**Ozone Transport Commission (OTC)**

Stationary & Area Sources Committee

White Paper on Reasonably Available Control Technology (RACT) Rules for Nitrogen Oxides (NOX)

Executive Summary

**Purpose**

This white paper identifies the Reasonably Available Control Technology (RACT) nitrogen oxides (NOX) emissions limitations in the Ozone Transport Commission’s (OTC’s) member jurisdictions, in partial fulfilment of item 4 of the November 5, 2015 Charge to the OTC’s Stationary and Area Sources (SAS) Committee. That Charge reads as follows:

“To provide each state with a common base of information, a workgroup will develop a listing of emissions rates in each state within the Ozone Transport Region (OTR) for source categories responsible for significant NOX and VOC emissions and identify a range of emissions rates that the respective state has determined to be RACT. Some of the source categories that should be included in the listing include electrical generating units, turbines, boilers, engines and municipal waste combustors.”

The range of NOX RACT emission rates, as called for in the Charge, is available in the source category-specific tables provided in this Executive Summary and in the Appendices to the white paper. Because of variation in the expression of NOX emission rates in the states (e.g., units, averaging times), a simple range is not provided.

A separate OTC workgroup (the CP/AIM workgroup) is currently working on a Technical Support Document for seven current OTC VOC model rules covering the period from about 2010 to 2014. Although not directly focused on RACT, the Technical Support Document may be useful in later developing a second chapter to this white paper.

Note that this white paper states the RACT emission rates required in the OTC states as of the date of this paper. The OTC states will be required to perform a RACT review for the 2015 ozone national ambient air quality standard (NAAQS), which may result in revisions to the emission rates provided here.

**NOX RACT Background**

The Environmental Protection Agency (EPA) defines RACT as “the lowest emission limitation that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility” (44 FR 53762, September 17, 1979).

Sections 182(f) and 184(b)(2) of the Clean Air Act (CAA) require states with ozone non-attainment areas, classified as moderate, serious, severe, and extreme--as well as all areas in the OTR--to implement RACT for existing major stationary sources of NOX.

**NOX RACT Applicability**

Section 302 of the CAA defines a major stationary source as any facility which has the potential to emit of 100 tons per year (tpy) of any air pollutant. Section 182 of the CAA reduces the major stationary source potential to emit threshold for certain ozone nonattainment classifications: 50 tpy for serious areas; 25 tpy for severe areas; and 10 tpy for extreme areas. The anti-backsliding provisions of the CAA require an area to continue to apply the area’s historical most stringent major source threshold. Current and historical area classifications may be found in the EPA Green Book online at <https://www3.epa.gov/airquality/greenbook/index.html>.

**NOX Emission Control Technologies and Strategies**

The following NOX emissions control technologies and strategies are described in this whitepaper:

* Combustion Modification
	+ Low Excess Air (LEA) or Reducing O2 levels
	+ Lean Combustion
	+ Staged Combustion
	+ Low Nitrogen Fuel Oil
	+ Flue Gas Recirculation (FGR)
	+ Low-NOX Burner (LNB) and Overfire Air (OFA)
	+ Wet controls
* Post-Combustion Modifications
	+ Gas Reburn
	+ Non-Selective Catalytic Reduction (NSCR)
	+ Selective Catalytic Reduction (SCR)
	+ Selective Non-Catalytic Reduction (SNCR)
* Other Control Strategies
	+ Combustion Tuning and Optimization
	+ Use of Preheated Cullet

**Current NOX RACT rules and emission limits for source categories in the Ozone Transport Region (OTR)**

**ICI Boilers in OTR**

Results of a recent survey of the NOX emission limits and RACT regulations for ICI Boilers in the OTR are found in **Appendix A** of this white paperand are summarized below:

NOX limit based on boiler capacity and fuel type

|  |  |
| --- | --- |
|  | **NOX Limit (lbs/mmBtu)** |
| **Capacity** |  |  | **Oil** |
| **(mmBtu/hr)** | **Coal** | **Nat. Gas**  | **Distillate** | **Residual**  |
| 50 – 100 | 0.28 – 0.45 | 0.05 – 0.43 | 0.08 – 0.43  | 0.20 -0.43  |
| 100 – 250 | 0.08 – 1.00 | 0.06 – 0.43 | 0.10 – 0.43 | 0.20 -0.43  |
| >250 | 0.08 – 1.00 | 0.10 – 0.70 | 0.10 – 0.43  | 0.15 -0.43  |

**Combustion Turbine Engines in OTR**

Results of a recent survey of the NOX emission limits and RACT regulations for Combustion Turbines (>25 MW capacity) in the OTR are found in **Appendix B** of this white paper and are summarized below.

|  |  |  |
| --- | --- | --- |
| **TURBINE ENGINES (>25 MW)** | **Simple Cycle** | **Combined Cycle** |
| **Gas-fired** | **Oil-fired** | **Gas-fired** | **Oil-fired** |
| **State** | **NOX Limit (ppmvd @15% O2)** |
| **CT – Statewide** | 258 (42 - 0.9 lb/MMBtu)**a**42 – 55**b**; 40**c** | 240 (40 - 0.9 lb/mmBtu)**a**40 – 75**b**; 40 – 50**c** | 258 (42 - 0.9 lb/MMBtu)**a**42**b**; 25**c** | 240 (40 - 0.9 lb/mmBtu)**a**40 – 65**b**; 40 – 42**c** |
| **DC (If** ≥**100 mmBTU/hr)** | NA | 75 | NA | NA |
| **DE - Statewide** | 42 | 88 | 42 | 88 |
| **MA - Statewide** | 65 | 100 | 42 | 65 |
| **MD - Select Counties** | 42 | 65 | 42 | 65 |
| **ME -**  |  |  |  |  |
| **NH -**  |  |  |  |  |
| **NJ – Statewide (≥15 MW)** | 25 (1.00 lb/MWh) | 42 (1.60 lb/MWh) | 25 (0.75 lb/MWh) | 42 (1.20 lb/MWh) |
| **NY - Statewide** | 50 | 100 | 42 | 65 |
| **PA - Statewide** | >1,000 bhp & <6,000 bhp (150); >6000 BHP (42) | >1,000 bhp and <6,000 bhp (150); >6000 BHP (96) | 1,000 bhp and <180 MW (42); >180 MW (4) | 1,000 bhp and <180 MW (96); >180 MW (8) F42 |
| **RI - Statewide** | No RACT Sources(new only) | No RACT Sources(new only) | No RACT Sources(new only) | No RACT Sources(new only) |
| **VA - OTR jurisdiction** | 42 | 65 - 77 | 42 | 65 - 77 |
| **VT -**  | NA |

Notes:

* CT: **a**Existing RCSA Sec. 22a-174-22; **b**Proposed RCSA Sec. 22a-174-22e starting June 1, 2018; **c**Proposed RCSA Sec. 22a-174-22e starting June 1, 2022.
* NJ: lb/mmBtu limit converted to ppmvd @15% O2 based on Part 75 Eq-F5 and F-factors of 8710 for natural gas and 9190 for oil; lb/MWh limit converted to ppmvd@15% O2 based on New Jersey technical support document; 25 ppm ≈ 1.0 lb/MWh for simple cycle gas; 42 ppm ≈ 1.60 lbs/hr for simple cycle oil. (NJ Proposal Number: PRN 2008-260).
* NA = Not Applicable

**IC Engines in OTR**

Results of a recent survey of the emission limits and RACT regulations for IC Engines (>500 hp) in the OTR are found in **Appendix C.** of this white paper and are summarized below.

|  |  |
| --- | --- |
| **IC ENGINES >500 hp** | **NOX Limit (g/hp-hr)** |
| **State** | **Gas-fired, Lean Burn** | **Gas-fired, Rich Burn** | **Diesel** | **Dual Fuel** |
| **CT – Statewide** | 2.5**\*;** 1.5 - 2.0**\*\*** | 2.5**\*;** 1.5 - 2.0**\*\*** | 8.0**\*;** 1.5 - 2.3**\*\*** | Multi-fuel provisions**\*;\*\*** |
| **DC**  | NA | NA | NA | NA |
| **DE - Statewide** | Technology Stds. | Technology Stds. | Technology Stds. | Technology Stds. |
| **MA - Statewide** | 3.0 | 1.5 | 9.0 | 9.0 |
| **MD - Select Counties** | 150 ppmvd @ 15% O2 (Approx. 1.7 g/hp-hr)\* | 110 ppmvd @ 15% O2 (Approx. 1.6 g/hp-hr)\* | 175 ppmvd @ 15% O2 | 125 ppmvd @ 15% O2 |
| **ME -** |  |  |  |  |
| **NH -**  |  |  |  |  |
| **NJ - Statewide** | 1.5 | 1.5 | 2.3 | 2.3 |
| **NY - Statewide** | 1.5 | 1.5 | 2.3 | 2.3 |
| **PA - Statewide** | 3.0 | 2.0 | 8.0 | 8.0 |
| **RI - Statewide** | 2.5 | 1.5 | 9.0 | No specified in Regulation, no sources. |
| **VA - OTR Jurisdiction** | Source-specific RACT | Source-specific RACT | Source-specific RACT | Source-specific RACT |
| **VT - Statewide** | 4.8 | 4.8 | 4.8 | 4.8 |

Notes:

* CT - \* existing RCSA section 22a-174-22; \*\* Proposed Standard RCSA section 22a-174-22e starting June 1, 2022
* MD - \* Conversion factors from ppmv @ 15% O2 to g/hp-hr from EPA ACT, July 1993 EPA453-R-93-032.

**MWCs in OTR**

Results of a recent survey of the emission limits and RACT regulations for MWCs in the OTR are found in **Appendix D** and are summarized below:

* There are no MWCs located in Delaware, the District of Columbia, Rhode Island and Vermont.
* The unit level capacity of MWCs ranges from 50 - 2,700 tpd of MSW.
* The types of combustors include: mass burn units (waterwall, refractory, stationary grate, reciprocating grate, single chamber), two types of rotary incinerators, and refuse-derived fuel incinerators.
* The types on NOX controls employed include FGR and SNCR with the majority of the units controlled with SNCR
* The NOX emission limits vary within the OTR by state and by combustor technology.
* 372 ppmvd NOX @ 7% O2, 1-hour average
* 185 - 200 ppmvd NOX @ 7% O2, 3-hour average
* 120 - 250 ppmvd NOX @ 7% O2, 24-hour average
* 150 ppmvd NOX @ 7% O2, calendar-day average
* 0.35 - 0.53 lb NOX/MMBtu, calendar-day average
* 135 ppmvd NOX @ 7% O2, annual average

**Cement kilns in OTR**

Results of a recent survey of the emission limits and RACT regulations for cement kilns in the OTR are presented below:

* There are no cement kilns in CT, DE, MA, NJ, VT, DC, NH, RI
* Virginia has no emission limits and New York sets source-specific limits.
* Depending on the type of kilns (wet or dry, with or without pre-calciner), the NOX emission limits range from 2.36 - 6.0 lbs/ton clinker in the existing state rules.

|  |  |  |
| --- | --- | --- |
| **State** | **NOX Limit (lbs/ton clinker)** | **RACT Regulations** |
|  | **Long Dry** | **Long Wet** | **Pre-heater** | **Pre-calciner** |  |
| MD | 5.13.4\* | 6.0NA\* | 2.82.4\* | 2.82.4\* | COMAR 26.11.30: <http://www.dsd.state.md.us/comar/SubtitleSearch.aspx?search=26.11.30>. |
| ME | 2.33 | - | - | - | EPA Consent Agreement (Docket 01-2013-0053, Sept 2013) |
| PA | 3.44 | 3.88 | 2.36 | 2.36 | Final RACT 2 Rule (46 Pa.B. 2036, April 23, 2016): <http://www.pabulletin.com/secure/data/vol46/46-17/694.html> |
| NY | Source-Specific Limits | Subpart 220-1 - Effective: 7/11/2010 Submitted: 8/19/2010; Final: 77 FR 13974, 78 Fr 41846: <https://www3.epa.gov/region02/air/sip/ny_reg.htm> |
| VA | No Limits |

\*After 04/01/2017

**Hot Mix Asphalt Production Plants in OTR**

Results of a recent survey of the RACT regulations for Asphalt Production Plants in the OTR are found in **Appendix E** and are summarized below.

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|  |  |  |
| --- | --- | --- |
| **State** | **HOT MIX ASPHALT PRODUCTION PLANTS – RACT REGULATIONS** | **State Contacts** |
| **CT** | RCSA section 22a-174-22 will be replaced with RCSA section 22a-174-22e (anticipate finalizing by 2017). Note: Neither section includes a limit that specifically applies to "asphalt production plants" but the fuel-burning equipment is regulated. <http://www.ct.gov/deep/lib/deep/air/regulations/mainregs/sec22.pdf> [http://www.ct.gov/deep/lib/deep/air/regulations/20160114\_draft\_sec22e\_dec2015(revised).pdf](http://www.ct.gov/deep/lib/deep/air/regulations/20160114_draft_sec22e_dec2015%28revised%29.pdf) | Merrily Gere, 860 424 3416,Merrily.Gere@ct.gov; |
| **DC** | 20 DCMR § 805.6, RACT for Major Stationary Sources of Oxides of Nitrogen: <http://www.dcregs.dc.gov/Gateway/RuleHome.aspx?RuleNumber=20-805>; | Jessica Daniels, 202-741-0862,jessica.daniels@dc.gov |
| **DE** | http://regulations.delaware.gov/AdminCode/title7/1000/1100/1112.shtml http://regulations.delaware.gov/AdminCode/title7/1000/1100/1144.shtml http://regulations.delaware.gov/AdminCode/title7/1000/1100/1146.shtml http://regulations.delware.gov/AdminCode/title7/1000/1100/1148.shtml |  |
| **MA** |  | Marc Cohen |
| **MD** | Search Title 26, Chapter 11; <http://www.dsd.state.md.us/COMAR/SearchTitle.aspx?scope=26>  | Randy Mosier, 410 537 4488,Randy.Mosier@maryland.gov; |
| **ME** |  |  |
| **NH** |  |  |
| **NJ** | N.J.A.C. 7:27‑19.9, based on OTC ADDENDUM TO RESOLUTION 06-02 <http://www.state.nj.us/dep/aqm/Sub19.pdf>  | Peg Gardner, 609 292 7095Margaret.Gardner@dep.nj.gov |
| **NY** | [www.dec.ny.gov/regs/2492.html](http://www.dec.ny.gov/regs/2492.html) | John Barnes, 518 402 8396, john.barnes@dec.ny.gov; Robert Bielawa, robert.bielawa@dec.ny.gov; |
| **PA** | Additional RACT Requirements for Major Sources of NOX and VOCs. Sections 129.96 - 129.100. Control of NOX from Major Sources of NOX and VOC; Effective April 23, 2016. Federal Register -TBD Case by Case; <http://www.pacode.com/secure/data/025/articleICIII_toc.html> | Susan Hoyle, shoyle@pa.gov;Randy Bordner, ranbordner@pa.gov;Susan Foster, sufoster@pa.gov;Sean Wenrich, sewenrich@pa.gov; |
| **RI** | No RACT sources. No regulations to date. | Laurie Grandchamp, 401 222 2808, laurie.grandchamp@dem.ri.gov |
| **VA - OTR jurisdiction** | No asphalt plants trigger the major stationary RACT source definition under 9 VAC 5 Chapter 40 Article 51 at this time. | Doris McLeoddoris.mcleod@deq.virginia.gov |
| **VT** | No action to date; <http://dec.vermont.gov/air-quality/laws> | Doug Elliott, 802 377 5939, Doug.Elliott@vermont.gov; |

### Glass Furnaces in OTR

Results of a recent survey of Glass Furnaces in the OTR are found in **Appendix F** and presented below.

|  |  |  |
| --- | --- | --- |
| **State** | **GLASS FURNACES – RACT REGULATIONS** | **State Contacts** |
| **DE** | http://regulations.delaware.gov/AdminCode/title7/1000/1100/1112.shtml http://regulations.delaware.gov/AdminCode/title7/1000/1100/1144.shtml http://regulations.delaware.gov/AdminCode/title7/1000/1100/1146.shtml http://regulations.delware.gov/AdminCode/title7/1000/1100/1148.shtml |  |
| **MA** |  |  |
| **MD** | COMAR 26.11.09.08I, Search Title 26, Chapter 11; <http://www.dsd.state.md.us/COMAR/SearchTitle.aspx?scope=26>  | Randy Mosier (410) 537-4488Randy.Mosier@maryland.gov |
| **ME** |  |  |
| **NH** | Env-A 1200: rule update has not been SIP approved; <http://des.nh.gov/organization/commissioner/legal/rules/documents/env-a1200.pdf>  | Gary Milbury (603) 271-2630Gary.milbury@des.nh.gov |
| **NJ** | N.J.A.C. 7:27‑19.10, based on OTC ADDENDUM TO RESOLUTION 06-02 <http://www.state.nj.us/dep/aqm/Sub19.pdf> | Peg Gardner, 609 292 7095Margaret.Gardner@dep.nj.gov |
| **NY** | Subpart 220-2 - Effective: 7/11/2010 Submitted: 8/19/2010; Final: 77 FR 13974, 78 Fr 41846; [www.dec.ny.gov/regs/2492.html](http://www.dec.ny.gov/regs/2492.html) | John Barnes (518) 402-8396 john.barnes@dec.ny.gov Robert Bielawa robert.bielawa@dec.ny.gov |
| **PA** | Control of NOX Emissions From Glass Melting Furnaces. Sections 129.301 - 129.310. The rule limits the emissions of NOX from glass melting furnaces on an annual basis. Effective September 21, 2011. 08/22/2011; 76 Federal Register 52283 <http://www.pacode.com/secure/data/025/articleICIII_toc.html> | Susan Hoyle shoyle@pa.gov Randy Bordner ranbordner@pa.gov Susan Foster sufoster@pa.gov Sean Wenrich sewenrich@pa.gov |
| **VA - OTR jurisdiction** | No glass plants trigger the major stationary source RACT threshold in 9 VAC 5 Chapter 40 Article 51 at this time that are located in the OTR portions of Virginia | Doris McLeoddoris.mcleod@deq.virginia.gov |

Notes:

* No Sources in CT, DC, RI, and VT;

### Natural Gas Pipeline Compressor Prime Movers in OTR

Results of a recent survey of RACT regulations for Natural Gas Pipeline Compressor Primer Movers in the OTR are found in **Appendix G** and presented below.

|  |  |  |
| --- | --- | --- |
| **State** | **NATURAL GAS PIPELINE COMPRESSOR Prime Movers – RACT REGULATIONS** | **State Contacts** |
| **CT** | RCSA section 22a-174-22. Will be replaced with RCSA section 22a-174-22e (anticipate finalizing by 2017). Note: Does not specifically apply to "natural gas pipelines," but fuel-burning equipment such as compressors is regulated;<http://www.ct.gov/deep/lib/deep/air/regulations/mainregs/sec22.pdf>  | Merrily Gere, 860 424-3416, Merrily.Gere@ct.gov |
| **DE** | http://regulations.delaware.gov/AdminCode/title7/1000/1100/1112.shtml http://regulations.delaware.gov/AdminCode/title7/1000/1100/1144.shtml http://regulations.delaware.gov/AdminCode/title7/1000/1100/1146.shtml http://regulations.delware.gov/AdminCode/title7/1000/1100/1148.shtml |  |
| **MA** |  |  |
| **MD** | COMAR 26.11.29; Search Title 26, Chapter 11; <http://www.dsd.state.md.us/COMAR/SearchTitle.aspx?scope=26> | Randy Mosier, 410 537 4488,Randy.Mosier@maryland.gov |
| **ME** |  |  |
| **NH** | Env-A 1200: rule update has not been SIP approved; <http://des.nh.gov/organization/commissioner/legal/rules/documents/env-a1200.pdf> | Gary Milbury, 603 271 2630,Gary.milbury@des.nh.gov |
| **NJ** | N.J.A.C. 7:27‑19.5 and 19.8, amendments in progress (applicable to turbines and engines at natural gas compressor stations) based on draft OTC white paper.<http://www.state.nj.us/dep/aqm/Sub19.pdf> | Peg Gardner, 609 292 7095Margaret.Gardner@dep.nj.gov |
| **NY** | Covered under NOX RACT Rule (Subpart 227-2) Effective: 7/8/2010, Submitted: 8/19/2010, Final: 77 FR 13974, 78 Fr 41846; [www.dec.ny.gov/regs/2492.html](http://www.dec.ny.gov/regs/2492.html) | John Barnes, 518 402 8396, john.barnes@dec.ny.gov Robert Bielawa, robert.bielawa@dec.ny.gov |
| **PA** | Additional RACT Requirements for Major Sources of NOX and VOCs. Sections 129.96 - 129.100. Control of NOX from Major Sources of NOX and VOC. Effective April 23, 2016. Federal Register - TBD (No Distinction) <http://www.pacode.com/secure/data/025/articleICIII_toc.html> | Susan Hoyle, shoyle@pa.gov;Randy Bordner ranbordner@pa.gov;Susan Foster, sufoster@pa.gov;Sean Wenrich, sewenrich@pa.gov; |
| **RI** | One source; Source specific RACT for engines at compressor station | Laurie Grandchamp, 401 222 2808, laurie.grandchamp@dem.ri.gov |
| **VA - OTR jurisdiction** | 9 VAC 5 Chapter 40 Article 51, case by case RACT | Doris McLeoddoris.mcleod@deq.virginia.gov |

The OTC identified natural gas pipeline compressor prime movers as a potential category for emission control strategies at its November, 2010 meeting and tasked the SAS Committee to explore the issue. In 2011 a SAS workgroup prepared a white paper to describe the issue and recommend potential Commission action, e.g., adopt a model rule drafted by the SAS to achieve NOX emissions reductions from this emission source and assist the OTC states in achieving the National Ambient Air Quality Standards (NAAQS) for ozone.

Within the OTR, natural gas pipeline compressor prime movers fueled by natural gas are used in several phases of natural gas supply: 1) gathering the natural gas from the well field and transporting it to the main transportation pipeline system; 2) moving natural gas through the main pipeline system to distribution points and end users; and 3) injecting and extracting natural gas from gas storage facilities. These natural gas pipeline compressor prime movers, mostly driven by internal combustion (IC) reciprocating engines and combustion turbines, are a significant source of nitrogen oxide (NOX) emissions year-round. Data sources indicate that nine OTR states have large natural gas compressor facilities (CT, MA, MD, ME, NJ, NY, PA, RI, VA); three OTR states contain a number of natural gas well field compressors (MD, NY, PA); and two OTR states have natural gas underground storage facilities (PA, NY).

The SAS Committee examined other areas of natural gas production (beyond the natural gas pipeline compressor prime movers addressed by the white paper) and concluded that potentially significant NOX reductions may be possible from the “upstream” activities of well drilling, well completion, and well head and field gathering natural gas compressor prime movers. Preliminary information indicates that NOX emissions from these sources may greatly exceed those of the pipeline and underground storage compression sources. This is more evident in the expansion of natural gas production due to shale gas activities.

Only limited data were available regarding the population of natural gas pipeline compressor prime movers fueled by natural gas in the OTR at the time that this white paper was written. The most comprehensive data that were available at that time was the 2007 emissions inventory (including a MARAMA point source emissions inventory for that year); therefore, 2007 was the base year used for analysis.[[1]](#footnote-1) The 2007 data indicate that there are a multitude of natural gas compressor facilities in the OTR (including 150 classified as “major emissions sources”) including 2-stroke lean-burn internal combustion (IC) reciprocating engines, 4-stroke lean-burn IC reciprocating engines, 4-stroke rich-burn IC reciprocating engines, and combustion turbines. The 2007 data showed:

* At least 409 reciprocating engine prime movers with ratings of 200 - 4300 hp, which includes a large number of makes and models
* At least 125 combustion turbine prime movers with ratings of 1000 - 20,000 hp, which includes a moderate number of makes and models.

Many of these prime movers may be >40 years old. The MARAMA point source emissions inventory data indicates that in 2007 this population of natural gas prime movers emitted ~11,000 tons of NOX in the OTR annually (~30 tpd on average).

1. OTC Nat Gas Compressor Prime Mover Inventory Rev 092711 from BC 092513.xlsx. [↑](#footnote-ref-1)