OZONE TRANSPORT COMMISSION

OTC Regulatory and Technical Guideline for Control of Nitrogen Oxides (NOx) Emissions from Natural Gas Pipeline Compressor Fuel-Fired Prime Movers

Analysis of Technical Feasibility and Cost Effectiveness

May 14, 2019

Contents

Introduction

On November 15, 2017, the Ozone Transport Commission (OTC) adopted a resolution[1] asking that the U.S. Environmental Protection Agency (EPA) take all actions necessary to fully address the good neighbor provision for the 2008 and 2015 ozone National Ambient Air Quality Standards. In this resolution, OTC also identified several high priority nitrogen oxides (NOx) reduction strategies for significantly contributing upwind states to consider when developing their Good Neighbor SIPs to fulfill the requirements of Clean Air Act (CAA) Section 110(a)(2)(D)(i)(I). One of these strategies was the implementation of the OTC's recommendations for natural gas (NG) pipeline compressor fuel-fired prime movers.

To this end, a Workgroup of the OTC Stationary and Area Source (SAS) Committee has performed regulatory and technical feasibility analyses including emissions reduction estimates and cost effectiveness analyses associated with the development of this guideline which was designed to provide NOx emissions limitations for existing natural gas fueled prime movers powering compressors used for pipeline transportation of natural gas, and to also provide NOx emissions limitations for existing natural gas fueled prime movers powering compressors used for the storage (injection and extraction) of natural gas.

This Guideline was developed by the Ozone Transport Commission (OTC) as part of a regional effort to attain and maintain the eight-hour ozone standard and reduce eight-hour ozone levels. Control of NOx emissions from subject sources will help reduce the adverse impact of those emissions on public health, safety, and welfare.

Table 1 Proposed OTC NOx Limits for NG Pipeline Compressor Fuel-Fired Prime Movers*

Equipment Type	Horsepower Applicability	Limit	% Reduction from Uncontrolled
2-Stroke Lean Burn	≥200 but <500	2.0 g/BHP-hour	80
	≥500 but <2000	1.5 g/BHP-hour	80
	≥2000	1.5 g/BHP-hour	90
4-Stroke Lean Burn	≥200	1.5 g/BHP-hour	90
4-Stroke Rich Burn	≥200 but <2000	1.5 g/BHP-hour	90
	≥2000	1.0 g/BHP-hour	95
Turbines	<2000	150 ppmvd @ 15% O_2	--
	≥2000 but <5000	50 ppmvd @ 15% O_2	--
	≥5000	25 ppmvd @ 15% O_2	--

Notes:

BHP = brake-horsepower

ppmvd = parts per million by volume, dry basis

Where a numeric limit and a % reduction from uncontrolled are shown, the resulting limit is whichever is greater of the two

*If the owner or operator of a natural gas fueled prime mover subject to this Guideline is unable to comply with the NOx emissions rate limitations or % NOx reduction from uncontrolled shown in Table 1 above and specified Section 4 of this Guideline, the owner or operator shall submit an alternative NOx RACT determination, in

[1] Resolution of the Ozone Transport Commission Requesting that the Unites States Protection Agency Take All Actions Necessary to Fully Address the Good Neighbor Provision for the 2008 and 2015 Ozone National Ambient Air Quality Standards, November 15, 2017 (https://otcair.org/document.asp?fview=meeting)

accordance with Section 5 of this Guideline, for review and approval by the appropriate State Agency which will prepare a revised SIP submittal to the U.S. EPA as required.

Technical Feasibility

Emissions control technologies for NG Pipeline Compressor Fuel-Fired Prime Movers[2]:

IC engines

Different emission control technologies such as SCR and NSCR are used to control emissions from stationary IC engines. The choice of control depends on the engine's A/F ratio, since the exhaust gas composition differs depending on whether the engine is operated in a rich, lean, or stoichiometric burn condition, and on the engine operating mode (speed and load) as it affects the exhaust gas temperature.[3]

NSCR is currently the most economical and accepted NOx emission control method for rich-burn, spark-ignited stationary gas engines, while SCR is used to reduce NOx emissions from diesel and lean-burn gas engines. For stationary lean-burn gas engines, two types of lean NOx catalyst formulations each of which controls NOx over a narrow temperature range (a low temperature catalyst based on Pt, and a high temperature catalyst utilizing base metals (usually Cu)) are used.

Turbines

"Gas turbines operate with high overall excess air because they use combustion air dilution as the means to maintain turbine inlet temperature below design limits. In older gas turbine models, where combustion is in the form of a diffusion flame, most of the dilution takes place downstream of the primary flame, which does not minimize peak temperature in the flame and suppress thermal NOx formation. Diffusion flames are characterized by regions of near-stoichiometric fuel/air mixtures where temperatures are very high leading to significant thermal NOx formation."[4]

"Newer model gas turbines use lean premixed combustion where the fuel is typically premixed with more than 50% theoretical air resulting in lower flame temperatures thus suppressing thermal NOx formation." Operation at excess air levels and at high pressures increases the influence of inlet humidity, temperature, and pressure leading to variations in emissions of ≥30%. For a given fuel firing rate, lower ambient temperatures lower the peak temperature in the flame, lowering thermal NOx significantly. "Similarly, turbine operating loads affect NOx emissions with higher emissions expected for higher loads due to higher peak temperature in the flame zone."[5]

Emission controls for gas turbines include wet controls that use water (to lower combustion temperature thereby reducing thermal NOx formation), and a combination of dry combustion control methods e.g. lean combustion, staged combustion, etc. and post-combustion catalytic controls such as SCR.

Additional information and documentation regarding the technical feasibility and availability of NOx Emissions control technologies for NG Pipeline Compressor Fuel-Fired Prime Movers can be found in the Bibliography section at the end of this document.

---

[2] OTC_White_Paper_NOx_Controls_Regs_Eight_Sources_Final_Draft_02152017.pdf
[3] http://www.meca.org/resources/MECA_stationary_IC_engine_report_0515_final.pdf
[4] https://www3.epa.gov/ttnchie1/ap42/ch03/final/c03s01.pdf
[5] *Ibid 4*

Cost Effectiveness Analyses

A cost effectiveness analysis associated with the OTC recommendations for NG pipeline compressor fuel-fired prime movers using emissions reduction estimation spreadsheets as a basis was performed by the staff from the Delaware Department of Natural Resources and Environmental Control (DE-DNREC). The Workgroup also performed a literature search and found relevant cost-effectiveness information from the Mohave Desert Air Quality Management District (MDAQMD) and from Pennsylvania Department of Environmental Protection (PA-DEP).

Summary of DE-DNREC analysis

- The cost-effectiveness spreadsheet provides unit-by-unit cost-effectiveness estimates for annual NOx reduction and potential to emit (PTE) hourly NOx reduction. Using an arbitrary cutoff of units (1 ton or more per year of NOx emissions, according to the 2023 inventory data), the annualized cost effectiveness ranged from approximately $45/ton to approximately $872,254/ton with an average of $22,427/ton and a mean of $6,609/ton.
- For the same group of units with 1 ton per year or greater NOx emissions, the PTE NOx emission reduction cost effectiveness ranged from approximately $3/ton to approximately $71,747/ton, with an average value of $1,574/to and a mean value of $1,493/ton. From this group of units, the annual reduction is approximately 60,800 tons, which is an approximate 82% reduction.
- For the OTR states, it is likely that the estimated reductions would be of a lower percentage as it is likely that a majority of the subject devices have already gone through a Reasonably Available Control Technology (RACT)-type evaluation in the past.

Summary of MDAQMD analysis

- Selected Cost Analyses from Proposed Amendments to Rule 1160 - Internal Combustion Engines Mojave Desert Air Quality Management District, for Adoption January 22, 2018
- The proposed amendment of Rule 1160 updates NOx RACT for the Internal Combustion Engine source category by lowering NOx limits from 140 ppmv to 125 ppmv for Spark-Ignited, Lean Burn Engines and from 700 ppmv to 80 ppmv for Compression-Ignited Engines.
- MDAQMD has evaluated the availability, feasibility, and cost-effectiveness of applying combustion source control measures related to internal combustion engines within the MDAQMD in the Technical Discussion and Feasibility Analysis for Internal Combustion Engines included in Appendix “F” of their proposed amendments. This analysis determined that the proposed RACT limits were found to have a maximum NOx cost effectiveness limit of no more than $12,320 per ton of NOx (2017 dollars). The District found this to be feasible and cost effective as required by H&S Code §39614(d).
- The cost-effectiveness analysis contained in the Technical Discussion and Feasibility Analysis for Internal Combustion Engines in Appendix “F” was based upon a cost effectiveness threshold of not more than $28,872 per ton (NOx, 2017 dollars) established when proposing adoption of amended Rule 1157 - Stationary Gas Turbines [MDAQMD Technical Report - Health & Safety Code §39614 Feasibility Analysis for Stationary Gas Turbines, January 13, 2009].

Summary of PADEP analysis

PADEP Cost effectiveness for Lean and Rich burn Engines ≤100 BHP

- The Department analyzed vendor data and found that engines rated less than 100 bhp are predominantly rich burn engines. However, the Department found a few lean burn engines that are rated near 100 bhp with NOx emissions of approximately 2 g/bhp-hr. The Department evaluated cost effectiveness for SCR technology for these engines with uncontrolled NOx emissions of 2 g/bhp-hr. Based on the evaluation, the Department found that the cost effectiveness for SCR technology is greater than $48,000 per ton of NOx removed, and therefore SCR is not considered as best available technology (BAT).
- The Department reviewed vendor data for rich-burn engines rated less than 100 bhp which showed that the uncontrolled NOx emissions ranged from 11.41 to 21.08 g/bhp-hr. The Department evaluated cost effectiveness for three-way catalyst technology for rich burn engines rated less than 100 bhp. Based on the cost analysis, the cost effectiveness for a 100 bhp engine is found to be less than $650 per ton of NOx removed, and less than $1,200 for a 50 bhp engine. Based on this information, three-way catalyst is found to be technically and economically feasible for rich burn engines. An NSCR three-way catalyst has an emission reduction efficiency of at least 90% and will reduce these emissions to less than 2 g/bhp-hr. Based on the above, the Department has determined a NOx emission limit of 2 g/bhp-hr. as BAT for engines rated equal to or less than 100 bhp.

PADEP Cost effectiveness for Lean burn engines >100 BHP and <500 BHP

- A review of the emission limits contained in similar general permits from other states, such as Ohio, West Virginia, and Colorado, showed limits no more stringent than the federal requirement. The Department analyzed vendor data for NOx emissions for engines without add-on control rated at greater than 100 bhp and equal to or less than 500 bhp. While the NOx emissions from these engines were as high as 16.4 g/bhp-hr, several engines achieved a NSPS NOx emission rate of 1 g/bhp-hr. The Department evaluated cost effectiveness for SCR technology for lean burn engines rated at 500 bhp with uncontrolled NOx emission of 1 g/bhp-hr.
    - Based on the evaluation, the Department found that the cost effectiveness for SCR technology is greater than $42,000 per ton of NOx removed, and therefore SCR is not considered as BAT for engines rated between 100 bhp and 500 bhp.
    - Based on the above information, the Department has determined a NOx emission limit of 1 g/bhp-hr as BAT for engines rated greater than 100 bhp and equal to or less than 500 bhp.

PADEP Cost Effectiveness for Lean burn engines >500 BHP

- A review of the emission limits contained in similar general permits from other states, such as Ohio, West Virginia, and Colorado, showed limits no more stringent than the federal requirement. The Department has reviewed vendor guarantees (not-to-exceed limits) and emissions of NOx for lean-burn engines rated at greater than 500 bhp from different engine manufacturers.
    - The previous GP-5 had a NOx emissions limit of 2 g/bhp-hr for engines rated greater than 500 bhp. As per 40 CFR Part 60, Subpart JJJJ, natural gas fired spark ignition non-emergency lean burn engines rated greater than 500 bhp are required to meet NOx emission limit of 1 g/bhp-hr.

- Vendor guarantee data showed a NOx limit of 0.5 g/bhp-hr. Stack test results show NOx emissions from these engines ranged from 0.22 to 0.50 g/bhp-hr. Due to limited available test data, the Department determined that a NOx emission limit of 0.5 g/bhp-hr is appropriate for engines rated greater than 500 bhp in order to accommodate variability.
- The Department's cost analysis shows that cost effectiveness for SCR for engines rated between 500 bhp and 4,000 bhp range from $71,000 to $60,000 per ton of NOx removed. Therefore, the SCR is considered as cost prohibitive for engines rated at greater than 500 BHP.
- Based on the above information, the Department has determined a NOx emission limit of 0.5 g/bhp-hr as BAT for engines rated greater than 500 bhp. This translates to 75% reduction in emissions from the previous GP-5 limit and a 50% reduction in emissions from the NSPS.

PADEP Cost Effectiveness for Rich Burn Engines >100 BHP and <500 BHP

- The previous GP-5 had a NOx emissions limit of 2 g/bhp-hr. for natural gas fired spark ignition non-emergency rich burn engines rated greater than 100 bhp and equal to or less than 1,500 bhp.
  - As per 40 CFR Part 60, Subpart JJJJ, natural gas fired spark ignition non-emergency rich burn engines rated greater than 100 and equal to or less than 500 bhp are required to meet NOx emission limit of 1 g/bhp-hr.
  - A review of the emission limits contained in similar general permits from other states, such as Ohio, West Virginia, and Colorado, showed limits no more stringent than the federal requirement. The evaluation of uncontrolled emission data from these rich-burn engines indicates emissions of NOx ranging from 13 to 16.4 g/bhp-hr. Cost analysis from both EPA and the Department show that NSCR is cost effective for rich burn engines rated at greater than 100 bhp at a cost of less than $177 per ton removed.
  - The Department reviewed vendor guarantees (not-to-exceed limits) and uncontrolled emissions of NOx for rich-burn engines rated at greater than 100 bhp from different engine manufacturers. The vendor data indicates that 98.8% NOx reduction can be achieved by the NSCR system. An engine with uncontrolled NOx emission rate of 16.4 g/bhp-hr and a catalyst NOx reduction efficiency of 98.8%, can achieve a controlled emissions rate of 0.25 g/bhp-hr. with a sufficient margin.
  - Based on the above, the Department has determined 0.25 g/bhp-hr. as the BAT limit.

PADEP Cost Effectiveness for Rich Burn engines >500 BHP

- The previous GP-5 had a NOx emissions limit of 2 g/bhp-hr for engines rated greater than 500 bhp.
  - As per 40 CFR Part 60, Subpart JJJJ, natural gas fired spark ignition non-emergency rich burn engines rated greater than 500 bhp are required to meet NOx emission limit of 1 g/bhp-hr.
  - A review of the emission limits contained in similar general permits from other states, such as Ohio, West Virginia, and Colorado, showed limits no more stringent than the federal requirement. The Department reviewed vendors' guarantees (not-to-exceed limits) and uncontrolled emissions of NOx for rich-burn engines rated at greater than 500 bhp from different engine manufacturers. Uncontrolled emissions of NOx range from 13

to 16 g/bhp-hr. Cost analysis from both EPA and the Department show that NSCR is cost effective for rich burn engines rated at greater than 100 bhp at a cost of less than $177 per ton removed.

- The vendor data indicates that 98.8% NOx reduction can be achieved by the NSCR system with a pre-controlled NOx emission rate of 13 g/bhp-hr. This translates to a post control NOx emission rate of 0.15 g/bhp-hr.
- An engine with uncontrolled NOx emission rate of 16 g/bhp-hr and a catalyst NOx reduction efficiency of 98.8%, can achieve a controlled emissions rate of approximately 0.20 g/bhp-hr. The stack test results from a 1,980 bhp engine indicate that actual NOx emissions range from 0.02 to 0.14 g/bhp-hr.
- Based on the above, the Department has determined 0.20 g/bhp-hr as the BAT limit.

PADEP Cost Effectiveness for Simple Cycle Turbines >1,000 BHP and <5,000 BHP

- The previous GP-5 was not applicable to turbines.
  - As per 40 CFR Part 60, Subpart KKKK, NOx emission standard for natural gas fired mechanical drive turbines rated equal to or less than 50 MMBtu per hour of heat input (approximately 7000 bhp) is 100 ppmvd @ 15% oxygen.
  - Vendors' guaranteed data show that natural gas fired turbines with dry low NOx combustors and rated at less than 5,000 bhp can achieve equal to or less than 25 ppm of NOx emissions @ 15% oxygen.
  - The Department evaluated cost effectiveness for SCR technology for these turbines with uncontrolled NOx emissions of 25 ppmvd @ 15% oxygen.
  - Based on the evaluation the Department found that the cost effectiveness for SCR technology range from $45,000 to $62,000 per ton of NOx removed for turbines rated equal to or greater than 1,000 bhp and less than 5,000 bhp. Therefore, SCR technology is considered as a cost prohibitive option for NOx control.
  - A review of the stack test results indicates that NOx emissions of 25 ppmvd @ 15% oxygen is achievable for turbines rated at equal to or greater than 1,000 bhp and less than 5,000 bhp.
  - Based on the above the Department has determined 25 ppmvd @ 15% O2 as BAT for NOx for turbines rated equal to or greater than 1,000 bhp and less than 5,000 bhp.

PADEP Cost Effectiveness for Simple Cycle Turbines >5,000 BHP and <15,000 BHP

- As per 40 CFR Part 60, Subpart KKKK, NOx emission standard for natural gas fired mechanical drive turbines rated equal to or less than 50 MMBtu per hour of heat input (approximately 7,000 bhp) is 100 ppmvd @ 15% Oxygen and the NOx emission standard for natural gas fired mechanical drive turbines rated greater than 50 MMBtu per hour of heat input (approximately 7,000 bhp) and less than or equal to 850 MMBtu per hour of heat input (approximately 115,000 bhp) is 25 ppmvd @ 15% oxygen.
  - Vendors' guaranteed data show that natural gas fired turbine with dry low NOx combustor and rated at equal to or greater than 5,000 bhp and less than 15,000 bhp could achieve equal to or less than 15 ppmvd of NOx emissions @ 15% oxygen.
  - The Department evaluated cost effectiveness for SCR technology for these turbines with uncontrolled NOx emissions of 15 ppmvd @ 15% oxygen.

  - Based on the evaluation the Department found that the cost effectiveness for SCR technology range from $71,000 to $76,000 per ton of NOx removed for turbines rated equal to or greater than 5,000 bhp and less than to 15,000 bhp.
  - Therefore, SCR technology is considered as a cost prohibitive option for NOx control.
  - A review of the stack test results show that a NOx emission level of 15 ppmvd @ 15% oxygen is achievable for turbines rated at equal to or greater than 5000 bhp and less than 15,000 bhp.
  - Based on the above the Department has determined 15 ppmvd @ 15% O2 as BAT for NOx for turbines rated equal to or greater than 5000 bhp and less than 15,000 bhp.

PADEP Cost Effectiveness for Simple Cycle Turbines rated ≥15,000 BHP

- As per 40 CFR Part 60, Subpart KKKK, NOx emission standard for natural gas fired mechanical drive turbines rated greater than 50 MMBtu per hour of heat input (approximately 7,000 bhp) and less than or equal to 850 MMBtu per hour of heat input (approximately 115,000 bhp) is 25 ppmvd @ 15% Oxygen and the NOx emission standard for natural gas fired mechanical drive turbines rated greater than 850 MMBtu per hour of heat input (approximately 115,000 bhp) is 15 ppmvd @ 15% Oxygen.
  - Vendors' guaranteed data show that natural gas fired turbines with dry low NOx combustors and rated at equal to or greater than 15,000 bhp could achieve equal to or less than 15 ppm of NOx emissions @ 15% oxygen.
  - The Department evaluated cost effectiveness for SCR technology for these turbines with uncontrolled NOx emissions of 15 ppmvd @ 15% oxygen.
  - Based on the evaluation the Department found that the cost effectiveness for SCR technology range from $69,000 to $71,000 per ton of NOx removed for turbines rated equal to or greater than 15,000 bhp.
  - Therefore, SCR technology is considered as a cost prohibitive option for NOx control.
  - A review of the stack test results indicates that NOx emissions of 15 ppmvd @ 15% oxygen is achievable for turbines rated at equal to or greater than 15,000 bhp.
  - Based on the above the Department has determined 15 ppmvd @ 15% O2 as BAT for NOx for turbines rated equal to or greater than 15,000 bhp.

Summary of Cost Effectiveness Analysis

DEDNR's cost effectiveness analysis, which was based on the Workgroup's emissions reduction estimates, showed that the annualized cost effectiveness ranged from approximately $45/ton to approximately $872,254/ton with an average of $22,427/ton and a mean of $6,609/ton. The PTE NOx emission reduction cost effectiveness ranged from approximately $3/ton to approximately $71,747/ton, with an average value of $1,574/to and a mean value of $1,493/ton.

MDAQMD evaluated the availability, feasibility, and cost-effectiveness of applying combustion source control measures related to internal combustion engines in the Technical Discussion and Feasibility Analysis for Internal Combustion Engines included in Appendix "F" to their proposed amendments to their Rule 1160. Their analysis determined that the proposed RACT limits were found to have a maximum NOx cost effectiveness limit of no more than $12,320 per ton of NOx (2017 dollars). The District found this to be feasible and cost effective as required by H&S Code §39614(d).

PADEP evaluated cost effectiveness for three-way catalyst technology for rich burn engines rated less than 100 bhp and found the cost effectiveness for a 100 bhp engine to be less than $650 per ton of

NOx removed, and less than $1,200 for a 50 bhp engine. Based on this information, three-way catalyst was found to be technically and economically feasible for rich burn engines. Cost analysis from both EPA and the PADEP showed that NSCR is cost effective for rich burn engines rated at greater than 100 bhp at a cost of less than $177 per ton removed. PADEP's analysis found that SCR technology was cost prohibitive for lean burn engines and simple cycle turbines.

Bibliography for Natural Gas Compressors NOx Controls Technical Feasibility

- Colorado Department of Public Health and Environment - Air Pollution Control Division Reasonable Progress Evaluation for RICE Source Category - RECIPROCATING INTERNAL COMBUSTION ENGINE (RICE) SOURCE CATEGORY NOx Emission 4-Factor Analysis for Reasonable Progress (RP) **2018.** https://www.colorado.gov/pacific/sites/default/files/AP_PO_Reciprocating-Internal-Combustion-Engine-RICE-engines_0.pdf
- State of Missouri DNR Peculiar Compressor Station Intermediate State Permit to Operate **February 22, 2017.** https://dnr.mo.gov/env/apcp/permits/docs/sstar-peculiar2017op.pdf
- Ozone Transport Commission (OTC) Stationary & Area Sources Committee White Paper on Control Technologies and OTC State Regulations for Nitrogen Oxides (NOx) Emissions from Eight Source Categories- **Final Draft 02/10/2017** https://otcair.org/ Look under Work Products for 2017
- Manufacturers of Emission Controls Association (MECA). Emission Control Technology for Stationary Internal Combustion Engines Revised: **May 2015** http://www.meca.org/resources/MECA_stationary_IC_engine_report_0515_final.pdf
- MOJAVE DESERT AIR QUALITY MANAGEMENT DISTRICT Federal Operating Permit 3101437 *For:* Southern California Gas Company *Facility:* Blythe Compressor **Station Issue Date: October 29, 2014** Expiration Date: October 29, 2019. http://mdaqmd.ca.gov/home/showdocument?id=6234
- Montana Air Quality Permit #2954-03 WBI Energy Transmission, Inc. Baker Compressor Station, 2010 Montana Avenue Glendive, MT 59330 **August 20, 2014.** https://deq.mt.gov/Portals/112/Air/AirQuality/Documents/ARMpermits/2954-03.pdf
- Availability and Limitations of NOx Emission Control Resources for Natural Gas-Fired Reciprocating Engine Prime Movers Used in the Interstate Natural Gas Transmission Industry – prepared for the INGAA Foundation, Inc. by Innovative Environmental Solutions, Inc. & Optimized Technical Solutions **July 2014.** https://www.ingaa.org/File.aspx?id=22780
- TECHNICAL REPORT STATIONARY ENGINES AIR EMISSIONS RESEARCH FINAL REPORT PREPARED FOR PTAC (Petroleum Technology Alliance Canada) Suite 400, 500-5th Avenue S.W. Calgary, Alberta T2P 3L5 Canada PREPARED BY Clearstone Engineering Ltd. 700, 900-6 Avenue S.W. Calgary, Alberta, T2P 3K2 Canada – (Final) **April 19, 2012.** http://www.ptac.org/wp-content/uploads/2016/08/ptac-stationary-engine-study-final-report-including-lit-review.pdf
- Written Statement of the Manufacturers of Emission Controls Association on the Ozone Transport Commissions Model Rule to Control NOx From Natural Gas Compressor Fuel-Fired Prime Movers - **September 26, 2011.** http://www.meca.org/galleries/files/MECA_comments_on_OTC_Gas_Compr_092611_final.pdf
- Emission Reduction Techniques for Oil & Gas Activities - US. Forest Service **2011.** https://www.fs.fed.us/air/documents/EmissionReduction-072011x.pdf

- Colorado Department of Public Health and Environment Air Quality Control Commission Regulation Number 7 Control of Ozone via Ozone Precursors (Emissions of Volatile Organic Compounds and Nitrogen Oxides) 5 CCR 1001-9 **2008.** https://www.sos.state.co.us/CCR/Upload/AGORequest/AdoptedRules02010-00857.DOC
- Compressor & Pump Station Research R&D Forum **December 2003** - Sam Clowney El Paso Pipeline Group. https://primis.phmsa.dot.gov/rd/mtgs/121103/Facilities/RD_Forum_12-11-03_Facilities_PRCI_Compressor.pdf
- State of the Art (SOTA) Manual for Reciprocating Internal Combustion Engines Section 3.13 - Effective Date: **2003** - State of New Jersey Department of Environmental Protection Division of Air Quality. https://www.state.nj.us/dep/aqpp/downloads/sota/sota13.pdf
- EPA AP 42 Section 3.2 Natural Gas Fired Reciprocating Engines **July 2000.** https://www3.epa.gov/ttnchie1/ap42/ch03/final/c03s02.pdf