Proposed Rule (PR) 1147.2

NO_x Reductions from Metal Processing Equipment

Working Group Meeting #3
November 6, 2019

Call-in Number / Passcode
866-705-2554 / 680785

Agenda

- Summary of Working Group Meeting #2
- Process Temperatures, Furnace Types, and NO_x Source Tests
- NO_x Formation Pathways
- Continuation of BARCT Analysis
  - Technology Assessment
  - Establishing Proposed BARCT Emission Limit
- Next Steps

Summary of Working Group Meeting #2

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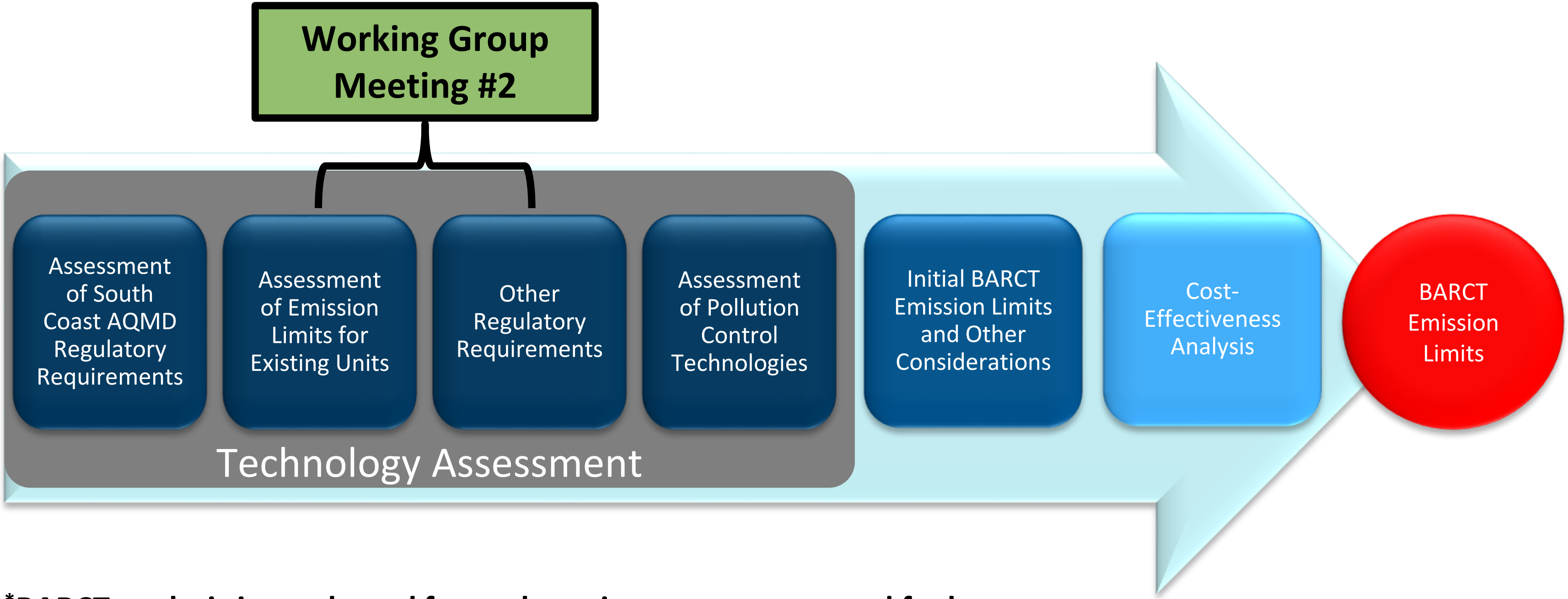
- Rule 1147 Equipment Data Request
- BARCT Analysis
  - Assessment of Emission Limits for Existing Units
    - Metal Melting Furnaces
    - Metal Heat Treating Furnaces
  - Other Regulatory Requirements

Working Group Meeting #2



*BARCT analysis is conducted for each equipment category and fuel type

Process Temperatures, Furnace Types, and NO_x Source Tests

Background & Approach

- Stakeholders commented about effects of differing temperatures and furnace types on NO_x emissions
- Staff analyzed
  - Process temperature versus source test result
  - Process temperature and furnace type versus source test result
- Analyses of process temperatures and furnace types seek to answer two questions:

1. Is there a correlation between process temperatures and source test results?

2. Is there a correlation between process temperatures, furnace types, and source test results?

Process Temperatures and Source Test Results – Methodology

- Evaluated metal melting and metal heat treating equipment categories separately for both RECLAIM and non-RECLAIM facilities
- For both equipment categories, graphed process temperatures and NO_x source test results to assess any correlations
  - Process temperature obtained from permits
- For both equipment categories, grouped units into two temperature ranges
  - Focused on lowest NO_x source test results in each temperature group

Process Temperatures and Source Test Results – Assumptions

- Only furnaces that had both a process temperature and NO_x source test result were included in this analysis
  - 228 of 250 units (87%) had both a source test result and listed a process temperature in its permit
  - Remaining units were not incorporated into this analysis
- Similar units processing the same materials at the same facility were given the same process temperature
- Average process temperature was used when a range of process temperatures was listed

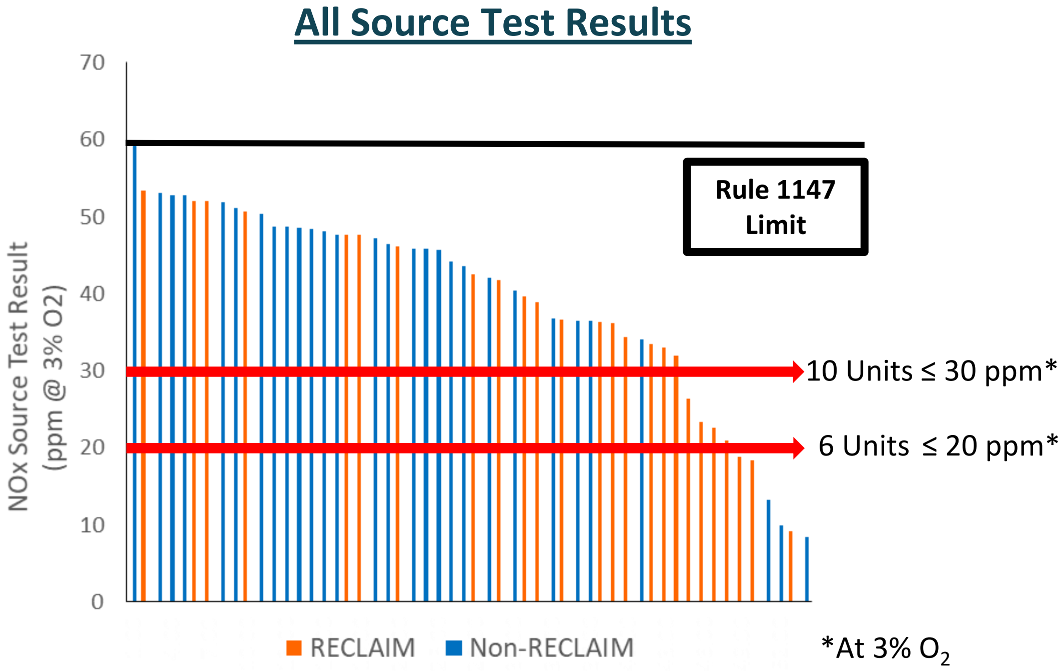
Process Temperatures & Furnace Types – Methodology and Assumptions

- Methodology
  - Evaluated metal melting and metal heat treating equipment categories separately for both RECLAIM and non-RECLAIM facilities
  - For both equipment categories, graphed furnace type and process temperature with NO_x source test result to assess any correlations
    - Process temperature and furnace type obtained from permits
- Assumptions
  - Furnace type as identified by permit's equipment description may be categorized differently over time and across facilities
  - Only furnaces that had both a process temperature and a NO_x source test result were included in this analysis

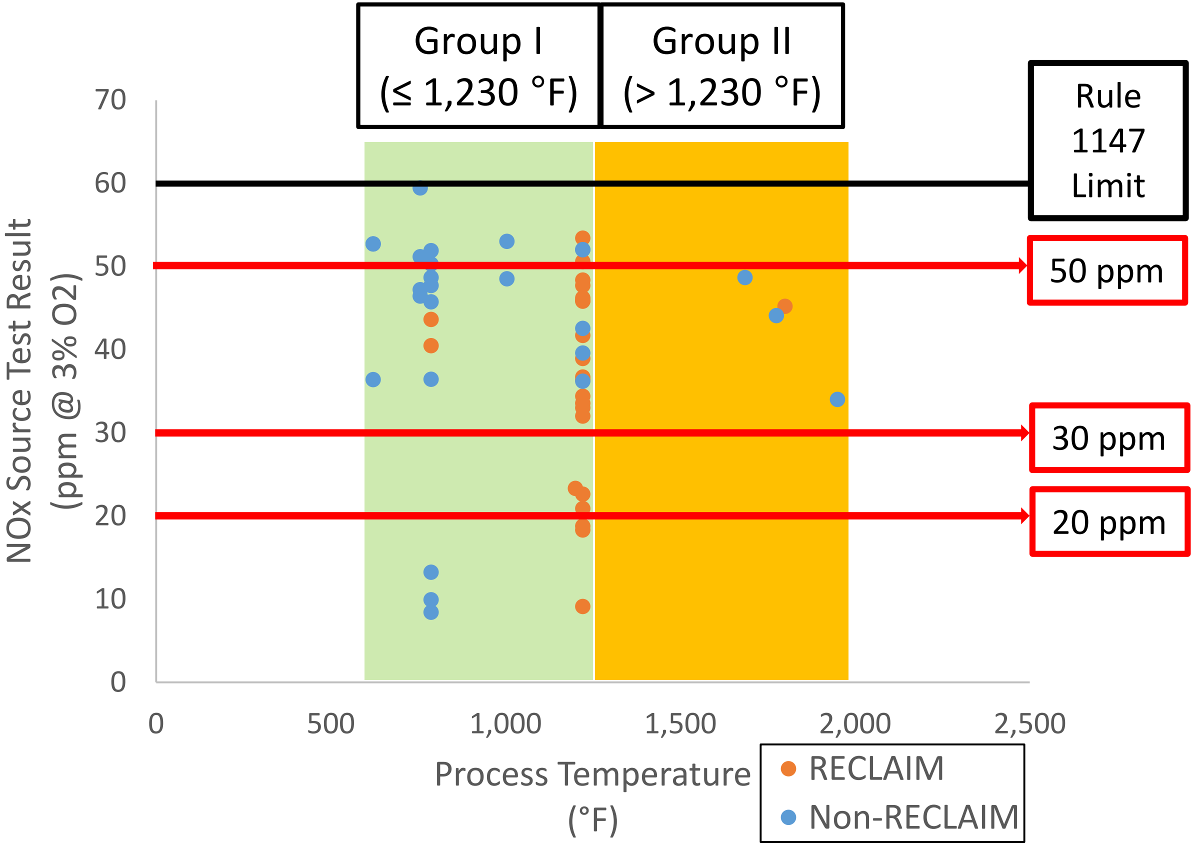
Metal Melting Furnaces

Metal Melting – Source Test Results from Working Group #2 Summary

- 54 NO_x source test results
- 50 of the 54 units with source tests also listed a process temperature
- Source test results range from 8.4 to 59.6 ppm NO_x from RECLAIM and non-RECLAIM facilities
  - 10 units ≤ 30 ppm
  - 6 units ≤ 20 ppm



Metal Melting – Process Temperatures and Source Test Results



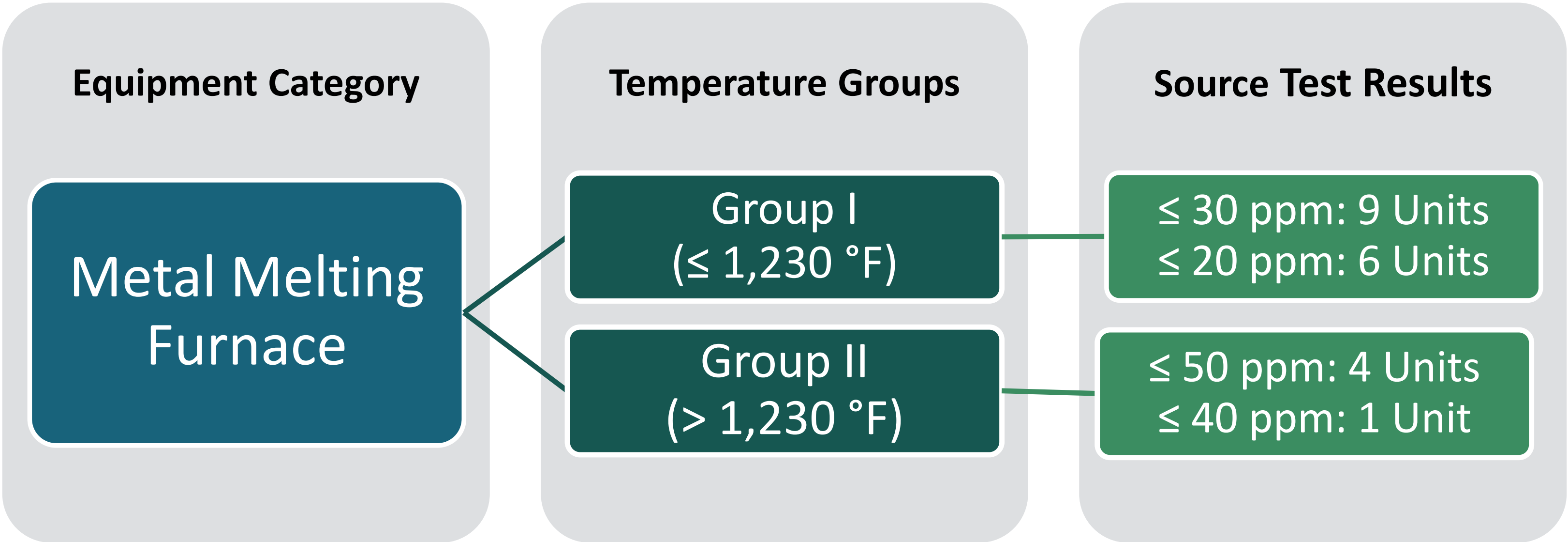
Observations

Unit Count	≤ 1,230 °F	> 1,230 °F
≤ 50 ppm*	35	4
≤ 30 ppm*	9	No Units
≤ 20 ppm*	6	

*At 3% O_2

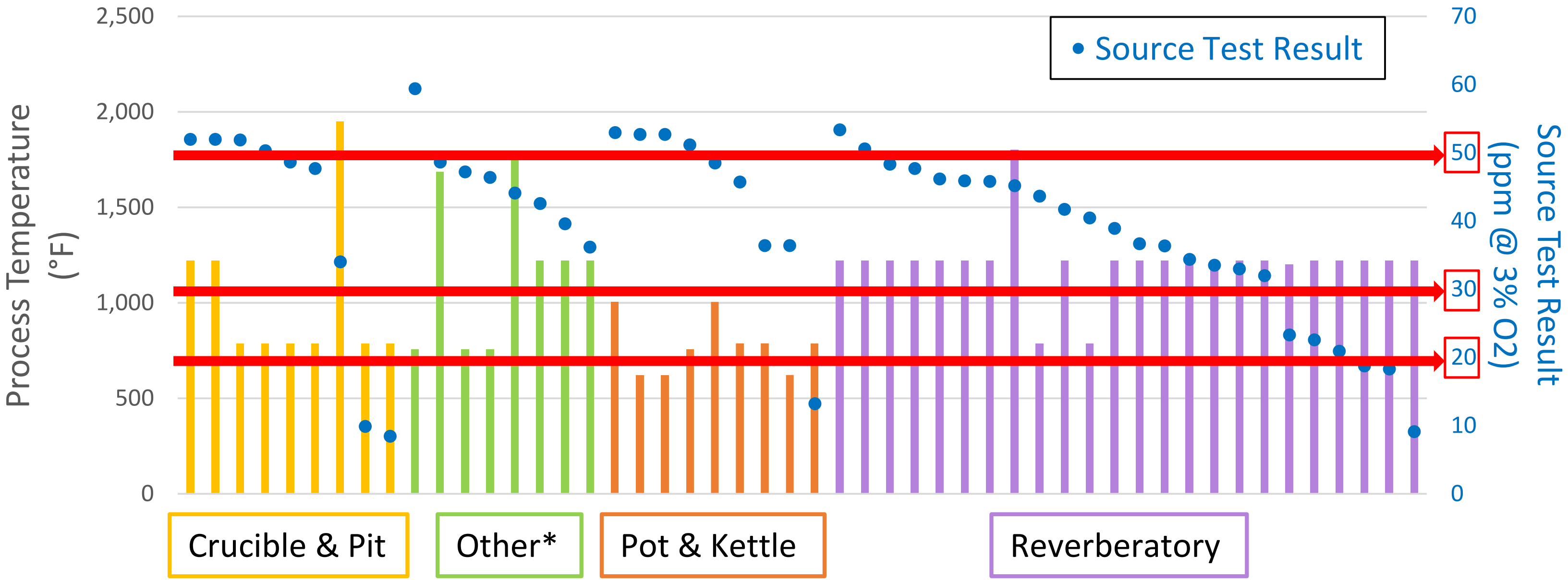
Metal Melting – Process Temperatures and Source Test Results

1. Is there a correlation between process temperatures and source test results*?



*At 3% O_2

Metal Melting – Process Temperatures and Furnace Types



* Other: Box, Furnace, Rotary (Non-Sweating), and Stack

Unit Count	Crucible & Pit	Other	Pot & Kettle	Reverberatory	Total
≤ 50 ppm†	5	7	5	22	39
≤ 30 ppm†	2	0	1	6	9
≤ 20 ppm†	2	0	1	3	6

†At 3% O_2

Metal Melting – Process Temperatures and Furnace Types

2. Is there a correlation between process temperatures, furnace types, and source test results*?

*At 3% O_2

- **Temperature Group I (≤ 1,230 °F)**
  - Crucible & Pit
    - ≤ 30 ppm: 2
    - ≤ 20 ppm: 2
  - Other
    - ≤ 30 ppm: 0
  - Pot & Kettle
    - ≤ 30 ppm: 1
    - ≤ 20 ppm: 1
  - Reverberatory
    - ≤ 30 ppm: 6
    - ≤ 20 ppm: 3
- **Temperature Group II (> 1,230 °F)**
  - Crucible & Pit
    - ≤ 50 ppm: 1
  - Other
    - ≤ 50 ppm: 2
  - Pot & Kettle
    - ≤ 50 ppm: 0
  - Reverberatory
    - ≤ 50 ppm: 1

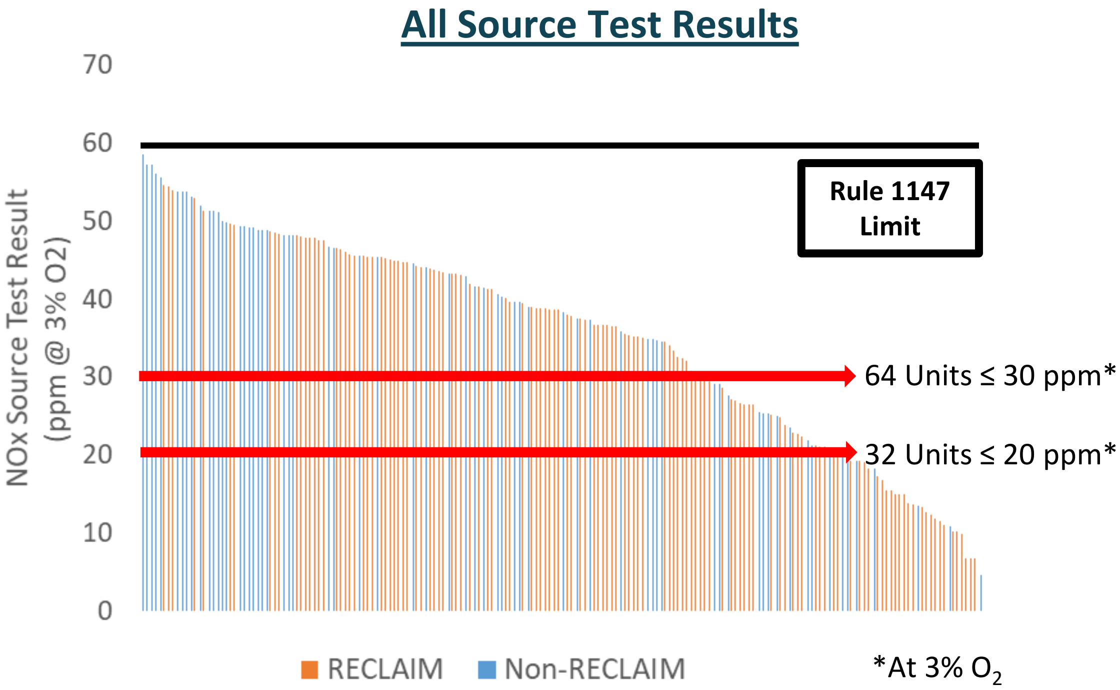
All furnace types except Other exhibit a wide range of NOx source test results

Metal Heat Treating Furnaces

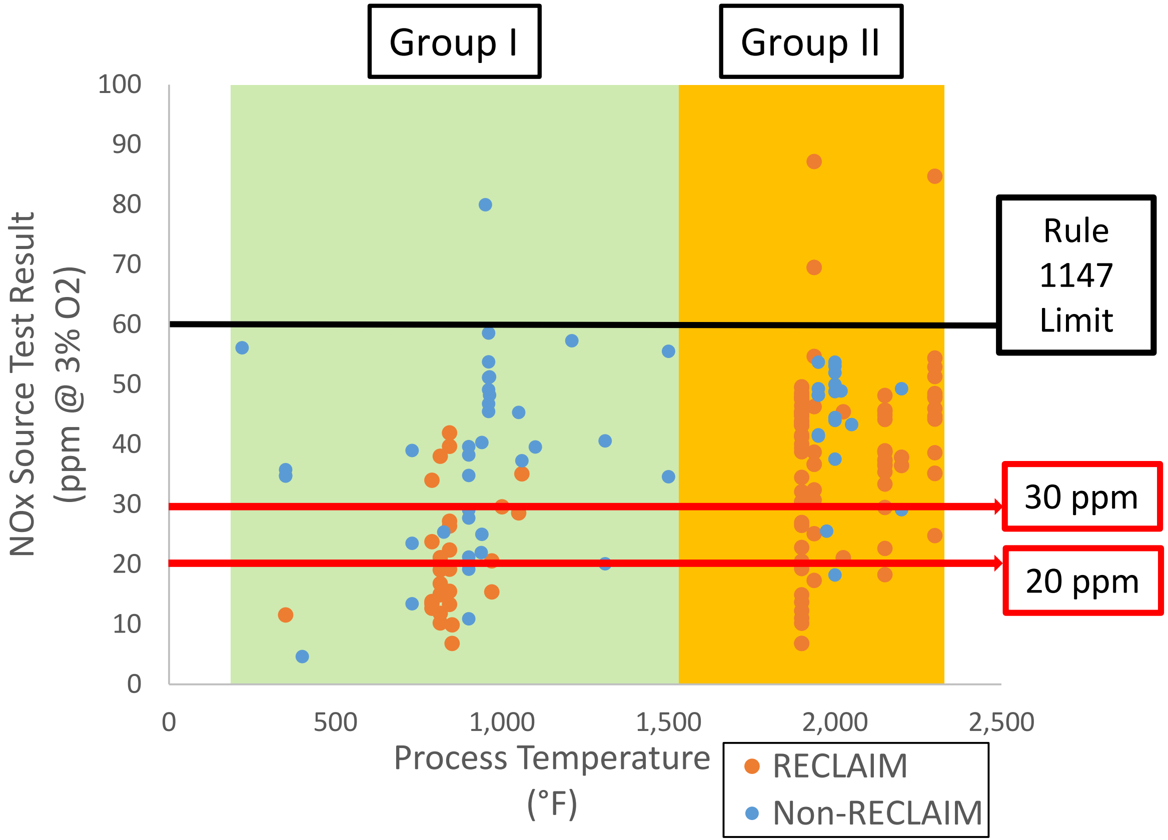
Metal Heat Treating – Source Test Results from Working Group #2 Summary

Slide Updated

- 196 NOx source tests
- Results range from 4.6 to 115 ppm NOx from RECLAIM and non-RECLAIM facilities
  - 64 units ≤ 30 ppm
  - 32 units ≤ 20 ppm
- 178 of the 196 units with source tests also listed a process temperature



Metal Heat Treating – Process Temperatures and Source Test Results



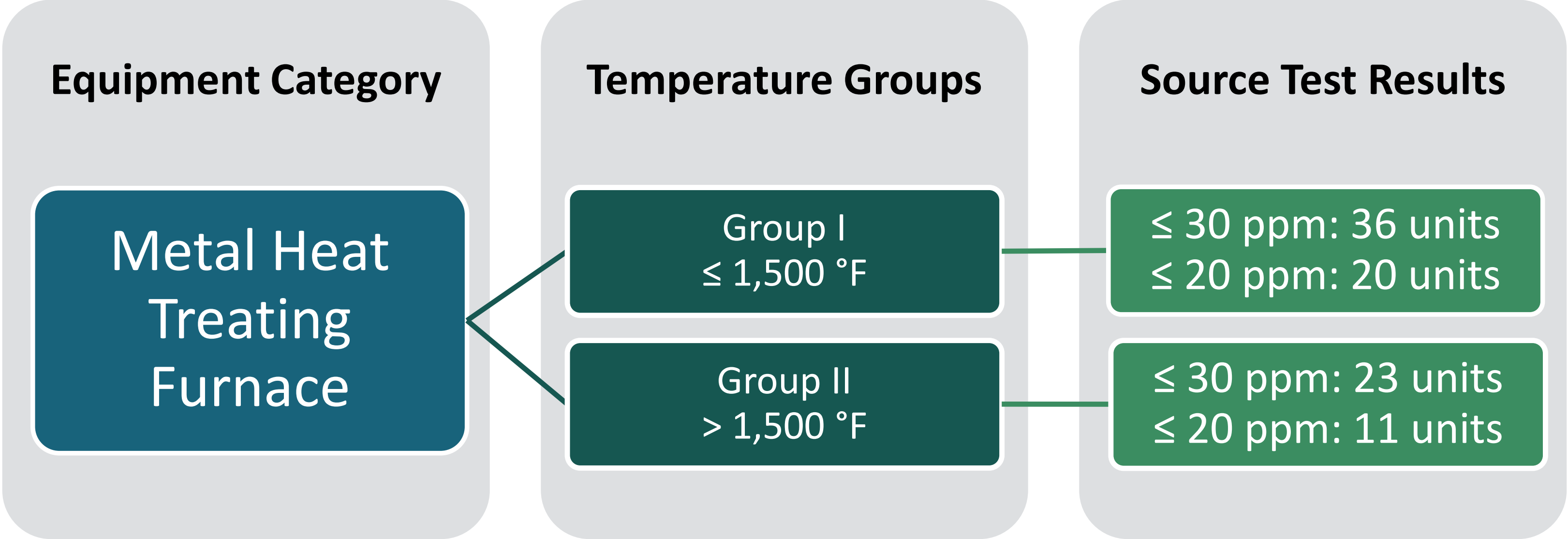
Observations

Unit Count	≤ 1,500 °F	> 1,500 °F
≤ 30 ppm*	36	23
≤ 20 ppm*	20	11

*At 3% O_2

Metal Heat Treating – Process Temperatures and Source Test Results

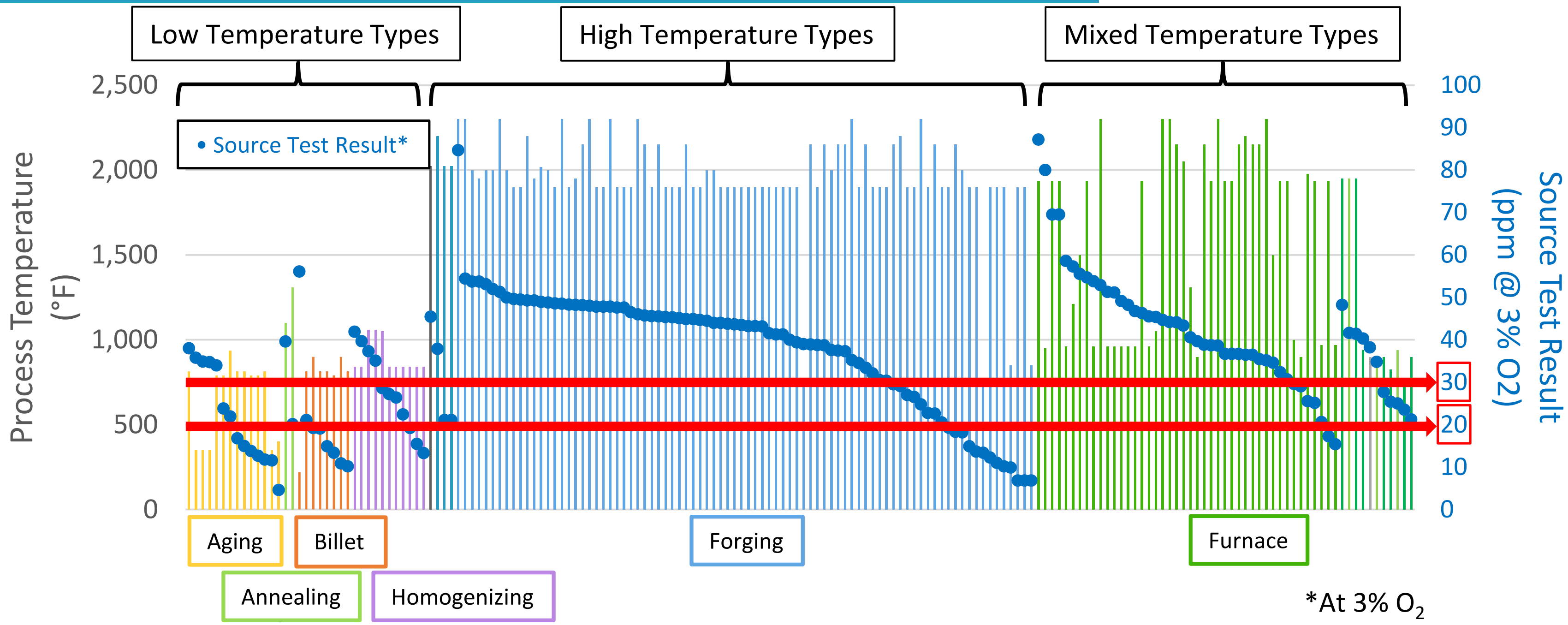
1. Is there a correlation between process temperatures and source test results*?



- No correlation observed across temperatures
- NO_x concentrations ≤ 20 ppm exist across temperatures

*At 3% O_2

Metal Heat Treating – Process Temperatures and Source Test Results



*At 3% O_2

Unit Count	Aging	Annealing	Billet	Forging	Furnace	Homogenizing	Total
≤ 30 ppm	9	1	7	23	12	7	59
≤ 20 ppm	7	0	6	13	2	3	31

Metal Heat Treating – Process Temperatures and Furnace Types

2. Is there a correlation between process temperatures, furnace types, and source test results*?

Temperature Group I (≤ 1,500 °F)

- Aging
  - ≤ 30 ppm: 9
  - ≤ 20 ppm: 7
- Billet
  - ≤ 30 ppm: 7
  - ≤ 20 ppm: 6
- Annealing
  - ≤ 30 ppm: 1
  - ≤ 20 ppm: 0
- Forging
  - ≤ 30 ppm: 3
  - ≤ 20 ppm: 3
- Furnace
  - ≤ 30 ppm: 9
  - ≤ 20 ppm: 1
- Homogenizing
  - ≤ 30 ppm: 7
  - ≤ 20 ppm: 3

Temperature Group II (> 1,500 °F)

- Annealing, Billet, Homogenizing
  - No Group II
- Forging
  - ≤ 30 ppm: 20
  - ≤ 20 ppm: 10
- Furnace
  - ≤ 30 ppm: 3
  - ≤ 20 ppm: 1

*At 3% O_2

- Forging-related units majority of applications > 1,500 °F
- NO_x concentrations ≤ 20 ppm exist for all types across all temperatures

NO_x Formation Pathways

Thermal & Process NO_x

- Thermal NO_x is formed from dissociation of N_2 from elevated temperatures, namely flame temperature
- Other sources of NO_x , although minor for natural gas, are captured in source test results
- Electric furnaces not required to source test for NO_x
  - EPA AP-42* provides a 0.22 lb NO_x/ton material processed emission factor for use in electric arc furnaces processing steel
    - 682 tons/month processed = 5 lb NO_x/day

*EPA. Emission Factor Documentation for AP-42 Section 12.5.1 – Iron and Steel Production – Steel Minimills Final Report. Apr 2009. https://www3.epa.gov/ttn/chief/ap42/ch12/final/c12s0501.pdf

Electric Furnaces & Process NO_x

Slide Updated

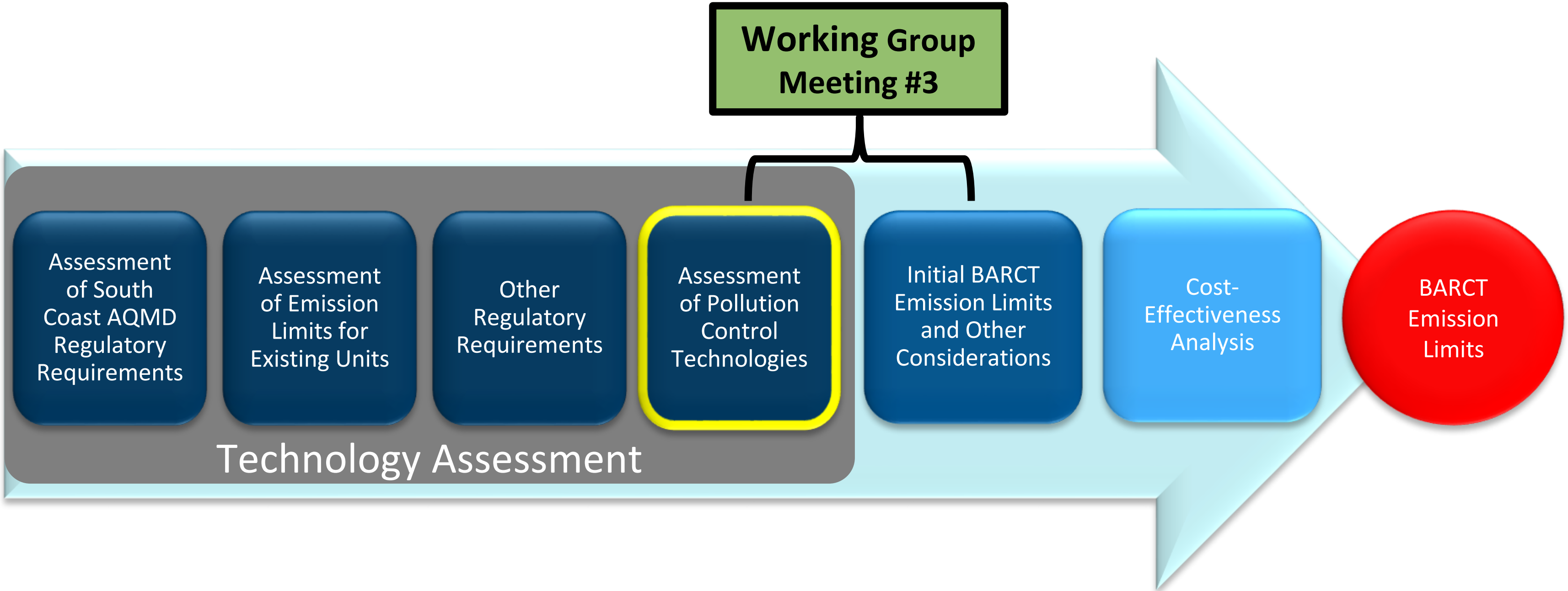
- Approximately 150 electric furnaces identified
- Largest electric furnaces have low NO_x emissions relative to natural gas-fired furnaces
  - Majority of electric furnaces emit < 1 lb/day NO_x
- Staff will continue to investigate cost-effectiveness of SCR control for process NOx

Largest Electric Furnaces

Electric Rating (KW)	Material Process Rate (ton/day equivalent)	NO_x Emissions (lbs/day)
2,500	83.2	18.3
1,250	39.9	8.8
1,250	39.9	8.8
1,250	39.9	8.8
1,250	39.9	8.8
1,500	31.7	7.0

Continuation of BARCT Analysis

Working Group Meeting #3: Current Progress



*BARCT analysis is conducted for each equipment category and fuel type

Working Group Meeting #2 Findings

- Previous Work Group Meetings established initial categories, analyzed permit limits and source test results, and reviewed existing regulations of other agencies
- Average NO_x concentration in proposed universe
  - Metal Melting: 44 ppm
  - Metal Heat Treating: 42 ppm
- Other California air district BARCT limit
  - Metal Melting: 60 ppm
  - Metal Heat Treating: 60 ppm
- U.S. EPA BACT limit
  - Metal Melting: 33 ppm
  - Metal Heat Treating: 39 ppm

Assessment of Pollution Control Technologies – Methodology & Approach

Researched multiple sources for available NO_x control technologies

- Scientific Literature
- Vendor meetings
- Consultant meetings
- Facility site visits

Analyzed Sources to:

- Identify relevant burner technologies
- Identify post-combustion control technologies
- Understand capability and limitations of each technology

Background

Slide Updated

- Purpose of technology assessment is to assess current NO_x control technologies for metal melting and metal heat treating furnaces
- Two strategies utilized to reduce NO_x emissions for metal melting and metal heat treating furnaces
  - Combustion Control
    - Low NO_x Burners
    - Flue Gas Recirculation
    - Recuperative & Regenerative Burners
  - Post-Combustion Control
    - Selective Catalytic Reduction
    - Selective Non-catalytic Reduction

Low NO_x Burners

- Low NO_x burners implement a variety of combustion optimization techniques to lower NO_x emissions:
  - Combustion Staging: Performing partial combustion
  - Low Excess Air: Lowers excess air to < 2% and is obtained through feedback control systems to minimize flame temperature
  - Flame Enlargement: Lowers peak flame temperature but may overlap with adjacent burner flames or impinge parts
  - Radiant Burning: Firing mechanism to produce lower NO_x emissions with higher excess air; more suited for new installations than retrofits

Low NO_x Burners *(Cont.)*

- Emissions Performance & Applicability
  - Product literature for two manufacturers[1,2,3] claim that both low and high temperature burners can meet 30 ppm @ 3% O_2
  - Excess air and combustion air temperature identified as key metrics in burner applicability
- Other Findings
  - Of the units with control technology, 86% of the technologies are listed as Low NO_x or Ultra-low NO_x Burners on the unit permit
    - Use of Low and Ultra-low NO_x language may not necessarily correlate to NO_x concentration
    - 64% of units with Low and Ultra-low NO_x Burners are > 30 ppm

[1] http://digital.bnpmedia.com/publication/?i=169784&article_id=1471463&view=articleBrowser&ver=html5#{"issue_id":169784,"view":"articleBrowser","article_id":"1471463"}
[2] https://www.eclipsenet.com/products/furnnox/
[3] https://www.asminternational.org/c/portal/pdf/download?articleId=HTP00801P033&groupId=10192

Flue Gas Recirculation (FGR)

- Recirculation of exhaust gas via dampers, fans, and educators to the burners to dilute the combustion air
- Emissions Performance & Applicability
  - In the steel mill industry, FGR alone has shown to reduce NO_x by an additional 10%
  - Can be retrofitted onto furnaces but may require ductwork and additional fan capacity
  - Is often combined with Low NO_x Burners
- Mechanism
  - Flue gas contains combustion products that dilute oxygen content and lower the peak flame temperature
  - Typically 10 – 15%* of combustion air is replaced with recirculated flue gas

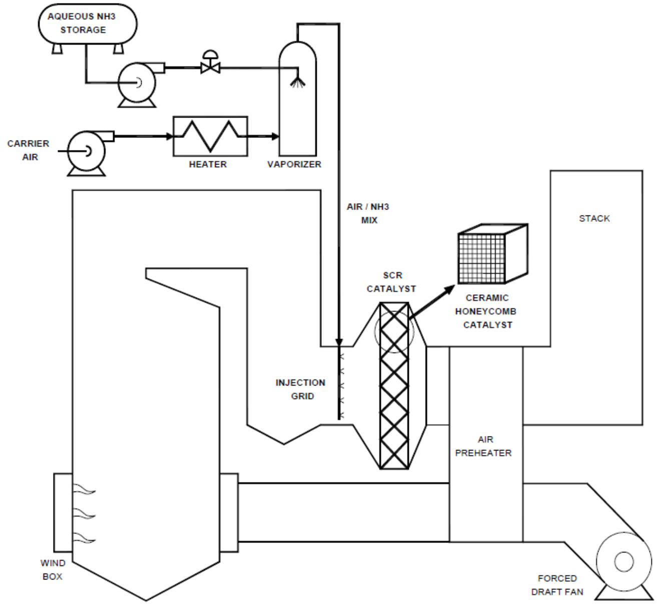
* In the boiler industry

Recuperative & Regenerative Burners

- Specific burner types utilizing heat exchange methods between exhaust gas and combustion air
- Due to elevated pre-heat temperatures, unit efficiency increases but NO_x concentrations may increase
- Emissions Performance & Applicability
  - NO_x concentration may not decrease due to elevated air pre-heat temperatures
  - Primary mechanism of NO_x mass emission reductions is by reducing fuel use by 30 – 50%
  - Regenerative burners are better suited for new installs rather than retrofits
  - Recuperative burner units demonstrated to have ≤ 30 ppm NO_x concentration

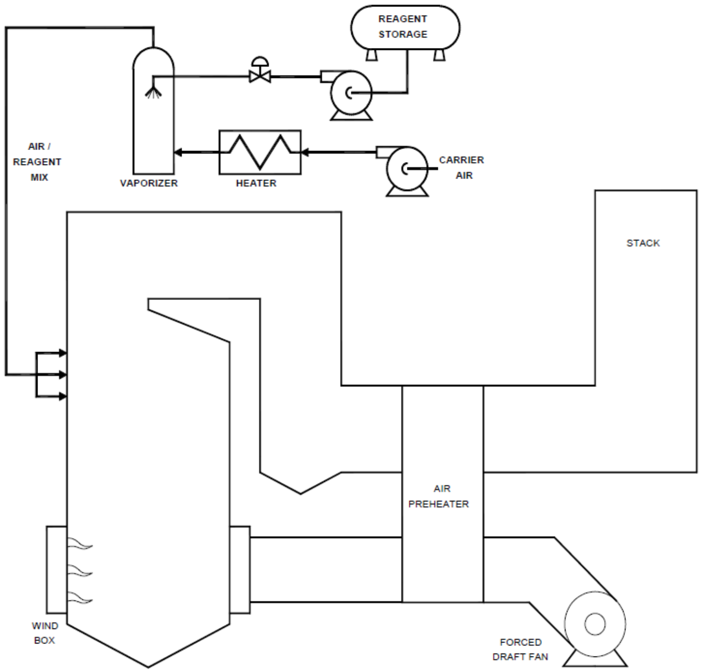
Selective Catalytic Reduction (SCR)

- Injection of ammonia or urea into flue gas stream to reduce NO_x to N_2 and H_2O with the use of catalysts
- Optimal Settings
  - Optimal temperature: 500 – 1,000 °F
  - Requires a 0.9:1 – 1:1 molar ratio of NH_3:NO_x
- Emissions Performance & Applicability
  - NO_x Reduction Efficiency: 80 – 85%+
  - One active furnace installation utilizes SCR to achieve an 80% NO_x reduction
  - Additional operating costs will be incurred over combustion control technologies (e.g. approximately $26,000/yr for a 44 MMBtu/hr furnace)
  - Regeneration of catalyst 40% less expensive than catalyst replacement



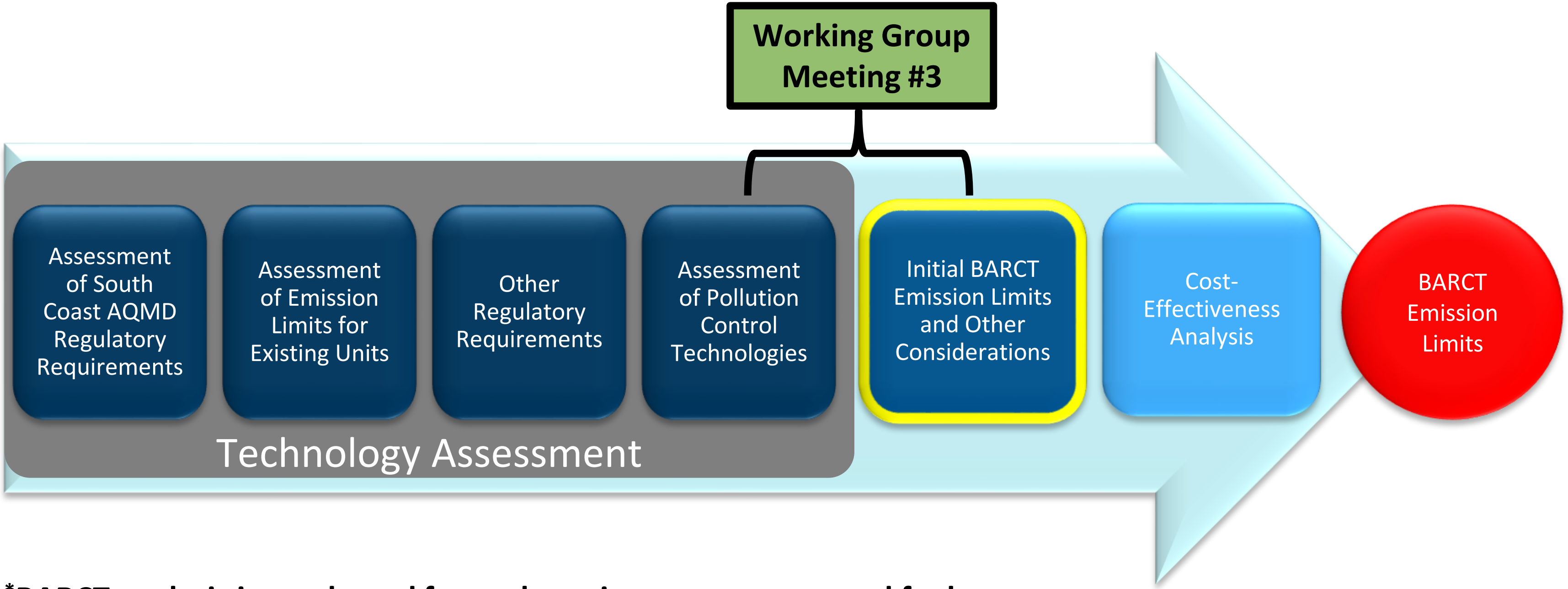
Selective Non-catalytic Reduction (SNCR)

- Injection of ammonia or urea into flue gas stream to reduce NO_x to N_2 and H_2O without the use of catalysts
- Optimal Settings
  - Optimal temperature: 1,500 – 2,200 °F
  - Requires a > 1 s residence time and a 2:1 – 4:1 molar ratio of NH_3:NO_x, leading to higher ammonia slip than SCR
- Emissions Performance & Applicability
  - NO_x Reduction Efficiency: 60%*
  - When combined with Low NO_x Burners, can achieve greater NO_x reductions than SCR alone (95%+ reductions)
  - Approximately 20% lower operating costs than SCR due to lack of catalyst
  - Optimal temperature difficult to maintain
    - No active installations in the proposed universe



*60% is typical in the boiler industry

Working Group Meeting #3: Current Progress



*BARCT analysis is conducted for each equipment category and fuel type

BARCT Limit Guidelines

- California Health and Safety Code Section 40406 defines BARCT as

  "…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 limit will adhere to Health and Safety Code Section 40920.6, which establishes requirements prior to adopting rules or regulations regarding retrofit control technologies
- In addition to the overall cost-effectiveness, additional considerations for:
  - Outliers
  - Stranded assets
  - Incremental cost-effectiveness
  - Accounting for recent installations – implementation of previous requirements (BARCT or BACT)

Metal Melting – Initial BARCT Emission Limit

Slide Updated

South Coast AQMD Regulatory Requirements	Existing Units (Source Testing)	Other California Air Districts	Technology Assessment	Initial BARCT Emission Limit
60 ppm	9 – 59 ppm 13 (26%) ≤ 30 ppm 7 (14%) ≤ 20 ppm	60 ppm	SCR Installation: 11 ppm	11 ppm
			Burner Replacement: 20 – 30 ppm	20 – 30 ppm

Heat Treating – Initial BARCT Emission Limit

Slide Updated

South Coast AQMD Regulatory Requirements	Existing Units (Source Testing)	Other California Air Districts	Technology Assessment	Initial BARCT Emission Limit
60 ppm	5 – 115 ppm 59 (33%) ≤ 30 ppm 31 (17%) ≤ 20 ppm	60 ppm	SCR Installation: 11 ppm	11 ppm
			Burner Replacement: 20 – 30 ppm	20 – 30 ppm

Next Steps

- Continue site visits
- Conduct Cost-effectiveness Analysis
- Continue meetings with burner manufacturers
- Draft Proposed Rule Language initial concepts

Rule Development Activity	Tentative Schedule
Next Working Group Meeting	December 2019
Public Workshop	January 2020
Set Hearing	February 2020
Public Hearing	March 2020

Contacts

PR 1147.2	PAR 1147	RECLAIM Questions	General Questions
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