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America's Evolving Oil and Natural Gas Transportation Infrastructure
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Topic Paper #4-10

METHANE LEAK RATE QUANTIFICATION VERSUS DETECTION

Prepared for the

Technology Advancement and Deployment Task Group

On December 12, 2019 the National Petroleum Council (NPC) in approving its report, *Dynamic Delivery – America's Evolving Oil and Natural Gas Transportation Infrastructure*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Permitting, Siting, and Community Engagement for Infrastructure Development Task Group. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached paper is one of 26 such working documents used in the study analyses. Appendix C of the final NPC report provides a complete list of the 26 Topic Papers. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

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Topic Paper (Prepared for the National Petroleum Council Study on Oil and Natural Gas Transportation Infrastructure)		
4-10	**Methane Leak Rate Quantification versus Detection**	
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SUMMARY

Historical gas transmission and storage leak studies have shown that a small number of large leaks contribute the majority of leak emissions and a large number of small leaks have a very small contribution to total leak emissions. Current technology identifies a leak but does not quantify the leak rate to prioritize resources to efficiently and effectively address the largest leaks. This topic paper addresses development and deployment of technologies that will identify, locate and quantify the leak flow rate.

I. Methane Leak Rate Quantification versus Detection

Historical gas transmission and storage leak studies have shown that a small number of large leaks contribute the majority of leak emissions and a large number of small leaks have a very small contribution to total leak emissions. Figure 1 presents the cumulative leak rates for the "EPA Leak Protocol"[1]. In the figure, gas service components are ordered from the smallest to the largest leak rate. For example, the ΣLeak Rates value for leak number 245 is the sum of the emission rates from the 245 smallest leaks. A small number of large leaks contribute the majority of the emissions; for example, about 2.5% of the leaks account for 50% of the gas leak emissions and about 15% of the leaks account for 90% of the leak emissions. Conversely, a large number of small leaks have a very small contribution to the total leak emissions; for example, the smallest 66% of the leaks only contribute about 1% of the total leak emissions. The figure shows that repairing the 200 smallest leaks in this dataset would result in minimal emission reduction and could increase emissions in some cases based on the repair and maintenance activities required. If repair of such a small leak is not readily achievable, additional actions other than ongoing tracking should not be required.

[1] EPA-453/R-95-017. Protocol for Equipment Leak Emission Estimates, November 1995

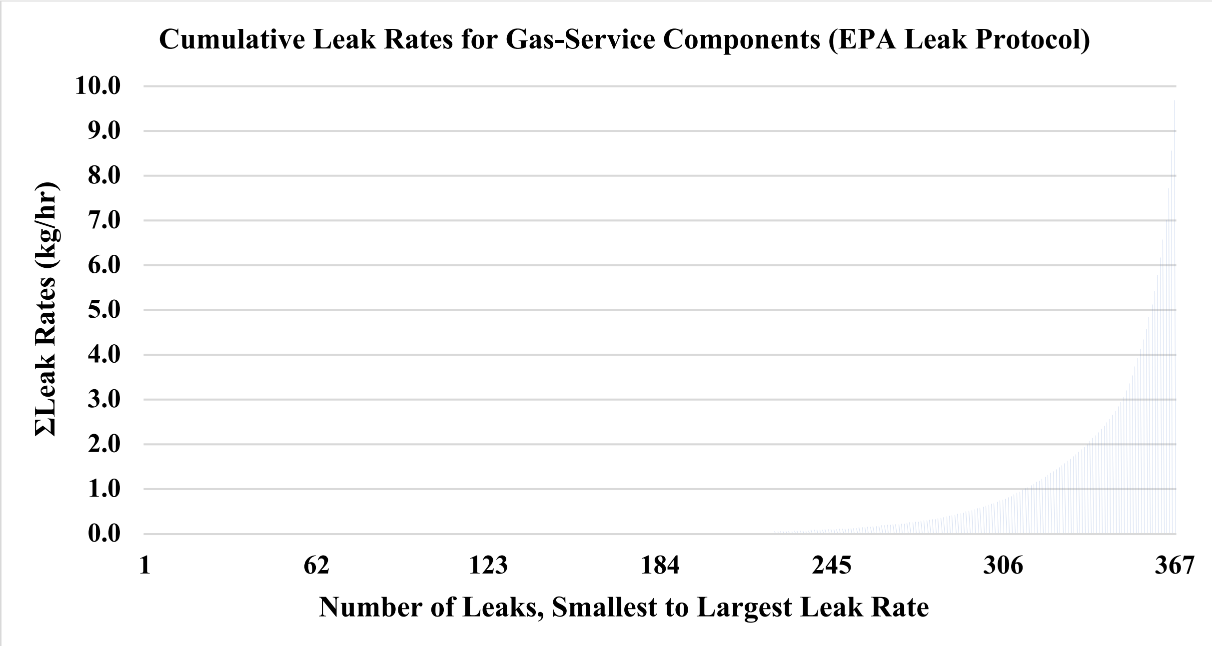

Figure 1 - Cumulative leak rates for EPA Leak Protocol gas-service components

Two common methods for identifying leaks are Method 21 and Optical Gas Imaging (OGI). With Method 21 a portable instrument is used to detect methane leaks from individual sources. The method is intended to locate leaks but is not capable of direct measure of mass emission rate. OGI uses a camera to identify leaking components. OGI cameras scan broad sections of equipment rapidly and survey areas that are hard to reach with traditional contact measurement tools like those used for Method 21. OGI does not have the ability to provide a measure of the mass emission rate.

Gas leak rates measured for a Method 21 screening value (SV)[2] can vary by several orders of magnitude, and SV is a very poor predictor of the mass emission rate of a leak. Figure 2 presents "EPA Leak Protocol" gas leak data for gas-service components with Method 21 SV on the x-axis and mass emission rate on the y-axis. This is a $\log_{10}$-$\log_{10}$ scale; thus, the difference between each division is a factor of ten. In addition, the leak rates reflected in the y-axis are very small emission rates (e.g., other than leaks with a "pegged" SV at 100,000 ppmv and one additional data point, the leak emission rates for this dataset are less than 0.1 kg/hr). A "pegged" SV, was recorded when the measured value exceeded the high range value for the Method 21 instrument (e.g., 10,000 or 100,000 ppmv). For not-pegged SVs, the SV was within the Method 21 instrument range and could be measured. The majority of the pegged-SVs are at 10,000 or 100,000 ppmv, and the range of the leak rates associated with these SVs is five to six orders of magnitude. Leak rates associated with not-pegged SVs also have a very large scatter and vary by

[2] "The original EPA studies correlated EPA Reference Method 21 measurement values (i.e., screening values) with a mass emissions rate from limited bagging results as a way to estimate emissions from the total population of components." (https://www.federalregister.gov/documents/2006/04/06/E6-5005/alternative-work-practice-to-detect-leaks-from-equipment)

up to three orders of magnitude or more. The majority of the largest leaks have pegged SVs of 10,000 and 100,000 ppmv (e.g. about 96% of leaks with leak rates > 0.003 kg/hr have pegged SVs).

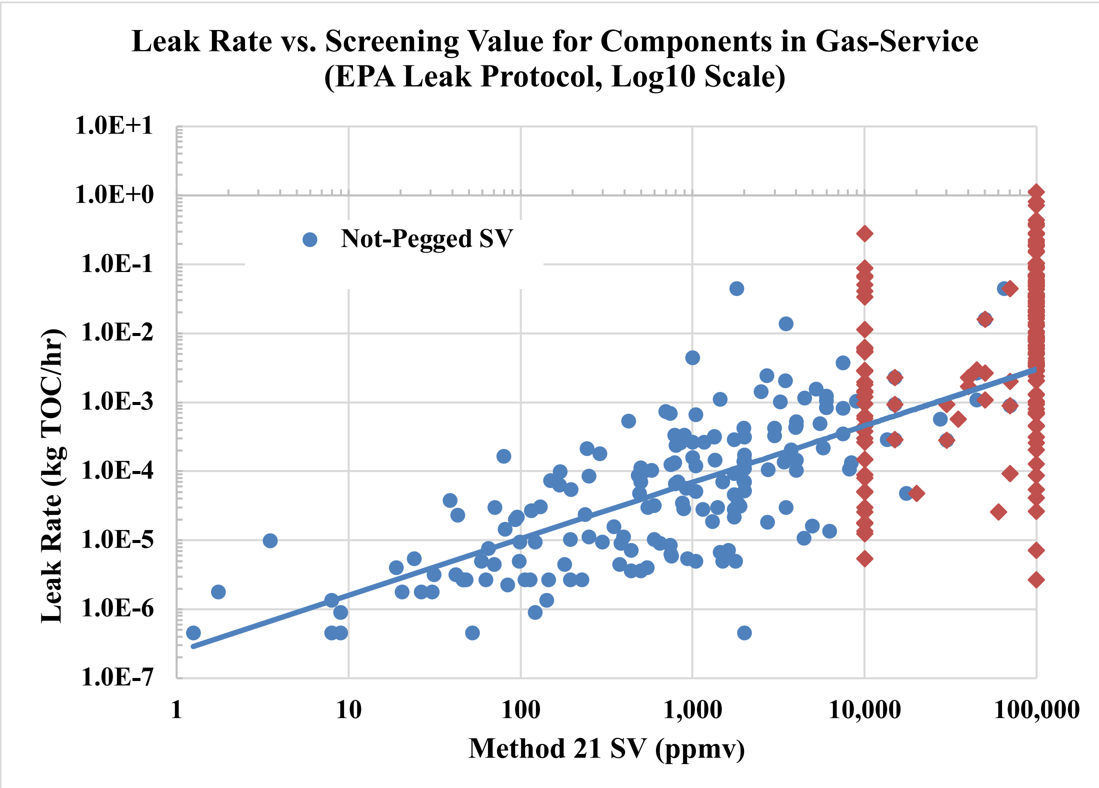

Figure 2 - EPA Leak Protocol gas leak rate vs. Method 21 SV for gas-service components

Leaks with SVs less than 10,000 ppmv have a very small contribution to total emissions. The great majority of large leaks have very high or pegged SVs, and leaks with SVs less than 10,000 ppmv have a very small contribution (e.g., ~ 2 to 3%) to the total emissions. Figure 3 graphs the data from Figure 2 using linear scales, and further illustrates that the majority of the largest leaks are associated with the pegged SVs of 10,000 and 100,000 ppmv.

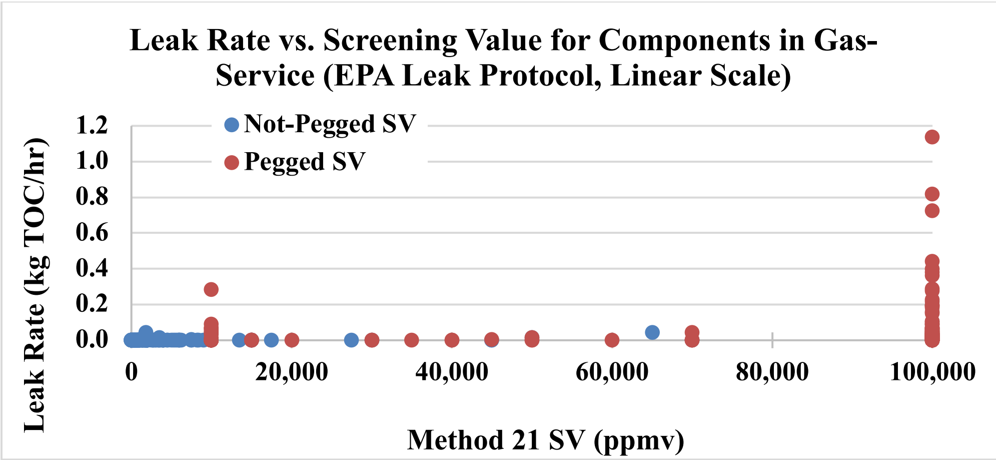

Figure 3 - Gas leak rate vs. Method 21 SV for gas-service components (linear scale)

Similarly, optical gas imaging (OGI) methods also detect many very small leaks. If not immediately achievable the repair of very small leaks may not be warranted. LDAR programs that require the repair of very small leaks according to a prescribed schedule may cause a net emissions increase (e.g., emissions from associated vehicular travel to conduct repair and/or emissions from equipment blowdown to allow safe repair).

Methane emission mitigation strategies for leaks could be advanced through deployment of "Smart LDAR" which would use OGI or similar screening tools to identify and quantify leak flow rates. This approach would be much more effective in reducing emissions and more efficient with resources than a conventional LDAR program. OGI does not currently have the capability to quantify leak flow rates, there is currently some research and product development to integrate leak rate quantification algorithms into OGI functionality. Before such leak rate quantification algorithms are developed, the ability to "bin" or classify leaks (e.g., as large or small) using OGI should be developed.

Another technology opportunity would be the development of next generation hi-volume samplers. Hi-volume samplers have the ability to directly measure the volumetric leak rate. Bacharach had been the sole supplier of a commercially available hi-volume sampler (i.e., the HI FLOW®) but has discontinued sales. These instruments had a limited range and suspected gas sensor and/or software malfunction[3]. There is a need for development of next generation hi-volume samplers, with improved flow meter range and more reliable gas sensors.

Another technology opportunity is development of instruments and methods to locate and quantify compressor unit isolation valves with through-valve leakage. At some compressor stations, numerous unit isolation valves vent though a common vent stack. Thus, vent measurement that shows through-valve leakage does not identify which isolation valve is leaking or if more than one valve may be contributing to the measured leak rate. The leaking valve must be identified to inform repair decisions. Current generation acoustic devices are not reliable for

[3] Howard, T., Ferrara, T.W, and A. Townsend-Small "Sensor transition failure in the high flow sampler: Implications for methane emission inventories of natural gas infrastructure," Journal of the Air & Waste Management Association, 65(7):856-862, 2015

detecting or measuring through valve leakage[4] [5], and next generation instruments are needed. For example, methods to correlate cross-valve thermal gradients measured by OGI / IR cameras to through-valve leakage.

In conclusion, there is need to develop technology that not only detects leaks but also quantifies the leak rate so that repair resources can be targeted to those leaks that will have the greatest impact on reducing emissions.

[4] Natural Gas Industry Methane Emission Factor Improvement Study Final Report. URS Corporation, The University of Texas, Austin, 2011.

[5] GHG Emission Factor Development for Natural Gas Compressors, PRCI Catalog No. PR-312-16202-R02, April 18, 2018.