PROPOSED AMENDED RULES 1146, 1146.1, 1146.2 & PROPOSED RULE 1100
WORKING GROUP #5

AUGUST 2, 2018
SCAQMD
DIAMOND BAR, CA
Agenda

- Rule Applicability
- Previous recommendations and public comments
- BARCT analysis
- Schedule
- Contacts
# Rule 1146 Series

<table>
<thead>
<tr>
<th>Rule</th>
<th>Applicability</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1146</td>
<td>Boilers, steam generators, and process heaters</td>
<td>≥ 5 million Btu per hour (MMBtu/hr)</td>
</tr>
<tr>
<td>Rule 1146.1</td>
<td>Boilers, steam generators, and process heaters</td>
<td>&gt;2 and &lt;5 MMBtu/hr</td>
</tr>
<tr>
<td>Rule 1146.2</td>
<td>Natural gas-fired water heaters, boilers, and process heaters</td>
<td>≤ 2 MMBtu/hr</td>
</tr>
</tbody>
</table>
Rule Applicability

- Remove exemption for RECLAIM facilities
- Rule 1146 and 1146.1 equipment at the following facilities will not be included:
  - Electricity Generating Facilities (EGFs);
    - Except for non-power producing boilers
  - Refineries
  - As discussed in previous Working Group Meetings other industry categories will be included in Rule 1146 and 1146.1
- Rule 1146.2 would apply to all RECLAIM facilities
  - Seeking input regarding refineries
Previous Recommendations for PARs 1146 and 1146.1 (May Set Hearing)

- Maintain existing NOx concentration limits
- Defer compliance for units between 2 – 20 MMBtu/hr if
  - Unit can demonstrate that NOx concentration is 12 ppm or less
    - Existing provisions allow natural gas units between 2 – 20 MMBtu/hr permitted at 12 ppm or less may defer compliance until burner(s) replacement (Rule limit = 9 ppm)
- Implementation schedule
  - 75% of units by heat input for Rule 1146 and 1146.1 units (including BARCT-compliant equipment) by Jan. 1, 2021; 100% of units by heat input by Jan. 1, 2022
  - Facilities committed to replace existing boilers/heaters (whole units) will be allowed until Jan. 1, 2023 to replace unit
  - Submit a complete permit application by 12 months after rule adoption
Previous Recommendations for PAR 1146.2
(May Set Hearing)

- Include commitment to conduct a technology assessment by January 1, 2022
  - If BARCT is the same as existing rule requirements (30 ppm), compliance by December 31, 2023
  - If BARCT is less than 30 ppm, a new compliance schedule will be developed

- Inventory data to be collected through:
  - Initial determination notifications and
  - Annual audit inspections
Summary of comments

- Program level CEQA and Socioeconomic analysis should be conducted
- NSR and permitting issues should be resolved before facilities transition out of RECLAIM
- BARCT levels may not be cost-effective, need to look at various levels of control
- BARCT should be defined for each class and category of equipment

Since the May 2018 Set Hearing

- BARCT has been re-assessed
- Baseline Emissions
  - RECLAIM (various levels from 5 to 40+ ppm)
  - Non-RECLAIM (mostly 5 to 12 ppm, following Rule 1146 series)
- Type of boilers (fire-tube vs. water-tube boilers)
Overview of BARCT Analysis
BARCT

- Is defined in the California Health and Safety Code Section 40406
  “…an emission limitation that is based on the maximum degree of reduction achievable, taking into account environmental, energy, and economic impacts by each class or category of source.”

- BARCT can be retrofit, replacement, fuel change, material substitution, etc.

- BARCT is reassessed periodically and is updated as technology advances.

- BARCT is an emission limitation, and is not limited to a particular technology, whether add-on or replacement. This definition does not preclude replacement technologies.
BARCT – Primary Considerations

- Applicability
- Feasibility
- Cost Effectiveness
BARCT Analysis for PARs 1146 and 1146.1
Objective of Technology Assessment

- Overall objective of Technology Assessment is to assess applicable technologies to identify a possible BARCT emission standard
  - Cost-effectiveness analysis must be completed before BARCT recommendation can be made
- Technology Assessment is specific to the equipment, plus fuel type, and takes into account size and application of the equipment
- Each step of the Technology Assessment should identify possible emission limit
- Four steps in the Technology Assessment
Overview of Technology Assessment

**Assessment of SCAQMD Regulatory Requirements**

**Purpose:** Identify existing SCAQMD regulatory requirements for that particular source category

**Assessment of Emission Limits for Existing Units**

**Purpose:** Evaluate existing units to identify emission levels achieved based on permitted and actual levels

**Other Regulatory Requirements**

**Purpose:** Identify any other regulatory requirements with lower emission limits

**Assessment of Pollution Control Technologies**

**Purpose:** Identify pollution control technologies and potential emission reductions
Rule 1146 and Rule 1146.1 Universe

- Approximate Size of Universe: 2,399 units
  - >97% of units utilize natural gas as primary fuel
  - <3% of units utilize landfill and digester gas as primary fuel
  - Liquid fuels mostly used as secondary
- NOx concentrations are adjusted to 3% O₂

<table>
<thead>
<tr>
<th>Size Range (MMBtu/hr)</th>
<th>Category</th>
<th>Number of Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Command-and-Control*</td>
</tr>
<tr>
<td>2-5</td>
<td>Rule 1146.1</td>
<td>1,072</td>
</tr>
<tr>
<td>5-20</td>
<td>Rule 1146 Group III</td>
<td>869</td>
</tr>
<tr>
<td>20-75</td>
<td>Rule 1146 Group II</td>
<td>184</td>
</tr>
<tr>
<td>75+</td>
<td>Rule 1146 Group I</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2,399</td>
</tr>
</tbody>
</table>

*Command and control equipment distribution figures obtained from 2008 rule revision staff report
Rule 1146.1 Permit Limits

Rule 1146 Group II Permit Limits

Rule 1146 Group III Permit Limits

Rule 1146 Group I Permit Limits
## SCAQMD Regulatory Requirements

<table>
<thead>
<tr>
<th>Size (MMBtu/hr) / Type</th>
<th>Rules 1146 &amp; 1146.1*</th>
<th>Compliance Date</th>
<th>Implementation Period (Sept 2008 Amendment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥75</td>
<td>5 ppm</td>
<td>January 1, 2013</td>
<td>4 years</td>
</tr>
<tr>
<td>≥20 to &lt;75</td>
<td>9 ppm</td>
<td>January 1, 2012 thru January 1, 2014</td>
<td>3 – 5 years</td>
</tr>
<tr>
<td>≥5 to &lt;20</td>
<td>9 ppm</td>
<td>January 1, 2013 thru January 1, 2015</td>
<td>4 – 6 years</td>
</tr>
<tr>
<td>&gt;2 to &lt;5</td>
<td>9 ppm</td>
<td>January 1, 2012 thru January 1, 2014</td>
<td>3 – 5 years</td>
</tr>
<tr>
<td>Atmospheric Units ( ≤10 )</td>
<td>12 ppm</td>
<td>January 1, 2014</td>
<td>5 years</td>
</tr>
<tr>
<td>Thermal Fluid Heaters</td>
<td>30 ppm</td>
<td>September 5, 2008</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

*Requirements are for natural gas fired units.*
SCAQMD Regulatory Requirements

- Current SCAQMD requirements are feasible and have been achieved since the 2008 amendment
  - Units have met the Rule 1146 and 1146.1 existing emission limits
  - Source test results have demonstrated compliance with existing emission limits
## Rules from Other Air Districts

- Reviewed other rules and regulations outside SCAQMD

### San Joaquin Valley APCD
- Less stringent than SCAQMD (7 ppm vs. 5 ppm) for units ≥75 MMBtu/hr
- More stringent than SCAQMD (7 ppm vs. 9 ppm) for units ≥20 to <75 MMBtu/hr
- Same limits for units <20 MMBtu/hr
- Mitigation fee option

### Bay Area AQMD
- Same limits for units ≥20 MMBtu/hr
- Less stringent than SCAQMD for units <20 MMBtu/hr

### Other Air Districts / Agencies*
- Less stringent requirements for units of all sizes

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*Mojave Desert, Antelope Valley, Ventura County, San Diego County, Arizona, Delaware, Illinois, Indiana, Maryland, Minnesota, New Jersey, Texas, Wisconsin, Wyoming*
**Rules from Other Air Districts (cont.)**

- More stringent emission limits required by San Joaquin Valley APCD for units between 20 and 75 MMBtu/hr
- Lower limits potentially feasible

<table>
<thead>
<tr>
<th>Size (MMBtu/hr) / Type</th>
<th>South Coast AQMD Rule 1146 &amp; Rule 1146.1</th>
<th>San Joaquin Valley APCD Rule 4320 &amp; Rule 4307</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥75</td>
<td>5 ppm</td>
<td>7 ppm (Standard) 5 ppm (Enhanced)</td>
</tr>
<tr>
<td>≥20 to &lt;75</td>
<td>9 ppm</td>
<td></td>
</tr>
<tr>
<td>≥5 to &lt;20</td>
<td>9 ppm</td>
<td>9 ppm (Standard) 6 ppm (Enhanced)</td>
</tr>
<tr>
<td>2 to 5</td>
<td>9 ppm</td>
<td>9 ppm</td>
</tr>
<tr>
<td>Atmospheric Units (≤10)</td>
<td>12 ppm</td>
<td>12 ppm</td>
</tr>
<tr>
<td>Thermal Fluid Heaters</td>
<td>30 ppm</td>
<td>9 ppm</td>
</tr>
</tbody>
</table>

*San Joaquin Valley APCD sources meeting the “enhanced” vs “standard” emission limit were given a longer implementation period*
Overview of Pollution Control Technologies

- Technologies that are commercially available and widely used
  - **Combustion control**
    - Reduce thermal NOx formation
    - Ultra-low NOx burners
    - Various burner configurations and designs (lean premix, flue gas recirculation, fuel/air staging)
    - Typically utilized for units less than 80 MMBtu/hr
  - **Post-Combustion control**
    - NOx after treatment of the boiler exhaust
    - Selective Catalytic Reduction (SCR) systems
    - Scalable and generally utilized for units > 10 MMBtu/hr

- Prospective transferable technologies being demonstrated in other combustion applications
  - ClearSign Duplex™ Technology
  - Cheng Low-NOx System
  - Flameless Combustion Technology
Feasibility of SCR Meeting 4 ppm or Less

- SCR retrofits for Rule 1146 applicable units at 3 ppm or less are potentially feasible but not guaranteed by vendors
- SCR retrofits can achieve 4 ppm or less with several limitations
  - Existing SCR systems might need larger catalyst bed for 5 ppm NH3 slip
  - NOx feedback analyzer might be needed for lower limits
  - Age and flow of catalyst can be limiting factors
- Might not have a sufficient safety margin between permitted limit and actual emissions to account for fluctuations in ambient temperature, gas BTU, etc.
Feasibility of Ultra-Low NOx Burners Meeting 7 ppm or Less

- Feasible for new units (not retrofits) to meet 5 ppm or less
- Retrofits for 7 ppm or less are potentially feasible below a certain size (<50 MMBtu/hr)
- Feasible for existing units currently meeting 9 ppm to potentially meet 7 ppm with burner tuning or replacement
- Some limitations for 7 ppm or less retrofits:
  - Only applicable to fire-tube boilers
  - Additional controls needed, such as VFD and O₂ trim
  - Minimum furnace size required
  - Dependent on back pressure/steam pressure of existing unit
Vendor Discussions (cont.)

Atmospheric Units

- Current requirement at 12 ppm
- 9 ppm with ultra-low NOx burners is achievable for new units, but not feasible for all retrofit applications
- Lower NOx emissions are not feasible for all applications since the fluctuations in ambient conditions affect atmospheric units more than sealed combustion boilers

Thermal Fluid Heaters

- Current requirement at 30 ppm
- Thermal fluid heaters operate at significantly higher temperatures, which results in greater NOx emissions
- Units with ultra-low NOx burners guaranteed to meet 20 ppm or less are available
  - Retrofit units could meet 12 to 15 ppm
    - Some efficiency loss with premix combustion due to higher O₂
  - New units for certain applications are capable of meeting 9 ppm
Vendor Discussions (cont.)

- Possible recommendations based on vendor discussions for rule 1146.1 and 1146 applicable units:

<table>
<thead>
<tr>
<th>Pollutant Type</th>
<th>Emission Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR retrofits</td>
<td>5 ppm</td>
</tr>
<tr>
<td>Ultra-low NOx burner retrofits</td>
<td>7 ppm</td>
</tr>
<tr>
<td>(Fire-tube Only)</td>
<td>≤ 50 MMBtu/hr</td>
</tr>
<tr>
<td>Atmospheric units</td>
<td>12 ppm</td>
</tr>
<tr>
<td>≤ 10 MMBtu/hr</td>
<td></td>
</tr>
<tr>
<td>Thermal fluid heaters</td>
<td>12 ppm</td>
</tr>
</tbody>
</table>
Emission Limits for Existing Units

- Reviewed permit limits from:
  - US EPA
  - CARB
  - Various local agencies
- Analyzed and reviewed source test results
- Information gathered was used to establish staff recommendations
Permitted Limits

- Reviewed lowest permitted limits from SCAQMD and SJVUAPCD permits
- Used available information from respective BACT clearing house

<table>
<thead>
<tr>
<th>Size (MMBtu/hr)</th>
<th>Permitted Level Below Currently Adopted Rules</th>
<th>Control Technology</th>
<th>New or Retrofit</th>
<th>Type of Boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>74</td>
<td>7 ppm</td>
<td>SCR</td>
<td>New</td>
<td>Water-Tube</td>
</tr>
<tr>
<td>69</td>
<td>5 ppm</td>
<td>SCR</td>
<td>Retrofit</td>
<td>Water-Tube</td>
</tr>
<tr>
<td>40 to 50</td>
<td>5 ppm</td>
<td>SCR</td>
<td>New</td>
<td>Water-Tube</td>
</tr>
<tr>
<td>29</td>
<td>5 ppm</td>
<td>ULNB</td>
<td>New</td>
<td>Fire-Tube</td>
</tr>
<tr>
<td>25</td>
<td>7 ppm</td>
<td>ULNB</td>
<td>New</td>
<td>Fire-Tube</td>
</tr>
<tr>
<td>21</td>
<td>5 ppm</td>
<td>SCR</td>
<td>Retrofit</td>
<td>Fire-Tube</td>
</tr>
<tr>
<td>19</td>
<td>5 ppm</td>
<td>SCR</td>
<td>Retrofit</td>
<td>Water-Tube</td>
</tr>
<tr>
<td>5 to 12</td>
<td>9 to 20 ppm</td>
<td>LNB</td>
<td>New and Retrofit</td>
<td>Thermal Fluid Heater</td>
</tr>
<tr>
<td>7</td>
<td>12 ppm</td>
<td>LNB</td>
<td>Retrofit</td>
<td>Thermal Fluid Heater</td>
</tr>
</tbody>
</table>
Installations at Other Air Districts or Other Regions Worldwide

Locating Applicable Equipment
(Clearing House and Vendor Information)

National
EPA

State
CARB

Other Local Districts
BAAQMD
SMAQMD
VCAPCD
SJVUAPCD

No records of equipment permitted at or below 7 ppm with ULNB only
One unit permitted at 5 ppm NOx

1. Clearing house data obtained might not reflect most recent permitting information
Source Test Records

- Source tests are used to demonstrate compliance with SCAQMD emission limits
  - Testing must be conducted according to district approved methods such as Method 100.1
- Reviewed source test reports obtained from SCAQMD database
  - Reports submitted by facilities
- Source test reports are used to analyze actual emissions from permitted equipment
  - Staff reviewed a total of 183 source test reports from RECLAIM and non-RECLAIM equipment
## Source Test Records Analysis

**Total units surveyed from RECLAIM and Non-RECLAIM**

- **Total Rule 1146 and Rule 1146.1 Universe:** 2,399
- **Total Surveyed:** 183
  - RECLAIM: 92
  - Non-RECLAIM: 91

### Number of units tested and current rule limit

<table>
<thead>
<tr>
<th>Unit Size</th>
<th>SCR Boilers 19 to 127 MMBtu/hr</th>
<th>Rule 1146 Group II 20-75 MMBtu/hr</th>
<th>Rule 1146 Group III 5-20 MMBtu/hr</th>
<th>Rule 1146.I 2-5 MMBtu/hr</th>
<th>Thermal Fluid Heaters 2+ MMBtu/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Limit:</strong></td>
<td>5 PPM</td>
<td>9 PPM</td>
<td>9 PPM</td>
<td>9 PPM</td>
<td>20 PPM</td>
</tr>
<tr>
<td><strong>Total Surveyed:</strong></td>
<td>15</td>
<td>44</td>
<td>75</td>
<td>35</td>
<td>14</td>
</tr>
</tbody>
</table>

### Emissions reported by source test

- **Retrofit**
  - Between 2.5-3.5 PPM: 6 Units
  - Between 3.5-6.3 PPM: 4 Units
  - Between 3.5-6.3 PPM: 4 Units
  - Between 3.3-6.3 PPM: 2 Units
  - Between 6.5-10.8 PPM: 2 Units

- **New**
  - Between 2.5-3.5 PPM: 2 Units
  - Between 3.5-6.3 PPM: 12 Units
  - Between 3.5-6.3 PPM: 13 Units
  - Between 3.3-6.3 PPM: 10 Units
  - Between 6.5-10.8 PPM: 3 Units

### Possible Recommendations

- **SCR Boilers >10 MMBtu/hr**
  - 4 PPM
- **R1146 Group I and II**
  - 2 to 75 MMBtu/hr
  - 7 PPM
- **R1146 Group III**
  - 5-20 MMBtu/hr
  - 9 PPM
- **R1146.1**
  - 2-5 MMBtu/hr
  - 9 PPM

### Unit Size

- **SCR Boilers 19 to 127 MMBtu/hr**
- **Rule 1146 Group II 20-75 MMBtu/hr**
- **Rule 1146 Group III 5-20 MMBtu/hr**
- **Rule 1146.I 2-5 MMBtu/hr**
- **Thermal Fluid Heaters 2+ MMBtu/hr**

### Unit Size

- **SCR Boilers 19 to 127 MMBtu/hr**
  - Between 2.5-3.5 PPM: 6 Units
  - Between 3.5-6.3 PPM: 4 Units
  - Between 3.5-6.3 PPM: 4 Units
  - Between 3.3-6.3 PPM: 2 Units
  - Between 6.5-10.8 PPM: 2 Units
- **R1146 Group I and II**
  - 2 to 75 MMBtu/hr
  - 7 PPM
- **R1146 Group III**
  - 5-20 MMBtu/hr
  - 9 PPM
- **R1146.1**
  - 2-5 MMBtu/hr
  - 9 PPM
- **Thermal Fluid Heaters 2+ MMBtu/hr**
  - 2 Units
  - 3 Units
CONTINUOUS EMISSION MONITORING SYSTEM (CEMS) - the total combined equipment and systems required to continuously determine air contaminants and diluent gas concentrations and/or mass emission rate of a source effluent (as applicable).

Consists of three major subsystems:

1. Sampling interface
2. Analyzer
3. Data acquisition system (DAS)

Required by units that meet minimum size and annual input thresholds:

- Rule 1146:
  - Rated to $\geq 40$ MMBtu/hr with annual heat input of $>200 \cdot 10^9$ MMBtu/yr

- Rule 2012:
  - Rated between 40 to 500 MMBtu/hr with annual heat input of $>90 \cdot 10^9$ MMBtu/yr; or
  - Rated to $>500$ MMBtu/hr
SCAQMD Requirements
- For units ≥ 75 MMBtu/hr, emission limit at 5 ppm
- For units between 2 – 75 MMBtu/hr, emission limit at 9 ppm
- Thermal fluid heaters at 30 ppm

Current Permit Limits for Existing Units
- Equipment with SCR permitted at 5 ppm
- Equipment with ULNB permitted between 7 to 9 ppm
- Thermal fluid heaters permitted at 12 ppm

Source Test Results
- Evaluated a total of 183 source test, and determined possible recommendations
- 4 ppm for Group I & SCR units
- 7 ppm for Group II & III and 1146.1 Units
- 12 ppm for Thermal Fluid Heaters

CEMS Data
- Evaluated CEMS data for 2 facilities with permit limits of 5 ppm for SCR retrofits
- Showed real time emissions fluctuating around 3-4 ppm

Additional Considerations
- Type of Boilers (Fire-tube vs. Water-tube)
Summary of Technical Assessment

Assessment of SCAQMD Requirements

Assessment of Emission Limits for Existing Units

Analysis of Source Test Results

Analysis of CEMS Data

Additional Considerations

Recommendations

- SCR
  - 5 ppm (Current)

- ULNB
  - 7 ppm for fire-tube
  - 9 ppm for water-tube

- Thermal Fluid Heaters
  - 12 ppm

- Atmospheric Units
  - 12 ppm (Current)
BARCT Analysis Process

Technology Assessment

- Assessment of SCAQMD Regulatory Requirements
- Assessment of Emission Limits for Existing Units
- Other Regulatory Requirements
- Assessment of Pollution Control Technologies

Possible BARCT Emission Standard

Cost-effectiveness analysis needed before BARCT emission standard established
## Technologically Achievable Emission Limit

<table>
<thead>
<tr>
<th>Group</th>
<th>Size (MMbtu/hr)</th>
<th>Existing Limit</th>
<th>Preliminary Recommendation</th>
<th>Supporting Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1146 Group I</td>
<td>≥75</td>
<td>5 ppm via SCR</td>
<td>Same as existing limit</td>
<td>n/a</td>
</tr>
<tr>
<td>Rule 1146 Group II</td>
<td>≥20 to &lt;75</td>
<td>9 ppm via ULNB</td>
<td>5 ppm via SCR</td>
<td>• Permitted equipment &lt;br&gt; • Vendor discussion &lt;br&gt; • Source test records</td>
</tr>
<tr>
<td>Rule 1146 Group III</td>
<td>≥5 to &lt;20</td>
<td>9 ppm via ULNB</td>
<td>Fire-tube boilers: 7 ppm via ULNB &lt;br&gt; Water-tube boilers: 9 ppm via ULNB</td>
<td>• Permitted equipment &lt;br&gt; • Vendor discussion &lt;br&gt; • Source test records</td>
</tr>
<tr>
<td>Rule 1146.1</td>
<td>2 to 5</td>
<td>9 ppm via ULNB</td>
<td>Fire-tube boilers: 7 ppm via ULNB &lt;br&gt; Water-tube boilers: 9 ppm via ULNB</td>
<td>• Permitted equipment &lt;br&gt; • Vendor discussion &lt;br&gt; • Source test records</td>
</tr>
<tr>
<td>Atmospheric Units</td>
<td>≤10</td>
<td>12 ppm</td>
<td>Same as existing limit</td>
<td>n/a</td>
</tr>
<tr>
<td>Thermal Fluid Heaters</td>
<td>NA</td>
<td>30 ppm</td>
<td>12 ppm</td>
<td>• Permitted equipment &lt;br&gt; • Vendor discussion &lt;br&gt; • Source test records</td>
</tr>
</tbody>
</table>
COST EFFECTIVENESS
Control technology cost consists of two main components:

- Capital Cost
- Annual Operating Cost

Source of information:

- Vendor discussion
- U.S. EPA SCR Cost Manual*

*Available at: https://www3.epa.gov/ttn/ecas/docs/SCRCostManualchapter7thEdition_2016.pdf
Capital Cost (Equipment + Installation)

- Obtained cost estimates from 5 vendors
- Capital cost based on:
  - Equipment size
  - NOx emission limit
  - Control technology (ultra-low NOx burner retrofits, SCR retrofits)
- Assumptions:
  - Retrofits only
  - No major changes to existing units (no structural or foundation changes)
  - An equipment lifespan of 15 years for ultra-low NOx burner and 25 years for SCR
- Significant deviation in cost from one vendor
  - Compared average cost
    - with outliers
    - without outliers
## Additional Electricity Cost

- Recurring annual cost for the additional energy consumption above that already required for the existing operation

<table>
<thead>
<tr>
<th>Potential cost increase</th>
<th>Potential savings</th>
<th>Staff Proposes</th>
</tr>
</thead>
</table>
| **Ultra-low NOx burner retrofit** | Flue gas recirculation (FGR) uses higher dilution requiring additional energy | ▪ Improved burner efficiency with higher turndowns  
▪ Installation of O$_2$ sensors and variable frequency drive (VFD) can reduce electricity cost | No additional energy cost |
| **SCR system retrofit** | Additional energy needed for higher pressure, ammonia vaporization, and induction fan | For units that currently use FGR, potential savings from lower use/removal of FGR | To account for savings from FGR reduction based on percentage of existing non-compliant units with FGR |
Additional Electricity Cost – SCR

- U.S. EPA SCR Cost Manual* used to estimate the additional energy cost.
- Annual electricity cost based on:
  - SCR power consumption (kW)
  - Annual electricity cost ($0.10 per kW-hr)
  - Operating capacity (50%)

*Available at: https://www3.epa.gov/ttn/ecas/docs/SCRCostManualchapter7thEdition_2016.pdf
Ammonia and Catalyst Cost

- SCR uses catalyst and ammonia (NH$_3$) to selectively reduce NOx
  - Ammonia is injected into the flue gas stream where it reacts with NOx and oxygen within the catalyst to produce nitrogen and water vapor
  - U.S. EPA SCR Cost Manual* used to estimate ammonia and catalyst cost

- Recurring annual cost for ammonia and catalyst based on:

<table>
<thead>
<tr>
<th>Ammonia</th>
<th>Catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Consumption rate (lb/hr)</td>
<td>• Catalyst volume (ft$^3$)</td>
</tr>
<tr>
<td>• Aqueous NH$_3$ price ($/lb$ NH$_3$)</td>
<td>• Catalyst cost ($/ft^3$)</td>
</tr>
<tr>
<td></td>
<td>• Replacement frequency (7 – 12 yrs)</td>
</tr>
</tbody>
</table>

Additional Operation & Maintenance Cost

- Recurring annual cost for operation & maintenance (O&M) labor and materials not already part of existing operations
- Emissions monitoring considered separately

<table>
<thead>
<tr>
<th>Ultra-low NOx burner retrofit</th>
<th>Contracts already in place to maintain existing burner</th>
<th>Less maintenance and fewer repairs for retrofit burner</th>
<th>No additional O&amp;M cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR system retrofit</td>
<td>Existing boiler O&amp;M with no SCR</td>
<td>Annual SCR maintenance checks</td>
<td>To account for additional SCR system O&amp;M</td>
</tr>
</tbody>
</table>
## Additional Monitoring Cost

- Recurring annual cost for additional monitoring, reporting, and recordkeeping (MRR) not already required
- Existing RECLAIM MRR requirements comparable with landing rule requirements (except for reporting)

<table>
<thead>
<tr>
<th>Ultra-low NOx burner retrofit</th>
<th>Requirements for existing unit specified in Rule 2012</th>
<th>Requirements for retrofit unit specified in R1146 series</th>
<th>No additional MRR cost</th>
</tr>
</thead>
</table>
| SCR system retrofit           | Not applicable for SCR retrofit                     | • Requirements for existing unit specified in R1146 series  
                                 |                                                      | • SCR system annual ammonia slip test                  | To account for additional emissions testing |
Potential Monitoring/Reporting Savings

- Reporting requirements

  - Savings based on estimated annual staffing cost needed to fulfill RECLAIM reporting requirements
    - Potential savings approximately $40,000 and $2,000 per piece of major and non-major sources, respectively

- Continuous emission monitoring system (CEMS) applicability threshold:

<table>
<thead>
<tr>
<th></th>
<th>Rule 1146</th>
<th>RECLAIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>40 MMBtu/hr</td>
<td>40 MMBtu/hr</td>
</tr>
<tr>
<td>Fuel Usage</td>
<td>200 Billion Btu per year</td>
<td>90 Billion Btu per year</td>
</tr>
</tbody>
</table>
Cost effectiveness is measured in terms of the control equipment cost in dollars per ton of air pollutant reduced

\[
\text{Cost Effectiveness} = \frac{\text{Present worth value}}{\text{Emissions reductions over equipment life}}
\]

Present worth value of the control equipment is the capital cost plus the annual operating cost over the life of the equipment

\[
\text{Present worth value} = \text{Capital cost} + (\text{Annual operating cost} \times \text{Present worth factor})
\]
1. Determine fuel usage from AER reports
2. Retrieve permit limit for equipment
3. For RECLAIM major sources without permit limits, emission limit was calculated using annual AER usage and CEMS throughout data
4. Emissions for equipment missing AER data were calculated assuming 50% capacity

**Baseline Calculation:**

\[ B_u = \sum (A \times P) \]

- \( B_u \) = Total Baseline Emissions for Universe [in Pounds]
- \( A \) = AER fuel usage [in mmSCF]
- \( P \) = Permit Limit [in Pounds per mmSCF]
**Emission Reduction Calculation:**

\[ P_e = \sum (Bex \frac{Pr}{P_l}) \]

\[ T_r = B_u - P_e \]

- \( P_e \) = Total Emissions from Proposed Limits [in tpd]
- \( B_e \) = Baseline Emission per Equipment [in tpd]
- \( P_r \) = Proposed Emissions Limit [in ppm]
- \( P_l \) = Current Permit Limit [in ppm]
- \( T_r \) = Total Reductions
- \( B_u \) = Total Baseline Emissions for Universe
Cost Effectiveness Methodology

- Cost effectiveness calculated using the discount cash flow methodology assuming:
  - 4% interest rate
  - A useful life of 25 years for SCR systems
  - A useful life of 15 years for ultra-low NOx burners
  - Considered potential savings, if applicable
  - Average equipment and installation cost with outliers
## Cost Effectiveness

<table>
<thead>
<tr>
<th>Group</th>
<th>Size (MMBtu/hr)</th>
<th>Preliminary Recommended Emission Limit</th>
<th>Cost Effectiveness ($/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1146 Group I</td>
<td>≥75</td>
<td>5 ppm via SCR (existing limit)</td>
<td>$16,000*</td>
</tr>
<tr>
<td>Rule 1146 Group II</td>
<td>≥20 to &lt;75</td>
<td>5 ppm via SCR</td>
<td>$29,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For units &gt; 12 ppm*</td>
<td>&gt;$50,000</td>
</tr>
<tr>
<td>Rule 1146 Group II</td>
<td>≥20 to &lt;75</td>
<td>7 ppm via ULNB for fire-tube boilers</td>
<td>$13,000 when compliance deferred until burner replacement</td>
</tr>
<tr>
<td>Rule 1146 Group III</td>
<td>≥5 to &lt;20</td>
<td>7 ppm via ULNB for fire-tube boilers</td>
<td>$29,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For units &gt; 12 ppm*</td>
<td>$14,000 when compliance deferred until burner replacement</td>
</tr>
<tr>
<td>Rule 1146.1</td>
<td>2 to 5</td>
<td>Same as above</td>
<td>$48,000</td>
</tr>
<tr>
<td>Atmospheric Units</td>
<td>≤10</td>
<td>12 ppm via ULNB (existing limit)</td>
<td>$34,000^</td>
</tr>
<tr>
<td>Thermal Fluid Heaters</td>
<td>NA</td>
<td>12 ppm via ULNB</td>
<td>$39,000^</td>
</tr>
</tbody>
</table>

* Estimated using emissions from RECLAIM units

^ Estimated assuming 20% operating capacity and a baseline of 30 ppm
PRELIMINARY STAFF RECOMMENDATION
## Staff Recommendation

<table>
<thead>
<tr>
<th>Group</th>
<th>Size (MMbtu/hr)</th>
<th>Preliminary Recommended Emission Limit</th>
<th>Requirements for Existing Units and for Group II, Group III and Rule 1146.1 Units ≤ 12 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1146 Group I</td>
<td>≥75</td>
<td>5 ppm via SCR (same as existing limit)</td>
<td>n/a</td>
</tr>
<tr>
<td>Rule 1146 Group II</td>
<td>≥20 to &lt;75</td>
<td>For units &gt; 12 ppm: 5 ppm via SCR</td>
<td>To apply Group III limits to Group II units upon burner replacement</td>
</tr>
<tr>
<td>Rule 1146 Group III</td>
<td>≥5 to &lt;20</td>
<td>For units &gt; 12 ppm: Fire-tube boilers: 7 ppm via ULNB Water-tube boilers: 9 ppm via ULNB</td>
<td>Compliance deferred until burner replacement</td>
</tr>
<tr>
<td>Rule 1146.1</td>
<td>2 to 5</td>
<td>For units &gt; 12 ppm: Fire-tube boilers: 7 ppm via ULNB Water-tube boilers: 9 ppm via ULNB</td>
<td>Compliance deferred until burner replacement</td>
</tr>
<tr>
<td>Atmospheric Units</td>
<td>≤10</td>
<td>12 ppm via ULNB (same as existing limit)</td>
<td>n/a</td>
</tr>
<tr>
<td>Thermal Fluid Heaters</td>
<td>NA</td>
<td>12 ppm</td>
<td>To apply 12 ppm limit to entire universe including non-RECLAIM units; Compliance deferred until burner replacement for units permitted at ≤ 20 ppm</td>
</tr>
</tbody>
</table>
Emission Reductions

- Emission reduction estimates are calculated with RECLAIM universe
- Units already covered by command and control limits will not need to meet proposed limits until burner replacement
- Based on preliminary staff recommendations, total emission reduction is 0.25 tpd by the compliance timeframe (Jan. 1, 2023 in Proposed Rule 1100)
Updated Schedule

- Aug – Oct 2018: Working Group Meetings
- Aug 29, 2018: Public Workshop
- Oct 19, 2018: Stationary Source Committee
- Nov 2, 2018: Set Hearing
- Dec 7, 2018: Public Hearing
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Proposed Amended Rules 1146, 1146.1, 1146.2 and Proposed Rule 1100

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