. *Leak Rate Measurements at U.S. Natural Gas Transmission Compressor Stations*, Gas Research Institute, July 1994." A total of 17 facilities were included in the study; however, leaks from non-compressor components were only measured at five of the facilities. It appears that only leaks from major compressor components were measured at the other 12 facilities. Volume 8 of the GRI/EPA study states that "Compressor emission factors for station components were based on a measurement program at six compressor stations"; however, data in the Indaco Air Quality Services, Inc. report (refer to Table 3) indicate measurements were only conducted at five stations.

The GRI/EPA study compressor component list in the above paragraph is incomplete. Further, the GRI/EPA study and the Subpart W equipment leak provisions differentiate non-major compressor components and non-compressor components using the same methodology.

PRCI plans to explain the nuanced historical construct of compressor emissions factors in the GRI/EPA study in an upcoming White Paper that will update compressor emission factors using Subpart W direct measurements of major compressor components. INGAA welcomes additional discussion of this topic, if needed.

In short, the GRI/EPA study included emission sources other than "the compressor seal, the blowdown open-ended line (through which both blowdown and isolation valve leakage emission are released), and starter open-ended lines."

- Volume 8 Table 4-17 "Average Facility Emissions for Transmission" and Table 3 above (which is based on Volume 8 Table 4-17) list Pressure Relief Valve (372 Mscf/component-yr) and Miscellaneous (180 Mscf/component-yr) as emission sources for each reciprocating compressor. Volume 8 describes the Miscellaneous emission source as follows:

  > "Compressors have the following types of components: . . . 5) Miscellaneous. There are many components on each compressor, such as valve covers on reciprocating compressor cylinders and fuel valves" and "For the miscellaneous component category, there are many components per compressor engine, but the emission rates were minor and so were added into one lump emission factor per compressor for miscellaneous components."[36]

  Volume 8 further describes compressor-related components:

  > "Emissions from compressor-related components were estimated separately because of the differences in leakage characteristics for components subject to vibrational conditions, in addition to the unique types of components associated with compressors. The types of components associated with compressors include blowdown open-ended lines, starter open-ended lines, pressure relief valves, compressor seals, and other components such as cylinder valve covers and fuel valves."[37]

In addition, the Indaco report[38] (which documents the gas leak rate measurements used to develop the Volume 8 transmission segment compressor-related component and non-compressor-related component gas leak emission factors) provides additional detail regarding compressor components.

> "Several categories of components were located on reciprocating compressors. These include the gas pocket (also known as loaders and unloaders) caps, the gas pocket flanges, fuel valve and flange combinations located at the engine cylinder

[36] *See* Volume 8 at B-16.
[37] *See* Volume 8 at 53.
[38] Refer to Reference 12 in Volume 8 "Indaco Air Quality Services, Inc. *Leak Rate Measurements at U.S. Natural Gas Transmission Compressor Stations*, Gas Research Institute, July 1994."

> head, and fuel injection flanges, pile thread and valves not located at the cylinder head but still on the compressor."

The Indaco report also states: "there is a significant difference between similar components located on and off of the compressor."

As these sources show, the emissions from Subpart W leaking compressor components (i.e., valves, connectors, open-ended lines, pressure relief valves, meter or instruments, and other) correspond to the emissions from "Miscellaneous" components, "Pressure Relief Valves" and "Compressor Starter Open Ended Line" in Volume 8 (e.g., Table 4-17), and emissions from Subpart W leaking non-compressor components (i.e., valves, connectors, open-ended lines, pressure relief valves, meter or instruments, and other) correspond to the emissions from "Compressor Station (non-compressor related components)" in Volume 8 (e.g., Table 4-17).

Second, Volume 8 and the supporting documents for the Subpart W fugitive emission factors demonstrate that EPA's conclusion about INGAA's analysis being erroneous due to "the differences in what is considered 'compressor components' between the GRI/EPA study and the Subpart W equipment leak provisions" is itself erroneous. For transmission compressor stations, Volume 8 differentiates non-compressor-related station components from compressor-related components as follows:

> "Equipment leaks from transmission compressor stations were separated into two distinct categories because of differences in leakage characteristics:
>
> - Station components including all sources associated with the station inlet and outlet pipelines, meter runs, dehydrators, and other piping located outside the compressor building; and
> - Compressor-related components including all sources physically connected to or immediately adjacent to the compressors."

On page 49 of Volume 8, GRI and EPA referred to "station components (i.e., non-compressor related components)" and in Table 4-17, there is a reference to "Compressor Station (non-compressor related components)."

These references indicate that the station components are the non-compressor related components.

Subpart W does not include a definition of "compressor components" and there is no guidance regarding categorizing leaking components as "compressor components" or "non-compressor components" in the rule (e.g., 40 C.F.R. § 98.233(q)). This could be because the above text from Volume 8 represents a common industry understanding of the difference between compressor components and non-compressor components, and formal definitions are not needed. Regardless, the development of the Subpart W "compressor" and "non-compressor" leaking component (i.e., "leaker") emission factors demonstrate consistency with the GRI/EPA Study "compressor" and "non-compressor" component emission factors.

The Subpart W docket memo "Revisions to Processing Leaker Emission Factors in Rule Table W-2"[39] presents the data and methodology used to develop the compressor component

[39] EPA-HQ-OAR-2009-0923-0024.

and non-compressor component leaker emission factors for the Processing, Transmission, and Storage segments. Data from emission surveys conducted by Clearstone Engineering Ltd. for EPA (Clearstone I[40] and Clearstone II[41]) and for the Canadian Energy Partnership for Environmental Innovation (CEPEI)[42] were used to develop the emission factors. The docket for the development of Subpart W describes how leaking components were classified as compressor or non-compressor components during emission factor development.

> "Clearstone Engineering Ltd. provided all of the field emissions data collected in 1998 and 2004 from leaking components in the processing sector. It measured hydrocarbon emissions from components found in nine processing plants and categorized them by site, process unit, component type, and stream type. . . . The Clearstone I and II data were further categorized into compressor and non-compressor related components. Several equipment leak studies, including Clearstone studies, demonstrate that the mechanical (vibration) and thermal stresses created by compressors put additional stress on connected components making them more susceptible to leaking. This was done by filtering those components with process unit descriptions referring to compressors. For example, if the process unit description contained 'compressor' or a comparable label the data point would be categorized as compressor, otherwise it would be categorized as non-compressor."
>
> "Unlike the Clearstone I and Clearstone II studies, it was not possible to separate the compressor station components into centrifugal, reciprocating and non-compressor related. It was assumed that any component found at compressor stations was compressor related because the count of non-compressor related components is relatively small compared with compressor related components." [43]

IES was a contractor working with Clearstone for the Clearstone I and Clearstone II studies, and IES personnel participated in the leak detection and measurement efforts and can attest that compressor components were classified consistent with the GRI/EPA Study criteria.

To summarize, Table 4 compares transmission compressor station gas leak emission sources for the GRI/EPA study and for Subpart W, and also lists associated Subpart OOOOa provisions.

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[40] Clearstone Engineering Ltd. *Identification and Evaluation of Opportunities to Reduce Methane Losses at Four Gas Plants*. Calgary, Alberta: 2002.

[41] Clearstone Engineering LTD. *Cost-Effective Directed Inspection and Maintenance Control Opportunities at Five Gas Processing Plants and Upstream Gathering Compressor Stations and Well Sites.* (Draft): 2006.

[42] Clearstone Engineering Ltd. *Measurement of Natural Gas Emissions from the Canadian Natural Gas Transmission and Distribution Industry,* (for CEPEI), 2007.

[43] EPA-HQ-OAR-2009-0923-0024. This paragraph refers to the CEPEI data referenced above. About 80% of the total data used to develop the Subpart W emission factors were from the Clearstone studies that separated the compressor components and the non-compressor components.

Table 4. Comparison of GRI/EPA Study and Subpart W Transmission Compressor Station Gas Leak Emission Sources, and Associated Subpart OOOOa Provisions

Emission Source	GRI/EPA Study Volume 8	Subpart W	Subpart OOOOa Requirements
Non-compressor components leaks	Table 4-17. "Compressor Station (non-compressor related components)"	Leak survey required by § 98.233(q) and "Leaker Emission Factors—Non-Compressor Components" in Table W-3A	Periodic LDAR [§ 60.5397a]
Non-major compressor components leaks	Table 4-17. "Miscellaneous" + "Pressure Relief Valve"	Leak survey required by § 98.233(q) and "Leaker Emission Factors—Compressor Components" in Table W-3A	Periodic LDAR [§ 60.5397a]
Major compressor components			
Compressor seal/rod packing leakage	Based on data in Tables 4-18, 4-20, and 4-21	Direct emission measurement required by § 98.233(p)[B]	Periodic rod packing replacement [§ 60.5385a]
Compressor isolation valve through valve leakage	Based on data in Tables 4-19 and 4-20[A]	Direct emission measurement required by § 98.233(o) and (p)	Periodic LDAR [§ 60.5397a]
Compressor blowdown valve through valve leakage	Based on data in Tables 4-19 and 4-20[A]	Direct emission measurement required by § 98.233(o) and (p)	Periodic LDAR [§ 60.5397a]

A. These emission sources are combined and reported under "Compressor Blowdown Open-Ended Line" in Tables 4-17 and 4-18.

B. Measurements in standby pressurized (SP) mode are not required.

Thus, the GRI/EPA reports "compressor components" are essentially equivalent to the "compressor sources" covered under the compressor reporting requirements in Subpart W.

> The information provided above by INGAA shows that EPA's conclusion in the previous sentence about compressor components is not supported by documentation in the GRI/EPA report and in the Subpart W docket. Table 4 provides a summary of the correlation between compressor sources in the GRI/EPA reports and in Subpart W.

The emissions factors for equipment leaks for transmission and storage stations in Subpart W are not based on the 1996 EPA/GRI study, but rather are based on Clearstone studies.[44] These studies used a different definition of "compressor components," attributing many more valves, connectors, and other equipment components as "compressor components" than in the GRI/EPA study.

> The information provided above by INGAA demonstrates that EPA's conclusion in the previous sentence about the equivalency of the definitions of compressor components in the 1996 GRI/EPA study and in the Clearstone studies is not supported by documentation in the

[44] See *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry, Background Technical Support Document*, (Docket ID EPA-HQ-OAR-2009-0923), available at https://www.epa.gov/ghgreporting/subpart-w-technical-support-document.

GRI/EPA report and in the Subpart W docket, and by the experience of Clearstone study participants.

Approximately half of the leaking components at transmission and storage stations are reported under Subpart W as “compressor components.” These components should be included in the emissions estimates for equipment leaks using the compressor component emissions factors in Subpart W.

The TSD Model Plant compressor station only includes non-compressor components. Any comparisons of the Subpart W data to the TSD Model Plant should only include the non-compressor component emissions.

As a result of using only the non-compressor component emissions factor (and perhaps ignoring the compressor component leakers entirely), the comparison provided in Figure 5-1 is flawed and misrepresentative.

The data in White Paper Figure 5-1 compare the average transmission and storage compressor station emissions from non-compressor components based on Subpart W leak surveys with the TSD Model Plant compressor station emissions, which is the GRI/EPA study estimate of “Compressor Station (non-compressor related components)” from Volume 8 Table 4-17. Emissions from non-compressor components are compared to emissions from non-compressor components, and this comparison is <u>not</u> flawed and is <u>not</u> misrepresentative. If the TSD Model Plant compressor station included the emissions from reciprocating compressor “Miscellaneous” and “Pressure Relief Valve” and centrifugal compressor “Miscellaneous” and “Compressor Starter Open Ended Line,” then it would be more appropriate to compare emissions from such a Model Plant compressor station to Subpart W emission estimates that includes both non-compressor components and non-major compressor components.

A more direct assessment of the average facility CH4 equipment leak emissions for transmission and storage facilities can be made by simply summing the CH4 emissions reported by each facility across all of their equipment components (including both non-compressor and compressor components) and determining the average CH4 equipment leak emissions across all of the reporting facilities for the transmission and storage sector.

INGAA agrees that using the Subpart W non-compressor components plus the compressor components leak data for transmission and storage compressor stations would provide a more accurate estimate of present-day natural gas leak emissions than the GRI/EPA Study data. However, this would not be an equitable comparison with the TSD Model Plant compressor station, and the TSD LDAR cost-effectiveness analysis would need to be revised to include all the components associated with the compressors (e.g., Table W-1B to Subpart W lists 259 components per Western U.S. gathering and boosting compressor and the GRI/EPA study estimates about 4.4 compressors per compressor station, and more components means higher repair costs). Further, an even more accurate Model Plant compressor station analysis would include Subpart W measured sources – i.e., leak emissions from blowdown valve and isolation valve through-valve leakage. It should be noted that the repair/replacement costs for these large valves, particularly the isolation valves, may be orders of magnitude greater than for the other compressor components; these costs would need to be considered in LDAR cost-effectiveness calculations.

This more direct use of the Subpart W reported data shows reasonable agreement between the EPA model plant assessments and the equipment leak emissions reported under Subpart W.

INGAA would appreciate the opportunity to review EPA's analysis upon which it concluded that there is "reasonable agreement between the EPA model plant assessments and the equipment leak emissions reported under Subpart W." INGAA attempted to simulate this analysis and summarized its results in Tables 5A and 5B below.

Table 5A below presents the calculation for the fugitive emissions for the TSD natural gas transmission station Model Plant compressor station. Estimated methane emissions from the non-compressor components are 40.4 tons per year. Table 5B presents calculations for the estimated fugitive emissions for natural gas transmission compressor stations based on Subpart W counts of leaking components and Subpart W leaker emission factors. Estimated methane emissions for the non-compressor components, comparable to the Table 5A emission estimate, are 9.4 tons per years, about 23% of the TSD Model Plant estimate.

Estimated methane emissions for the non-compressor plus non-major compressor components are 20.2 tons per years, about 50% of the TSD Model Plant estimate. It is not clear if this 50% is the "reasonable agreement" to which EPA refers. If so, INGAA does not agree that a comparison of emissions from non-compressor components and emissions from non-compressor plus non-major compressor components is valid. These data strongly suggest that fugitive emissions from present day natural gas compressor stations are considerably lower than fugitive emissions from natural gas compressor stations in the early 1990s when the GRI/EPA study data were collected. Thus, the Subpart OOOOa TSD model plant data are very likely not representative of current natural gas operations that include a greater awareness of and attention to leaks that include improved equipment components (e.g., improved seal and valve technology) and maintenance practices. Participation in the voluntary EPA Natural Gas STAR program may also have been a factor that led to lower emissions.

Table 5A. Estimated Fugitive Emissions for TSD Natural Gas Transmission Model Plant Compressor Station[A]

Component[B]	**Model Plant Component Count[C]**	**Component Methane Emission Factor[C] (Mscf/year/component)**	**Methane Emissions (Mscf/yr)**	Tons CH_4/ Mscf CH_4	**Methane Emissions[D] (tpy)**	**VOC Emissions[D] (tpy)**
Valve	673	0.867	583.5	0.02082	12.1	0.337
Control Valve	31	8	248.0	0.02082	5.2	0.143
Connectors	3,068	0.147	451.0	0.02082	9.4	0.260
OEL	51	11.2	571.2	0.02082	11.9	0.329
PRV	14	6.2	86.8	0.02082	1.8	0.050
Total			**1,940.5**		**40.4**	**1.12**

A. Data from Subpart OOOOa TSD Table 4-8 and GRI/EPA Study Volume 8 Table 4-17

B. Excludes site blowdown OEL from GRI/EPA Study Volume 8 Table 4-17

C. Component counts and methane emission factors for non-compressor related components

D. VOC emissions calculated using 0.0277 weight ratio for VOC/methane obtained from Gas Composition memorandum.

Table 5B. Estimated Fugitive Emissions for Natural Gas Transmission Compressor Stations Based on Subpart W Counts of Leaking Components

Component	Sub W Leaking Components Count[A]	Sub W EF (scf THC/hr/ component[B]	CH_4 in THC[C]	scf CH_4/hr	Pressurized Time Factor[D]	Mscf CH_4/yr	tons CH_4/ Mscf CH_4	CH_4 Emissions (tpy)	VOC Emissions[E] (tpy)
Non-Compressor Components									
Valve	3.1	6.42	95%	18.9	1.0	165.6	0.02082	3.45	0.096
Connectors	3.7	5.71	95%	20.1	1.0	175.8	0.02082	3.66	0.101
OEL	1.1	11.27	95%	11.8	1.0	103.2	0.02082	2.15	0.059
PRV	0.28	2.01	95%	0.5	1.0	4.7	0.02082	0.10	0.003
Meter	0.083	2.93	95%	0.2	1.0	2.0	0.02082	0.04	0.001
Non-Compressor Components Total								**9.40**	**0.26**
Non-Major Compressor Components									
Valve	3.2	14.84	95%	45.1	0.67	264.8	0.02082	5.51	0.153
Connectors	4.2	5.59	95%	22.3	0.67	130.9	0.02082	2.73	0.075
OEL	0.72	17.27	95%	11.8	0.67	69.3	0.02082	1.44	0.040
PRV	0.23	39.66	95%	8.7	0.67	50.9	0.02082	1.06	0.029
Meter	0.033	19.33	95%	0.6	0.67	3.6	0.02082	0.07	0.002
Non-Major Compressor Components Total								**10.8**	**0.30**
Transmission Compressor Station Facility Total								**20.2**	**0.56**

A. Leaking component count data (average number of leaking components per facility) from Table 3-2 of the INGAA White Paper

B. Emission factors from Table W-3A of Subpart W

C. § 98.233(u)(2)(iii)&(iv)

D. Average time compressors either in operating pressurized mode or in standby pressurized mode. Data from Subpart W reporting.

E. VOC emissions calculated using 0.0277 weight ratio for VOC/methane obtained from Gas Composition memorandum.

3.3 California Air Resources Board (CARB) Correlation Equations

The third report that INGAA references in the White Paper is a study conducted by CARB titled "Enhanced Inspection & Maintenance for GHG & VOCs at Upstream Facilities – Final (Revised)".[45] The purpose of this limited-scope study was to develop correlation equations for leaking equipment in dry natural gas service located at production facilities (e.g., gas wells and natural gas processing plants) located in California. The study team modified the site-specific

[45] CARB (California Air Resources Board). 2016. *Air Resources Board RFP No. 13-414: Enhanced Inspection & Maintenance for GHG & VOCs at Upstream Facilities – Final (Revised).* Prepared by Sage ATC Environmental Consulting, LLC, available at Docket ID No. EPA-HQ-OAR-2017-0483.

correlation equation development method that is described in the EPA's "Protocol for Equipment Leak Emission Estimates" (1995 Protocol).[46]

For purposes of the CARB study, a test matrix was developed to collect screening values (in parts per million (ppm)) from monitoring components using Method 21. A total of 160 components at 39 sites were measured using the Bacharach Hi Flow Sampler® to calculate a methane emission rate for each type of component within the specific ppm ranges of the test matrix. The matrix was considered completed once at least 6 leaks were identified for each component within the specific ppm ranges. Once the matrix was complete, it is our understanding that additional leaks that had been detected were not used.

In the INGAA White Paper, an analysis is presented using the correlation equations that were developed in the CARB study in order to demonstrate that "emissions from gas leaks with EPA Method 21 screening values of 500 ppmv may be extremely low."[47] Figure 5-1 of the INGAA White Paper provides information regarding calculations performed by INGAA using various data sources for emissions, including the correlation equations from the CARB study. For transmission and storage stations, INGAA used a combination of the average number of leaking components (by component type) reported to the GHGRP under Subpart W, an assumed screening value of 50,000 ppm, and the component-specific correlation equations developed by CARB. EPA was not able to replicate this analysis.

> INGAA created the table below to aid EPA's analysis. The estimated emissions are provided as another example showing that leak emission estimates based on more recent measurements are much lower than the 25-year old GRI/EPA study data. INGAA understands that the CARB data has limitations and this issue is discussed below. However, the data from the EPA analysis is also very limited in scope and applicability (as discussed throughout these comments). INGAA's discussion of the CARB data was intended to illustrate another source that indicates lower leak emissions than historical data (e.g., lower than data used for Subpart W leaker emission factors, lower than 1990s data from the GRI/EPA report, lower than 1970s-1980s data from a chemical plant).

Further, EPA has several concerns with the analysis and use of the information from the CARB study.

[46] EPA-453/R-95-017. *Protocol for Equipment Leak Emission Estimates, November 1995*, available at Docket ID No. EPA-HQ-OAR-2017-0483.

[47] See "Methane Emissions from Natural Gas Transmission and Storage Facilities: Review of Available Data on Leak Emission Estimates and Mitigation Using Leak Detection and Repair," prepared for INGAA by Innovative Environmental Solutions, Inc., June 8, 2018, section 4.0, included as Attachment 1 to this memorandum.

Transmission facility-level non-compressor components gas leak emissions estimated using Subpart W Leaker Component Counts and CARB/Sage EFs									
Component	Count of Sub W Leaking Components[a]	CARB/Sage Emission Correlation[b]	M21 SV (ppmv)	50,000 ppmv EF (kg CH4/hr)	Total Emissions (Kg CH4/hr)	lb CH4/ kg CH4	Hr/yr	lb/ ton	ton CH4/ yr
	A	B	C	D=Bconstant* C^Bexponent	E=A*D	F	G	H	I=E*F*G/H
Valve	3.1	4.633E-11 x (SV)1.332	50,000	8.41E-05	2.61E-04	2.2046	8,760	2,000	2.5E-03
Connectors	3.7	1.946E-09 x (SV)0.8989	50,000	3.26E-05	1.21E-04	2.2046	8,760	2,000	1.2E-03
OELs	1.1	1.492E-10 x (SV)1.4328	50,000	8.06E-04	8.87E-04	2.2046	8,760	2,000	8.6E-03
Other (PRVs & Meters)	0.36	6.351E-12 x (SV)1.7547	50,000	1.12E-03	4.02E-04	2.2046	8,760	2,000	3.9E-03
Total									**1.6E-02**
a. Non-compressor leaking component count data from Table 3-2 of the INGAA White Paper (average for 2011 - 2016)									
b. Sage Report, Methane-equivalent Total Organic Compound (TOC) emission rates. (Table 1-2. Correlation Equations for Components in Natural Gas Service)									

First, while INGAA is attempting to provide information for comparison to the model plant estimates that EPA has developed, there is no direct comparison made. The information from the CARB study is not representative of transmission and storage compressor stations. Out of the 160 components used to develop the correlation equations in the CARB study, only 7 were identified as being associated with "NG Compressor & Transmission". It is not clear from the information presented in the CARB study whether these 7 sites are gathering and boosting stations or transmission stations. That is, EPA is unable to determine if these data points were collected from sites that are upstream or downstream of the natural gas processing plant. This information is important because the composition of the natural gas is chemically changed at the processing plant which will result in a different emissions profile for components located downstream of the processing plant. Even if these 7 data points represent emissions from transmission and storage compressor stations, this data set is extremely limited and unrepresentative for nationwide emissions estimation.

INGAA acknowledged the limitations of the CARB study data by stating in the INGAA White Paper:

> "direct comparisons between the CARB correlation equations and the Subpart W leaker EFs are not straightforward but can provide insight. The CARB leak rate/SV correlation equations are based on a relatively small data set, and the measurements were not intended to develop EFs. The Subpart W leaker EFs are based on older data that comprise a much larger data set with a wide range of measured leak rates."

But INGAA emphasized that regardless which methodology is used to estimate non-compressor component leak emissions, these leak emissions are minor relative to the emissions from major compressor components.

> "In either case, the leak estimates from facility components are relatively minor compared to the leak estimates from measured data (e.g., compare leak rates in Figure 5-1 to section 3 leak rates)."

INGAA did not intend to suggest that the compressor station gas leak emission estimates in White Paper Figure 5-1 based on the CARB study data should be used as a substitute for the Model Plant compressor stations gas leak emission estimates. But INGAA does consider the compressor station gas leak emission estimates in White Paper Figure 5-1 based on the Subpart W leaker counts and leaker emission factors (for non-compressor components) to be better estimates of gas leaks from present-day compressor stations than the TSD Model Plant compressor station gas leak emissions estimate.

The information collected by CARB was collected at 39 sites located in California. CARB specifically states the sites are "gas wells and natural gas processing plants".[48] Even though there are 7 data points labeled for transmission, these 7 data points are averaged with 153 data points collected from gas wells and natural gas processing plants. Given the change in chemical composition of the gas after processing, it is not appropriate to use correlation equations generated for upstream gas compositions to estimate downstream emissions. Further, it is well known that gas compositions vary across basins and formations. Therefore, while the information developed by CARB may be representative for sites in the state of California, it is not appropriate to assume these same correlations are representative of emission rates elsewhere in the country.

INGAA believes that estimates based on current data from upstream natural gas industry operations are more representative of current natural gas compressor station operations than 35 – 40 year old data from chemical plants. However, the key "take-away" from the CARB gas leak rate versus Method 21 screening value correlations is that gas leaks associated with leak screening values on the order of regulatory leak definitions/repair thresholds (e.g., order of 500 or 10,000 ppmv) are generally very small. Even if the correlations are biased low by a factor of 2 or 3 relative to correlations that would be developed for an average U.S. natural gas composition (e.g., due to different Method 21 instrument response factors for different gas streams), gas leaks associated with small screening values would still be very small and a very small percentage of the total leak emissions.

INGAA concurs with EPA's concern that the CARB data set is small and that the natural gas composition may not be representative of an average US natural gas composition. However, these data are current generation data from oil and natural gas operations, and they provide valuable insight into gas leak rate versus Method 21 screening value correlations. INGAA hopes that EPA has a similar concern about the data in Table 1 that were used for the example calculations for the EPA Leak Protocol LDAR CE model. Those data were from a very small data set for one type of component (valves only), are approximately 40 years old, and were collected from a different industry with gas composition that is not representative of oil and natural gas systems. If the criteria listed above (e.g., small data set based on possibly non-representative equipment and/or gas compositions) are valid reasons to refrain from relying on the CARB correlations, EPA should apply the same level of technical scrutiny to the data and assumptions used in the EPA Leak Protocol LDAR CE model example calculations.

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[48] CARB (California Air Resources Board). 2016. *Air Resources Board RFP No. 13-414: Enhanced Inspection & Maintenance for GHG & VOCs at Upstream Facilities – Final (Revised).* Prepared by Sage ATC Environmental Consulting, LLC, available at Docket ID No. EPA-HQ-OAR-2017-0483.

The INGAA analysis presented in Figure 5-1 uses the average number of components (by type) identified as leaking during the required Subpart W monitoring survey. The use of this information will underestimate the number of components leaking that are subject to NSPS OOOOa because different leak definitions apply to these standards.

OGI is BSER for Subpart W and the vast majority of Subpart W leak surveys were conducted using OGI; thus, the Subpart OOOOa and Subpart W leak definitions are essentially the same for most data collected.

While both regulations allow the use of OGI to identify leaks, Subpart W data in the INGAA analysis is based on a survey requirement of once per calendar year, while NSPS OOOOa requires quarterly surveys.

The leak survey frequency is not relevant to the data use. The Subpart W data are being compared to the TSD Model Plants as an indication of leak emissions from present-day transmission and storage natural gas compressor stations that are not subject to Subpart OOOOa LDAR requirements (i.e., "uncontrolled" facilities), not leaks identified by quarterly surveys. Subpart W leaker counts could be considered "somewhat controlled" facility data because it is likely some leaks are repaired after the Subpart W surveys are conducted, but Subpart W does not mandate leak repair. Further, the number of leaks detected during Subpart W surveys from 2012 to 2016 are similar to and not less than the number of leaks found in 2011, the first year of Subpart W surveys (refer to Table 6, data from Table 3-2 of the White Paper). This may suggest facilities were implementing some type of leak detection and repair activities prior to the first Subpart W surveys, but also that facilities were not implementing comprehensive leak repair programs because the number of leaking components did not decrease after the 2011 baseline year (e.g., the 2012 – 2016 average number of leaking components are generally greater than the 2011 values). As noted previously, current equipment, operations and maintenance practices include greater attention to leaks than in the early 1990s when the GRI/EPA Study was conducted.

Table 6. White Paper Table 3-2. Subpart W Component Leak Survey Results

Component	2011	2012	2013	2014	2015	2016	2012 - 2016 AVG
	Transmission (average number of leaking components per station)						
NC - Meter	0	0	0	0.1	0.2	0.2	0.1
NC - PRV	0.3	0.2	0.3	0.2	0.4	0.3	0.3
NC - OEL	0.8	0.8	1	1	1.4	1.4	1.1
NC - Connector	2.1	2.2	5.5	3.3	5.2	3.6	4.0
NC - Gas Service Valve	2.4	2.1	4	3	3.6	3.3	3.2
C - Meter	0	0	0	0.1	0.1	0	0.0
C - PRV	0.2	0.3	0.4	0.1	0.2	0.2	0.2
C - OEL	0.5	1	0.6	0.6	0.9	0.7	0.8
C - Connector	3.7	3.1	7.4	2.7	5	3	4.2
C - Valve	2.8	3	4.8	2.6	3.5	2.6	3.3

NC – non-compressor, C – compressor

Further, both Subpart W and NSPS OOOOa also allow the use of Method 21 to identify leaks. However, a leak is defined as a screening value of 10,000 ppm or greater in the Subpart W data in the INGAA analysis, but defined as a screening value of 500 ppm or greater under NSPS OOOOa.

As noted above, the vast majority of Subpart W leak surveys were conducted using OGI due to cost considerations; therefore, it is logical to assume that the vast majority of Subpart OOOOa leak surveys will likewise be conducted using OGI. Thus, the different Method 21 screening values for Subpart OOOOa and Subpart W leak surveys likely have minimal impact on the comparability of Subpart OOOOa and Subpart W leak survey data sets.

Further, there are some compressor stations that may not be subject to Subpart W reporting, but will be subject to NSPS OOOOa, depending on whether the emissions exceed the reporting threshold under the GHGRP. Additionally, NSPS OOOOa requires specific procedures to be followed for the detection of leaks, whereas Subpart W does not include all of these procedures (e.g., site-specific monitoring plans). Finally, the information presented in the INGAA White Paper presents the reported average number of leaking components identified for the years 2011 through 2016. This information predates the required fugitive emissions monitoring for NSPS OOOOa. Therefore, it is not appropriate to assume that the number of leaking components reported to Subpart W is representative of the number of leaking components subject to NSPS OOOOa.

Subpart W data was gathered to provide a better estimate of transmission and storage compressor station gas leak emissions before imposing regulatory obligations. Figure 5-1 in the White Paper compares estimated annual gas leak emissions from compressor stations based on Subpart W data (i.e., average number of components detected leaking during Subpart W leak surveys multiplied by Subpart W "leaker" emission factors) and the TSD Model Plant compressor station emissions. The TSD Model Plants were intended to estimate compressor station gas leak emissions before the implementation of Subpart OOOOa fugitive emissions monitoring provisions. As EPA noted about the Subpart W data: "This information predates the required fugitive emissions monitoring for NSPS OOOOa"; thus, the Subpart W data are the best available data to estimate "pre-Subpart OOOOa LDAR" compressor station gas leak emissions (i.e., before the implementation of Subpart OOOOa fugitive emissions monitoring provisions). The Subpart W data are much more representative of present-day compressor stations than the GRI/EPA study data. The Subpart W data include hundreds of leak surveys conducted over the six years, whereas the GRI/EPA study surveyed five facilities over 25 years ago. Thus, it would be appropriate to replace the TSD Model Plants emissions estimates with the Subpart W compressor stations emissions estimates.

In contrast, for both transmission and storage stations, EPA used average non-compressor component counts and average methane emissions factors that were developed in the GRI/EPA study from 1996 titled, "Methane Emissions from the Natural Gas Industry".[49] To estimate fugitive emissions at transmission and storage stations, the GRI/EPA study measured emissions using the GRI Hi-Flow Sampler. Fugitive emissions were detected using a soap solution at 6 transmission compressor stations. Every leak that was identified was measured

[49] Gas Research Institute (GRI)/U.S. EPA. Research and Development, *Methane Emissions from the Natural Gas Industry, Volume 8: Equipment Leaks*. June 1996 (EPA-600/R-96-080h).

using the GRI Hi-Flow Sampler. Emissions from components not identified as leaking were assumed negligible. In some cases, the leak rate exceeded the range of the GRI Hi-Flow Sampler. For those leaks, direct measurement was obtained using a rotameter. The average component emissions factors were derived from the measured leak rates for all components (leaking and nonleaking). These average emissions factors were then applied to the average component counts reported per site from the GRI/EPA study in order to estimate the total methane and VOC emissions at transmission compressor stations.[50] Therefore, the GRI/EPA analysis is still considered the most representative data set for estimating fugitive emissions in the EPA model plant analysis.

EPA has accurately described the GRI/EPA study data collection. However, INGAA disagrees that "the GRI/EPA analysis is still considered the most representative data set for estimating fugitive emissions in the EPA model plant analysis."

To be legally sound and withstand further scrutiny, the Subpart OOOOa record should reflect the data that provides the best estimate of uncontrolled (i.e., before Subpart OOOOa LDAR provisions are implemented) gas leak emissions from compressor stations that will be subject to Subpart OOOOa LDAR provisions. As discussed above, the Subpart W natural gas leak emissions estimates for compressor stations are based on a much more robust and representative data set than the GRI/EPA data that are the basis for the TSD Model Plants. The Subpart W data set is much larger (hundreds of stations surveyed vs. five) and were collected significantly more recently (2011 – 2106 versus the early 1990s). The Subpart W data also predate the required fugitive emissions monitoring for NSPS OOOOa. As EPA explained when it promulgated Subpart W in 2010, the purpose of gathering and reporting the Subpart W data was to inform future decision-making and potential regulations.[51] EPA should therefore now use the Subpart W data as part of its Subpart OOOOa decision-making.

Given the uncertainties and limitations of the data used to develop the correlation equations for the CARB study, EPA does not agree that it is appropriate to compare emissions estimated in the evaluation presented by INGAA to the emissions estimated in the EPA model plant analysis.

As noted above, INGAA did not intend to suggest that the compressor station gas leak emission estimates in White Paper Figure 5-1 based on the CARB study data should be considered a substitute for the Model Plant compressor stations gas leak emission estimates. INGAA provided a discussion of the CARB study because data from a recent study can provide insight into the current emissions, and the CARB study shows that current emissions are lower than leak emissions from many year ago. INGAA does consider the compressor stations gas leak emission estimates in White Paper Figure 5-1 based on the Subpart W leaker counts and leaker emission factors (for non-compressor components) to be better estimates of present-day compressor stations than the TSD Model Plant compressor stations gas leak emission estimates.

With respect to data uncertainties, the Model Plant gas leak emission estimate has an uncertainty of ±102% (at 90% confidence interval).[52] This is not an atypical uncertainty for gas leak emission estimates. INGAA makes this point because high uncertainty and

[50] Additional information about the EPA model plant analysis can be found in the Technical Support Document (TSD) located at Docket ID No. EPA-HQ-OAR-2017-0483.
[51] 75 Fed. Reg. 74,458, 74,460 (Nov. 30, 2010).
[52] 1996 GRI/EPA Report Volume 8, Table 4-17.

limitations are the norm when evaluating leak emissions data. Component gas leak rates can vary by orders of magnitude and faculty component counts can also have high variability; the resulting high uncertainties (e.g., standard deviations) for these parameters propagate to high uncertainties in calculated emission factors and emission estimates. As noted above, "perfect" data for estimating LDAR control efficiencies and gas leak emissions do not exist. All LDAR and gas leak emissions data have uncertainties and limitations, and analyses should focus on determining the best of the flawed data. As explained above, and in the INGAA comments regarding the proposed rule, the EPA TSD LDAR cost-effectiveness and LDAR control efficiency analyses have significant uncertainties and limitations. EPA implied that uncertainties impugn the CARB data but did not apply the same level of scrutiny to the TSD analyses and datasets as it applied to the information that INGAA provided.

4.0 CONCLUSIONS

In summary, the INGAA White Paper presents an analysis of third-party studies and reports as justification for annual monitoring at compressor stations. INGAA states in their analysis that EPA has underestimated the control effectiveness of annual OGI monitoring and overestimated emissions from fugitive emissions components at compressor stations. EPA has several concerns with the analysis and conclusions presented by INGAA in their White Paper. Based on our review of the conclusions presented by INGAA and the referenced third-party reports, we are unable to conclude at this time that this information supports annual monitoring for compressor stations.

In the 2018 proposed reconsideration, we are proposing semiannual monitoring for compressor stations. While recognizing our concerns with the information presented by INGAA, we are also co-proposing annual monitoring for compressor stations. At this time, EPA has not received data that supports a proposal to change the monitoring frequency to annual monitoring; however, EPA is soliciting comment and supporting information related to our analysis of the information, including data that supports the annual monitoring frequency suggested by INGAA as discussed in the 2018 proposed reconsideration.

Enclosures:

Attachment 1 – June 8, 2018 INGAA White Paper
Attachment 2 – June 20, 2018 Supplemental Information from INGAA
Attachment 3 – June 28, 2018 Supplemental Information from INGAA (revised)

INGAA appreciates the opportunity to provide further clarification regarding its earlier submittals to EPA regarding fugitive emissions monitoring frequency. Given the flaws in the three data sources that EPA cited when adopting quarterly monitoring for compressor stations, INGAA believes that this additional dialogue is warranted. It is possible that the EPA Leak Protocol LDAR CE model may be an appropriate method for estimating LDAR control efficiencies, provided the input data are accurate and representative of present-day natural gas operations. However, as explained above, the input parameters that EPA used are not representative of present-day natural gas operations. Rather, the input parameters were from a very limited, 40-year old, synthetic organic chemical manufacturing industry process stream data set. INGAA would be more willing to support EPA Leak Protocol LDAR CE model calculations if the input parameters were based on recent data from natural gas systems. For example, the leaking component counts from the Subpart W leak surveys combined with estimates of total facility component counts could possibly be used to estimate the initial leak rate for the LDAR CE model. Data reported to state LDAR programs could be evaluated to estimate leak occurrence rates and unable to repair rates. Ideally, the initial leak rate, leak occurrence rate, and unable to repair rates should be from the same or comparable data sets (e.g., find data from facilities that historically reported emissions for Subpart W and subsequently became subject to state or local LDAR regulations). In addition, a more representative compressor station model plant for LDAR cost-effectiveness calculations would include emissions from more than just the non-compressor components. These would include blowdown valves, isolation valves, and other non-major compressor components. Subpart W data could be a source of emission estimates for these sources, and source-specific repair cost data would need to be collected (e.g., for isolation valves). However, until such data are available for leak control model calculations, the CAPP report remains the most reliable and best supported estimate of leak emissions reductions. The CAPP report concluded that about 80% of gas leaks can be reduced through annual leak surveys. Given that EPA's regulations should be based upon the "best available science,"[53] the CAPP report should be the basis for EPA's decision-making regarding the frequency of fugitive emissions monitoring at natural gas compressor stations.

[53] 83 Fed. Reg. at 52,088.