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To: Peter Zalzal

From: Dana Lowell

Date: November 21, 2019

Re: **Rate of Equipment and Site Turnover to NSPS OOOOa Regulation**

This memo summarizes available information and analysis as to the rate at which existing, unregulated oil and gas equipment and facilities of various types will either be retired or fall under EPA's New Source Performance Standards (OOOOa) due to replacement or modification. The specific types of sites covered include oil and gas well sites, gas system gathering and boosting compressor stations, and transmission system compressor stations. The specific types of equipment covered include pneumatic controllers, pneumatic pumps, compressors, and storage tanks.

The analysis summarized here draws from numerous data sources, including the Regulatory Impact Analyses (RIA) and Technical Support Documents (TSD) developed by EPA over the last four years to support proposed changes to NSPS OOOOa, well data from Enverus™, data submitted to EPA from companies in the oil and gas industry under an Information Collection Request (ICR) in 2016 and 2017, NSPS OOOOa compliance reports submitted to EPA by oil and gas companies in 2017-2019, and prior research by MJB&A.

Table 1 Existing O&G Sources - Estimated Rates of Turnover to NSPS OOOOa Regulation

Facility/Equipment	Estimated Number of Existing Sources	NSPS OOOa Requirements	Time for All Existing Sources to be Retired or Regulated
Oil and Gas Well Sites	440,000	Fugitive emissions monitoring & repair	20+ years
Gathering and Boosting Compressor Stations	27,000 – 38,000	Fugitive emissions monitoring & repair	25+ years
Transmission Compressor Stations	1,872	Fugitive emissions monitoring & repair	Unknown
Transmission Pneumatic Controllers	84,000+	Emissions Limit	7 - 10 years*
Pneumatic Pumps	Unknown	Route emissions to control equipment	Unknown
Compressors	122,000 – 172,000	Maintenance requirements	30+ years
Storage Tanks	445,000+	Professional certification of design	Unknown

***** *This reflects EPA's own estimate. MJB was not able to separately substantiate EPA's assumptions*

See Table 1 for a summary of the number of existing sites/pieces of equipment of each type, the NSPS OOOOa requirements for new or modified facilities, and the estimated number of years before all in-use facilities will be subject to NSPS OOOOa requirements. The data sources and method(s) used to develop the data in Table 1 are described below.

The estimated turnover rates in Table 1 are based on average data and, while some individual sources might retire or be replaced more quickly, it is equally likely that other individual sources would be retired or replaced on a longer time frame. The timeframe for full retirement or replacement of every existing unit of each facility/equipment type could therefore be even longer than the averages suggest.

Oil and Gas Well Sites

According to the U.S. Energy Information Administration, in 2016 there were 566,930 existing natural gas wells and 442,790 existing oil wells in the U.S [1]. The current NSPS OOOOa requirements took effect in 2016; all new wells drilled, or wells modified since September 2015 are subject to these requirements. EPA assumes that there are an average of two wells per site across the country; based on this assumption, in 2016 there were approximately 505,000 well sites in the U.S.

While there is significant variability from well to well, the general industry consensus is that most oil and gas wells will continue to produce for 20 to 30 years. In the literature one can find numerous examples of statements such as this, from geology.com: "The typical well might yield as much as half of its gas in the first five years of production. Wells might then continue to produce for a total of twenty to thirty years but at lower and lower production rates".[2] The idea that wells will continue to produce for many years despite declining monthly production is supported by the fact that between 2000 and 2017 80 percent of all U.S. oil and gas wells were so-called "stripper wells" with very low production rates, less than 15 barrel-of-oil-equivalents per day (BOE/day); over this time period more than 40 percent of in-use wells produced less than 2 BOE/day [3].

Assuming an average 25-year life, about 4 percent of existing wells are retired or "shut-in" each year. As such, of the one million producing wells in existence in 2016, at least 88 percent (880,000 wells, at 440,000 well sites) are likely still producing, and some of these wells will continue to operate for another 20 years or more.

Existing wells will be subject to NSPS OOOOa if significantly "modified" in order to increase or prolong their production – for example by re-fracking an unconventional shale well. Available data suggests, however, that the number of well modifications each year is small. For a previous project completed for EDF, MJB&A analyzed data from Enverus™ [1] which included details of all new and modified wells developed in the U.S. between October 2015 and October 2018[2] [4]. Over this three-year period after the NSPS OOOOa implementation date, a total of 26,977 wells were determined to be "new" and a total of 6,733 wells were determined to be "modified". This is an average of 8,992 new wells and 2,244 modified wells per year. Between late 2015 and late 2018 approximately 0.67 percent of the wells in operation in 2016 were modified, or an average of 0.22 percent per year.

MJB&A also analyzed Air Emission Reports (AERs) submitted to EPA by oil and gas production companies in compliance with the reporting requirements of NSPS OOOOa [5]. Across all of the reports submitted as of

[1] Enverus™ was previously called DrillingInfo.

[2] This includes all wells with listed "First Production Date" between 10/1/15 and 10/30/18, and total production over this time period >1 BOE.

October 2018 MJB&A was able to identify 3,116 unique wells for which the various companies had submitted the required data. This included reports submitted for reporting years 2017 and 2018. In late August 2019 MJB&A downloaded all additional reports which had been submitted since October 2018; this included reports for the 2018 and 2019 reporting years. MJB&A was able to identify a total of 5,122 unique wells among all of the submitted reports (2017, 2018, and 2019). This was an increase of 2,006 wells subject to NSPS OOOOa. This is in fact lower than the number of new wells (subject to NSPS OOOOa) that would be expected to come on line each year (see above), and is further evidence that only a small number of existing wells is "modified" each year in a way that would subject them to the fugitive emissions requirements of NSPS OOOOa.

MJB&A also analyzed Oil and Gas Industry data received by EDF from EPA under a Freedom of Information Act (FOIA) request [6]. This data was originally collected by EPA from companies in the Oil and gas industry under a 2016 Information Collection Request (ICR). This data, which was received by EPA prior to them withdrawing the request, includes details of the installed equipment at 160,929 oil and gas "well sites" and 20,263 oil and gas "central production sites"[3]. This represents approximately 36 percent of all existing oil and gas well sites, but an unknown percentage of gas gathering and processing facilities.

Under Part 1 of the surveys, due in January 2017 (roughly 15 months after September 2015 imposition of NSPS OOOOa) facilities were required to report whether they were subject to OOOOa. Only 3 percent of reported wells (4,880 of 160,929 reported wells) and 14 percent of reported central production sites (2,893 of 20,263 central production facilities) were reported as subject to OOOOa.

Based on the available evidence, MJB&A estimates that including both shut-ins and modifications, approximately 4.25 percent of existing wells and well sites will be either removed from service or will come under NSPS OOOOa regulation each year. That means that the NSPS OOOOa requirements will not apply to the entire universe of U.S. wells for at least another 20 years.

Gathering and Boosting Compressor Stations

In the Technical Support Document for the 2016 NSPS OOOOa rule making, EPA estimated that there were 8,015 compressor stations in the gathering and boosting system [7]. This estimate was based on their estimate of the number of gathering and boosting compressors, which itself was based on the then current national GHG inventory. As noted below in the discussion of compressors, based on new information provided to EPA in 2017 by companies in the O&G industry in response to an EPA Information Collection Request (ICR), it appears that EPA's estimate of the number of gathering and boosting compressors is significantly understated. As such, EPA's estimate of the number of gathering and boosting compressor stations is likely also significantly understated. Based on the ICR data, and EPA's original assumption that there are an average of 4.5 compressors

[3]In the ICR request, EPA defined central production sites as "Any onshore surface site that obtains crude oil or a mixture of crude oil and natural gas directly from multiple well surface sites without a custody transfer, and includes all equipment used in the transportation, compression, stabilization, separation, storing or treating of crude oil and/or natural gas (including condensate) located at the surface site under the control of the same person (or persons under common control)." EPA defined well sites as "One or more surface sites that are constructed for the drilling and subsequent operation of any oil well, natural gas well, or injection well. For purposes of this ICR, well surface site refers only to the well(s) and equipment at the disturbed area of land associated with the well(s) that are under the control of the same person (or persons under common control)."

per compressor station, MJB&A estimates that there are between 27,000 and 38,000 gathering and boosting compressor stations nation-wide.

Existing compressor stations installed prior to 2016 will become subject to the fugitive emission requirements of NSPS OOOOa if they are "modified". Only the expansion of a compressor station is considered a "modification" that triggers NSPS OOOOa applicability, either by 1) installation of an additional compressor, or 2) replacement of one or more compressors at a compressor station by compressor(s) of greater total horsepower than the compressor(s) being replaced. When one or more compressors is replaced by one or more compressors of an equal or smaller total horsepower than the compressor(s) being replaced, installation of the replacement compressor(s) is not considered modification of the station with respect to NSPS OOOOa [8].

The only reason to expand an existing gathering and boosting compressor station is to accommodate an increase in gas volume or pressure within the surrounding system. Such increases are highly unlikely in mature locations without much new drilling activity, as production from all gas wells falls quickly after completion. In built-out locations volume and pressure within the gathering system will be continuously falling, and it will be more likely that compressor stations will be down-sized (by removing compressors) than expanded. In areas with significant new drilling activity, it is possible that existing compressor stations will be expanded, in addition to new compressor stations being developed.

In their 2019 Annual Energy Outlook, the Energy Information Administration estimates that an average of 34,000 new oil and gas wells will be drilled each year between 2020 and 2030, and that in 2030 annual natural gas production will be 15 percent higher than in 2020 [9]. Given that the average productive life of most wells is 25 years, this is just enough new wells (~4 percent/year) to replace the wells projected to be shut-in, and the total number of active wells should stay relatively static. If all of this new drilling activity was in already developed areas, it would therefore affect about 4 percent of the existing boosting and gathering system each year, potentially requiring expansion of 4 percent of existing compressor stations. If all of this new drilling activity was in undeveloped areas, new compressor stations would be required, and up to 4 percent of existing compressor stations might be completely abandoned as old wells were shut in, and pressure and throughput in the surrounding gathering system fell. Either way, each year up to 4 percent of existing compressor stations could either be replaced with new stations (in a different location) or expanded. This means that it will likely take at least 25 years or more for all boosting and gathering compressor stations nation-wide to become subject to the fugitive emission requirements of NSPS OOOOa.

Transmission Compressor Stations

In the Regulatory Impact Analysis for the 2019 NSPS OOOOa reconsideration, EPA states that there were 1,800 transmission compressor stations in 2014, and that this number grew by an average of 36 stations per year in the 10 prior years; this data comes from the national GHG inventory [10]. Based on this data, the number of existing stations not subject to the NSPS OOOOa fugitive emission requirements is estimated to be 1,872 (the number existing in 2016).

MJB&A was not able to find any information on the number of transmission compressor stations that are expanded each year, thus triggering NSPS OOOOa fugitive emission requirements. We therefore cannot estimate how long it will take for all in-use transmission compressor stations to be subject to NSPS OOOOa.

Pneumatic Controllers

In the Technical Support Document for the 2016 NSPS OOOOa rule making, EPA estimated that there were 84,000 pneumatic controllers in the natural gas transmission and storage segment; the source of this estimate was

EPA's Gas Star Program [11]. The number of pneumatic controllers throughout the entire natural gas value chain, including at well sites, processing facilities, and gathering and boosting stations is likely significantly higher, but MJB&A was not able to find any additional information that would allow us to produce a better estimate.

In the Regulatory Impact Analysis for the 2019 NSPS OOOOa reconsideration, EPA states that "Pneumatic controllers are assumed to have a lifetime of ten years." [12]. No source or justification is noted for this assumption.

MJB&A was not able to find any information to confirm or refute EPA's assumption as to the useful life of pneumatic controllers.

Pneumatic Pumps

MJB&A was not able to find any information on the number of pneumatic pumps in the oil and gas supply chain, or any information on the useful life of this equipment. We therefore cannot estimate how long it will take for all in-use pneumatic pumps to be subject to NSPS OOOOa requirements to have emissions routed to control equipment.

Compressors

Number of Compressors

In the Technical Support Document for the 2016 NSPS OOOOa rule making, EPA estimated that there were 36,000 compressors installed in the natural gas gathering and boosting system, based on the then current GHG inventory [13]. This is almost certainly a significant under-estimate.

The ICR data received by EPA from oil and gas companies and analyzed by MJB&A (see discussion of Oil and Gas Well Sites above) included data on the number of compressors installed at reported well sites and central production sites. The companies reported a total of 8,201 compressors at the 160, 929 reported well sites (one for every 19.6 sites) and 53,335 compressors at the 20,263 reported central production sites (2.6 per site).

Based on this sample, it is likely that there are at least 22,000 compressors associated with the 440,000 existing wells sites, and between 100,000 and 150,000 associated with existing boosting, gathering, and processing facilities[4].

Compressor Turn-over Rate

In 2014 MJB&A conducted an extensive literature review to determine the turn-over rate of compressors used in the natural gas gathering and boosting system, and in the natural gas transmission system. This review included websites, press releases, and financial reports from the major compressor manufacturers and compressor service companies; a compressor database, environmental impact statements, and rate case files produced or maintained by the Federal Energy Regulatory Commission (FERC); air emissions permits and siting permits available online from Colorado state agencies; and air emissions permitting guidance from the Pennsylvania Department of Environmental Protection. In addition, MJB&A staff had conversations with air regulators in Pennsylvania, a

[4] The higher number would apply if the facilities for which EPA received data represent a similar percentage of all facilities as for well sites (36 percent).

former air emissions inventory expert from a gas producing state, and members of the environmental policy and permitting staff at a natural gas distribution company that owns and operates compressors for storage.

It is clear from this literature review that the in-service life of most large reciprocating compressors, like those used for gas gathering and transmission, is 30 – 50 years, indicating that the turnover rate of existing to new machines is generally less than 3% per year.

This conclusion is supported by anecdotal statements from companies and individuals that operate throughout the natural gas value chain and by numerical data on the actual age of a limited number of in-service compressors. The general consensus is that compressors are rebuilt regularly (every 3 – 6 years), but are only "replaced" if: 1) a compressor station is upgraded to increase capacity, 2) a compressor catastrophically fails in service, or 3) annual maintenance costs increase significantly compared to similar machines.

Some examples of industry statements that support this conclusion:

- [Rotary equipment] has a typical operating life of 30 years or more. [Dresser Rand annual report]
- Our compressors can operate 50 years or longer. [Neumann & Esser annual report]
- NiSource Midstream Services recently completed a significant compressor upgrade project at its Majorsville compressor station in Dallas, West Virginia. The project consisted of the replacement of four vintage Ingersoll Rand KVG412 compressors, installed in 1956 [56 years old], with four new CAT 3606 engines using Ariel JGC4 compressors. [Ariel Press Release]
- The first compressor ever sold by Ariel (the JG, serial no. 1) was found in 1995 still working, 27 years later. [Ariel website].
- "We estimate that roughly 50 percent of all of the units we've ever built are still in service," said Dave Morse, consultant, at Dresser-Rand, who has been with the company for more than 50 years…"Most recip units are designed for a minimum life span of 20 years. But many have reached the 40-year mark, and some have been operating for 50 years or more." [Dresser Rand press release]

In addition, at least two major manufacturers (Dresser, Neumann) advertise "Revamp and Modernization Programs" for older, in-service compressor units. Designed to replace original parts with new, upgraded parts that incorporate modern design elements, these programs are advertised to provide "cost advantages compared to new" and to include "structural improvements to extend the working life of a machine by a considerable factor."

Review of filings related to rate cases, which are maintained by the Federal Energy Regulatory Commission (FERC), yielded the following statements from utility companies related to compressor age:

- "The life expectancy for simple and complex gas transmission stations and PG&E's three gas terminals is based on the life expectancy of individual asset components, and typically is 40-50 years. Currently, there is a large population of M&C stations above this age." (Pacific Gas and Electric Company 2015 Gas Transmission and Storage Rate Case Prepared Testimony, Dec 2013)
- "It's selection for this account is supported by evidence on the average age of Viking's current compressor stations (41.6 years), the average age of compressors overhauled as capital overhaul projects during 2006-2011 (35.4 years), and the average age of compressors overhauled as operation and maintenance overhaul projects during 2006-2011 (42.1 years)" (Viking Gas Transmission Company Docket No. RP13-185-000 Direct Testimony of Commission Trial Staff, May 2013)

- "The Ruston Storage Compressor Station consists of one 4,000 hp Worthington MLV-14 Reciprocating Compressor unit that was originally installed 40 years ago. Worthington has since gone out of business and CEGT can no longer purchase replacement parts for the Worthington Unit, rendering it obsolete." (CenterPoint Energy Gas Transmission Company, LLC Ruston Storage Compressor Replacement Project, May 2012)
- In the document, "Summary of the Prepared Answering Testimony on NGA Section 5 Issues of Dennis D. Alters" which was prepared by Florida Gas Transmission Company, LLC a list of compressors by age and horsepower was provided as an attachment. The list contained a total of 92 reciprocating compressors with a total combined horsepower of 209,789 HP. Of the total number of compressors, 40 compressors (43%) were older than 50 years, 24 (26%) were between 40 and 50 years and 21 (23%) were between 20 and 30 years old.

Storage Tanks

The ICR data noted above in the discussion on well sites and compressors also included data on the number of "atmospheric storage tanks" at each well site and central production site reported by responding companies. The companies reported a total of 162,374 storage tanks at the well sites (1 per site) and 2,687 storage tanks at the central production sites (one for every 7.5 sites).

Based on this sample, it is likely that there are at least 440,000 storage tanks located at the existing 440,000 well sites, and between 5,300 and 8,000 storage tanks at existing boosting, gathering, and processing facilities[5].

MJB&A was not able to uncover data on the typical service life of storage tanks in the oil and gas industry, so it is not possible to estimate a turn-over rate for this equipment.

[5] The higher number would apply if the facilities for which EPA received data represent a similar percentage of all facilities as for well sites (36 percent).

REFERENCES

[1] U.S. Energy Information Administration, *U.S. Oil and Natural Gas Wells by Production Rate,* Appendix C, https://www.eia.gov/petroleum/wells/

[2] Geology.com, Geoscience News and Information, *Production and Royalty Declines in a Natural Gas Well Over Time*, https://geology.com/royalty/production-decline.shtml, accessed November 21, 2019

[3] U.S. Energy Information Administration, *The Distribution of Oil and Natural Gas Wells by Production Rate,* Figure 1, October 2018, https://www.eia.gov/petroleum/wells/pdf/full_report.pdf

[4] Three separate DrillingInfo queries were conducted to identify new and modified wells relative to September 18, 2015. Filters used were COUNTRY= 'USA' and PRODUCTION TYPE = 'CBM', 'GAS', 'O&G', 'OIL', 'OIL (CYCLIC STEAM)', 'STEAMFLOOD', and 'WATERFLOOD'. The first data pull filtered for spud dates on or after September 18, 2015. The second filtered for completion dates on or after September 18, 2015. The third filtered for first production dates on or after September 18, 2015. These three datasets were combined and narrowed to unique records. Wells were classified as new or modified as follows: If a well had a spud date on or after 9/18/15, it was classified as new. If a well had a missing spud and a first production date on or after 9/18/15, it was classified as new. If neither of the above were true, but the well had a completion date on or after 9/18/15, it was classified as modified. Wells not classified as new or modified were removed from the dataset. Yearly production data were pulled for this set of wells. For wells in which PRAC IP BOE was less than or equal to 15, monthly production data were also pulled.

[5] U.S. Environmental Protection Agency, Clearinghouse for Inventories & Emission Factors, Emission Factors & AP-42, webFIRE, https://cfpub.epa.gov/webfire/reports/eSearchResults.cfm; Accessed on July 31, 2018 and August 29, 2019

https://www.foiaonline.gov/foiaonline/action/public/submissionDetails?trackingNumber=EPA-HQ-2018-001886&type=request: Last accessed on October 9, 2018.

[6] https://foiaonline.gov/foiaonline/action/public/submissionDetails?trackingNumber=EPA-HQ-2017-003014&type=request.

[7] U.S. Environmental Protection Agency, *Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources, Background Technical Support Document for the Final New Source Performance Standards 40 CFR Part 60, subpart OOOOa*, May 2016; page 135

[8] Code of Federal Regulations, Part 40, Subpart 60.5365a (j); [40 CFR 60.5365a (j)]

[9] U.S. Energy Information Administration, *Annual Energy Outlook 2019*, Reference Case, Table 14, Oil and Gas Supply, January 2019

[10] U.S. Environmental Protection Agency, *Regulatory Impact Analysis for the Proposed Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Review,* EPA-452/R-19-001, August 2019, page 2-8

[11] U.S. Environmental Protection Agency, *Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources, Background Technical Support Document for the Final New Source Performance Standards 40 CFR Part 60, subpart OOOOa*, May 2016; page 58

[12] U.S. Environmental Protection Agency, *Regulatory Impact Analysis for the Proposed Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Review,* EPA-452/R-19-001, August 2019, pg 2-13

[13] U.S. Environmental Protection Agency, *Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources, Background Technical Support Document for the Final New Source Performance Standards 40 CFR Part 60, subpart OOOOa*, May 2016; page 135