ETS, INC.

INDEPENDENT TECHNICAL REVIEW OF SCAQMD DRAFT TECHNOLOGY ASSESSMENT FOR SMALL AND LOW EMISSIONS SOURCES – REGULATED BY SCAQMD RULE 1147 (NO_X REDUCTIONS FROM MISCELLANEOUS SOURCES)

FINAL REPORT

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SCAQMD CONTRACT NO. 16398

ETS, INC. CONTRACT # 16-2350-C

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I. EXECUTIVE SUMMARY

South Coast Air Quality Management District (SCAQMD) Rule 1147 – NOx Reductions from Miscellaneous Sources was adopted by the SCAQMD Governing Board on December 5, 2008 for the purpose of reducing NOx emissions from a wide variety of combustion sources. Rule 1147 affects new and existing (in-use) combustion equipment requiring permits that is not regulated by other SCAQMD NOx rules and incorporates the following two control measures of the 2007 Air Quality Management Plan (AQMP): 1) CMB-01 – NOx Reductions from Non-RECLAIM Ovens, Dryers and Furnaces and 2) MCS-01 – Facility Modernization. SCAQMD Rule 1147 has been identified as an important component of the attainment strategy to meet both the federal annual $PM_{2.5}$ ambient air quality standard and the federal 8-hour ozone standard.

Rule 1147 was amended by the SCAQMD Governing Board on September 9, 2011 and included a requirement for SCAQMD Staff to perform an updated technology assessment for combustion equipment with NOx emissions of one pound per day or less. Also, at the September 9, 2011 Governing Board Meeting Staff proposed to hire an independent third party to review, discuss with Stakeholders, and provide comments on the Technology Assessment. A Request for Proposals (RFP # P2016-22) titled "Technical Review of Rule 1147 Technology Assessment for Small and Low Emission Sources" was released by SCAQMD on April 1, 2016 with a proposal due date of May 5, 2016. The purpose of the RFP was to solicit qualified firms to review and provide comments on the SCAQMD Draft Technology Assessment of small and low emission combustion equipment regulated by SCAQMD Rule 1147.

ETS, Inc. (ETS), an independent air emissions control consulting firm, submitted a proposal in response to RFP # P2016-22 and was notified as being selected for contract award in June 2016. The primary focus of the ETS review, as described in the scope of work, was to review and provide comments on SCAQMD Staffs' Draft Technology Assessment for Rule 1147 Small and Low Emission Sources that was released for public review on January 29, 2016. The purpose of the SCAQMD assessment was to evaluate the technical feasibility of retrofitting small and low emission units to comply with Rule 1147 NOx emission limits and the cost and cost effectiveness of replacing heating systems in those units for the categories of Rule 1147 equipment that were not addressed through amendment of Rules 219 and 222 and adoption of Rule 1153.1.

The ten major categories of equipment that were identified in the Draft Technology Assessment and evaluated by ETS were: 1) afterburner technologies, 2) spray booths, 3) crematories, 4) fryers, 5) heated process tanks, 6) heat treating, 7) metal melting furnaces, 8) multi-chamber burn-off ovens and incinerators, 9) ovens and dryers, and 10) food ovens. Some of the processes utilizing the above equipment and regulated by Rule 1147 were described as including, but not limited to, coating, printing, textile processing, material processing, and manufacturing using wood, plastics, ceramic and metal materials.

After ETS conducted the initial review of the February 2016 Draft Technology Assessment, a Rule 1147 Task Force meeting was scheduled for August 3, 2016 at SCAQMD headquarters. The purpose of the meeting was as follows:

- Introduce ETS to SCAQMD Staff, Rule 1147 Task Force members, and Stakeholders
- Receive input from the Stakeholders on SCAQMD's Draft Technology Assessment which was released for public review on January 29, 2016
- Discuss the future activities and schedule for Rule 1147

Subsequent to the Rule 1147 Task Force Meeting, Stakeholders were given a deadline of August 23, 2016 to submit all inputs, data, comments, and/or concerns to ETS for independent review. ETS received information from the Stakeholders between August 3, 2016 and the August 23, 2016 deadline. All of the information received came from the following three Stakeholders: 1) Furnace Dynamics, Inc., 2) Industrial Process Equipment, Inc., and 3) Wirth Gas Equipment, Inc. ETS identified the information received from the three Stakeholders as nine distinct item numbers (Item #'s 1-9) by the date received. Additionally, two undated items and a third item were received after the August 23, 2016 deadline (Item #'s 10-12) from Industrial Process Equipment, Inc. and Furnace Dynamics, Inc.

The first category of comments received from the Stakeholders dealt with the availability of low NOx replacement burner technology for a specific application within the heated process tanks, evaporators and parts washers' equipment category. Similar comments were received from all three Stakeholders regarding a specific parts washer application within that equipment category, which was one of the ten major categories of equipment identified in the Draft Technology Assessment. The second category of comments from one Stakeholder was regarding the methodology of the cost effectiveness analysis. A third category of Stakeholder comments received by ETS included copies of comments that were indicated as being submitted directly to SCAQMD Staff prior to the release of the solicitation for third-party review; however, many of the comments were not explicitly applicable to the review of the February 2016 Draft Technology Assessment Rule for 1147 Small and Low Emission Sources. Those Stakeholder comments were related to topics such as Rule 1147 compliance activities or past rule development and potential future rule amendments.

The ETS comments on the burner technology review and the cost and cost effectiveness data and analysis conducted in the Draft Technology Assessment are included in this report. Comments received from the three Stakeholders during this project have also been addressed with ETS responses. In consideration of the Stakeholder comments received and based upon a detailed review of the February 2016 Draft Technology Assessment for Rule 1147 Small and Low Emission Sources, ETS concurs with the five recommendations that were presented in SCAQMD Staff's assessment. The five recommendations by equipment category for Rule 1147 may be found in Table ES-1 along with the following additional recommendation by ETS:

> Change the NOx emission limit from 30 ppm to 60 ppm in the afterburner technologies equipment category for processes that operate at or below 800°F. This new NOx limit of 60 ppm will be the same compliance limit required for higher temperatures and therefore the same limit at any process temperature in the afterburner technologies category. (ETS Recommendation #6)

TABLE ES-1

Summary of Recommendations from Rule 1147 Draft Technology Assessment and ETS Comments/Recommendations

Equipment Category	Rule 1147 Recommendations	Basis for Recommendation	ETS Comments
SCAQMD Staff Recommendations in Rule 1147 Draft Technology Assessment:			
Low Temperature Operations Including Ovens and Dryers	Exempt new and existing in-use units with total rated heat input of less than 325,000 Btu/hour	Technical Feasibility	ETS concurs with SCAQMD Staff Recommendation #1
Evaporators, Heated Process Tanks, or Parts Washers with an Integrated Heated Tank	Delay compliance with the NOx emission limit for existing in-use units until the combustion system or tank is modified, relocated or replaced	Technical Feasibility	ETS concurs with SCAQMD Staff Recommendation #2
Multi-chamber Burn-off Ovens, Burn-out Furnaces, and Incinerators	Change the NOx emissions limit from 30 ppm to 60 ppm NOx for the primary chamber of equipment in this category for processes that operate at or below 800°F (same limit for all process temperatures)	Technical Feasibility	ETS concurs with SCAQMD Staff Recommendation #3
Units with actual NOx emissions of one pound per day or less	Delay compliance with the NOx emission limit for other existing in-use units with actual NOx emissions of one pound per day or less until the unit or combustion system is modified, relocated or replaced	Cost Effectiveness	ETS concurs with SCAQMD Staff Recommendation #4
Spray Booths	Delay compliance with the NOx emission limit for existing in-use units until the booth or heating system is modified, relocated or replaced	Cost Effectiveness	ETS concurs with SCAQMD Staff Recommendation #5
ETS Recommendation After Review of Rule 1147 Draft Technology Assessment:			
Afterburner Technologies	Change the NOx emissions limit from 30 ppm to 60 ppm NOx for equipment in this category with processes that operate at or below 800°F (same limit for all process temperatures)	Technical Feasibility	ETS Recommendation #6

II. STATEMENT OF WORK

ETS, Inc. (ETS) was commissioned by the South Coast Air Quality Management District (SCAQMD), under the direction of the Planning and Rules Manager, to review and provide comments on SCAQMD Staff's Draft Technology Assessment of small and low emission combustion equipment subject to SCAQMD Rule 1147. This independent review focused on the purpose of the Technology Assessment, which was to evaluate the technical feasibility of retrofitting small and low emission units to comply with Rule 1147 nitrogen oxide (NOx) emission limits and the cost and cost effectiveness of replacing heating systems in these units. The review and comments were specific to the Rule 1147 requirements and not the requirements of other SCAQMD rules, including Regulation XIII (New Source Review) or other agencies' or organization's regulations and requirements. ETS was contracted to perform the following services:

<u>Task 1</u> – Review and analyses of technical and cost information compiled by SCAQMD in Draft Rule 1147 Technology Assessment

The SCAQMD Draft Technology Assessment for Rule 1147 Small and Low Emission Sources, found in Appendix A, evaluated the following ten major categories of small and low emission combustion equipment regulated by SCAQMD Rule 1147 – NOx Reductions from Miscellaneous Sources:

1. Afterburner Technologies
2. Spray Booths
3. Crematories
4. Fryers
5. Heated Process Tanks
6. Heat Treating Operations
7. Metal Melting Processes
8. Multi-Chamber Burn-Off Ovens and Incinerators
9. Ovens and Dryers
10. Food Ovens

<u>Task 2</u> – Provide comments and suggestions on the technology review, cost and cost effectiveness data and analysis in the SCAQMD Draft Technology Assessment

The project included a review of the ten major categories of equipment evaluated by SCAQMD and their associated costs and cost effectiveness. ETS also provided review and commentary on the costing approach and the cost effectiveness methodologies used by the agency.

<u>Task 3</u> – Attend at least two meetings with SCAQMD Staff and one with Stakeholders at a Rule 1147 Task Force Meeting at SCAQMD Headquarters

III. RULE 1147 TASK FORCE MEETING HELD ON AUGUST 3, 2016 AT SCAQMD HEADQUARTERS

ETS attended a Rule 1147 Task Force Meeting with SCAQMD Staff, Rule 1147 Task Force members, and Stakeholders that was held at SCAQMD Headquarters on August 3, 2016. The purpose of the meeting was as follows:

- Introduce ETS to SCAQMD Staff, Rule 1147 Task Force members, and Stakeholders
- Receive input from the Stakeholders on SCAQMD's Draft Technology Assessment which was released for public review on January 29, 2016.
- Discuss the future activities and schedule for Rule 1147

The focus of this project effort was to review and provide comments on SCAQMD Staff's Draft Technology Assessment for Rule 1147 Small and Low Emission Sources, dated February 2016, which is located in Appendix A of this report. The Draft Technology Assessment was made available on January 29, 2016 for public review at the following SCAQMD web address: http://www.aqmd.gov/home/regulations/rules/support-documents#r1147. Additionally, Appendix A contains the SCAQMD Governing Board Letter and Draft Rule 1147 Technology Assessment from the Board Meeting date of March 4, 2016 (Agenda No. 25). The synopsis from the Board Meeting states that Staff had proposed to hire a third party to review the Draft Technology Assessment and the Board action was to receive and file the Draft Rule 1147 Technology Assessment.

Appendix B contains items from the August 3, 2016 Rule 1147 Task Force Meeting such as the Meeting Agenda (Attachment B-1), the SCAQMD Staff Presentation (Attachment B-2), and the ETS Presentation (Attachment B-3). Appendix B also contains the sign-in sheet from the Rule 1147 Task Force Meeting (Attachment B-4) and business cards that were provided to both SCAQMD and ETS at the meeting (Attachments B-5 and B-6, respectively).

The primary purpose of the Task Force Meeting was to receive input from Stakeholders prior to preparing an analysis of the Draft Technology Assessment. ETS was under the impression that Rule 1147 Task Force Meeting attendees would have previously reviewed the SCAQMD Staff's February 2016 Draft Technology Assessment for Rule 1147 Small and Low Emission Sources prior to the August 3, 2016 meeting date since it had been released for public review on January 29, 2016. Based on that assumption, ETS created presentation slides for each of the five SCAQMD Staff Recommendations that were already documented in the Draft Technology Assessment in order to generate Stakeholder input and discussion during the meeting. Many of the Stakeholder questions or comments received during the meeting required input from SCAQMD Staff present at the meeting because they dealt with topics related to compliance and rule implementation that were either not applicable to the specific ETS tasks or they were topics raised and addressed during the rulemaking process. Also, some of the Stakeholder comments received appeared to have already been addressed and agreed upon by SCAQMD in the Staff Recommendations of the February 2016 Draft Technology Assessment. Staff indicated to the Stakeholders that ETS would be available immediately following the meeting to receive comments and that the ETS contact information could be obtained so that Stakeholders could submit comments subsequent to the meeting.

Several pieces of information were received right after the conclusion of the Rule 1147 Task Force Meeting from Anthony Endres of Furnace Dynamics, Inc. Subsequent to the Rule 1147 Task Force Meeting, Stakeholders were given a deadline of Tuesday, August 23, 2016 to submit all inputs, data, comments, and/or concerns to ETS for independent review. All of the Stakeholder information received by ETS and the ETS responses to comments are addressed in Sections VIII and IX of this report.

IV. INFORMATION REVIEWED BY ETS TO DATE

A. General Information Pertaining to Rule 1147

As previously stated, the primary focus of the ETS project effort was to review and provide comments on SCAQMD Staff's Draft Technology Assessment for Rule 1147 Small and Low Emission Sources, dated February 2016 (Appendix A). Relevant sections from the following additional sources, which were referenced in the Draft Technology Assessment, were also examined during the ETS independent review:

1. EPA, 2002; *EPA Air Pollution Control Cost Manual, Sixth Edition* [EPA/452/B-02-001], United States Environmental Protection Agency, Office of Air Quality Planning and Standards, January 2002.
2. SCAQMD, 2011; *Rule 1147 – NOx Reductions from Miscellaneous Sources*, South Coast Air Quality Management District, September 2011.
3. SCAQMD, 2000; *Best Available Control Technology Guidelines Part C: Policies and Procedures for Non-Major Polluting Facilities*, South Coast Air Quality Management District (August 17, 2000, Proposed Amended October 2016).
4. SCAQMD, 2000; *Best Available Control Technology Guidelines Part D: BACT Guidelines for Non-Major Polluting Facilities*, South Coast Air Quality Management District (October 20, 2000, Proposed Amended October 2016).

B. Information Received from SCAQMD

In order to effectively perform an independent review and analysis of the technical and cost information presented in the Draft Technology Assessment, ETS requested some of the supporting files that SCAQMD Staff had compiled for the development of the Draft Technology Assessment. The following files were provided by SCAQMD to ETS for review, with some confidential information therein:

1. SCAQMD Source Test Databases as of January 2015
2. Summary of Low and High Temp Burner Costs

3. Spray Booth Costs
4. Immersion Tube Heating and Metal Melt Furnace Calculations
5. Contacts for Low NOx Burner Manufacturers
6. Rule 1147 Equipment Category Estimates

C. Additional Sources Referenced by ETS

In addition to the sources mentioned above, ETS consulted numerous sources of information regarding low NOx burner technology applicable to Rule 1147 such as burner manufacturer data, technical feasibility, industry expert reports, etc. Specific sources were cited throughout this report where appropriate.

V. ETS COMMENTS AND SUGGESTIONS ON SCAQMD TECHNOLOGY REVIEW

As explained in the SCAQMD Draft Technology Assessment and as understood by ETS, the primary focus of the ETS independent review was the availability of burner systems and units for small and low use equipment in processes with NOx emissions of one pound per day or less for the remaining categories of Rule 1147 equipment that were not addressed through the amendment of Rules 219 and 222 and adoption of Rule 1153.1. These small and low emission sources are not subject to the best available control technology (BACT) requirements as new sources.

The Draft Technology Assessment contained a large amount of information on the equipment and wide variety of processes regulated by Rule 1147 and utilized information from the SCAQMD permit system, SCAQMD emissions testing programs, and discussions with equipment and burner manufacturers, affected businesses, consulting engineers, industry, and business representatives. The ETS review encompassed SCAQMD Staff's evaluation on the types and number of equipment affected by Rule 1147, the emission characteristics of that same equipment, and the estimates for cost and cost effectiveness of replacing old burners, either by retrofit or replacement of the unit.

The ten major categories of equipment that were evaluated in the Draft Technology Assessment were: 1) afterburner technologies, 2) spray booths, 3) crematories, 4) fryers, 5) heated process tanks, 6) heat treating, 7) metal melting furnaces, 8) multi-chamber burn-off ovens and incinerators, 9) ovens and dryers, and 10) food ovens. Some of the processes utilizing the above equipment and regulated by Rule 1147 were described as including, but not limited to, coating, printing, textile processing, material processing, and manufacturing using wood, plastics, ceramic and metal materials. The largest fraction of the equipment subject to Rule 1147 heats air that is directed to a process chamber which transfers heat to process materials (convective heating). The other categories of equipment directly heat products using a combination of radiant and convective heating.

As defined by SCAQMD Rule 1147, "NOx emissions means the sum of nitrogen oxide and nitrogen dioxide in the flue gas, collectively expressed as nitrogen dioxide." NOx emissions are formed by the following three different mechanisms[1]:

1. **Thermal NOx** is formed by the reaction of nitrogen and oxygen at high combustion temperatures (typically above flame temperatures of 2,370°F (1299°C)).
2. **Fuel Bound NOx** is formed by the direct oxidation of the already-ionized nitrogen contained in the fuel source. For cleaner burning fuels like natural gas and liquefied petroleum gas (LPG), fuel NOx generation is insignificant.
3. **Prompt NOx** is formed from molecular nitrogen in the air combining with fuel in fuel-rich conditions. This nitrogen then oxidizes along with the fuel and becomes NOx during combustion, just like fuel NOx.

The main functions of low NOx burners are to create more uniform combustion, better control the air-fuel mixture, and reduce the combustion residence times. These characteristics will reduce NOx formation and reduce the peak flame temperature at which thermal NOx is formed. The combustion uniformity reduces the formation of fuel rich zones where prompt NOx is formed. Premixing of combustion air with fuel can also aid in keeping the temperature uniform in an oven or furnace, which is often necessary to obtain critical product characteristics.

Another method for controlling NOx emissions for some of the equipment categories regulated by Rule 1147 is flue gas recirculation (FGR). FGR is a technique in which a portion of the cooled exhaust flue gas is recirculated back to the burner. FGR aids in lowering NOx by absorbing heat from the flame to reduce the peak flame temperature and by diluting the oxygen content of the combustion air.

Matt Brueck, Sales Engineer at Maxon Corporation, states the following in an article published in 2002 regarding an oven retrofit to meet lower environmental emission standards:

> [2]The first and most important step in controlling NOx emissions is to use the latest low emission technology. Low emission burners control the air-fuel mixture and flame temperature better than traditional burners that have been on the market for the last 30 years. Traditional oven burners typically produce emissions on the order of 100 ppm NOx corrected (to 3 percent O_2). Newer technology burners can reduce the emission rates to 25 ppm NOx corrected and lower. The second important step is evaluating the application and the environment in which combustion will occur. The chamber temperature is critical to make any emissions guarantee. NOx is formed more easily at higher temperatures, especially above 1,000°F (538°C). Most oven applications are in the range of 300 to 500°F (149 to 260°C), making it easier to control NOx than in a high temperature application.

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[1] EPA, 1999; *EPA Technical Bulletin: Nitrogen Oxides (NO_x), Why and How They are Controlled* [EPA/456/F-99-006R], United States Environmental Protection Agency, Office of Air Quality Planning and Standards, November 1999.

[2] Brueck, Matt; California Emissions Standards Met With Oven Retrofit; *Process Heating*, May 1, 2002.

Low NOx burners are a mature, well proven technology for NOx control and they are available from numerous vendors. The advent of commercially available low NOx burners in the last two decades for miscellaneous combustion sources has allowed for adoption of new rules in the San Joaquin Valley Unified APCD in 2005 and the SCAQMD in 2008.[3] SCAQMD Rule 1147 has been identified as being an important component of the attainment strategy to meet both the federal annual $PM_{2.5}$ ambient air quality standard and the ozone standard.

Based on the analysis conducted in the Draft Rule 1147 Technology Assessment, which was released in February 2016, SCAQMD Staff made a total of five recommendations for proposed changes to Rule 1147. Three of the recommendations were determined based on technical feasibility and the other two recommendations were determined based on cost effectiveness. The two SCAQMD recommendations based upon cost effectiveness, including the ETS comments, will be discussed in Section VII of this report.

ETS concurs with the statement made in the SCAQMD Draft Technology Assessment which states that "with the exception of a few categories of equipment, the technology review demonstrates that low NOx burner systems are available for every category of equipment subject to Rule 1147." For the cases where SCAQMD determined that either low NOx combustion systems are currently not available for some types of small units or some categories of equipment are difficult to retrofit, Staff proposed the following three changes to Rule 1147 based upon technical feasibility:

- Exempt new and existing in-use units with total rated heat input of less than 325,000 Btu/hour from the Rule 1147 NOx emission limit (Staff Recommendation #1)
- Delay compliance with the NOx emission limit for existing in-use heated process tanks, evaporators and parts washers with an integrated heat tank until such time that the combustion system or tank is modified, replaced, or relocated (Staff Recommendation #2)
- Change the NOx emission limit from 30 ppm to 60 ppm NOx for the primary chamber of multi-chamber incinerators, burn-off ovens, burn-out furnaces and incinerators for all process temperatures (Staff Recommendation #3)

VI. ETS COMMENTS AND SUGGESTIONS ON THE SCAQMD DRAFT TECHNOLOGY ASSESSMENT BY EQUIPMENT CATEGORY

The ETS comments and suggestions on the burner availability/technology assessment for all ten major categories of equipment identified and discussed in the Draft Technology Assessment are incorporated below, including any additional ETS recommendations for changes to Rule 1147.

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[3] Ventura County Air Pollution Control District (APCD); *Staff report for: Proposed New Rule 74.34, NOx Reductions from Miscellaneous Sources*, November 2015.

A. ETS Comments on Afterburner Technologies

Based on the estimates in the Draft Technology Assessment, there are approximately 900 units in the afterburner technologies category, representing the third largest group of equipment regulated by Rule 1147, which are used to capture and incinerate VOCs, PM and toxic air contaminates. A review of the information presented in Appendix E of the Draft Technology Assessment and the SCAQMD as of January 2015 indicates that there are a wide variety of processes and burner types represented in this category. The Draft Technology Assessment also stated that "given the variety of processes used as afterburners, their different emission characteristics and older equipment permitted at emission levels close to but above some current BACT levels, a rule NOx limit of 60 ppm was proposed for this category of equipment and adopted in Rule 1147."

While the Source Test Database as of January 2015 indicated that the 24 afterburner units tested passed the 60 ppm NOx limit (with average NOx emissions of approximately 40 ppm and a range from 21 ppm to 54 ppm), it was unclear if any of the units tested had a process temperature ≤ 800°F and were required to meet the 30 ppm NOx limit in Rule 1147 (as defined in Table 2-1 of the Draft Technology Assessment). Most catalytic oxidizers operate at lower process temperatures, ranging from approximately 550°F to 850°F, due to the assistance of the catalyst which promotes the oxidation reaction to occur at a lower temperature than is required for thermal ignition. Some of the catalytic oxidizer units subject to Rule 1147 may utilize the same type of high temperature, medium to high velocity burners that are used in crematories, kilns, heating treating, and burn-off furnaces, which are designed to have NOx emissions in the 40 to 60 ppm range. For example, some catalytic oxidizer units may use the Eclipse Thermjet burner and be capable of meeting the 60 ppm NOx emission limit; however, at a process temperature less than 800°F may not be able to meet the existing 30 ppm NOx emission limit. For the above technical feasibility reasons ETS recommends that consideration be given to change the following in Rule 1147 for the afterburner technologies equipment category:

> Change the NOx emission limit in the afterburner technologies equipment category from 30 ppm to 60 ppm for processes that operate at or below 800°F. This new NOx limit of 60 ppm would be the same compliance limit required for higher temperatures and therefore the same limit at any process temperature in the afterburner technologies category (ETS Recommendation #6)

ETS concurs that the 60 ppm NOx emission limit for the afterburner technologies equipment category is technically feasible, can be achieved with a variety of combustion technologies or possibly with the original burners, and that the source testing demonstrates "achieved in practice."

B. ETS Comments on Spray Booths

The majority of heated spray booths in the SCAQMD are auto body refinishing booths used for refinishing passenger cars and light trucks. ETS reviewed the spray booth equipment category information presented in Appendix F of the Draft Technology Assessment. It was noted that due to an achieved in practice LAER/BACT limit of 30 ppm NOx for makeup air heaters in spray booth applications and the fact that many SCAQMD permitted booths are used as curing or drying ovens in manufacturing operations, a Rule 1147 NOx limit of 30 ppm was justified. It was also noted that BACT for ovens and most dryers has been 30 ppm NOx since 1998.

ETS concurs that there is a variety of available burner technology in this equipment category and the NOx emission limit of 30 ppm is technically feasible. It also appears that there are at least 32 models of booths and heating systems available from eight manufacturers that received certification of compliance with the Rule 1147 emission limits. The average NOx emission concentration of 24 ppm, with a range from 6 ppm to 30 ppm, for the 10 spray booths used in auto body repair was confirmed by ETS in the SCAQMD Source Test Database as of January 2015. The average NOx emission concentration of 18 ppm for the normal/high fire testing of the 13 spray booths that are not used for auto body repair (spray booth (other) category) was also confirmed by ETS.

Please see Section VII.B of this report for ETS comments on heating system costs and cost effectiveness for the spray booth category of equipment.

C. ETS Comments on Crematories

A review of the information presented in Appendix G of the Draft Technology Assessment regarding the 20 crematories that have been tested and comply with the Rule 1147 NOx emission limit was conducted. The 20 crematory compliance tests reviewed by SCAQMD Staff which complied with the 60 ppm NOx emission limit included original burners and many units with new burners and control systems. ETS concurs that the 60 ppm NOx emission limit for the crematories equipment category is technically feasible, can be achieved by available burners and combustion control systems, and that the source testing demonstrates “achieved in practice”. The average NOx emission concentration of 50 ppm, with a range from 30 ppm to 59 ppm, for the 20 crematory tests was also confirmed by ETS in the SCAQMD Source Test Database as of January 2015.

D. ETS Comments on Fryers

ETS conducted a review of the information presented in Appendix H of the Draft Technology Assessment regarding the two major types of fryers, conveyor and batch, which also had different types of heating systems including immersion tube heating in conveyor units and external oil heating system for the batch type fryers. It was reported that 7 existing in-use fryers have completed emission testing and comply with the Rule 1147 NOx emission limit of 60 ppm, all of which were tested with their original burner systems. ETS concurs that the 60 ppm NOx emission limit for the fryers equipment category is technically feasible, may be achievable with original heating systems, and that the source testing demonstrates “achieved in practice”. The average NOx emissions of 29 ppm for the 7 fryer tests completed, with a range from 14 ppm to 56 ppm, were confirmed by ETS in the SCAQMD Source Test Database as of January 2015.

E. ETS Comments on Heated Process Tanks, Evaporators, and Parts Washers

The review conducted by ETS on this category of equipment consisted primarily of the information presented in Appendix I of the Draft Technology Assessment. Based on Staff's estimations there are roughly 63 units affected by Rule 1147 in this category which consists of heat process tanks, parts washers and evaporators. Within the approximately 63 affected units, Staff has identified and very thoroughly described five different types of tank heating systems that are represented in this equipment category based on individual component factors such as heat exchanger configurations, diameter of heated tube systems, burner types, burner heat inputs, burner firing rates, burner firing pressures, and burner combustion control. Many of the units in this category utilize immersion tube heating tube systems to heat solutions in a tank.

ETS reviewed the Source Test Database as of January 2015 compiled by Staff on the seven units that have completed testing in this category of equipment. All seven units complied with the Rule 1147 NOx limit of 60 ppm for heated process tanks, evaporators and parts washers with average NOx emissions of approximately 37 ppm and range of 4 to 55 ppm. Also, it should be noted that all seven of those units complied with the NOx emission limits using their original burners; however, only three of the different types of heating systems that were described in Appendix I of the Draft Technology Assessment have been identified within the Rule 1147 testing program to date.

The fourth type of heating system identified in the Draft Technology Assessment uses high pressure burners firing into smaller diameter tubes typically ranging from 2 to 8 inches, but none appear to have been tested to date. A fifth type of tank heating system with tube firing burners used in heat treating has also been demonstrated to meet the 60 ppm NOx emission limit, but was noted as not being tested in heated tank applications as of yet.

Fundamentally, ETS concurs that the Rule 1147 NOx emission limit of 60 ppm for this category of equipment should be technically feasible, there is an array of equipment that should be available to achieve the limit, and three of the different types of heating systems have been "achieved in practice". The importance of the design metric utilized in Figure I-1 of the Draft Technology Assessment is appropriately noted as well, since it impacts the formation of NOx in the heating tubes.

One of the challenges within this equipment category, however, is the fact that the burners and heat exchanger tubes are designed as one integrated system and some of the heat exchanger tube systems are custom designed to suit the specific application. This means that if an individual heated tank (process tank or parts washer) or an evaporator system on an existing in-use unit within Rule 1147 does not comply with the emission limit, then likely the entire process tank would have to be replaced.

This issue, however, appears to have already been addressed in the SCAQMD Draft Technology Assessment, which was released for public review on January 29, 2016.

Based upon technical feasibility, ETS concurs with the following SCAQMD Staff recommendation for Rule 1147:

> Delay compliance with the NOx emission limit for existing in-use evaporators, heated process tanks, or parts washers with an integrated heated tank until the combustion system or tank is modified, relocated or replaced. New units would be required to meet the emission limit unless the total unit heat rating is less than or equal to 325,000 Btu/hour. (Staff Recommendation #2)

F. ETS Comments on Heat Treating Furnaces and Kilns

A review was conducted on the information presented in Appendix J of the Draft Technology Assessment regarding the heat treating equipment category. The processes in this category generally involve heating metals or alloys in a furnace or oven or treating metals and nonmetallic refractory materials in a manufactured vessel, furnace, or other product using temporary burner systems (i.e., kilns used for heat treating products made from ceramics, clay, and other non-metallic materials). The types of burners utilized in the heat treating equipment category depend upon the temperature required and whether they fire directly into the furnace or into tubes which transfer the heat from the tubes to the furnace via fans.

In the case of lower temperature heat treating ovens, the burners are typical of other types of ovens with air heating burners such as the Eclipse Winnox and Maxon Cyclomax burners. For higher temperature applications with direct fired furnaces, high velocity burners such as the Maxon Kinedizer and the Eclipse Thermjet are typically utilized. In the case of indirect fired furnaces, specialized tube firing burners such as the Eclipse Tube Firing Burner (TFB) are commonly used. The high velocity and tube firing burners, however, are available from many different manufacturers and several of the tube firing burner manufacturers also have an option to add flue gas recirculation (FGR) for reducing NOx emissions.

SCAQMD Staff reported in the Draft Technology Assessment that the emission test results as of January 2015 cover a variety of furnaces processing aluminum and steel alloys across a broad temperature range. Most of the heat treating furnaces tested met the Rule 1147 emission limit with their existing burners and it appears that only a few furnaces have either had their burners replaced, added an FGR system, or replaced their furnace in order to comply with Rule 1147. Despite the fact that new emission test results for kilns have not yet been received, emission tests completed on small and large kilns prior to rule adoption in 2008 and rule amendment in 2011 demonstrated compliance with a 60 ppm NOx emission limit.

ETS concurs that the 60 ppm NOx emission limit for the heat treating equipment category is technically feasible. ETS confirmed that most of the furnace NOx emission concentrations were in the range from 45 ppm to 55 ppm with an average of approximately 50 ppm in review of the 23 source test information for metal heat treating obtained from the SCAQMD Source Test Database as of January 2015 and the source testing demonstrates “achieved in practice”.

G. ETS Comments on Metal Melting

ETS conducted a review of the information presented in Appendix K of the Draft Technology Assessment regarding the metal melting furnace category. ETS concurs that the 60 ppm NOx emission limit for the metal melting equipment category is technically feasible, may be achievable with original burners, and that the source testing demonstrates “achieved in practice”. The average NOx emissions of 42 ppm for the 8 larger metal melting furnaces tested and 54 ppm for the 5 small pot and crucible melting furnaces were confirmed by ETS in the SCAQMD Source Test Database as of January 2015.

H. ETS Comments on Multi-chamber Burn-off Ovens and Incinerators

ETS conducted a review of the information presented on page 2-3 and in Appendix L of the Draft Technology Assessment on multi-chamber burn-off ovens and incinerators. It was reported that 12 burn-off ovens, furnaces and incinerators have completed review of their test results and most units were tested with original burners. Review of the SCAQMD Source Test Database as of January 2015 confirmed that the average NOx concentration in the stack after the afterburner section was less than 45 ppm and the range was from 26 to 55 ppm. However, SCAQMD Staff had previously received inputs from Stakeholders (local manufacturers of burn-off furnaces and company representatives) to indicate that it is not possible to use the preferred type of burner and meet a 30 ppm emission limit in the primary chamber for a process temperature ≤ 800°F. Those particular burners are designed to have NOx emissions in the range of 40 to 60 ppm. ETS concurs that a 60 ppm NOx emission limit for both the primary and secondary chambers in this equipment category is technically feasible, may be achievable with the original burners, and that the source testing demonstrates “achieved in practice”.

Also, based on the previously held discussions and assessments between SCAQMD and Stakeholders, ETS concurs with the following SCAQMD Staff recommendation for the multi-chamber burn-off ovens and incinerators category of equipment:

> Change the NOx emission limit from 30 ppm to 60 ppm NOx for the primary chamber of multi-chamber incinerators, burn-off ovens, burn-out furnaces and incinerators for all process temperatures (Staff Recommendation #3)

I. ETS Comments on Ovens and Dryers

ETS conducted a review of the information presented on page 2-3 and in Appendix M of the Draft Technology Assessment on ovens and dryers, which were reported to be the second largest category of equipment regulated by Rule 1147. The ovens and dryers are utilized in a variety of processes including curing of coatings and other materials, drying coated and printed products, and drying materials. There are a variety of burner types used in this equipment category with the most common type being nozzle mixing air heating burners manufactured by Eclipse and Maxon.

During the review of the SCAQMD Source Test Database, ETS also observed that approximately 66% of the 140 tested ovens and dryers used Maxon burners and approximately 25% used Eclipse burners. Over 50% of the Maxon burners tested were from the Cyclomax product line and almost 85% of the Eclipse burners tested were from the Winnox product line. ETS conducted a general search for other manufacturers of low NOx burners for very small, low temperature ovens and dryers that are designed to comply with a 30 ppm NOx limit, in addition to a detailed review of the aforementioned low NOx burner product line specifications. The smallest low NOx air heating burners designed to comply with the 30 ppm NOx emission limit that could be found by ETS were between 400,000 and 500,000 Btu/hour. For example, the Maxon packaged Cyclomax® burners are available in 5 sizes with the smallest burner size rated at 400,000 Btu/hour (Cyclomax Model Number 0.4M).[4] The Maxon packaged Ovenpak® LE burners were available in 10 sizes with the smallest burner size rated at 500,000 Btu/hour (LE 5).[5] The Eclipse Winnox burners were available in 8 sizes with the smallest burner size rated at 550,000 Btu/hour (Eclipse Model Number WX0050).[6]

ETS was able to find smaller sizes of low NOx burners; however, they were for high temperature applications such as heat treating furnaces and kilns. The available smaller burners for high temperature applications typically require multiple small burners and they are designed to have NOx emissions in the range of 40 to 60 ppm. As an example, Eclipse makes a "nozzle-mixing burner with a packaged blower that is designed to fire with fixed combustion air over a wide turndown range" called ThermAir. These burners are available in 9 sizes ranging from the smallest size of 150,000 Btu/hour to the largest size of 5,000,000 Btu/hour; however, the Eclipse product literature states the low NOx emissions are 60 ppm at high fire.[7]

It was reported that 140 units used for a variety of processes have approved test results and comply with the 30 ppm NOx limit. ETS' review of the SCAQMD Source Test Database as of January 2015 confirmed that the average NOx emission concentration for most ovens and dyers was about 20 ppm with a range of 4 ppm to 30 ppm. ETS concurs that the 30 ppm NOx emission limit for the ovens and dryers equipment category is technically feasible and can be achieved by available technology, with the exception of low NOx burners with a total rated heat input of less than 325,0000 Btu/hour, and that the source testing demonstrates "achieved in practice."

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[4] *Honeywell Maxon Product Catalog: Industrial Burners* (accessed September 20, 2016); available from https: //www.maxoncorp.com/Directory/product/CYCLOMAX-Low-NOx/24/Natural-Gas-Burner-Low.

[5] *Honeywell Maxon Product Catalog: Industrial Burners* (accessed September 20, 2016); available from https://www.maxoncorp.com/Directory/product_detail/OVENPAK-LE-natural-gas-lownox/113/.

[6] *Honeywell Eclipse Product Catalog: Air Heating Burners* (accessed September 20, 2016); available from www.eclipsenet.com/products/winnox/.

[7] *Honeywell Eclipse Product Catalog: Air Heating Burners* (accessed September 20, 2016); available from www.eclipsenet.com/products/thermair/.

ETS agrees with the SCAQMD Draft Technology Assessment which states that "there is a lower limit on the availability of low NOx burners for ovens and dryers" to meet a NOx emission limit of 30 ppm and concurs with the following SCAQMD Staff recommendation:

> Exempt new and existing in-use units with total rated heat input of less than 325,000 Btu/hour from the Rule 1147 NOx emission limit (Staff Recommendation #1)

As part of the research conducted by ETS for this project, another noteworthy item pertinent to this category of equipment from the previously referenced article by Matt Brueck of Maxon Corporation is the following:

> [8]Traditional oven burners have higher thermal turndowns than low emission oven burners. Because of this, low NOx oven burners should never be oversized. In the past, a larger-than-necessary burner may have been used without concern for overheating the oven at low fire. Now it is recommended that engineers look closer at an oven's heat balance, especially at low fire. In short, use the smallest low NOx burner possible for any application below about 5,000,000 Btu/hour.

J. ETS Comments on Food Ovens

It was reported in Appendix N of the Draft Technology Assessment that food ovens in use at the time SCAQMD Rule 1153.1 was adopted are no longer subject to Rule 1147. However, new food ovens are currently subject to Rule 1147 requirements. It also stated that Staff is currently evaluating alternative rule development options for exempting new food ovens from Rule 1147. ETS has no specific comments on the food ovens category of equipment and there were no Rule 1147 Stakeholder inputs received in regard to this specific category.

Upon review of the February 2016 Rule 1147 Draft Technology Assessment by major equipment category, ETS concurs with SCAQMD's three recommendations for proposed changes to Rule 1147 based on technical feasibility (Staff Recommendations #1, #2 and #3). ETS had one additional recommendation for a change to Rule 1147 based on technical feasibility for the Afterburner Technologies category of equipment discussed in Section VI.A above:

> Change the NOx emission limit in the afterburner technologies equipment category from 30 ppm to 60 ppm for processes that operate at or below 800°F
> (ETS Recommendation #6)

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[8] Brueck, Matt; California Emissions Standards Met With Oven Retrofit. *Process Heating*, May 1, 2002.

VII. ETS COMMENTS AND SUGGESTIONS ON COST AND COST EFFECTIVENESS ANALYSIS IN THE SCAQMD DRAFT TECHNOLOGY ASSESSMENT

A. ETS Comments and Suggestions on Cost Effectiveness

The basic methodology utilized for calculating cost and cost effectiveness in the SCAQMD Rule 1147 Draft Technology Assessment is consistent with prior SCAQMD rule development studies, including those that ETS has been contracted as an independent consultant to either prepare or review. As described on page 3-3 of the Draft Technology Assessment, SCAQMD BACT Guidelines and rule development use a discounted cash flow analysis to estimate the cost and cost effectiveness of emission control options. As stated in the BACT Guidelines for minor (non-major) sources, “the discounted cash flow method calculates the present value” (also referred to as net present value) “of the control costs over the life of the equipment by adding the capital cost to the present value of all annual costs and other periodic costs over the life of the equipment.”

For the scenarios developed in the Draft Technology Assessment, a net present value was calculated for the control equipment using the total installed cost (which consists of the purchased equipment cost, shipping, tax, and installation costs) and annual costs. The minor source BACT Guidelines also state that “a real interest rate of four percent and a 10-year equipment life is used.” However, it is noted by ETS in the SCAQMD Draft Technology Assessment that there is a key difference in the calculation of cost effectiveness between the BACT Guidelines and rule development. For rule development, such as the Rule 1147 Draft Technology Assessment, a best estimate of the equipment’s useful life is used in the calculation of cost effectiveness instead of a fixed 10-year life assumption that is associated with financing of new equipment. An example is shown below by Equation 1, with a factor of 13.59 to estimate the cumulative annual operating costs during the 20-year life of a control device:

$$NPV = TIC + (13.59 \times AC) \qquad \text{(Equation 1)}$$

Where:

NPV = Net present value, $

TIC = Total installed cost, $

AC = Annual cost, $

As described in the SCAQMD minor source BACT Guidelines:

> “Cost effectiveness evaluations consider both capital and operating costs. Capital cost includes not only the price of the equipment, but the cost for shipping, engineering, and installation. Operating costs or annual costs includes expenditures associated with utilities, labor and replacement costs. Finally, costs are reduced if any of the materials or energy created by the process result in cost savings.”

SCAQMD noted in the Draft Technology Assessment that “because the useful life of boilers, ovens and furnaces can be several decades, the costs of routine maintenance and equipment replacement unrelated to control equipment is not included in the cost effectiveness analysis of regulatory requirements to meet emission standards”.

In terms of annual costs for the types of burners and combustion system components that were evaluated as part of the Draft Technology Assessment, ETS concurs with the exclusion of annual costs because ETS is unaware of specific items in the “Total Annual Cost” list found in Appendix D, Attachment 1-3 of the Draft Technology Assessment (Appendix A of this report) which would result in significant increases in annual expenditures for low NOx burners over the existing burner types. It is the opinion of ETS that maintenance of burner components is required for existing burner systems or new low NOx burner systems, so recurring costs for annual maintenance of retrofit burners would not be appropriate to include in the cost effectiveness analysis. Moreover, there are likely energy savings (gas and/or electricity) and rebate programs associated with the new equipment which would mitigate any potential increases in annual costs.

Accounting for the excluded annual costs, Equation 1 would be reduced to the net present value being equal to the total installed cost as shown below in Equation 2:

$$NPV = TIC \qquad \text{(Equation 2)}$$

The method utilized by SCAQMD Staff to calculate the total cost of replacing equipment, including shipping, tax, and installation costs as described on page 3-6 of the Draft Technology Assessment, is consistent with ETS’ experience in using the EPA Air Pollution Control Cost Manual.

The cost effectiveness of the emission control equipment can then be estimated by dividing the net present value by the emission reduction benefit over the control equipment life (ex. 20-25 years). The cost effectiveness is shown in Equation 3 below in $/ton of NOx removed:

$$CE = NPV / (\text{Total NOx ER Over Project Life}) \qquad \text{(Equation 3)}$$

Where:

CE = Cost Effectiveness, $/ton

NPV = Net present value, $

ER = Emission Reduction, ton

SCAQMD Staff indicated on page 3 of the March 4, 2016 Board Letter (see Appendix A) that the current SCAQMD BACT Guidelines criteria for equipment that does not have a defined BACT was utilized as a guide to evaluate the cost effectiveness of low NOx retrofits for Rule 1147 equipment. ETS reviewed the “Maximum Cost Effectiveness Values” section of the SCAQMD Proposed Amended BACT Guidelines - Part C: Policy and Procedures for Non-Major Polluting Facilities (dated October 2016). The cost effectiveness criteria as found in the Proposed Amended BACT Guidelines are $26,910 per ton of NOx for average cost effectiveness and $80,590 per ton of NOx for the incremental cost effectiveness between two or more control options. These numbers were reported to be based on the criteria adopted by the SCAQMD Governing Board in the 1995 BACT Guidelines, adjusted to second quarter 2016 values using the Marshall and Swift Equipment Cost Index. Discussions in the body of the Rule 1147 Draft Technology Assessment then use the current numbers rounded up to $27,000 per ton and $81,000 per ton as a guide to evaluate cost effectiveness for the low NOx retrofits for Rule 1147 equipment.

ETS concurs that the utilization of the minor source BACT criteria of $27,000 per ton of NOx for average cost effectiveness and $81,000 per ton of NOx for incremental cost effectiveness is appropriate to use as a screening tool for small equipment with NOx emissions of one pound per day or less. However, as noted in the Draft Technology Assessment, "there is no single cost or cost effectiveness limit established by the SCAQMD Board for use in rule development, permitting, or other programs. Cost effectiveness for CARB and SCAQMD rules and programs differ and depend upon the program, the pollutant, the nature of the process and equipment affected and the types of feasible emission control options." For example, SCAQMD Staff indicated to ETS that thresholds for other SCAQMD rules including Rules 1146/1146.1 (which includes small businesses) and RECLAIM have been significantly higher with cost effectiveness criteria up to $50,000 - $60,000 per ton. Staff also indicated that the $27,000 per ton average cost effectiveness from the BACT Guidelines is not a threshold for rule development or any other program outside of a limited application for BACT (sources without defined BACT or an old BACT). Based on ETS' review of the Draft Technology Assessment, it appears that the $27,000 per ton was utilized as a screening tool for the small and low emission sources evaluated in the Draft Technology Assessment for Rule 1147 and was not considered as a threshold that should not be exceeded.

It was stated in the Rule 1147 Draft Technology Assessment that the calculation of cost and cost effectiveness for both Rule 1147 adoption and the 2011 amendment were done on a per burner basis. It further stated that the cost effectiveness analysis in that document focused on the cost and emission reduction per burner replaced utilizing the cost for a burner with an integrated blower. In general ETS concurs with the cost effectiveness methodology in the Draft Technology Assessment for the simple fact that for rules, calculations can't be performed for individual pieces of equipment used in every specific situation. A range of average cost effectiveness values for the following three types of burner categories identified in the Draft Technology Assessment: 1) Low Temperature Ovens and Dryers, 2) High Temperature Applications, and 3) Spray Booths. The different methods utilized by Staff for determination of the emissions reductions for those burner categories are described further in Section VII.B of this report.

As a result of the cost effectiveness analysis conducted in the February 2016 Draft Technology Assessment for Rule 1147, SCAQMD Staff made the following two recommendations for proposed changes to Rule 1147 based upon cost effectiveness considerations:

1. Delay compliance with the NOx emission limit for existing in-use units with actual NOx emissions of one pound per day or less until the combustion system is modified, relocated or replaced (Staff Recommendation #4)

2. Delay compliance with the NOx emission limit for existing in-use spray booth until the heating system is modified or replaced or the unit is relocated (Staff Recommendation #5)

B. ETS Comments and Suggestions on Cost and Cost Effectiveness Data for Small and Low Emission Equipment

The ETS comments on the cost and cost effectiveness data for the specific categories of small and low emission equipment that were presented in the Rule 1147 Draft Technology Assessment may be found in the sections below:

1. <u>Burner Cost and Cost Effectiveness for Low Temperature Ovens and Dryers:</u>

ETS reviewed both the "Summary of Low and High Temp Burner Costs" developed by SCAQMD (Confidential Information) and the cost and cost effectiveness information presented from pages 3-5 to 3-7 of the Draft Technology Assessment. The typical equipment costs ranging from $7,500 to $15,000 for packaged burners and combustion systems in the size range of 500,000 Btu/hour to 2,000,000 Btu/hour, respectively, were reviewed by ETS. Since the focus of this section dealt with the cost effectiveness for low temperature applications with emissions of one pound per day or less, the specific burner types and sizes evaluated by SCAQMD were appropriate and appeared to representative of typical costs. Also, SCAQMD utilized the higher end of the burner cost range ($15,000) to perform the cost effectiveness evaluation displayed on page 3-6 of the Draft Technology Assessment.

ETS is familiar with the EPA method utilized by the SCAQMD to calculate the total installed cost, which includes capital cost items such as shipping, tax, and installation costs in addition to the price of the equipment. The cost estimating factor of 2.0 was a conservative approach and included a contingency factor of 13% to address uncertainties in the cost estimation. A total installed cost of $30,000 was then used to calculate the cost effectiveness for estimated emission reductions of 0.25, 0.50 and 0.75 pounds per day over 260 days per year and 20 years. This resulted in cost effectiveness numbers of $46,154, $23,077, and $15,385 per ton, respectively. By using a midpoint of the cost effectiveness range for typical emission reductions of 0.25 to 0.50 pounds per day, SCAQMD arrived at a midpoint of $34,500 per ton. The cost effectiveness of $34,500 per ton to replace combustion systems for low emission ovens and dryers was greater than the SCAQMD minor source (non-major) BACT average criteria of $27,000 per ton; however, it was less than the incremental criteria of $81,000 per ton. SCAQMD Staff indicated to ETS that thresholds for other SCAQMD rules including Rules 1146/1146.1 (which includes small businesses) and RECLAIM have been significantly higher with cost effectiveness criteria up to $50,000 - $60,000 per ton.

ETS concurs that the cost of the replacement burners and combustion system components can vary (higher, as well as lower) depending upon which components must be replaced and many other site-specific factors. It was noted by SCAQMD in the Draft Technology Assessment that minor source BACT criteria applies to new sources only; however, ETS concurs that the criteria is appropriate to use as a screening tool for small equipment with emissions of one pound per day or less.

Based upon the review of the Draft Technology Assessment, ETS agrees that the cost effectiveness for some low temperature/low emission ovens and dryers to comply with the Rule 1147 NOx emission limit of 30 ppm may exceed the SCAQMD minor source BACT average criteria for NOx of $27,000 per ton for new sources without a defined BACT or an old BACT. Therefore, ETS concurs with the following SCAQMD Staff recommendation:

> Delay compliance with the NOx emission limit for existing in-use units with actual NOx emissions of one pound per day or less until the combustion system is modified, relocated or replaced (Staff Recommendation #4)

2. **Burner Cost and Cost Effectiveness for High Temperature Applications:**

ETS reviewed both the "Summary of Low and High Temp Burner Costs" developed by SCAQMD (Confidential Information) and the cost and cost effectiveness information presented from pages 3-7 to 3-9 of the Draft Technology Assessment. The equipment costs for high temperature/low emission applications ranging from $5,000 to $15,000 per burner for applications up to 2,000,000 Btu/hour were reviewed by ETS. Since the focus of this section dealt with the cost effectiveness for high temperature applications with emissions of one pound per day or less, the specific burner types and sizes evaluated by SCAQMD were appropriate and appeared to be representative of typical costs.

ETS concurs that the cost of the replacement burners and combustion system components can vary (higher, as well as lower) depending upon which components must be replaced and many other site-specific factors. It was noted by SCAQMD in the Draft Technology Assessment that minor source BACT criteria applies to new sources only, however, ETS concurs that the criteria is appropriate to use as a screening tool for small equipment with emissions of one pound per day or less. SCAQMD Staff indicated to ETS that thresholds for other SCAQMD rules including Rules 1146/1146.1 (which includes small businesses) and RECLAIM have been significantly higher with cost effectiveness criteria up to $50,000 - $60,000 per ton.

Based upon the SCAQMD cost effectiveness analyses performed for this equipment class, ETS agrees that the cost effectiveness for high temperature/low emission units with emission reductions of less than 0.2 pound per day to comply with the Rule 1147 NOx emission limit of 60 ppm may exceed the SCAQMD minor source BACT average criteria for NOx of $27,000 per ton for new sources without a defined BACT or an old BACT. Therefore, ETS concurs with the following SCAQMD Staff recommendation:

> Delay compliance with the NOx emission limit for existing in-use units with actual NOx emissions of one pound per day or less until the combustion system is modified, relocated or replaced (Staff Recommendation #4)

3. **Heating System Cost and Cost Effectiveness for Spray Booths:**

ETS reviewed the "Heating System Cost and Cost Effectiveness for Spray Booths" found on pages 3-9 and 3-10 of the Draft Technology Assessment and the vendor costing information collected by SCAQMD (Confidential Information). As stated in Appendix A-4 of the Draft Technology Assessment, "business owners and equipment vendors indicated typical automotive booths and many other booth operations have annual average emissions of less than one third pound per day."

Based on the Draft Technology Assessment, the cost information supplied by SCAQMD and reviewed by ETS supports the cost effectiveness calculation of a new low NOx SCAQMD certified auto repair booth to be at most $22,000 per ton. However, the cost effectiveness reviewed by ETS for retrofitting an existing in-use auto repair booth with an SCAQMD certified heating system was significantly higher, with a range of $66,000 to $80,000 per ton. The cost information supplied to SCAQMD by multiple equipment vendors for adding a new natural gas fired certified heating system (equipment plus labor) to an existing spray booth ranged from $30,000 to $50,000, depending upon manufacturer, type of booth and the individual installation. It was stated in the Draft Technology Assessment that "to use an SCAQMD certified burner on a used spray booth, the owner/operator must also install a new heater box, blower, other mechanical components with a new thermostat and control system for moving air in addition to installing the burner, mounting hardware and combustion control system."

It was noted by SCAQMD in the Draft Technology Assessment that minor source BACT criteria applies to new sources only, however, ETS concurs that the criteria is appropriate to use as a screening tool for small equipment with emissions of one pound per day or less. SCAQMD Staff indicated to ETS that thresholds for other SCAQMD rules including Rules 1146/1146.1 (which includes small businesses) and RECLAIM have been significantly higher with cost effectiveness criteria up to $50,000 - $60,000 per ton.

Since the cost effectiveness to retrofit existing in-use spray booths is greater than the minor source average cost effectiveness criteria of $27,000 per ton for equipment categories without a defined BACT or a very old BACT and may exceed the incremental criteria of $81,000 per ton, ETS concurs with the following SCAQMD Staff recommendation for the spray booth category of equipment:

> Delay compliance with the NOx emission limit for existing in-use spray booths until the heating is modified, relocated or replaced (Staff Recommendation #5)

Upon review of the cost and cost effectiveness analysis presented in the February 2016 Rule 1147 Draft Technology Assessment, ETS concurs with SCAQMD's two recommendations for proposed changes to Rule 1147 based upon cost effectiveness considerations (Staff Recommendations #4 and #5). ETS did not have any additional recommendations for changes to Rule 1147 based on cost effectiveness considerations.

VIII. ETS RESPONSES TO INFORMATION RECEIVED FROM RULE 1147 STAKEHOLDERS BY AUGUST 23, 2016 DEADLINE

This section summarizes the inputs, data, comments, and/or concerns that ETS received from Stakeholders at the Rule 1147 Task Force Meeting on August 3, 2016 and subsequent to the meeting, but prior to the August 23, 2016 deadline. The information received came from the following three Stakeholders: 1) Furnace Dynamics, Inc., 2) Industrial Process Equipment, Inc., and 3) Wirth Gas Equipment, Inc. ETS identified the information received from the three Stakeholders as nine distinct item numbers (Item #'s 1-9) by the date received. The ETS responses to the Rule 1147 Stakeholder information received by item number are also incorporated in this section.

A summary of the information received from the President of Furnace Dynamics, Inc. at the Rule 1147 Task Force meeting on August 3, 2016 may be found in Appendix C and copies of the four input items received from the Stakeholder are located in Attachments C-1, C-2, C-3, and C-4. Brief summaries of Stakeholder Item #'s 1-4 and the ETS responses are provided below:

A. Stakeholder Item #1 – Furnace Dynamics, Inc.

Stakeholder Item #1 (Attachment C-1) contains a letter from Furnace Dynamics, Inc. titled "A discussion on Potential to Emit (PTE)" with no specific addressee that is dated 11/19/15. The Stakeholder recommended more options for the determination and verification of NOx emissions of one pound per day or less other than PTE. An example case was presented from a large forge facility to try to compare the actual annual NOx emissions to the PTE. A series of charts were also included by the Stakeholder to try to convey the relationship of daily emissions vs. BTU input vs. hours of operation at a variety of different average firing rates.

<u>ETS Response to Item #1:</u> This Stakeholder letter is related to rule requirements and compliance issues and the Stakeholder is presenting a recommendation for different demonstration options for NOx emissions of one pound per day or less. These comments are not specific to the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources.

B. Stakeholder Item #2 – Furnace Dynamics, Inc.

Stakeholder Item #2 (Attachment C-2) contains a letter from Furnace Dynamics, Inc. titled "RE. Items of Concern Technology Assessment" that was addressed to Mr. Joe Cassmassi at SCAQMD and dated 02/18/16. The letter stated that the Stakeholder had conducted a cursory review of the Draft Technology Assessment and the Stakeholder provided comments on the following items:

Stakeholder Item #2-1: Cost Effectiveness: Excluded Costs (Burner Cans) – In this section of Item #2, the Stakeholder indicated that there was an exclusion of replacement components in burner systems. The Stakeholder had found that low NOx Eclipse Winnox burner cans need to be replaced, usually in 3-10 years with the cost of the can being between $2,500 - $5,000 plus installation which can run a couple of thousands.

ETS Response to Stakeholder Item #2-1: It is ETS' understanding that the Eclipse Winnox burners, along with other similar vendor models of low NOx nozzle-mixing air heating burners, typically have options for the material of construction of the burner can. Those options can be different types of alloys and a ceramic or refractory option depending upon the temperature of the process. Older, non-compliant burners had options for burner can construction as well. The selection of the proper burner can material of construction for the specific application is an important design consideration.

Additionally, there are specific manufacturer installation instructions and operational guidelines which may impact burner can life if not properly followed. For example, the Maxon Cyclomax Low NOx burner specification states that the burners should be operated with interrupted pilot and note that emissions can be 20% higher if the pilot is left on continuously and burner can life may be reduced.[9]

There were no details provided on the low NOx burner can issue, no other Stakeholders raised concerns regarding this matter to ETS, and the issue was presented by the Stakeholder as being a specific issue related to one particular manufacturer and equipment model. There were several other burner options presented in the Draft Technology Assessment capable of meeting the Rule 1147 NOx emission limits for this category of equipment, so ETS does not believe that it would be appropriate to include this issue in the calculation of average cost effectiveness for this category of equipment.

Stakeholder Item #2-2: Cost Effectiveness: Evaluation of cost effectiveness methods – In this section of Item #2, the Stakeholder stated that "Staff had indicated that the cost effectiveness was based on the differential between the cost of an existing burner and the cost of a new low NOx burner." The Stakeholder doesn't feel that this is a valid consideration since this is a replacement rule and would only apply to the very few cases where the existing burner was scheduled for replacement and not to the general population of equipment covered under Rule 1147.

[9] *Maxon Product Catalog: Cyclomax® Low NOx Burner Specifications* (accessed September 20, 2016); available from www.maxoncorp.com/Files/pdf/S-lt-cyclomax.pdf.

ETS Response to Stakeholder Item #2-2: If the Stakeholder's comments pertain to the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources that was released for public review on January 29, 2016, then this comment does not seem applicable. The average cost effectiveness analysis performed for the three types of burner categories defined in the Draft Technology Assessment that ETS reviewed was calculated based on the cost of a replacement burner. Please see Section VII of this report and the "Cost and Cost Effectiveness" section of the Draft Technology Assessment.

Stakeholder Item #2-3: Cost Effectiveness: Methods of Determining Cost Effectiveness – The Stakeholder commented that a single cost effective methodology should be utilized for all 1147 devices and recommends that the 2006 SCAQMD Best Available Control Technology Guidelines, Part C: Policy and Procedures for Non-Major Polluting Facilities be used.

ETS Response to Stakeholder Item #2-3: In the February 2016 Draft Technology Assessment that ETS reviewed, SCAQMD did use the BACT guidelines for conducting the cost effectiveness analysis. Please see Section VII of this report and the "Cost and Cost Effectiveness" section of the Draft Technology Assessment. As noted in both of those sections, the lifetime costs of emissions were used as opposed to the 10 year life that is described in the BACT guidelines. According to SCAQMD this was based on comments from industry representatives that the full life of equipment should be considered in rule development analysis.

Stakeholder Item #2-4: Cost Effectiveness: Maximum Acceptable Cost Effectiveness – The Stakeholder commented that the actual cost effectiveness should be considered on a case-by-case basis and there should be a fixed maximum cost effectiveness level established so it would not disproportionately affect small industries. The Stakeholder recommended an absolute value of $30,000/controlled ton.

ETS Response to Stakeholder Item #2-4: These Stakeholder comments are related to rule requirements and are not comments specific to the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources. Of particular note, however, the Stakeholder recommended criteria of $30,000, which is higher than the minor source BACT criteria of $27,000 per ton of NOx for average cost effectiveness that was utilized as a screening tool in the Draft Technology Assessment for small equipment with NOx emissions of one pound per day or less.

Stakeholder Item #2-5: Burners Mentioned: Turndown – The Stakeholder commented that they have had good results with Eclipse Winnox burners for low temperature recirculation types of ovens and they have all passed source tests. The Stakeholder then expressed concerns about an inherent problem of limited turndown with the new "low NOx" burners and provided an example where pretesting of a Cyclomax burner by the Stakeholder produced unacceptable results and the burner had to be replaced despite being "classified and purchased as a low NOx burner."

ETS Response to Stakeholder Item #2-5: While the specific burner ratings, process conditions, and pretesting data from the Stakeholder's example case are unknown, the following general responses to the comments in Item #2-5 are offered by ETS. As previously stated in Section VI.I of this report, the ETS review of the SCAQMD Source Test Database noted that approximately 66% of the 140 tested ovens and dryers used Maxon burners and approximately 25% used Eclipse burners. An additional statistic noted from the ETS review is that out of the 140 tested units in the ovens and dryers equipment category with approved test results complying with the 30 ppm NOx limit, approximately 33% of the units had Maxon Cyclomax burners and approximately 19% of the units had Eclipse Winnox burners. There have also been more Maxon Cyclomax burners tested with approved test results complying with the 30 ppm NOx limit at "Low Fire" conditions than the Eclipse Winnox burners. As stated in the Draft Technology Assessment, both of those nozzle mix low NOx burner product lines for low temperature applications were developed about 15 years ago. The Stakeholder's suggestion that the Maxon Cyclomax burner is not a viable low NOx burner option for the low temperature oven category does not appear to ETS to be substantiated.

Stakeholder Item #2-6: Burners Mentioned: Efficiency – The Stakeholder commented that claims of increased efficiency with the installation of new low NOx burners may be false and that decreased efficiency may occur due to the manufacturers having to use more excess air to lower flame temperatures and thus reduce NOx. The Stakeholder stated the following, "if the existing burner is ratio fired and the new burner has to use 60 – 80% excess air to achieve the emission reductions, the total gas usage can actually increase. This becomes a problem if the existing burner is just marginally over the 1147 limit, the new burner that is installed can actually put more pollution into the air even with lower NOx values due to efficiency losses."

ETS Response to Stakeholder Item #2-6: These Stakeholder comments are vague in nature and the scenario described does not provide enough detail to accurately assess what the Stakeholder is trying to convey. These comments are not specific to the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources.

Stakeholder Item #2-7: Other Burners Mentioned in the Technology Assessment – The Stakeholder comments that "other burners mentioned in the Technology Assessment (outside of the major manufacturers) are specific use burners and can only be used in very specific applications."

ETS Response to Stakeholder Item #2-7: Since a primary focus of the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources was to evaluate the technical feasibility of retrofitting small and low emission units to comply with Rule 1147 emission limits, ETS found the discussion of all of the burners mentioned to be relevant to the assessment. All of the "other burners" mentioned and the information provided on them in the Technology Assessment combined with the Source Testing Database as of January 2015, indicated that the NOx emission limits in Rule 1147 are technically feasible and have been achieved in practice (with the exceptions noted therein). Since there are specific applications identified in Rule 1147 and prior public comments have dealt with the concerns regarding burner availability, then the mention of those specific use burners and their applications certainly does seem to be relevant to the Draft Technology Assessment on the opinion of ETS.

<u>Stakeholder Item #2-8:</u> Section headings in the letter labelled **"Enforcement Considerations"**, **"Rule Compliance Date Issues"**, **"PTE"** and **"Mitigation Fee"**

<u>ETS Response to Stakeholder Item #2-8:</u> These sections are related to Rule 1147 compliance, enforcement, and potential future rule amendments and are not comments specific to the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources.

C. Stakeholder Item #3 – Furnace Dynamics, Inc.

Stakeholder Item #3 (Attachment C-3) from Furnace Dynamics, Inc. contains a one page sheet titled "SCAQMD Minor Source BACT Cost Effectiveness Calculation." The sheet has cost effectiveness calculations performed for a Smokehouse Afterburner listed as being rated at 260,000 Btu/hour.

<u>ETS Response to Stakeholder Item #3:</u> This item appears to have already been addressed on page 3-10 of the Draft Technology Assessment in the section titled "Afterburner Controlling Smoke and Odors from Smokehouse"; however, ETS would like to point out the following details:

- In the Smokehouse Afterburner example presented in the Draft Technology Assessment, the operating schedule of the equipment was confirmed with the company owner by an SCAQMD inspector to be 12 hours per day for three days a week and 4 hours per day for two days a week (44 hours total per week) as opposed to 1.55 hours per day for 5 days per week (7.75 hours total per week) as found in the Furnace Dynamics, Inc. Cost Effectiveness Calculation in Attachment C-3.
- In Attachment C-3 under the heading of "Equipment Costs", the Stakeholder has costs for the following items: permit to construct fee ($2,200), source test evaluation fee ($611), and source test ($3,000). In prior SCAQMD rule development studies, including those that ETS has been contracted as an independent consultant, the types of permitting and source testing fees included by the Stakeholder are typically not appropriate to include in the calculation of emission control equipment cost effectiveness. As stated in the Draft Technology Assessment, "compliance demonstration costs including emissions testing, recordkeeping and other costs beyond what is recommended by equipment manufacturers are included in the socioeconomic assessment for rule adoptions."
- In Attachment C-3 under the heading of "Annual Costs", the Stakeholder has a cost for an annual source test fee ($100/yr). ETS does not believe that the inclusion of an annual source test fee is applicable or appropriate for the cost effectiveness analysis of a burner retrofit with a low NOx burner. Furthermore, upon review of Rule 1147, ETS found no requirement for source testing beyond the first year, so it is not appropriate to include that as a recurring annual cost.

- In Attachment C-3 under the heading of "Annual Costs", there is a cost for periodic maintenance ($400/yr). There was no documentation provided with the sheet to indicate what the annual maintenance costs related to the replacement of the existing burner with a new low NOx burner represents. Also, there was no evidence provided that the annual maintenance costs were above and beyond the costs for a non-compliant burner system; therefore, it is not appropriate to include those costs in the cost effectiveness calculations.
- The cost effectiveness calculations were performed using an equipment life of 10 years. For an afterburner such as this, ETS finds an equipment life of at least 20-25 years to be more appropriate.

D. Stakeholder Item #4 – Furnace Dynamics, Inc.

Stakeholder Item #4 (Attachment C-4) from Furnace Dynamics, Inc. contains a one page sheet titled "SCAQMD Minor Source BACT Cost Effectiveness Calculation." The sheet has cost effectiveness calculations performed for an Afterburner listed as being rated at 5,000,000 Btu/hour.

<u>ETS Response to Stakeholder Item #4:</u> This item does not appear to be within the scope of the Draft Technology Assessment because the daily NOx emissions listed are 1.671 lbs/day. In addition, there is insufficient information provided to determine if the process, emissions, usage, operating hours, and other parameters are appropriate. Information from the owner's application for permit would have been helpful. As stated in the synopsis of the SCAQMD Board Meeting on March 4, 2016, "the rule requires staff to conduct a technology assessment and report to the Board on the availability of burner systems and heating units for processes with NOx emissions of one pound per day or less". The same comments provided above in Stakeholder Item #3 regarding additional fees that should not be included in the cost effectiveness calculations and the utilization of an equipment life of 20-25 years as opposed to 10 years are also applicable to this item (Stakeholder Item #4).

A summary of the information received from Rule 1147 Stakeholders subsequent to the Rule 1147 Task Force Meeting and by the August 23, 2016 deadline may be found in Appendix D and copies of the five input items received from the Stakeholders are located in Attachments D-1, D-2, D-3, D-4, and D-5. Brief summaries of Stakeholder Item #'s 5-9 and the ETS responses are provided below:

E. Stakeholder Item #5 – Industrial Process Equipment, Inc.

Stakeholder Item #5 (Attachment D-1) from Industrial Process Equipment, Inc. contains the product information sheet on an immersion tube burner line (Titan Industrial Heating Systems, Immersion Tube Gas Burners). The Titan Immersion Tube Gas Burner was an example of a type of immersion burner line in the heated process tanks, evaporators and parts washers' category of equipment that has been tested in the SCAQMD with NOx emission results below 60 ppm and was emailed to Industrial Process Equipment, Inc. by SCAQMD Staff at the Stakeholder's request.

ETS Response to Stakeholder Item #5: The time and date stamp were not displayed on the original email from SCAQMD Staff to the Stakeholder. ETS has no specific comments on the exchange between Stakeholders regarding this item because the context is unclear.

F. Stakeholder Item #6 – Industrial Process Equipment, Inc.

Stakeholder Item #6 (Attachment D-2) from Industrial Process Equipment, Inc. was supplied to ETS after a discussion with Stakeholders during the Rule 1147 Task Force Meeting held at SCAQMD Headquarters on August 3, 2016. ETS asked the Stakeholder if they could provide any specific cost information with regard to the immersion tube heating systems that were being discussed during the Task Force Meeting. The Stakeholder email stated that "an average burner replacement with a low nox burner is $27,000 plus AQMD permits, Source testing and Down time costs being the line is shut down and any city permits. Could be more money if they do not have enough gas pressure in there plant to service the new burner."

ETS Response to Stakeholder Item #6: There was no supporting documentation or detail provided along with the average burner replacement cost of $27,000. The specific burner model number, burner size, burner cost, and installation costs were not supplied for verification by ETS.

G. Stakeholder Item #7 – Wirth Gas Equipment, Inc.

Stakeholder Item #7 (Attachment D-3) contains a letter from Wirth Gas Equipment, a supplier of industrial combustion equipment, which conveyed three areas of concern regarding SCAQMD's assessment of the "Burner availability and feasibility to retrofit units."

Stakeholder Item #7-1: The first area of Stakeholder concern in the Draft Technology Assessment was regarding SCAQMD's recommended "exemption for burners with a maximum rated capacity of 325,000 Btu/hour or less and "the delay or exemption for equipment that produces < 1lb. of NOx emissions per day." The Stakeholder states that "if this is in fact the criteria I suggest they make the exemption for all processes/equipment at this level."

ETS Response to Stakeholder Item #7-1: If ETS' comprehension of the Stakeholder's first area of concern is correct, then it appears that SCAQMD has already made recommendations in the Draft Technology Assessment to address the issues raised in Stakeholder Item #7-1. Please see Table ES-1 of this report for Staff Recommendation #1 which was based on technical feasibility and Staff Recommendation #5 which was based on the cost effectiveness evaluation.

Stakeholder Item #7-2: The second area of Stakeholder concern was Staff Recommendation #2 for the heated process tanks, evaporators and parts washers' category of equipment in the Draft Technology Assessment. The Stakeholder stated that "in exempting existing units from meeting a < 60 ppm requirement they are acknowledging that a good replacement piece of equipment does not exist. They state their testing has identified three types of heating systems that comply with the NOx emission limit and yet do not specifically identify what these systems are.....It is my opinion that not only a good replacement burner does not exist to meet the required firing conditions for immersion heating, but a good immersion burner that will meet a **<** 60 ppm NOx requirement for new units does not exist. The only unit I am aware of, which is available from a division of our principal company, requires firing tubes that are four times larger than current standard equipment. Using this "low NOx" option requires a tank that needs to be four times deeper to accommodate the tube."

ETS Response to Stakeholder Item #7-2: After reviewing the Draft Technology Assessment, it is ETS' understanding that the reason for Staff Recommendation #2 (see Table ES-1) was to address specific Stakeholder comments that it might not be technically feasible to retrofit certain types of existing heated process tanks with different burners that would meet the 60 ppm NOx emission limit. ETS reviewed both the Draft Technology Assessment, Appendix I (which discusses the heat process tanks, parts washers and evaporators category of equipment) and the SCAQMD Source Test Databases as of January 2015 (containing confidential information) and can confirm that the three types of heating systems that comply with the NOx emission limit of 60 ppm were in fact identified in Appendix I on pages I-2 and I-3.

Additionally, Appendix I of the Draft Technology Assessment identifies the new low NOx Maxon XPO burner for immersion heating that has been installed in new heated tanks with a 3,300,000 Btu/hour burner which demonstrated emissions of 4 ppm NOx at high fire and 34 ppm low fire in an SCAQMD approved emissions test. It should be noted that a comparison drawing presented to ETS by Industrial Process Equipment, Inc. in Stakeholder Item #8 depicts sizing information which contradicts this Stakeholder's claim of the firing tube being as much as four times larger and the tank being four times deeper.

Note: Additional comments regarding an acceptable immersion tube heating burner for parts washer tanks that would meet a NOx emission limit of 60 ppm were also brought up by two other Stakeholders, Industrial Process Equipment, Inc. and Furnace Dynamics, Inc. and those comments may be found in Stakeholder Item #8 (see Attachment D-4) and Stakeholder Item #9 (Attachment D-5), respectively.

Stakeholder Item #7-3: The third area of Stakeholder concern is that "exempting existing units until the tank is modified or replaced encourages industry to continue to use old, outdated, in-efficient equipment as long as possible. Additionally it does not honestly address the need for new equipment and falsely supports the suggestion that equipment to meet this requirement in a properly engineered design exists."

ETS Response to Stakeholder Item #7-3: It is unclear to ETS what type of suggestion, recommendation, or change to Staff Recommendation #2 from the Draft Technology Assessment for Rule 1147 that the Stakeholder is making in this third area of concern.

H. Stakeholder Item #8 – Industrial Process Equipment, Inc.

Stakeholder Item #8 (Attachment D-4) was a packet of information from Industrial Process Equipment, Inc. that was mailed to ETS and received on August 23, 2016. The packet contained a letter titled "Attention: Rule 1147" and manufacturer information was provided on the following burners: Eclipse ImmersoJet (IJ), Maxon Tube-O-Therm, Maxon XPO Immersion, Titan Immersion Heater. Comparison drawings of heated washer tanks with an Eclipse IJ6 burner tube arrangement and a Maxon XPO burner, including a washer Btu/hour burner sizing worksheet were also included in the packet.

Stakeholder Item #8-1: The Stakeholder stated in the letter that "in one of the meetings they changed the oven burners from 20 ppm to 30 ppm due to the fact there were no burners that would comply."

ETS Response to Stakeholder Item #8-1: The reference to a 20/30 ppm limit for oven burners does not appear to be relevant for the heated process tanks, evaporators and parts washers category of equipment since it has a completely different NOx emission limit in Rule 1147 (60 ppm or 0.073 lb/mmBtu). It should be noted; however, that ETS' review of the SCAQMD Source Test Database as of January 2015 confirmed that the average NOx emission concentration for most ovens and dyers tested (140 units) was about 20 ppm with a range of 4 ppm to 30 ppm.

Stakeholder Item #8-2: The Stakeholder stated in the letter that "the washer burners did not get the same attention. I feel the tube fired washer burners should be exempt along with other burners in this category or change the rule to 100 PPM."

ETS Response to Stakeholder Item #8-2: ETS was tasked with performing an independent review and analysis of the technical information presented in the Draft Technology Assessment for Rule 1147. In regard to the heated process tanks, evaporators and parts washers' category of equipment, it is ETS' understanding that SCAQMD Staff has already proposed a change to Rule 1147 based on Stakeholder concerns that it might not be technically feasible to retrofit an existing heated tank with different burners. The proposed change is to "delay compliance with the NOx emission limit for existing in-use heated process tanks, evaporators and parts washers with an integrated heated tank until such time the combustion system or tank is modified, replaced, or relocated." See Staff Recommendation #2 in Section V. of this report.

It was verbally reported to ETS (by the Stakeholder) that the ideal parts washer systems are designed for 2 to 3 mmBtu/hour and testing of some existing units indicates that current NOx emission levels range from 90 to 100 ppm for the high pressure burner system identified; however, no specific data or source testing information was supplied to ETS by the Stakeholder for review of actual emissions. It was also reported in the Draft Technology Assessment, Appendix I (which discusses the heat process tanks, parts washers and evaporators category of equipment) that there are currently no emission test results available for the types of tube heating system burners that produce higher pressures and can fire into smaller diameter tubes. It is unclear to ETS why the test results have not been submitted for any of these types of burners to date.

It is ETS' understanding through discussions with SCAQMD and as stated in the Draft Technology Assessment for Rule 1147 that under both federal and state law, SCAQMD cannot exempt equipment when it has a requirement under an existing rule and/or there is technology available for new units to meet the limit. Furthermore, it is understood by ETS that for Title V facilities (major sources), these types of processes will have to meet the NOx emission levels that have been demonstrated by systems with the Maxon XPO burners (30-35 ppm) since the emission level has been achieved in practice. Even a limit of 60 ppm NOx is significantly less stringent than other SCAQMD emission limits for boilers, water heaters, and process heaters which can range from 6 to 20 ppm NOx at 3% O_2.

Stakeholder Item #8-3: **Eclipse IJ Burner** - The Stakeholder provided product information and specification sheets from the Eclipse website on ImmersoJet (IJ) nozzle-mix tube-firing burners for Models IJ-8, Version 2 and IJ-6, Version 2 dated 4/5/2013. Also included were "Emissions Data Request" sheets from the Eclipse Home Office to the Stakeholder with guaranteed NO_x emission values that were dated as 6/19/2001 to 6/22/2001 and ranged from 80 to 90 ppm @ 3% O_2.

ETS Response to Stakeholder Item #8-3: ETS' prior experience indicates that many manufacturers are reluctant to guarantee burners to a lower NOx emission limit than is required by BACT or a rule and these guarantees were dated as being from June 2001. Were the "newer" Eclipse IJ Version 2 Models even available in 2001? ETS noticed a discrepancy between the Eclipse Product Datasheet for the ImmersoJet Burner, Model IJ-8, Version 2 that was provided in the packet from the Stakeholder (print date of 8/20/2016) and the Eclipse Emissions Data Request Sheet (dated 6/22/2001) with a NOx guarantee value of 80 ppm @ 3% O_2.

According to the Eclipse Design Guide for Immersion Burners (ImmersoJet Series, Version 2), the number in the Model signifies the immersion tube size in inches (i.e., Model IJ-8 Burner has a tube size of 8").[10] The Product Datasheet provided by the Stakeholder for the Model IJ-8 Burner lists 2 available burner maximum input ratings (firing rates) of 3,500,000 Btu/hour with the packaged blower and 4,800,000 Btu/hour with the remote blower; however, the corresponding Eclipse Emissions Data Request Sheet (dated 6/21/2001) that was attached to the IJ-8 Product Datasheet lists the burner model as IJ-6 v2, the burner firing rate as 3,000,000 Btu/hour, and the burner location as being an 8" Immersion Tube. It should also be noted that the Eclipse Product Datasheet for the Model IJ-6, Version 2 supplied by the Stakeholder lists a maximum input of 2,500,000 Btu/hour for the high pressure packaged blower and the only option for a maximum input that is greater than or equal to 3,000,000 Btu/hour for the Model IJ-6 burner is the option with a remote blower, which has a maximum input of 3,600,000 Btu/hour. These discrepancies will be discussed further in Stakeholder Item #8-5.

[10] *Honeywell Eclipse Product Catalog: Tube Firing Burners* (accessed September 20, 2016); available from www.eclipsenet.com/products/immersojet/.

Stakeholder Item #8-4: **Maxon XPO Immersion Burner Tube Diameter and Efficiency** - The Stakeholder provided the Technical Catalog for the Maxon XPO Burners and stated that "problems with retrofits and even new applications for this type of new burner is the first 8 feet of the fire tube is 24" in diameter versus the Eclipse IJ 8" tube diameter, 3,000,000 Btu/hour." The Stakeholder commented that the small tubes, such as the 8" diameter Eclipse IJ and Maxon Tube O Therm are more efficient (80%) than the old style larger diameter burners (69%).

ETS Response to Stakeholder Item #8-4: The Stakeholder claims regarding efficiency do not make sense to ETS. As stated in the Eclipse Immersion Burner (ImmersoJet Series, Version 2) Design Guide referenced in the ETS Response to Item #8-3,

> "efficiency is determined by the effective tube length. The diameter of the tube has little influence on the efficiency. At a given burner input, the net input to the tank is higher for a longer tube than for a relatively short tube. It is customary to size conventional immersion tubes for 70% efficiency, a reasonable compromise between fuel economy and tube length. However, small diameter tubes occupy less tank space than conventional tubes, so their length can easily be increased to provide efficiencies of 80% or more."

The Maxon XPO immersion burners, however, are a "new" style of indirect fired low temperature burners for use in liquid backed applications, including: water back heater, fire tube boiler, thermal oil heater, direct contact water heater, solution heating/tanks, and snow melters that will achieve ultra low NOx emissions while operating at 30% excess air level.[11] Due to the need for the burners and heat exchangers (tubes) to be designed as one integrated system in the heated process tank category of equipment and the fact that the burner tubes are typically a customer-supplied item, this is likely the reason that guarantees of emissions are not stated or implied in the burner manufacturer's general product literature.

Stakeholder Item #8-5: **Comparison Drawing of Parts Washer Tank Layout with the Eclipse IJ6 Burner Tube Arrangement and a Maxon XPO Burner** – The Stakeholder stated that the Maxon XPO burner is not a good solution for a new application since the tank would have to be significantly deeper, thus requiring more water and more heat input to heat the water. Additionally, the Maxon XPO heat exchange layout could not be well accommodated in wash tank applications, it has not been achieved in practice on enough pieces of equipment, and the wash tank applications should be exempted from the rule.

ETS Response to Stakeholder Item #8-5: The comparison drawing that was provided by the Stakeholder is labeled as "Eclipse Burner IJ 6" Immersojet Packaged Blower High

[11] *Honeywell Maxon Product Catalog: Low NOx Burners* (accessed September 20, 2016); available from https://www.maxoncorp.com/Directory/product_detail/XPO-Burner-Low-NOx/443/?ex=jqf0jt-li1r2l-ef151a.com/Directory/product_detail/OVENPAK-LE-natural-gas-lownox/113/.

Pressure, Burner Output Max 3,000,000 BTU's"; however, the washer tank layout drawing for the Eclipse burner arrangement depicts an 8" diameter stainless steel tube in the parts washer as opposed to a 6" diameter tube that is typically indicative of the IJ 6 Model burner. Irrespective of the differences noted, the overall dimensions of the washer tank for the Eclipse IJ 6 burner tube arrangement in the Stakeholder's comparison drawing were 19'-11" long x 7'-⅝" wide x 39" tall, with a water level depth of 34".

The other wash tank on the comparison drawing provided by the Stakeholder was labeled as "XPO Maxon Burner, Burner Output Max 3,000,000 BTU's", with the fire tube of the XPO burner shown as 24" in diameter for the first 8' feet of tube length and the remaining tube depicted as 8" in diameter. The overall dimensions of the washer tank for the Maxon XPO burner tube arrangement were 19'-11" long x 8'-2⅝" wide x 45" tall, with a water level depth of 40".

On the assumption that the design and sizing of the immersion tubes for each of the parts washer tanks was accurate, ETS noted the following between the layouts of the Eclipse IJ6 burner and the Maxon XPO burner:

- The overall length of both parts washers were identical at 19'-11"
- The parts washer layout for the Maxon XPO burner arrangement was 1'-2" wider than the overall width of the parts washer layout for the Eclipse IJ 6 burner
- The Maxon XPO burner tube depicted was 24" in diameter for the first 8' of tube length and the remaining tube length was 8" in diameter; however, the Eclipse IJ tube diameter depicted was 8" for the entire tube length. Note: The Maxon XPO Technical Catalog included by the Stakeholder indicated that the inside diameter of the fire tube for the 3,000,000 Btu/hour (maximum capacity) burner that was selected could be between 18 and 24" in diameter based on manufacturer suggested heat flux values (Btu/in^2). ETS also noted in the Technical Catalog that for the 3,000,000 Btu/hour Maxon XPO burner the corresponding blast tube listed was 6" outside diameter by 4' in length.
- The parts washer overall height of the Maxon XPO burner layout depicted was 6" taller than the Eclipse IJ6 parts washer. There was also a 6" difference in water level depth between the Maxon XPO and Eclipse IJ6 parts washers.

The differences that ETS noted above between a parts washer tank with an Eclipse IJ6 burner and a parts washer tank with a Maxon XPO burner in the Comparison Drawing provided by Industrial Process Equipment, Inc. in Stakeholder Item #8 seem to contrast with the comments made by another Stakeholder in Item #7. The comments made by Wirth Gas Equipment, Inc. in Stakeholder Item #7 were the following: "The only unit I am aware of, which is available from a division of our principal company, requires firing tubes that are four times larger than current standard equipment. Using this "low NOx" option requires a tank that needs to be four times deeper to accommodate the tube."

Also in response to Stakeholder Item #8-5, the information and data presented by SCAQMD Staff in Appendix I of the Draft Technology Assessment regarding the Maxon XPO burner states that both heated process tanks and parts washers have been permitted with this burner. It further states that an SCAQMD approved emissions test on one of these systems (required for Regulation XIII and new source review) with a 3,300,000 Btu/hour burner had emissions of 4 ppm NOx at high fire and 34 ppm at low fire. This data suggests to ETS that for new systems, the emission limit of 60 ppm is certainly technically feasible and has been "achieved in practice".

Stakeholder Item #8-6: Titan Heater – Information was supplied by the Stakeholder from the Titan Industrial Heating Systems website with a paragraph highlighted on Downdraft Burners which stated that "the down draft gas burner system is for heating: Phosphates Waste Water Hot Seal tanks and many other applications." The Stakeholder comments related to the Titan Heater were that the maximum firing rate is 450,000 Btu/hour. The Stakeholder then stated that "most of our washers are 2,000,000 Btu/hour or more. The tube diameter is 4" to 6". You would need 5 burners and tubes to do 2,000,000 Btu/hour. Not a practical or efficient design…This is an old style application. Goes back to the first washer ever built."

ETS Response to Stakeholder Item #8-6: ETS does not understand the relevancy of the Stakeholder comments on the Titan burner to the Rule 1147 Draft Technology Assessment. Appendix I of the Draft Technology Assessment lists the burner manufactured by Titan as one of many manufacturers of burners for the most common type of heating tube system that typically has tubes that vary from about 4" up to 14" in diameter (one of the five different types of tank heating systems described in Appendix I). The Draft Technology Assessment then states that three of the manufacturer systems within this type of tank heating system, which all use a burner with a maximum rating of 350,000 Btu/hour and 4 inch diameter heating tubes, have been tested with NOx emissions that range between 30 to 55 ppm and meet the NOx emission limit of 60 ppm for this category of equipment. ETS did not find that the Draft Technology Assessment implied that this type of burner would necessarily be the most suitable design for the Stakeholder's specific application as described above. That type of tube heating system was also not described as using burners which produce higher pressures and can fire into smaller diameter tubes such as the part washer burners that the Stakeholder is referring to. However, ETS does find it noteworthy that an "old style" partial premix burner system, such as the Titan burner, was capable of achieving NOx emissions of less than 60 ppm for the specific application in which it was tested.

Stakeholder Item #8-7: BTUs out of California Information – This Stakeholder item contained a list (labelled "BTUs out of California Information") of California companies that reportedly have shut down or moved out of California due to the costs of doing business in the state.

ETS Response to Stakeholder Item #8-7: While ETS recognizes the economic impacts of companies moving or going out of business, the supplied information could not be analyzed as a part of the review of the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources.

NOTE: Additional comments regarding an acceptable immersion tube heating burner for parts washer tanks that would meet a NOx emission limit of 60 ppm were also brought up by two other Stakeholders, Wirth Gas Equipment, Inc. and Furnace Dynamics, Inc. and those comments may be found in Stakeholder Item #7 (see Attachment D-3) and Stakeholder Item #9 (Attachment D-5), respectively.

I. Stakeholder Item #9 – Furnace Dynamics, Inc.

Stakeholder Item #9 (Attachment D-5) contains an e-mail with the subject line "Tech Assessment" and an attachment file titled "Tech Assessment Complete.pdf" (16 pages). The file included a write-up with regard to the SCAQMD Draft Technology Assessment, a comprehensive evaluation of a company that is now in compliance with the rule (Exhibits A through I of Stakeholder file), additional comments regarding a couple of other applications, and a cost effectiveness spreadsheet for an auto body spray booth (Exhibit J of Stakeholder file). Note: Stakeholder Item #9, Exhibits A - J were excluded from Attachment D-5 in this report due to the Stakeholder's request to maintain company confidentiality regarding financial information.

Stakeholder Item #9-1: **Technology Assessment** – The Stakeholder expressed concern over the vast array of devices in Rule 1147 that are covered by the Technology Assessment and a database received by Staff containing approximately 270 categories of equipment and approximately 6,500 devices. The Stakeholder concerns were stated in regard to the "limited ETS contract value" which would make it "impossible to evaluate a large number of sources."

ETS Response to Stakeholder Item #9-1: It appears to ETS that the Stakeholder concerns over 270 categories of equipment covered by the "Technology Assessment" are in reference to a different earlier document or search of the SCAQMD permit database and not the February 2016 version of the Draft Technology Assessment for Rule 1147 which ETS was tasked with reviewing. The February 2016 Draft Technology Assessment clearly states that "ten major categories of equipment were evaluated through the technology assessment" with the focus of the report on "equipment with NOx emissions of one pound per day or less." In addition, it is ETS' understanding that it would not be appropriate to do individual cost effectiveness calculations for pieces of equipment on a case-by-case basis as part of a rule requirement; rulemaking uses averages for calculating emissions for categories of equipment. Furthermore, the February 2016 Draft Technology Assessment described in detail the methodology utilized, including writing out the equations for the cost effectiveness analysis of replacing burner systems in three types of burner systems for small equipment with estimated emissions of one pound per day or less for which ETS was tasked with reviewing. Within each of the three types of burner systems defined (low temperature ovens and dryers, high temperature applications, and spray booths), the Draft Technology Assessment described the range of typical replacement burner and combustion system component costs from confidential information provided by the vendors for the various types of equipment that would be subject to Rule 1147.

Stakeholder Item #9-2: **General Comments Regarding the Technology Assessment**– There were 3 separate comments discussed by Furnace Dynamics, Inc. in Item #9-2 as listed below:

Item #9-2-a: The Stakeholder expressed concerns regarding burner manufacturers providing guarantees for NOx emissions on a burner in a forge company furnace; however, none would guarantee an acceptable uniformity survey required by the aerospace industry.

ETS Response to Stakeholder Item #9-2-a: This item does not appear to be a comment on the Rule 1147 Draft Technology Assessment dated February 2016.

Item #9-2-b: The Stakeholder had concerns regarding an acceptable immersion tube burner that can be used in wash tanks.

ETS Response to Stakeholder Item #9-2-b: These comments were very similar in nature to comments made by two other Stakeholders, Wirth Gas Equipment, Inc. and Industrial Process Equipment, Inc., in regard to the heated process tanks, evaporators and parts washers' category of equipment. The ETS responses may be found in Stakeholder Item #'s 7 and 8 above.

Item #9-2-c: The Stakeholder included a cost effectiveness spreadsheet that relates to a typical auto body spray booth retrofit application with a comparison of "PTE" and "Actual" cost effectiveness calculations (Exhibit J).

ETS Response to Stakeholder Item #9-2-c: It is unclear why the Stakeholder included cost effectiveness calculations for an auto body spray booth retrofit because a recommendation was already presented by SCAQMD Staff in the Draft Technology Assessment for the spray booth category of equipment in consideration of cost effectiveness. The Staff recommendation was to delay compliance with the NOx emission limit for existing in-use spray booths until the heating is modified, relocated or replaced (Staff Recommendation #5). ETS did note in the Stakeholder cost effectiveness spreadsheet, however, that the total equipment cost to retrofit an existing auto body spray booth to meet the Rule 1147 NOx emission limit was listed as $26,000, which is slightly less than the Draft Technology Assessment range of $30,000 to $50,000.

Stakeholder Item #9-3: ETS Consulting – The Stakeholder comments in this section of Attachment D-5 were regarding a discussion during the Rule 1147 Task Force Meeting held on August 3, 2016. The comments pertained to the Stakeholder's opinion of how the emissions values and cost effectiveness for Rule 1147 should have been conducted from the outset of rule development.

ETS Response to Stakeholder Item #9-3: - This Stakeholder comments are not related to the February 2016 Draft Technology Assessment for Rule 1147 Small and Low Emission Sources that ETS was tasked with reviewing.

Stakeholder Item #9-4: Pretesting to Determine the Current State of Compliance – The Stakeholder commented that over the last 3 years they have conducted approximately 190 pretests with the most advanced emission analyzers on the market (Testo 350) with 98% of the tests conducted on Rule 1147 devices.

ETS Response to Stakeholder Item #9-4: ETS reviewed the pretesting data that was presented with Stakeholder Item #9 (Exhibit A) and had follow-up questions and clarifications for the Stakeholder to gain a better understanding of how the pretesting data was utilized for the starting NOx emissions in the "Actual" cases of cost effectiveness conducted by the Stakeholder. Responses from the Stakeholder to the ETS follow-up questions were received in a timely fashion; however the follow-ups continued until September 12, 2016. ETS understands the importance of proper tuning and regular maintenance on combustion equipment to ensure that optimal conditions are being achieved and the utilization of portable analyzers may be a useful tool for many equipment owners to assess if compliance with Rule 1147 can be achieved with existing burners; however, the use of the pretesting data as the starting NOx emissions in the cost effectiveness for the "Actual" cases does not seem appropriate and will be addressed in additional ETS responses below.

Stakeholder Item #9-5: Facility Evaluation, Cost Effectiveness, and Actual Numbers vs. Default Values – The Stakeholder selected a facility where extensive pretesting was conducted in order to determine the compliance status for a specific facility and provide a basis for them to embark on a retrofit program prescribed under Rule 1147. The Stakeholder acquired a spreadsheet of the facility costs associated with each retrofit conversion that was determined as being needed based upon the pretesting data and the hours per day of operation. The Stakeholder then used the values as a basis of comparing the existing emission values and thus the overall reduction to calculate the cost effectiveness of each device. The average firing rates of the ovens, derived from actual source testing data, were used as the average firing rates of each of the ovens evaluated. The Stakeholder stated that it was important to understand that the indicated average was relevant to the understanding of how the equipment actually operates and then gave a description of that operation (see Attachment D-5).

The Stakeholder provided cost effectiveness charts for a specific facility and individual equipment where upgrades (burner retrofits) to their equipment were made and source testing was successfully completed. The Stakeholder stated "to assure consistency with staff's methodology, I created a spreadsheet using the same formulas found in the Districts Minor Source BACT Guidelines and the same values that are illustrated in the guidelines to assure the methods are consistent with what staff used in the initial evaluation. Staffs' and our numbers compare to the exact same dollar per controlled ton."

The Stakeholder also felt it important to provide actual numbers that represented actual information relating to specific devices. The Stakeholder stated that he had "used the actual starting ppm for each device to show a comparison to the Districts default values. The approach was to look at the actual daily use in hours then use a value that would represent the District's approach of using 100% firing rate for the normal hours of operation and also using the default emission factor that the staff used of 130#/MMcf natural gas (101.4 ppm).

ETS Response to Stakeholder Item #9-5: ETS conducted an extensive review of Exhibits A – I provided by the Stakeholder (which contained facility confidential information and were not included as an attachment to this report). It appears to ETS that the Stakeholder comments regarding the creation of a spreadsheet "to assure the methods are consistent with what staff used in the initial evaluation are in reference to an evaluation conducted by SCAQMD for Rule 1147 adoption in 2008. It is ETS' opinion that the Stakeholder's cost effectiveness calculations for individual pieces of equipment **are not consistent** with the cost effectiveness analysis presented by SCAQMD in the February 2016 version of the Draft Technology Assessment for Rule 1147 which ETS was tasked with reviewing.

After conducting an extensive review of the February 2016 version Draft Technology Assessment cost effectiveness calculations, ETS could not determine where the use of a default emission factor of 130#/MMcf natural gas (101.4 ppm) as commented by the Stakeholder was applicable. ETS did note in Appendix C, page C-2 of the Draft Technology Assessment dated February 2016 that "most rule 1147 emission test results are adjusted by the testing company or SCAQMD Staff to address issues with a test's acceptable range or with other testing and calculation issues. As a result, most test results can demonstrate compliance but cannot be used to accurately estimate concentration or mass emissions from individual units and categories of equipment."

The Stakeholder performed side-by-side cost effectiveness calculations with a column on the left of each page listed as "PTE" and a column on the right of each page listed as "Actual" for 6 pieces of equipment that would fall under the category of Small Ovens and Dryers as described in various sections of the Draft Technology Assessment. The NOx emission reductions for the "PTE" cost effectiveness calculations were calculated from the starting NOx emissions of 101.4 ppm and the "modified source emissions" of 30 ppm using 100% firing rate for the normal hours of operation for each of the 6 pieces of equipment. The NOx emission reductions for the "Actual" cost effectiveness calculations were calculated based on the Stakeholder pretesting data and "modified source emissions" of 30 ppm using an average firing rate for the normal hours of operation for the 7 pieces of equipment. Note: For calculating actual emission reductions, the Stakeholder should have used actual low NOx burner emissions instead of a default emission limit of 30 ppm. Actual low NOx burner emissions provided by the Stakeholder were in the range of approximately 7 to 20 ppm NOx.

The focus of the February 2016 Draft Technology Assessment was on processes with NOx emissions of one pound per day or less as called for on page 1147-16 of SCAQMD Rule 1147 – NOx Reductions from Miscellaneous Sources (Adopted December 5, 2008) (Amended September 9, 2011). For the cost effectiveness analysis performed for both the low temperature ovens and dryers and the high temperature applications, SCAQMD started with the NOx emissions of one pound per day and then performed the cost effectiveness calculations using NOx emission reductions in increments of 0.25 pounds per day for the following cases: 0.25, 0.50 and 0.75 pounds per day. Note: The initial NOx emissions from the equipment examples provided by the Stakeholder appeared to be above one pound per day from equipment that was more than 20 years old.

In addition, it is ETS' understanding that it would not be appropriate to do individual cost effectiveness calculations for pieces of equipment on a case-by-case basis as part of a rule requirement; rulemaking uses averages for calculating emissions for categories of equipment. Based on the responses given above, ETS does not believe that the Stakeholder's cost effectiveness calculations affect the recommendations that were made by SCAQMD Staff in the February 2016 Draft Technology Assessment. However, there were several key items that were gleaned from ETS' review of the all of the Exhibits provided by the Stakeholder in Item #9 that will be listed at the end of this section.

Stakeholder Item #9-7: Cost Effectiveness Methodologies – The Stakeholder commented that "there were multiple values illustrated in the technology assessment. They varied in duration of the starting and ending points. Some had a 10-year cost effectiveness value and some had 15 year or even a 20 year criteria used for the evaluation of cost effectiveness." The Stakeholder believes a singular methodology should be utilized for determining cost effectiveness and should be uniform for all Rule 1147 devices, should be conducted on a case-by-case basis, and the Stakeholder has offered to assist in streamlining this effort.

ETS Response to Stakeholder Item #9-7: The cost effectiveness values that ETS reviewed in the February 2016 version of the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources for the three types of burner systems previously defined utilized the following equipment lives:

- Low Temperature Ovens and Dryers – 20 year equipment life
- High Temperature Applications – 25 year equipment life
- Spray Booths – 20 year equipment life

ETS could not find either a 10 year or a 15 year cost effectiveness value in the "Technology Assessment" in the February 2016 Draft Technology Assessment.

Stakeholder Item #9-10: Conclusions: – The Stakeholder stated that the "Technology Assessment is rather comprehensive in nature. However, we find fault in the cost effectiveness numbers due to staffs' using default numbers and potential to emit. We have provided spreadsheets that can be evaluated to determine what constitutes one pound per day of NOx based on BTU input and hours of operation at a number of average BTU inputs from PTE to an average of 20% of PTE."

ETS Response to Stakeholder Item #9-10: ETS would agree that the February 2016 version of the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources (found in Appendix A of this document) was very comprehensive in nature and detailed the methodologies that were utilized; however, the Stakeholder's comments do not correspond with how the cost effectiveness calculations were actually conducted by SCAQMD Staff in the February 2016 Draft Technology Assessment that was the primary focus of the ETS review.

ETS Overall Comments on the Review of Stakeholder Exhibits A - J:

- The Stakeholder used a 10 year equipment life for all of the cost effectiveness calculations presented to ETS. ETS does not believe that the 10 year equipment life utilized by the Stakeholder in performing the cost effective calculations for low temperature ovens/dryers and a spray booth in Exhibits D – I is appropriate for these applications. ETS believes that a 20 year equipment life would be more appropriate for these categories of equipment. Modifying the Stakeholder's cost effectiveness calculations to a 20 year equipment life would reduce the cost effectiveness (in $ per ton) for the equipment evaluated by roughly 50%.
- The rating of the low NOx burners purchased for the retrofit at the facility evaluated by the Stakeholder ranged from 1,000,000 to 2,000,000 Btu/hour. Cost information presented by the Stakeholder for those burners would be applicable to the "Burner Cost and Cost Effectiveness for Low Temperature Ovens and Dryers" section of the Draft Technology Assessment for Rule 1147 Small and Low Emission Sources (pages 3-5 to 3-7). Without revealing any of the facility confidential information provided by the Stakeholder to ETS or the confidential information in the confidential burner costing information provided by SCAQMD to ETS, the following comments could still be made by ETS:

    1. Under the heading of "Equipment Costs" in Exhibits D - I, the Stakeholder included varying costs for the following in each cost effectiveness evaluation: permit to construct fee, source test evaluation fee, and source test. As previously stated, ETS does not believe that these costs are appropriate to include in the cost effectiveness calculations for Draft Technology Assessment for Rule 1147 Small and Low Emission Sources.

    2. Note to Stakeholder: The costs listed in columns labeled "Protocol Fees" and "Performance Test Plan Evaluation" in Exhibit C were added together and totaled in the column labeled "Combined Proto and ST Fees"; however all 3 of those columns of costs were then summed to arrive at the total in the column labeled "Individual Device Costs". Therefore, the "Protocol Fee" and "Performance Test Plan Evaluation" cost columns are being double counted in the sum total for the "Individual Device Cost" column for every piece of equipment listed. As previously stated, however, ETS does not believe that those costs are appropriate to include.

    3. With the exclusion of the Stakeholder fees listed in #1 above, ETS reviewed the Stakeholder "Burner Cost" and "Installation" costs columns for new low NOx burners ranging from 1,000,000 to 2,000,000 Btu/hour. With the exception of one piece of equipment, the sum of the "Burner Cost" and "Installation" (which be the total installed equipment cost) for 6 different ovens in Exhibit C were within the range of total installed equipment costs evaluated from the SCAQMD costing information. In fact, the total installed equipment costs for those 6 ovens were below $30,000 (the estimated cost for installing a low NOx burner in small

ovens and dryers found on page 3-6 of the Draft Technology Assessment).

4. After considerable follow-up with the Stakeholder, it is still not understood by ETS why the Stakeholder used average firing rates for the determination of both the starting emissions and the modified source emissions to arrive at the emissions reduction. The following example explains how an "Actual" Stakeholder cost effectiveness calculation for a low temperature oven appears to be grossly overstated with the "DCF Cost Per Ton Reduced" calculated by the Stakeholder as $212,921.

    - The pretest starting emissions of 87 ppm (original burner) and an average BTU input of 300,000 Btu/hour (determined from a gross input of 1,000,000 Btu/hour multiplied by an average BTU input of 30%) were used to calculate the annual starting emissions. Note: Through ETS follow-up questions, the Stakeholder indicated that the average BTU input of 30% was derived from the source test summary sheets listing a maximum input and the average firing rate. However, the Stakeholder indicated that the original burner rating was 600,000 Btu/hour and it was retrofitted with a new Eclipse Winnox burner rated at 1,000,000 Btu/hour. The source test summary sheets provided by the Stakeholder listing the average BTU input of 30% were for the new Eclipse Winnox burner rated at 1,000,000 Btu/hour burner for the "Low Load" source testing. This methodology does not seem logical.

    - The modified source emissions of 30 ppm (new Eclipse Winnox burner) and an average BTU input of 300,000 Btu/hour (determined from a gross input of 1,000,000 Btu/hour multiplied by an average BTU input of 30%) were used to calculate the annual reduced emissions. In presenting an "Actual" case following the Stakeholder's methodology, it would seem to ETS that the actual "Low Load" NOx emissions that were achieved of 6.15 ppm @ 3% O_2 should have been utilized. This would result in higher NOx emissions reduced over the life of the equipment and a significantly lower DCF. Note: The "High Load" source testing provided to ETS indicated NOx emissions of 6.34 ppm @ 3% O_2 with a "Fire Rate" of 410,000 Btu/hour.

    - ETS noted that the original burner had a rating of 600,000 Btu/hour and the new retrofit burner (Eclipse Winnox) had a rating of 1,000,000 Btu/hour. During the ETS manufacturer data review in Section VI.I of this document, ETS noted that the Eclipse Winnox burners were available in 8 sizes with the smallest burner size rated at 550,000 Btu/hour (Eclipse Model Number

WX0050).[12] Additional review of the Eclipse Winnox Model WX0050 Datasheet by ETS indicates a maximum burner input range from 470,000 to 650,000 Btu/hour depending upon the type of blower selected. While ETS can't comment on the specific design reasons for oversizing the new retrofit burner, it does not seem appropriate to include a higher cost for that in the Stakeholders "Actual" cost effectiveness calculations.

5. After ETS obtained the follow-up items requested from the Stakeholder, there were numerous inconsistencies noted between the equipment names, data supplied on the original burner ratings, the new retrofit burner ratings, and the burner ratings that were then utilized in the cost effectiveness calculations for the specific equipment names. In addition, there was insufficient information provided to determine if the process, emissions, usage, operating hours, and other parameters utilized were appropriate.

IX. ETS RESPONSES TO INFORMATION RECEIVED FROM RULE 1147 STAKEHOLDERS AFTER AUGUST 23, 2016 DEADLINE

A summary of the information received from Stakeholders after the August 23, 2016 deadline may be found in Appendix E. The information received by ETS came from the following two Stakeholders: 1) Industrial Process Equipment, Inc. and 2) Furnace Dynamics, Inc. Brief summaries of Stakeholder Item #'s 10-12 and the ETS responses are provided below:

A. Stakeholder Item #10 – Industrial Process Equipment, Inc.

Stakeholder Item #10 (Attachment E-1) contains an undated letter that was received by email from Industrial Process Equipment, Inc. on September 2, 2016. The undated letter was addressed to Wayne Barcikowski at SCAQMD from Jim Waggoner of Industrial Process Equipment, Inc. The Stakeholder concerns were regarding the amount of burners that needed to be changed by July 2012. The Stakeholder also suggested rule amendments for "the added categories that work for the different applications" and for burners that are on the market and have been achieved in practice for a minimum of one year. The final page of the Stakeholder letter recommends "getting with the burner manufacturers to see if the below are correct categories that they can make burners for and to what type of burner will meet the PPM requirements. When can they meet the PPM requirements and then implement them into the rule."

<u>ETS Response to Stakeholder Item #10:</u> The items in this letter do not appear to be applicable to the specific ETS tasks or comments on the February 2016 Draft Technology Assessment for Rule 1147 Small and Low Emission Sources.

[12] *Honeywell Eclipse Product Catalog: Air Heating Burners* (accessed September 20, 2016); available from www.eclipsenet.com/products/winnox/.

B. Stakeholder Item #11 – Industrial Process Equipment, Inc.

Stakeholder Item #11 (Attachment E-2) contains an email from Industrial Process Equipment, Inc. dated September 2, 2016. The email also contained an attachment file of a CAD layout drawing of a conveyorized powder coat system. The CAD drawing, however, was not included as an attachment in this report since it contained client-specific details for a system that is located in Texas.

The CAD drawing is dated as 11/11/15 and is a Conveyorized Powder Coat System for a specific client with the following: "a Spray Power Washer in the front that goes to a Dry Off Oven, then cools down to Two Powder Booths, and then to the Cure Oven, and then to the Unload Area."

ETS Response to Stakeholder Item #11: It is ETS' understanding that the CAD layout drawing was provided by the Stakeholder to convey to ETS the location of the parts washer tank (which is a piece of equipment that falls under Rule 1147) with respect to the layout of the entire system. ETS appreciates the additional Stakeholder information; however, the drawing does not appear to be applicable to the specific ETS tasks or comments on the February 2016 Draft Technology Assessment for Rule 1147 Small and Low Emission Sources.

C. Stakeholder Item #12 – Furnace Dynamics, Inc. (Energy Services Corporation)

Stakeholder Item #12 is an email from Anthony Endres of Furnace Dynamics, Inc. that was received by ETS on September 20, 2016. The email contained an undated document from Anthony Endres of Energy Services Corporation addressed to Wayne Barcikowski at SCAQMD (Attachment E-3). The letter discusses the applicability of the 60 ppm NOx emission limit to different types of metal melting and heat treating furnaces. The commenter proposes each type of furnace should have a different NOx emission limit. The letter also contains a general discussion of BACT for new metal melting and heat treating furnaces that proposes that each type of furnace should have its own BACT limit. Finally, the Stakeholder recommends the use of a pounds per hour basis for determining compliance based on the pounds per hour emitted at 100% for a given burner or classification of equipment. Note: All other Stakeholder items received from Anthony Endres were indicated with the company Furnace Dynamics, Inc.; however, Attachment E-3 was from Energy Services Corporation.

ETS Response to Stakeholder Item #12: The items in this document do not appear to be applicable to the specific ETS tasks or comments on the February 2016 Draft Technology Assessment for Rule 1147 Small and Low Emission Sources.

X. ETS COMMENTS ON RULES CHANGES UNDER CONSIDERATION BY SCAQMD

In conclusion, ETS concurs with the five Rule 1147 changes under consideration as found in Executive Summary Table ES-1 and would like to offer the following additional recommendation for Rule 1147:

> Change the NOx emission limit from 30 ppm to 60 ppm in the afterburner technologies for processes that operate at or below 800°F. This new NOx limit of 60 ppm will be the same compliance limit required for higher temperatures and therefore the same limit at any process temperature in the afterburner technologies category. The burner utilized for these types of applications is not designed to achieve 30 ppm (ETS Recommendation #6).

APPENDIX A

SCAQMD DRAFT TECHNOLOGY ASSESSMENT FOR RULE 1147 SMALL AND LOW EMISSION SOURCES DATED FEBRUARY 2016

BOARD MEETING DATE: March 4, 2016 AGENDA NO. 25

PROPOSAL: Rule 1147 Technology Assessment

SYNOPSIS: At its September 9, 2011 meeting, the SCAQMD Board amended Rule 1147 – NOx Reductions from Miscellaneous Sources. The rule requires staff to conduct a technology assessment and report to the Board on the availability of burner systems and heating units for processes with NOx emissions of one pound per day or less. The draft technology assessment considers potential changes to Rule 1147 for specific categories of equipment based on analysis of technical feasibility and cost effectiveness. Staff has proposed to hire a third party to review the draft Technology Assessment, report findings to Rule 1147 stakeholders and incorporate the reviewer's comments. This action is to receive and file the draft Rule 1147 Technology Assessment.

COMMITTEE: Stationary Source, November 20, 2015; February 19 and January 22, 2016, Reviewed

RECOMMENDED ACTION:
Receive and file.

Barry R. Wallerstein, D. Env.
Executive Officer

PF:JC:GQ:WB

Background
Rule 1147 – NOx Reductions from Miscellaneous Sources, was adopted by the SCAQMD Board on December 5, 2008 with a compliance schedule phased in over 10 years. Rule 1147 incorporates two control measures of the 2007 AQMP: CMB-01 – NOx Reductions from Non-RECLAIM Ovens, Dryers and Furnaces and MCS-01 – Facility Modernization. Control Measure MCS-01 proposed that existing in-use equipment meet best available control technology (BACT) emission limits in place at the time the AQMP was adopted. Control Measure CMB-01 proposed emission NOx limits in the range of 20 ppm to 60 ppm for ovens, dryers, kilns, furnaces and other

combustion equipment. Emission reductions from the equipment addressed by Rule 1147 and Control Measure CMB-01 of the 2007 AQMP were also proposed in prior AQMPs.

Rule 1147 was amended September 9, 2011 to delay implementation dates up to two years, remove a requirement for fuel or time meters and provide compliance flexibility for small and large sources. In addition, the rule includes a requirement for a technology assessment on the availability of low NOx burner systems for processes with NOx emissions of one pound per day or less and that are not typically subject to a BACT requirement as new sources. The technology assessment also includes an evaluation of cost and cost effectiveness for small and low emission sources.

Technology Assessment

Initially the SCAQMD technology assessment targeted sources in which burner technology was either not available or the retrofit cost was comparable to the cost of replacing the unit. Several categories of equipment were identified and removed from Rule 1147 and the requirement for a permit through the May 2013 amendments to SCAQMD Rules 219 and 222. Staff continued its technical evaluation and developed Rule 1153.1 – Emissions of Oxides of Nitrogen from Commercial Food Ovens to move existing in-use food ovens, roasters and smokehouses from Rule 1147 into their own rule. Rule 1153.1 was adopted on November 7, 2014 and provided more appropriate temperature ranges for defining emission limits, food oven specific emission limits, later compliance dates and an exemption for small units.

The last phase of the technology assessment focuses on the remaining categories of small and low emission equipment that were not addressed through the Rule 219, 222 and 1153.1 rulemaking efforts. While the focus of this report is on equipment with NOx emissions of 1 pound per day or less, the report also includes information and analysis applicable to larger units. This information is provided in order to address stakeholders' concerns regarding the availability of technology for larger equipment.

This assessment utilizes information on affected equipment from the SCAQMD permit system, New Source Review and Rule 1147 emissions testing programs, and from discussions with equipment and burner manufacturers, affected businesses, consulting engineers and industry representatives. The technology assessment provides information on the types and number of equipment affected by Rule 1147, emissions characteristics of this equipment and estimates of the cost and cost effectiveness of replacing existing older combustion systems. This information provides insight into compliance and affordability challenges faced by businesses affected by Rule 1147.

With the exception of a few categories of equipment, the technology review demonstrates that low NOx burner systems are available for every category of equipment subject to Rule 1147 and have been since the late 1990's. However, staff has identified the following three types of equipment for which burners are not readily available or cannot be retrofitted: 1) low temperature ovens and dryers with heat inputs of less than 325,000 Btu per hour (0.325 mmBtu/hour); 2) existing heated process tanks, evaporators and parts washers; and 3) low temperature burn-off ovens and incinerators.

Cost and Cost Effectiveness

The staff report for the adoption of Rule 1147 in 2008 reviewed costs for a wide range of equipment with heat inputs from less than 1 million Btu per hour to over 20 million Btu per hour. That analysis of cost and cost effectiveness was averaged over a wide range of burner sizes. However, most of the equipment subject to Rule 1147 requirements have heat inputs less than 4 million Btu per hour, and burners used in Rule 1147 equipment are typically smaller than 2 million Btu per hour. The most common burner size in Rule 1147 equipment is about 1 million Btu per hour. Most of the burner sizes analyzed in the 2008 staff report are larger and rarely used in equipment subject to Rule 1147. The burner sizes evaluated in 2008 are more likely to be found in units at RECLAIM facilities.

In the 2008 Rule 1147 staff report, the average cost effectiveness for replacing the smallest burners with the lowest potential NOx emission reductions was estimated to be about $22,400 per ton (adjusted to 2015 dollars). In the current analysis, the cost effectiveness of replacing burners and other components in small and low emission units varies widely. It is highly dependent upon how often a unit is used, which determines potential emission reductions. Staff estimates that a cost effectiveness range of $15,000 to $46,000 per ton is typical for retrofits of small and low emission equipment. However, retrofits of specific types of low emission equipment could result in cost effectiveness as high as $88,000 per ton of NOx reduced.

Staff has used the current SCAQMD BACT Guidelines criteria of $27,000 per ton for equipment that does not have a defined BACT as a guide to evaluate the cost effectiveness of low NOx retrofits for Rule 1147 equipment. Based on this analysis, staff is suggesting a delay of the requirements for equipment with NOx emissions of 1 pound per day or less until the equipment is modified, relocated or replaced with a new unit. This delay would include all spray booths and most small ovens and furnaces. Staff estimates that 4,900 to 5,650 out of 6,400 Rule 1147 units would be affected by this proposal.

Recommendations
As a result of this technology assessment, the following changes are proposed for consideration:

- Exempt sources with total rated heat input less than 325,000 Btu per hour from the Rule 1147 NOx emission limit.
- Change the NOx emission limit from 30 ppm to 60 ppm NOx for the primary chamber for all burn-off ovens, burnout furnaces and incinerators.
- Delay compliance for existing in-use heated process tanks, evaporators and parts washers from the NOx emission limit until the combustion system or tank is modified, replaced or relocated.
- Delay compliance with the NOx emission limit for existing in-use spray booths until the heating system is modified or replaced or the unit is relocated.
- Delay compliance with the NOx emission limit for existing in-use units with actual NOx emissions of one pound per day or less until the combustion system is modified or replaced or the unit is relocated.

Comments Received
Staff held a meeting of the Rule 1147 Task Force on February 17, 2016 to receive comments on a draft copy of the Technology Assessment that was released for public review. Staff also received comments in a letter from Furnace, Dynamics, Incorporated sent to SCAQMD staff on February 18, 2016. Stakeholders also provided comments at the Stationary Source Committee meeting on February 19, 2016. The attached Draft Technology Assessment does not yet include a discussion of these comments, but staff will incorporate these comments, other stakeholder's comments, contractor suggestions and staff responses into the next draft of the technology assessment, after the contractor meets with stakeholders.

The comments received at the Rule 1147 Task Force Meeting, in the comment letter and at the Stationary Source Committee focused on staff's initial recommendations and potential future rule amendments including: additional criteria for identifying low emission units, providing long term mitigation options, delaying compliance dates, and individual cost effectiveness calculations for every permit application. Another major category of comments dealt with rule implementation by SCAQMD Engineering and Compliance, including permit application review time, changing how potential emissions are estimated under new source review, and postponing Rule 1147 enforcement actions. There were a few comments received by letter and one comment at the committee meeting on the analysis of cost effectiveness in the technology assessment. These comments will be incorporated into the final document and discussed with stakeholders and the contractor prior to presenting the draft final technology assessment to the Stationary Source Committee.

Key stakeholder requests and staff responses are summarized in the table below:

Stakeholder Requests and Staff Response

• Delay compliance or exempt small and low emission units	• Agree: Exempt small units and delay for low emission units
• Change emission limit for burn-off ovens	• Agree: Raise emission limit for primary chamber
• Exempt existing in-use heated process tanks	• Agree: Delay compliance until modified, replaced or moved
• Delay compliance for existing in-use spray booths	• Agree: Delay compliance for low emission booths until modified, replaced or moved
• Provide more options for demonstrating low emissions other than default PTE	• Rule currently allows options requested, but staff will clarify in rule and provide additional guidance
• Provide different exemption criteria for some equipment, including a 400,000 Btu/hr threshold and a pound per day measurement based on fuel usage	• Staff will work with stakeholders to evaluate alternatives

Future Activity

Staff will continue working with members of the Rule 1147 Task Force and other stakeholders to collect additional information regarding the feasibility and cost of replacing combustion systems in equipment subject to Rule 1147. Staff will release a Request for Proposals to hire a third-party consultant to review the technology assessment and report back to the Rule 1147 Task Force. Staff has invited stakeholders to participate in the contractor selection process, and the contractor will present draft findings at a future Rule 1147 Task Force meeting, receive feedback and answer questions. The results of the contractor analysis and staff response will be reported back to the Stationary Source Committee with a draft final assessment and a list of actions to consider for future rule amendment.

Attachment

Draft Technology Assessment for Rule 1147 Small and Low Emission Sources

ATTACHMENT

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Draft Technology Assessment for Rule 1147 Small and Low Emission Sources

February 2016

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EXECUTIVE SUMMARY

Background

SCAQMD Rule 1147 – NOx Reductions from Miscellaneous Sources was adopted in December 2008 and is an important component of the attainment strategy to meet the federal annual PM2.5 ambient air quality standard as well as meet the ozone standard. The rule regulates NOx emissions from combustions sources that were not addressed by SCAQMD rules other than Rule 474 – Fuel Burning Equipment - Oxides of Nitrogen. Rule 474 was last amended in 1981 and limits NOx emissions rates from equipment burning gaseous fuels to 125 ppm and equipment burning liquid and solid fuels to 225 ppm (at 3% oxygen). Many categories of equipment used in a wide variety of processes are now regulated by Rule 1147. However, similar equipment can have a wide range of operating characteristics, process temperatures and emissions rates. Because of the number and variety of equipment affected, the rule compliance schedule was phased in over 10 years starting in 2010.

Rule 1147 was amended September 2011 to address compliance challenges, remove a requirement for fuel or time meters, delay compliance dates and provide regulatory relief to affected businesses. Throughout the rule amendment process, discussions with affected businesses, equipment manufacturers, and installers focused on concerns that there were many unique pieces of equipment and on the availability of cost effective and affordable low NOx technology. A major concern was the impact of the rule on small and low use equipment with NOx emissions of one pound per day or less. To address this challenge, the amended rule provided two solutions: first, sources with daily emissions rates less than or equal to one pound per day were given a delay of up to two years (until 2017 at the earliest) before they were required to comply with emission limits. These small and low emission units originally had compliance dates five years later than larger units. Second, Rule 1147 included a requirement that staff perform a technology assessment for these small and low emission sources that are not typically subject to the best available control technology (BACT) requirement as new sources.

Technology Assessment

Initially the technology assessment targeted sources where burner technology was either not available or the retrofit cost is comparable to the cost of replacing the unit. Several categories of equipment were identified and removed from Rule 1147 and the requirement for a permit through the May 2013 amendments to SCAQMD Rules 219 and 222. Staff continued its technical evaluation and developed Rule 1153.1 – Emissions of Oxides of Nitrogen from Commercial Food Ovens to move existing in-use food ovens, roasters and smokehouses from regulation by Rule 1147 into their own rule. Rule 1153.1 was adopted in November 2014 and provided more appropriate temperature ranges for defining emission limits, food oven specific emission limits and later compliance dates. In addition, Rule 1153.1 provided a small source exemption for existing in-use units with emissions of up to one pound per day.

The last phase of the technology assessment focuses on the remaining categories of Rule 1147 equipment that were not addressed through the Rule 219, 222 and 1153.1 actions. This assessment utilizes information on affected equipment from the SCAQMD permit system, SCAQMD emissions testing programs and discussions with equipment and burner manufactures, affected businesses, consulting engineers and industry and business representatives. This report provides information on the types and number of equipment affected by Rule 1147, emission characteristics of these equipment and estimates of the cost and cost effectiveness of replacing old burners. Taken together, this information provides insight into compliance and affordability challenges faced by businesses affected by Rule 1147. While the focus of this report is on equipment with NOx emissions of 1 pound per day or less, the report also includes information and analysis applicable to larger units. This information is provided in order to address stakeholder's concerns regarding the availability of technology for larger equipment.

Staff conducted extensive outreach to equipment manufacturers and product installers. Staff went into the field to identify equipment that will comply with Rule 1147 emission limits with available burners and those that may not. Rule development staff has worked closely with industry representatives and other staff to develop solutions to unique compliance challenges. These discussions resulted in a number of proposals to staff that are included in this report.

Ten major categories of equipment were evaluated through the technology assessment including: afterburner technologies, spray booths, crematories, fryers, heated process tanks, metal melting furnaces, heat treating, multi-chamber burn-off ovens and incinerators, ovens and dryers. As a result of this assessment, the following five recommendations are proposed for consideration in future rule development:

- Exempt sources with total rated heat input less than 325,000 Btu per hour from the Rule 1147 NOx emission limit
- Change the NOx emission limit from 30 ppm to 60 ppm NOx for the primary chamber of all multi-chamber burn-off ovens, burn-out furnaces and incinerators for all process temperature
- Delay compliance for existing in-use heated process tanks, evaporators and parts washers from the NOx emission limit until such time the combustion system or tank is modified, replaced or relocated
- Delay compliance with the NOx emission limit for existing in-use spray booths until the heating system is modified or replaced or the unit is relocated
- Delay compliance with the NOx emission limit for existing in-use units with actual NOx emissions of one pound per day or less until the combustion system is modified or replaced or the unit is relocated

Staff estimates that 4,900 to 5,650 out of 6,400 units would be affected by these proposed changes. Staff will continue working with members of the Rule 1147 Task Force and other stakeholders to collect additional information regarding the feasibility and cost of replacing combustion systems in equipment subject to Rule 1147. Staff will release a Request for Proposals (RFP) to hire a third-party consultant to review the technology assessment and report back to the Rule 1147 Working Group. Staff has invited stakeholders to participate in the contractor selection process. The results of the contractor analysis and staff response will be reported back to the Stationary Source Committee with a list of actions to consider for future rule amendment.

BACKGROUND

INTRODUCTION

The California Health and Safety Code requires the AQMD to adopt an Air Quality Management Plan to meet state and federal ambient air quality standards and adopt rules and regulations that carry out the objectives of the AQMP. The California Health and Safety Code also requires the AQMD to implement all feasible measures to reduce air pollution.

SCAQMD Rule 1147 was adopted December 2008 and because of the number and variety of equipment affected, the rule compliance schedule was phased in over 10 years. The NOx reductions from Rule 1147 are a vital component of our attainment strategy and essential for achieving compliance with federal and state ambient air quality standards for PM2.5, PM10 and ozone. Rule 1147 was also amended in September 2011 to address compliance challenges and provide regulatory relief for affected businesses.

REGULATORY HISTORY

Rule 1147 – NOx Reductions from Miscellaneous Sources, was adopted by the AQMD Governing Board on December 5, 2008. Rule 1147 incorporates two control measures of the 2007 Air Quality Management Plan (AQMP): NOx Reductions from Non-RECLAIM Ovens, Dryers and Furnaces (CMB-01) and Facility Modernization (MCS-01).

Control measure MCS-01 proposed that equipment operators meet best available control technology (BACT) emission limits at the end of a combustion system's useful life. Control measure CMB-01 proposed emission NOx limits in the range of 20 ppm to 60 ppm (referenced to 3% oxygen) for ovens, dryers, kilns, furnaces and other miscellaneous combustion equipment. Emission reductions from the equipment addressed by Rule 1147 and control measure CMB-01 of the 2007 AQMP were proposed in prior AQMPs (e.g., control measure 97CMB-092 from the 1997 AQMP).

Rule 1147 was amended September 9, 2011 to delay implementation dates one to two years, remove a requirement for fuel or time meters and provide compliance flexibility for small and large sources. In addition, the rule includes a requirement for a technology assessment for small and low emission sources that are not typically subject to the best available control technology (BACT) requirement as new sources.

RULE REQUIREMENTS

Rule 1147 established nitrogen oxide (NOx) emission limits for a wide variety of combustion equipment and affects both new and existing (in-use) combustion equipment. Rule 1147 requires equipment with AQMD permits that are not regulated by other NOx rules to meet an emission limit of 30 to 60 parts per million (ppm) of NOx depending upon equipment type and process temperature. The compliance schedule for existing equipment is phased in over 10 years starting in 2010. Compliance dates for emission limits are based on the date of equipment manufacture and emission limits are applicable to older equipment first. Owners of existing equipment are provided at least 15 years of use before they must meet rule emission limits. The first group of equipment affected had to comply with rule emission limits when they were 20 to 30 years old. Owners of small units and units with emissions of one pound per day or less will comply with emission limits later starting in 2017.

Rule 1147 also establishes test methods and provides alternate compliance options including a process for certification of equipment NOx emissions through an AQMD approved testing program. Certification eliminates the requirement for end-users to test their equipment. Other rule requirements include equipment maintenance and recordkeeping.

In developing rule, staff worked extensively with many stakeholders. Staff held Task Force meetings with representatives from affected businesses, manufacturers, trade organizations and other interested parties. Staff also had separate meetings with manufacturers and distributors of equipment and burner systems. In addition, staff met individually with and visited local businesses to observe operations and equipment affected by Rule 1147. Staff committed to continued discussion with industry through the Rule 1147 Task Force and meetings with individual businesses on issues affecting small business including availability of low NOx burners for unique applications and specific processes.

The majority of the comments made at the Public Workshop and Task Force meetings for the 2011 amendment supported the proposed delay of compliance dates and limits on the use of meters. However, some consultants commented that the compliance delay was not needed and the AQMD should have made a greater effort to educate businesses affected by Rule 1147. An enhanced outreach program to the regulated community was a high priority for the AQMD.

The comments on the proposed amendments received at the workshop and meetings for the 2011 amendment typically fit into two categories. One set of comments dealt with implementation of the rule and asked for clarification or simplification of rule requirements. In response, staff proposed a number of changes relating to equipment identification, maintenance, recordkeeping, and source testing requirements, which ultimately will result in cost savings compared to the original rule. In addition, the amendment added a mitigation fee option that allows business with equipment emissions greater than one pound per day to delay compliance by three years but will provide emission reductions from other sources during that three year period. Together with AQMD efforts to streamline the permit modification process, the amendment helped businesses comply with rule requirements.

The second category of comments received addressed issues beyond the scope of the 2011 amendment which was crafted to respond to the compliance challenges existing at the time. These comments included proposals for new alternative industry-specific rules, questioning availability of low NOx replacement burners, requests for exemption from the rule for small sources, requests to reevaluate rule cost and cost effectiveness and a request to require a cost effectiveness analysis for every piece of equipment subject to the rule. To address many of these issues and as previously stated, the rule amendment committed the SCAQMD to conduct a technology assessment for smaller sources with emissions of one pound per day or less no later than 18 months prior to the first effective compliance date for these smaller sources (July 1, 2017).

AFFECTED INDUSTRIES AND EQUIPMENT

A wide variety of processes use equipment that is regulated by Rule 1147. These processes include, but are not limited to, food products preparation, printing, textile processing, product coating; and material processing. A large fraction of the equipment subject to Rule 1147 heats air that is then directed to a process chamber and transfers heat to process materials. Other processes heat materials directly such kilns, process tanks and metallurgical furnaces.

Rule 1147 affects manufacturers (NAICS 31-33), distributors and wholesalers (NAICS 42) of combustion equipment, as well as owners and operators of ovens, dryers, furnaces, and other equipment in the District (NAICS 21, 23, 31-33, 42, 44, 45, 48, 49, 51-56, 61, 62, 71, 72, 81, and 92). The units affected by the rule are used in industrial, commercial and institutional settings for a wide variety of processes. Some examples of the processes regulated by the rule include metal casting and forging, coating and curing operations, asphalt manufacturing, baking and printing.

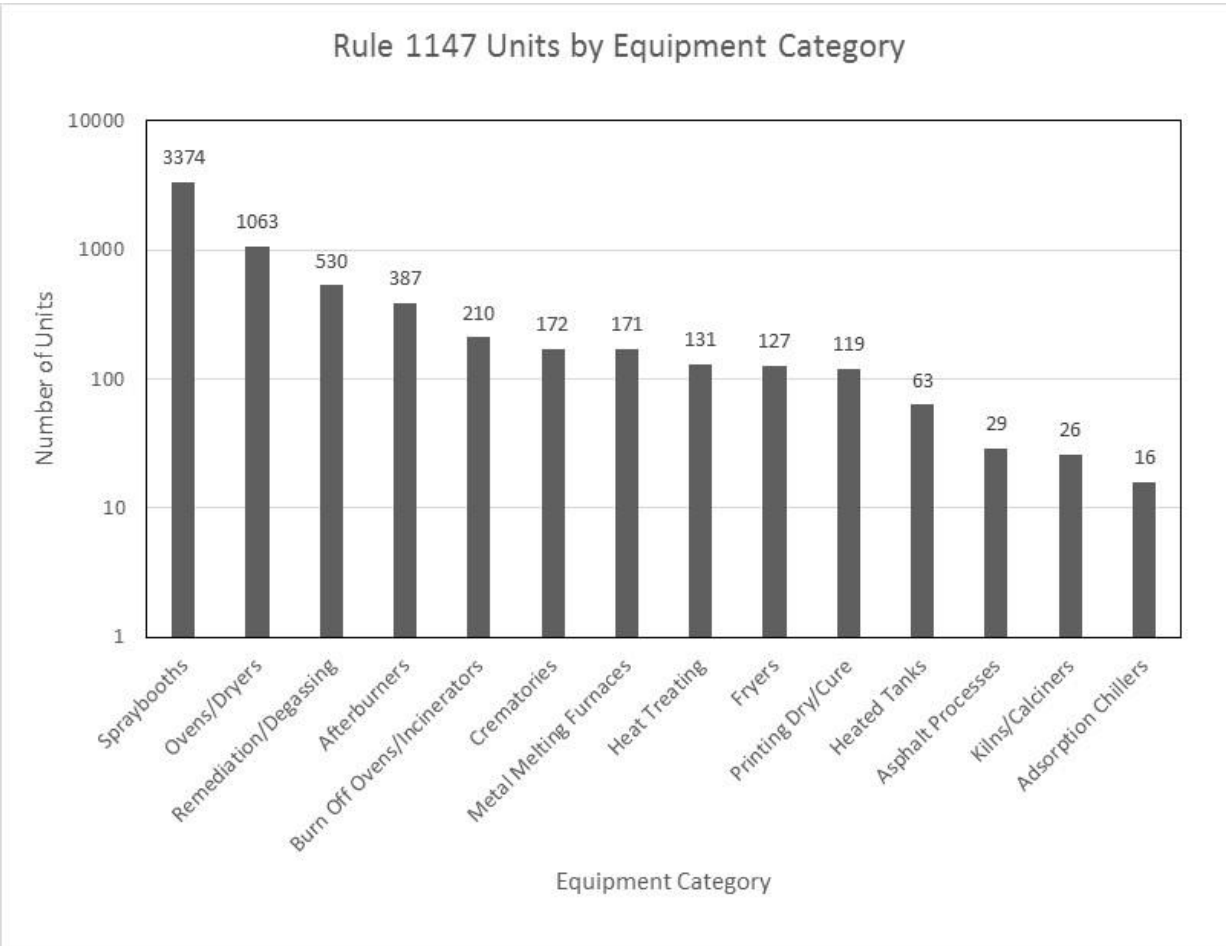
Staff originally estimated approximately 6,600 units subject to the emission limits of Rule 1147 are located at approximately 3,000 facilities. Staff estimated that about 1,600 units at about 800 facilities affected meet the NOx emission limits of Rule1147. This leaves about 2,200 facilities that are expected to require retrofit of burners in their equipment. Staff estimated as many as 2,500 permitted units with NOx emission limits greater than one pound per day and an additional 2,500 permitted units with NOx emission limits of less than one pound per day will require modification to comply with the emission limits.

Based on an update of the active permitted equipment in the SCAQMD, an estimate of the number of equipment potentially subject to Rule 1147 and the fraction of units in different categories is presented in Figure 1-1. Staff estimates that as many as 6,400 pieces of equipment are potentially subject to Rule 1147 requirements. More than half of the units (≈ 3,400) are spray booths and prep-stations. Excluding spray booths and prep-stations, staff estimates that at least one quarter of the units in each category will meet Rule 1147 emission limits without retrofitting burners.

The second largest category of equipment is ovens and dryers with approximately 1,100 units subject to the rule. Staff estimates that at least one-third of the permitted ovens will meet Rule 1147 emission limits based on a sample of the burners used in the ovens. There are also approximately 500 additional ovens and dryers with SCAQMD permits that are not subject to Rule 1147 because they are heated electrically, with infrared lamps, or using a boiler or thermal fluid heater. Electric, infrared lamp, and boiler and thermal fluid heated ovens and dryers are not included in the Figure 1-1.

The third largest group of equipment is air pollution control units that capture and incinerate VOCs, CO, PM and toxics. There are approximately 900 afterburners, degassing units and remediation units. The remaining categories of equipment have significantly fewer units with high temperature processes (metal melting, heat treating, burn off ovens, kilns and crematories) being the next largest group with approximately 700 units in these five categories. Although these categories have fewer equipment, many units have significantly higher emissions than spray booths and small ovens. Appendix A provides a more detailed summary of the industries and equipment categories affected by Rule 1147.

Figure 1-1



Based on permitted emissions and information provided by manufacturers, vendors and businesses, staff has calculated an emissions inventory of 3.0 to 5.2 tons of NOx per day from the equipment regulated by Rule 1147. Spray booths (≈ 3,400 units) contribute about 0.5 to 0.6 tons per day. Other types of equipment with permit limits of one pound per day or less (≈ 1,500 units) have NOx emissions totaling about 0.4 tons per day. Equipment with a potential to emit of more than one pound per day (≈ 1,500 units) contribute NOx emissions of 2.1 to 4.2 tons per day. These emission estimates are consistent with the 6.2 tons per day emission estimate developed from the 2007 AQMP for adoption of Rule 1147 in 2008.

Note that the AQMP inventory was based on fuel use and default emission factors. The 2007 AQMP inventory did not take into account lower emissions from units that met

BACT emission limits. Using the midpoint of the estimated range from the above calculation for larger sources gives a total inventory estimate for all equipment of about 4.1 tons of NOx per day. This estimate is consistent with the AQMP inventory and permit information that at least one quarter of the units have burners that can comply with BACT and Rule 1147 emission limits.

In addition, staff estimates that as many as half of the units (750 out of 1,500) with a potential to emit greater than one pound per day may have actual daily NOx emissions less than a pound per day. If this estimate is correct, then more than half of units with emissions greater than one pound per day of NOx (about 375) have already submitted test protocols and test results. Moreover, because of the Rule 1147 compliance schedule, most of the remaining half of the 750 units with actual emission greater than one pound per day have been permitted since the late 1990s and installed burners that comply with BACT and Rule 1147 NOx emission limits.

TECHNOLOGY ASSESSMENT

SOURCES OF INFORMATION

This report includes information from the technology assessments for Rule 1147 adoption in 2008, the rule amendment in 2011 and new information from the Rule 1147 emission testing program. This information is summarized by equipment category and by rule emission limit. The basis for the technology based emission limits in the rule are in Part D of the SCAQMD BACT Guidelines. In addition, testing performed to demonstrate compliance with SCAQMD permit limits indicated when an emission limit was achieved in practice and was used in the technology assessments for rule adoption and amendment. While the focus of this report is on equipment with NOx emissions of 1 pound per day or less, the report also includes information and analysis applicable to larger units. This information is provided in order to address stakeholder's concerns regarding the availability of technology for larger equipment.

The appendices to this report provide detailed information on affected industries, emission testing, cost effectiveness calculations, available technology and emission test results for these equipment categories. Appendix A provides a detailed summary of the equipment categories and businesses affected by Rule 1147. Appendix B of this report includes a summary of the sources of information used for rule adoption and the subsequent 2011 amendment. Appendix C provides a discussion of the SCAQMD emission test program, testing guidelines and a summary of the Rule 1147 emissions test completed. Appendices E through N provide details on the equipment, burners and emission test results for the different categories of equipment subject to Rule 1147.

In addition to information available from SCAQMD programs, this report includes recommendations from equipment and burner manufactures, affected businesses, consulting engineers and industry and business representatives. Staff conducted outreach to equipment manufacturers and product installers. Staff went into the field to identify equipment that will comply with Rule 1147 emission limits with available burners and those that may not. Rule development staff has worked with industry representatives and other staff to develop solutions to compliance challenges. These discussions resulted in a number of proposals to staff that are included in this report.

RESULTS OF THE RULE 1147 EMISSION TESTING PROGRAM

Emission testing is performed to demonstrate compliance with an emission limit. Testing companies do enough calibration, testing and calculation to prove that pollutant concentration or mass emissions are below the applicable limit. Most Rule 1147 emission test results are adjusted by the testing company or SCAQMD staff to address issues with a test's acceptable range or with other testing and calculation issues. While emission tests can demonstrate compliance with an emission limit, many test results cannot be used to accurately estimate concentrations or mass emissions from individual units and categories of equipment. However, the Rule 1147 testing program does demonstrate that burners and their control system comply with the rule emission limits.

Table 2-1 provides a summary of submitted Rule 1147 NOx emission test results that have completed SCAQMD staff review and demonstrated compliance with Rule 1147 emission limits. These test results indicate that equipment subject to Rule 1147 comply with the NOx emission limits. Table 2-1 shows the number of test results and average NOx emission concentrations for units tested at the highest and at a low firing rate if applicable. In most cases the highest firing rated tested is the normal operating condition. However, in a small number of cases the low firing rate is the normal condition. The table also indicates the applicable NOx emission limit for each category of equipment. Table 2-1 does not include results from tests that were subsequently repeated because the original test did not comply with the test method, test protocol or SCAQMD guidelines.

Table 2-1

Rule 1147 Emission Test Results

Equipment Category	Rule 1147 NOx Limit (ppm [1])	Number of Units Tested at Normal/High Fire	Average NOx Concentration at Normal/High Fire (ppm)	Number of Units Tested at Low Fire	Average NOx Concentration at Low Fire (ppm)
Afterburner/ Regenerative Thermal Oxidizer	30 or 60 [2]	13	26	4	13
Afterburner/ Thermal or Catalytic Oxidizer	30 or 60 [2]	9	40	1	41
Afterburner/ Remediation Unit	60	2	23	1	24
Spray Booth (Automobile)	30	10	24		
Spray Booth (Other)	30	13	18	2	22
Crematory	60	20	50		
Dryer/Asphalt	40	1	35		
Fryer	60	7	29		
Fuel Cell Heater	30 or 60 [2]	1	11	1	9
Heated Tank	60	7	37	1	34
Metallizing Spray	30 or 60 [2]	1	22		
Metal Heat Treat	60	23	48		
Metal Melting (Large)	60	8	42	1	58
Metal Melting Pot/Crucible	60	5	54		
Multi-chamber Burn Off Oven or Furnace	30/60 or 60/60 [3]	11	42 [4]		
Multi-chamber Incinerator	30/60 or 60/60 [3]	1	54 [4]		
Oven/Dryer	30 or 60 [2]	112	20	35	21
Print Dryer/Oven	30	19	20	4	23
Textile Shrink Dryer	30	2	24		
Textile Tenter Dryer	30	4	23	4	26
Unit Heater	30 or 60 [2]	3	20	1	13
Number of Units		272		55	

[1] The Rule 1147 NOx limit is based on a reference level of 3% oxygen (O_2) in the exhaust. All emission test results are converted to a concentration in parts per million at the reference level of 3% O_2.
[2] The emission limit depends upon the process temperature.
[3] The emission limit for the primary chamber varies depending upon process temperature.
[4] Average NOx emissions measured after the secondary chamber (afterburner).

BURNER AVAILABILITY AND FEASIBILITY TO RETROFIT UNITS

While the Rule 1147 emissions testing program indicates that the rule limits are achievable for all categories of equipment with current available technology, there is one situation where low NOx burners are not available. There is also one type of process for which staff recommends changing an emission limit based on the type of burners used in that process. In addition, there are several related categories of equipment where it is not feasible to retrofit an existing unit.

Burners for Small Ovens and Dryers

Low NOx burners are not available for very small low temperature ovens or dryers. The smallest burners produced are between 0.4 and 0.5 mmBtu per hour. If an oven requires a burner to consistently operate below about 0.3 mmBtu per hour, low NOx burners are not available to meet the 30 ppm NOx emission limit. There are smaller low NOx burners for high temperature applications that must meet an emission limit of 60 ppm. However, these applications typically require multiple burners and the total heat input exceeds 0.4 mmBtu per hour. Based on these findings, staff is considering exempting units with heat inputs less than 325,000 Btu per hour from the rule emission limit.

Emission Limit for Burn off Ovens and Furnaces

The second category of equipment that may have difficulty meeting an emission limit of 30 ppm in low temperature applications is burn off ovens, furnaces and incinerators. Burn off ovens and furnaces melt and incinerate coatings and other materials on a product that is being recycled. This occurs in a chamber where the process temperature may be above or below 800 °F. For processes below 800 °F the NOx emission limit is 30 ppm. The incinerated materials go to a second chamber or incinerator that operates above 800 °F and has a NOx emission limit of 60 ppm.

However, the preferred type of burner for the primary incineration chamber is the same type of burner used in high temperature applications such as afterburners. These are also the same types of burners used in kilns, direct fired furnaces and crematories. These burners have been designed to comply with emission limits in the 50 to 60 ppm range. After discussions of this issue with equipment and burner manufacturers, staff is considering changing the emission limit for the primary chamber of burn off ovens, furnaces and incinerators to 60 ppm.

Heated Process Tanks, Evaporators and Parts Washers

The Rule 1147 testing program has identified three types of heating systems used in process tanks, evaporators and some parts washers that comply with the NOx emission limit. There is no information yet available for the fourth type of heating system. For all four of these systems, the burners and heat exchangers or tubes are designed as one integrated system. If an individual heated tank or evaporator system using any of systems does not comply with the emission limit, then the whole tank will have to be replaced. Exempting existing in-use units from complying the rule emission limit unless the combustion system is modified would address the issue that it is not feasible to retrofit an existing heated tank with different burners. If a tank is retrofitted with new burners, the owner will likely replace the heating tubes or heat exchanger. If the owner rebuilds a process tank, then a rule compliant system can be installed at that time.

COST AND COST EFFECTIVENESS

REVIEW OF SCAQMD COST EFFECTIVENESS ANALYSIS

There is no single cost or cost effectiveness limit established by the SCAQMD Board for use in rule development, permitting or other programs. Cost effectiveness for CARB and SCAQMD rules and programs differ and depend upon the program, the pollutant, the nature of the process and equipment affected and the types of feasible emission control options. For example, in 1993 a $15,000 per ton criteria for RECLAIM Trading Credits was adopted by the Board for the SCAQMD emission trading program to trigger additional evaluation and potential rule amendment. Adjusted to 2015 dollars using the Marshall & Swift Equipment Cost Index, that criteria would now be approximately $25,000 per ton. However, for amendment of the SOx RECLAIM program in 2010, the SCAQMD Board approved an amendment with cost effectiveness up to $60,000 per ton (adjusted to 2015 dollars).

For Rule 1147 adoption, staff estimated average cost effectiveness for replacement of different sizes of burners. Most of the burners evaluated for adoption of Rule 1147 were too large and not used by equipment subject to the rule. Those burners are only used by large equipment subject to the RECLAIM program. Most of the equipment subject to Rule 1147 requirements have heat inputs less than 4 million Btu per hour and burners used in Rule 1147 equipment are less than 2 million Btu per hour. The most common burner size in Rule 1147 equipment is 1 million Btu per hour. In the 2008 staff report, the average cost effectiveness for replacing the smallest burners with the lowest potential NOx emission reductions was about $22,400 per ton (adjusted to 2015 dollars).

For new source review under SCAQMD Regulation XIII, cost effectiveness can be included in the determination of what is best available control technology (BACT) for emission control for non-major sources. For BACT decisions affecting new sources at major facilities, cost or cost effectiveness is not included in the evaluation. However, BACT determinations for non-major (minor) sources are established by two approaches. One path evaluates technology and cost effectiveness as part of a public process to establish minor source BACT. The public process includes workshops and stakeholder input. The cost effectiveness for those decisions varies depending upon the pollutant, process and equipment involved. Note that there is one important difference in the calculation of cost effectiveness between traditional BACT analysis and rule development. For rule development, a best estimate of equipment's useful life is used in the calculation of cost effectiveness instead of a fixed 10 year assumption that is associated with financing of new equipment.

Historically, the second path used to establish minor source BACT was demonstration by a permitted unit at a non-major facility that an emission limit was "achieved in practice." If an emission limit was achieved in practice at a non-major facility, that emission limit became minor source BACT and was required by SCAQMD for applications for subsequent SCAQMD permits for similar new units regardless of the cost and cost effectiveness.

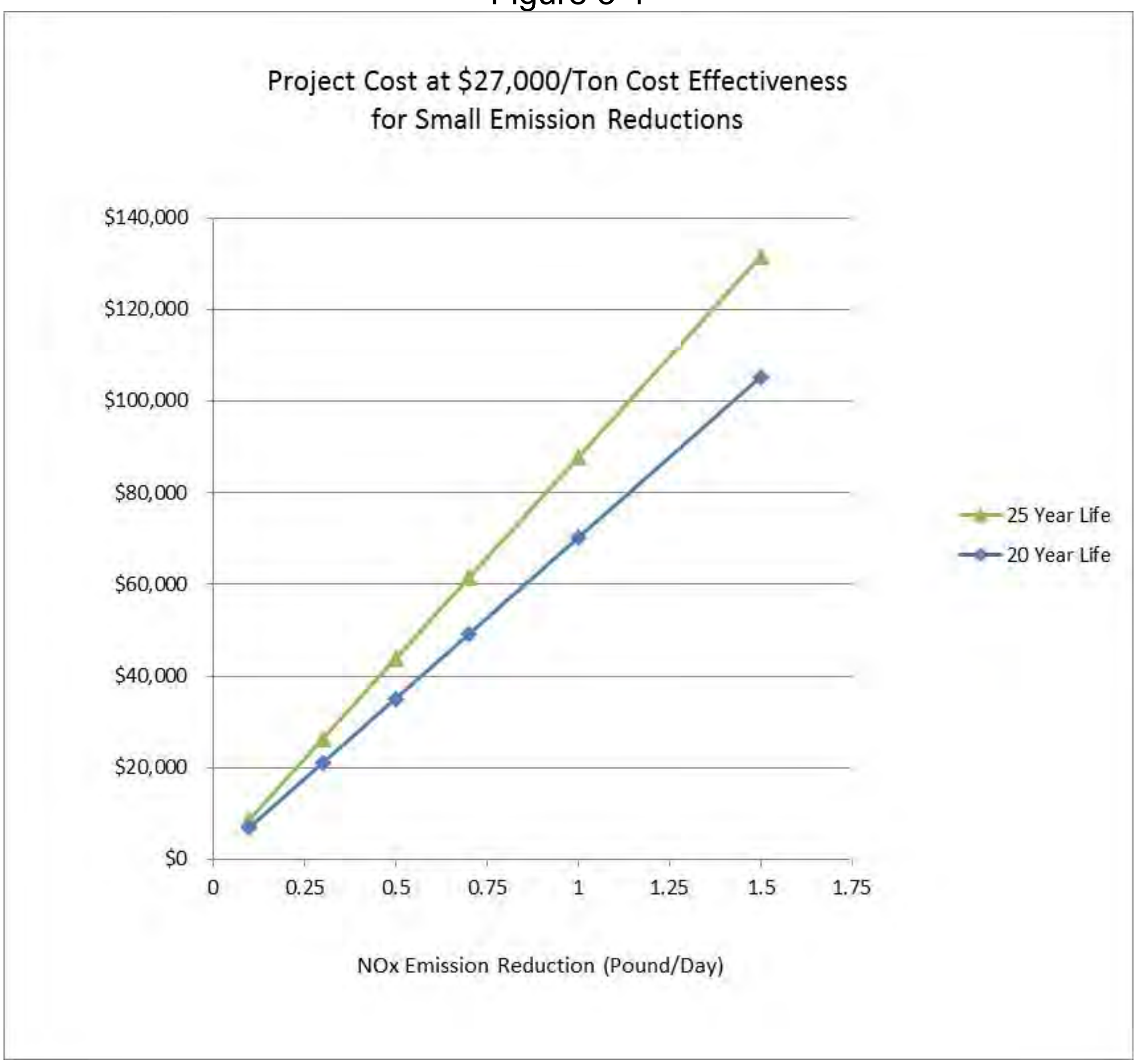
The SCAQMD has also established maximum cost effectiveness criteria in the SCAQMD BACT guidelines for sources for which there is no defined minor source BACT (Appendix

D). These cost effectiveness criteria is adjusted every calendar quarter by the Marshall & Swift Equipment Cost Index to account for changes in equipment cost. The cost effectiveness criteria for processes that do not have an established BACT is currently about $27,000 per ton of NOx for average cost effectiveness and about $81,000 per ton of NOx for the incremental cost effectiveness between two or more control options. The incremental cost effectiveness for Rule 1147 equipment is the difference in cost and emissions between an old natural gas burner (BACT prior to 1998) and a low NOx gas burner meeting rule emission limits. These minor source BACT criteria are appropriate for the analysis of cost effectiveness for small equipment with emissions of one pound per day or less.

SCAQMD BACT COST EFFECTIVENESS CRITERIA

The cost to retrofit equipment and the NOx emission reductions for the project can be illustrated for different cost effectiveness criteria with a graph. Figure 3-1 shows an example using small emission reductions of approximately a pound per day and project cost that results in a cost effectiveness of $27,000/ton of NOx reduced. The cost is shown for projects with equipment lifetimes of 20 and 25 years.

Figure 3-1



For emission reductions of 0.25, 0.5 and 1 pound per day, project costs of $20,000, $40,000 and $80,000 have cost effectiveness of $27,000 per ton. Emission reductions of 0.25 to 1 pound per day bound the range of emission reductions achievable from small and low emission equipment that are the subject of this technology assessment. This equipment has NOx emissions of one pound per day or less, are exempt from the BACT requirement under new source review and have more time to comply with Rule 1147 emission limits.

DISCOUNTED CASH FLOW ANALYSIS

For calculating cost and cost effectiveness, SCAQMD BACT guidelines (Appendix D) and rule development use a discounted cash flow (DCF) analysis to estimate the cost and cost effectiveness of emission control options. The DCF method is used to calculate a net present value (NPV) of current and future expenses and savings (cash flows) from installing emission control equipment. When determining the cost and cost effectiveness of a control option, the current costs associated with the purchase and installation of equipment are added to the net current value of future costs and savings associated with operating the new equipment. In a situation where one emission control system is replacing another, the future cost and savings incorporated into the analysis are those above and beyond the cost of maintaining and operating the current equipment.

To calculate the cost effectiveness of an emission control system, the purchase, installation and operating cost of new equipment (the NPV) is divided by the emission reduction benefit of the new equipment over the operating life of the equipment. The operating life of equipment can vary from about 10 years for a residential tank type water heater to 25 or more years for residential heating furnaces, boilers, ovens, furnaces, kilns and afterburners. There is a significant number of permitted equipment including ovens, kilns, furnaces and afterburners systems operating in the SCAQMD that are 20 to 50 years old.

LEVELIZED CASH FLOW ANALYSIS

In response to recommendations from a SCAQMD sponsored review of its socioeconomic analysis conducted by Abt Associates and stakeholder comments, all current and future rule analyses will include both the DCF and levelized cast flow (LCF) estimates of costs and cost effectiveness. The cost-effectiveness values based on DCF and LCF methods are not directly comparable to each other: DCF discounts all future operation and maintenance costs to their present values whereas LCF amortizes the initial capital and installation costs over the equipment lifetime. This is why DCF values are always lower than LCF values for the exact same amount of estimated compliance cost.

EXCLUDED COSTS

Because the useful life of boilers, ovens and furnaces can be several decades, the cost of routine maintenance and equipment replacement unrelated to control equipment is not included in the cost effectiveness analysis of regulatory requirements to meet emission standards. For example, a boiler's heat exchange tubes may be replaced several times over the boiler's life. Burners and combustion control systems in boilers and other equipment must be maintained and are routinely repaired or replaced. In addition, heat treating furnaces have refractory and door seals replaced several times over the furnace's lifetime. Indirect fired heat treating furnaces also require replacement of heating tubes and may require replacement of heat shields and recirculation fans as the furnace ages. Furnace refractory, seals, tubes and heat shields may be replaced two to three times over a twenty year period. These routine maintenance and repair expenses are independent of the cost of upgrading equipment to meet emission standards.

Costs for demonstrating compliance with SCAQMD rules and regulations are excluded from cost effectiveness analyses for emission control equipment. SCAQMD BACT Guidelines, permit processing policy, and rule development process do not include the cost of demonstrating rule compliance such as source testing in the calculation of emission control equipment cost effectiveness. However, compliance demonstration costs including emissions testing, recordkeeping and other costs beyond what is recommended by equipment manufacturers are included in the socioeconomic assessment for rule adoptions.

Compliance demonstration costs are not included in a cost effectiveness analysis of new pollution control systems because all units regulated by a rule are subject to the same compliance costs. All units required to meet the Rule 1147 NOx emission limit must be tested and the owner/operator must keep maintenance and test records. A rule compliant unit that does not replace its heating system has the same compliance costs as a unit that does replace burners and other components. Moreover, costs due to compliance with other SCAQMD rules such as Regulation XIII (new source review), including BACT and emission offsets, should not be included in the calculation of cost effectiveness for emission control equipment installed to comply with Rule 1147 emission limits.

CALCULATION OF COST EFFECTIVNESS PER BURNER

The calculation of cost and cost effectiveness for Rule 1147 adoption and the 2011 amendment were done on a per burner basis. There are four reasons for this approach. First, combustion systems retrofit to comply with Rule 1147 emission limits use the same system components whether the unit has one or multiple burners. Burners, valves, and control systems will be the same for each burner. The system component that will differ is the combustion air blower (fan). Some units will use packaged burners with an integrated combustion air blower (fan) and others will use an external blower for one or multiple burners. Second, the cost per burner for a burner with its own integrated combustion air blower is higher than for a system with multiple burners and one blower. Third, most small or low emission units have only one burner and tend to use package burners with integrated combustion air blowers. Fourth, the emissions for the whole unit and per burner will be comparable whether one or multiple combustion air blowers are used. For these reasons, the cost effectiveness analysis in this document focuses on the cost and emission reduction per burner replaced utilizing the cost for a burner with an integrated blower.

COST AND COST EFFECTIVNESS OF REPLACING BURNER SYSTEMS

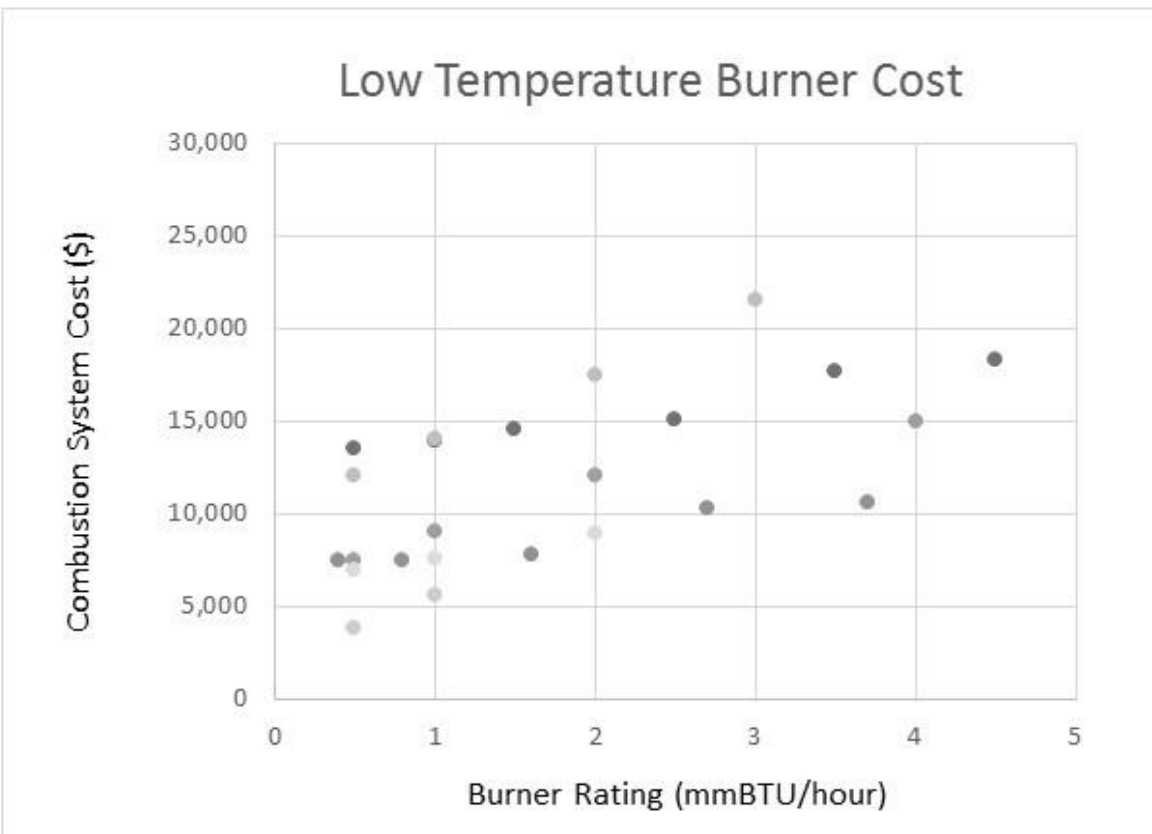
The cost of replacing burners and other combustion system components with the most commonly used low NOx burners is shown in Figures 3-2 and 3-3. Burner and combustion system replacement cost for low temperature applications that are required to comply with a 30 ppm NOx limit are displayed in Figure 3-2. Figure 3-3 shows replacement cost for high temperature applications that are required to meet a 60 ppm NOx limit. These figures include information for the most common burners from the three manufacturers that provide the majority of low NOx burners used in Rule 1147 equipment in the SCAQMD.

Burner Cost and Cost Effectiveness for Low Temperature Ovens and Dryers

Figure 3-2 summarizes information on low NOx burners and system components for low temperature operations including ovens and dryers. These costs represent a typical equipment cost to the customer and do not include tax, shipping and installation costs. The information provided is for nozzle mix burners with packaged combustion air blowers including the Eclipse Winnox and HaloFire, the Maxon Cyclomax and Ovenpak-LE and the MidCo low NOx burner.

Other types of systems can also be installed in ovens and dryers, but the cost of those alternatives are comparable to the cost of burner systems with packaged combustion air blowers. The cost for a burner with a separate combustion air blower is comparable to the cost of a packaged burner. Separate combustion air blowers are used for larger burners or where multiple burners with one blower providing combustion air to all reduces the cost of the system. Low NOx line burners are also available from Eclipse and Maxon but are more commonly used for larger systems than those that are the focus of this report. However, the cost for small line burners are comparable to the cost of the low NOx packaged burner systems shown in Figure 3-2.

Figure 3-2



Eclipse and Maxon each have two nozzle mix low NOx burner product lines for low temperature applications. Each has one system that was developed about 15 years ago (Cyclomax and Winnox) and a recently developed burner system (HaloFire and Ovenpak-LE). Maxon also has a third low NOx burner (the M-Pakt) that uses a different technology to lower NOx that is not included in this Figure but has been installed in a small number of units in the SCAQMD. The M-Pakt burner costs more than the burners included in Figure 3-2 but can achieve significantly lower NOx emissions (less than 10 ppm).

Because some replacements do not require the replacement of the fuel supply components and the control system while other retrofits require the replacement of all components, the Maxon Cyclomax and Eclipse Winnox cost in Figure 3-2 only include the cost of the burner with combustion air blower. The Eclipse HaloFire and the Maxon OvenPak-LE cost include the replacement of fuel and control systems. If a retrofit with a Winnox and Cyclomax burner requires replacement of other components including fuel and control systems, the total equipment replacement cost is comparable to the cost of purchasing a HaloFire or OvenPak-LE with all combustion system components. The MidCo low NOx burners are only sold with MidCo fuel and control system components and have two costs depending upon options requested. Replacement of a units fuel line and control system components depend upon the age of the original equipment and the replacement burner. If fuel line and control system components do not meet current building and safety codes, then they must be replaced with new components that comply with current code requirements.

The majority of the low emission equipment (1 pound/day NOx) subject to Rule 1147 have combustion systems rated less than 2 mmBtu/hour. Most use single burners rated less than 2 mmBtu/hour. The cost for installing a burner in the size range of 0.5 to 2 mmBtu/hour is a good estimate of the cost to replace combustion systems in typical low emission units. The cost of packaged burners and combustion systems of this size varies from about $5,000 to $15,000 with typical equipment costs ranging from $7,500 to $15,000.

However, to calculate total cost of replacing equipment, shipping, tax and installation costs must be added. One approach to estimate installed cost is an established EPA method that uses a multiplying factor to include sales tax and estimate shipping and installation cost. Based on the EPA method and the sales tax rate in southern California, the SCAQMD has used a factor or 1.87 times the cost of equipment to estimate installed cost. In this method, installation costs are assumed to be 50% of the equipment cost and are included in the factor. A contingency can also be included to address uncertainties in the cost estimation. For this analysis an additional 13% is added which results in an installed cost estimating factor of 2.0. Using this factor, an estimated cost for installing a low NOx burner in small ovens and dryers is approximately $30,000 [$15,000 X 2.0] but can be lower or higher depending upon the components replaced and other factors.

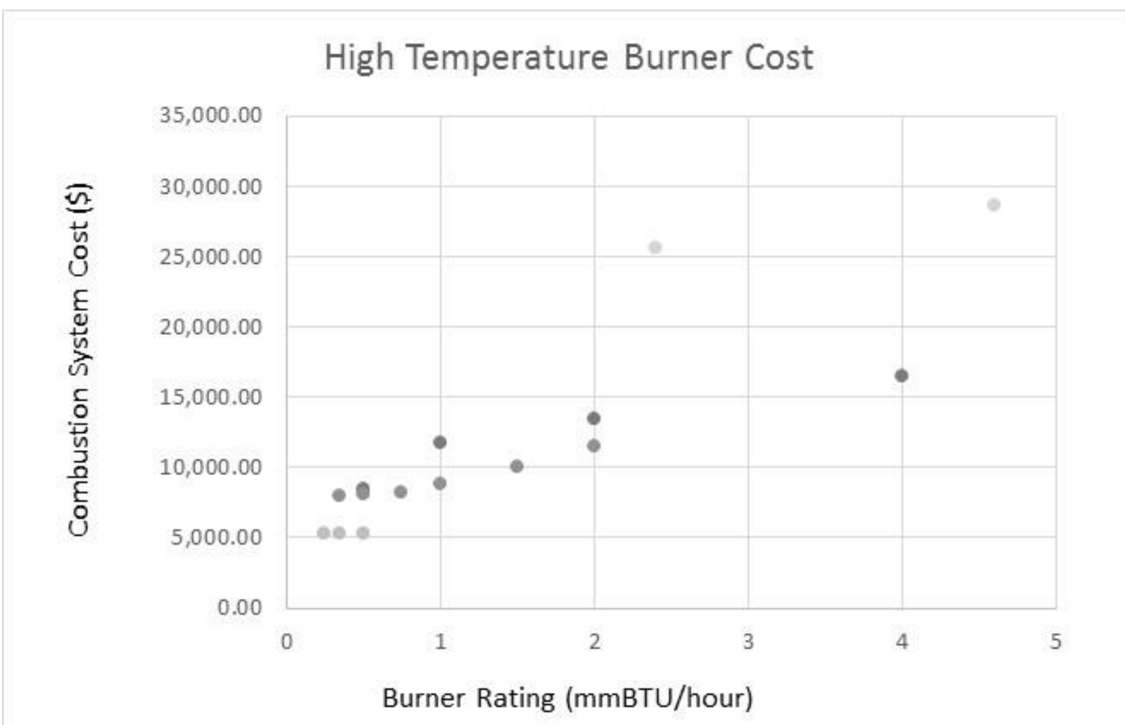
The cost effectiveness of replacing oven and dryer burners in this size range can be estimated using the NOx reductions possible from low emission units. Emission reductions of 0.25, 0.5 and 0.75 pounds per day over 260 days per year and 20 years result in a cost effectiveness of $46,154, $23,077, and $15,385 per ton for a project cost of $30,000. Since most reductions are likely in the range of 0.25 to 0.5 pounds per day, the range is best represented as $23,000 to $46,000 per ton of NOx reduced with the midpoint of this range at $34,500 per ton. This cost effectiveness to replace combustion systems for low emission ovens and dryers is greater than the SCAQMD BACT $27,000 per ton average criteria but less than the $81,000 per ton incremental criteria for minor source BACT.

In summary, the cost of replacement burners and combustion system components can vary depending upon which components must be replaced. Depending upon the age of the original installation, the burner or the entire combustion system may be replaced. In addition, installation cost can vary depending upon the particular piece of equipment and whether the equipment owner has requested additional work that is not required for compliance with Rule 1147 emission limits. Additional cost will be incurred when upgrading capacity and performing other equipment maintenance. Disregarding other costs the equipment owner may choose to include in a retrofit project, the cost effectiveness for low emission units to comply with the Rule 1147 emission limit may exceed the SCAQMD minor source BACT average criteria for NOx.

Burner Cost and Cost Effectiveness for High Temperature Applications

Figure 3-3 displays burner and combustion system costs for high temperature applications. These costs represent a typical equipment cost to the customer and do not include tax, shipping and installation costs. The three most common burners used in high temperature applications to comply with the Rule 1147 NOx emission limit of 60 ppm are the Maxon Kinedizer, the Eclipse Thermjet and Eclipse Tube Firing Burner (TFB). The Kinedizer and Thermjet are used in direct fired heating applications including metal melting, heat treating and in afterburners. The TFB is used for indirect heating applications such as heat treating. Burners from other major manufacturers including Bloom, Facultatieve, and North American/Fives have also been available for more than 15 years and were tested for Rule 1147 compliance. However, these systems were original installed burners and were not retrofits. Staff is not aware of any units that were retrofit with burners from these manufacturers in order to comply with Rule 1147.

Figure 3-3



Pot and crucible furnaces use small nozzle mix burners from a number of manufacturers. Figure 3-3 includes cost for different sizes of the Eclipse Ratio Air burner which has been installed in a small crucible furnace to comply with the Rule 1147 NOx emission limit. A Kinedizer burner has also been used to retrofit a small crucible furnace to increase capacity, reduce fuel cost and lower NOx emissions.

The cost per burner for high temperature applications is similar to the cost for low temperature applications. However, in larger metal melting and heat treating furnaces, multiple small burners are typically used to provide a more even distribution of heat in the furnace. In situations with multiple burners, the furnace is designed with one combustion air blower for all burners. However, the Eclipse Thermjet, the Ratio Air and the Maxon Kinedizer are also used in many applications requiring one burner. Consequently, the cost shown for the Thermjet, Ratio Air and Kinedizer in Figure 3-3 includes the cost of an individual combustion air blower, new fuel supply components and a new control system. In situations where multiple burners are installed with one combustion air blower and a common control panel, the cost per burner will be less. The cost for each TFB burner is based upon the cost for a system with six burners, new combustion air blower, fuel supply components and control system. The cost of the TFB burner also includes a flue gas recirculation (FGR) system for each burner that lowers NOx emissions. The FGR system is currently available for burners rated up to 0.5 mmBtu per hour.

For small high temperature applications up to 2 mmBtu per hour, the cost per burner is similar to the cost for low temperature applications and is in the range of $5,000 to $15,000. Using the EPA based multiplier factor of 2.0 to estimate installation cost for individual NOx burners in small high temperature equipment is approximately $10,000 to $30,000 but can be lower or higher depending upon the components replaced, number of burners and other factors.

Similar to the case of replacing burners in low temperature applications, the cost effectiveness of retrofitting smaller high temperature units with low NOx burners for emission reductions of 0.5 pounds per day or less may exceed the SCAQMD minor source BACT NOx average cost effectiveness criteria. For example, replacing burners at a cost of $10,000 to $30,000 per burner for an emission reduction of 0.5 pound per day per burner over 25 years gives a cost effectiveness range of $6,150 to $18,500. However, emissions are highly dependent on the size of unit and operating schedule. A reduction of 0.25 pounds per day per burner for the same cost gives a cost effectiveness range of $12,300 to $37,000 per ton. With this smaller emission reduction, the cost effectiveness may exceed the minor source BACT average cost effectiveness criteria of $27,000 per ton depending upon the cost of the burners and other components selected. For emission reductions less than 0.2 pound per day the cost effectiveness is likely to exceed the BACT average cost effectiveness criteria.

As with low temperature applications, the cost of replacing burners and combustion system components varies depending upon components replaced. Contingent upon the age of the original equipment, the burner or the entire combustion system may require replacement. Installation cost varies between equipment and locations. In addition, the equipment owner may request additional work that is not required for compliance with Rule 1147 emission limits which will increase the cost of the project.

Heating System Cost and Cost Effectiveness for Spray Booths

The cost difference to a customer between a new certified rule compliant heated spray booth and a new non-compliant unit is less than $10,000 based on information from manufacturers, vendors and the cost of booths prior to rule adoption. The cost for new units includes markups from the booth manufacturer applied to the cost of the burner, gas train and control system. Most of the specialty booths used for applications other than auto body repair were tested with standard burners, so there was no additional equipment cost to comply with Rule 1147 limits. However, the cost for adding a new natural gas fired certified heating system to an existing spray booth varies from $30,000 to $50,000 with a typical cost of about $40,000. The heating system cost varies depending upon the manufacturer, type of booth and the individual installation.

The cost of a complete new booth is highly variable depending upon the type of booth and options. According to vendor supplied information, the cost to purchase and install a new spray booth is about 20% higher than in 2008 when Rule 1147 was adopted. This increase is consistent with industry data on the cost to purchase and install new equipment (i.e., Marshall & Swift Equipment Cost Index which includes inflation, the cost of materials and manufacturing costs). The typical new installation is a semi down draft (side draft) booth for about $80,000. A new basic cross draft booth without recirculation is less and the cost of a new full down draft booth is about $115,000 and up depending upon options. Although the cost for semi down draft and down draft booths are higher than for a basic cross draft, the heating system costs are about the same for basic and premium booths from the same manufacturer or vendor.

The cost effectiveness of a new low NOx SCAQMD certified auto repair booth is at most $22,000 per ton [($10,000 at most) / (70% reduction in NOx) X (0.25 lb/day / 2000 lb/ton) X 260 days/year X 20 years)]. For higher volume shops, the cost effectiveness is lower than $22,000/ton.

The cost to retrofit a used booth to install in the SCAQMD as a new permitted unit is significantly less than purchasing a new booth. However, the cost effectiveness for retrofitting an existing permitted auto repair booth with an SCAQMD certified heating system is $88,000 per ton of NOx reduced based on a cost of $40,000 and a 20 year life. For a high volume booth used two shifts a day, the cost effectiveness could be less than half this value ($44,000/ton). For a booth retrofit costing $30,000 the cost effectiveness is $33,000 to $66,000 per ton depending upon the number of cars processed. This cost effectiveness of retrofitting an existing permitted booth is higher than the minor source average cost-effectiveness criteria of $27,000 per ton and may exceed the incremental cost effectiveness of $81,000 per ton used for equipment without a defined BACT.

Depending upon the age of a used booth, the owner may have to upgrade the booth to meet current building and safety codes. The local building and safety agency may require mechanical, electrical, fire safety and other components be upgraded or replaced. These costs are not attributable to Rule 1147 and are also not included in the cost effectiveness analysis for new, modified or relocated units that require a new SCAQMD permit.

The preceding analysis indicates the cost effectiveness for upgrading existing spray booths to comply with the Rule 1147 emission limit exceeds the minor source average cost-effectiveness criteria of $27,000 per ton used by SCAQMD for equipment categories without a defined BACT and in some cases may exceed the incremental criteria of $81,000 per ton. However, the cost effectiveness for new units is at most $22,000 per ton and is less than the BACT Guidelines criteria. Because the cost effectiveness to retrofit an existing permitted booth is significantly higher than the minor source BACT criteria, staff is considering amending Rule 1147 to delay compliance for existing in-use permitted booths and heating units until they are modified, relocated or replaced. Staff is proposing that new, modified, or relocated units requiring an SCAQMD permit continue to be required to comply with the Rule 1147 NOx limit at the time of modification or installation. Currently a change of ownership in a business with an existing in-use permitted booth is exempt from the retrofit requirement unless the booth or heating unit is modified, relocated, replaced or becomes 20 years old.

EXAMPLES OF CALCULATIONS FOR SMALL SOURCES

A number of equipment replacement scenarios have been submitted to SCAQMD staff as examples of high cost effectiveness for replacing burners in some small Rule 1147 equipment. This section reevaluates some of those scenarios presented to staff. In order to accurately reflect equipment operation and regulatory requirements, the following analyses use permit application information provided by the applicant, SCAQMD permit conditions and SCAQMD BACT guidelines.

Afterburner Controlling Smoke and Odors from Smokehouse

An after burner for a smokehouse has been in operation since the 1960s. The afterburner is rated at 250,000 Btu/hour, is 50 years old and uses pipe burners. NOx emissions are more than 101 ppm (0.136 pound/million Btu). According to the equipment permit and application, the smokehouse operates 12 hours per day for three days a week and 4 hours per day two days per week. This operating schedule was confirmed by the company owner when recently questioned by an SCAQMD inspector. A permit condition requires the afterburner to operate whenever the smokehouse is in use (40 to 44 hours per week). If the current afterburner operates an average of 40 hours per week every week, NOx emissions over 25 years are 0.88 tons (0.25 mmBtu/hour X [0.136 lb/mmBtu] X [40 hour] X [52 weeks/year] X [25 years] / [2000 lb/ton]). While this operating schedule includes some holidays, it ignores second shifts and weeks when the company operates on a Saturday.

Because of the age and design of this particular afterburner, the entire unit likely needs to be replaced in order to comply with the Rule 1147 NOx emission limit. The burners in the unit are pipe burners which are pipes with holes in them. A consultant working with the company estimated that a replacement rule compliant afterburner would cost about $30,000 (equipment and installation). Staff also contacted vendors to estimate the cost of a replacement afterburner for this application. Based on vendor information, a total project cost of $30,000 is typical for a new afterburner of this size. A new rule compliant afterburner with emissions of less than 60 ppm (0.72 lb/mmBtu) would reduce emissions by at least 0.42 tons over 25 years. The estimated cost effectiveness for this emission reduction is $30,000 divided by 0.42 tons or about $71,000/ton. For this afterburner and other types of equipment with very small burners, the cost of retrofitting or replacing the unit may be higher than the minor source BACT average cost effectiveness criteria for sources without a defined BACT.

The analysis of this case presented to staff showed a much higher cost effectiveness than $71,000/ton because it assumed the afterburner operates only one hour per day. However, this afterburner must be operated at all times the oven is operating and contains smoke. This requirement is common to all emission control equipment permitted in the SCAQMD. In fact, the operator of this particular unit was cited in the past by the SCAQMD for not operating the afterburner consistent with this permit requirement.

Small Heated Process Tank or Evaporator

Many small heated process tanks and evaporators have burners, heat exchangers, and tank dimensions that are specific to each manufacturer and product line. Replacement with different burners may require replacement of the entire tank if the heat exchange system cannot be replaced. The cost for replacing the smallest process tank and heat exchange system is at minimum $30,000 to $40,000. Burners purchased separately for a new tank rated less than one mmBtu/hour may cost as much as $5,000 to $10,000. The minimum cost for a new tank with burners is about $40,000.

Most small heated tanks and evaporators operate with burners that cycle between high fire and off. A typical small system has burners in the size range of 350,000 Btu per hour (0.35 mmBtu/hour) to one million Btu per hour. NOx emissions based on a burner rating of 0.7 mmBtu/hour, a 20 year life and a default emission factor of 0.136 lb/mmBtu for natural gas are about 0.43 pounds per day or 1.1 tons over 20 years [(0.7 mmBtu/hour) X (50%) X (0.136 lb/mmBtu) X (9 hours/day) X (5 days/week) X (52 weeks/year) X (20 years)/(2000 lb/ton)]. This operating schedule does not take into account holidays but it also does not include any weeks with second shifts or operation on Saturdays. A rule compliant system (60 ppm NOx or 0.72 lb/mmBtu) would reduce NOx emission by about 0.52 tons over a 20 year period. The cost effectiveness for replacing the whole system would be about $79,000 per ton ($40,000/ 0.52 tons). The cost to retrofit or replace this type of small low emission unit may be higher than the minor source BACT average cost effectiveness criteria for sources without a defined BACT.

Burners for Generating Smoke and Heating Smokehouse Oven

A smokehouse has been in operations since the 1960s. The burner in the smokehouse is rated 35,000 Btu/hour with NOx emissions of more than 101 ppm (0.136 pound/million Btu of natural gas). Since 1990, BACT for smokehouse smoke generators is an electric heating element instead of a gas fired burner. An electric heating element costs less than $100 including tax and shipping. Electric heating elements come in a variety of shapes and sizes. If the smokehouse burner is similar to round burners used in water heaters or ranges prior to 1983, the owner could also replace the old burner with a low NOx burner (15 ppm) used in modern water heaters for about $100. The cost to install a circuit for the electric heating element or retrofit the gas burner would be about $500 for a total cost of about $600.

The burner/heating element in the smokehouse is used to heat wood chips to slowly generate smoke. It is also used to heat the smokehouse and is assumed to operate an average of two hours per day for 5 days each week. The amount of time the burner fires is determined the amount of wood chips and by the required oven temperature. The oven temperature depends upon the type of sausage produced and whether the smoked products contain sodium nitrite. Products without nitrites must be smoked at a higher temperature to kill bacteria.

For this example, the NOx emissions over 20 years are 50 pounds (0.0250 tons). The cost effectiveness for replacing the burner with a heating element or low NOx burner is at most $24,000/ton of NOx reduced ($600/0.0250 ton). If the burner or heating element operates for more than two hours per day, the cost effectiveness is lower. This example highlights that some small equipment can be retrofit to comply with Rule 1147 emission limits for low cost and reasonable cost effectiveness. Note that on adoption of Rule 1153.1 at the November 2014 Board meeting, existing smokehouses were removed from Rule 1147, included in Rule 1153.1 and are not required to comply with the rule's emission limits.

RECOMENDATIONS

RULE CHANGES UNDER CONSIDERATION

The emission testing program for Rule 1147 indicates that most equipment regulated by the rule can comply with the NOx emission limit (i.e., Table 2-1). The appendices of this report discuss the emissions test results for each category of equipment which demonstrate compliance with rule emission limits. However, low NOx combustion systems are not available for some types of small units. In addition, some categories of equipment are difficult to retrofit. Based on technical feasibility, staff is considering the following changes to Rule 1147:

- Exempt new and existing in-use units with total rated heat input of less than 325,000 Btu/hour from the Rule 1147 NOx emission limit. There are no burners in this size range for ovens and dryers that are designed to meet BACT and Rule 1147 emission limits. The smallest low NOx air heating burners designed to comply with the 30 ppm NOx limit are 400,000 to 500,000 Btu/hour (0.4 to 0.5 mmBtu/hour). If this size burner is set up to operate at less than 325,000 Btu/hour and used in an oven that requires the burner to frequently operate at heat inputs of less than 30% of its capacity, then the burner is not likely to comply with the 30 ppm emission limit. While there are burners in this size range for high temperature equipment including heat treating furnaces and kilns, these units typically use multiple small burners (four or more), have total heat ratings much greater than 325,000 Btu/hour and must comply with a 60 ppm emission limit. This change would affect an unknown number of small units regulated by Rule 1147.
- Delay compliance with the NOx emission limit for in-use heated process tanks, evaporators and parts washers with an integrated heated tank until such time the combustion system or tank is modified. New units would be required to meet the emission limit unless the total unit heat rating is less than or equal to 325,000 Btu/hour. Source test information on three of the four available types of heating systems for these heated process tanks can comply with the emission limits. However, if a unit does not comply with the emission limit, the entire process tank must be replaced. Staff estimates this change would affect less than 50 units subject to the Rule 1147 NOx emission limit.
- Change the NOx emission limit from 30 ppm to 60 ppm NOx for the primary chamber of multi-chamber incinerators, burn-off ovens, burn-out furnaces and incinerators that operate below 800 °F. This new limit will be the same compliance limit required for higher temperatures. The burner needed for the primary chamber of these devices is not designed to achieve 30 ppm. This change would affect a small unknown number of units.

Based on cost effectiveness considerations, staff is considering the following changes to Rule 1147:

- Delay compliance with the NOx emission limit for most existing in-use spray booths until the booth or heating system is modified, relocated or replaced. Modified, relocated and new spray booths and prep stations would be required to meet the emission limit at the time of modification or installation unless the total unit heat rating is less than or equal to 325,000 Btu/hour. However, staff is considering to evaluate existing in-use operations with multiple booths and locations separately from smaller operations with one location and single booths and prep stations. The cost effectiveness for a new unit that meets the Rule 1147 NOx emission limit is at most $22,000 per ton. The cost effectiveness for retrofitting an existing unit can be as high as $88,000 per ton. This change will affect more than half of the units now subject to Rule 1147 emission limits. This will result in delays in emission reductions of 0.3 to 0.4 tons/day starting July 1, 2017. These emission reductions forgone will be reduced as new units replace old units.
- Delay compliance with the NOx emission limit for other existing in-use units with actual NOx emissions of one pound per day or less until the unit or combustion system is modified, relocated or replaced. In addition, if the unit's emissions exceed one pound per day of NOx at a later date, then the unit must comply with the NOx emission limit. Staff is considering to further evaluate operations with multiple small units whose emissions are significant. Unit emissions can be documented using gas or time meters and daily recordkeeping. The cost effectiveness for retrofitting low emission units varies considerably and can be significantly higher than the SCAQMD BACT Guidelines average cost effectiveness criteria for equipment for which BACT has not been defined. This change will affect at least one quarter of the in-use units subject to the Rule 1147 emission limit. This will result in delays of emission reductions of about 0.3 to 0.5 tons/day starting in July 1, 2017. These forgone reductions will decrease as new units replace old units.

These five changes to the rule would address infeasibility of retrofitting specific types of units and reduce cost by delaying compliance with the NOx concentration limit for units with low emissions. These changes would affect at least 4,900 permitted units of which two thirds are spray booths. In addition, up to half of the remaining 1,500 units subject to Rule 1147 may also have NOx emissions less than one pound per day which would result in compliance delays for 5,650 out of 6,400 units. These changes will result in a delay in emission reductions of 0.6 to 0.9 tons per day. However, these forgone emission reductions will be made up over 15 to 25 years as old units are replaced with new compliant units.

REFERENCES

REFERENCES

EPA, 2002. *EPA Air Pollution Control Cost Manual, Sixth Edition* [EPA-452-02-001], United Stated Environmental Protection Agency, February 2002

SCAQMD, 2011. *Rule 1147 – NOx Reductions from Miscellaneous Sources*, South Coast Air Quality Management District, September 2011.

SCAQMD, 2008. *Rule 1147 – NOx Reductions from Miscellaneous Sources*, South Coast Air Quality Management District, December 2008.

SCAQMD, 2000. *Best Available Control Technology Guidelines Part D: BACT Guidelines for Non-Major Polluting Facilities*, South Coast Air Quality Management District (October 2000, Revised October 3, 2008)

APPENDICES

Appendix A – Summary of Rule 1147 Equipment Categories

SUMMARY OF RULE 1147 EQUIPMENT CATEGORIES

Units regulated by Rule 1147 are used in commercial, industrial, government and institutional settings and by a variety of businesses. Rule 1147 affects manufacturers (NAICS 31-33), distributors and wholesalers (NAICS 42) of combustion equipment, as well as owners and operators of ovens, dryers, furnaces, and other equipment in the SCAQMD (NAICS 21, 23, 44, 45, 48, 49, 51-56, 61, 62, 71, 72, 81, and 92).

A wide variety of processes use equipment that is regulated by Rule 1147. These processes include, but are not limited to, coating; printing, textile processing, material processing, and manufacturing using wood, plastics, ceramic and metal materials. A large fraction of the equipment subject to Rule 1147 heat air that is then directed to an oven or dryer in order to dry or cure materials or coatings (convective heating). In addition, most paint booths and semi-enclosed prep-stations that are used to control overspray of coatings during application also have a heat source to accelerate curing and drying of coatings. Other types of equipment heat products directly using a combination of radiant and convective heating (e.g., radiant ovens, kilns, process tanks and furnaces). Some ovens, dryers, furnaces and kilns do not use burners to provide heat and consequently are not regulated by Rule 1147. They use electric heaters, electric infrared lamps, or heat provided by a boiler or thermal fluid heater. Boilers and thermal fluid heaters are regulated by SCAQMD Rules 1146, 1146.1 and 1146.2.

In 2008 SCAQMD staff originally estimated about 6,600 pieces of equipment located at approximately 3,000 facilities would be subject to the emission limits of Rule 1147. Staff also estimated that at least 1,600 units at about 800 facilities already met the NOx emission limits of Rule1147. The remaining 2,200 facilities were expected to require retrofit of at least one unit. Staff estimated up to 2,500 permitted units with NOx emission limits greater than one pound per day and an additional 2,500 permitted units with NOx emission limits of less than one pound per day might require modifications in order to comply with the emission limits.

Based on an update of the active permitted equipment in the SCAQMD, an estimate of the number of equipment potentially subject to Rule 1147 and the fraction of units in different categories is presented in Figures A-1, A-2 and A-3 below. Staff estimates that as many as 6,400 pieces of equipment are potentially subject to Rule 1147 requirements. More than half of the units (≈ 3,400) are spray booths and prep-stations. Excluding spray booths and prep-stations, staff estimates that at least one quarter of the units in each category will meet Rule 1147 emission limits without retrofitting burners.

The second largest category is ovens and dryers with approximately 1,100 units subject to the rule. Staff estimates that at least one-third of the permitted ovens will meet Rule 1147 emission limits based on a sample of the burners used in the ovens. There are also approximately 500 additional ovens and dryers with SCAQMD permits that are not subject to Rule 1147 because they are heated electrically, with infrared lamps, or using a boiler or thermal fluid heater. Electric, infrared lamp, and boiler and thermal fluid heated ovens and dryers are not included in the Figures A-1, A-2 and A-3.

The third largest group of equipment is air pollution control units that capture and incinerate VOCs, CO, PM and toxics. There are approximately 900 afterburners, degassing units and remediation units. The remaining categories of equipment have significantly fewer units with metallurgical processes (metal melting and heat treating) being the next largest group with approximately 300 units between the two categories. Although these categories have fewer equipment, many include equipment with significantly higher emissions.

Figure A-1

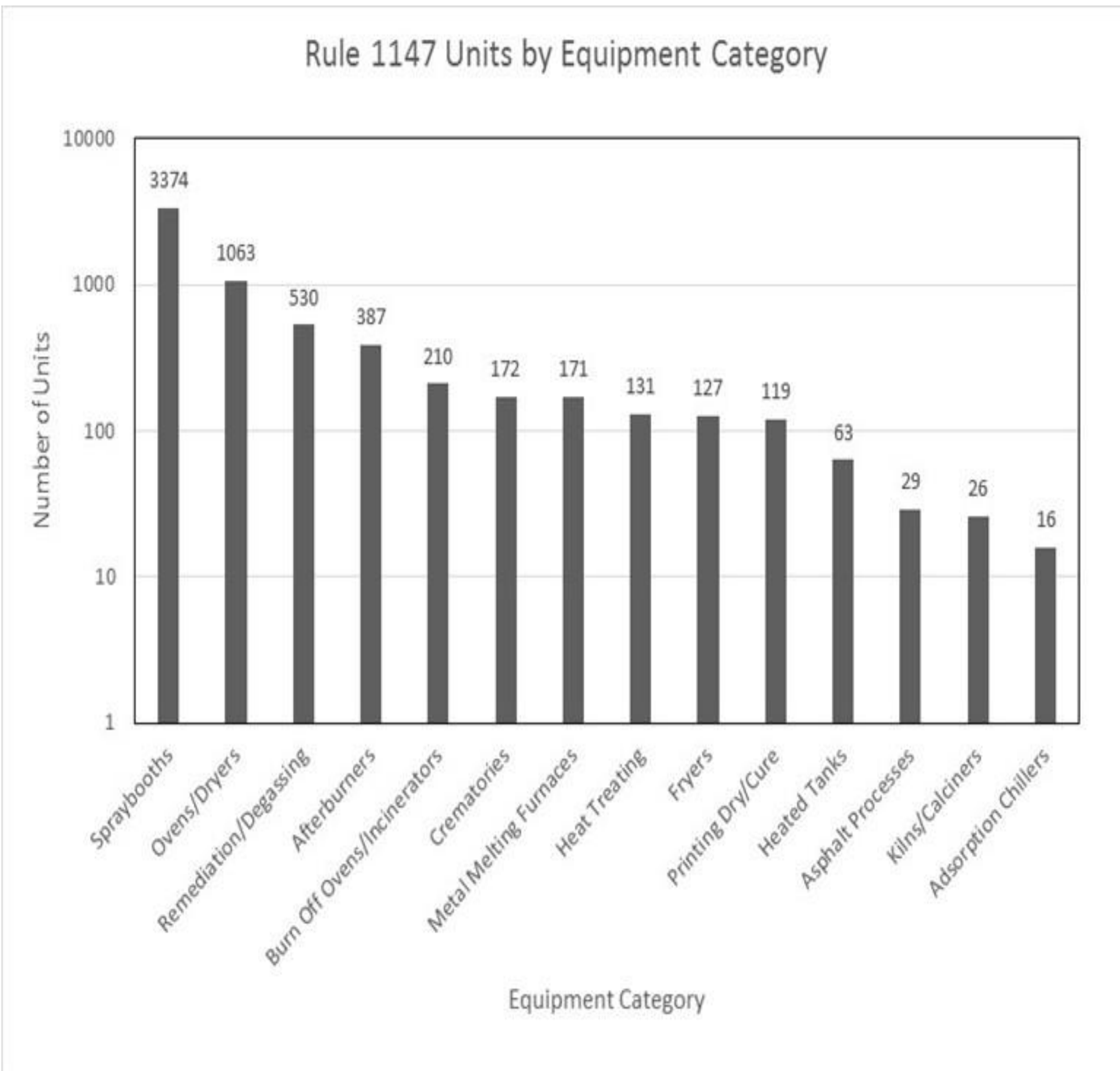


Figure A-2

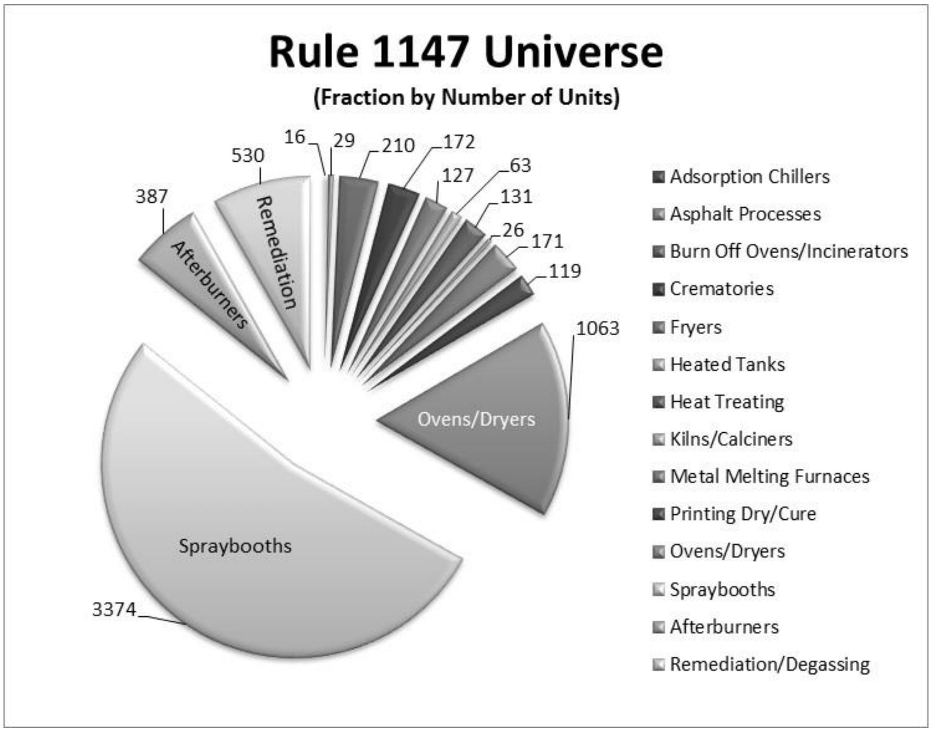
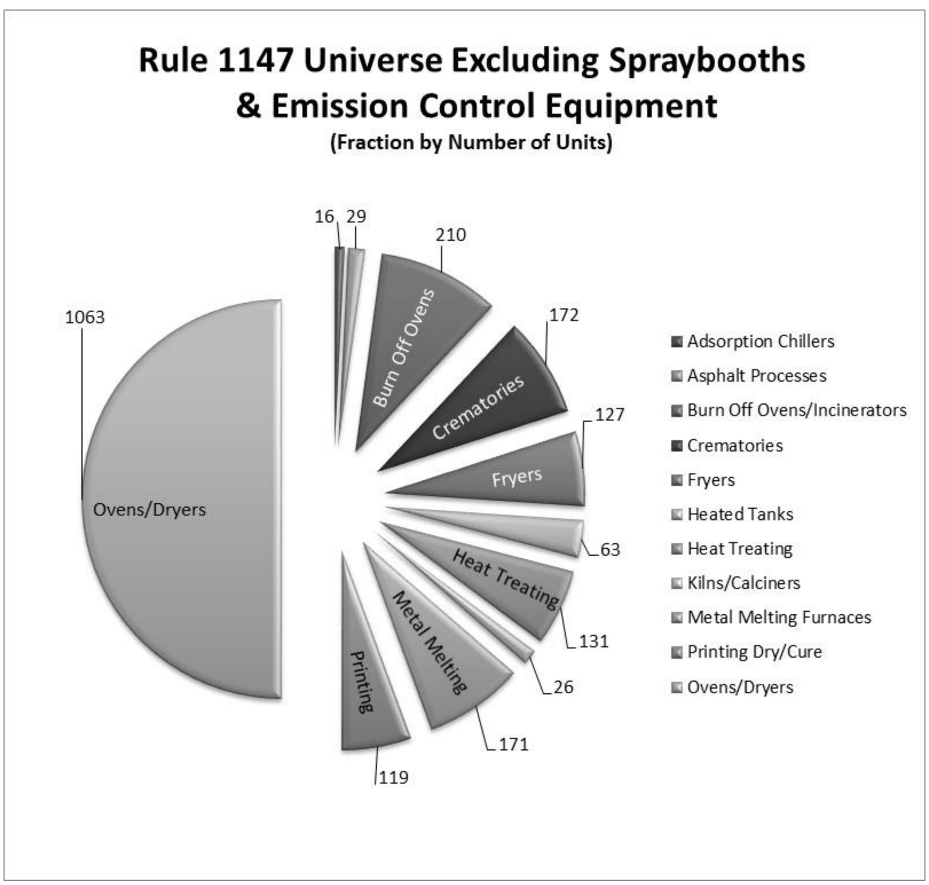


Figure A-3



The focus of this technology assessment is on smaller low emission equipment with emissions of one pound per day or less. An emission level of one pound per day is used to determine a unit's Rule 1147 compliance schedule. Units with emissions of one pound per day or less are provided up to 20 years from date of manufacture before they are required to demonstrate compliance with the NOx emission limit. Units with emissions greater than one pound per day must demonstrate compliance by the time a unit is 15 years old. New or relocated units must demonstrate compliance when they are installed. A potential to emit (PTE) of greater than one pound per day for new or relocated units also triggers the requirement to install best available control technology (BACT) under new source review (NSR) pursuant to SCAQMD Regulation XIII.

Staff has estimated the number of Rule 1147 units with NOx emissions greater than one pound per day based on a unit's PTE in the SCAQMD permit database. For spray booths and prep stations (semi-enclosed spray booths), approximately 5% (about 170) have NOx emissions greater than one pound per day. These higher emitting booths are either larger than the booths used for refinishing automobiles and light trucks or they are used in a production line at a manufacturing facility. For the remaining categories of equipment, approximately 50% have a PTE greater than one pound per day. This means approximately 1,700 units subject to Rule 1147 potentially have NOx emissions greater than one pound per day. The remaining 4,700 units have a PTE of one pound per day or less.

In previous analyses presented in rule staff reports and to the Rule 1147 Task Force, staff estimated that with the exception of spray booths at least 25% of the units in each category will comply with Rule 1147 limits without retrofitting burners. However, recent results from emissions testing of Rule 1147 units suggest that the compliance rate for units with their original burners and NOx emissions greater than one pound per day could be 50% or greater for some categories of equipment. In addition, some units with a PTE less than one pound per day have low emissions because the owner originally installed BACT compliant burners and reduced their PTE below one pound per day. New or modified sources are not required to purchase emission offsets if the average emission increase is a pound per day or less.

As an alternative to estimating emissions based on the inventory developed for the SCAQMD AQMP, total NOx emissions from equipment subject to Rule 1147 can be estimated using these units' PTE and other information. Business owners and equipment vendors indicate typical automotive booths and many other booth operations have annual average emissions of less than one third pound per day. However, up to 200 booths used in manufacturing and other applications may have emissions of a pound per day or more. Based on this information, the 3,400 permitted booths and spray stations have emissions of 0.5 to 0.6 tons NOx per day. The 1,500 other types of combustion equipment with PTE of less than or equal to a pound per day have average emissions of 0.5 pound per day per unit for a total of about 0.4 tons NOx per day. Based on this approach, the 4,700 Rule 1147 units with a PTE equal to or less than one pound per day emit about one ton of NOx per day.

The average PTE for the remaining 1,500 units is 5.6 pounds NOx per day using each units 30 day average PTE. The 30 day average PTE is calculated for a month using the weekly operating schedule but the monthly emissions are divided by 30 days instead of the number of days the equipment operates each month. Assuming these 1500 units emit at least half of their 30 day average PTE, the range for the emission estimate from the 1,500 greater than one pound per day units is from 2.1 to 4.2 tons of NOx per day. Using the range for the emission estimates calculated above provides an estimated total Rule inventory of 3.0 to 5.2 tons of NOx per day from the equipment regulated by Rule 1147. This emissions estimate is consistent with the 6.2 tons per day emission estimate developed from the 2007 AQMP for adoption of Rule 1147 in 2008.

It should be noted that the AQMP inventory was based on fuel use and default emission factors. The 2007 AQMP inventory did not take into account lower emissions from units with burners that can achieve BACT emission limits. Using the midpoint of the estimated range for larger sources gives a total inventory estimate of 4.1 tons of NOx per day for Rule 1147 equipment. This emission estimate is consistent with the AQMP inventory and permit information that at least one quarter of the units have burners that can comply with BACT and Rule 1147 emission limits.

In addition, staff estimates that as many as half of the units (750 out of 1,500) with a potential to emit greater than one pound per day may have actual daily NOx emissions less than a pound per day. If this estimate is correct, then half of the units with actual NOx emissions greater than one pound per day of NOx have already been tested (about 375) and comply with Rule 1147 emission limits. Moreover, because of the Rule 1147 compliance schedule, most of the remaining half of the 750 units are likely to have been permitted since 2000 and would have installed burners that will comply with BACT and Rule 1147 emission limits.

Appendix B – SCAQMD BACT and Test Results for Emission Limits Achieved in Practice and Used for Rule Development

SCAQMD BACT AND TEST RESULTS FOR EMISSION LIMITS ACHIEVED IN PRACTICE AND USED FOR RULE DEVELOPMENT

Rule 1147 was adopted on December 5, 2008 and amended September 9, 2011. Rule 1147 is based on two control measures from the 2007 Air Quality Management Plan (AQMP): NOx reductions from Non-RECLAIM Ovens, Dryers and Furnaces (CMB-01) and Facility Modernization (MSC-01). NOx emission from ovens, furnaces, kilns and afterburners had been proposed as control measure CMB-02 in the 1994 and 1997 AQMPs. Facility Modernization was a new AQMP measure that proposed equipment be upgraded to the best available control technology (BACT) available at the time the 2007 AQMP was adopted. The Facility Modernization measure is also proposed to be continued in the upcoming revision to the AQMP.

This appendix provides a summary of the NOx BACT determinations and SCAQMD permit limits achieved in practice by different types of units prior to rule adoption in 2008 and the 2011 rule amendment. The following figures were presented in rule development Task Force meetings and Rule 1147 Staff Reports for the 2008 adoption and the 2011 amendment. Figures B-1 to B-4 identify BACT determinations that were published by the SCAQMD and other air agencies prior to rule adoption. Figures B-5 and B-6 identify NOx emission limits that were achieved in practice through test results for equipment permitted prior to rule adoption. Figures B-7 and B-8 identify additional emission test results indicating NOx emission limits that were achieved in practice by permitted equipment tested in the SCAQMD prior to the 2011 rule amendment.

Figure B-1

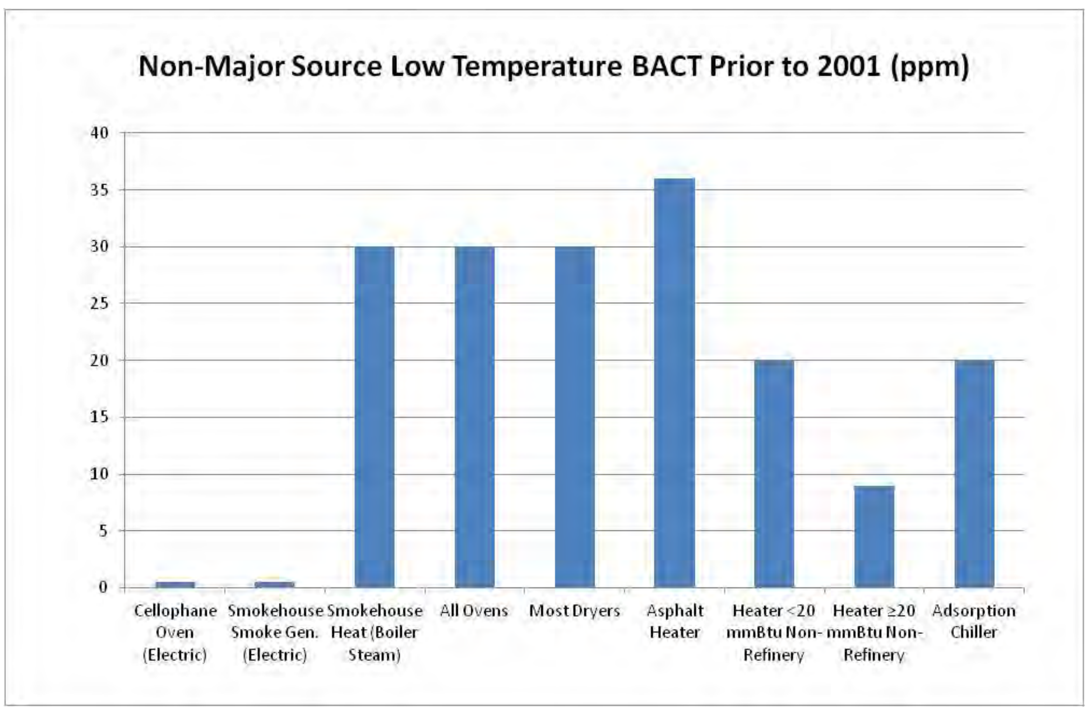


Figure B-2

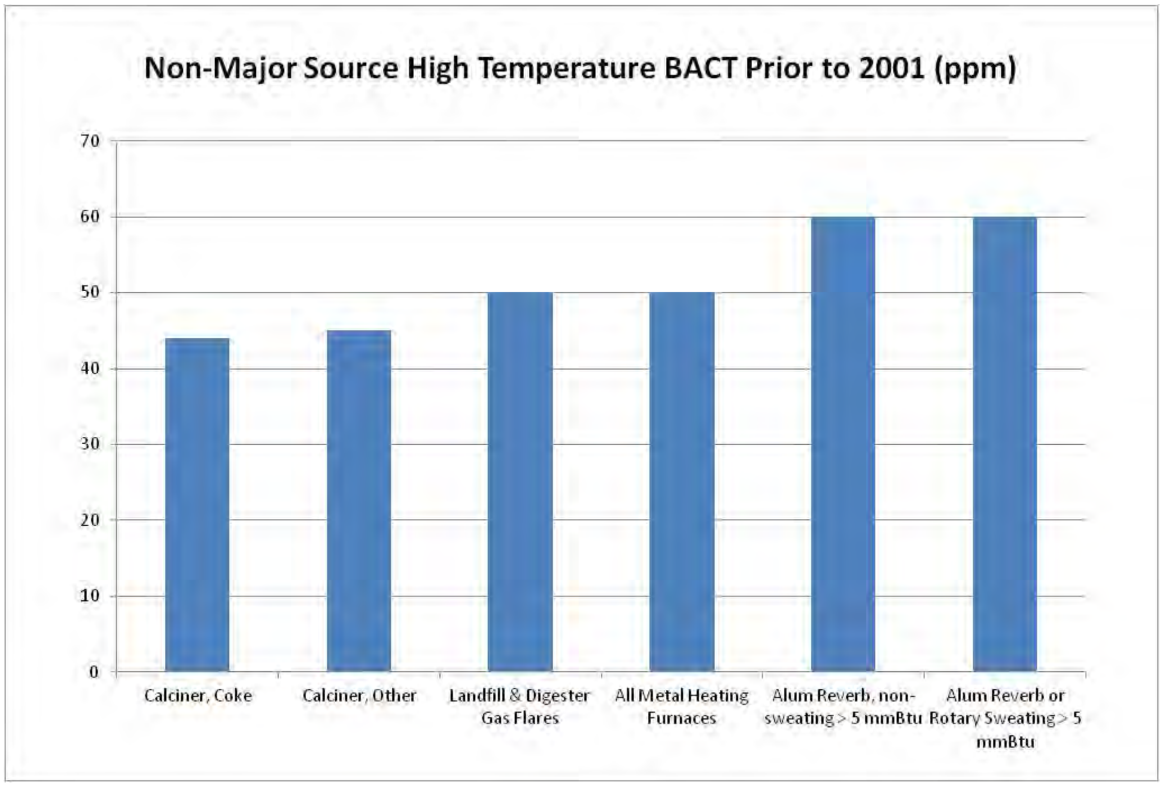


Figure B-3

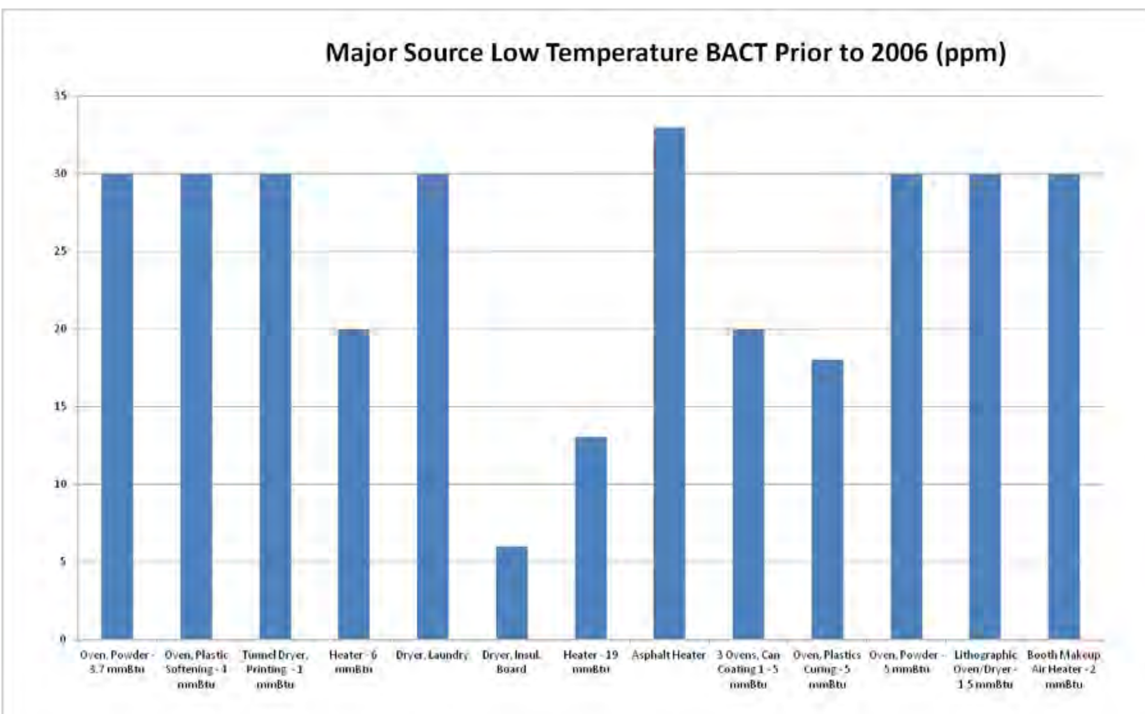


Figure B-4

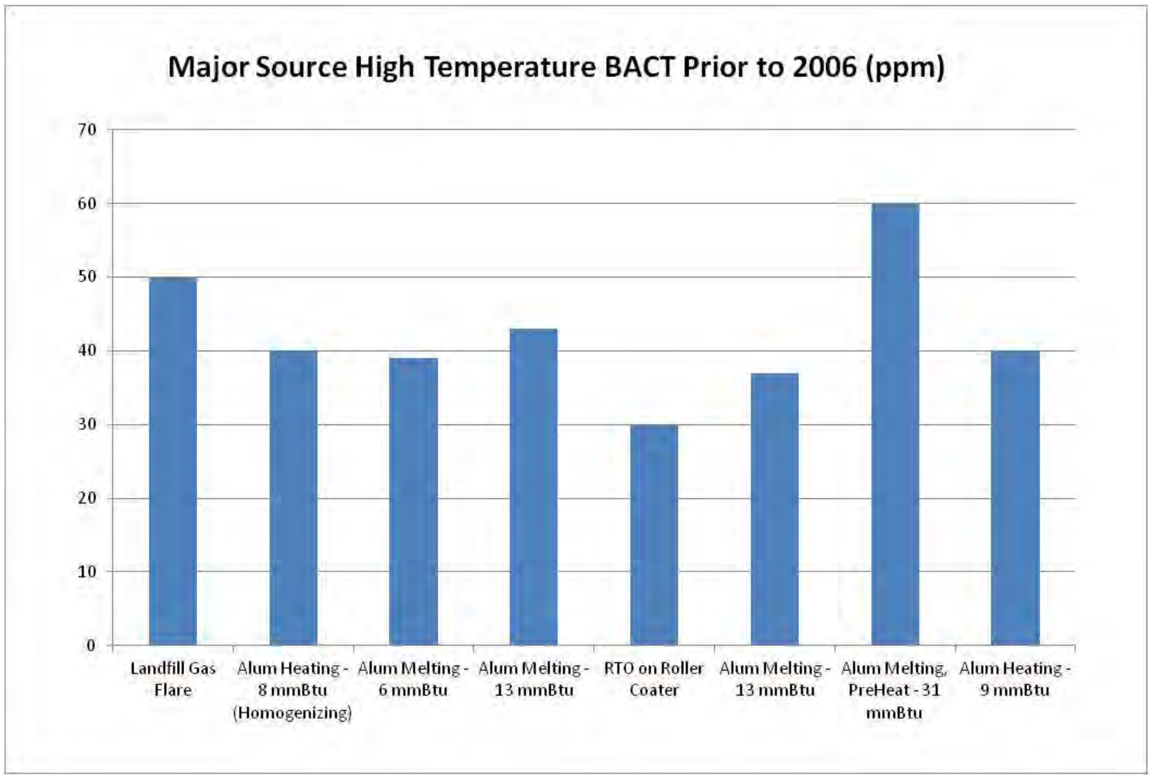


Figure B-5

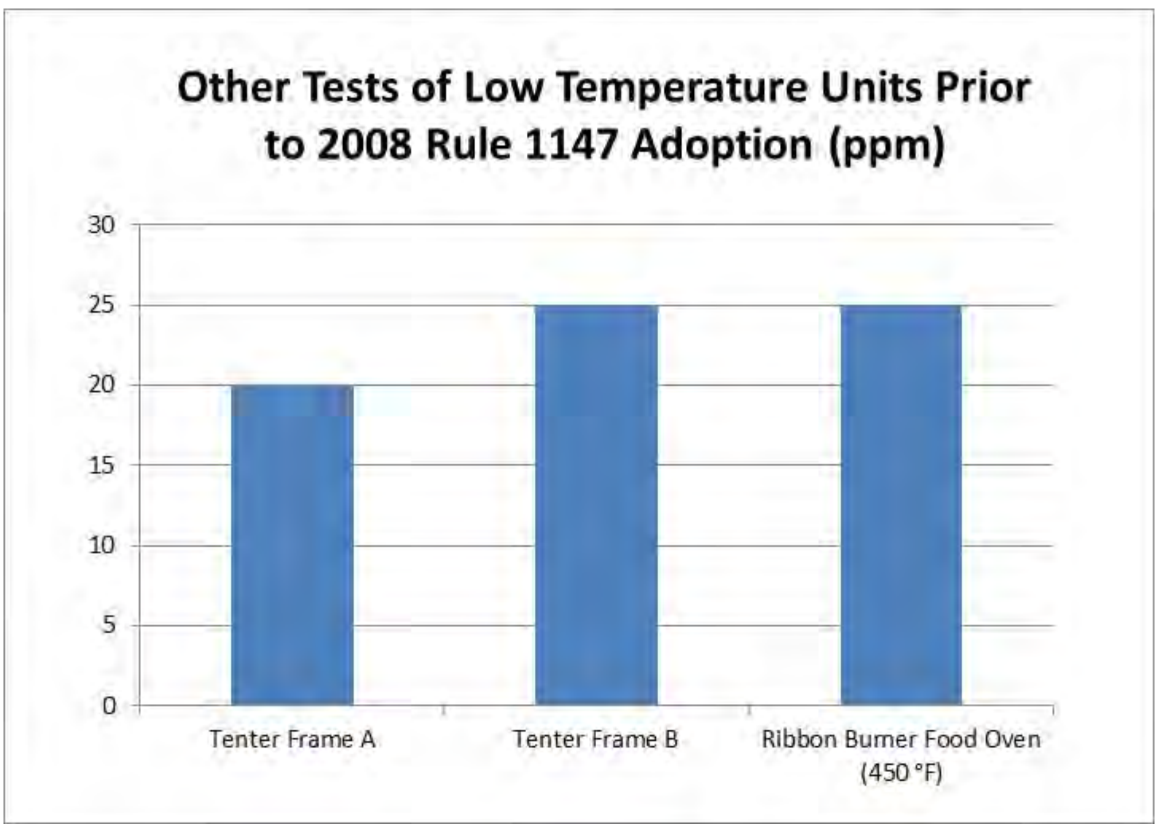


Figure B-6

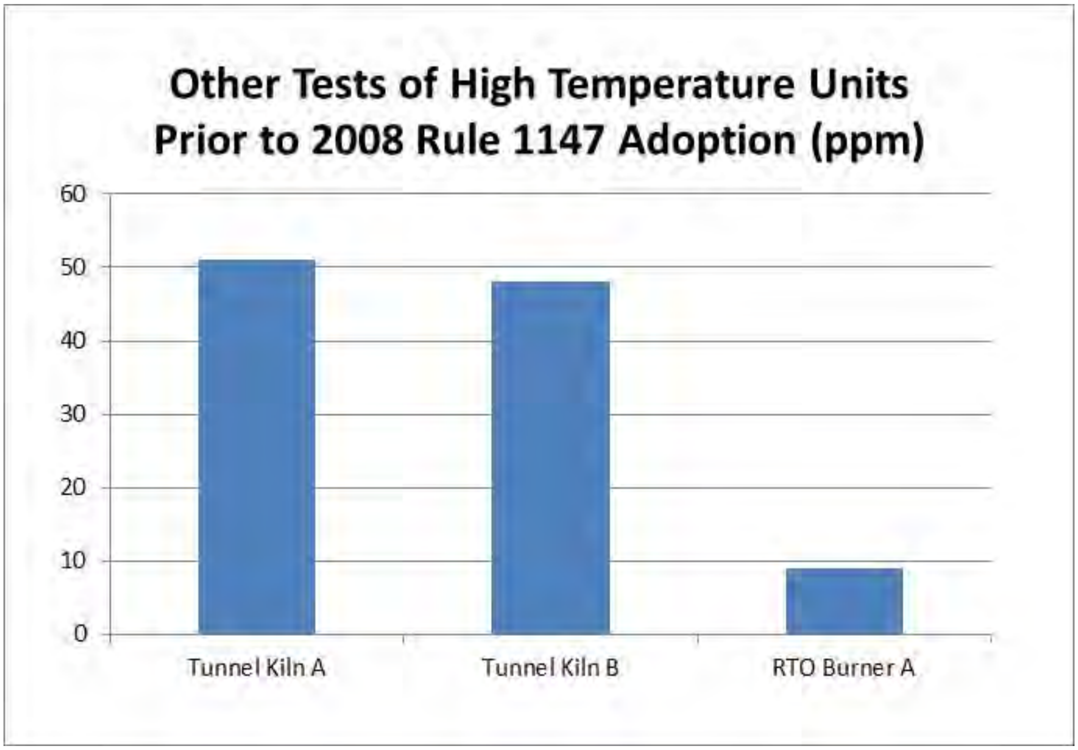


Figure B-7

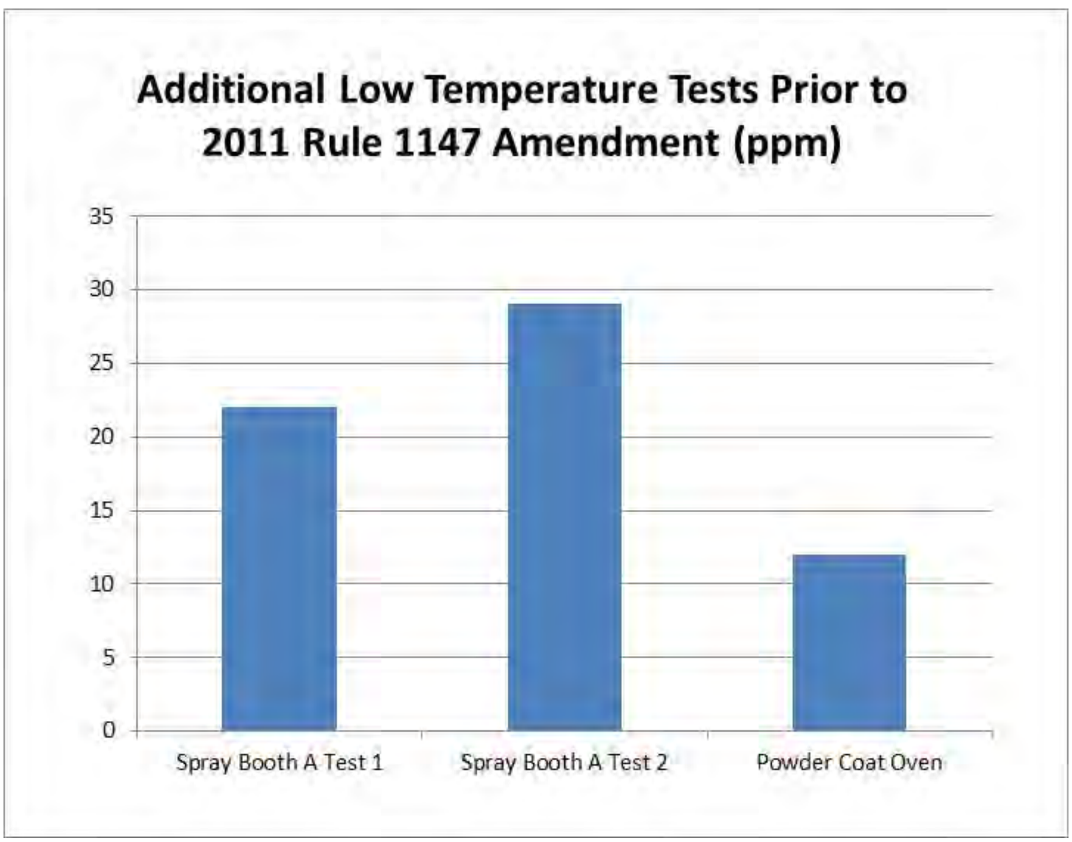
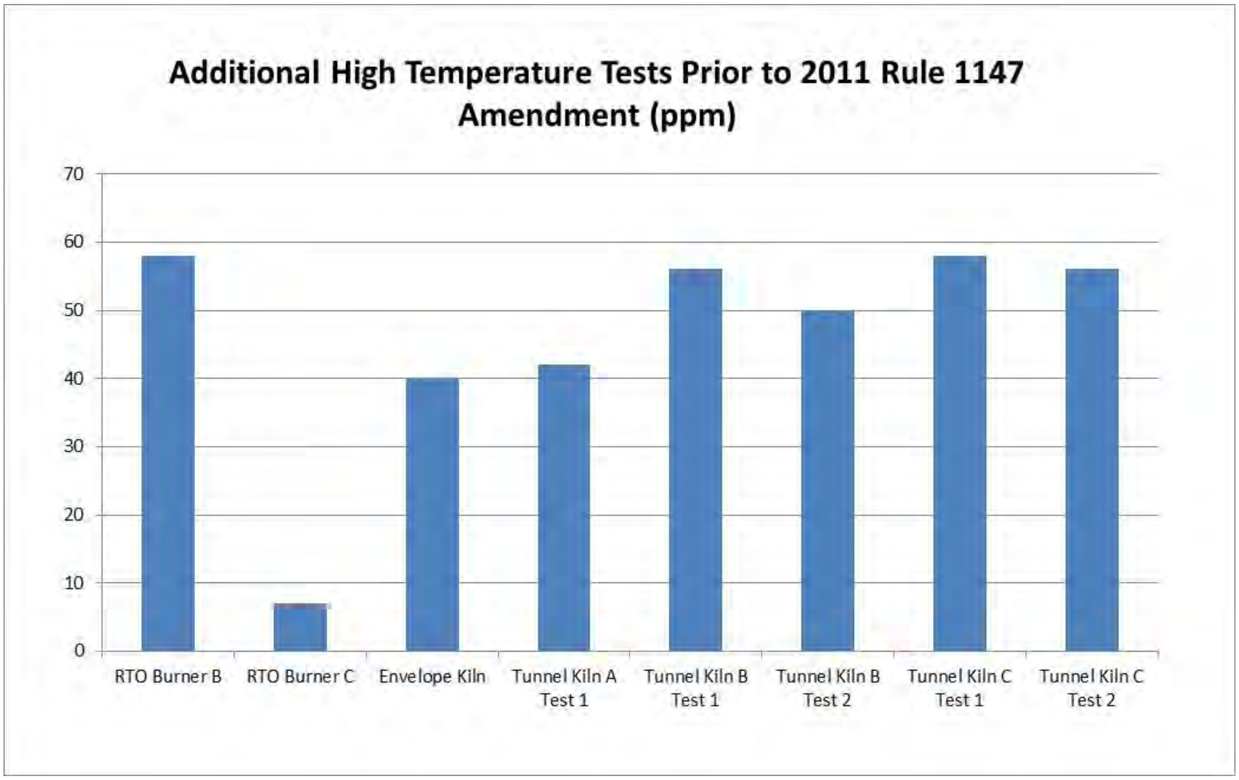


Figure B-8


Additional High Temperature Tests Prior to 2011 Rule 1147 Amendment (ppm)
70
60
50
40
30
20
10
0
RTO Burner B
RTO Burner C
Envelope Kiln
Tunnel Kiln A Test 1
Tunnel Kiln B Test 1
Tunnel Kiln B Test 2
Tunnel Kiln C Test 1
Tunnel Kiln C Test 2

Appendix C –Rule 1147 Emission Testing and Test Limitations

RULE 1147 EMISSION TESTING AND TEST LIMITATIONS

Demonstrating compliance with emission or other limits is required for Rule 1147 and all federal, state and SCAQMD air pollution regulations. In order for a new or amended SCAQMD rule to be approved for inclusion in the State Implementation Plan (SIP), test methods must be identified in the rule and approved by CARB and EPA. Rule 1147 identifies test methods that may be used to determine NOx, CO, O_2 and CO_2 concentrations and mass emissions.

In addition to EPA approved test methods, the SCAQMD also provides guidelines and generic test protocols to assist equipment owners and testing companies to prepare for and perform approvable emission tests. Because of the large variety of equipment regulated by Rule 1147, the equipment owner and the testing company must submit a test protocol and receive SCAQMD approval before testing a unit.

Emission testing can be more difficult for open direct fired units and dryers that heat large quantities of air because pollutant concentrations are diluted. Examples of these types of equipment include conveyor type ovens, textile dryers and drying ovens. Testing these units may require using a calibrated fuel meter in order to demonstrate compliance with the rule's fuel-based mass emission limit (pounds per million BTU of fuel) and additional sampling and analysis to determine carbon dioxide (CO_2) concentrations in the exhaust. CO_2 concentrations are used as an alternative to O_2 concentrations in order to adjust NOx concentrations to the Rule 1147 reference level of 3% O_2 when exhaust oxygen (O_2) concentrations are high (close to ambient levels),

The test results used for this report have been reviewed by SCAQMD Engineering, Compliance and Source Testing staff. When Rule 1147 emission testing protocols and test reports are reviewed by SCAQMD staff, they are rated as acceptable, conditionally acceptable, or unacceptable. Test reports are classified unacceptable when the report does not include all required documentation, the test was not performed consistent with the test method and approved protocol, or the test results cannot be used to demonstrate compliance with the applicable emission limit.

Tests reports are classified conditionally acceptable when the test results indicate compliance with the applicable emission limit but results are adjusted by SCAQMD staff, emissions cannot be estimated accurately but mass emissions or concentrations are equal to or less than the applicable emission limit or carbon monoxide (CO) emissions cannot be accurately determined. Rule 1147 does not include a CO emission limit because the SCAQMD is in compliance with federal and California ambient air quality standards. However, CO concentrations are routinely measured to ensure compliance with permit or facility requirements if applicable.

The most common reason for an emission test report to be rated conditionally acceptable is the reported emissions of NOx or CO have been adjusted by staff so results are consistent with SCAQMD testing and reporting guidelines. Mass emissions or concentrations may be adjusted higher or lower but the adjusted results demonstrate compliance with the rule limit.

For many test results, emissions are expressed as less than a specific concentration or mass emission rate that demonstrates compliance with the applicable emission limit. In order to be considered accurate, SCAQMD guidelines require that test results fall between 20% and 95% of the concentration of the highest concentration (high span) calibration gas used for that pollutant for that test. When results are not within the test's acceptable range, they are adjusted up to 20% of the acceptable range if they are lower, additional calibration gasses are tested to expand the range or define a lower sub-range, or the test is repeated using a different set of calibration gasses.

Adjustment up to the low end of the acceptable range (20% of the high span calibration gas) is a common result for equipment with dilute pollutant concentrations and high O_2 concentration in the unit's exhaust. Although these test results can be used to demonstrate that pollutant levels are less than a specific concentration (i.e., the low end of the acceptable range), they cannot be used to accurately estimate concentration or mass emissions. When the estimated concentrations are lower than the acceptable range of the individual test but an adjustment up to 20% of the acceptable range is still less than or equal to the applicable emission limit, the test result is satisfactory for the needs of the client and no further calibration or testing is performed by the testing company.

Test results for CO are often adjusted up to 20% of the acceptable range and because most permits do not limit CO emissions, no further analysis for CO is performed. However, when CO concentrations are adjusted up to 20% of the acceptable range, the adjusted estimated CO concentration can be up to three orders of magnitude higher than the actual concentration.

In summary, testing is performed to demonstrate compliance with an emission limit and businesses and testing companies do enough calibration, testing and calculation to prove that pollutant concentration or mass emissions are below the applicable limit. Most Rule 1147 emission test results are adjusted by the testing company or SCAQMD staff to address issues with a test's acceptable range or with other testing and calculation issues. As a result, most test results can demonstrate compliance but cannot be used to accurately estimate concentrations or mass emissions from individual units and categories of equipment.

Table C-1 provides a summary of submitted Rule 1147 NOx emission test results that have completed SCAQMD staff review and demonstrated compliance with Rule 1147 emission limits as of March 2015. Table C-1 shows the number of test results and average NOx emission concentrations for units tested at the highest and at a low firing rate if applicable. In most cases the highest firing rated tested is the normal operating condition. However, in a small number of cases the low firing rate is the normal condition. The table also indicates the applicable NOx emission limit for each category of equipment. Table C-1 does not include results from tests that were subsequently repeated because the original test did not comply with test method or SCAQMD guidelines. In addition, the table does not include test results for units that were shut down or that were withdrawn by the unit operator.

Table C-1

Rule 1147 Emission Test Results

Equipment Category	Rule 1147 NOx Limit (ppm [1])	Number of Units Tested at Normal/High Fire	Average NOx Concentration at Normal/High Fire (ppm)	Number of Units Tested at Low Fire	Average NOx Concentration at Low Fire (ppm)
Afterburner/ Regenerative Thermal Oxidizer	30 or 60 [2]	13	26	4	13
Afterburner/ Thermal or Catalytic Oxidizer	30 or 60 [2]	9	40	1	41
Afterburner/ Remediation Unit	60	2	23	1	24
Spray Booth (Automobile)	30	10	24		
Spray Booth (Other)	30	13	18	2	22
Crematory	60	20	50		
Dryer/Asphalt	40	1	35		
Fryer	60	7	29		
Fuel Cell Heater	30 or 60 [2]	1	11	1	9
Heated Tank	60	7	37	1	34
Metallizing Spray	30 or 60 [2]	1	22		
Metal Heat Treat	60	23	48		
Metal Melting (Large)	60	8	42	1	58
Metal Melting Pot/Crucible	60	5	54		
Multi-chamber Burn Off Oven or Furnace	30/60 or 60/60 [3]	11	42 [4]		
Multi-chamber Incinerator	30/60 or 60/60 [3]	1	54 [4]		
Oven/Dryer	30 or 60 [2]	112	20	35	21
Print Dryer/Oven	30	19	20	4	23
Textile Shrink Dryer	30	2	24		
Textile Tenter Dryer	30	4	23	4	26
Unit Heater	30 or 60 [2]	3	20	1	13
Number of Units		272		55	

[1] The Rule 1147 NOx limit is based on a reference level of 3% oxygen (O_2) in the exhaust. All emission test results are converted to a concentration in parts per million at the reference level of 3% O_2.
[2] The emission limit depends upon the process temperature.
[3] The emission limit for the primary chamber varies depending upon process temperature.
[4] Average NOx emissions measured after the secondary chamber (afterburner).

Appendix D – Calculation of Cost Effectiveness

CALCULATION OF COST EFFECTIVENESS

Cost effectiveness calculations for this document are performed using the methodology in SCAQMD's BACT guidelines and cost effectiveness analyses for rule development. Note that there is one key difference in the calculation of cost effectiveness between the BACT Guidelines and rule development. For rule development, a best estimate of equipment's useful life is used in the calculation of cost effectiveness instead of a fixed 10 year assumption that is associated with financing of new equipment. In addition, in rule development various emission control options are evaluated to determine the option that provides the most reductions and reasonable cost effectiveness.

For new source review (NSR) under SCAQMD Regulation XIII, equipment for which BACT is defined must meet the emission limits defined by BACT regardless of the cost. This applies to equipment at both major and non-major sources (facilities). However, for permit applications for new equipment without established BACT at non-major sources, SCAQMD staff is required to evaluate the cost effectiveness of emission reduction options. New, modified or relocated equipment with a potential to emit of one pound per day or less are not required to comply with BACT by the SCAQMD.

The cost effectiveness analysis determines which emission reduction options are below the SCAQMD Board approved maximum cost effectiveness limits established by the SCAQMD BACT committee for equipment without minor source BACT. In addition, the SCAQMD BACT guidelines and rule development are required to calculate incremental cost effectiveness for the difference in cost and emission reductions between two or more emission control options. The cost effectiveness criteria for processes that do not have an established BACT is currently about $27,000 per ton of NOx for average cost effectiveness and about $81,000 per ton of NOx for the incremental cost effectiveness between two or more control options. A copy of the section of the SCAQMD BACT Guidelines that discusses calculation of cost effectiveness is included in Attachment 1 of this appendix.

Attachment 1 of Appendix D – Cost Effectiveness Methodology from Part C: Policy and Procedures for Non-Major Polluting Facilities of July 2006 SCAQMD Best Available Control Technology Guidelines

Attachment 1

Cost Effectiveness Methodology

Cost effectiveness is measured in terms of control costs (dollars) per air emissions reduced (tons). If the cost per ton of emissions reduced is less than the maximum required cost effectiveness, then the control method is considered to be cost effective. This section also discusses the updated maximum cost effectiveness values, and those costs, which can be included in the cost effectiveness evaluation.

There are two types of cost effectiveness: average and incremental. Average cost effectiveness considers the difference in cost and emissions between a proposed MSBACT and an uncontrolled case. On the other hand, incremental cost effectiveness looks at the difference in cost and emissions between the proposed MSBACT and alternative control options.

Applicants may also conduct a cost effectiveness evaluation to support their case for the special permit considerations discussed in Chapter 2.

Discounted Cash Flow Method

The discounted cash flow method (DCF) is used in the MSBACT Guidelines. This is also the method used in the 1999 Air Quality Management Plan. The DCF method calculates the present value of the control costs over the life of the equipment by adding the capital cost to the present value of all annual costs and other periodic costs over the life of the equipment. A real interest rate* of four percent, and a 10-year equipment life is used. The cost effectiveness is determined by dividing the total present value of the control costs by the total emission reductions in tons over the same 10-year equipment life.

Maximum Cost Effectiveness Values

The MSBACT maximum cost effectiveness values, shown in Table 4, are based on a DCF analysis with a 4% real interest rate.

Table 4: Maximum Cost Effectiveness Criteria (Second Quarter 2003)

Pollutant	Average (Maximum $ per Ton)	Incremental (Maximum $ per Ton)
ROG	20,200	60,600
NOx	19,100	57,200
SOx	10,100	30,300
PM_{10}	4,500	13,400
CO	400	1,150

The cost criteria [in Table 4] are based on those adopted by the AQMD Governing Board in the 1995 BACT Guidelines, adjusted to second quarter 2003 dollars using the Marshall and Swift Equipment Cost Index. Cost effectiveness analyses should use these figures adjusted to the latest Marshall and Swift Equipment Cost Index, which is published monthly in Chemical Engineering.

* The real interest rate is the difference between market interest rates and inflation, which typically remains constant at four percent.

Top Down Cost Methodology

The AQMD uses the top down approach for evaluating cost effectiveness. This means that the best control method, with the highest emission reduction, is first analyzed. If it is not cost effective, then the second-best control method is evaluated for cost effectiveness. The process continues until a control method is found to be cost-effective.

AQMD staff will calculate both incremental and average cost effectiveness. The new MSBACT must be cost effective based on both analyses.

Costs to Include in a Cost Effectiveness Analysis

Cost effectiveness evaluations consider both capital and operating costs. Capital cost includes not only the price of the equipment, but the cost for shipping, engineering and installation. Operating or annual costs include expenditures associated with utilities, labor and replacement costs. Finally, costs are reduced if any of the materials or energy created by the process result in cost savings. These cost items are shown in Table 5. Methodologies for determining these values are given in documents prepared by USEPA through their Office of Air Quality Planning and Standards (OAQPS Control Cost Manual, 4th Edition, USEPA 450/3-90-006 and Supplements).

The cost of land will not be considered because 1) add-on control equipment usually takes up very little space, 2) add-on control equipment does not usually require the purchase of additional land, and 3) land is non-depreciable and has value at the end of the project. In addition, the cost of controlling secondary emissions and cross-media pollutants caused by the primary MSBACT requirement should be included in any required cost effectiveness evaluation of the primary MSBACT requirement.

Table 5: Cost Factors

Total Capital Investment

- Purchased Equipment Cost
  - Control Device
  - Ancillary (including duct work)
  - Instrumentation
  - Taxes
  - Freight
- Direct Installation Cost
  - Foundations and Supports
  - Handling and Erection
  - Electrical
  - Piping
  - Insulation
  - Painting
- Indirect Installation Costs
  - Engineering
  - Construction and Field Expenses
  - Start-Up
  - Performance Tests
  - Contingencies

Total Annual Cost

Direct Costs
- Raw Materials
- Utilities
  - Electricity
  - Fuel
  - Steam
  - Water
  - Compressed Air
- Waste Treatment/Disposal
- Labor
  - Operating
  - Supervisory
  - Maintenance
- Maintenance Materials
- Replacement Parts

Indirect Costs
- Overhead
- Property Taxes
- Insurance
- Administrative Charges

Recovery Credits
- Materials
- Energy

Appendix E – Afterburner Technologies

AFTERBURNER TECHNOLOGIES

The afterburner category is comprised of a variety of technologies that are used to capture and incinerate VOCs, PM and toxic air contaminants. These include direct flame afterburners (often called an oxidizer or incinerator), regenerative thermal oxidizers (RTO) that heat a ceramic bed which oxidizes pollutants, and catalytic oxidizers which incinerate pollutants with the help of a catalytic matrix. Remediation systems for removing contaminants from soil or groundwater also use the same types of technologies to incinerate VOCs or toxic air contaminants.

Alternative non-combustion technologies for control of VOC, PM and toxic air pollutants are also available and include electrostatic precipitation, wet or dry scrubbers, carbon adsorption, and other filter media. Remediation systems and some other types of units may combine carbon adsorption or other technologies with a direct flame, catalytic or regenerative thermal oxidizer. An afterburner or oxidizer can also be as simple as a stack with a burner and pilot flame (i.e., a flare).

At the time of rule development, two sources of information were available to identify BACT for this category of equipment. BACT determinations had been made for flare based oxidizers. These determinations established a BACT/LAER limit for non-major and major sources of 50 ppm NOx. However, there were a significant number of flare based oxidizers that had been permitted with a 60 ppm NOx limit prior to that BACT determination. In addition, emission test results that varied across a range from below 30 ppm up to about 50 ppm NOx for new catalytic and regenerative thermal oxidizer systems were being used by the SCAQMD permitting group as the basis to require new applicants to meet equivalent emission limits. Given the variety of processes used as afterburners, their different emission characteristics and older equipment permitted at emission levels close to but above some current BACT levels, a rule NOx limit of 60 ppm was proposed for this category of equipment and adopted in Rule 1147.

Depending upon the type of afterburner system, different burners are used. Most of the RTOs tested use a high temperature Maxon Kinedizer burner but one uses an air heating burner from Eclipse – the Winnox burner. A Kinedizer burner is also used in a remediation unit that incorporates an RTO. Thermal and catalytic oxidizers use a variety of burners from Maxon, MidCo, Eclipse, and others. Some of these units use air heating burners and others use higher temperature burners such as the Eclipse Thermjet. A variety of burners are also used in remediation units that incorporate a thermal or catalytic oxidizer.

Newer flare based systems incorporate low NOx burners that can meet the 60 ppm NOx limit (e.g., John Zink and Flare Industries/Bekaert). However, RTO based systems offer a significant advantage over direct flame systems because they can significantly reduce fuel consumption and the cost of operating the system. Staff is aware of one facility that replaced an old flare based oxidizer with a new RTO in order to meet the Rule 1147 emission limit and to reduce fuel cost.

The afterburners that have been tested are used to control emissions from a wide variety of processes. Afterburners are widely used to control emissions of VOCs and PM from printing, coating and chemical manufacturing operations. Afterburners are also used for the control of VOCs from food bakery ovens and fryers. Larger coffee roasters are required to use afterburners to control emissions of PM, toxics and for odor control. One tested unit controls emission of PM from an animal feed dryer. Several of the tested units are portable and are used to control emissions of VOCs from degassing of storage tanks, pipelines and other equipment.

The 24 units tested easily passed the 60 ppm NOx limit. Most of the units were tested with their original burners. The RTO and remediation units have average NOx emissions of about 25 ppm at high fire with a range of 16 to 55 ppm. One unit with emissions of 55 ppm NOx has a Maxon Kinemax burner instead of a Kinedizer. Thermal and catalytic oxidizers averaged about 40 ppm NOx with a range of 21 to 54 ppm at high fire. Units with air heating burners including the Eclipse Winnox have lower emissions than units with high temperature burners such as the Eclipse Thermjet.

A large number of afterburner units using different combustion technologies have been tested and comply with the Rule 1147 NOx emission limit of 60 ppm. Most of the units complied with the emission limit using their original burners. The emission vary depending upon the combustion technology. However, all of the units for which tests were submitted and reviewed comply with the rule emission limit.

Appendix F – Spray Booths

SPRAY BOOTHS

A variety of coating operations use heated spray booths and prep stations. Prep stations are paint booths that are not fully enclosed. The majority of heated spray booths in the SCAQMD are auto body refinishing booths used for refinishing passenger cars and light trucks. Larger booths are used for industrial coating operations, large trucks and trailers and a variety of maintenance applications. In addition, auto body type spray booths are also used by manufacturing operations for drying and curing components and assembled products. An achieved in practice LAER/BACT limit of 30 ppm NOx for makeup air heaters in spray booth applications and the fact that many SCAQMD permitted booths are used as curing or drying ovens in manufacturing operations justified a Rule 1147 NOx limit of 30 ppm. It should be noted that BACT for ovens and most dryers has been 30 ppm NOx since 1998.

To date, only new or relocated spray booths have been subject to the Rule 1147 emission limit. Because more than 90% of in-use heated booths are estimated to have annual average emissions less than one pound per day of NOx, existing units are not subject to the emission limit until on or July 1, 2017. Most of the new booths have been installed in the SCAQMD are for auto body repair and have been permitted based on certification of the burner and related components of the makeup air unit for the booth.

Auto body repair businesses use paint booths for reducing the amount of spray leaving the facility and keeping dust off newly painted surfaces. In addition, booths speed up the drying process by moving air through the booth. Spray booths can also be fitted with heating units that further accelerate the drying and curing of coatings.

Auto body repair businesses use heated booths in order to increase the number of painted cars that can be dried in a day. Businesses that coat four or more cars a day use heated booths. About three painted cars can be dried each day with an unheated booth. According to spray booth vendors, the average number of cars dried per day in a spray booth is about five. The maximum number of cars that can be processed by a heated booth during one shift is eight. Some auto body repair businesses operate more than one shift per day thus increasing the number of cars processed.

Technology

Ten booths used in auto body repair from a variety of manufacturers have been tested as part of the process to certify a company's spray booth heating systems. These certified units comply with the Rule 1147 emission limit of 30 ppm NOx and with workplace exposure standards for CO. To date, all of the certified spray booths have used a burner system from MidCo. This new low NOx burner replaced line burners in a number of booth manufacturers heating units. Many of the previous units were built around a MidCo line burner. Since 2010, more than 125 low NOx heating systems based on the MidCo low NOx burner have been installed in the SCAQMD. The majority of these have been installed in heating units for new auto body spray booths.

Several spray booth manufacturers have taken advantage of the option to certify their booths and heating system. Certified models do not require individual emission tests. Currently there are 32 models of booths and heating systems from eight manufacturers certified compliant with the Rule 1147 emission limit. Non-certified models must perform individual tests in order to receive an SCAQMD permit. The SCAQMD certified systems vary from basic cross flow booths to down flow booths constructed with below ground air exhaust systems. The manufacturers represent a significant portion of the industry and include companies that manufacture their booths and heating systems in California.

The SCAQMD permitting group certifies the whole spray booth mechanical system including the combustion components. This approach significantly increases the cost of retrofitting existing spray booths with certified low NOx burners. To use an SCAQMD certified burner on a used spray booth, the owner/operator must also install a new heater box, blower, other mechanical components with a new thermostat and control system for moving air in addition to installing the burner, mounting hardware and combustion control system.

Other manufacturers have decided not to certify their heating units, but instead have decided to have their distributors and local installers test each new installation. For example, three auto body booths at one location have been tested and complied with the Rule 1147 NOx limit using a newer design line burner from Maxon.

Other types of booths and some auto body booths used for different applications have also been tested and comply with the Rule 1147 emissions limit. These units submitted individual emission test results. Thirteen test results have been submitted for booths that are not used for auto body repair. These booths use heating units or burners from Hastings, MidCo, PowerFlame, and Riello. In these cases, the air movement system and other components were not required to be replaced by the SCAQMD.

The burners in these other booths use a variety of technologies to achieve the emission limit of 30 ppm. The heater manufactured by Hastings is a roof mounted unit that can also be used to heat other processes or large building spaces such as a warehouse. All of the burners in these systems use premixing of air and fuel with a controlled amount of excess air to reduce emissions. The MidCo burner uses a knit steel fabric material to stabilize and spread the flame over a larger surface area to reduce peak flame temperature and NOx emissions. The Hastings, PowerFlame and Riello burners use premixing, swirl for mixing with air in the combustion zone and other technologies to keep emissions low. The new control systems for these low NOx burners can be the most important component of the system because they provide more precise tuning and control of the combustion process across the firing range of the burner.

Cost Effectiveness of Rule Compliant Spray Booth Heating Systems

NOx Emissions for most auto body spray booths average less than on half pound per day on an annual basis. NOx emissions contribute to the formation of secondary particulates in addition to ozone. A typical booths' annual average NOx emissions are less than one third pound per day. However, during late fall and winter when PM 2.5 concentrations can be high, daily NOx emissions can be two to three times annual average emissions.

The cost difference between a new certified rule compliant heated spray booth and a new non-compliant unit is less than $10,000 on typical new booth based on information from manufacturers, vendors and the cost of booths prior to rule adoption. The cost for new units includes markups from the booth manufacturer applied to the cost of the burner, gas train and control system. Most of the specialty booths used for applications other than auto body repair were tested with standard burners, so there was no additional equipment cost to comply with Rule 1147 limits. However, the cost for adding a new natural gas fired certified heating system to an existing spray booth varies from $30,000 to $50,000 with a typical cost of about $40,000. The cost varies depending upon the manufacturer, type of booth and the individual installation.

The cost of new booths are highly variable depending upon the type of booth and options. According to vendor supplied information, the cost to purchase and install a new spray booth is about 20% higher than in 2008 when Rule 1147 was adopted. This increase is consistent with industry data on the cost to purchase and install new equipment (i.e., Marshall & Swift Equipment Cost Index which includes inflation, the cost of materials and manufacturing costs). The typical new installation is a semi down draft (side draft) booth with for about $80,000. A new basic cross draft booth without recirculation is less and costs $65,000 to $80,000. However, some vendors do not sell heated cross flow booths. The heating system and installation cost of the booth and heating constitute most of the cost for a new basic cross draft booth. A new full down draft booth is about $115,000 and up depending upon options. Although the cost for semi down draft and down draft booths are higher than for a basic cross draft, the heating system costs are about the same for basic and premium booths from the same manufacturer or vendor.

The cost effectiveness for a new SCAQMD certified low NOx auto repair booth is at most $22,000 per ton [($10,000 at most) / (70% reduction in NOx) X (0.25 lb/day / 2000 lb/ton) X 260 days/year X 20 years)]. In higher volume shops, the cost effectiveness is better (lower than $22,000/ton).

The cost to retrofit a used booth to install in the SCAQMD as a new permitted unit is significantly less than purchasing a new booth. However, the cost effectiveness for retrofitting an existing in-use auto repair booth with a SCAQMD certified heating system is $88,000 per ton of NOx reduced based on a cost of $40,000 and a 20 year life. The cost of the heating system ranges from $30,000 to $50,000. For a high volume booth used two shifts a day, the cost effectiveness could be less than half this value ($44,000/ton). For a booth retrofit costing $30,000 the cost effectiveness is $66,000 per ton. This cost effectiveness of retrofitting an existing permitted booth is higher than the minor source average cost-effectiveness criteria of $27,000 per ton used by SCAQMD for equipment without defined BACT. Depending upon the number of cars processed per day, the retrofit cost effectiveness may also be higher than the BACT incremental cost effectiveness criteria of $81,000 per ton.

It must be noted that depending upon the age of the used booth, the owner may have to upgrade the booth to meet current building and safety codes. The local building and safety agency may require mechanical, electrical, fire safety and other components be upgraded or replaced. These costs are not attributable to Rule 1147 and are also not included in the cost effectiveness analysis for new, modified or relocated units that require a new SCAQMD permit. The SCAQMD BACT Guidelines does not include the cost of compliance with non SCAQMD regulations in the calculation of cost effectiveness. The calculation of cost effectiveness is an analysis of the cost of new equipment and the cost of operating the new equipment. In the cost effectiveness analysis for new rule requirements, the recurring costs for new or modified equipment are those above and beyond the costs associated with original existing equipment.

The cost effectiveness for upgrading existing spray booths to comply with the Rule 1147 emission limit exceeds the minor source cost-effectiveness criteria of $27,000 per ton used by SCAQMD for equipment categories without a defined BACT. However, the cost effectiveness for new units is at most $22,000 per ton and is less than the BACT Guidelines criteria. Because the cost effectiveness to retrofit an existing permitted booth is significantly higher than the minor source BACT criteria, staff is considering amending Rule 1147 to delay compliance for existing in-use permitted booths and heating units until they are modified (modification of the combustion or air circulation system), relocated (including moved to a different location within the facility) or replaced. Staff is proposing that new, modified, or relocated units requiring an SCAQMD permit continue to be required to comply with the Rule 1147 NOx limit at the time of modification or installation. A change of ownership in a business with an existing in-use permitted booth would be exempt from the retrofit requirement unless the booth or heating unit is modified, relocated or replaced.

Appendix G – Crematories

CREMATORIES

Twenty crematories have been tested and comply with the Rule 1147 NOx emission limit. This list includes units tested with their original burners and units tested after replacing their burners. The burners tested in these units are manufactured by Eclipse, Facultatieve and others. The most common burner installed for new units in the SCAQMD and for replacing old burners is the Eclipse Thermjet, a medium to high velocity burner used in many high temperature applications including kilns, metal melting, heat treating and burn off furnaces.

Crematories are constructed as two integrated chambers each with their own burners. The first chamber is used for incineration and the second is an afterburner for reducing emissions of PM, VOCs and odors. Typically both chambers use the same type of high temperature burner but the size and number of burners in each chamber may differ. The primary chamber typically has one or two smaller burners than the one burner used in the secondary chamber afterburner section.

The Rule 1147 NOx emission limit for crematories is 60 ppm. The NOx emission concentrations for the tested crematories average 50 ppm with a range from 30 to 59 ppm. The 20 crematory tests that have been reviewed and comply with the emission limit include those with original burners and many units with new burners and control systems. Many crematories more than 20 years old had burners that are no longer produced and would not comply with the Rule 1147 emission limit. However, those crematories replaced their burners and comply with the 60 ppm NOx emission limit. Most crematories less than 20 years old have been installed with burners that comply with the Rule 1147 NOx emission limit and will not require replacement a retrofit. These units will only be required to demonstrate compliance through an emissions test.

The Rule 1147 test program has demonstrated that the NOx emission limit of 60 ppm is achieved by the burners and combustion control system available since the late 1990s. Crematories that have had their burners replaced use the same burners that are installed in new units. The average emission concentration from the tested units is 50 ppm and some units are significantly lower.

Appendix H – Fryers

FRYERS

There are two major types of fryers – conveyor and batch type. In addition, there are different types of heating systems including immersion tube heating in conveyor units and external oil heating systems for many batch type fryers. The external oil heaters use a heat exchanger with a gas fired burner or another heat source such as a thermal fluid heater regulated by SCAQMD Rules 1146.1 or 1146.2. Both types of fryers and heating systems have been tested and comply with the rule 1147 emission limit.

Seven existing in-use fryers have completed emission testing and comply with the Rule 1147 NOx emission limit of 60 ppm. The tested units are from three different manufacturers. All units were tested with their original burner systems. One unit is a conveyor fryer with many small immersion tube burners and a total heat rating of 1.5 mmBtu/hour. The other units use single burners with a heat exchanger and have heat ratings from 1.5 to 2.5 mmBtu/hour. The average NOx emissions are about 30 ppm with a range from 14 ppm to 56 ppm.

A variety of systems from three different manufacturers have been tested and comply with the Rule 1147 NOx emission limit. The units complied with the 60 ppm using different types of heating systems. Based on the units completing testing, the Rule 1147 emission limit is achievable with the original heating systems installed for these fryers.

Appendix I – Heated Process Tanks

HEATED PROCESS TANKS

Heated process tanks, parts washers and evaporators are a category of 1147 equipment for which it is difficult to accurately estimate the number of units that are subject to Rule 1147. While evaporators and parts washers with an integrated heated tank are typically separate units with their own permit, most process tanks are permitted as part of a process line with other processes and tanks. Because Rule 1147 only applies to units that require a permit; an individual tank is only subject to Rule 1147 if it is heated by burners and either has emissions of VOC, PM or toxic air contaminants or the rating of the burner system is greater than two million BTU per hour (2 mmBtu/hour).

For example, tanks with mixing from an air sparging system are more likely to have VOC, PM or toxic emissions and require emission controls and a permit than those that do not. Otherwise a tank is exempt from the requirement for a permit as defined by SCAQMD Rule 219. However, if a process tank does not require a permit, it is still included in the description of a process line in order to provide a complete description of the process for SCAQMD permitting and compliance staff. Process lines are permitted as one unit in order to reduce the cost and administrative burden of permits.

There are approximately 1,400 process tanks identified in the SCAQMD permit system. About 1,200 of them are unheated, heated electrically or heated by a boiler. Of the remaining 200, at least 160 have burners rated less than the size requiring a permit. The number of heated process tanks subject to Rule 1147 is estimated to be between 20 and 40 with a best estimate of 25 units. The heat ratings of process tanks subject to Rule 1147 varies from 2.2 to 9 mmBtu/hour. Staff has also identified 23 evaporators with SCAQMD permits that are potentially subject to Rule 1147. There are also an unknown number of parts washers that are potentially subject to Rule 1147 depending upon their size, configuration and emissions. Tanks, evaporators and washers with electric, boiler steam or thermal fluid heating are exempt from Rule 1147. Equipment heated using a separate enclosed heated tank are potentially subject to SCAQMD Rules 1146, 1146.1 or 1146.2 which regulate boilers and enclosed process heaters.

Many heated process tanks, evaporators and parts washers use immersion heating tubes to heat a solution in a tank. Immersion tube burners fire into and heat a tube and that heat is transferred to the solution from the tube by conduction and convection. The efficiency of heat transfer depends upon the diameter and length of the tube. The efficiency of heat transfer in a tank system can vary from about 60% to over 90%.

To date only a few heated process tanks and evaporators have performed testing because some were installed within the last 15 years, others have emissions less than or equal to one pound per day and most are exempt because they do not require a permit. Seven units have been tested and reviewed by SCAQMD staff. None of these units replaced their burners. All tested units comply with the Rule 1147 NOx limit of 60 ppm for heated process tanks, evaporators and washers with their original burners.

Process tanks, evaporators and washers with their own burners use a variety of heat exchange systems to heat a solution or assist in evaporation. Most process tanks use a constant diameter tube to heat a solution. Evaporators either use custom designed air to solution heat exchangers or constant diameter tubes to provide heat to a solution. Most parts washers use a custom designed heat exchange system or a separate water heater.

Custom designed heat exchange systems have various configurations but start out with a combustion zone with a larger cross section than the remainder of the heat exchanger. These systems typically start with a combustion chamber that is about 8 to 16 inches across that extends the full length of the burner's flame. The combustion section of the heat exchanger is large because manufacturers use burners that are designed for a wide variety of applications including boilers, furnaces and ovens.

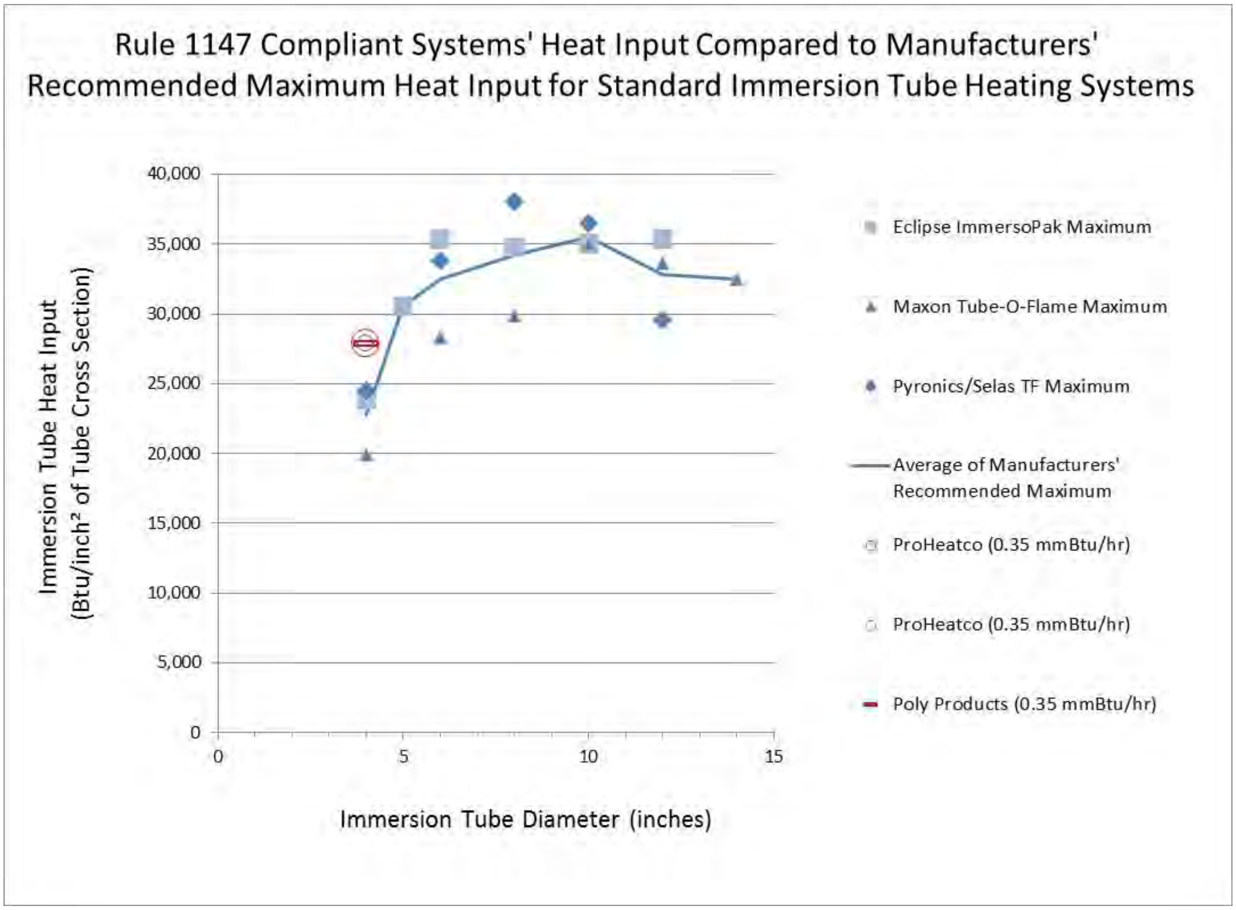
Emission testing has been performed on three evaporators using custom designed heat exchangers – two units from Encon using MidCo burners and one unit from Lakeview Engineering unit using a burner from Industrial Combustion. The heat input for these systems are 220,000 and 650,000 Btu/hour for the Encon evaporators and 1.5 mmBtu/hour for the unit built by Lakeview Engineering. NOx emission for these units ranged from 25 to 52 ppm.

Most process tanks and some evaporators use a constant diameter tube system and immersion tube burners to heat the solution tank. However, there are three types of heat exchange systems using constant diameter tubes. Each system has its own range of tube diameter depending upon the amount of pressure the burner produces and the allowable heat input to an individual tube. In addition, burners for these systems can be set up in a variety of ways depending upon the type of process tank. Burners can be set to fire at a maximum firing rate and off, fire at a high and low rate or modulate and fire across the whole range of the burner. Burners can also be set to fire at a fixed amount of combustion air or variable amount of combustion air in order to maintain a constant ratio of fuel and air over the firing range of the burner.

The most common heating tube system typically has tubes that vary from about four inches up to 14 inches in diameter. Burners for this system are available from many manufacturers including Eclipse, Maxon, Selas/Pyronics and Titan Engineering. The heat input in this type of system varies from about 20,000 to 30,000 Btu per square inch of tube cross section in four and five inch tubes and 25,000 to 40,000 Btu per square inch in six to 14 inch diameter tubes. Three of these systems have been tested – two heated evaporator tanks from Proheatco and one heated evaporator tank from Poly Products. All of these systems use a burner with a maximum rating of 350,000 Btu/hour and 4 inch diameter heating tubes. NOx emissions from these three units vary from 30 to 55 ppm. In addition, preliminary testing of a unit at another facility with a higher output burner of about 3 mmBtu/hour indicates that unit has NOx emissions of 40 to 50 ppm.

Figure I-1 provides a summary of burner and tube characteristics of the three tested units from Proheatco and Poly Products. The figure illustrates that the units have firing rates (heat input per square inch) near the maximum recommended by three major manufacturers for the most common type of tube immersion tube heating burners. This metric is important because it impacts the formation of NOx in the heating tubes. The information presented in Figure I-1 and the emission test data indicate that it is technically feasible to comply with the Rule 1147 NOx limit with the most common type of immersion heating burners.

Figure I-1



A second type of tube heating system uses burners that produce higher pressures and can fire into smaller diameter tubes. This type of system uses tubes two to eight inches in diameter with heat inputs per tube cross sectional area double the heat inputs of the standard system discussed above. Eclipse, Maxon and PowerFlame manufacture burners for this type of application. There are currently no emission test results available for these types of burners so it is not possible to determine if they comply with the Rule 1147 NOx emission limit of 60 ppm.

A third type of tube heating system for process tanks has been installed in new heated tanks. This system has a new type of burner from Maxon (an XPO burner) that requires larger diameter tubes (14 inches and above). An SCAQMD approved emissions test on one of these systems (required for Regulation XIII and new source review) with a 3.3 mmBtu/hour burner showed emissions of 4 ppm NOx at high fire and 34 ppm at low fire.

The Rule 1147 testing program has identified three types of heating systems used in process tanks and evaporators that comply with the NOx emission limit. There is no information yet available for a fourth type of heating system that uses high pressure burners firing into smaller diameter tubes of 2 to 8 inches. A fifth type of tank heating system with tube firing burners used in heat treating also been demonstrated to meet the 60 ppm NOx limit but have not yet been tested in heated tank applications.

For all five types of tank heating systems, the burners and heat exchangers or tubes are designed as one integrated system. If an individual heated tank or evaporator system using any of the four systems does not comply with the emission limit, then the whole tank will likely have to be replaced. Delaying compliance for existing in-use units from the rule emission limit until the combustion system is modified or replaced will address the issue that it is not feasible to retrofit an existing heated tank with different burners. If a tank is retrofitted with new burners, the owner will replace the heating tubes or heat exchanger. If the owner rebuilds a process tank, then a rule compliant system can be installed at that time.

SCAQMD staff is considering to amend Rule 1147 to delay compliance with the NOx emission limit for existing in-use process tanks, evaporators and parts washers with an integrated heated tank until the combustion system is modified or replaced. New units would still be required to meet the emission limit unless the total unit heat rating is less than or equal to 325,000 Btu/hour. Staff estimates this change would affect less than 50 heated tanks and evaporators currently subject to the Rule 1147 emission limit. There are more than 1,200 process tanks which are not subject to Rule 1147 requirements because they are exempt from the requirement for a permit by SCAQMD Rule 219, are unheated or are heated electrically or with a boiler.

Appendix J – Heat Treating

HEAT TREATING

Heat treating typically involves heating metals or alloys in a furnace or oven in order to develop specific properties in the metal or alloy before and after a part is made. However, heating can also be used to treat metals and nonmetallic refractory materials in a manufactured vessel, furnace or other product using temporary burners systems. The burners used in these systems are the same kinds of burners used in direct fired heat treating furnaces and kilns. Kilns are used for heat treating products made from ceramics, clay and other non-metallic materials.

Metal heat treating temperatures vary from a few hundred degrees Fahrenheit, used in tempering, to over 2,100 degrees for forging steel and titanium. With the exception of tempering, steel and titanium alloy heat treatments are typically at higher temperatures than for non-ferrous alloys based on aluminum. Kilns processing non-metallic materials also vary temperature depending upon the material and final product.

The type of burners used for heat treating depend upon the temperature required and whether they fire directly into the furnace or into tubes and heat is then transferred from the tubes to the furnace by fans. Lower temperature heat treating ovens have burners that are typically found in other types of ovens including air heating burners such as Eclipse Winnox and Maxon Cyclomax burners. Higher temperature direct fired furnaces typically use a different type of burner with a higher flame velocity, longer flame length and more radiant heat output for heating refractory material in the furnace or the tubes they fire into. High velocity burners are also used because they increase mixing and eliminate temperature stratification in direct fired furnaces. The new control systems for these low NOx burners are an important component of the system because they provide more precise tuning and control of the combustion process across the firing range of the burner.

Indirect fired furnaces typically have specialized tube firing burners. However, high velocity burners, similar to those found in direct fired applications, have also been used in indirect fired furnaces permitted in the SCAQMD. Temperature stratification in indirect fired furnaces is avoided because large fans move the air in the furnace past the tubes and into the section where the material being treated is held. High velocity and tube firing burners are available from many manufacturers including North American/Fives, Bloom, Eclipse, Maxon, Hot Work, Hauck, Industrial Combustion, and Selas. Tube firing burners from a number of manufacturers including Bloom, Hauck, North American/Fives, and Eclipse also have an option to add flue gas recirculation (FGR) to reduce NOx emissions.

Heat treating furnace designs have evolved over time. Newer furnace designs have more and smaller burners than many earlier designs. For both direct and indirect fired furnaces, more burners provide better control of the temperature profile in the furnace. Finer control of the furnace temperature allows the operator to meet newer more stringent temperature uniformity requirements than those that were in existence when older furnace designs were first built. Some of the older furnace designs predate modern temperature uniformity standards developed since the 1970s. The number and type of burners used in a furnace depend upon the size of the furnace, type of heat treating, process temperature and temperature uniformity requirements of the heat treating processes performed by the furnace.

Figures J-1 to J-4 summarizes the size and number of burners in the heat treating furnaces that have successfully completed emission testing. This information indicates that most of the burners used have heat ratings of 0.5 mmBtu/hour (500,000 Btu/hour) or less and the largest burners are about 2 mmBtu/hour. The largest furnaces have a heat rating of about 8 mmBtu/hour. There are furnaces permitted in the SCAQMD with larger heat ratings, but they are found at facilities in the RECLAIM program and are exempt from Rule 1147.

Figure J-1

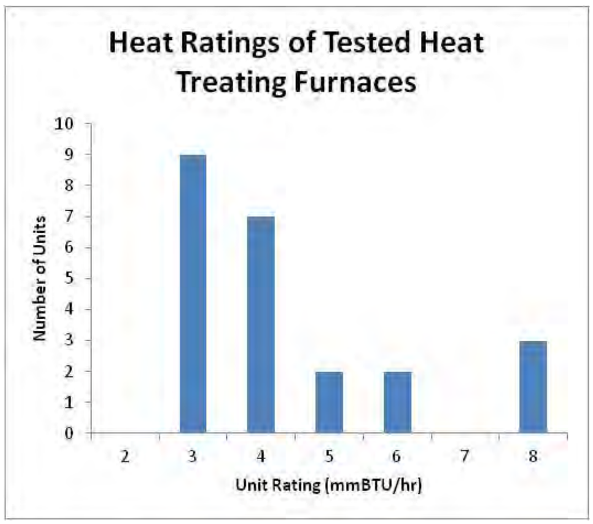


Figure J-2

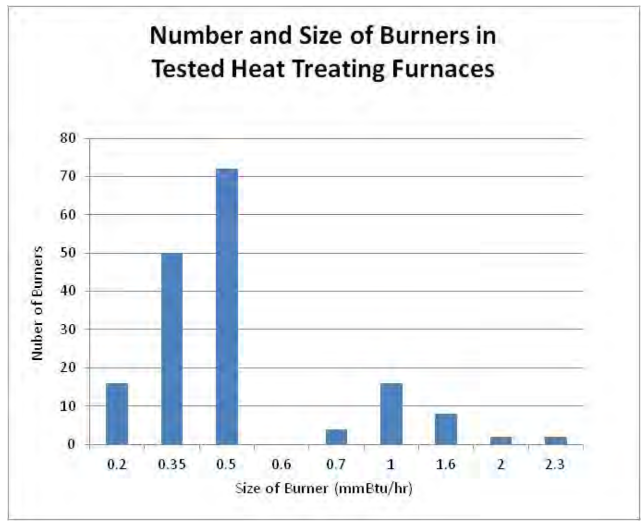


Figure J-3

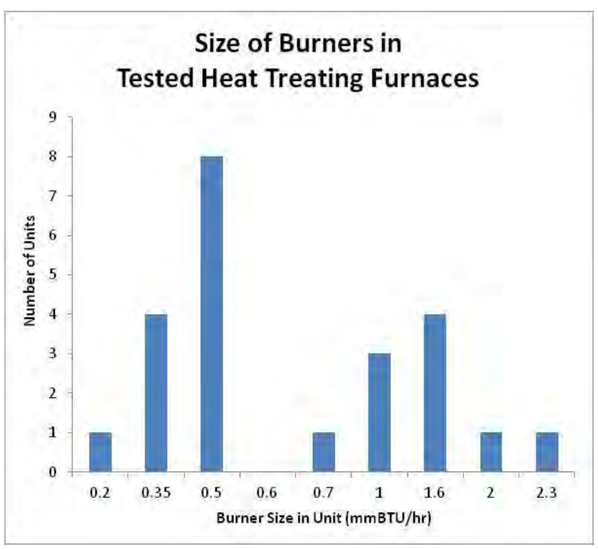
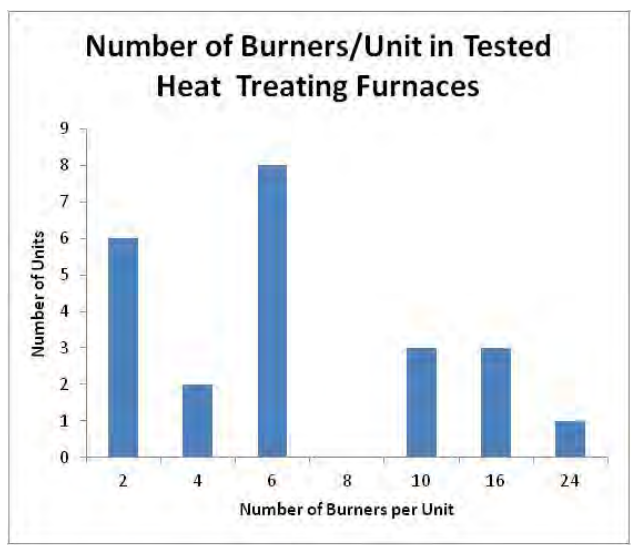


Figure J-4



The emission test results for heat treating furnaces indicate most furnace NOx emission concentrations are in the range from 45 ppm to 55 ppm with an average of about 50 ppm. These results cover a variety of furnaces processing aluminum and steel alloys across a broad temperature range. Some of the furnaces were new and were required to meet the new source BACT requirement of 50 ppm NOx, but most have been in use long before Rule 1147 was adopted in 2008 and before the BACT limit of 50 ppm was put in place in 2000. To date, only a few furnaces have had their burners replaced, added an FGR system or replaced their furnace in order to comply with Rule 1147. Most heat treating furnaces tested have met the Rule 1147 emission limit with their existing burners.

Kilns use the same burners that are found in direct fired heat treating furnaces and crematories. Kilns are used to heat treat clay, ceramic and other nonmetallic materials. Kilns are also used to heat treat glazes and other coatings applied to products made from these materials. Rule development staff have not yet received new emission test results for kilns from the Rule 1147 testing program. However, there were a number of emission tests completed on small and large kilns prior to rule adoption in 2008 and the rule amendment in 2011. These test results are summarized in Appendix B of this document. The emission test results demonstrate that a variety of kilns comply with the Rule 1147 emission limit of 60 ppm NOx with the burners installed prior to rule adoption. In addition, many small kilns are not subject to Rule 1147 because they are exempt from the requirement for a permit under SCAQMD Rule 219 (some of these use electric heat).

Appendix K – Metal Melting

METAL MELTING

A variety of metal melting furnaces are subject to Rule 1147. They include small pot and crucible furnaces for melting lead, lead alloys, aluminum, zinc and zinc alloys and larger units including kettle furnaces for galvanizing and reverberatory furnaces for melting aluminum. There are about 170 metal melting furnaces potentially subject to Rule 1147 NOx emission limits. Most of the furnaces subject to Rule 1147 melt non-ferrous metals and alloys. Furnaces for melting iron or making steel are often electric and therefore not subject to Rule 1147. There are also many furnaces at large facilities which are exempt from Rule 1147 because the facility is in the RECLAIM program.

To date, most of the metal melting furnaces tested complied with the Rule 1147 NOx limit with the burners in place when the rule was adopted. All of the larger kettle and reverberatory furnaces passed the emission limit with their original burners. However, one kettle furnace and one reverberatory furnace were recently built to replace older units and were subject to BACT under new source review. The four larger furnaces whose permits identified the burner manufacturer had Eclipse burners.

Of the five small pot and crucible melting furnaces tested, three furnaces met the emission limit with their original burners. The other two units had their burners replaced before testing. This type of furnaces can be built with burners from many manufacturers including Eclipse, Maxon, MidCo and others. One pot furnace had its original burner replaced with an Eclipse Ratio Air burner in order to comply with the NOx emission limit of 60 ppm. The new burner also had low CO emissions. A second company chose to replace two burners on a large pot furnace (2 mmBtu/hour originally) with one larger 2.4 mmBtu/hour Maxon Kinedizer LE burner, but it is not known whether the original burners would have met the Rule 1147 NOx limit. The burners were replaced in order to increase production of the furnace and to reduce fuel consumption and emissions. The new configurations was subject to BACT under new source review and complies with the Rule 1147 NOx emission limit and has low CO emissions.

The heat ratings of the pot/crucible furnaces tested ranged from 0.5 - 2.4 mmBtu/hour. The NOx emissions for these pot/crucible furnaces were in the range of 49 to 60 ppm. The eight kettle and reverberatory furnaces have unit heat ratings from 1.2 – 6 mmBtu/hour with emission ranging from 40 ppm to 53 ppm. However, the units greater than 4 mmBtu/hour have multiple burners rated 1.2 – 1.5 mmBtu/hour. The highest heat rating for a unit with one burner is 2 mmBtu/hour. There are furnaces with larger heat ratings permitted in the SCAQMD, but they are at facilities in the RECLAIM program and are exempt from Rule 1147.

The eight metal melting furnaces tested complied with the Rule 1147 NOx emission limit. Two of the units were new and built to replace old units. It is not known whether the old units would comply with the emission limit. One pot/crucible furnace was rebuilt with a larger burner to increase capacity. Another small pot furnace had its burner replaced to comply with the Rule 1147 NOx emission limit. All of the unmodified units, the new units and the units with replaced burners complied with the rule emission limit.

Appendix L – Multi-chamber Burn-off Ovens and Incinerators

MULTI-CHAMBER BURN-OFF OVENS AND INCINERATORS

This category includes various equipment that are used for similar purpose but named differently. These units may be called burn-off or burn-out ovens, kilns or furnaces and incinerators. However, all of the units perform a similar function and operate in a similar fashion. They are built with a primary chamber for melting, vaporizing or pyrolizing some material on a part or piece of equipment in order to recycle the material or component. Some units are used for incinerating material that cannot be reclaimed or must be incinerated prior to disposal. The primary chamber leads to an integrated secondary afterburner chamber that destroys particulate matter, carbon monoxide, VOCs and any other organic material that enter this afterburner section. The incinerated material is reduced to carbon dioxide and water vapor.

The Rule 1147 NOx emission limit for the primary chamber of a furnace depends upon the process temperature in this burn-off chamber. If the process temperature exceeds 800 °F, then the NOx emission limit in the primary chamber is 60 ppm. If the process temperature is lower, then the NOx limit is 30 ppm which is consistent with a typical oven or low temperature furnace operating at those temperatures. The NOx limit for the secondary afterburner chamber is 60 ppm NOx and the same as for other afterburners.

Twelve burn-off ovens, furnaces and incinerators have completed review of their test results. Most units were tested with original burners. The number of burners in these units varies from two to six burners and the most common configuration has two or three burners. The heat ratings of the units range from 0.5 to 2.2 mmBtu/hour. The average NOx concentration in the stack after the afterburner section is less than 45 ppm and the range is from 26 to 54 ppm.

Discussion with a local manufacturer of burn-off furnaces indicates that it is not possible to use the preferred type of burner and meet a 30 ppm emission limit in the primary chamber for a process temperature less than 800 °F. The typical burner that is used to remove materials from a part is the same type of high temperature medium to high velocity burner used in crematories, kilns, heat treating and some types of afterburners. These burners are designed to have NOx emissions in the 40 to 60 ppm range.

The manufacturer has tested a design with an air heating burner in the afterburner section to achieve emissions of less than 30 ppm in the secondary chamber and meet an average emission limit for the two chambers of less than 45 ppm NOx. However, this redesign will not achieve the required PM, VOC and carbon monoxide reductions in all applications. In addition, using the averaging provision of the rule may not always achieve compliance with the NOx limit. Company representatives have suggested that since it is not always possible to comply with the emission limit of 30 ppm in the primary chamber of these types of devices, the NOx limit in the primary chamber should be 60 ppm NOx regardless of the process temperature. SCAQMD staff agree with this assessment and are considering a rule change that the NOx emission limit in both chambers of this type of equipment should be

60 ppm at any process temperature. This change in the rule limit would affect a small number of equipment regulated by Rule 1147.

Appendix M – Ovens and Dryers

OVENS AND DRYERS

Excluding spray booth systems, the number of ovens and dryers under permit in the SCAQMD is slightly less than 1,200 units. This is the second largest category of equipment regulated by Rule 1147. These units are used in a variety of processes including curing of coatings and other materials, drying coated and printed products, and drying materials. The oven or dryer can be a small enclosed batch oven with a heating system, a large walk in oven, a conveyor system with a coating tank or coating spray station followed by a heated oven, or a drying room with a unit heater. Some printing and all textile drying operations use large conveyor units with multiple burners for high speed production of large quantities.

There are a variety of burners used in ovens and dryers. Each type of burner has its own characteristic emission profile. For example, radiant infrared burners have low emissions and NOx concentrations are typically less than 20 ppm. The most common type of burners used are nozzle mixing air heating burners. Some of the same types of ovens use premix burners with a metal fiber fabric cylinder or panel as a flame holding surface. Other units are designed to use line type air heating burners. Some small ovens and large conveyor systems use many flat panel radiant infrared burners. Powder coating operations are one of the processes that use radiant burners. Radiant infrared burners are required to directly heat a part in order to melt and then cure the coating. Ovens in which combustion gases cannot come in contact with the produce use indirect fired heater units with an air to air heat exchanger to provide clean heated air to the oven. However, both direct and indirect-fired unit heaters can be used to provide heat and move air through large drying ovens or rooms.

Ovens subject to the Rule 1147 NOx emission limit use burners from a number of manufacturers. The most common burners used in the SCAQMD are line and nozzle mix burners manufactured by Eclipse and Maxon. Two thirds of the tested ovens and dryers use Maxon burners and one fourth of the units use Eclipse burners. Eclipse burners used in compliant ovens and dryers include the Eclipse Winnox and Linnox product lines. Maxon burners used in compliant ovens include several versions of the OvenPak series, the Cyclomax, the LN-4 line burner and the Kinedizer. However, low NOx burners from other manufacturers including MidCo, PowerFlame, Riello, and Yukon also comply with the Rule 1147 NOx emission limit. The newer control systems for these low NOx burners are the most important component of the combustion system because they offer more precise tuning and control of the combustion process across the firing range of the burner.

Most ovens and dryers tested use only one burner. However, coating, printing and curing lines often have multiple burners. Many coating and printing lines use two identical burners, but the oven section of a coating line can also have up to 40 infrared radiant panels.

The tested ovens' heat ratings varies across a wide range from 0.4 mmBtu/hour for a small batch oven up to 20.5 mmBtu/hour for a large rotary dryer. However, most ovens have ratings less than 2.5 mmBtu/hour. Most burners in ovens with multiple burners are also less than 2.5 mmBtu/hour. The most common size of burner installed in all types of oven is 1.0 mmBtu/hour.

Figures M-1 through M-4 identify burner heat rating, number of burners and the range of the heat ratings for the tested units. Printing oven and textile dryer data is not included in Figures M-1 and M-2. Printing oven data is summarized in Figures M-3 and M-4.

Figure M-1

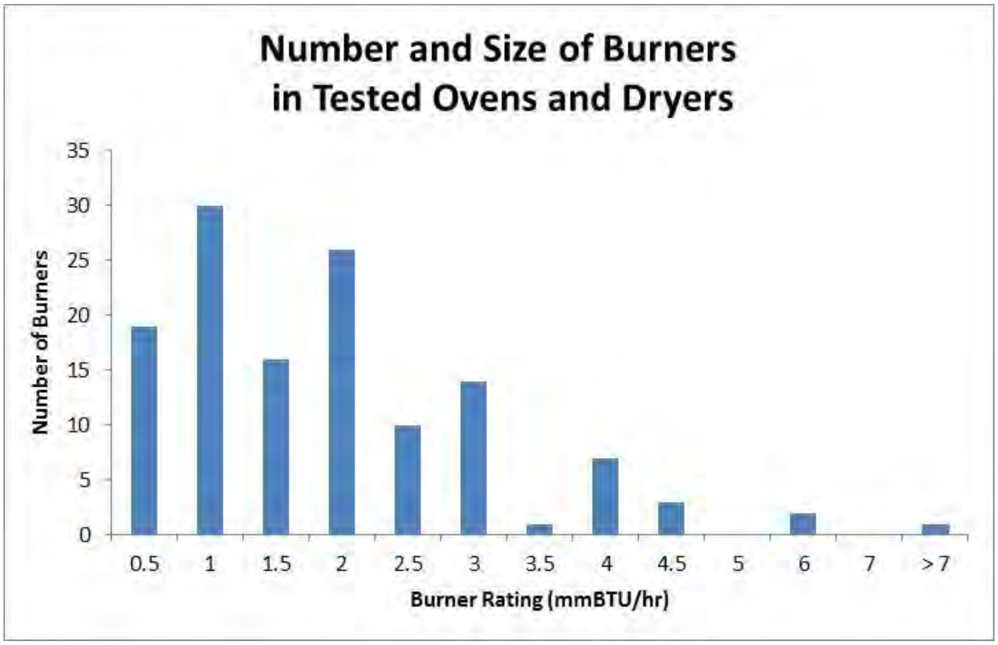


Figure M-2

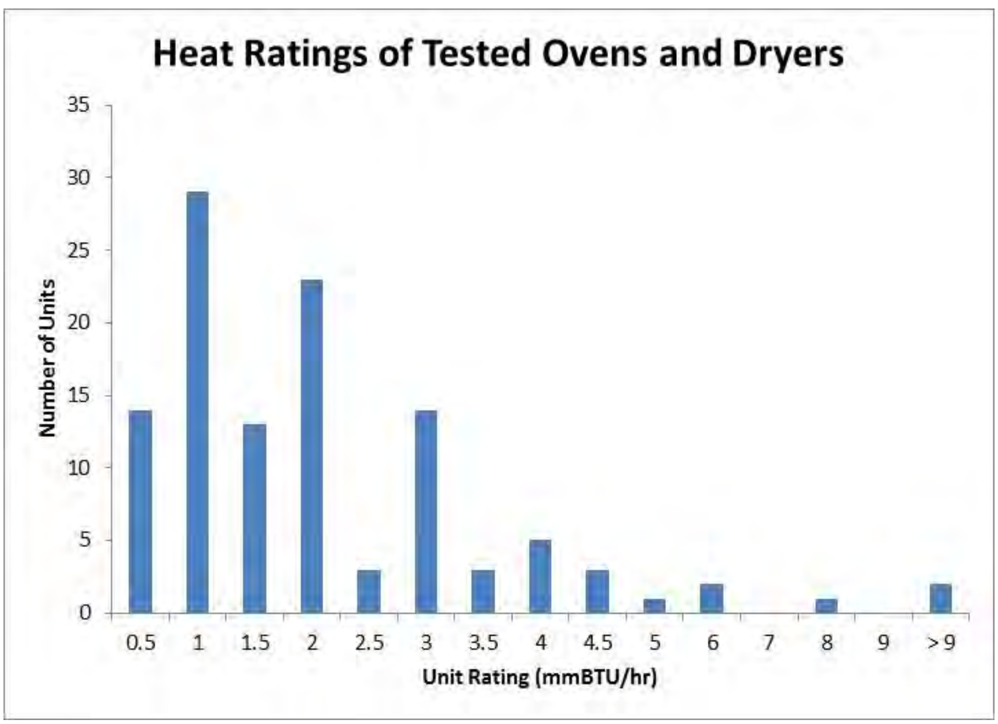


Figure M-3

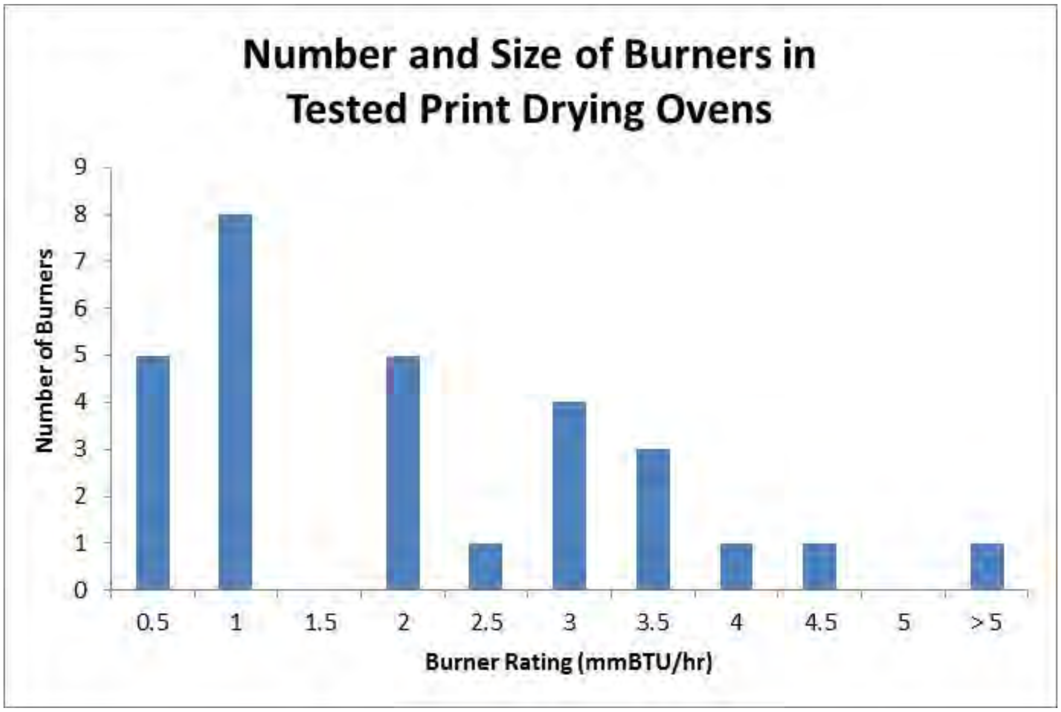
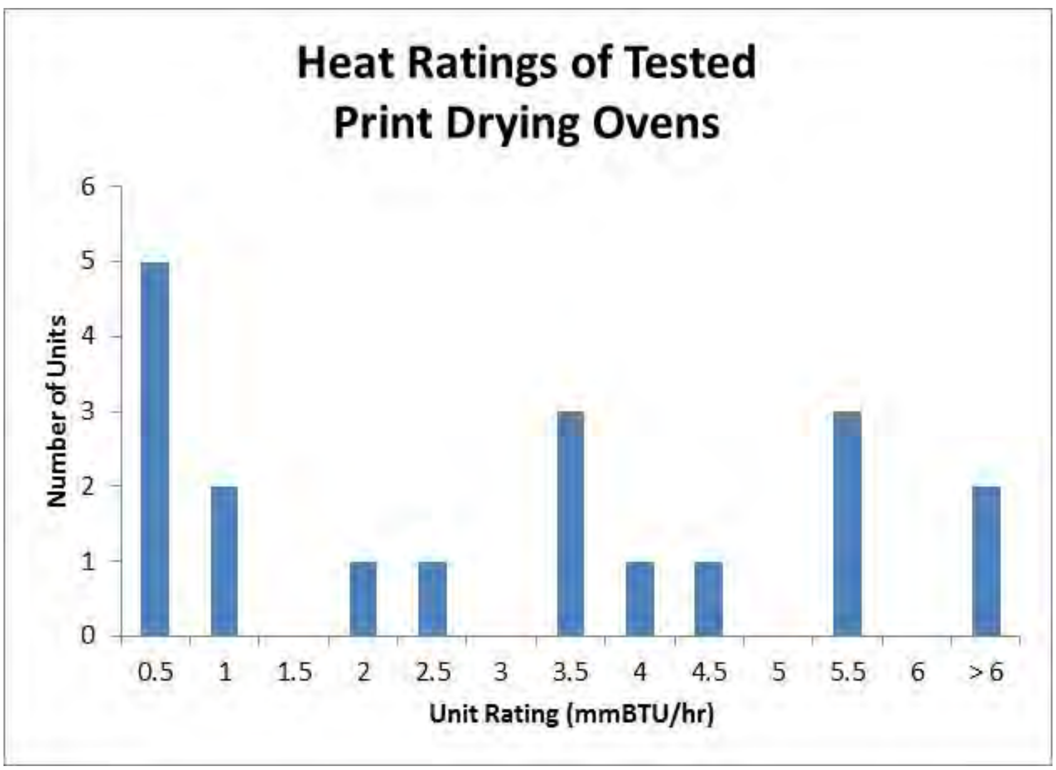


Figure M-4



Printing oven and dryer heat ratings vary from about 0.4 mmBtu/hour to 7.4 mmBtu/hour. The most common burner size in these ovens is also 1.0 mmBtu/hour. Textile tenter dryers typically have eight or nine burners that are rated less than 1.0 mmBtu/hour. The other type of textile dryer typically has four burners each rated about 1.0 mmBtu/hour.

The emission test results for ovens and dryers indicate that all types of units tested comply with the Rule 1147 NOx emission limit. Table M-1 provides a summary of the completed Rule 1147 emission tests for ovens and dryers. At this time, 140 units used for a variety of processes have approved test results and comply with the 30 ppm NOx limit. The average emission concentration for most ovens and dryers is about 20 ppm NOx. The average emission concentration for textile dryers is about 25 ppm NOx. The range of emission concentrations for all ovens and dryers is from 4 ppm to 30 ppm. The range emission concentrations for printing lines and ovens is 4 ppm to 29 ppm and for textile dryers is 14 ppm to 27 ppm. In addition, two ovens complied with the rule limit by averaging emissions from the oven and an afterburner that must comply with a NOx emission limit of 60 ppm.

Table M-1

Rule 1147 Emissions Test Results for Ovens and Dryers

Equipment Category	Rule 1147 NOx Limit (ppm [1])	Number of Units Tested at Normal/High Fire	Average NOx Concentration at Normal/High Fire (ppm)	Number of Units Tested at Low Fire	Average NOx Concentration at Low Fire (ppm)
Oven/Dryer	30 or 60 [2]	112	20	35	21
Print Dryer/Oven	30	19	20	4	23
Textile Shrink Dryer	30	2	24		
Textile Tenter Dryer	30	4	23	4	26
Unit Heater	30 or 60 [2]	3	20	1	13
Number of Units		140		44	

[1] The Rule 1147 NOx limit is based on a reference level of 3% oxygen (O_2) in the exhaust. All emission test results are converted to a concentration in parts per million at the reference level of 3% O_2.
[2] The emission limit depends upon the process temperature.

The results from the Rule 1147 emission testing program indicate that rule compliant technology is available for ovens and dryers from many sources. In addition, all of the types of ovens and dryers under permit in the SCAQMD can comply with the Rule 1147 NOx limit. However, there is a lower limit on the availability of low NOx burners for ovens and dryers. The smallest low NOx burners available are rated 0.4 and 0.5 mmBtu/hour (400,000 and 500,000 Btu/hour). Burners in this size are available from a number of manufacturers including Eclipse, Maxon, MidCo and PowerFlame. For lower firing rates, oven manufacturers will use this size of burner but limit the firing rate to less than the burner's maximum capacity. If these burners must regularly operate at less than 30% of the maximum firing rate, it may be difficult to comply with the NOx emission limit. Because there is a lower limit on the size of compliant burners for ovens and dryers, staff is considering an exemption from the Rule 1147 NOx emission limit for units with heat input capacities less than 325,000 Btu/hour.

Appendix N – Food Ovens

FOOD OVENS

Food ovens in use at the time SCAQMD Rule 1153.1 was adopted are no longer subject to Rule 1147. However, new food ovens are currently subject to Rule 1147 requirements. Staff are currently evaluating alternative rule development options for exempting new food ovens from Rule 1147. Although new food ovens may be exempt from Rule 1147 in the future, some operators of food ovens have reported results under the rule's emission testing program. At the time of this report, 13 food ovens used for a variety of baking and cooking operations have completed testing under the Rule 1147 program.

These ovens use burners from many manufacturers including Eclipse, Ensign/Selas, Flynn, Maxon and Weishaupt. Eclipse, Maxon and Weishaupt burners air heating burners are used in both batch and conveyor type convective ovens. Ensign and Flynn provide ribbon burners for heating specific types of conveyor ovens and some small batch ovens. For example, conveyor ovens with moving bands that must be heated in order to cook products on the band such as chips and crackers require ribbon or a similar type of burner. Batch type convective ovens can use a variety of burners and do not require ribbon burners. In addition, there are many conveyor type convective ovens that do not require or use ribbon burners. These convective batch and conveyor ovens use air heating nozzle mix or line burners.

Radiant infrared burners are used in both batch and conveyor ovens. This type of burner is available from many manufacturers including those identified earlier in this discussion. Three bakery ovens using only radiant infrared burners were tested and complied with Rule 1147 and Rule 1153.1 emission limits. This type of burner is used in both batch type and conveyor type ovens. The average NOx emission concentration for these burners is 13 ppm with a range of 6 to 19 ppm. Ovens with radiant infrared burners are exempt from the Rule 1153.1 requirement to perform an emissions test because these burners have NOx emissions significantly less than the emission limits in the rule (40 and 60 ppm NOx).

Four ovens with ribbon burners have been tested through the Rule 1147 emission testing program. Two baking ovens with operating temperatures less than 500 °F both had NOx emission concentrations of 21 ppm at their high or normal fire rate. One had NOx emission concentrations of 26 ppm at low fire. One of the units is used for baking tortillas and the other unit is used for baking breads and snacks. In addition, two griddle ovens used for making English muffins and other products cooked in griddles had emission concentrations of 41 ppm and 45 ppm. Griddle ovens with ribbon burners typically operate at temperatures above 500 °F. Both of these ovens comply with the Rule 1153.1 NOx emission limit of 60 ppm for this process temperature.

Five convection type ovens using nozzle mix air heating burners have been tested and comply with Rule 1147 and 1153.1 NOx emission limits. Two of the ovens are used to cook meat products and three cook breads and snacks. These ovens have average emission concentrations of 25 ppm NOx with a range of 22 ppm to 30 ppm. One of these units has a permit limit of 25 ppm NOx that was established prior to adoption of Rule 1147. This oven has been operating for more than seven years with this permit condition and demonstrates that a 25 ppm NOx emission limit is achieved in practice for convection ovens.

The remaining oven that was tested is used for cooking meat and has two cooking sections. The first section is a charbroiler and the second is a convective heating section using steam and heated air. The heated air in the second section is produced using an Eclipse Air Heat line burner. The NOx emission concentration from all burners for this unit was 33 ppm. This result demonstrates compliance with Rule 1153.1 NOx emission limits of 40 ppm and 60 ppm. However, given the design and purpose of this unit, the first section of this device is exempt from the emission limits of Rules 1147 and Rule 1153.1 because it is a charbroiler. The exemption for charbroiling in both Rules 1147 and 1153.1 was not taken into account when the emission test protocol was prepared for this unit.

The results for the 13 food ovens tested through the Rule 1147 program indicate that every type of food oven and burner comply with Rule 1153.1 NOx emission limits. In addition, convection ovens using air heating burners, ovens with radiant infrared burners and conveyor type food ovens with ribbon burners operating at less than 500 °F also comply with the Rule 1147 NOx emission limit of 30 ppm. Moreover, another conveyor oven with ribbon burners and a process temperature less than 500 °F was tested prior to Rule 1147 adoption and had NOx emissions of less than 30 ppm (Figure B-5, Appendix B).

Currently, there are projects funded by SEMPRA Energy and the California Energy Commission to reduce NOx emissions from ribbon burners used in commercial and residential cooking ovens. The data from the Rule 1147 and Rule 1153.1 emissions testing programs and these technology projects will provide staff with data to determine how Rule 1147 and Rule 1153.1 should be amended in the future to limit NOx emissions from new food ovens.

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APPENDIX B

RULE 1147 TASK FORCE MEETING HELD ON AUGUST 3, 2016

Appendix B, Attachment B-1

Agenda for Rule 1147 Task Force Meeting on August 3, 2016

Agenda

Rule 1147 Task Force Meeting

10:30 a.m., August 3, 2016
Room CC-2
SCAQMD Headquarters, Diamond Bar, CA

- Introductions
- Background
  - Rule 1147 History, Implementation and Associated Activity
  - SCAQMD Commitments Including Technology Assessment
- Summary of SCAQMD's Draft Technology Assessment
- ETS, Inc. Presentation
- Stakeholder Input on Draft Technology Assessment
- Future Activity
- Project Contact

Appendix B, Attachment B-2

Rule 1147 Task Force Meeting Presentation by SCAQMD Staff

Rule 1147 Task Force Meeting

August 3, 2016
10:30 AM
Conference Room CC-2
SCAQMD Headquarters, Diamond Bar, CA

Rule 1147 History

- Rule 1147 adopted December 2008 with a 10 year implementation schedule for existing equipment starting July 1, 2010
  - Units with NOx emissions > 1 pound/day phased in from July 1, 2010 to 2014 starting with equipment 25 years and older
  - Units with NOx emission ≤ 1 pound/day phased in 5 years later from July 1, 2015 to 2019 starting with equipment 30 years or older
- September 2010 amendment delayed compliance for the first two years of each category and removed requirement for timing or gas meter
  - Units with NOx emissions > 1 pound/day phased in from July 1, 2012 to 2014 starting with equipment 25 years and older
  - Units with NOx emission ≤ 1 pound/day phased in 5 years later (July 1, 2017 to 2019)
  - Included a requirement for a Technology Assessment of small and low use sources with NOx emissions ≤ 1 pound/day
- Amendment of Rules 219 & 222 for Construction & Portable Equipment
- Adoption of Rule 1153.1 for Food Ovens

Purpose

- Introduce the Contractor Reviewing the SCAQMD Technology Assessment -- ETS, Inc.
- Receive Input from Stakeholders on SCAQMD's Draft Technology Assessment
- Discuss Future Activities and Schedule

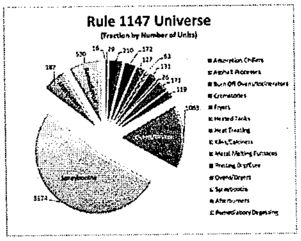
Commitments from September 2010 Rule Amendment

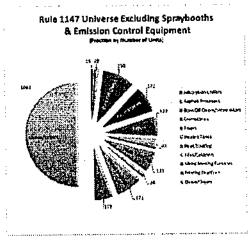
- September 2010 Rule Amendment Includes a Requirement to Perform a Technology Assessment of Small and Low Emission Sources (≤ 1 pound/day NOx)
- Board Resolution to Fund Technology Development if Low NOx Burners Not Available for Small Sources
- EO Commitment to 3rd Party Review of SCAQMD's Technology Assessment

Background

SCAQMD's Draft Technology Assessment

Types of Equipment Evaluated





Future Activities and Schedule

SCAQMD Technology Assessment Findings

- Technical Feasibility
  - The smallest low NOx burners available for low temperature sources are 400,000 to 500,000 Btu/hour
  - Retrofitting heated process tanks that do not comply with the NOx limit requires replacement of the whole system
  - A 30 ppm emission limit for the primary chamber of multi-chamber incinerators, burn-off ovens, burn-out furnaces and incinerators is not possible with the available burners
- Cost Effectiveness
  - Replacing heating systems on existing in-use spray booths to meet the NOx emission limit may result in a cost effectiveness higher than SCAQMD criteria used for minor sources
  - Retrofitting units with daily emissions of 1 pound/day or less to meet the NOx limit may result in a cost effectiveness higher than SCAQMD criteria used for minor sources

Future Activities and Schedule

- Summarize ETS Findings and Recommendations
- Revise Draft Technology Assessment, if Needed
- Report to SSC – October 2016
- Initiate Rule Development – October 2016
- Rule Amendment – Spring 2017

Presentation and Discussion with ETS, Inc.

Rule 1147 Contact

Wayne Barcikowski

wbarcikowski@aqmd.gov

909-396-3077

SCAQMD
21865 Copley Dr.
Diamond Bar, CA 91765

Appendix B, Attachment B-3

Rule 1147 Task Force Meeting Presentation by ETS, Inc.

Rule 1147
Task Force Meeting

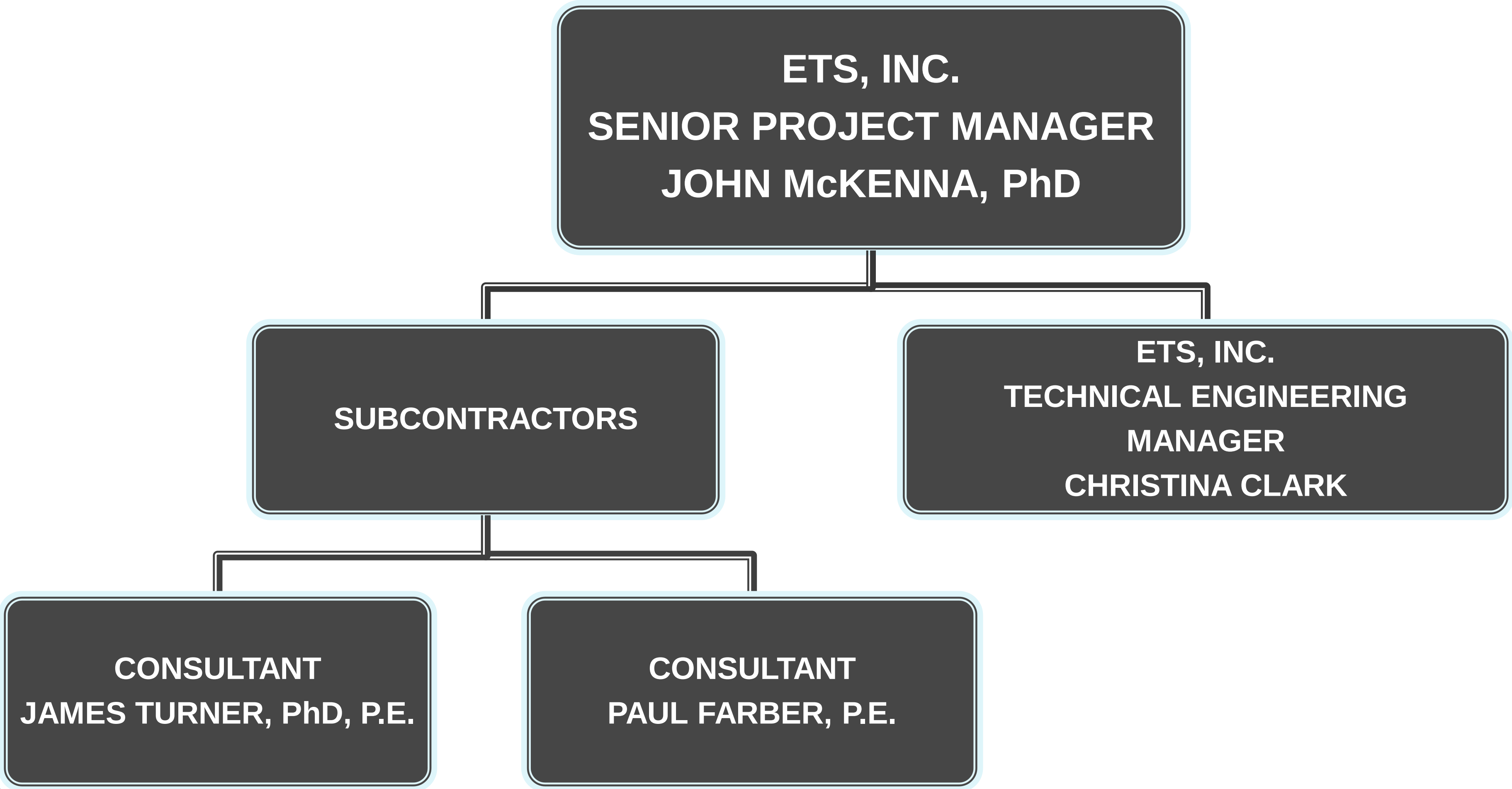
Independent Third Party Review of Draft Rule 1147 Technology Assessment for Small and Low Emission Sources

By ETS, Inc.

August 3, 2016

SCAQMD Headquarters

Project Organization Chart



Information Reviewed by ETS to Date

- SCAQMD *Rule 1147 – NOx Reductions from Miscellaneous Sources* (September 2011)
- SCAQMD *Draft Technology Assessment for Rule 1147 Small and Low Emission Sources* (February 2016)
- SCAQMD *Best Available Control Technology Guidelines (May 2016 Draft)*

Information Reviewed by ETS to Date

- Confidential Information Received:
  - SCAQMD Source Test Databases as of January 2015
  - Summary of Low and High Temp Burner Costs
  - Spray Booth Costs
  - Immersion Tube Heating and Metal Melt Furnace Calculations
  - Contacts for Low NOx Burner Manufacturers

Assumptions Made by ETS in Review

- Annual average NOx emissions by equipment category utilized in cost effectiveness calculations are representative
- Cost effectiveness calculations in the Draft Technology Assessment include total capital investment costs (i.e., price of the equipment, cost for shipping, engineering and installation) per burner
    - Total annual costs are assumed to be not applicable
    - Routine maintenance & equipment costs unrelated to control equipment excluded
    - Compliance demonstration costs are excluded
    - Costs due to compliance with other rules are excluded

Stakeholder Input on Rule 1147 Changes Under Consideration (1)

Exempt sources with total rated heat input less than 325,000 Btu/hour from the Rule 1147 NOx emission limit

- There are no burners in this size range for ovens and dryers that are designed to meet BACT and Rule 1147 emission limits
- The smallest low NOx air heating burners designed to comply with the 30 ppm NOx limit are 400,000 to 500,000 Btu/hour
- If this size burner is set up to operate at < 325,000 Btu/hour and used in oven that requires burner to frequently operate at heat inputs < 30% of capacity, then burner not likely to comply with 30 ppm emission limit
- Burners available in this size range for high temp. equipment; however, these applications (heat treating furnaces & kilns) typically use multiple small burners, total heat ratings > 325,000 Btu/hour, and must comply with emission limit of 60 ppm
- Change would affect unknown # of small units regulated by Rule 1147

Stakeholder Input on Rule 1147 Changes Under Consideration (2)

Delay compliance for existing in-use heated process tanks, evaporators and parts washers from the NOx emission limit until such time the combustion system or tank is modified, replaced or relocated

- New units would be required to meet the emission limit unless the total unit heat rating is less than or equal to 325,000 Btu/hour
- Source test information on three of the four available types of heating systems for these heated process tanks can comply with the emission limits; however, if a unit does not comply with the emission limit, the entire process tank must be replaced
- Staff estimates this change would affect less than 50 units subject to the Rule 1147 NOx emission limit

Stakeholder Input on Rule 1147 Changes Under Consideration (3)

Change the NOx emission limit from 30 ppm to 60 ppm NOx for the primary chamber of multi-chamber incinerators, burn-off ovens, burn-out furnaces and incinerators that operate below 800°F

- This new limit will be the same compliance limit required for higher temperatures
- The burner needed for the primary chamber of these devices is not designed to achieve 30 ppm
- This change would affect a small unknown number of units

Stakeholder Input on Rule 1147 Changes Under Consideration (4)

Delay compliance with the NOx emission limit for existing in-use spray booths until the heating system is modified, relocated

- Modified, relocated and new spray booths & prep stations would be required to meet emission limit at time of modification or installation unless the total unit heat rating is ≤ 325,000 Btu/hour; however, Staff is considering to evaluate existing in-use operations with multiple booths and locations separately from smaller operations with one location and single booths and prep stations.
- Cost effectiveness for a new unit that meets Rule 1147 NOx emission limit is at most $22,000 per ton. The cost effectiveness for retrofitting an existing unit can be as high as $88,000 per ton.
- Change will affect > 50% of units now subject to Rule 1147 emission limits
- Will result in delays in emission reductions of 0.3 to 0.4 tons/day starting July 1, 2017. These emission reductions forgone will be reduced as new units replace old units.

Stakeholder Input on Rule 1147 Changes Under Consideration (5)

Delay compliance with NOx emission limit for existing in-use units with actual NOx emissions of one pound per day or less until the combustion system is modified, relocated or replaced

- Staff considering to further evaluate operations with multiple small units whose emissions are significant. Unit emissions can be documented using gas or time meters and daily recordkeeping.
- Cost effectiveness for retrofitting low emission units varies considerably and can be significantly higher than the SCAQMD BACT Guidelines average cost effectiveness criteria for equipment for which BACT has not been defined.
- Change will affect at least one quarter of in-use units subject to Rule 1147 emission limit
- Will result in delays of emission reductions of about 0.3 to 0.5 tons/day starting on July 1, 2017. These forgone reductions will decrease as new units replace old units.

Stakeholder Input on Rule 1147 Changes

THANK YOU FOR THE INPUTS

Appendix B, Attachment B-4

Rule 1147 Task Force Meeting Sign-in Sheet

R. 1147 Task Force

Wednesday August 3, 2016– 10:30 AM (PT)

SCAQMD Headquarters | 21865 East Copley Drive, Diamond Bar, CA 91765 | Conference Room CC2

PLEASE PRINT LEGIBLY | SIGN-IN SHEETS MAY BE USED TO NOTIFY YOU OF FUTURE RULE RELATED WORKING-GROUPS AND HEARINGS
SIGN-IN SHEETS MAY BECOME PUBLIC RECORD | SIGNING-IN IS VOLUNTARY

South Coast AQMD

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Geoffrey Blake	MFASC		949 212 0770	
Glenn Kasai	AQMD		x 2271	
Barbara Radlein	AQMD		x2716	
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John McKenna	ETS, Inc.	" "	540-265-0004 x 293	jmck@etsi-inc.com

PAGE ___ OF ____

Appendix B, Attachment B-5

Business Cards Provided to SCAQMD at Rule 1147 Task Force Meeting

R. 1147 Task Force

Wednesday August 3, 2016– 10:30 AM (PT)

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SIGN-IN SHEETS MAY BECOME PUBLIC RECORD | SIGNING-IN IS VOLUNTARY

South Coast AQMD

Name:	Organization:	Address (including zip code)	Phone Number:	Email:

MARK ABRAMOWITZ ✓
Board Consultant to Dr. Joseph K. Lyou
Governing Board Member
Governor's Appointee

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recycled paper

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Appendix B, Attachment B-6

Business Cards Provided to ETS, Inc. at Rule 1147 Task Force Meeting

fdi

Anthony W. Endres
President

Furnace Dynamics, Inc.

Innovative Consulting And Furnace Designs For Industry

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APPENDIX C

INFORMATION RECEIVED FROM FURNACE DYNAMICS, INC. AT RULE 1147 TASK FORCE MEETING ON AUGUST 3, 2016

SUMMARY OF INFORMATION RECEIVED FROM FURNACE DYNAMICS, INC. AT RULE 1147 TASK FORCE MEETING

ITEM #	DESCRIPTION OF INFORMATION RECEIVED BY ETS	NAME/TITLE	COMPANY	ADDITIONAL RELEVANT INFORMATION	DATE RECEIVED BY ETS	FOLLOW-UP BY ETS
Information Received at Rule 1147 Task Force Meeting on 08/03/16 at SCAQMD Headquarters:						
1	Letter titled "A discussion on Potential to Emit (PTE)" with no specific addressee and dated 11/19/15	Anthony Endres, President	Furnace Dynamics, Inc.	Includes a series of charts with relationship of daily emissions vs. BTU input vs. hours of operation at a variety of different average firing rates.	08/03/16	ETS response in Section VIII.A of ETS Independent Technical Review Document
2	Letter titled "RE. Items of Concern Technology Assessment" addressed to Joe Cassmassi, Sr. Rules Manager, SCAQMD, dated 02/18/16	Anthony Endres, President	Furnace Dynamics, Inc.	Cursory review of the SCAQMD Rule 1147 Draft Technology Assessment	08/03/16	ETS response in Section VIII.B of ETS Independent Technical Review Document
3	One page sheet titled "SCAQMD Minor Source BACT Cost Effectiveness Calculation" - Type of Project: Smokehouse AB	Anthony Endres, President	Furnace Dynamics, Inc.		08/03/16	ETS response in Section VIII.C of ETS Independent Technical Review Document
4	One page sheet titled "SCAQMD Minor Source BACT Cost Effectiveness Calculation" - Type of Project: Afterburner	Anthony Endres, President	Furnace Dynamics, Inc.		08/03/16	ETS response in Section VIII.D of ETS Independent Technical Review Document

Appendix C, Attachment C-1

Stakeholder Item #1 – Furnace Dynamics, Inc.

Spoke at length, to Anthony Endres

Furnace dynamics, inc.
261 Euclid Ave.
Long Beach, CA 90803
562-433-3025

November 19, 2015

A discussion on Potential to Emit (PTE)

Potential to Emit is defined as the maximum amount of emissions that can be generated from a device operating at maximum capacity, 100% all of the time, twenty-four hours per day, seven days a week. On an annualized basis that number would be multiplied by 365 days per year. Whereas this is a relatively simplistic approach to determining emissions, it actually is impossible for devices to operate under these conditions. They can only operate under these conditions for relative short intervals when the equipment is first fired. The reason has to do with the fact that all of the devices in Rule 1147 are based on a defined operating temperature. This is true from forging, heat treating, metal melting, powder coating, crematories, cooking ovens, etc.

For example, I have designed combustion systems for over 120 furnaces in forging, heat treating and metal melting. Categorically, no device design is based on PTE. They are based on the objective for the process; the production throughput, operating temperatures, refractory losses, etc. It boils down to the net available heat to do work in the furnace or oven, after combustion losses balanced with the production of a given product.

On direct fired forge furnaces, the typical operating temperature range can be anywhere from 800F to as high as 2250°F and they can be in the same furnace. The theoretical flame temperature under optimal air fuel ratio conditions is between 3000°F and 3100°F. To put this into perspective, carbon steel in a molten state is cast at temperatures around 2900°F to 3050°F. Thus if operated in a typical high temperature furnace you could melt metal. Since the operating temperatures are dramatically less, the firing rate overall is consequently less. Since different alloys require tight control on operating temperatures, the heat input must be precisely maintained to not metallurgical destroy the parts contained in the furnaces. For instance, titanium is finish forged at 1750°F. If the temperature goes to 1825°F, the parts are scrap. It can thus be seen that it is impossible to operate at PTE without destroying parts. This goes for any operating range.

This is true regardless of the process albeit, in the metals industry, powder coating, burn off and a plethora of other processes covered in Rule 1147. They all provide heat input to match a specific set point temperature that are required to maintain the product quality necessary to satisfy customer needs. When looking at powder coating, the low NOx burners provide an operating temperature of between 300°F and 650°F, particular powder materials require tight temperature control. If that temperature is exceeded, the powder will be burnt, rendering the parts unusable. Due to the nature of oven burners and the necessity to achieve 30 ppm, the burners typically operate at higher amounts of excess air than high temperature operations. Even so, the actual flame temperatures can reach over 2000°F. Again, the PTE value would be incorrect to apply as a determinate consideration of emissions and thus pound per day emission profiles.

Actual Annual Use vs. PTE: To make the determination of actual vs. PTE, we acquired So. Cal Gas Company annual use in therms, converted them to millions of cubic feet, then got to total BTU/hr maximum input of each device in the plant and correlated the actual MMcf to the potential if operated at the maximum input, 24 hours per day on an annual basis. I conducted a study to determine the correlation of PTE to actual usage on two forge plants, one very large and a medium small shop. By the above method, the large forge facility was operating at a 25% of PTE. On the smaller facility there were gas consumption limits on all of their furnaces. The actuals were 19.6% of the permit limits which was well below the devices PTE. This facility was evaluated for actual annual vs. PTE and the results showed 10.82%. I have just completed an evaluation of a couple of powder coating companies. One had an actual annual, compared to PTE of 12%. Another powder coat facility showed a six-year average of 10.49%. during the six years the annual averages ranged from 9.16% to 11.99%. It is important to understand that these facilities were operating under normal production capabilities. Some companies are single shift, others are two shift and one is a three shift operation 5 days per week. I will be conducting additional analysis on a number of other facilities and forwarding those values to staff. However, I would believe the Actual compared to PTE is going to be in the 10% - 25% range.

Included Charts: I have included a series of charts that can provide a level of understanding of the relationship of daily emissions vs. BTU input vs. hours of operation at a variety of different average firing rates. The first charts are related to the SCAQMD default emission factor of 130#/MMcf natural gas or 101.4 ppm. The first chart shows the correlation of values assuming 100% of the capacity of the combustion system or PTE. The next three charts show the same correlations of firing rate to hours of operation at 50% of PTE and 20% of PTE. The fourth chart shows how high the BTU rating could be per hour of operation and still stay under 1#/day of NOx. The last three charts show the same data but based on a lower emission value of 60 ppm.

It can be seen the lower emission values reflect a substantially lower pound per day emission value. This is for illustrative value only. However, it should be understood that few devices operate anywhere near the default ppm values. In the last 3 years I have conducted approximately 175 pretests (mostly on 1147 devices) using a Testo 350 combustion analyzer. I have also parallel tested about 70 official source tests and my readings are typically less than 2 ppm deviation from the official source test results. I have yet to see any device that operated near the 101.4 ppm level. The lower temperature devices such as ovens are even lower relative to the default emission factor. Thus even with the values shown on the first 4 charts, the pound per day values are overstated.

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I believe a collaborative effort on behalf of District staff and industry representatives can arrive at a reasonable means of determining what constitutes one pound per day usage. Perhaps the simplest approach could be the use of non-resettable timers on devices, with a limit of X hours per day for a given BTU input. Obviously this would have to be backed up with logs of hours of operation that could be verified by an inspector. If, as was suggested in the 1147 Task Force Meeting, an exemption (or an extended compliance date) be given to devices operating at less than a pound per day, verification is essential. There could be other means of quantification of daily emissions – these need to be discussed in a meaningful way to determine what works for the District and industry.

As always, we appreciate the opportunity to work with staff to assist in developing a bridge of understanding of how industry actually operates. Should you have any questions regarding this subject, please feel free to engage me in a meaningful dialogue to assist in developing rules that relate to real-world conditions.

Sincerely,

Anthony Endres
President

Determination of <1#/day NOx Emissions At Maximum Firing Rate

Average Input: 100%

ppm NOx: 101.4

	Maximum BTU Input													
Hours Per Day	**200,000**	**250,000**	**300,000**	**350,000**	**400,000**	**450,000**	**500,000**	**550,000**	**600,000**	**800,000**	**900,000**	**1,000,000**	**1,500,000**	**2,000,000**
1	0.025	0.031	0.037	0.043	0.050	0.056	0.062	0.068	0.074	0.099	0.111	0.124	0.186	0.248
2	0.050	0.062	0.074	0.087	0.099	0.111	0.124	0.136	0.149	0.198	0.223	0.248	0.371	0.495
3	0.074	0.093	0.111	0.130	0.149	0.167	0.186	0.204	0.223	0.297	0.334	0.371	0.557	0.743
4	0.099	0.124	0.149	0.173	0.198	0.223	0.248	0.272	0.297	0.396	0.446	0.495	0.743	0.990
5	0.124	0.155	0.186	0.217	0.248	0.279	0.310	0.340	0.371	0.495	0.557	0.619	0.929	1.238
6	0.149	0.186	0.223	0.260	0.297	0.334	0.371	0.409	0.446	0.594	0.669	0.743	1.114	1.486
7	0.173	0.217	0.260	0.303	0.347	0.390	0.433	0.477	0.520	0.693	0.780	0.867	1.300	1.733
8	0.198	0.248	0.297	0.347	0.396	0.446	0.495	0.545	0.594	0.792	0.891	0.990	1.486	1.981
9	0.223	0.279	0.334	0.390	0.446	0.501	0.557	0.613	0.669	0.891	1.003	1.114	1.671	2.229
10	0.248	0.310	0.371	0.433	0.495	0.557	0.619	0.681	0.743	0.990	1.114	1.238	1.857	2.476
11	0.272	0.340	0.409	0.477	0.545	0.613	0.681	0.749	0.817	1.090	1.226	1.362	2.043	2.724
12	0.297	0.371	0.446	0.520	0.594	0.669	0.743	0.817	0.891	1.189	1.337	1.486	2.229	2.971
13	0.322	0.402	0.483	0.563	0.644	0.724	0.805	0.885	0.966	1.288	1.449	1.610	2.414	3.219
14	0.347	0.433	0.520	0.607	0.693	0.780	0.867	0.953	1.040	1.387	1.560	1.733	2.600	3.467
15	0.371	0.464	0.557	0.650	0.743	0.836	0.929	1.021	1.114	1.486	1.671	1.857	2.786	3.714
16	0.396	0.495	0.594	0.693	0.792	0.891	0.990	1.090	1.189	1.585	1.783	1.981	2.971	3.962
17	0.421	0.526	0.631	0.737	0.842	0.947	1.052	1.158	1.263	1.684	1.894	2.105	3.157	4.210
18	0.446	0.557	0.669	0.780	0.891	1.003	1.114	1.226	1.337	1.783	2.006	2.229	3.343	4.457
19	0.470	0.588	0.706	0.823	0.941	1.059	1.176	1.294	1.411	1.882	2.117	2.352	3.529	4.705
20	0.495	0.619	0.743	0.867	0.990	1.114	1.238	1.362	1.486	1.981	2.229	2.476	3.714	4.952
21	0.520	0.650	0.780	0.910	1.040	1.170	1.300	1.430	1.560	2.080	2.340	2.600	3.900	5.200
22	0.545	0.681	0.817	0.953	1.090	1.226	1.362	1.498	1.634	2.179	2.451	2.724	4.086	5.448
23	0.570	0.712	0.854	0.997	1.139	1.281	1.424	1.566	1.709	2.278	2.563	2.848	4.271	5.695
24	0.594	0.743	0.891	1.040	1.189	1.337	1.486	1.634	1.783	2.377	2.674	2.971	4.457	5.943

Notes:
1. BTU/CF = 1050
2. Emissions are based on the SCAQMD default value of 130#/MMCF or 101.4 ppm
3. All emissions are pound per day based on the hours per day operated.
4. Shaded areas indicate the operational values that exceed one pound per day
5. Formula is (BTU/1050) x pounds per million cubic feet/1,000,000 x hours of operation

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Determination of <1#/day NOx Emissions At Less Than 100% Firing Rate

Average Input: 50%

ppm NOx: 101.4

	Maximum BTU Input													
Hours Per Day	**200,000**	**250,000**	**300,000**	**350,000**	**400,000**	**450,000**	**500,000**	**550,000**	**600,000**	**800,000**	**900,000**	**1,000,000**	**1,500,000**	**2,000,000**
1	0.012	0.015	0.019	0.022	0.025	0.028	0.031	0.034	0.037	0.050	0.056	0.062	0.093	0.124
2	0.025	0.031	0.037	0.043	0.050	0.056	0.062	0.068	0.074	0.099	0.111	0.124	0.186	0.248
3	0.037	0.046	0.056	0.065	0.074	0.084	0.093	0.102	0.111	0.149	0.167	0.186	0.279	0.371
4	0.050	0.062	0.074	0.087	0.099	0.111	0.124	0.136	0.149	0.198	0.223	0.248	0.371	0.495
5	0.062	0.077	0.093	0.108	0.124	0.139	0.155	0.170	0.186	0.248	0.279	0.310	0.464	0.619
6	0.074	0.093	0.111	0.130	0.149	0.167	0.186	0.204	0.223	0.297	0.334	0.371	0.557	0.743
7	0.087	0.108	0.130	0.152	0.173	0.195	0.217	0.238	0.260	0.347	0.390	0.433	0.650	0.867
8	0.099	0.124	0.149	0.173	0.198	0.223	0.248	0.272	0.297	0.396	0.446	0.495	0.743	0.990
9	0.111	0.139	0.167	0.195	0.223	0.251	0.279	0.306	0.334	0.446	0.501	0.557	0.836	1.114
10	0.124	0.155	0.186	0.217	0.248	0.279	0.310	0.340	0.371	0.495	0.557	0.619	0.929	1.238
11	0.136	0.170	0.204	0.238	0.272	0.306	0.340	0.375	0.409	0.545	0.613	0.681	1.021	1.362
12	0.149	0.186	0.223	0.260	0.297	0.334	0.371	0.409	0.446	0.594	0.669	0.743	1.114	1.486
13	0.161	0.201	0.241	0.282	0.322	0.362	0.402	0.443	0.483	0.644	0.724	0.805	1.207	1.610
14	0.173	0.217	0.260	0.303	0.347	0.390	0.433	0.477	0.520	0.693	0.780	0.867	1.300	1.733
15	0.186	0.232	0.279	0.325	0.371	0.418	0.464	0.511	0.557	0.743	0.836	0.929	1.393	1.857
16	0.198	0.248	0.297	0.347	0.396	0.446	0.495	0.545	0.594	0.792	0.891	0.990	1.486	1.981
17	0.210	0.263	0.316	0.368	0.421	0.474	0.526	0.579	0.631	0.842	0.947	1.052	1.579	2.105
18	0.223	0.279	0.334	0.390	0.446	0.501	0.557	0.613	0.669	0.891	1.003	1.114	1.671	2.229
19	0.235	0.294	0.353	0.412	0.470	0.529	0.588	0.647	0.706	0.941	1.059	1.176	1.764	2.352
20	0.248	0.310	0.371	0.433	0.495	0.557	0.619	0.681	0.743	0.990	1.114	1.238	1.857	2.476
21	0.260	0.325	0.390	0.455	0.520	0.585	0.650	0.715	0.780	1.040	1.170	1.300	1.950	2.600
22	0.272	0.340	0.409	0.477	0.545	0.613	0.681	0.749	0.817	1.090	1.226	1.362	2.043	2.724
23	0.285	0.356	0.427	0.498	0.570	0.641	0.712	0.783	0.854	1.139	1.281	1.424	2.136	2.848
24	0.297	0.371	0.446	0.520	0.594	0.669	0.743	0.817	0.891	1.189	1.337	1.486	2.229	2.971

Notes:
1. BTU/CF = 1050
2. Emissions are based on the SCAQMD default value of 130#/MMCF or 101.4 ppm
3. All emissions are pound per day based on the hours per day operated.
4. Shaded areas indicate the operational values that exceed one pound per day
5. Formula is (BTU/1050) x pounds per million cubic feet /1,000,000 x hours of operation x percent of maximum firing rate

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Determination of <1#/day NOx Emissions At Less Than 100% Firing Rate

Average Input: 20%

ppm NOx: 101.4

	Maximum BTU Input													
Hours Per Day	**200,000**	**250,000**	**300,000**	**350,000**	**400,000**	**450,000**	**500,000**	**550,000**	**600,000**	**800,000**	**900,000**	**1,000,000**	**1,500,000**	**2,000,000**
1	0.005	0.006	0.007	0.009	0.010	0.011	0.012	0.014	0.015	0.020	0.022	0.025	0.037	0.050
2	0.010	0.012	0.015	0.017	0.020	0.022	0.025	0.027	0.030	0.040	0.045	0.050	0.074	0.099
3	0.015	0.019	0.022	0.026	0.030	0.033	0.037	0.041	0.045	0.059	0.067	0.074	0.111	0.149
4	0.020	0.025	0.030	0.035	0.040	0.045	0.050	0.054	0.059	0.079	0.089	0.099	0.149	0.198
5	0.025	0.031	0.037	0.043	0.050	0.056	0.062	0.068	0.074	0.099	0.111	0.124	0.186	0.248
6	0.030	0.037	0.045	0.052	0.059	0.067	0.074	0.082	0.089	0.119	0.134	0.149	0.223	0.297
7	0.035	0.043	0.052	0.061	0.069	0.078	0.087	0.095	0.104	0.139	0.156	0.173	0.260	0.347
8	0.040	0.050	0.059	0.069	0.079	0.089	0.099	0.109	0.119	0.158	0.178	0.198	0.297	0.396
9	0.045	0.056	0.067	0.078	0.089	0.100	0.111	0.123	0.134	0.178	0.201	0.223	0.334	0.446
10	0.050	0.062	0.074	0.087	0.099	0.111	0.124	0.136	0.149	0.198	0.223	0.248	0.371	0.495
11	0.054	0.068	0.082	0.095	0.109	0.123	0.136	0.150	0.163	0.218	0.245	0.272	0.409	0.545
12	0.059	0.074	0.089	0.104	0.119	0.134	0.149	0.163	0.178	0.238	0.267	0.297	0.446	0.594
13	0.064	0.080	0.097	0.113	0.129	0.145	0.161	0.177	0.193	0.258	0.290	0.322	0.483	0.644
14	0.069	0.087	0.104	0.121	0.139	0.156	0.173	0.191	0.208	0.277	0.312	0.347	0.520	0.693
15	0.074	0.093	0.111	0.130	0.149	0.167	0.186	0.204	0.223	0.297	0.334	0.371	0.557	0.743
16	0.079	0.099	0.119	0.139	0.158	0.178	0.198	0.218	0.238	0.317	0.357	0.396	0.594	0.792
17	0.084	0.105	0.126	0.147	0.168	0.189	0.210	0.232	0.253	0.337	0.379	0.421	0.631	0.842
18	0.089	0.111	0.134	0.156	0.178	0.201	0.223	0.245	0.267	0.357	0.401	0.446	0.669	0.891
19	0.094	0.118	0.141	0.165	0.188	0.212	0.235	0.259	0.282	0.376	0.423	0.470	0.706	0.941
20	0.099	0.124	0.149	0.173	0.198	0.223	0.248	0.272	0.297	0.396	0.446	0.495	0.743	0.990
21	0.104	0.130	0.156	0.182	0.208	0.234	0.260	0.286	0.312	0.416	0.468	0.520	0.780	1.040
22	0.109	0.136	0.163	0.191	0.218	0.245	0.272	0.300	0.327	0.436	0.490	0.545	0.817	1.090
23	0.114	0.142	0.171	0.199	0.228	0.256	0.285	0.313	0.342	0.456	0.513	0.570	0.854	1.139
24	0.119	0.149	0.178	0.208	0.238	0.267	0.297	0.327	0.357	0.475	0.535	0.594	0.891	1.189

Notes:
1. BTU/CF = 1050
2. Emissions are based on the SCAQMD default value of 130#/MMCF or 101.4 ppm
3. All emissions are pound per day based on the hours per day operated.
4. Shaded areas indicate the operational values that exceed one pound per day
5. Formula is (BTU/1050) x pounds per million cubic feet/1000000 x hours of operation x percent of maximum firing rate

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Determination of <1#/day NOx Emissions At Less Than 100% Firing Rate

Average Input: 20%

ppm NOx: 101.4

Hours Per Day	Maximum BTU Input													
	1,000,000	1,200,000	1,400,000	1,600,000	1,800,000	2,000,000	2,200,000	2,400,000	2,600,000	2,800,000	3,000,000	3,200,000	3,400,000	3,600,000
1	0.025	0.030	0.035	0.040	0.045	0.050	0.054	0.059	0.064	0.069	0.074	0.079	0.084	0.089
2	0.050	0.059	0.069	0.079	0.089	0.099	0.109	0.119	0.129	0.139	0.149	0.158	0.168	0.178
3	0.074	0.089	0.104	0.119	0.134	0.149	0.163	0.178	0.193	0.208	0.223	0.238	0.253	0.267
4	0.099	0.119	0.139	0.158	0.178	0.198	0.218	0.238	0.258	0.277	0.297	0.317	0.337	0.357
5	0.124	0.149	0.173	0.198	0.223	0.248	0.272	0.297	0.322	0.347	0.371	0.396	0.421	0.446
6	0.149	0.178	0.208	0.238	0.267	0.297	0.327	0.357	0.386	0.416	0.446	0.475	0.505	0.535
7	0.173	0.208	0.243	0.277	0.312	0.347	0.381	0.416	0.451	0.485	0.520	0.555	0.589	0.624
8	0.198	0.238	0.277	0.317	0.357	0.396	0.436	0.475	0.515	0.555	0.594	0.634	0.674	0.713
9	0.223	0.267	0.312	0.357	0.401	0.446	0.490	0.535	0.579	0.624	0.669	0.713	0.758	0.802
10	0.248	0.297	0.347	0.396	0.446	0.495	0.545	0.594	0.644	0.693	0.743	0.792	0.842	0.891
11	0.272	0.327	0.381	0.436	0.490	0.545	0.599	0.654	0.708	0.763	0.817	0.872	0.926	0.981
12	0.297	0.357	0.416	0.475	0.535	0.594	0.654	0.713	0.773	0.832	0.891	0.951	1.010	1.070
13	0.322	0.386	0.451	0.515	0.579	0.644	0.708	0.773	0.837	0.901	0.966	1.030	1.094	1.159
14	0.347	0.416	0.485	0.555	0.624	0.693	0.763	0.832	0.901	0.971	1.040	1.109	1.179	1.248
15	0.371	0.446	0.520	0.594	0.669	0.743	0.817	0.891	0.966	1.040	1.114	1.189	1.263	1.337
16	0.396	0.475	0.555	0.634	0.713	0.792	0.872	0.951	1.030	1.109	1.189	1.268	1.347	1.426
17	0.421	0.505	0.589	0.674	0.758	0.842	0.926	1.010	1.094	1.179	1.263	1.347	1.431	1.515
18	0.446	0.535	0.624	0.713	0.802	0.891	0.981	1.070	1.159	1.248	1.337	1.426	1.515	1.605
19	0.470	0.565	0.659	0.753	0.847	0.941	1.035	1.129	1.223	1.317	1.411	1.506	1.600	1.694
20	0.495	0.594	0.693	0.792	0.891	0.990	1.090	1.189	1.288	1.387	1.486	1.585	1.684	1.783
21	0.520	0.624	0.728	0.832	0.936	1.040	1.144	1.248	1.352	1.456	1.560	1.664	1.768	1.872
22	0.545	0.654	0.763	0.872	0.981	1.090	1.198	1.307	1.416	1.525	1.634	1.743	1.852	1.961
23	0.570	0.683	0.797	0.911	1.025	1.139	1.253	1.367	1.481	1.595	1.709	1.822	1.936	2.050
24	0.594	0.713	0.832	0.951	1.070	1.189	1.307	1.426	1.545	1.664	1.783	1.902	2.021	2.139

Notes:

1. BTU/CF = 1050
2. Emissions are based on the SCAQMD default value of 130#/MMCF or 101.4 ppm
3. All emissions are pound per day based on the hours per day operated.
4. Shaded areas indicate the operational values that exceed one pound per day
5. Formula is (BTU/1050) x pounds per million cubic feet/1000000 x hours of operation x percent of maximum firing rate

Prepared by:

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Furnace Dynamics, Inc.
261 Euclid Ave. Long Beach, CA 90803
562-433-3025
Email: awefdi@gmail.com

Determination of <1#/day NOx Emissions At Maximum Firing Rate

Average Input: 100%

NOx ppm: 60

	Maximum BTU Input													
Hours Per Day	**200,000**	**250,000**	**300,000**	**350,000**	**400,000**	**450,000**	**500,000**	**550,000**	**600,000**	**800,000**	**900,000**	**1,000,000**	**1,500,000**	**2,000,000**
1	0.011	0.014	0.017	0.020	0.023	0.026	0.029	0.031	0.034	0.046	0.051	0.057	0.086	0.114
2	0.023	0.029	0.034	0.040	0.046	0.051	0.057	0.063	0.069	0.091	0.103	0.114	0.171	0.229
3	0.034	0.043	0.051	0.060	0.069	0.077	0.086	0.094	0.103	0.137	0.154	0.171	0.257	0.343
4	0.046	0.057	0.069	0.080	0.091	0.103	0.114	0.126	0.137	0.183	0.206	0.229	0.343	0.457
5	0.057	0.071	0.086	0.100	0.114	0.129	0.143	0.157	0.171	0.229	0.257	0.286	0.429	0.571
6	0.069	0.086	0.103	0.120	0.137	0.154	0.171	0.189	0.206	0.274	0.309	0.343	0.514	0.686
7	0.080	0.100	0.120	0.140	0.160	0.180	0.200	0.220	0.240	0.320	0.360	0.400	0.600	0.800
8	0.091	0.114	0.137	0.160	0.183	0.206	0.229	0.251	0.274	0.366	0.411	0.457	0.686	0.914
9	0.103	0.129	0.154	0.180	0.206	0.231	0.257	0.283	0.309	0.411	0.463	0.514	0.771	1.029
10	0.114	0.143	0.171	0.200	0.229	0.257	0.286	0.314	0.343	0.457	0.514	0.571	0.857	1.143
11	0.126	0.157	0.189	0.220	0.251	0.283	0.314	0.346	0.377	0.503	0.566	0.629	0.943	1.257
12	0.137	0.171	0.206	0.240	0.274	0.309	0.343	0.377	0.411	0.549	0.617	0.686	1.029	1.371
13	0.149	0.186	0.223	0.260	0.297	0.334	0.371	0.409	0.446	0.594	0.669	0.743	1.114	1.486
14	0.160	0.200	0.240	0.280	0.320	0.360	0.400	0.440	0.480	0.640	0.720	0.800	1.200	1.600
15	0.171	0.214	0.257	0.300	0.343	0.386	0.429	0.471	0.514	0.686	0.771	0.857	1.286	1.714
16	0.183	0.229	0.274	0.320	0.366	0.411	0.457	0.503	0.549	0.731	0.823	0.914	1.371	1.829
17	0.194	0.243	0.291	0.340	0.389	0.437	0.486	0.534	0.583	0.777	0.874	0.971	1.457	1.943
18	0.206	0.257	0.309	0.360	0.411	0.463	0.514	0.566	0.617	0.823	0.926	1.029	1.543	2.057
19	0.217	0.271	0.326	0.380	0.434	0.489	0.543	0.597	0.651	0.869	0.977	1.086	1.629	2.171
20	0.229	0.286	0.343	0.400	0.457	0.514	0.571	0.629	0.686	0.914	1.029	1.143	1.714	2.286
21	0.240	0.300	0.360	0.420	0.480	0.540	0.600	0.660	0.720	0.960	1.080	1.200	1.800	2.400
22	0.251	0.314	0.377	0.440	0.503	0.566	0.629	0.691	0.754	1.006	1.131	1.257	1.886	2.514
23	0.263	0.329	0.394	0.460	0.526	0.591	0.657	0.723	0.789	1.051	1.183	1.314	1.971	2.629
24	0.274	0.343	0.411	0.480	0.549	0.617	0.686	0.754	0.823	1.097	1.234	1.371	2.057	2.743

Notes:

1. BTU/CF = 1050
2. Emissions are based on the "NOx ppm ___" value.
3. All emissions are pound per day based on the hours per day operated.
4. Shaded areas indicate the operational values that exceed one pound per day
5. Formula is (BTU/1050) x pounds per million cubic feet/1,000,000 x hours of operation

Prepared by:
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Determination of <1#/day NOx Emissions At Less Than 100% Firing Rate

Average Input: 50%

NOx ppm: 60

	Maximum BTU Input													
Hours Per Day	**200,000**	**250,000**	**300,000**	**350,000**	**400,000**	**450,000**	**500,000**	**550,000**	**600,000**	**800,000**	**900,000**	**1,000,000**	**1,500,000**	**2,000,000**
1	0.006	0.007	0.009	0.010	0.011	0.013	0.014	0.016	0.017	0.023	0.026	0.029	0.043	0.057
2	0.011	0.014	0.017	0.020	0.023	0.026	0.029	0.031	0.034	0.046	0.051	0.057	0.086	0.114
3	0.017	0.021	0.026	0.030	0.034	0.039	0.043	0.047	0.051	0.069	0.077	0.086	0.129	0.171
4	0.023	0.029	0.034	0.040	0.046	0.051	0.057	0.063	0.069	0.091	0.103	0.114	0.171	0.229
5	0.029	0.036	0.043	0.050	0.057	0.064	0.071	0.079	0.086	0.114	0.129	0.143	0.214	0.286
6	0.034	0.043	0.051	0.060	0.069	0.077	0.086	0.094	0.103	0.137	0.154	0.171	0.257	0.343
7	0.040	0.050	0.060	0.070	0.080	0.090	0.100	0.110	0.120	0.160	0.180	0.200	0.300	0.400
8	0.046	0.057	0.069	0.080	0.091	0.103	0.114	0.126	0.137	0.183	0.206	0.229	0.343	0.457
9	0.051	0.064	0.077	0.090	0.103	0.116	0.129	0.141	0.154	0.206	0.231	0.257	0.386	0.514
10	0.057	0.071	0.086	0.100	0.114	0.129	0.143	0.157	0.171	0.229	0.257	0.286	0.429	0.571
11	0.063	0.079	0.094	0.110	0.126	0.141	0.157	0.173	0.189	0.251	0.283	0.314	0.471	0.629
12	0.069	0.086	0.103	0.120	0.137	0.154	0.171	0.189	0.206	0.274	0.309	0.343	0.514	0.686
13	0.074	0.093	0.111	0.130	0.149	0.167	0.186	0.204	0.223	0.297	0.334	0.371	0.557	0.743
14	0.080	0.100	0.120	0.140	0.160	0.180	0.200	0.220	0.240	0.320	0.360	0.400	0.600	0.800
15	0.086	0.107	0.129	0.150	0.171	0.193	0.214	0.236	0.257	0.343	0.386	0.429	0.643	0.857
16	0.091	0.114	0.137	0.160	0.183	0.206	0.229	0.251	0.274	0.366	0.411	0.457	0.686	0.914
17	0.097	0.121	0.146	0.170	0.194	0.219	0.243	0.267	0.291	0.389	0.437	0.486	0.729	0.971
18	0.103	0.129	0.154	0.180	0.206	0.231	0.257	0.283	0.309	0.411	0.463	0.514	0.771	1.029
19	0.109	0.136	0.163	0.190	0.217	0.244	0.271	0.299	0.326	0.434	0.489	0.543	0.814	1.086
20	0.114	0.143	0.171	0.200	0.229	0.257	0.286	0.314	0.343	0.457	0.514	0.571	0.857	1.143
21	0.120	0.150	0.180	0.210	0.240	0.270	0.300	0.330	0.360	0.480	0.540	0.600	0.900	1.200
22	0.126	0.157	0.189	0.220	0.251	0.283	0.314	0.346	0.377	0.503	0.566	0.629	0.943	1.257
23	0.131	0.164	0.197	0.230	0.263	0.296	0.329	0.361	0.394	0.526	0.591	0.657	0.986	1.314
24	0.137	0.171	0.206	0.240	0.274	0.309	0.343	0.377	0.411	0.549	0.617	0.686	1.029	1.371

Notes:

1. BTU/CF = 1050
2. Emissions are based on the SCAQMD default value of 130#/MMCF or 101.4 ppm
3. All emissions are pound per day based on the hours per day operated.
4. Shaded areas indicate the operational values that exceed one pound per day
5. Formula is (BTU/1050) x pounds per million cubic feet /1,000,000 x hours of operation x percent of maximum firing rate

Prepared by:

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Determination of <1#/day NOx Emissions At Less Than 100% Firing Rate

Average Input: 20%

NOx ppm: 60

	Maximum BTU Input													
Hours Per Day	**200,000**	**250,000**	**300,000**	**350,000**	**400,000**	**450,000**	**500,000**	**550,000**	**600,000**	**800,000**	**900,000**	**1,000,000**	**1,500,000**	**2,000,000**
1	0.002	0.003	0.003	0.004	0.005	0.005	0.006	0.006	0.007	0.009	0.010	0.011	0.017	0.023
2	0.005	0.006	0.007	0.008	0.009	0.010	0.011	0.013	0.014	0.018	0.021	0.023	0.034	0.046
3	0.007	0.009	0.010	0.012	0.014	0.015	0.017	0.019	0.021	0.027	0.031	0.034	0.051	0.069
4	0.009	0.011	0.014	0.016	0.018	0.021	0.023	0.025	0.027	0.037	0.041	0.046	0.069	0.091
5	0.011	0.014	0.017	0.020	0.023	0.026	0.029	0.031	0.034	0.046	0.051	0.057	0.086	0.114
6	0.014	0.017	0.021	0.024	0.027	0.031	0.034	0.038	0.041	0.055	0.062	0.069	0.103	0.137
7	0.016	0.020	0.024	0.028	0.032	0.036	0.040	0.044	0.048	0.064	0.072	0.080	0.120	0.160
8	0.018	0.023	0.027	0.032	0.037	0.041	0.046	0.050	0.055	0.073	0.082	0.091	0.137	0.183
9	0.021	0.026	0.031	0.036	0.041	0.046	0.051	0.057	0.062	0.082	0.093	0.103	0.154	0.206
10	0.023	0.029	0.034	0.040	0.046	0.051	0.057	0.063	0.069	0.091	0.103	0.114	0.171	0.229
11	0.025	0.031	0.038	0.044	0.050	0.057	0.063	0.069	0.075	0.101	0.113	0.126	0.189	0.251
12	0.027	0.034	0.041	0.048	0.055	0.062	0.069	0.075	0.082	0.110	0.123	0.137	0.206	0.274
13	0.030	0.037	0.045	0.052	0.059	0.067	0.074	0.082	0.089	0.119	0.134	0.149	0.223	0.297
14	0.032	0.040	0.048	0.056	0.064	0.072	0.080	0.088	0.096	0.128	0.144	0.160	0.240	0.320
15	0.034	0.043	0.051	0.060	0.069	0.077	0.086	0.094	0.103	0.137	0.154	0.171	0.257	0.343
16	0.037	0.046	0.055	0.064	0.073	0.082	0.091	0.101	0.110	0.146	0.165	0.183	0.274	0.366
17	0.039	0.049	0.058	0.068	0.078	0.087	0.097	0.107	0.117	0.155	0.175	0.194	0.291	0.389
18	0.041	0.051	0.062	0.072	0.082	0.093	0.103	0.113	0.123	0.165	0.185	0.206	0.309	0.411
19	0.043	0.054	0.065	0.076	0.087	0.098	0.109	0.119	0.130	0.174	0.195	0.217	0.326	0.434
20	0.046	0.057	0.069	0.080	0.091	0.103	0.114	0.126	0.137	0.183	0.206	0.229	0.343	0.457
21	0.048	0.060	0.072	0.084	0.096	0.108	0.120	0.132	0.144	0.192	0.216	0.240	0.360	0.480
22	0.050	0.063	0.075	0.088	0.101	0.113	0.126	0.138	0.151	0.201	0.226	0.251	0.377	0.503
23	0.053	0.066	0.079	0.092	0.105	0.118	0.131	0.145	0.158	0.210	0.237	0.263	0.394	0.526
24	0.055	0.069	0.082	0.096	0.110	0.123	0.137	0.151	0.165	0.219	0.247	0.274	0.411	0.549

Notes:
1. BTU/CF = 1050
2. Emissions are based on the SCAQMD default value of 130#/MMCF or 101.4 ppm
3. All emissions are pound per day based on the hours per day operated.
4. Shaded areas indicate the operational values that exceed one pound per day
5. Formula is (BTU/1050) x pounds per million cubic feet/1000000 x hours of operation x percent of maximum firing rate

Prepared by:

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Appendix C, Attachment C-2

Stakeholder Item #2 – Furnace Dynamics, Inc.

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261 Euclid Ave.
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562-433-3025

February 18, 2016

Mr. Joe Cassmassi
Sr. Rules Manager
South Coast Air Quality Management District
21865 Copley Drive
Diamond Bar, CA 91765

RE. Items of Concern Technology Assessment

Dear Joe,

I have conducted a cursory review of the Draft Technology Assessment and have provided some comments below. Whereas, this is a significant document, more analysis is necessary. I believe this is a start toward a more complete review.

Enforcement Considerations:

1. Between July 2010 and the announcement that Rule 1147 was to be revised, there were a number of NOVs and NCs issued to permit holders. Once the rule revision was announced, all of the notices were rescinded through prosecutorial discretion authorized by the Executive Officer. Since we are at the same crossroads pursuant to the pending rule change and the pending rule change will render many of the existing NOVs null and void, it is requested that these existing NOVs be rescinded until after the final rule changes are made and approved by the Governing Board.
2. Delay any enforcement action until after the rule is modified so the notices will be appropriate to the new rule change.

Cost Effectiveness

1. ***Excluded Costs.*** There was an exclusion of replacement components in burner systems. Whereas, this is may be appropriate for boilers and other types of devices such as radiant tubes, the issue is with burner cans for low NOx recirculation type burners such as the Eclipse Winnox burners. These burners replaced non low NOx burners that did not have issues with burner cans. We

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have found that these burner cans need to be replaced, usually in 3-10 years. Cost of the can is between $2.5K – $5K plus installation which can run a couple of thousands. The replacement requires two technicians to remove the burners from the oven, that includes disconnecting the electrical and plumbing from the burner, removing the old burner can, installing the new burner can, re installing the burner on the oven, reconnecting the electrical and plumbing then test firing. Therefore since this is not associated with a normal existing operation it needs to be included in the cost effectiveness considerations relating to maintenance costs.

2. ***Evaluation of cost effectiveness methods***. Staff has indicted that the cost effectiveness was based on the differential between the cost of an existing burner vs. the cost of a new low NOx burner. This is not a valid consideration in that this is a replacement rule and would only apply to the very few cases where the existing burner was scheduled for replacement and not to the general population of equipment covered under 1147.
3. ***Methods of Determining Cost Effectiveness.*** The Technology Assessment cites a number of methods for determining the cost effectiveness of the devices contained within the rule structure. We believe this should be simplified so a single cost effective methodology is utilized for all 1147 devices. It is recommended that the 2006 SCAQMD Best Available Control Technology Guidelines, Part C: Policy and Procedures for Non-Major Polluting Facilities shown on Appendix D Attachment 1 – 4 be used.
4. ***Maximum Acceptable Cost Effectiveness***. Since there are a significant number of devices in many different industries, there exists some significant differences in the actual cost effectiveness. Some devices have minimal use compared to other devices within the same category. These should be considered on a case by case basis. Consider that the RECLAIM Program must be reevaluated if the cost effectiveness exceeds $25,000 per controlled ton. Yet there is no constraint as to the cost effectiveness of devices contained in Rule 1147. These are also small facilities with few clients compared to the large companies in the RECLAIM Program who, in many cases, like utilities have millions of customers and can easily distribute the cost of reduction to a point where the relative impact is inconsequential. We are therefore recommending a fixed maximum cost effectiveness level be established so it would be not disproportionately affect small industries. We would recommend an absolute value of $30,000/controlled

ton. With the methodology for calculating contained in Appendix D Attachment 1-4.

Burners Mentioned:

1. We have had very good results with Eclipse Winnox burners for low temperature recirculation types of ovens. Another burner mentioned was a Maxon Cyclomax. Winnox burners have all passed source tests. When we pretested a Cyclomax burner, the NOx values at 100% were 25 ppm, as the set point was reached and the burner turned down, the NOx went up to around 95 ppm. The turndown on the burner was about 3:1. Thus, the burner had to be replaced even though the original Cyclomax burner was classified and purchased as a low NOx burner. One of the inherent problems with the new "low NOx" burners is the limited turndown to maintain emission values.
2. Whereas, there has been discussions of increased efficiency with the installation of new low NOx burners, the opposite can also be true due to the manufacturers having to use more excess air to lower flame temperatures and thus reduce NOx. If the existing burner is ratio fired and the new burner has to use 60 – 80% excess air to achieve the emission reductions, the total gas usage can actually increase. This becomes a problem if the existing burner is just marginally over the 1147 limit, the new burner that is installed can actually put more pollution into the air even with lower NOx values due to efficiency losses.
3. Other burners mentioned in the Technology Assessment (outside of the major manufacturers) are specific use burners and can only be used in very specific applications.

PTE:

4. Since PTE assumes maximum BTU input, 24 hours per day and no devices operate under those conditions, a better method of determination is necessary. A simple methodology by using reference charts and dialogue sent to staff for determining #/day is the most sensible approach.
5. The use of non-resettable timer for small units can satisfy this analysis
6. We evaluated a facility that operates 24/7 heating tanks with on/off temp control. Based on therms used to PTE they operate at about 15% PTE

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7. Many other examples exist of actual use vs. PTE show a range of 10.49% - 25% of PTE

Rule Compliance Date Issues

1. Will the compliance dates be extended due to substantial rule changes?
2. If there is a 2016 compliance date for a device that will be effected by the rule change, can the proposed rule changes be applied?

Mitigation Fee

1. Extremely costly related to RTCs considering a typical RTC is going for about $0.60/lb. The Mitigation fee of $10.50/pound for a 3-year period, to be paid for by the permit holder is not comparable with other programs and after the fee is paid, the installation is still required which can significantly increase the cost of reduction. This issue should be taken up in the rule development phase of the modification to Rule 1147.
2. We need to explore another alternative method of offsetting emissions for low emitting sources. This again places a disproportionate economic burden on small business.
3. Consider a non-RECLAIM method of funding cost effective projects

We appreciate your consideration of the above and look forward working with staff in the ongoing efforts to address the considerable issues relating to Rule 1147.

Sincerely,

Anthony W. Endres
President

Appendix C, Attachment C-3

Stakeholder Item #3 – Furnace Dynamics, Inc.

SCAQMD MINOR SOURCE BACT
COST EFFECTIVENESS CALCULATION

Type of Project		**Smokehouse AB**	
Use			
Hours per Day		1.55	
Days per Week		5	
Weeks per Year		20	
Annual Hours of Use		155	Hours
Gross Input BTU/hr		260,000	BTU/hr
Average Input (%)		100%	% Input
Average BTU Input		260,000	BTU/hr
Starting Emissions		101.4	ppm
Pounds/MMCF		130.00	#/MMCF
Pounds per Hour		0.032	
Pounds per Day		0.050	
Annual Emissions		**4.99**	**# NOx/Year**
Modified Source Emissions			
Average Input (%)		100%	% Input
Average BTU Input		260,000	
Starting Emissions		30	ppm
Pounds/MMCF		38.46	#/MMCF
Pounds per Hour		0.010	
Pounds per Day		0.015	
Annual Emissions		1	# NOx/Year
Annual Reduced Emissions		**4**	**# NOx/year**
Annual Tons Reduced		0.002	**T/Y Reduced**
10 Year Emissions Reduction		0.018	**Tons**
Equipment Costs			
Burners	$	30,000	
Engineering			
Piping Costs			
Installation Costs	$	1,500	
Refractory Cost			
Start Up Costs			
Gas Meter & Gages	$	-	
Permit to Construct Fee	$	2,200	
Source Test Evaluation Fee	$	611	
Source Test	$	3,000	
Equipment Cost	**$**	**37,311**	
Annual Costs			
Periodic Maintenance	$	400	per year
Annual ST Fee	$	100	per year
Total Annual Cost	$	500	
Cost 10 Year Cost	$	5,000	
Annual Cost (10 year average)	**$**	**500**	
DCF Cost Per Ton Reduced	**$**	**2,354,801**	

Appendix C, Attachment C-4

Stakeholder Item #4 – Furnace Dynamics, Inc.

SCAQMD MINOR SOURCE BACT
COST EFFECTIVENESS CALCULATION

Type of Project	**Afterburner**	
Use		
Hours per Day	9	
Days per Week	0.9	
Weeks per Year	50	
Annual Hours of Use	405	Hours
Gross Input BTU/hr	5,000,000	BTU/hr
Average Input (%)	30%	% Input
Average BTU Input	1,500,000	BTU/hr
Starting Emissions	101.4	ppm
Pounds/MMCF	130.00	#/MMCF
Pounds per Hour	0.186	
Pounds per Day	1.671	
Annual Emissions	**75**	**# NOx/Year**
Modified Source Emissions		
Average Input (%)	30%	% Input
Average BTU Input	1,500,000	
Starting Emissions	60	ppm
Pounds/MMCF	76.92	#/MMCF
Pounds per Hour	0.110	
Pounds per Day	0.989	
Annual Emissions	45	# NOx/Year
Annual Reduced Emissions	**31**	**# NOx/year**
Annual Tons Reduced	0.015	**T/Y Reduced**
10 Year Emissions Reduction	0.154	**Tons**
10 Year Emissions Reduction	307	**Pounds**

Equipment Costs		
Burners	$	110,000
Engineering		
Piping Costs		
Installation Costs		
Refractory Cost		
Start Up Costs		
Gas Meter & Gages	$	2,500
Permit to Construct Fee		
Source Test Evaluation Fee	$	611
Source Test	$	2,500
Equipment Cost	**$**	**115,611**

Annual Costs			
Periodic Maintenance	$	500	per year
Annual ST Fee	$	100	per year
Total Annual Cost	$	600	
Cost 10 Year Cost	$	6,000	
Annual Cost (10 year average)	**$**	**600**	

DCF Cost Per Ton Reduced	**$**	**784,642**

APPENDIX D

STAKEHOLDER COMMENTS RECEIVED SUBSEQUENT TO RULE 1147 TASK FORCE MEETING AND BY AUGUST 23, 2016 DEADLINE

SUMMARY OF INFORMATION RECEIVED FROM STAKEHOLDERS SUBSEQUENT TO RULE 1147 TASK FORCE MEETING

ITEM #	DESCRIPTION OF INFORMATION RECEIVED BY ETS	NAME/TITLE	COMPANY	ADDITIONAL RELEVANT INFORMATION	DATE RECEIVED BY ETS	FOLLOW-UP BY ETS
Information Received Subsequent to Rule 1147 Task Force Meeting, But Prior to August 23, 2016 Deadline:						
5	E-mail with subject line "Emailing: img083.pdf" and attachment file "img083.pdf" (3 pages). First page of attachment contained a product sheet on Titan Industrial Heating Systems Immersion Tube Gas Burners and the second & third pages contained emails between Stakeholders about the applicability of the burner in a wash tank.	Jim Waggoner, CEO	Industrial Process Equipment, Inc.		08/04/16	ETS response in Section VIII.E of ETS Independent Technical Review Document
6	E-mail with no subject line. Stated that an average burner replacement with a low nox burner is $27,000 plus AQMD permits, source testing, any city permits, and down time costs being the line is shut down.	Jim Waggoner, CEO	Industrial Process Equipment, Inc.	Stated that it could be more money if they do not have enough gas pressure in the plant to service the new burner	08/04/16	ETS response in Section VIII.F of ETS Independent Technical Review Document
7	E-mail with attachment containing a letter titled "Re: SCAQMD Technical Assessment" (2 pages). Letter states concerns for SCAQMD Draft Technology Assessment of the "burner availability and feasibility to retrofit units". Second area of concern is regarding heated process tanks, evaporators and parts washers - "opinion that not only a good replacement burner does not exist to meet the required firing conditions for immersion heating, but a good immersion burner that will meet a <60 ppm NOx requirement for new units does not exist". Third area of concern is that "exempting existing units until the tank is modified or replaced encourages industry to continue to use old, outdated, in-efficient equipment as long as possible."	Allan Roughton, Sales Engineer	Wirth Gas Equipment, Inc.		08/18/16	ETS response in Section VIII.G of ETS Independent Technical Review Document
8	Packet of information received by mail with letter titled "Attention: Rule 1147" which describes why "the tube fired washer burners should be exempt along with other burners in this category or change the rule to 100 PPM". Information provided on the following burners: Eclipse ImmersoJet (IJ), Maxon Tube-O-Therm, Maxon XPO Immersion, Titan Immersion Heater. Comparison drawings of heated washer tanks with an Eclipse IJ6 burner tube arrangement and a Maxon XPO burner, including a washer BTU/hr burner sizing worksheet.	Jim Waggoner, CEO	Industrial Process Equipment, Inc.	Jim Waggoner states that he has been building spray washers for over 43 years. He also provided a "chart of companies that have shut down or moved out of California due to the costs of doing business in California".	08/23/16	ETS response in Section VIII.H of ETS Independent Technical Review Document

SUMMARY OF INFORMATION RECEIVED FROM STAKEHOLDERS SUBSEQUENT TO RULE 1147 TASK FORCE MEETING

ITEM #	DESCRIPTION OF INFORMATION RECEIVED BY ETS	NAME/TITLE	COMPANY	ADDITIONAL RELEVANT INFORMATION	DATE RECEIVED BY ETS	FOLLOW-UP BY ETS
Information Received Subsequent to Rule 1147 Task Force Meeting, But Prior to August 23, 2016 Deadline:						
9	E-mail with subject line "Tech Assessment" and attachment file titled "Tech Assessment Complete.pdf" (16 pages). The file includes a write-up with regards to the SCAQMD Draft Technology Assessment, a comprehensive evaluation of a company that is now in compliance with the rule (Exhibits A through I), additional comments regarding a couple of other applications, and a cost effectiveness spreadsheet for an auto body spray booth (Exhibit J).	Anthony Endres, President	Furnace Dynamics, Inc.	Anthony Endres indicated that there was some financial information that should be maintained in a confidential basis, so Exhibits A - J were excluded from the ETS report.	08/23/16	08/26/16 - Email sent by ETS to Anthony Endres with an attachment letter containing a list of ETS clarifications & questions on the comprehensive evaluation presented in the "Tech Assessment Complete.pdf" file.
Information Received After August 23, 2016 Deadline, But Continuation and Follow-up of Item #9:						
9a	E-mail with subject line "Responses to your questions" and the following attachment files: 1) "Response to Christine Clark 1147 Letterhead.pdf" (8 pages), 2) "Burner Retrofit Info.pdf" (1 page), and 3) "Autobody Industry Summary.pdf" (2 pages). The files include responses to the ETS request for specific clarifications and answers to questions on the comprehensive evaluations presented in the Furnace Dynamics, Inc. "Tech Assessment Complete.pdf" file.	Anthony Endres, President	Furnace Dynamics, Inc.		08/31/16	09/01/16 - Email sent by ETS to Anthony Endres requesting a summary sheet from the source test results for a particular oven that was stated as being included in Item #9a. ETS could not find a source test summary sheet in the Item #9a files received.
9b	E-mail with subject line "Re: Responses to your questions" and an attachment file titled "ST Results Normal Firing all ovens.pdf" (7 pages). The attachment file contained source test summary sheets for 7 different ovens with the title sheet for each oven containing the words "Low Load".	Anthony Endres, President	Furnace Dynamics, Inc.		09/01/16	09/09/16 - Email sent by ETS to Anthony Endres requesting the normal/high load source test summary sheets corresponding to the low load sheets received for the 7 ovens in Item #9b.
9c	E-mail with subject line "ST High Load Data" and an attachment file titled "ST High Load.pdf" (8 pages). The attachment file contained source test summary sheets for 8 different ovens. The first 7 sheets had 7 different oven names as received in Item #9b with the title sheet for each oven containing the words "High Load". The 8th sheet was a different style of source test summary sheet for an 8th oven name.	Anthony Endres, President	Furnace Dynamics, Inc.		09/12/16	ETS response to Items #9, 9a, 9b, and 9c located in Section VIII.I of ETS Independent Technical Review Document

Appendix D, Attachment D-1

Stakeholder Item #5 – Industrial Process Equipment, Inc.

Titan Industrial Heating Systems
www.titanindustrialheating.com
Phone: (562) 951-9500 info@titanindustrialheating.com

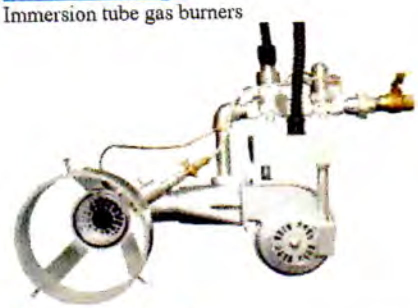
Immersion Tube Gas Burners

Immersion tube type gas burner systems are commonly used on hot caustic, Alkaline, Sodium dichromate, black oxide and hot seal tanks.

Use a Titan Industrial Heating Systems Gas Burner 4" or 6"and your heating problems are solved.

Please contact us for application assistance.

Click to enlarge
Immersion tube gas burners



Click to enlarge
450K Dual Immersion Tube Gas Burners for alkaline tank

Titan Industrial Heating Systems | 8323 Loch Lomond Drive | Pico Rivera, California 90660 USA
Phone: 562.951.9500 | Fax: 562.436.2044 | Email: info@titanindustrialheating.com

Jim Waggoner

From: Anthony Endres <awefdi@gmail.com>
Sent: Wednesday, August 03, 2016 3:37 PM
To: Jim Waggoner
Subject: Wayne's comments.

Jim,

* I particularly like the comment using a bunch of the small burners and tubes to achieve the 50 ppm results. That would make an interesting wash tank and you would have fun with the tubes in the tank.

Tony

--

FDI

Innovative Consulting & Furnace Designs for Industry
Anthony Endres
President
Furnace Dynamics, Inc.
Phone: 562-433-3025
Fax: 562-433-9282
Cell: 562-480-8833

Jim Waggoner

From: Allan Roughton <allanr@wirthgasequipment.com>
Sent: Thursday, August 04, 2016 9:47 AM
To: Jim Waggoner
Subject: RE: Emailing - html2ps.pdf

Jim – Now that's a real throw back to the 1950's! Talk about 10 steps backwards with efficiency. If it's <2.0mm Btu/hr. and the process isn't regulated it doesn't need a permit in the first place. Another example of double talk from the district.

A

From: Jim Waggoner [mailto:JimW@ipeontime.com]
Sent: Wednesday, August 03, 2016 2:10 PM
To: Anthony Endres; Allan Roughton
Subject: Fwd: Emailing - html2ps.pdf

Hi, this is Wayne's tube fired burners less than 60 ppm. No larger than 450,000 btu s Jim

Sent from my iPhone

Begin forwarded message:

> **From:** "Wayne Barcikowski" <wbarcikowski@aqmd.gov>
> **To:** "Jim Waggoner" <JimW@ipeontime.com>
> **Subject: Emailing - html2ps.pdf**
>
> Jim,
>
> This is an information sheet on the immersion burner line that has been tested with results below 60 ppm.
>
> Wayne

Appendix D, Attachment D-2

Stakeholder Item #6 – Industrial Process Equipment, Inc.

Christina Clark

From: Jim Waggoner <JimW@ipeontime.com>
Sent: Thursday, August 04, 2016 7:54 PM
To: christinac@etsi-inc.com

Follow Up Flag: Follow up
Flag Status: Flagged

Hi Christina, an average burner replacement with a low nox burner is $ 27,000 plus AQMD permits, Source testing and Down time costs being the line is shut down and any city permits. Could be more money if they do not have enough gas pressure in there plant to service the new burner.

Thank you

Jim Waggoner

CEO
Industrial Process Equipment, Inc.
1700 Industrial Ave, Norco, Ca. 92860
Ph (951) 808-9192 Ext 313 Fax (951) 808-9193 Cell (714) 984-4783
e-mail jimw@ipeontime.com
IPEwebsite links: WWW.IPEONTIME.COM
Lasernut profile video: http://www.youtube.com/watch?v=YN75vyjMVNM
Lasernut website: **www.lasernut.com**
"We Fabricate Your Future"

Appendix D, Attachment D-3

Stakeholder Item #7 – Wirth Gas Equipment, Inc.

WIRTH GAS EQUIPMENT, INC.
P.O. BOX 3277 · GLENDALE, CA 91221
1233W. GLENOAKS BLVD. · GLENDALE, CA 91201
PH: 323-245-9523 · AZ: 602-254-6225 · FAX: 818-243-3382

August 18, 2016

ETS, Inc.
Christina Clark
1401 Municipal Read NW
Roanoke, VA 24012

Re: SCAQMD Technical Assessment

As a supplier of industrial combustion equipment I am particularly concerned in regards to the districts assessment of the "Burner availability and feasibility to retrofit units." They initially state, "testing program indicates that the rule limits are achievable for all categories of equipment with current available technology," and then proceed to note three areas where in fact that is not the case.

They acknowledge the existence of oven burners rated for 400K Btu/hr. capable of meeting the <30ppm Nox emission limit. They then proceed to recommend exemptions for burners with a maximum rated capacity of 325K Btu/hr. or less. In other areas of this document they address the delay or exemption for equipment that produces < 1lb. of Nox emissions per day. If this is in fact the criteria I suggest they make the exemption for all processes/equipment at this level. If you review the Eclipse product catalog you will note this manufacture offers fifteen different style burners for air heating applications, four different style burners for furnace applications, and four different style burners for tube firing applications. Due to the design of the different burners they are capable of varying emission levels. There are cases where one style burner capable of firing at 1.0mm Btu/hr. produces 60 ppm Nox which at full capacity for twenty-four hours equals 1.464 lbs. and yet a different style produces 40ppm Nox at high fire resulting in 0.864 lbs. Under the district's proposal of exempting burners at the 325K Btu/hr. level both burners would be unacceptable and yet the < 1lb. criteria could be met with option two. The districts approach suggests any burner firing at or less than 325K Btu/hr. will produce < 1lb. of Nox in a 24 hour period. This also suggests a burner fires at full capacity the entire time it is in operation. Both of these assumptions are false and do not represent real world situations. This is like assuming since all cars have four wheels and an engine they are all capable of doing 150 mph and getting 50 mpg, while doing it.

The second area of significant concern is the heated process tanks, evaporators and parts washers. In exempting existing units from meeting a <60 ppm requirement they are acknowledging that a good replacement piece of equipment does not exist. They state their testing has identified three types of heating systems that comply with the Nox emission limit and yet do not specifically identify what these systems are. As one who has supplied combustion equipment for these applications for over forty years

I do not know what equipment the district is aware of and do not understand why this information is not provided by the district if in fact it does exist.

It is my opinion that not only a good replacement burner does not exist to meet the required firing conditions for immersion heating, but a good immersion burner that will meet a <60 ppm Nox requirement for new units does not exist. The only unit I am aware of, which is available from a division of our principal company, requires firing tubes that are four times larger than current standard equipment. Using this "low Nox" option requires a tank that needs to be four times deeper to accommodate the tube. A deeper tank means more solution which means higher Btu/hr. input to heat more solution which means more lbs. of emissions. One step forward and ten steps backwards.

Exempting existing units until the tank is modified or replaced encourages industry to continue to use old, outdated, in-efficient equipment as long as possible. Additionally it does not honestly address the need for new equipment and falsely supports the suggestion that equipment to meet this requirement in a properly engineered design exists.

Thank you for your consideration of the issues I have raised. Please feel free to contact me if you have any questions or need any clarification. I have enjoyed helping industry meet their industrial heating requirements in an efficient, practical, and clean fashion for many years and hope to be of benefit for the future.

Regards,

Allan Roughton

Allan Roughton

Appendix D, Attachment D-4

Stakeholder Item #8 – Industrial Process Equipment, Inc.

NOTE: All of the Burner Manufacturer Information and CAD Drawings That Were Mailed to ETS from the Stakeholder for the Information Discussed in Item #8 Have Not Been Included in This Report, but Can Be Provided if Needed

See us on our website: www.ipeontime.com

August 22, 2016

Attention: Rule 1147

To Whom It May Concern, I have been following rule 1147 for many years. I have been building spray washers for over 43 years.

In one of the meetings they changed the ovens burners from 20 ppm to 30 ppm due to the fact there were no burners that would comply. Staff did not have technical backing to support a burner to meet the 20 PPM.

The washer burners did not get the same attention. I feel the tube fired washer burners should be exempt along with other burners in this category or change the rule to 100 PPM.

From my findings:

I have provided information on the Eclipse IJ burners along guarantees of their NOX levels for some of the different size burners and specs on the burners. The NOX numbers range from 80 to90 PPM@3% 02 dry.

I have provided information on the Maxon Tube O Therm tube fired burner, in their literature there is no commitment to any guarantees or listing of their NOX levels. This Maxon Tube O Flame burner is somewhat a comparison choice to the Eclipse IJ tube fired burner.

I have supplied information on the Maxon XPO Immersion burner, information shows no NOX information. One of the problems with retrofits and even new applications for this type of new burner is the first 8 feet of the fire tube is 24" in diameter versus the Eclipse IJ 8" tube diameter 3'000'000 BTU/Hr and the Maxon Tube O Therm 8" tube diameter 3.5 million BTU/Hr. The small tube to me is very efficient due to the fact it will not get the chemical building up on the tube and not allowing heat to get out of the tube. The old stile burners where larger and the chemical would build up and the fire tubes would burn up because the heat could not get out of the fire tube to the water due to the insulating effect from the chemical building up. The burners prior to these new style burners were 69% efficient, Maxon Tube O Therm and the Eclipse IJ burners are 80% efficient. The tube sizes were larger in diameter.

I would add that even the Maxon XPO burner is not a good solution for even a completely new application since the tank would have to be significantly deeper, thus requiring more water and more heat input to heat the water. Additionally, the heat exchanger layout could not be well accommodated. Thus there are not good solutions to wash tank applications and thus the wash tank applications should be exempted from the rule. I believe this burner has not been achieved in practice on enough pieces of equipment, this needs to be addressed to when and where these pieces of equipment have been used and tested.

I have supplied information on the Titian Heater, no information or guarantees on the NOX level. There max firing rate is 450,000 BTUs/Hr. Most of our washers are 2,000,000 BTUS/Hr or more. The tube diameter is 4” to 6”. You would need 5 burners and tubes to do 2,000,000 BTUS/Hr. Not a practical or efficient design. There is no good way of cleaning the tubes and you would need to put somewhere? There would be 5 stacks going up thru the roof. This is an old style application. Goes back to the first washer ever built.

Please see the Comparison Drawing of the tanks with an Eclipse IJ6 burner tube arrangement and a Maxon XPO burner. Please see the difference in the tube layout and the tank size. The spray washer tank that we have drawn is for a washer spraying 860 gallons per minute of spray at 140 degrees F. I supplied BTU calculations for this type application. This application requires this size burner to heat up the amount of gallons at start up. When the solution gets to temperature the burner throttles down as low as 500,000 BTUS/Hr. and keeps the solution at temperature. When the tube fired burners throttle down is when the NOX levels go up.

I have a Major Question since the rule was started years ago, I have been asking the district and staff for years about what was the mean when the rule was started or what is the goal to achieve as far as a reduction of NOX. I provided a chart of companies that have shut down or moved out of California due to the costs of doing business in California. One major cost is dealing with AQMD. Just the BTUS/Hr that I know of, adds up to 373,620,000 as you can see on my sheet. Seems the goal is having no manufacturing in California.

If you should have any questions, please feel free to ask.

Sincerely,

Industrial Process Equipment Inc.

Jim Waggoner
President
Industrial Process Equipment Inc.
Ph 951 808-9192 ext 313
Company Fax 951 808-9194
Cell 714 984-4783
E Mail: jimw@ipeontime.com

Appendix D, Attachment D-5

Stakeholder Item #9 – Furnace Dynamics, Inc.

NOTE: Stakeholder Item #9, Exhibits A - J Were Excluded From This Report Due to Stakeholder Request to Maintain Company Confidentiality Regarding Financial Information

Furnace Dynamics, Inc.
261 Euclid Ave.
Long Beach, CA 90803
562-433-3025

August 23, 2016

Ms. Christina Clark
Engineering Manager
ETS, Inc.
1401 Municipal Road, NW
Roanoke, VA 24012

Dear Christina,

I have included an overview of the Technology Assessment as well as a case study of a specific plant that is now in compliance with Rule 1147. The facility is a job shop powder coating company. We received actual accounting of dollars spent in compliance that include all phases of each project this formed the basis for our cost effectiveness evaluation.

Personnel Background: I have been involved with combustion devices since 1971 with the development of an advanced technology boiler. In 1980 I started a company to engineer, design and manufacture waste heat recuperators to be applied to high temperature forge and heat treat furnaces. I have been providing clients energy efficiency consulting from 1980 to the present. Over the years we have designed the combustion systems for approximately 120 furnaces in forge, heat treating and the metal melting industries. Concurrent with the energy efficiency consulting, we have set up the combustion systems for approximately 7,000 temperature uniformity surveys to satisfy aerospace requirements. We have also engineered and designed many heat treat and forge furnaces that will accommodate furnace loads of up to 200,000 pounds and temperatures up to 2300F. Through the last 29 years we have been providing air quality consulting to a wide variety of organization disciplines and have assisted staff in rule development for the RECLAIM Program and multiple other rules including Rule 1147.

Technology Assessment: The Technology Assessment covers a vast array of devices included in Rule 1147. Based on the database I received from staff on the devices included in 1147, there are approximately 270 categories of equipment contained therein and approximately 6,500 devices. With the limited ETS contract value, it would be impossible to evaluate a large number of sources. I therefore recommend that a relatively few (but representative) number of sources be evaluated where actual data exists. We have provided data from one such facility for your evaluation and consideration. The data provided represents the real cost of compliance and the real cost effectiveness of the retrofits. See Exhibits A – I.

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General Comments Regarding the Technology Assessment: There are a couple of actual examples of where the staffs position and reality depart. A case in point is one of our forge company clients. Whereas, I was able to conduct some fine tuning and get 7 of the 8 furnaces to comply, the last could not be tuned into compliance. Quotes were obtained from the five largest burner manufacturers. All suppliers would guarantee the NOx values but none would also guarantee an acceptable temperature uniformity survey required by the aerospace industry. If you cannot pass an acceptable uniformity survey, you cannot use the furnace. In this case the issue was trying to adopt a low NOx burner to a furnace that was not designed for their use at the time of construction.

There are other examples of the same issues. In the meeting with staff, Mr. Barcikowski suggested there was an acceptable emersion heater burner that could be used in wash tanks. The burner has a maximum input of 450,000 BTU/hr. On a 3MMBTU/hr application there would have to be over 6 burners each with its own immersion tube. Due to the nature of these tank designs this is not an acceptable solution and thus should not be given any consideration. There are also Maxon XPO burners for immersion tube applications, they require a tube of between 18" – 22" in diameter that would extend into the tank up to 6 feet. To accommodate the larger burner, the tank would have to be deeper and potentially wider. This would require a larger amount of water or solution to be heated thus more BTU input. For numerous reasons this is not an acceptable solution. Thus these wash tank applications should be exempted and even new applications would not be deemed feasible. These are just a few examples, there are probably many related to the unacceptable nature of a retrofit project.

We have included a cost effective spreadsheet that relates to a typical auto body spray booth retrofit application. As with the other comparisons, both a PTE vs. actual evaluation are included. See Exhibit J.

ETS Consulting:
In the meeting with stakeholders and staff you heard staff indicating they must use default emission factors. However, we believe the public, the SCAQMD Governing Board, the ARB and EPA should be told the emissions profile and cost effectiveness that relates to individual units compared to assumptions based on default values. To achieve this, actual case studies should have been involved, not gross assumptions. At the outset of rule development, actual case studies should have been conducted to provide assurances that the basis of the program was valid and represented real emission values and actual cost effectiveness evaluations. By using assumed values and potential to emit criteria, the initial emissions from the array of sources included in Rule 1147 is over stated as well as the amount of reductions achieved by the rule. At the same time the cost effectiveness can be vastly understated.

Furnace Dynamics, Inc.
261 Euclid Ave.
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562-433-3025

Pretesting to Determine the Current State of Compliance: We use one of the new Testo 350 emission analyzers. It is the most advanced analyzer on the market. Over the last 3 years, we have conducted approximately 190 pretests. Approximately 2% of those tests were conducted on larger furnaces that fall under the RECLAIM Program. The rest have been Rule 1147 devices. They include heat treat, forge, powder coating, precision casting, etc. The temperature ranges run from about 300F to 2250F. We have also conducted approximately 70 parallel tests with official source test companies. Predominantly, our results are within 2 ppm NOx of the official test. I have gone through the SCAQMDs work shop on using portable analyzers and passed the test required for certification. Our goal is to inform companies of their compliance status and determine if retrofitting of the equipment is required. Refer to Exhibit A for pre testing data.

We also have provided tuning of the equipment to determine if compliance can be achieved. With our software and a laptop computer connected to the analyzer, we can observe, in real-time, the results of the tuning activity. Within the confines of the tuning activity, we will evaluate how the equipment is normally operated for the job done at the client site. We will make adjustments to determine if compliance can be achieved – without having any negative impact on the company's normal operation. Whereas, not all tuning attempts are successful, we have adjusted or worked with others to fine tune approximately 37 devices that would not have complied in the initial state of tune. The savings to clients amounts to about $1.3 million in not having to retrofit their equipment.

Facility Evaluation: I have chosen a facility where we conducted extensive pre testing in order to determine the compliance status. This testing formed a basis for the company to embark on a retrofit program prescribed under Rule 1147. We have included the results of my pretesting of their ovens. We acquired a spreadsheet of the costs associated with each retrofit conversion. The values were then used as a basis of comparing the existing emission values and thus the overall reduction and then the cost effectiveness of each device. The average firing rates were derived from actual source testing data. These values were used as the average firing rates of each of the ovens evaluated. It is important to understand that the indicated average is relevant to the understanding how the equipment actually operates. The firing rate for each oven is controlled by a temperature controller. The temperature range for this equipment is from 325F to 700F. A set point is selected and the equipment is fired to accommodate that set point. Due to the relatively low temperature of operation, the temperature is reached rather quickly, then the burners are throttled back to maintain the set point value during the production cycle. An interview with management provided the hours per day of operation. These were also used in the cost effectiveness evaluation.

Furnace Dynamics, Inc.
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Cost Effectiveness: I have provided some cost effectiveness charts for a specific facility and their individual equipment where upgrades to their equipment were made and source testing was successfully completed. To assure consistency with staff's methodology, I created a spreadsheet using the same formulas found in the Districts Minor Source BACT Guidelines and the same values that are illustrated in the guidelines to assure the methods are consistent with what staff used in the initial evaluation. Staffs' and our numbers compare to the exact same dollar per controlled ton.

With the attached spreadsheets, I illustrate the actual hours of operation, days per week, weeks per year, starting emission factor, the rule compliance emission factor and the costs associated with the retrofit. The formula includes the cost of money and follows the discounted cash flow (DCF) method of evaluation. Therefore, real, actual information can be evaluated. For comparison, we have included a spreadsheet next to the actual that would indicate how the District might conduct the same evaluation. As you observe there are dramatic differences. In the 2008 staff report, the cost effectiveness was stated to be in a range from $3,000 to $17,000 per controlled ton of emissions reduction. At a recent 1147 task force meeting, staff indicated the average cost effectiveness is $26,000 per controlled ton. At the same time, they indicated they did not do any individual analysis. We are not sure how it is possible to provide a definitive value and then indicate no individual analysis was conducted.

You will observe, the cost effectiveness varies dramatically due to hours of operation, initial emission factors and cost to modify. It should be noted that these are real values not default or assumed values. In this company the actual cost effectiveness ranged from $58,157/t to $499,000/t. See Exhibits D – I.

Cost Effectiveness Methodologies: There were multiple values illustrated in the technology assessment. They varied in duration of the starting and ending points. Some had a 10-year cost effectiveness value and some had 15 year or even a 20 year criteria used for the evaluation of cost effectiveness. We have always been a proponent of utilizing a singular methodology of determining cost effectiveness. This has been expressed to senior staff as well as to the Executive Officer. We have also suggested that the cost effectiveness criterion should be uniform for all 1147 devices. Additive to the above, a singular – not to exceed value should be established. If the cost effective value is exceeded, an extension for compliance should be issued with enforceability included.

As you review the accompanying documents, it will become very apparent that cost effectiveness should be conducted on a case by case basis. Staff opposes this due to the extra work involved. We have offered to assist in streamlining this effort – to no avail.

furnace dynamics, inc.
261 Euclid Ave.
Long Beach, CA 90803
562-433-3025

Actual Numbers vs. Default Values: It is important that we provide actual numbers that represent actual information relating to specific devices. We have provided a profile of an actual facility. This facility has pretested the existing equipment to determine compliance and upgraded all their equipment that would not comply. In this case an existing burn off furnace was adjusted to a NOx value that proved compliance and was successfully source tested. In the company illustrated in our profile, we were not able to tune one of the burn off ovens. The result was the client spending $94,230 to purchase a compliant replacement device.

None of the other devices pretested would pass the 30 ppm compliance requirement. In my evaluation, I have used the actual starting ppm for each device to show a comparison to the Districts default values. See the section on pretesting. The approach was to look at the actual daily use in hours then use a value that would represent the Districts approach of using 100% firing rate for the normal hours of operation and also using the default emission factor that the staff uses of 130#/MMcf natural gas (101.4 ppm). If the values for each device were to be determined based on a 12-hour day, the values would be skewed even more.

There was one oven where the O2 values were above the 19.5% where my analyzer cuts off. All the remaining ovens were pretested to determine compliance. There were cases where some of the equipment showed issues that required additional maintenance prior to determining if compliance was possible.

Cost of Compliance: We have provided a spreadsheet that came from the client to show the various costs for each device. The numbers vary significantly. This is due to the amount of work required to install the equipment. Significant sheet metal modification was sometimes required to accommodate the new burner configuration. In some cases, the gas train had to be updated to assure compliance with current standards.

The included spreadsheet documents the expenditures to assure compliance. The grand total was approximately $362,683. There are some minor additional costs that will still come in due to an oven that needs to be source tested. See Exhibit C for cost evaluation.
These values include:

1. Application fees
2. Burner costs
3. Installation costs
4. Protocol fees
5. Source testing costs
6. Source test report evaluation costs

Furnace dynamics, inc.
261 Euclid Ave.
Long Beach, CA 90803
562-433-3025

There is also a cost of $12,345 that went to pretesting the various devices and conducting some parallel testing with the source test company. These are all real costs to industry.

Conclusions: The Technology Assessment is rather comprehensive in nature. However, we find fault in the cost effectiveness numbers due to staffs' using default numbers and potential to emit. We have provided a series of spreadsheets that can be evaluated to determine what constitutes one pound per day of NOx based on BTU input and hours of operation at a number of average BTU inputs from PTE to an average of 20% of PTE.

It is important the staff knows that real number are more important than assumed values. Assumed value understate the cost effectiveness and overstate the actual reductions. The public, the Governing Board, California Air Resources Board and the EPA need to be advised of the real costs to industry. It does require more effort from staff in the rule making process and stakeholders need to be intimately involved in the process of developing rules. The burden of high cost effectiveness, expensive rules and sometimes marginal environmental impact should not fall on small businesses.

Should you have any questions regarding the information supplied please feel free to call me any time and I will be happy to assist you.

Sincerely,

Anthony W. Endres
President

Enc.

APPENDIX E

STAKEHOLDER COMMENTS RECEIVED AFTER AUGUST 23, 2016

SUMMARY OF INFORMATION RECEIVED FROM STAKEHOLDERS AFTER AUGUST 23, 2016 DEADLINE

ITEM #	DESCRIPTION OF INFORMATION RECEIVED BY ETS	NAME/TITLE	COMPANY	ADDITIONAL RELEVANT INFORMATION	DATE RECEIVED BY ETS	FOLLOW-UP BY ETS
Information Received After August 23, 2016 Deadline:						
10	E-mail with subject line "Emailing: img131.pdf" and an attachment file titled "img131.pdf" (3 pages). The attachment file contains an undated letter addressed to Wayne Barcikowski of SCAQMD. The letter concerns were regarding the amount of burners that needed to be changed by July 2012. The Stakeholder also suggested rule amendments for the "added categories that work for the different applications" and for burners that are on the market and have been achieved in practice for a minimum of one year. The final page of the Stakeholder letter recommends "getting with burner manufacturers to see if the below are correct categories that they can make burners for and to what type of burner will meet the PPM requirements. When can they meet the PPM requirements and then implement them into the rule."	Jim Waggoner, CEO	Industrial Process Equipment, Inc.		09/02/16	ETS response in Section IX.A of ETS Independent Technical Review Document
11	E-mail with subject line "Emailing: 25760-1- System Layout PDF.pdf" and an attachment file titled "25760-1- System Layout PDF.pdf" (1 page). The attachment file contains a CAD layout drawing dated 11/11/15 of a Conveyorized Powder Coat System with the following: a Spray Power Washer in the front that goes to a Dry Off Oven, then cools down to Two Powder Booths, and then to the Cure Oven, and then to the Unload Area.	Jim Waggoner, CEO	Industrial Process Equipment, Inc.	Attachment file "25760-1- System Layout PDF.pdf" was excluded from the ETS report since it contained client-specific details for a system located in Texas	09/02/16	ETS response in Section IX.B of ETS Independent Technical Review Document
12	E-mail with subject line "1147 Documents submitted to staff in 2008" and attachment file titled "2008 Letter to staff re 1147.pdf" (28 pages). The attachment file contains an undated document from Anthony Endres of Energy Services Corporation addressed to Wayne Barcikowski. The letter discusses the applicability of the 60 ppm NOx emission limit to different types of metal melting and heat treating furnaces. The commenter proposes each type of furnace should have a different NOx emission limit. The letter also contains a general discussion of BACT for new metal melting and heat treating furnaces that proposes that each type of furnace should have its own BACT limit. Finally, the Stakeholder recommends the use of a pounds per hour basis for determining compliance based on the pounds per hour emitted at 100% for a given burner or classification of equipment.	Anthony Endres, President	Furnace Dynamics, Inc. (Energy Services Corporation)		09/20/16	ETS response in Section IX.C of ETS Independent Technical Review Document

Appendix E, Attachment E-1

Stakeholder Item #10 – Industrial Process Equipment, Inc.

Wayne Barcikowski
Air Quality Specialist
SCAQMD
21865 Copley Drive
Diamond Bar, Ca. 91765

Mr. Barcikowski,

Thank you for allowing rule 1147 to be amended.

As you know this rule allows us added business so we are not here to stop any progress.

The reason that I will be mentioning the below is that I do not want to see companies in a penalty situation as to the reason it was important to put the rule on hold before the end of the year. This would cost business's time and money to deal with. Thank you.

There are too many burners in the industry to change by July 2012. It has taken 4 months to get permits to construct and I know of others waiting for months to get an acceptance to the test protocol after they get the permit to construct.

We need to have the rule amended for the added categories that work for the different applications. The rule is way to general for this industry.

I believe the rule needs to be amended for what is on the market and the burners are achieved in practice for a minimum of one year. I know the smallest Low Nox Burner that Eclipse makes is a 500,000 BTU which works very nicely for an oven application. One of the situations is that we use to put in oven burners that were 1,500,000 BTU'S and now we would have to put in 2,000,000 BTU burners on. The burners use more gas do to the fact that the burner requires more ambient air to get the same Btu's as the old burners and as you can see the burners require to be larger. This follows the same perimeters as the burners go up in sizes.

Multiple units, dead line to me does not work. Some people have more than 20 burners to rework. What does that look like in a feasibility study?

We have actual costs for one burner up grade of $ 26,865.32 plus down time of the factory.

No equipment normally is exactly the same, each burner needs to be adjusted at the time of start up. We manufacturer ovens from 2700 square foot to 80 square foot. This does not allow for having equipment certified.

Burn Off Systems, heating chamber and afterburner. This equipment works in conjunction with each other with all the effluent going through the afterburner. This unit is not an oven/afterburner. AQMD permits are specified to run the afterburner and then turn on the oven. Both units can not work separately due to the safety circuit.

What happens in 15 years if there is nothing better to go to?

I believe it will be 5 to 10 year process to change the burners, we have changed 2 burners since 2009, 4 months to get a permit to construct for a burner upgrade to Low Nox from AQMD. If you due a simple calculation of say 492 burners per year divided by 60 per year = a minimum of 8 years. There are not enough technical people in the industry and time that it takes to change all of these burners. It will just put companies in a violation situation. Why would we allow this to happen to our economy?

It is interesting we are asking to change burners when there are old ovens, other equipment and the design of the equipment is very inefficient?

We have lost a minimum of 111,000,000 BTUS out of the South Coast Air Basin that come to mind plus many others over the past 10 years.

It is interesting in our last meeting of the workshops before the rule went into effect that the Nox level was set at 20 PPM on ovens and just by asking a question if the burner manufacturers made a 20 PPM burner and both manufacturers said no, the rule was change to 30 PPM right on the spot. For other burners categories that the burner manufactures did not make burners to meet the PPM levels at this point, the rule did not get changed and now the time line has been extended to a future date.

I would recommend getting with the burner manufactures to see if the below are the correct categories that they can make burners for and to what type of burner will meet the PPM requirements. When can they meet the PPM requirements and then implement them into the rule.

Gaseous Fuel Fired Equipment

Asphalt Manufacturing Operation

Afterburners, Degassing Units, Redemption Units, Catalytic Oxidizers, Vapor Incinerator, Crematory, Incinerators, Caliners, Cookers, Roasters, Furnaces, Heated Storage Tanks, Evaporators, Fryers, Heated Immersion Process Tanks, Parts Washers, Conveyorized Spray Power Washers, Metal Heat Treating, Metal Melting Furnaces, Melting Pots, Tar Pots, Kilns, Burn Off Systems, Heating Chamber and Incineration Systems

Cure Ovens, Dry Off Ovens, Dryers, Carpet Dryers, Fabric Dryers, Heat Treat Ovens, Paper Making Dryers, Food Baking Ovens, Textile Production , Grain Drying, Heat Exchangers

Direct Fired Burners for Cooking, Ribbon Type

Heat Paint Spray Booths, Make Up Air Units

Tenter Frame

What is a Other Unit or Process Temperature?

Liquid Fuel Fired Equipment

What is a All Liquid Fuel-Fired Unit?

Thank you for taking the time to review. Please let me know your thoughts or questions.

Jim Waggoner
Industrial Process Equipment Inc.
1700 Industrial Ave.
Norco, Ca. 92860

714 984-4783 Ext. 313

Appendix E, Attachment E-2

Stakeholder Item #11 – Industrial Process Equipment, Inc.

NOTE: **Stakeholder Item #11, Attachment File "25760-1- System Layout PDF.pdf" Was Excluded From This Report Since it Contained Client-Specific Details**

Christina Clark

From: Jim Waggoner <JimW@ipeontime.com>
Sent: Friday, September 02, 2016 2:25 PM
To: christinac@etsi-inc.com
Subject: Emailing: 25760-1- System Layout PDF.pdf
Attachments: 25760-1- System Layout PDF.pdf

Hi Christina, see an attached Conveyorized Powder Coat System which has the following functions to complete the system. Spray Power Washer is in the front then goes to the Dry Off Oven then cools down to the Two Powder Booths and then to the Cure Oven and then to unload.
This is much more than a wash tank, the Spray Power Washer is part of the System.
Have a nice weekend.
Thank you

Jim Waggoner
CEO
Industrial Process Equipment, Inc.
1700 Industrial Ave, Norco, Ca. 92860
Ph (951) 808-9192 Ext 313 Fax (951) 808-9193 Cell (714) 984-4783
e-mail jimw@ipeontime.com

Appendix E, Attachment E-3

Stakeholder Item #12 – Furnace Dynamics, Inc.
(Energy Services Corporation)

ENERGY SERVICES CORPORATION

261A Euclid Avenue
Long Beach, California 90803
Tel: 562-433-3025 Fax: 562-433-9282

AIR QUALITY AND ENERGY EFFICIENCY CONSULTING

Mr. Wayne Barcikowski
Air Quality Specialist
South Air Quality Management District
21865 E. Copley Drive
Diamond Bar, CA 9176530-Oct

RE. Proposed Rule 1147.

Dear Mr. Barcikowski,

The following dialogue will further clarify many of the comments made during the consultation meeting held at the District on October 28, 2008. I feel that even though a large number of relevant issues were discussed a more in depth analysis is required to shape a cogent understanding of the critical elements of the rule and the associative implications to industry. My area of expertise is in the metal melting, heat treating and forging industries.

I represented this industry group during the formation of RECLAIM on 4 separate advisory committees. Over the years I have set up the combustion systems for over 6,500 temperature uniformity surveys in forging and heat treating applications. I have designed the combustion systems for about 100 furnaces in Southern California. We currently design forging and heat treat furnaces that satisfy the needs for product heating and temperature uniformity. I have worked with staff to assist in the rule making process that has yielded an improved understanding from industry to the SCAQMD rule making process and also worked with the SCAQMD to help them understand the technical challenges of industry. Ultimately, the net result was rules that make sense for both the SCAQMD and industry. I have updated and included a paper that I wrote a few years ago discussing the differences in heat treat furnaces as related to BACT. The tenant of the discussion is that an emission level that is applicable to one classification of heat treat furnace is completely inappropriate to other heat treat furnaces. Forge furnaces though more limited in nature in the design and operation compared to heat treat furnaces have the same relevant issues that are affected by this proposed rule. To this end, I present the following for your consideration and reflection.

Issues Relating to Proposed SCAQMD Rule 1147

A number of very serious issues were discussed in the meeting that has significant implications as to how the proposed rule affects certain segments of industry.

RULE LANGUAGE AND CONTENT: The following are issues relating to the specific rule language, intent or relative emissions limit.

1147(C)(1) Table 1 NOx Emission Limit. This table is entirely too broad as related to ***Metal Heat Treating (metal forging)*** and ***Other – Process Temperature > 1200^{o}F***. Refer to included paper on BACT for Heat Treating Furnaces for insight into the industry and the variety of associated heat treat furnaces. As an example, the same furnace can operate from 800F to 2250F. The emissions at these two ranges can be very different in the same furnace let alone furnaces of significantly different configurations. The staff needs to define the configuration and type of furnace for this to make sense. The *Other – Process Temperature > 1200^{o}F* category is not acceptable due to the lack of definition. This paints perhaps a very large grouping of equipment with the same brush. That would be like saying a hippopotamus and a giraffe are the same because they are both animals and have four legs. While there may be some equipment in this category the NOx value of 60 ppm may be acceptable, there could be many others where this is not acceptable.

The same is true for the next category requiring 20 ppm. This is again too broad a listing of equipment without specifying which equipment in that category applies. The 30 ppm grouping of equipment suffers from the same inadequacy of the preceding grouping of equipment. As stated above there are many furnaces that operate in a range from 800^{o}F – 2250^{o}F, does this mean that the equipment would have to be 30 ppm when operated between 800^{o}F and 1200^{o}F and 60 ppm > 1200^{o}F?

Rule 1147(C)(9) This section should define that if a timer is used the time be connected to reflect only the time of operation of the device, not the total time that electrical power is applied to the device.

Rule 1147(d)(3)(D) the last word should be ***"or"*** not ***"and".***

Rule 1147(d)(3) The section relating to source testing should have a section **(G)** added to allow EPA Method 19 "F" factor calculations where the device being tested does not possess a traditional flue that could utilize the previous indicated test methods.

Another section should be added that specifies that if an existing combustion system satisfies the applicable requirement, that compliance may be satisfied by a source test pursuant to one of the provisions under (d)(3)(A)-(G)

1147(g) Exemptions. There needs to be an added exemption placed in this section pursuant to the inability of combustion company manufacturers to guarantee compliance with the NOx levels and temperature uniformity surveys required by aerospace specification such as AMS 2750D. This is addressed in detail in the body of this discussion.

Comments Relating to the Preliminary Draft Staff Report

Page 1-3 Technology Assessment, Low NOx Burner Technology, paragraph 4: In the comments relating to the use of staged combustion where there is a fuel rich zone and a lean zone, it is not mentioned that this type of burner requires the chamber temperature to exceed 1600^{o}F to function. Therefore use on a lower temperature furnace could be ineffectual and not achieve the desired NOx reduction. Another issue is the fact that these burners, by their nature are considered a "normal" velocity burner. Whereas this technology could be used in some applications they would not provide adequate temperature uniformity surveys if placed in a furnace where compliance with AMS 2750D was required. Many of these applications require high velocity burners to maintain the required uniformity. After any modification a new temperature uniformity survey is required. If this survey fails, the furnace must be shut down. The company cannot use the furnace for processing forgings and heat treated parts.

Page 1-4 Technology Assessment, Low NOx Burner Technology, paragraph 6: This paragraph addresses the use of excess air to reduce NOx. Whereas, this methodology does reduce NOx by reducing hot mix temperature, its primary purpose in heat treating and forging is to improve temperature uniformity at lower operating temperatures. The last sentence in this paragraph is fundamentally incorrect. By virtue of the fact that excess air is used, the loss of efficiency cannot be adjusted out without loss of efficiency or increase in fuel consumption. Refer to North American Combustion Handbook Volume 2, Available Heat chart for technical analysis. This shows how the available heat diminishes when operating at a specific furnace temperature and a specific amount of excess air.

Attached you can find 2 examples the Department of Energy Process Heating Assessment & Survey Tool (PHAST 2.0). This is a software tool utilized to analyze projects. The calculator section shows the differences in excess air and ratio firing. Also please find two printouts showing the differences in efficiency by using 2% O2 (10% excess air) vs. 11% O2 (100% excess air) for a heat treat application where the fuel savings would be 46.6%. Also included is a forging application where differences in efficiency at 2% O2 vs. 7.5% O2 yielded a savings of 42.3%.

Whereas, the statements associated with turndown have some efficacy for some applications. Those associated with forging and heat treating face far greater challenges. This is due to varying load factors and temperature ranges of operation. The forging ranges for these furnaces range from 800F to 2250F. They are operated in an excess air mode at the lower temperatures but on ratio at higher temperatures. Since these companies are job shops, their furnace loads vary. A given furnace might have a load of 3,000 lbs. on one day and 15,000 lbs on a subsequent day. It is not unusual for a furnace to operate at multiple temperatures on any given day. Virtually all the burners used in forging and heat treating industries increase in NOx emissions as the burners turn down. NOx levels also increase as the operating temperature increases. For example, according to the data sheet an Eclipse ThermJet 100 burner at high fire generates 35 ppm, at 35% approximately 60 ppm, at 20% it generates about 80 ppm. By any measure this is a good low NOx burner. By the way the rule is written, this burner could only be operated when at a reasonably high firing rate and still maintain compliance with the rule. Yet the pounds per hour values (see the write up later in this dialogue) are much less at turndown than at high fire. Thus the actual emissions are lower. The purpose of this rule is to reduce emissions. This burner could do that but could be used in only a few applications. Staff needs to alter the compliance methodology to include pounds per hour as an alternative method assurance of emissions reduction.

Comments relating to the consultation meeting held at the SCAQMD October 28, 2008.

TECHNOLOGY TRANSFER: This topic was presented and discussed at length in our meeting. There has been a general feeling that when a combustion system manufacturer comes up with a new low NOx burner that works in a specific application, it can be utilized in a significant number of other applications with uniform success. Unfortunately this is not possible. The comments by the two burner manufacturer's representatives very well articulated this point. Due to the disparate nature of furnaces, sizes, firing rates, temperature ranges, operating conditions, etc. the utilization of a burner in one furnace may not be applicable on another furnace even within the same general usage category.

By reviewing the included paper "BACT Considerations of Heat Treat Furnaces" one will gain an appreciation of the inability of using a specific burner for one furnace vs. another in the same category. The same issues are relevant in the forging industry and metal melting industries. In forging, for example, operating temperatures range from 800ºF to 2300ºF in many cases within the same furnaces. There are box furnaces, rotary hearth furnaces, slot forge furnaces, low temperature recirculating furnaces and the list goes on. Furnace sizes and configurations vary vastly depending upon the job for which they were designed. These furnaces operate in the excess air mode, ratio mode and pulse firing mode of operation. There are standard velocity and high velocity burners that are designed to provide a particular heating pattern in the furnace proper. The paper on heat treat furnaces addresses the issues of temperature uniformity. Most of the forge furnaces in Southern California are certified to forge aerospace components and critical commercial forgings. These components ultimately go into a variety of aircraft, engines, structure or various control systems. Twice a year each of these furnaces must pass customer required uniformity survey to either +/- 20ºF or +/- 25ºF. If the furnaces do not pass these surveys the furnaces must be shut down and cannot be used for forging of any aerospace components.

The issue came up that there were furnaces within a particular broad based classification that have passed source tests. Whereas this is true, those same burners may not yield the same results in other furnace configurations.

Temperature Uniformity vs. NOx vs. Manufacturer Guarantee: This issue was discussed at some length. These furnaces were designed to do a particular job and have been successful for many years. The question comes up regarding the use of a particular burner on a specific furnace that was not intended to use that burner. Two manufacturer's representatives were present one from Eclipse Combustion and the other from Maxon. When asked if they would not only guarantee the NOx values but successful temperature uniformity survey they both indicated that they could not. We believe this would be true of the other major manufacturers. The primary problem is trying to apply a burner design to a furnace that it was not designed to operate in. For instance, Eclipse has a low NOx burner that is designed to operate on higher temperature furnaces. It is a staged air type of burner. The primary combustion portion of the burner generates a fuel rich flame. That flame then combines with the bypassed air injected into the furnace through additional ports in the burner. If the furnace temperature is too low < 1600ºF the recombining of the gasses cannot take place and the burner will not function properly. Thus the manufacturer would not guarantee the burner performance. Bear in mind that most of these furnaces operate over a wide variety of temperature ranges.

As was mentioned above, a specific burner cannot be used in all operations. Manufacturers have only a limited number of burner configurations that can satisfy the needs of a very large variety of furnace configurations. Due to the overall market for these low NOx burners, manufacturers allocate a specific amount of resources for R & D relating to low NOx burners due to the relatively limited market for these products. Even then the range of available equipment is somewhat limited.

The other issue with this and other low NOx burners is that the burners are a normal velocity design. That means that temperature uniformity can be compromised. If this happens the furnace will not pass a uniformity survey, the furnace must be shut down and not operated for forging any parts requiring these surveys. The bulk of forging activity in Southern California is aerospace and critical commercial forgings also requiring these surveys.

SAE-AMS-2750D Aerospace Material Specification: This is the specification that covers virtually all aerospace forging and heat treating in Southern California. Whereas there are other specifications such as AMS – 6875 Heat Treatment of Steels et al that cover heat treatment of titanium and other alloys, AMS – 2750D is the major specification controlling forging and heat treating. This is a 46 page document with high degrees of specificity on a plethora of items relating to the heat processing of aerospace alloys. To improve understanding of the critical nature of this specification we have included a few sections that relate to scope (1.1), equipment modification (section 3.5.3) and temperature uniformity survey failures (section 3.5.19.1).

1.1 This specification covers pyrometric requirements for thermal processing equipment used for heat treatment. It covers temperature sensors, instrumentation, thermal processing equipment, system accuracy tests, and temperature uniformity surveys. These are necessary to ensure that parts or raw materials are heat treated in accordance with the applicable specification(s).

3.5.3 Furnace Modifications: An initial TUS (temperature uniformity survey) shall also be performed after any furnace modification or adjustment that could have altered the temperature uniformity characteristics of the furnace. Examples where an initial TUS shall be required include, but are not limited to the following:

- *Increase in the maximum qualified operation temperature or the decrease in the minimum qualified operating temperature*
- *Burner size, number, type, or location change*
- *Changes to air flow pattern/velocity*
- *Change to refractory thickness*
- *New refractory with different thermal properties*

- *Change in control sensor location*
- *Change in combustion pressure settings from the original setting*
- *Temperature control scheme change (proportional versus high-low/off-onn)*
- *Adjustment to tuning constants*
- *Work zone volume increase covering area not previously tested*
- *Work zone location change covered area not previously tested*

There are a few other items that cover electrically heated furnaces that were not included. The last section (3.5.19) for reference is the one that addresses TUS failures. See the following:

3.5.19.1 If the temperature uniformity is not within the tolerances of Table 8 or 9 (parts and raw material furnace classification based on furnace class), the cause of the deviation shall be determined and documented and the requirements of 4.2 shall apply. The equipment shall not be used for additional processing until the cause has been corrected and the TUS has been performed successfully.

4.2 In the event of any test failure or out of tolerance condition, an evaluation of the possible effects of the non-conformance on product processed since the last successful corresponding test shall be performed and documented. The evaluation shall be documented per established material review procedures; appropriate corrective action shall be taken, documented and maintained on file. When material processing conditions deviate from specification requirements affected purchaser(s) shall be notified.

In essence AMS – 2750D controls all aspects of how a furnace is operated. If a TUS is not successful after a modification to the furnace as indicated in 3.5.3 the furnace cannot be used for forging and heat treating aerospace parts.

Therefore, without manufacturers guarantee of both NOx and successful uniformity surveys, the companies would be reluctant to purchase a burner that could put them out of business. This could constitute a taking of property.

Recommendation: *We would recommend that staff needs to rethink their position that the same burners can universally be used on a wide range of applications without any actual testing on specific furnace configurations. Further, without manufacturer's guarantees these classifications should not be considered in the rule structure at this time. Perhaps with more in depth analysis by industry, the*

SCAQMD and manufacturers in a subsequent rule could generate a rule that is more specific in nature and that would not potentially put companies out of business. We would be willing to assist in this effort. Unfortunately, due to the time constraints posed by the presentation to the Governing Board, a significant amount of unresolved technical issues are yet to be resolved. Further exacerbating the issue is the problem that in some of these categories even years downstream, burners that a manufacturer would guarantee to meet both emissions levels and uniformity requirements may still not be available. As has been indicated the South Coast Air Basin represents a very small percentage of the total market for combustion equipment. Prior to invoking a rule as extensive as PR 1147, manufacturers must have the equipment available, tested and guaranteed for each specific application.

BACT vs. Furnace Configuration: As was discussed in the heat treat furnace paper, BACT could vary for different furnace configurations. Some furnaces may lend themselves to relatively easy source testing while others would create significant problems. For instance, slot forge furnaces. They do not have any physical flues and have open slots. There are no doors due the nature of the furnace configuration and the way they forge parts. Due to this configuration there is some air infiltration, NOx values are affected by this infiltration. To our knowledge there are no low NOx burners that have been successfully used on this furnace configuration and in talking to the manufacturers; they would not guarantee results in combination with acceptable uniformity surveys.

Recommendation: *When combustion equipment manufacturers will not guarantee Rule compliance results from a NOx value AND successful temperature uniformity surveys in these critical heat treat and forging industries, the District should not include those industries in this proposed rule. Thus these and many other types of furnaces with similar issues should be dealt with at a future date when and only if technology is available that would allow the manufacturers to guarantee NOx and uniformity surveys.*

Compliance Dates: An issue also addressed at the meeting was compliance dates. There are a number of companies; one which was represented at the meeting, that has a significant number of furnaces. To require all of these to be retrofitted by a certain date would represent a severe economic burden, particularly in slow economic times.

Recommendation: *In this case it would be recommended that extending the compliance dates over a period of years would be a reasonable approach. The intent would be achieved without the company* *incurring financial peril. The rule might be tied into the overall cost of the projects or a quantity specific retrofits that would be required per year.*

Cost Effectiveness: This area is one that came under discussion that deserves due consideration particularly due to the size of many of these units. The district has indicated a cost effectiveness of $6,000 - $13,000 per ton emitted. If the District believes these are the general rule that could be a consideration, however, for the very small sources that emit extremely small daily, weekly or annual emissions, the cost could be extremely high relative to the net benefit to the environment. We feel that in these few cases the typical BACT guidelines cost effectiveness should apply. Bear in mind that these sources are typically on the very small end of the emissions scale. For the smallest sources included in this rule the device may only produce 50 or so pounds/year. Going from 90 ppm to 30 ppm reduces this to about 18 pounds/year. It is conceivable that the Districts DCF (discounted cash flow) cost to control could be $30,000/ton to perhaps $200,000/ton depending upon the application. Two examples are included.

Recommendation: *The staff should consider the cost/benefit relationship in these few isolated cases. This consideration should be placed in the rule rather than requiring these companies to go through the further expense of getting an attorney to represent them in a hearing board for a variance. This is particularly true due the minimal emissions generated and thus reduced.*

Pounds/Hour vs. ppm: Most burners that could be utilized in metallurgical operations are medium or high velocity burners. The exit velocity can be as high as 300 mile per hour. This very high velocity induces an in-furnace recirculation of products of combustion. The result is a lowering of NOx emissions at the maximum firing rate of the furnace proper. As the firing rate is reduced the NOx levels in ppm tend to go up due the reduced exit velocity of the products of combustion. However they go up at a lower rate than the relative reduced energy input. Thus at maximum firing rate the total emissions entering the atmosphere are higher than the emissions generated at a lower firing rate, even though the ppm values have risen. For instance an Eclipse ThermJet TJ100 burner (1MMBTU/hr capacity) emits an estimated 35 ppm, however as the firing rate decreases, the NOx levels go up, as an example, at approximately 35% firing rate (350,000 BTU/hr) the NOx levels are about 60 ppm. At lesser percentages of the maximum firing rates the NOx levels are actually higher. The result is actually lower NOx into the atmosphere.

The following is a very important note that accompanies the charts in the Eclipse data sheets. This statement is indicative of all manufacturers and what they will guarantee for a particular application. The charts are a general guide. The actual conditions under which a particular burner is used dictates the actual NOx values. The Eclipse data sheet states:

"Emissions from the burner are influenced by:

1. *Fuel type*
2. *Combustion air temperature*
3. *Firing rate*
4. *Chamber conditions*
5. *Percent of excess air"*

As a general rule, as the chamber temperature increases the NOx levels go up. A furnace operating at 1600°F will generate considerably lower NOx than the same furnace operating at 2200°F. With that in mind, let us review the example below that shows the pounds per hour of emissions into the atmosphere vs. the firing rate and ppm values. The actual NOx value for a given furnace would still fall on what the manufacturer is willing to guarantee at a specific furnace operating condition for that process. Thus with the same burner Eclipse (or any other manufacturer) would guarantee a higher NOx level for a high temp forge furnace than a lower temperature furnace using the same burners. Again one size and one burner do not have the same characteristics in multiple applications.

Observe:

20% firing rate = 80 ppm = 102.6 lbs / MMcf

35% firing rate = 60 ppm = 76.9 lbs / MMcf

100% firing rate = 35 ppm = 44.9 lbs / MMcf

100% firing rate = 1,000,000 BTU/hr /1020 BTU/cf = 980 cf/hr.

35% firing rate = 350,000 BTU/hr / 1020 BTU/cf = 343 cf/hr

20% firing rate = 200,000 BTU/hr / 1020 BTU/cf = 196 cf/hr

Therefore:

At 100% firing rate NOx emission are: (980 / 1,000,000 cf) x 44.9 = **.044 pounds of NOx per hour**

At 35% firing rate NOx emissions are: (343 / 1,000,000 cf) x 76.9 = **.026 pounds of NOx per hour**

At 20% firing rate NOx emissions are: (196 / 1,000,000 cf) x 102.6 = **.020 pounds of NOx per hour**

In the above example, it is readily seen that even with the lower firing rate and higher ppm values the emissions entering the atmosphere are actually considerably lower.

Recommendation: *We therefore propose that the District use a pound per hour basis for determining compliance. This would be based on the pounds per hour emitted at 100% for a given burner or classification of equipment. Therefore the pounds per hour for that device will never exceed the emissions rate of the equipment operated at 100% firing rate. The intent of the rule is met, the flexibility is established and at no time would the emissions exceed the maximum atmospheric emissions of maximum firing rate. The SCAQMDs main concern should be the total pounds of NOx entering the atmosphere. Using ppm is only a part of the picture.*

Conclusion: This proposed Rule 1147 has a multitude of problems on a technical basis. There are so many unresolved problems that it is recommended that further input from knowledgeable industry representatives and burner manufacturers be further consulted prior to submittal to the Governing Board. This would result in a much improved rule for the District and industry. Currently the proposed rule is heavily flawed. It serves no purpose to proceed with a rule that is unworkable for various segments of industry. The only alternative would be to exempt various segments of industry from this rule where manufacturers are not willing or able to guarantee NOx emissions results AND temperature uniformity surveys. Failed uniformity surveys put these companies out of business.

We have included some reference material for your consideration and evaluation. We believe this material supports the various presented statements above. Should you wish some additional information that relates to the above dialogue, we can provide whatever additional information will be helpful in assisting your increased knowledge base of our industry.

As always, we stand ready to assist the SCAQMD in their efforts to clean up the air in the SCAB. Rules to be effective must be well thought out. The breath of this rule demands high degrees of technical acuity by those developing the rule. Too much technical work remains for this to be deemed an acceptable rule.

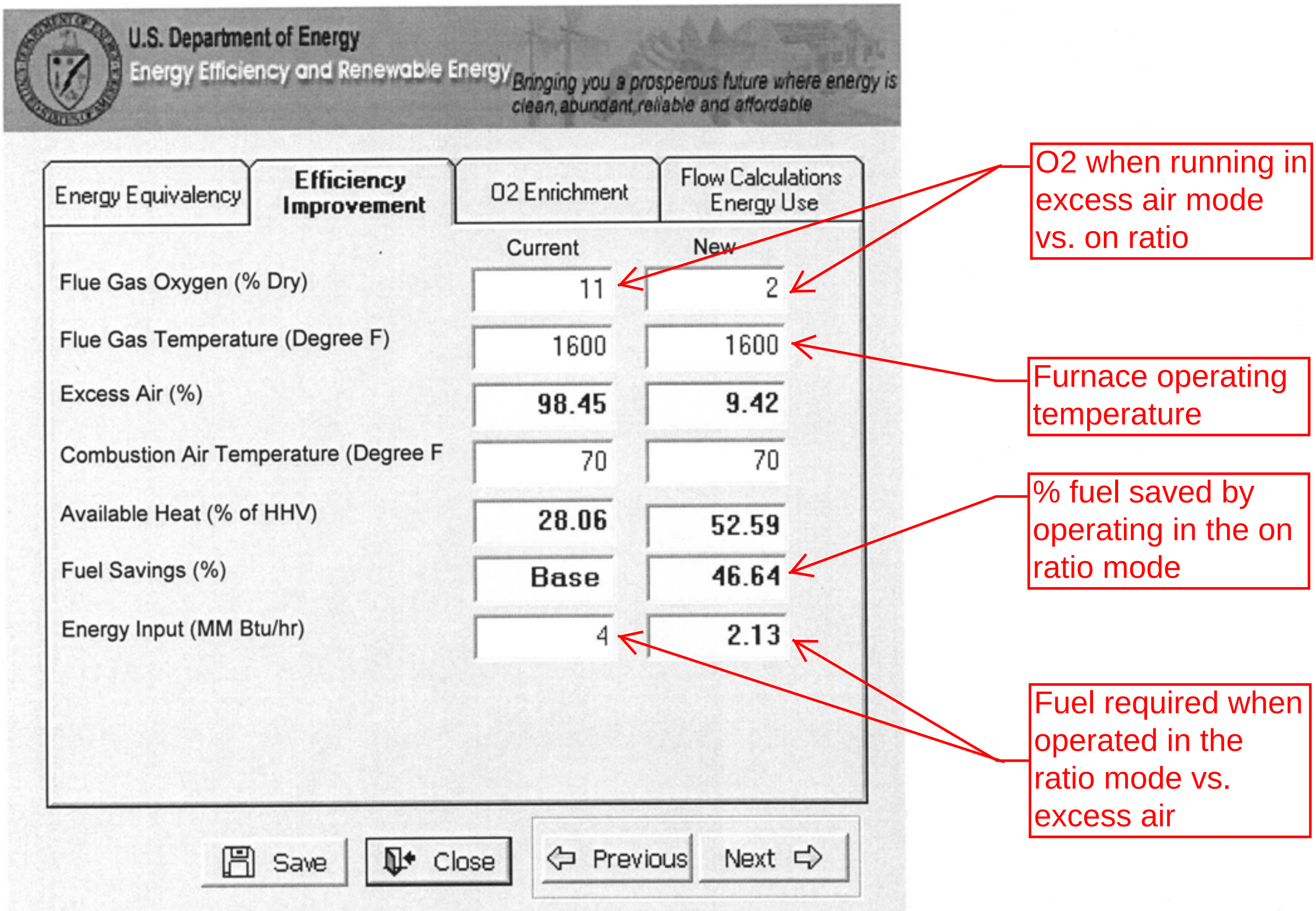
Sincerely,

Anthony W. Endres
President

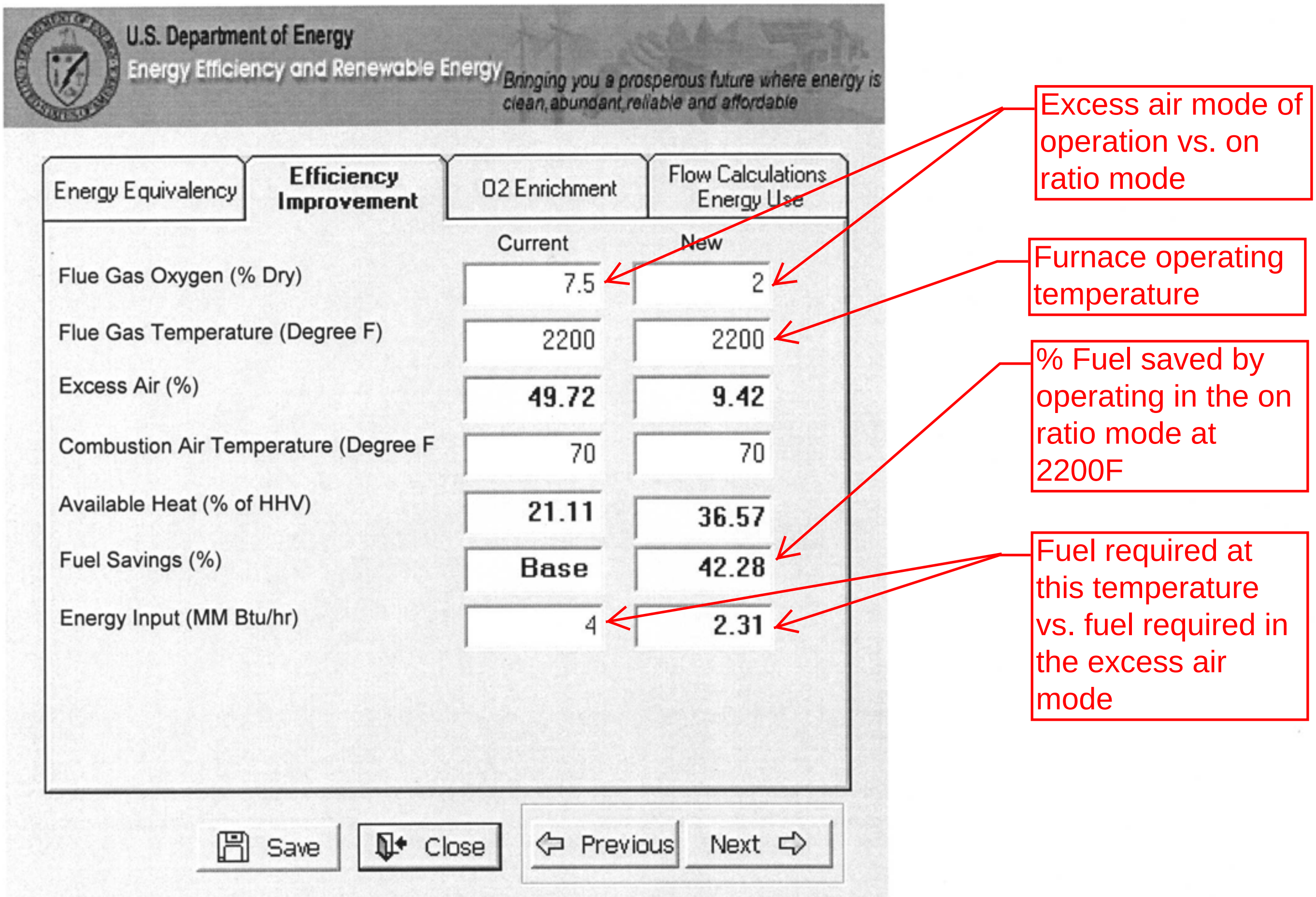
Enc.

REFERENCE MATERIAL

1. DOE Calculator section showing a typical heat treat application. The comparison shows the relationship of efficiency when operating on excess air vs. ratio when operating the furnace at 1600°F.
2. DOE Calculator section showing a typical forging application. This comparison shows an excess air vs. ratio when operating a furnace at 2200°F.
3. Cost effectiveness calculation showing a typical forging application. All the formulas are those used for BACT Cost Effectiveness Evaluation presented in District publications.
4. Cost effectiveness calculation showing a typical soil remediation application. All the formulas are those used for BACT Cost Effectiveness Evaluation presented in District publications.
5. Eclipse ThermJet Model TJ0100 Data Sheet. Page 2 shows the NOx values at different firing rates.
6. Paper "BACT Considerations of Heat Treat Furnaces" that articulates the differences in configuration of heat treat furnaces.



Heat Treat Furnace Operation
Typical Heat Treat Operation



Forge Furnace Operation

Typical High Temperature operation

COST EFFECTIVENESS CALCULATION

Type of Project		**Forge Furnace**	
Use			
Hours per Day		16	
Days per Week		5	
Weeks per Year		50	
Annual Hours of Use		4000	Hours
Gross Input BTU/hr		4,000,000	BTU/hr
Average Input (%)		40%	% Input
Average BTU Input		1,600,000	BTU/hr
Starting Emissions		80	ppm
Pounds/MMCF		102.56	#/MMCF
Pounds per Hour		0.156	
Annual Emissions		**625**	**# Nox/Year**
Modified Source Emissions			
Average Input (%)		40%	% Input
Average BTU Input		1,600,000	
Starting Emissions		60	ppm
Pounds/MMCF		76.92	#/MMCF
Pounds per Hour		0.117	
Annual Emissions		469	# Nox/Year
Annual Reduced Emissions		**156**	**# NOx/year**
Annual Tons Reduced		0.078	T/Y Reduced
10 Year Emissions Reduction		0.781	
Equipment Costs			
Burners	$	5,000	
Engineering	$	1,000	
Piping Costs	$	1,000	
Installation Costs	$	800	
Refractory Cost	$	500	
Start Up Costs	$	300	
Loss of production	$	5,000	
Gas Meter & Gages	$	3,000	
Permit to Construct Fee	$	2,051	
Source Test	$	2,200	
Equipment Cost	**$**	**20,851**	
Annual Costs			
Surveys 2 per year	$	1,000	per year
Periodic Maintenance	$	500	per year
Source Test 5 years	$	2,500	once every 5 years
Cost 10 Year Cost	$	15,250	
Annual Cost (10 year average)	**$**	**1,525**	
DCF Cost Per Ton Reduced	**$**	**42,510**	

COST EFFECTIVENESS CALCULATION

Type of Project	**Soil Remediation**		
Use			
Hours per Day		24	
Days per Week		7	
Weeks per Year		50	
Annual Hours of Use		8400	Hours
Gross Input BTU/hr		150,000	BTU/hr
Average Input (%)		40%	% Input
Average BTU Input		60,000	BTU/hr
Starting Emissions		90	ppm
Pounds/MMCF		115.38	#/MMCF
Pounds per Hour		0.007	
Annual Emissions		**55**	**# Nox/Year**
Modified Source Emissions			
Average Input (%)		40%	% Input
Average BTU Input		60,000	
Starting Emissions		30	ppm
Pounds/MMCF		38.46	#/MMCF
Pounds per Hour		0.002	
Annual Emissions		18	# Nox/Year
Annual Reduced Emissions		**37**	**# NOx/year**
Annual Tons Reduced		0.018	T/Y Reduced
10 Year Emissions Reduction		0.185	
Equipment Costs			
Burners	$	2,000	
Engineering	$	500	
Piping Costs	$	250	
Installation Costs	$	500	
Refractory Cost	$	250	
Start Up Costs	$	300	
Loss of production	$	-	
Gas Meter & Gages	$	2,500	
Permit to Construct Fee	$	2,051	
Source Test	$	2,200	
Equipment Cost	**$**	**10,551**	
Annual Costs			
Periodic Maintenance	$	500	per year
Source Test 5 years	$	2,500	once every 5 years
Cost 10 Year Cost	$	5,250	
Annual Cost (10 year average)	**$**	**525**	
DCF Cost Per Ton Reduced	**$**	**80,214**	

Data 205-5
4/20/04

Eclipse®
Eclipse Combustion

ThermJet Burners

Model TJ0100

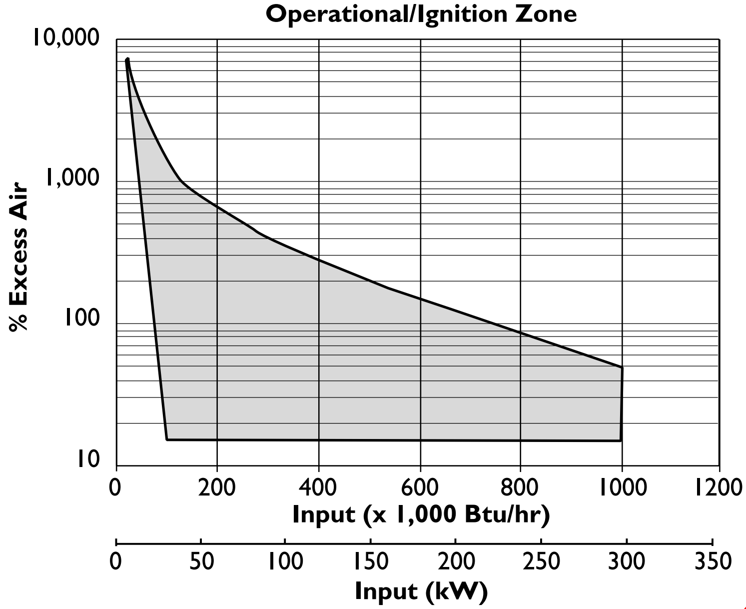
Version 2

PARAMETER	BURNER VELOCITY		MODEL TJ0100
Maximum input Btu/hr (kW)	Medium & High Velocity		1,000,000 (293)
Minimum Input, on-ratio Btu/hr (kW)	Medium & High Velocity		100,000 (29)
Minimum Input, fixed air Btu/hr (kW)	Medium & High Velocity		20,000 (6)
Gas inlet pressure required "w.c. (mbar) • Fuel pressure at gas inlet (Tap "B"– see page 3)	High Velocity	Nat. Gas Propane Butane	12.5 (31.0) 13.5 (34.0) 14.5 (36.0)
	Medium Velocity	Nat. Gas Propane Butane	5.5 (14.0) 8.0 (20.0) 7.5 (19.0)
Air inlet pressure required "w.c (mbar) • 15% excess air at maximum input (Tap "A" – see page 3)	High Velocity	Nat. Gas Propane Butane	16.5 (41.0) 17.0 (43.0) 17.0 (43.0)
	Medium Velocity	Nat. Gas Propane Butane	9.0 (23.0) 9.0 (23.0) 9.0 (23.0)
High Fire Flame Length Inches (mm) (measured from end of combustor)	High Velocity	Nat. Gas Propane Butane	33 (835) 34 (865) 35 (890)
	Medium Velocity	Nat. Gas Propane Butane	38 (965) 37 (940) 42 (1065)
Maximum flame velocity ft/s (m/s) • 15% excess air, at maximum input	High Velocity Medium Velocity		500 (152.4) 250 (76.2)
Flame detection	U.V. scanner available for all combustors Flame Rod available for use with alloy or silicon carbide combustors only		
Fuel	Natural Gas, Propane, Butane *For any other mixed gas, contact Eclipse for orifice sizing.*		

- All information is based on laboratory testing in neutral (0.0"w.c.) pressure chamber. Different chamber size and conditions may affect the data.
- All information is based on standard combustor design. Changes in the combustor will alter performance and pressures.
- All inputs based upon gross caloric values.
- Eclipse reserves the right to change the construction and/or configuration of our products at any time without being obliged to adjust earlier supplies accordingly.
- Plumbing of air and gas will affect accuracy of orifice readings. All information is based on generally acceptable air and gas piping practices.

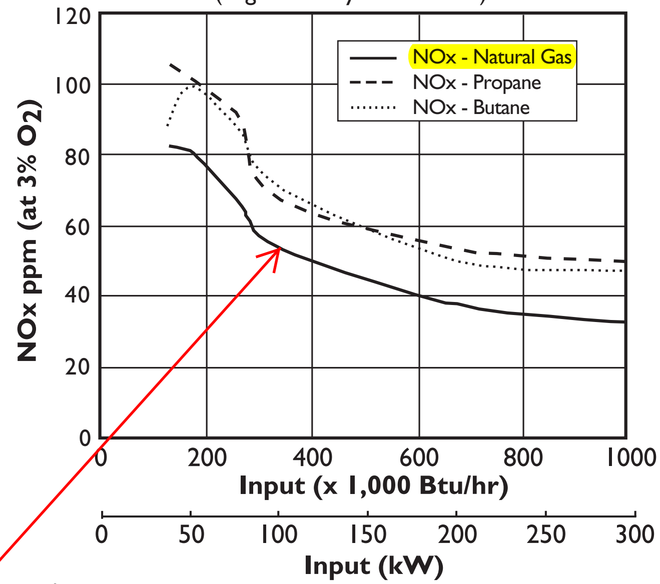
ECLIPSE™
Innovative Thermal Solutions

Operational/Ignition Zone



NO_x Emissions

(High Velocity Combustor)



Correction factor for medium velocity combustor is 1.20

On Ratio: Combustion air is adjusted to 3% O_2 at any given input.

Approximate NOx emissions at different firing rates. Note that the operating conditions effect the actual emissions of an application

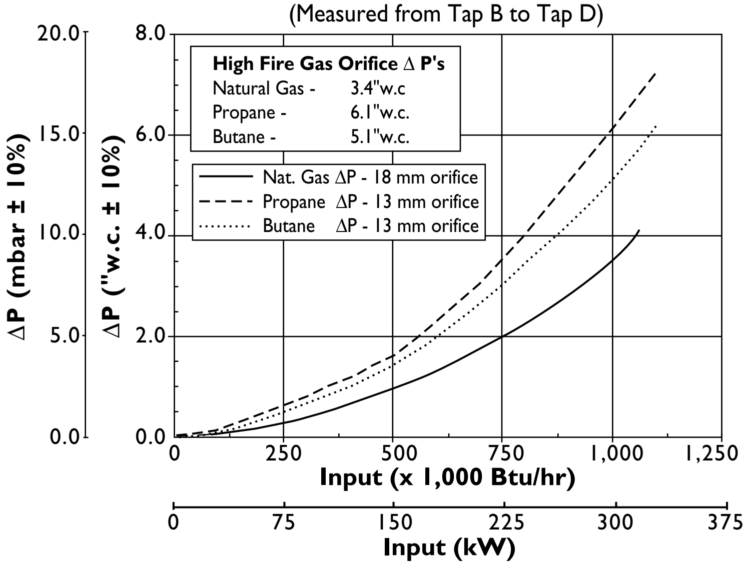
Emissions from the burner are influenced by:

- fuel type
- combustion air temperature
- firing rate
- chamber conditions
- percent of excess air

For estimates of other emissions, contact Eclipse Combustion.

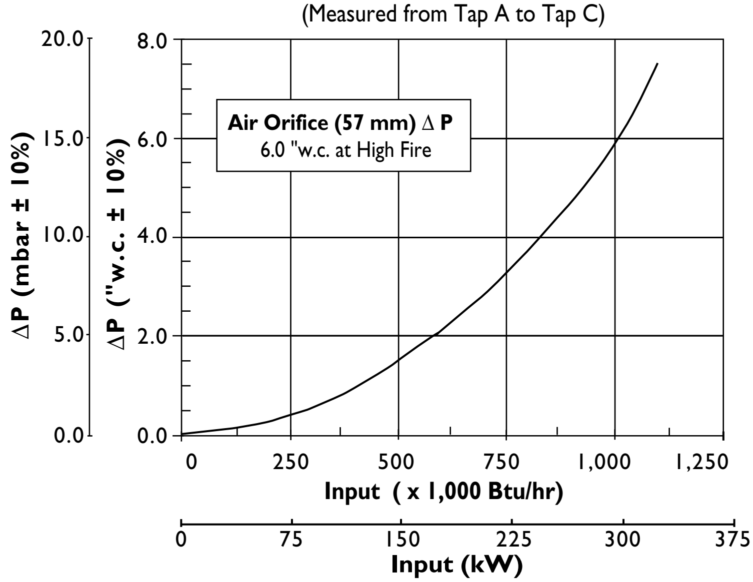
Gas Orifice Δ P vs. Input

(Measured from Tap B to Tap D)



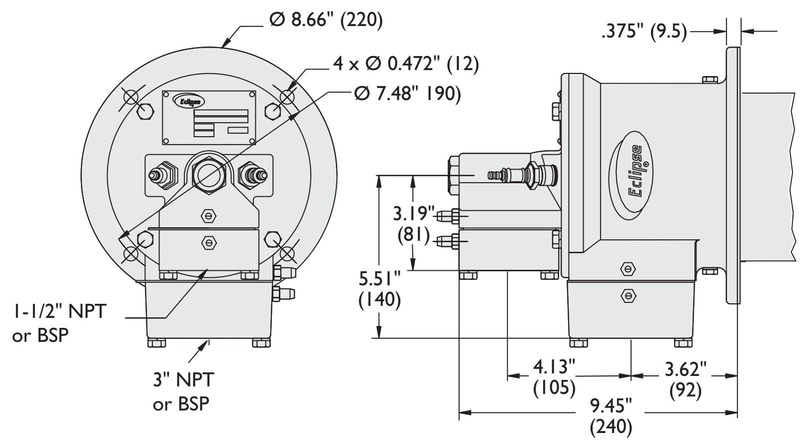
Air Orifice Δ P vs. Input

(Measured from Tap A to Tap C)



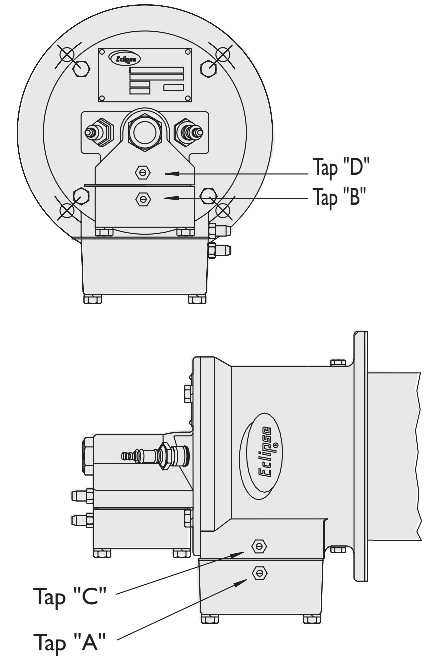
Dimensions & Specifications
Inches (mm)

Burner Housing



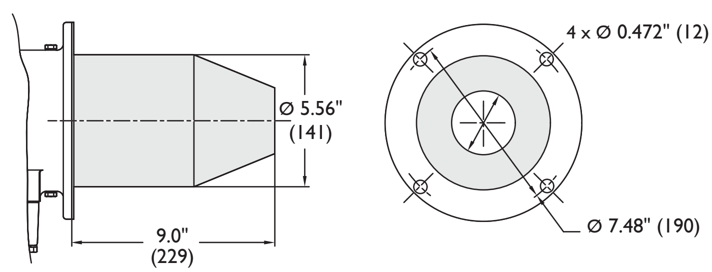
Burner weight less combustor: 42 lb (19 kg)

Tap Locations



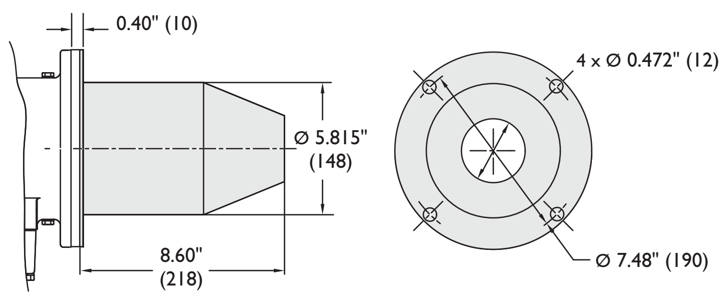
Combustor

Exhaust outlet diameter : High Velocity : Ø 2.125 (54)
Medium Velocity : Ø 3.0" (76.4)



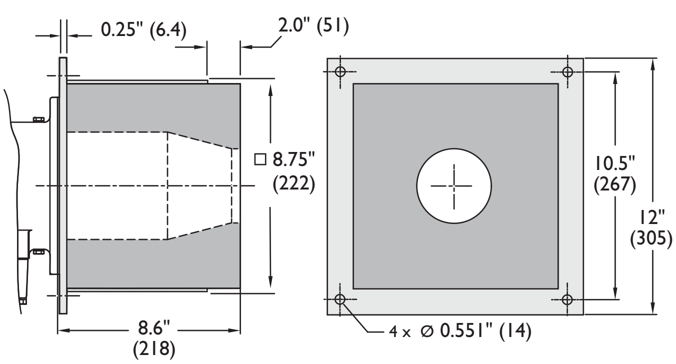
Alloy Tube (AISI 310)

Weight: 3.2 lb (1.45 kg)
Max Chamber Temp: 1,750ºF (950ºC)



Silicon Carbide Tube

Weight: 3.2 lb (1.45 kg)
Max Chamber Temp: 2,500ºF (1371ºC)



Refractory Block (w/RA330 wrapper)

Weight: 61.3 lb (28 kg)
Max Chamber Temp: 2,800ºF (1538ºC)

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Eclipse Combustion

www.eclipsenet.com

ENERGY SERVICES CORPORATION

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Long Beach, California 90803
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AIR QUALITY AND ENERGY EFFICIENCY CONSULTING

BACT CONSIDERATIONS OF HEAT TREAT FURNACES

Heat Treat Companies in Southern California: There are a large number of companies that heat treat products in Southern California. Different heat treat companies have specific metallurgical requirements specified by their customers. Some specialize in only aluminum; while others heat treat small fasteners, yet others concentrate on aerospace alloys. Different furnace designs and methods of firing are required to satisfy those needs. Further, many heat treat companies specialize in very narrow ranges of heat treat capabilities and therefore design custom furnaces that satisfy that requirement. It is not unusual for companies to have one-of-a-kind (proprietary) furnaces used in only one plant.

Temperature Uniformity: This term is mentioned in the dialogue above. This is critical to all types of heat treat equipment. The companies who operate these types of furnaces must pass a temperature uniformity survey, typically twice a year at the representative temperatures that the furnaces operate. The uniformity requirements are spelled out in AMS 2750D, AMS H-6875 as well as many other specifications that regulate the industry for aerospace materials and commercial heat treating. Typically the uniformity requirements are dependent upon furnace class and temperature range. For lower temperatures the limit is +/- 10^{o}F, as the temperatures increase the limit is +/- 15^{o}F, the upper limits are +/- 20^{o}F or +/- 25^{o}F depending upon the specification. A uniformity survey is setup to measure how uniform the temperature is within the working envelope of the furnace. The temperature is measured by placing stands inside the furnace and attaching thermocouples at the representative levels in the furnace. The minimum number of thermocouples is 9 and the maximum is 44, depending on a formula spelled out in the heat treat specification relative to volume of the work zone.

The customers define which specification they must comply. The requirements are very stringent. If a furnace does not pass a uniformity survey they must shut down the furnace and not operate it for heat treating. The heat treaters are audited to assure compliance with the uniformity standards as well as calibration of instruments, etc. Should they not be able to comply with the requirements they are essentially out of business.

BACT guidelines require that to achieve a BACT classification the technology must be specific to a particular type of furnace observed as being continuously successfully operated for a period of 12 months. Once this criterion has been established for a specific type of furnace, the BACT classification remains intact for a period of 2 years.

Objective: To provide an understanding of the differentiation of types of heat treat furnaces as associated with BACT requirements. To this end, this paper will define both the basic different types of the heat treat processes as well as the associative furnaces to satisfy the vastly different requirements of the heat treat industry. Furnaces are designed to accomplish a specific task with a specific combustion system. The physical size, configuration and method of firing are all taken into consideration in the engineering phase of the design process. It must be understood that there is no one NOx emission limit that can be ascribed to the industry as a whole or for a specific temperature range or type of furnace within that type. BACT is a condition specific rule.

Background: To accurately determine the appropriate BACT for a type or classification of equipment, it is important that one completely understand the depth and breathe of said equipment. It is also important that the "achieved in practice" criteria be established for the specific application rather than an industry as a whole. This is particularly true of heat treating furnaces. The general classification is very expansive in differences of configuration and cannot be painted with the broad brush for all furnaces within that industry. There can be significantly different configurations within the same operating temperature range. It is impossible to determine the appropriate BACT by only looking at heat treating as a single category. There are a large variety of heat treat furnaces. The two basic types are ***direct firing*** and ***indirect firing***. Each of the different types has specific uses and can have dramatically different physical characteristics, combustion systems, furnace temperature, and burner types. This dialogue will articulate the differences in hopes of clarifying the differences.

Direct Firing is a process where the products of combustion are in contact with the parts to be heat treated. The materials heat treated in these furnaces are aluminum and carbon steel (where further processing such as machining is required), stainless steels, exotic aerospace alloys, etc. Temperature ranges are typically from 400°F to 2,100°F. Within this category there are a variety of significantly different types of furnaces that satisfy specific metallurgical requirements. The processes are homogenizing (for aluminum), hardening and annealing processes for other alloys. Some of these are air quenched, liquid quenched or slow cooled, depending upon the process.

Indirect Firing is used where a controlled atmosphere is required. This atmosphere is an inert gas, which will maintain a non-oxidized surface. There are both high temperature and low temperature applications. Alloys run from the aluminum to exotic alloys (aerospace grades) and carbon steel.

Aluminum alloys must be protected from contact with product of combustion to maintain their bright finish, typical of parts already machined and ready for installation in final assemblies. Temperatures are usually less than 1,000°F and are generally for homogenizing to relax the grain structure after casting or coiling but can also include hardening where rapid quenching is required.

Steel is also annealed much in the same manner as aluminum but the furnaces operate at higher temperatures – up to 1,600°F. There are also indirect fired strip annealing, a continuous process where long coils of stainless or non-ferrous steels are passed through long vertical or horizontal furnaces. These furnaces are very constant in firing rate and run for long periods without being shut down.

As indicated above, within each of the two major categories are sub categories that describe the different furnace configurations; burners and combustions unique to these sub categories.

1. Direct Fired
    a. Low Temperature Recirculating
    b. Medium Temperature Recirculating
    c. High Temperature Direct Fired (ratio, excess air & pulse)

2. Indirect Fired
    a. Low Temperature Recirculating (radiant tube, atmosphere)
    b. Medium Temperature Recirculating (bell annealing, atmosphere)
    c. High Temperature Vacuum (gas and electric)
    d. High Temperature, silicone or ceramic tube type
    e. Strip Annealing
    f. Wire Annealing

The following will be an explanation of each type, their uses and differences in operation.

DIRECT FIRING

Direct Fired, Low Temperature, Recirculating: This type of furnace is used typically for temperatures less than 1,000°F where the products of combustion can come in direct contact with the parts to be heat treated. Aluminum homogenizing furnaces fall in this category. Typically there are one to four burners firing into or at one end of a plenum chamber. In the opposite end of the plenum is a large recirculating fan (in some cases multiple fans). These fan(s) provide a high volume heated air to scrub the parts. At low temperatures there is little radiant heat transfer, so the large volumes of air flowing across the parts provide the required convective heat transfer. On the burner end of the chamber there is a duct that comes from the large heat treating chamber of the furnace. The burners fire into a chamber where the products of combustion are mixed with the recirculated air from the furnace proper. The mixture of hot gases and recirculated gases are drawn into a recirculating fan and redirected into the furnace. Typically the volume changes range from 10 to 60 furnace volume changes per minute. With the large amounts of air volumes circulating the actual exhaust from the furnace can contain O_2 concentrations of 10% to 16%.

Even within this type of furnace there are two types of furnace layouts. One has the burner(s) firing into a specific chamber or plenum where the recirculated air is mixed with the products of combustion prior to entering the recirculating fan inlet. This type of furnace is defined as a batch type. Another configuration is that of a continuous nature that utilizes a conveyer to move parts through the furnace. The conveyer type is frequently used for lower temperature applications starting as low as 425°F, however there are conveyorized furnaces that can run up to about 1700°F. Within this category there are two types of firing scenarios. One is an excess air method of firing and the other is using a recirculating fan method. Generally speaking, the lower the operating temperature the lower the NOx values.

In all cases the firing rate is modulated to maintain the temperature in the heating chamber. In this type of furnace the combustion systems are usually (but not always) ratio based. The ratio however tends to be biased to the excess air side of the stoichiometric ratio. There are some older types of combustion systems that utilize an excess air only type of firing. NOx levels are usually relatively low in this type of furnace, again depending upon furnace configuration and temperature of operation.

Medium Temperature Recirculating: These furnaces are used for steel or alloy heat treating. Temperature ranges are up to approximately 1,700°F. Some of these are continuous conveyorized and others are box batch type. Due to the limitations of recirculating fans, direct firing is used for higher temperature. In this category, usually a single burner configuration is utilized. Many of these furnaces do not have specific flues. The exhaust (products of combustion) exits from the entrance and exit end of the furnace.

High Temperature Direct Fired (ratio, excess air & pulse): This category is used for heat treating a variety of different alloys up to 2100°F. It should be noted that these furnaces are usually very flexible in temperature and many times operate as low as 900F. It should be remembered that temperature uniformity is critical to effective heat treating metallurgy. The combustion systems are multi burner systems that can use as many as three distinctive different methods of firing, ratio, excess air and pulse firing. In some cases, more than one mode of operating is incorporated in the same furnace, usually ratio and excess air.

The different modes of operation are used at different temperatures with the ultimate goal to maintain maximum temperature uniformity to satisfy metallurgical requirements. *Ratio systems* operate by modulating air and the gas is modulated based on air pressure feed to a gas ratio regulator. The correct air/fuel ratio is thereby maintained through the firing rate, this type of system is usually only used at higher temperature. *Excess air* is where the air flow rate is maintained at the maximum and the gas is modulated. This method is used when very tight temperature uniformity is required. *Ratio firing* will typically not yield tight enough uniformity for lower temperatures or critical jobs. The third method of firing is *pulse firing* where the burners are fired on ratio at 100%, but pulsed on and off (or high fire/low fire operation) with the quantity of burners and duration of on/off cycles determined by the temperature requirements of the parts being heat treated. Even this type of system may need some amounts of excess air to achieve desired temperature uniformity. NOx levels vary depending upon burner types, temperatures, air fuel ratio, firing rate and firing method. Needless to say a furnace operating at 900°F is going to have a much lower NOx level than the same furnace operating at 2100°F. Many of the direct fired furnaces utilize high velocity burners to help achieve the high degrees of temperature uniformity required in the lower temperature ranges. The exit velocity of these burners can be as high as 300 miles per hour.

Direct Fired NOx Considerations: As with all categories of heat treat furnaces and processes, the NOx values are wide ranging. Lower temperatures usually yield lower NOx values; higher temperatures yield higher NOx values. Multiple use furnaces operating from 900°F to 2100°F will have different NOx values depending on firing rate, mode of operation, burner type and temperature. The indirect fired recirculating type can generally yield the lowest NOx values (when operating at lower temperatures), the direct fired – the highest NOx values. With that in mind, the NOx values could be from in the 30 ppm range to 60 ppm range at high fire depending upon variables of configuration. On high turn down the NOx ppm values may be as high as 80 ppm, as evidenced by reviewing burner manufacturers published NOx curves.

INDIRECT FIRED FURNACES

Indirect Fired – Recirculating Radiant Tube: Within this type of furnace there are many different types of indirect fired heat treat furnaces – *low temperature radiant tube, medium temperature radiant tube, bell annealing, high temperature radiant tube, continuous strip annealing and wire annealing.*

Low Temperature Radiant Tube: The radiant tube type has multiple burners that fire into individual isolated tubes and is operated usually at less than 1,000°F. These tubes are normally in a "U" shape firing into one end and exhausting from the other end. By design, the flames are usually quite long extending half the length of the tube (in a "U" tube – to the bend). If the total tube length is 16', the flame length will be approximately 8' long. The burners are normally pulse fired with the duration of the on/off cycles determined by the demand for heat. If continuously fired on a modulating cycle, the burner could cause excessive temperature in the tube closest to the burner, causing premature failure to the radiant tube. The tube extends into the heating chamber using radiant heat to transfer heat to the chamber. There is normally a large propeller type of fan that circulates the air across the parts and around the radiant tubes. Normally, there is an inert gas that is introduced into the heating chamber to prevent oxidization of the surface of the metal being heat treated. This type of furnace usually has multiple low BTU (perhaps in the .5 MMBTU/hr range) burners firing into individual radiant tubes. In the previous example the burner, a single large burner (up to >3 MMBTU/hr) fires directly into the firing chamber. In this type of furnace, there may be a metallurgical necessity to purge the working zone of the furnace with an inert gas. This inert gas protects the parts to be heat treated from becoming discolored, particularly important with aluminum where a bright finish is required. In other cases inert gas may not be required, in which case only hot air is recirculated within the furnace – still without products of combustion in direct contact with the parts being heat treated.

Medium Temperature Bell Annealing is another type of indirect fired heat treat furnace. Normally, this furnace operates at higher temperatures, up to 1,500°F, and usually used for annealing steel parts or steel coils. These furnaces are configured quite differently than the radiant tube type of furnace. There is a large bell made of stainless steel that fits over the parts to be annealed. As in the previous case the parts are isolated from the products of combustion but in a dramatically different way. The parts are not aluminum, but share the necessity of not having the products of combustion in direct contact with the parts being annealed. Steel coils are the type of part that requires this type of annealing. The annealing relaxes the stresses introduced into coils when rolling to a precision cross section or slitting to specific widths. Annealing in an inert atmosphere, maintains a bright surface compared to an oxidized (rusted) surface that would occur if the products of combustion were in direct contact with the coils. In this type of furnace there are also fans that recirculate the heated inert gas around the coils to assure the required temperature uniformity while transferring the heat energy from the outside of the bell to the parts contained therein. The coils usually being sold to companies that stamp the coils into finished parts that go into thousands of different parts.

In bell annealing furnaces there are two types of burners used – forward velocity fired tangentially around the large bell and flat flame burners firing directly toward the bells. It is important to note that these burner configurations are specifically designed for a particular furnace configuration, and are not interchangeable. Typically, similar burners can also be used in direct-fired high temperature heat treat furnaces. Whereas, the radiant tube burners can only be used in radiant tubes. This is because there is a need for the flame to extend as far into the tube as possible (usually half the length of the tube or to the bend). These burners cannot be used for any other applications.

Vacuum: There are two types of vacuum heat treat furnaces, electric and gas fired. Obviously, the electric heat treat vacuum generates no NOx emissions. The gas fired vacuum furnaces are a rarity. Due to the low BTU input they are exempt from permitting requirements per Rule 219(b)(2).

High Temperature Radiant Tube: These furnaces typically use silicone carbide or ceramic tubes to transfer the heat to the load. These can operate over 2000°F. Typically, they are not "U" tube configuration but straight through due to the nature of the material used and the furnace configuration. Many of these furnaces are relatively small and would therefore be exempt per Rule 219(b)(2).

Wire Annealing Furnaces: These furnaces are again unique compared to other types of heat treat furnaces. The wire to be annealed is pulled through the furnace heating zone in many strands. The wire comes off of coils of wire and is taken up on coils. The wire is continuously moving through the furnace and has heating and cooling zones of the furnace. Most of these have an inert gas in contact with the wire in the heating zone and are radiant tube fired not dissimilar to other types of radiant tube furnaces. However, the operation is significantly different from other types of radiant tube fired furnaces.

Salt Bath and Fluidized Bed Furnaces: The salt bath type uses salt that is heated with an emersion heater. This is a tube fired burner that heats up a tube that transfers the heat to a salt. The salt becomes molten and when at the proper temperature the parts are placed in a basket and immersed in the liquid salt bath. After a given time the parts are removed and quenched or allowed to air cool. Fluidized bed furnaces have a fluidized bed of material where the heat is directed through a media. The parts are placed in the media and heated to the representative temperature. Generally these are have small BTU input but could possibly be over 2 MMBTU/hr.

There are many other types of small heat treat furnaces that have inputs less than 2 MMBTU/hr and are thus also exempt pursuant to Rule 219(b)(2).

Indirect Firing NOx Considerations: In this indirect firing group of heat treat furnaces, the lowest NOx levels are achieved in the Bell Annealing type of furnace, operating in the 45 – 70 ppm range. However, as is true of heat treat furnaces the NOx levels are dependent upon the furnace temperature, combustion system and furnace configuration. Condition dependent, is the operative word.

The *radiant tube type*s of burners generate the highest emissions from a ppmv NOx point of view, typically over 70 ppm, again depending upon the furnace configuration and temperature of operation. This is primarily due to the nature of pulse firing of radiant tube firing where the flame is designed to travel approximately 50% of the tube length. However, once the parts are up to temperature, the total NOx (pounds per hour) are usually reasonably low compared to the direct-fired furnaces. This is because, once up to temperature, there is a relatively low energy input to maintain temperature. There are new technologies that have come out that can lower the NOx values to less than 60 ppm. However they may not be acceptable for every type of radiant tube firing.

Conclusion: In general, the NOx emissions are determined by a combination of factors: burner type, furnace temperature, combustion system operational system, and furnace configuration. The two different issues are total NOx and ppmv NOx. Even within this type of furnace and burner types there are variables. Total NOx would be the pounds per hour emissions vs. the ppm values, which are an instantaneous value. Virtually all heat treat operations involve a ramping to temperature and a soaking of the material at temperature. There is ramped heating that takes place over many hours and then a soak period that can take longer than 8 hours at temperature. Frequently, once the set point temperature is reached, a relative small input is required to maintain temperature. So for some types of furnaces, the ppm value may be higher but the average firing rate may be relatively low. Thus the overall pounds of NOx emitted into the atmosphere is lower at average firing rates then it is at maximum firing rates with a lower ppm value.

Summary: By a review of the above, one can see that there are a large number of different types of heat treat furnaces – each with its own combustion system and NOx consideration. Even within a specific type of heat treat furnace there are significant numbers of different furnace configurations. Generally there are no standard part number furnaces defined by a manufacturer. Most are custom made for a specific customer, conducting a specific type of heat treating in his facility. Within a given facility there may be more than 6 different configurations of furnace, each type with different burners, controls and operating conditions. These were originally designed to provide a specific heating and uniformity profile. In many cases the burners and combustion systems are not interchangeable from one furnace to another.

Overall, to determine NOx BACT for a particular furnace type one must consider the combination of issues relating to the furnace configuration, burner selection, operating temperature and combustion system firing methodology. We also must understand that the same burners operated under different furnace configuration and temperatures will yield different NOx values and still will be BACT for that specific furnace type.

As it can be seen heat treating is not a one size fits all industry similar to boilers of other types of industries where the process remains relatively constant from company-to-company and job-to-job, furnace to furnace. Many custom built furnaces answer very specific metallurgical requirements that are completely unique to one company, and perhaps only one or two furnaces of that configuration are in existence. For this reason the SCAQMD must evaluate heat treat furnaces on an individual basis - not lumped into a general category. In fact BACT for the heat treating industry could vary from 30 ppm in NOx ppm values to as high as 80 ppm and will still be BACT acceptable, based on furnace type, temperature, firing rate and operating configuration.