UTAH DIVISION OF AIR QUALITY
SOURCE PLAN REVIEW

William Snarr
Tesoro Refining & Marketing Company LLC
474 W 900 N
Salt Lake City, UT 84103

Project Number: N103350066

RE: Installation of a Wet Gas Scrubber and Ultra-Low NO_x Burners
Salt Lake County; CDS A; MACT (Part 63), Nonattainment or Maintenance Area, Title V (Part 70) major source, PM_{10} SIP / Maint Plan, $PM_{2.5}$ Moderate Area SIP, Major criteria source, NESHAP (Part 61), Major HAP source, NSPS (Part 60)

Review Engineer: John Jenks
Date: February 29, 2016

Notice of Intent Submitted: June 11, 2015

Plant Contact: Michelle Bujdoso
Phone Number: (801) 366-2036
Fax Number: (801) 521-4965 Email: Michelle.D.Bujdoso@tsocorp.com

Source Location: 474 West 900 North, Salt Lake City, UT
Salt Lake County
4,515,950 m Northing, 423,400 m Easting, UTM Zone 12
UTM Datum: NAD27

DAQ requests that a company/corporation official read the attached draft/proposed Plan Review with Recommended Approval Order Conditions. If this person does not understand or does not agree with the conditions, the review engineer should be contacted within five days after receipt of the Plan Review. If this person agrees with the Plan Review and Recommended Approval Order Conditions, this person should sign below and return (FAX # 801-536-4099) within 10 days after receipt of the conditions. If the review engineer is not contacted within 10 days, the review engineer shall assume that the company/corporation official agrees with this Plan Review and will process the Plan Review towards final approval. A public comment period will be required before the Approval Order can be issued.

Applicant Contact ____
(Signature & Date)

OPTIONAL: In order for this Source Plan Review and associated Approval Order conditions to be administratively included in your Operating Permit (Application), the Responsible Official as defined in R307-415-3, must sign the statement below and the signature above is not necessary. THIS IS STRICTLY OPTIONAL!

If you do not desire this Plan Review to be administratively included in your Operating Permit (Application), only the Applicant Contact signature above is required. Failure to have the Responsible Official sign below will not delay the Approval Order, but will require a separate update to your Operating Permit Application or a request for modification of your Operating Permit, signed by the Responsible Official, in accordance with R307--415-5a through 5e or R307-415-7a through 7i.

> **"Based on reasonable inquiry, I certify that the information provided for this Approval Order has been true, accurate and complete and request that this Approval Order be administratively amended to the Operating Permit (Application)."**

Responsible Official ____
(Signature & Date)

Print Name of Responsible Official ______________________________

ABSTRACT

On June 11, 2015, Tesoro Refining & Marketing Company LLC (Tesoro) submitted a NOI to construct and operate a wet gas scrubber and LoTOx project to control emissions from the FCCU/CO Boiler at the Tesoro Refinery in Salt Lake City (Refinery). The Refinery is located in Salt Lake City, Salt Lake County, which is a nonattainment area for PM10, PM2.5 and SO2, and a maintenance area for ozone and CO. This project was submitted in partial fulfillment of the PM2.5 requirements found in Sections IX.H.11.g.i and IX.H.12.r of the Utah SIP.

The project involves the installation of an ozone generation system to react with and remove NOx from the FCCU/CO boiler exhaust stream. The exhaust gases are then passed through a new spray tower, which removes the NOx compounds, as well as SO2/SO3 and particulates. The removed compounds are retained in the spray tower's liquid medium - water, buffered with a sodium hydroxide reagent. The liquid is then processed in a purge treatment unit, which separates and dewaters the solids. This results in a final effluent stream that is low in total suspended solids.

Although there will be a small increase in fugitive dust emissions from increased truck traffic to deliver raw materials and haul away waste byproducts associated with the project, no change in plant-wide particulate emissions is anticipated as a result of this project.

This project was supplemented on October 12, 2015, with the submission of additional information. Tesoro determined that approximately 17,500 lb/hr of additional steam generation would be needed to drive the combustion air fan, providing the higher pressures needed in the flue gas train. There would be a slight increase in actual emissions from the existing cogeneration units at the refinery, the largest being approximately 6 tpy of NOx, although this increase would be within Tesoro's existing permitted emission caps. Tesoro also provided information regarding truck haul road emissions as part of this submission. The fugitive dust emissions from the haul roads amount to less than 0.1 tons of total particulates (either PM10 or PM2.5).

Finally, on November 10, 2015, Tesoro submitted a separate NOI for the installation of ultra-low NOx burners on the ultraformer unit (UFU) F-1 furnace. Also submitted in partial fulfillment of the PM2.5 requirements of the Utah SIP, this project is scheduled to be installed at roughly the same time as the wet gas scrubber project. Therefore, Tesoro has requested that the two projects be processed concurrently. Since both projects affect equipment covered by the same existing AO (DAQE-AN103350065-14), both NOIs have been combined into a single AO modification for purposes of convenience and project timing.

The installation of the new burners on the UFU yields no change in established source-wide permitted emissions (no change in Tesoro's emission caps), as this installation was already included and anticipated in Tesoro's emission caps as required by January 1, 2019. Only the UFU will be directly physically changed by this portion of the project. A slight increase in actual emissions (<1 tpy) of PM/PM10/PM2.5 and VOC is expected from the UFU Furnace F-1. In addition, some additional steam from the cogeneration units will be required to assist the operation of the new burners. The total increase in actual emissions from increased utilization of the cogeneration units is less than 1 tpy of any pollutant (the largest being 0.78 tpy of CO). Like the emission increases associated with the wet gas scrubber steam demand, these emission increases are included in Tesoro's existing emission caps.

Any increase in emissions associated with increased utilization of the cogeneration units can be accomplished under existing permit requirements and without a physical change or change in the method of operation of those units; therefore, a review of BACT is not required for the cogeneration units. The F-

1 Furnace is being physically changed by the installation of the new burners, and will experience a small increase in emissions of both particulates and VOC; therefore, a BACT review is required for this emissions unit.

The source is subject to federal NSPS, NESHAP and MACT requirements, and is defined as a major contributing source in both the Salt Lake County PM10 Maintenance and Salt Lake City PM2.5 Nonattainment Area sections of the SIP. The SIP has established emission caps for PM10, PM2.5, SO2 and NOx. The new and project-affected equipment will be included in these emission caps which shall remain at their present values. Total PTE from the entire refinery is estimated at the following tons per year values: PM10 = 282, PM2.5 (a subset of PM10) = 154, NOx = 638, SO2 = 1637, CO = 1,376, VOC = 793.

SOURCE SPECIFIC DESIGNATIONS

Applicable Programs:

NSPS (Part 60), Subpart A: General Provisions applies to North Flare
NSPS (Part 60), Subpart A: General Provisions applies to South Flare
NSPS (Part 60), Subpart Db: Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units applies to CG1 and CG2
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to F-15
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to F-680 and F-681
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to F-701
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to FCCU/CO Boiler
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to H-101
NSPS (Part 60), Subpart Ja: Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After May 14, 2007 applies to F-1
NSPS (Part 60), Subpart K: Standards of Performance for Storage Vessels for Petroleum Liquids for Which Construction, Reconstruction, or Modification Commenced After June 11, 1973, and Prior to May 19, 1978 applies to Permitted Source
NSPS (Part 60), Subpart Ka: Standards of Performance for Storage Vessels for Petroleum Liquids for Which Construction, Reconstruction, or Modification Commenced After May 18, 1978, and Prior to July 23, 1984 applies to Permitted Source
NSPS (Part 60), Subpart Kb: Standards of Performance for Volatile Organic Liquid Storage Vessels (Including Petroleum Liquid Storage Vessels) for Which Construction, Reconstruction, or Modification Commenced After July 23, 1984 applies to Tank 327: Storage vessel - gasoline
NSPS (Part 60), Subpart GG: Standards of Performance for Stationary Gas Turbines applies to CG1 and CG2
NSPS (Part 60), Subpart XX: Standards of Performance for Bulk Gasoline Terminals applies to Permitted Source
NSPS (Part 60), Subpart GGG: Standards of Performance for Equipment Leaks of VOC in Petroleum Refineries for which Construction, Reconstruction, or Modification Commenced After January 4, 1983, and on or Before November 7, 2006 applies to Permitted Source
NSPS (Part 60), Subpart GGGa: Standards of Performance for Equipment Leaks of VOC in Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After November 7, 2006 applies to Permitted Source
NSPS (Part 60), Subpart NNN: Standards of Performance for Volatile Organic Compound (VOC) Emissions From Synthetic Organic Chemical Manufacturing Industry (SOCMI) Distillation Operations

applies to Permitted Source
NSPS (Part 60), Subpart QQQ: Standards of Performance for VOC Emissions From Petroleum Refinery Wastewater Systems applies to Permitted Source
NESHAP (Part 61), Subpart A: General Provisions applies to Permitted Source
NESHAP (Part 61), Subpart M: National Emission Standard for Asbestos applies to Permitted Source
NESHAP (Part 61), Subpart FF: National Emission Standard for Benzene Waste Operations applies to Permitted Source
MACT (Part 63), Subpart A: General Provisions applies to Permitted Source
MACT (Part 63), Subpart CC: National Emission Standards for Hazardous Air Pollutants From Petroleum Refineries applies to Permitted Source
MACT (Part 63), Subpart UUU: National Emission Standards for Hazardous Air Pollutants for Petroleum Refineries: Catalytic Cracking Units, Catalytic Reforming Units, and Sulfur Recovery Units applies to Permitted Source
MACT (Part 63), Subpart EEEE: National Emission Standards for Hazardous Air Pollutants: Organic Liquids Distribution (Non-Gasoline) applies to Permitted Source
MACT (Part 63), Subpart DDDDD: National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters applies to Permitted Source
Major HAP source applies to Permitted Source
Major criteria source applies to Permitted Source
PM_{10} SIP / Maint Plan applies to Permitted Source
Title V (Part 70) major source applies to Permitted Source
Salt Lake City CO Maintenance Area applies to Permitted Source
Salt Lake County O3 Maintenance Area applies to Permitted Source
Salt Lake County PM_{10} NAA applies to Permitted Source
Salt Lake County $PM_{2.5}$ NAA applies to Permitted Source
Salt Lake County SO_2 NAA applies to Permitted Source

Permit History:

When issued, the approval order shall supersede or will be based on the following documents:

Supersedes	DAQE-AN103350065-14 dated September 5, 2014
Is Derived From	Source Submitted NOI dated June 11, 2015
Incorporates	Additional Information Received From EPA dated September 29, 2015
Incorporates	Additional Information Received dated September 23, 2015
Incorporates	Additional Information Received dated October 12, 2015
Incorporates	Additional Information Received dated November 10, 2015
Incorporates	Additional Information Received dated January 8, 2016
Incorporates	Additional Information Received dated February 1, 2016

SUMMARY OF NOTICE OF INTENT INFORMATION

Description of Proposal:

On June 11, 2015, Tesoro Refining & Marketing Company LLC (Tesoro) submitted a NOI to construct and operate a wet gas scrubber and LoTOx project to control emissions from the FCCU/CO Boiler at the Tesoro Refinery in Salt Lake City (Refinery). The Refinery is located in Salt Lake City, Salt Lake County, which is a nonattainment area for PM_{10}, $PM_{2.5}$ and SO_2, and a maintenance area for ozone and

CO. This project was submitted in partial fulfillment of the $PM_{2.5}$ requirements found in Sections IX.H.11.g.i and IX.H.12.r of the Utah SIP.

The project involves the installation of an ozone generation system to react with and remove NO_x from the FCCU/CO boiler exhaust stream. The exhaust gases are then passed through a new spray tower, which removes the NO_x compounds, as well as SO_2/SO_3 and particulates. The removed compounds are retained in the spray tower's liquid medium - water, buffered with a sodium hydroxide reagent. The liquid is then processed in a purge treatment unit, which separates and dewaters the solids. This results in a final effluent stream that is low in total suspended solids.

Although there will be a small increase in fugitive dust emissions from increased truck traffic to deliver raw materials and haul away waste byproducts associated with the project, no change in plant-wide particulate emissions is anticipated as a result of this project. There is the potential for a small amount of unreacted ozone being released as "slip" from the treatment process. The total amount of ozone released is expected to be quite small (likely less than 5 tpy).

This project was supplemented on October 12, 2015, with the submission of additional information. Tesoro determined that approximately 17,500 lb/hr of additional steam generation would be needed to drive the combustion air fan, providing the higher pressures needed in the flue gas train. There would be a slight increase in actual emissions from the existing cogeneration units at the refinery, the largest being approximately 6 tpy of NO_x, although this increase would be within Tesoro's existing permitted emission caps. Tesoro provided updated information regarding truck haul road emissions as part of this submission. The fugitive dust emissions from the haul roads amounts to less than 0.1 tons of total particulates (either PM_{10} or $PM_{2.5}$).On November 10, 2015, Tesoro submitted a separate NOI for the installation of ultra-low NO_x burners on the ultraformer unit (UFU) F-1furnace. Also submitted in partial fulfillment of the $PM_{2.5}$ requirements of the Utah SIP, this project is scheduled to be installed at approximately the same time as the wet gas scrubber project. Therefore, Tesoro has requested that the two projects be processed concurrently. Since both projects affect equipment covered by the same existing AO (DAQE-AN103350065-14), both NOIs have been combined into a single AO change for purposes of convenience and project timing.

The installation of the new burners on the UFU yields no change in established source-wide permitted emissions. The installation of these burners was already included and anticipated in Tesoro's $PM_{2.5}$ SIP-required emission caps, which come into effect on January 1, 2019. However, these emission caps will be added to this AO as a separate and distinct permit requirement.

Only the UFU will be directly physically modified by this portion of the project. A slight increase in actual emissions (<1 tpy) of $PM/PM_{10}/PM_{2.5}$ and VOC is expected from the UFU Furnace F-1. In addition, some additional steam from the cogeneration units will be required to assist the operation of the new burners. The total increase in actual emissions from increased utilization of the cogeneration units is less than 1 tpy of any pollutant (the largest being 0.78 tpy of CO). Like the emission increases associated with the wet gas scrubber steam demand, these emission increases are included in Tesoro's existing and future (1/1/2019) emission caps.

The changes anticipated by this combined permitting project are:
1. Adding one entry to Section II.A to list the new wet gas scrubber and Lo-TOx unit
2. Updating the entry in Section II.A referring to the UFU F-1 Furnace to reflect the new burners
3. Adding new requirements in Section II.B on the FCCU/CO Boiler based on the expected performance of the wet gas scrubber

4. Adding new requirements to reflect the new emission caps from SIP Sections IX.H.2 and IX.H.12
5. Adding 40 CFR 63, Subpart DDDDD to the list of applicable subparts as it was previously left out.

Summary of Emission Totals:

The emissions listed below are an estimate of the total potential emissions from the source. Some rounding of emissions is possible.

Estimated Criteria Pollutant Potential Emissions		
CO_2 Equivalent	1.00	tons/yr
Carbon Monoxide	1376.00	tons/yr
Nitrogen Oxides	638.00	tons/yr
Particulate Matter - PM_{10}	282.00	tons/yr
Particulate Matter - $PM_{2.5}$	154.00	tons/yr
Sulfur Dioxide	1637.00	tons/yr
Volatile Organic Compounds	793.00	tons/yr

Review of Best Available Control Technology:

1. BACT Review

As a combined project with two distinct sections, the requirement to review BACT applies separately to each sub-project.

Wet Gas Scrubber Project:

The wet gas scrubber and LoTOx unit are being installed entirely as pollution control devices. The only emission "increase" associated with the installation is the release of ozone as part of the NO_x control process. Although every effort is made to balance the amount of ozone required to control NO_x, some amount of additional ozone is required as no process can be truly isometric in practice. Some portion of this ozone can pass through the process unreacted and be emitted in what is called "slip". This is very similar to the passage of ammonia slip used in the SCR process.

In fact, within the NSR permitting process the way this ozone would be reviewed must be handled exactly as would the ammonia slip from an SCR treatment process. In other words, not as a separate pollutant emission, but as an unfortunate by-product of the treatment process. Nevertheless, UDAQ has conducted a search for potential applicable control technology for direct ozone emissions and found only a single process which claims to reduce ozone emissions directly.

The PremAir and PremAir NXT direct ozone reduction catalysts from BASF are based on an earlier design by Engelhard (BASF bought Engelhard in 2006). These catalysts are designed for use in vehicle radiators and reduce ozone into oxygen. Unfortunately, this technology is not currently transferable to control the ozone slip emissions generated in the Tesoro wet gas scrubber. As is explained in the process description, the wet gas scrubber is being installed primarily to control SO_2 (and other sulfur oxide and acid gas) emissions. This system was chosen because of the high initial particulate loading, and the ability to control multiple sulfur-based pollutants simultaneously. This type of system has also been demonstrated as highly effective in controlling emissions from FCCU regenerators; especially when combined with a

LoTOx unit for controlling NO_x emissions.

In the LoTOx system, the ozone is injected prior to the packed bed scrubber, in order to ensure good mixing and elevated temperatures (which speeds the reduction). Attempting to install an ozone reducing catalyst in this section would lead to fouling of that catalyst due to the high particulate loading. Unfortunately, attempting to install the catalyst after the packed bed yields a different problem. The catalyst has been shown to have greatly lowered effectiveness in high humidity environments, and can be actively poisoned by chemical salts.

Given that the exhaust stream following the packed bed will approach 100% relative humidity, UDAQ asserts that this technology is not transferable at this time. UDAQ was unable to find any other direct ozone emission-controlling technology which could be applied to this process.

Operating under the assumption that the wet gas scrubber/LoTOx unit operates as an emission control device, and the ozone used in the process is considered "slip", no existing emissions will increase as a result of this sub-project, no new emissions will be generated, and several existing pollutants will experience a decrease in emissions.

Thus, no additional BACT is required for this sub-project. [Last updated February 11, 2016]

2. BACT Review cont.
From the definition of BACT found at R307-401-2:

"Best available control technology" means an emissions limitation (including a visible emissions standard) based on the maximum degree of reduction for each air contaminant which would be emitted from any **proposed stationary source or modification** which the director, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant... [emphasis added]

In this particular case, the installation of the new wet gas scrubber/LoTOx system is not a new (proposed) stationary source, as the refinery is already existing; nor does it qualify as a modification, since by definition a modification requires there to be an increase in emissions (see the definition of "modification" in R307-101-2).

Even if the emissions of ozone are treated as a separate emission, there are no new emissions of any other air contaminants besides ozone, and so BACT would only need to be reviewed for control of that single pollutant. Ozone is not a regulated NSR pollutant. No other processes are being physically modified or experiencing an increase in emissions of any air contaminant. Thus, BACT for this sub-project is no additional controls beyond installation of the wet gas scrubber and LoTOx unit as described. [Last updated February 11, 2016]

3. BACT Review cont.
Installation of the Ultra-Low NO_x Burners on the Ultraformer Unit F-1 Furnace:

As with the wet gas scrubber/LoTOx system, the new ultra-low NO_x burners are being installed to reduce the NO_x emissions from the F-1 Furnace; ultra-low NO_x burners are inherently lower in NO_x emissions than standard or "regular" low-NO_x burners. However, a slight increase in actual emissions (< 1 tpy) of $PM/PM_{10}/PM_{2.5}$ and VOC is expected from the UFU Furnace F-1.

This results in two changes which need to be considered in the BACT review process. Steam from the existing cogeneration units is used to control the flame temperature of the new burners. This places additional steam demand on the cogeneration units, making them affected units under NSR. The new burners make the F-1 Furnace a modified unit.

Since the cogeneration units are not being physically changed in any way, no BACT review is required for these units. While the emissions from these two units are included in the overall NSR analysis, the lack of a physical change means that no BACT review is necessary. The F-1 furnace is being physically changed by the installation of the new burners, and will experience a small increase in emissions of both particulates and VOC (see the emission calculation section for further details).

The total estimated increase in actual particulate and VOC emissions for the F-1 furnace is less than 1 ton per year each (0.4 tpy of PM_{10}, 0.4 tpy of $PM_{2.5}$ and 0.3 tpy of VOC). The source of the emissions is gaseous fuel combustion - a combination of refinery fuel gas and natural gas. At this level of emissions, UDAQ is unaware of any add-on controls for additional reduction of particulate emissions beyond good combustion control and use of gaseous fuel. The same holds true for VOC emissions - although additional VOC control could be obtained with thermal oxidation, this leads to additional emissions in the form of CO, CO_2, NO_x and particulates from combustion. In addition, there are no economically viable add-on controls, as outlined below.

Tesoro evaluated several possible additional control measures:
For particulate emissions - the use of baghouses, ESPs, or wet scrubber technology;
and for VOC control - the use of catalytic oxidation.
None of these control options were found to be technically or economically feasible. The expected emission rates achievable by any of the add-on particulate controls is actually larger than the emission rate expected from just the new burners alone, making the use of add-on controls superfluous. Tesoro was unable to identify any available add-on controls for the CO emissions. Although catalytic reduction technology has been applied to CO emissions, it has not been utilized in this context - for emission increases on such a small scale.

Therefore, the NSR section recommends that the existing project to install ultra-low NO_x burners proceed without changes and be accepted without additional add-on controls as BACT. Proper design, implementation of good combustion practices, and use of gaseous fuels is considered BACT. [Last updated February 25, 2016]

4. BACT Review Cont.
Control of Fugitive Dust.
No BACT Review for fugitive dust is required, as no physical change is taking place. The increase in fugitive dust emissions are the direct result of increased vehicle traffic on Tesoro's internal haul roads. These roads are already paved and swept/washed as needed under Tesoro's existing dust control plan in order to meet the opacity requirements of R307-309. The increased vehicle traffic does not change the control technique applicable to reduce fugitive dust emissions. As Tesoro is already employing the most effective control strategy available, and no changes or improvements are possible, no additional review of BACT for this "process" is required.

Thus, the NSR section recommends that BACT continue to remain sweeping/washing the existing paved roads as needed. [Last updated February 29, 2016]

Modeling Results:

This combined project results in no increase in total permitted emissions of any pollutant. Under the provisions of R307-410-4 and R307-410-5, no modeling is required. Similarly, the only modification occurring under the federal provisions of 40 CFR 51, 40 CFR 60, 40 CFR 61 or 40 CFR 63 would be the small increase in actual emissions of particulates and VOC resulting from the installation of the new ultra-low NO_x burners at the UFU. These increases are less than 1 ton per year for each pollutant, well below the federal modeling thresholds.

With regard to the direct emissions of ozone (the ozone "slip" emissions), no model has been approved for modeling direct ozone emissions, and no modeling threshold exists.

Therefore, no modeling is required for this project.
[Last updated January 14, 2016]

RECOMMENDED APPROVAL ORDER CONDITIONS

The intent is to issue an air quality Approval Order (AO) authorizing the project with the following recommended conditions and that failure to comply with any of the conditions may constitute a violation of the AO. The AO will be issued to and will apply to the following:

Name of Permittee:	**Permitted Location:**
Tesoro Refining & Marketing Company LLC 474 W 900 N Salt Lake City, UT 84103	Salt Lake City Refinery 474 West 900 North Salt Lake City, UT 84103

UTM coordinates:	423,400 m Easting, 4,515,950 m Northing, UTM Zone 12
SIC code:	2911 (Petroleum Refining)

Section I: GENERAL PROVISIONS

I.1 All definitions, terms, abbreviations, and references used in this AO conform to those used in the UAC R307 and 40 CFR. Unless noted otherwise, references cited in these AO conditions refer to those rules. [R307-101]

I.2 The limits set forth in this AO shall not be exceeded without prior approval. [R307-401]

I.3 Modifications to the equipment or processes approved by this AO that could affect the emissions covered by this AO must be reviewed and approved. [R307-401-1]

I.4 All records referenced in this AO, which are required to be kept by the owner/operator, shall be made available to the Director or Director's representative upon request, and the records shall include the two-year period prior to the date of the request. Records shall be kept for a minimum of five (5) years. Records for the Consent Decree, Civil Action No. 2:96 CV 095 RL shall be kept for the life of the Consent Decree. [R307-415-6a]

I.5 A. The owner/operator shall comply with R307-150 Series. Inventories.

B. The owner/operator shall maintain records of annual actual emissions of NO_x, SO_2, VOC, and H_2SO_4 on a calendar year basis in accordance with 40 CFR 52.21(r)(6). These records will be maintained for the following emission units:

Crude Unit Furnace H-101
FCCU/CO Boiler
Ultraformer Unit Furnace F-1
UFU Regeneration Heater F-15
DDU Charge Heater F-680
DDU Rerun Boiler F-681
SRU/TGTU/TGI
GHT Unit F-701
Ultraformer Compressors K1s
Cogeneration Unit Turbines
Cogeneration Unit HRSGs

DDU Reactor (SSM events)
VRU Vessels (SSM events)
FGDU/SWS (SRU) Flare
Cooling Tower UU3
LPG Rack
Gasoline and Diesel Truck Loadout Rack
Storage Tanks (186, 188, 204, 212, 213, 242, 243, 252, 321, 324, 325, 326, 327, 330, 331, 503, 504)
New and Replaced Components. [R307-150, R307-405-19]

I.6 The owner/operator shall comply with UAC R307-107. General Requirements: Breakdowns. [R307-107]

Section II: SPECIAL PROVISIONS

II.A The approved installations shall consist of the following equipment:

II.A.1 **Permitted Source**
Permitted Source

II.A.2 **H-101**
Crude Unit Furnace, with ultra-low NO_x burners and one (1) stack, PS #1

II.A.3 **F-1**
Ultraformer Unit (UFU) Furnace, with ultra-low NO_x burners and four (4) stacks, PS #2

II.A.4 **F-15**
UFU Regeneration Heater, with low NO_x burners and one (1) stack, PS #3

II.A.5 **FCCU/CO Boiler**
Fluid catalytic Cracking Unit (FCCU) Regenerator, Carbon Monoxide Boiler (Heat Recovery Unit), with $CONO_x$ oxygen injection, ammonia injection, electrostatic precipitator (ESP), wet gas scrubber/LoTOx system (WGS), and one (1) stack, PS #4

II.A.6 **F-680 and F-681**
Distillate Desulfurization Unit (DDU) charge heater and rerun boiler, combined rating approx. 37.8 MMBtu/hr, equipped with "ultra-ultra" low NO_x burners. Heaters share common convection section and stack, PS #5.

II.A.7 **K1s**
Hydrogen Compressors (Ultraformer compressors), with catalytic converters and two (2) stacks, PS #6

II.A.8 **South Flare**
Flare covering Crude/UFU Unit/DDU,
Flare gas header routed to FGR system, PS #7

II.A.9 **North Flare**
Flare covering FCCU/VRU/Alkylation Unit/GHT,
Flare gas header routed to FGR system, PS #8

II.A.10 **Modular FGR System (FGR)**
Flare gas recovery compressors (electrically driven) and associated equipment

II.A.11 **CO Boiler Bypass**
CO Boiler Bypass, with one (1) stack, PS #9

II.A.12 **SRU/TGI/TGTU**
Sulfur Recovery Unit/Tail Gas Incinerator/Tail Gas Treatment Unit, PS #10

II.A.13 **FGDU/SWS**
Fuel Gas Desulfurization Unit/Sour Water Stripper (FGDU/SWS) Flare (this unit is physically integrated with the Sulfur Recovery Unit (SRU)), PS #11

II.A.14 **T-104**
Sour Water Storage Tank

II.A.15 **Emergency/Standby Sources**
Waste Water Treatment Plant (WWTP) Generator, Electrical Generators, Plant Air Compressors, Miscellaneous Air Compressors, Fire Water Pumps, B-1 Air Preheater, Package Boilers

II.A.16 **F-701**
Gasoline Hydrotreater (GHT) Unit with 8.0 MMBtu/hr process heater

II.A.17 **BSU**
Benzene Saturation Unit (BSU):

	3,000 bpd Bensat reactor and 10,000 bpd reformate splitter.
II.A.18	**CG1 and CG2** Cogeneration Unit: two cogeneration trains (CG1 and CG2), each with one 11.8 MW (based on an annual average) turbine with SoLoNO$_x$ controls and one heat recovery steam generating unit rated at approx 157.8 MMBtu/hr (HHV). Both rates based on an annual average.
II.A.19	**Loading/Unloading Racks**
II.A.20	**Tank 140: Storage vessel - petroleum liquids** Storage tank with internal floating roof and primary seals
II.A.21	**Tank 141: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.22	**Tank 142: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.23	**Tank 144: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.24	**Tank 157: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.25	**Tank 158: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.26	**Tank 186: Storage vessel - petroleum liquids** Storage tank with internal floating roof, primary and secondary seals
II.A.27	**Tank 188: Storage vessel - petroleum liquids** Storage tank with internal floating roof, primary and secondary seals
II.A.28	**Tank 189: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.29	**Tank 190: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.30	**Tank 201: Storage vessel - amine** Storage tank with fixed roof
II.A.31	**Tank 203: Storage vessel - stormwater** Storage tank with fixed roof
II.A.32	**Tank 204: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.33	**Tank 206: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.34	**Tank 212: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.35	**Tank 213: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.36	**Tank 236: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.37	**Tank 241: Storage vessel - surge tank** Storage tank with external floating roof, primary and secondary seals
II.A.38	**Tank 242: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.39	**Tank 243: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.40	**Tank 244: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals

II.A.41	**Tank 245: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.42	**Tank 246: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.43	**Tank 247: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.44	**Tank 252: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.45	**Tank 270: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.46	**Tank 271: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.47	**Tank 291: Storage vessel - petroleum liquids** Storage tank with fixed roof to be retrofitted with internal floating roof
II.A.48	**Tank 297: Storage vessel - petroleum liquids** Storage tank with internal floating roof and primary seals
II.A.49	**Tank 298: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.50	**Tank 307: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.51	**Tank 308: Storage vessel - chemicals** Storage tank with external floating roof, primary and secondary seals
II.A.52	**Tank 309: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.53	**Tank 310: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.54	**Tank 311: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.55	**Tank 312: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.56	**Tank 313: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.57	**Tank 314: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.58	**Tank 315: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.59	**Tank 321: Storage vessel - petroleum liquids** Storage tank with internal floating roof and primary seals
II.A.60	**Tank 322: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.61	**Tank 323: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.62	**Tank 324: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.63	**Tank 325: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.64	**Tank 326: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.65	**Tank 327: Storage vessel - gasoline**

Storage tank with external floating roof, primary and secondary seals, and slotted guide pole controls

II.A.66 Tank 328: Storage vessel - petroleum liquids
Storage tank with external floating roof, primary and secondary seals

II.A.67 Tank 330: Storage vessel - petroleum liquids
Storage tank with external floating roof, primary and secondary seals

II.A.68 Tank 331: Storage vessel - petroleum liquids
Storage tank with internal floating roof, primary and secondary seals

II.A.69 SO_2 Cap Sources
Sources included in emissions cap: includes F-701, CG1 and CG2, H-101, FCCU/CO Boiler, K1s, F-1, F-15 , F-680 and F-681

II.A.70 NO_x Cap Sources
Sources included in emissions cap: includes F-701, CG1 and CG2, H-101, FCCU/CO Boiler, K1s, F-1, F-15 , F-680 and F-681

II.A.71 PM_{10} Cap Sources
Sources included in emissions cap: includes F-701, CG1 and CG2, H-101, FCCU/CO Boiler, K1s, F-1, F-15 , F-680 and F-681

II.B Requirements and Limitations

II.B.1 <u>Conditions on Permitted Source</u>

II.B.1.a Visible emissions from the stacks of combustion units without controls shall be no greater than 10 percent (%) opacity. Compliance shall be determined using opacity observations performed in accordance with 40 CFR 60, Appendix A, Method 9. [R307-401]

II.B.1.b Tesoro shall limit operation of the emergency/standby package boilers listed in Section II.A.14 to an annual capacity factor of 10% (0.10) or less for natural gas as specified in 40 CFR 60 Subpart Db. [R307-401]

II.B.1.c Visible emissions from the FCCU/CO Boiler and fugitive emissions shall not exceed 20% opacity. Compliance shall be determined using opacity observations performed in accordance with 40 CFR 60, Appendix A, Method 9.

Visible emissions from process flares, fugitive dust, and the FCCU (when going through the bypass stack) shall not exceed 20% opacity. Compliance shall be determined using opacity observations performed in accordance with 40 CFR 60, Appendix A, Method 9. [40 CFR 60, R307-401-8]

II.B.1.d Tesoro shall submit to the Director a projection of planned and required process shutdowns for the upcoming calendar year by January 15 of each year. [R307-401]

II.B.1.e Tesoro shall control the sulfur pit emissions by continuing to route sulfur pit emissions to the incinerator at the SRU. [R307-401]

II.B.1.f Tesoro shall supply no more than one-third of its potential electrical output capacity on an annual basis to any utility power distribution system for sale (on a gross basis). Records of capacity and annual electrical sales shall be maintained. [R307-401]

II.B.1.g Tesoro shall install and operate a flare gas recovery system designed to limit hydrocarbon flaring from each of the North Flare and South Flare to levels below the values listed in 40 CFR 60.103a(c), except during periods of startup, shut down, or malfunction. [40 CFR 60 Subpart Ja, SIP Section IX.H.11]

II.B.1.h Plant-wide Emission Limits:

By no later than January 1, 2019, combined emissions of:

1. Total (Filterable+Condensable) PM_{10} shall not exceed 2.25 tons per day,
2. Filterable $PM_{2.5}$ shall not exceed 0.42 tons per day and 110 tons per rolling 12-month period,
3. NO_x shall not exceed 1.988 tons per day and 475 tons per rolling 12-month period, and
4. SO_2 shall not exceed 3.1 tons per day and 300 tons per rolling 12-month period

For purposes of this requirement, a "day" is defined as a period of 24-hours commencing at midnight and ending at the following midnight. Compliance with the emission limits shall be determined as outlined in Section IX.H.2 and Section IX.H.12 of the SIP, as adopted by the Air Quality Board on December 2, 2015. [SIP Section IX.H.12, SIP Section IX.H.2]

II.B.1.i Tesoro shall notify the Director in writing within 30 days after the new ultra-low NO_x burners (II.A.3) and wet gas scrubber/LoTOx system (II.A.5) are installed and operational, as an initial compliance inspection is required. To ensure proper credit when notifying the Director, send your correspondence to the Director, attn: Compliance Section.

Approval orders issued by the Director in accordance with the provisions of R307-401 will be reviewed eighteen months after the date of issuance to determine the status of construction, installation, modification, relocation or establishment. If a continuous program of construction, installation, modification, relocation or establishment is not proceeding, the Director may revoke the approval order. [R307-401-18]

II.B.2 **Conditions on Crude Unit Furnace (H-101)**

II.B.2.a Emissions of NO_x shall not exceed 0.054 lb/MMBtu on a 3-hour average basis.

Compliance shall be demonstrated by means of annual NO_x emissions testing as directed in 40 CFR 60 Appendix A, Test Method 7, 7A, 7B, 7C, 7D or 7E.
[R307-401]

II.B.3 **Conditions on FCCU/CO Boiler and CO Boiler Bypass**

II.B.3.a As of January 1, 2018, emissions of NO_x and SO_2 shall not exceed the following values:

1. 10 ppmvd NO_x at 0% O_2 on a 365-day rolling average basis
2. 20 ppmvd NO_x at 0% O_2 on a 7-day rolling average basis
3. 10 ppmvd SO_2 at 0% O_2 on a 365-day rolling average basis
4. 18 ppmvd SO_2 at 0% O_2 on a 7-day rolling average basis

For the 365-day NO_x and SO_2 limits, the first complete 365-day rolling average shall be calculated on January 1, 2019, based on monitoring data from January 1, 2019, and the 364 days prior to January 1, 2019.

NO_x and SO_2 emissions during periods of startup, shutdown, or malfunction of the FCCU, or malfunction of the associated NO_x or SO_2 control equipment, if any, shall not be used in determining compliance with the 7-day NO_x and SO_2 limits established above provided that during such periods Tesoro, to the extent practicable, maintains and operates the FCCU, including associated air pollution control equipment, in a manner consistent with good air pollution control practices for minimizing emissions. The 365-day NO_x and SO_2 limits shall apply at all times.

Tesoro shall use NO_x, SO_2, and O_2 CEMS to monitor performance of the FCCU. CEMS shall be used to demonstrate compliance with the 7-day and 365-day NO_x emission limits established above. Tesoro shall make CEMS data available to UDAQ or EPA within thirty (30) days of a written request. Tesoro shall install, certify, calibrate, maintain, and operate all CEMS at the FCCU required by this paragraph in accordance with the provisions of 40 C.F.R. § 60.13 that are applicable to CEMS (excluding those provisions applicable only to COMS) and Part 60 Appendices A and F, and the applicable performance specification test of 40 C.F.R. Part 60 Appendix B.
[R307-401]

II.B.3.b By no later than January 1, 2018, Tesoro shall comply with an SO_2 emission limit of 25 ppmvd @ 0% excess air on a 365-day rolling average basis and 50 ppmvd @ 0% excess air on a 7-day rolling average basis.

Compliance with this limit shall be determined by following 40 C.F.R. §60.105a(g). [SIP Section IX.H.11.g.i]

II.B.3.c By no later than January 1, 2018, Tesoro shall comply with an emission limit of 1.0 pounds PM per 1000 pounds coke burned on a 3-hour average basis.

Compliance with this limit shall be determined by following the stack test protocol specified in 40 C.F.R. §60.106(b) to measure PM emissions on the FCCU. Stack tests shall be conducted once every five years.

By no later than January 1, 2019, each owner or operator of an FCCU shall install, operate, and maintain a continuous parameter monitor system (CPMS) to measure and record operating parameters for determination of source-wide $PM_{2.5}$ emissions as appropriate. [SIP Section IX.H.11.g.i]

II.B.3.d By no later than October 1, 2015, Tesoro shall comply with the following CO limits at the FCCU: (1) a short-term FCCU CO emission limit of 500 ppmvd CO @ 0% O_2 (one-hour block average); and (2) a long-term FCCU CO emission limit of 100 ppmvd CO @ 0% O_2 (365-day rolling average). For 365-day CO emission limit, the first complete 365-day rolling average shall be calculated on October 1, 2015, based on monitoring data from October 1, 2015 and the 364 Days prior to October 1, 2015.

CO emissions during periods of startup, shutdown, or malfunction of the FCCU, or malfunction of the associated CO control equipment, if any, shall not be used in determining compliance with the 7-day FCCU CO emission limit established above, provided that during such periods Tesoro, to the extent practicable, maintains and operates the FCCU, including associated air pollution control equipment, in a manner consistent with good air pollution control practices for minimizing emissions. The 365-day CO emission limit established above, shall apply at all times.

Tesoro shall use a CO and O_2 CEMS to monitor the performance of the FCCU. Tesoro shall make CEMS data available to UDAQ or EPA within thirty (30) days of a written request. Tesoro shall install, certify, calibrate, maintain, and operate all CEMS at the FCCU required by this Paragraph in accordance with the provisions of 40 C.F.R. § 60.13 that are applicable to CEMS (excluding those provisions applicable only to COMS) and Part 60 Appendices A and F, and the applicable performance specification test of 40 C.F.R. Part 60 Appendix B. [R307-401]

II.B.3.e The FCCU Catalyst Regenerator is an "affected facility" as that term is used in 40 C.F.R. Part 60, Subparts A and J for PM, SO_2, and CO. On and after October 1, 2015, until January 1, 2018, the FCCU Catalyst Regenerator shall continue to be subject to and shall comply with 40 C.F.R. Part 60, Subparts A and J for SO_2. [40 CFR 60 Subpart J]

II.B.3.f Beginning on October 1, 2015, the FCCU shall become an "affected facility" as that term is used in 40 C.F.R. Part 60, Subpart Ja for PM and CO in lieu of Subpart J. Beginning on January 1, 2018, the FCCU shall become an "affected facility" as that term is used in 40 C.F.R. Part 60, Subpart Ja for NO_x, and Subpart Ja for SO_2 in lieu of Subpart J. On and after January 1, 2018, Tesoro shall comply with all applicable requirements in 40 C.F.R. Part 60, Subpart Ja at the FCCU. [40 CFR 60 Subpart J, 40 CFR 60 Subpart Ja]

II.B.4 Conditions on SRU/TGI/TGTU

II.B.4.a Gaseous emissions from the SRU shall be treated by the TGTU during normal operations prior to final treatment at the TGI. [R307-401-8]

II.B.4.b The SO_2 limit at the SRU/TGI/TGTU is 1.68 tons/day. Compliance with the daily limitation shall be determined as follows:

Daily sulfur dioxide emissions from the SRU/TGI/TGTU shall be determined by multiplying the SO_2 concentration in the flue gas by the mass flow of the flue gas.

Emissions of SO_2 from the SRU/TGI/TGTU shall not exceed 60 tons per rolling 12-month period. Compliance shall be determined on a 12-month rolling total. Within 20 days of the beginning of each calendar month, the SO_2 emission totals calculated to demonstrate compliance with the daily limitations shall be totaled for the previous month. The monthly total shall be added to the totals from the previous 11 months to determine the new 12-month rolling total. [R307-401]

II.B.4.b.1 The SO_2 concentration in the flue gas shall be determined by a CEM that meets or exceeds the requirements contained in 40 CFR 60, Appendix B, Performance Specification 2. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170. 40 CFR 60 Methods 2, 3 and 6 shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, Performance Specification 2. Notification must be made to the Director prior to conducting the performance test. Whenever the SO_2 CEM is bypassed for short periods, SO_2 CEM data from the previous three days will be averaged and used as an emission factor to determine emissions.

The mass flow rate of the flue gas shall be determined by a volumetric flow measurement device that meets or exceeds the requirements contained in 40 CFR 60 Appendix B. An annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170 and 40 CFR 60 Appendix B. If a new volumetric flow measurement device is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 52 Appendix E. Notification must be made to the Director prior to conducting the performance test.

Tesoro shall comply with a 95% recovery efficiency requirement for all periods of operation except during periods of startup, shutdown, or malfunction of the SRU/TGI/TGTU. The 95% recovery efficiency will be determined on a daily basis; however, compliance will be determined on a rolling 30-day average basis. Tesoro shall determine the percent recovery by measuring the flow rate and concentration of H_2S in the feed streams going to the SRU and by measuring the SO_2 emissions with the CEMS at the SRU incinerator. The feed streams shall include the overhead stream from the Fuel Gas Desulfurization unit (Amine unit) regenerator and the overhead stream from the Sour Water Stripper. The flow rate will be determined continuously; the H_2S concentration shall be determined at least once every three years (samples may be collected as manual grabs or through remote monitoring). The flow rate and H_2S concentration values will be used to determine the daily feed rate. SRU efficiency results shall be reported to the Director a minimum of once per year.
[R307-401]

II.B.5 **Conditions on SO_2 Cap Sources**

II.B.5.a Combined emissions of SO_2 from the SO_2 Cap Sources shall not exceed the following limits:

November 1 through end of February: 3.699 tons/day

March 1 through October 31: 4.374 tons/day

Compliance with the daily limitation shall be determined by summing the emissions calculated in conditions II.B.4.a.1 and II.B.4.a.2 below.
[R307-401]

II.B.5.a.1 Daily SO_2 emissions from the FCCU/CO Boiler stack shall be determined by multiplying the sulfur dioxide concentration in the flue gas by the mass flow of the flue gas.

The SO_2 concentration in the flue gas shall be determined by a CEM that meets or exceeds the requirements contained in 40 CFR 60, Appendix B, Performance Specification 2. The monitor span shall be 350 ppm. No later than January 1, 2018 the span shall be 200 ppm. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with 40 CFR 60, Appendix F and UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with 40 CFR 60 Appendix F and UAC R307-170. 40 CFR 60 Methods 2, 3 and 6 shall be used to determine relative accuracy. If a new SO_2 monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, Performance Specification 2. Notification must be made to the Director prior to conducting the performance test. Whenever the SO_2 CEM is unavailable for short periods (i.e. CO boiler or CO Boiler emergency bypass, FCCU start-up and shutdowns), SO_2 CEM data from the previous three days will be averaged and used as an emission factor to determine emissions from the FCCU.

The mass flow rate of the flue gas shall be determined by a volumetric flow measurement device that meets or exceeds the requirements contained in 40 CFR 60 Appendix B. An annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170 and 40 CFR 60 Appendix B. If a new volumetric flow measurement device is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 52 Appendix E. Notification must be made to the Director prior to conducting the performance test.

SO_2 emissions from the FCCU regenerator shall be calculated by subtracting the emissions attributable to the CO Boiler from the mass emissions. Emissions attributable to combustion of plant gas in the CO Boiler shall be calculated by multiplying the quantity of fuel used in the CO boiler by the emission factor for plant gas as determined below. [R307-401]

II.B.5.a.2 Daily SO_2 emissions from other affected units shall be determined by multiplying the quantity of each fuel used daily (24 hour usage) at each affected unit by the appropriate emission factor below. The values shall be summed to show the total daily SO_2 emission.

Emission factors (EF) for the various fuels shall be as follows:

Natural gas: EF = 0.60 lb/MMscf
Propane: EF = 0.60 lb/MMscf
Plant fuel gas: the emission factor shall be calculated from the H_2S measurement or from the SO_2 measurement obtained in section II.B.5.g of this permit. The emission factor, where appropriate, shall be calculated as follows:

EF (lb SO_2/MMscf gas) = [(24 hr avg. ppmdv H_2S) /10^6] [(64 lb SO_2/lb mole)] [(10^6 scf/MMscf)/(379 scf/lb mole)]

Where mixtures of fuel are used in a Unit, the above factors shall be weighted according to the use of each fuel. [R307-401]

II.B.5.b Emissions of SO_2 from the permitted source shall not exceed 1,637 tons per rolling 12-month period. The SO_x limit at the FCCU is 705 tons per rolling 12-month period.

Compliance shall be determined on a 12-month rolling total. Within 20 days of the beginning of each calendar month, the SO_2 emission totals calculated to demonstrate compliance with the daily (24-hr) limitations shall be totaled for the previous month. The monthly total shall be added to the totals from the previous 11 months to determine the new 12-month rolling total. [R307-401]

II.B.5.c Until January 1, 2018, the SO_x emissions from the FCCU regenerator shall not exceed 9.8 lbs/1000 lbs coke burned, based on a seven-day average.

The following monitoring protocol has been approved by EPA staff in accordance with 40 CFR 60.106(i)(12), in letters from EPA dated August 29, 1997, May 12, 2003, June 20, 2005 and August 8, 2008, and may not be modified without prior EPA approval. [40 CFR 60 Subpart J]

II.B.5.c.1 Until January 1, 2018, each day, the daily SO_x emissions from the FCCU regenerator, as calculated below, shall be multiplied by a factor of 1.05 and divided by the amount of coke burned in the FCCU regenerator during the same period. The result shall be added to the calculated values for the previous six days and the total divided by seven to determine the seven-day average.

The weight of coke burned in the FCCU regenerator shall be determined by a mass balance calculation utilizing the measured airflow to the regenerator, and the volume percent CO and O_2 measured in the regenerator flue gas, in accordance with the procedure documented in correspondence to the DAQ dated November 3, 1995.

This monitoring method is valid only if the following process conditions and procedures are met.

(a) Sulfur content of the feed to the FCCU is not greater than 0.85 wt%, based on a seven-day average.

The sulfur content of the feed shall be determined by obtaining and analyzing a minimum of three grab-samples per seven-day period.

(b) Temperature of the FCCU regenerator is between 1182° Fahrenheit and 1419° Fahrenheit, based on an 8-hour average.

The temperature of the FCCU regenerator shall be determined using a suitable temperature-sensing device. The device shall be calibrated according to manufacturer's specifications.

(c) The oxygen concentration in the FCCU regenerator is less than or equal to 3.4 % by volume, based on an 8-hour average.

A CEM shall be used to determine the oxygen concentration in the regenerator flue gas. The monitor shall meet or exceed the requirements specified in 40 CFR 60, Appendix B, and Performance Specification 3. The monitor span shall be 1.5-2.0 times the allowable level. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170. 40 CFR 60 Method 3B shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, and Performance Specification 3. Notification must be made to the Director prior to conducting the performance test.

(d) The CO concentration in the FCCU regenerator is less than or equal to 4.4% by volume based on an 8-hour average.

A CEM shall be used to determine the CO concentration in the regenerator flue gas. The monitor shall meet or exceed the requirements specified in 40 CFR 60, Appendix B, and Performance Specification 4, and 40 CFR 60, Appendix F. The monitor span shall be 1.5-2.0 times the allowable level. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170. 40 CFR 60 Method 10 or 10A shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, and Performance Specification 4. Notification must be made to the Director prior to conducting the performance test.

If Tesoro intentionally changes the FCCU's operating parameters (FCCU's feed sulfur content, the regenerator temperature, the regenerator oxygen concentration, or the regenerator CO concentration) to a value outside the listed ranges, compliance with the sulfur oxides limitation shall be demonstrated in accordance with 40 CFR 60.106(i). Performance of such compliance demonstrations shall begin within two weeks of first recording the change in operating parameters.

Tesoro may then conduct performance tests as required to establish a new set of parameters for the above alternate monitoring procedure, in accordance with 40 CFR 60.106(i)(12). Tesoro must submit the new parameters and associated test data for approval by the EPA before use.

An unintentional variation of any of the operating parameters associated with this monitoring method beyond the range allowed by this method shall constitute a violation of this monitoring condition, unless the variation can be positively identified as the result of an unavoidable breakdown. [40 CFR 60 Subpart J, R307-401]

II.B.5.d Until January 1, 2018, the following information shall be maintained and made available upon request:

1. The monitoring record of the lbs SO_x /1000 lb coke burned
2. Results of the sulfur analysis of the feed, including sample dates, times, and sulfur concentration
3. The monitoring record of the temperature sensor, the date of each calibration of the sensor and any corrective actions required or performed
4. The monitoring record of the oxygen CEM and any calibration or maintenance activity on the monitor
5. The monitoring record of the CO CEM and any calibration or maintenance activity on the monitor
6. The date, time, and description of any change in the listed FCCU operating parameters, whether or not such change was intentional
7. All information associated with the performance of 40 CFR 60.106(i)(12), Compliance Demonstration, if such demonstration is performed. [40 CFR 60 Subpart J, R307-401]

II.B.5.e Until January 1, 2018, if any of the listed operating parameters are intentionally changed, Tesoro shall submit written notification of the change and confirmation of the initiation of the 40 CFR

60.106(i)(12), Compliance Demonstration, within 14 days of first recording the change. The notification shall be submitted to the Director and to EPA.

If any of the listed operating parameters are unintentionally exceeded, Tesoro shall submit a report of the exceedance to the Director on the next quarterly monitoring report. The report shall include a description of the exceedance, an estimate of any excess emissions, the time of the exceedance, and the actions taken to correct the situation. [40 CFR 60 Subpart J, R307-401]

II.B.5.f Until January 1, 2019, the following sources shall not be regulated for SO_2 or NO_x emissions nor shall they be included in the emission limitation totals herein:

1. North flare (FCCU/VRU/GHT/Alky Flare)
2. South flare (Crude/UFU/DDU Flare). [R307-401, SIP Section IX.H.12]

II.B.5.g The H_2S content of fuel gas combusted at any affected unit shall not exceed 0.10 grains H_2S/dscf (162 ppmdv), based on a rolling three-hour average. Compliance with this limitation shall be determined as follows:

1. For natural gas, compliance is assumed while the fuel comes from a public utility.

2. For plant gas, the H_2S content of the fuel gas shall be measured with a CMS that meets or exceeds the requirements contained in 40 CFR 60, Appendix B, Specification 7. The monitor shall be installed in a location representative of the H_2S content in the fuel gas system. The location shall be approved in writing by the Director prior to installation. The current approved location of the H_2S monitor is on the outlet of fuel-gas blending vessel V-917. The span of the monitor shall be 300 ppm. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with 40 CFR 60 Appendix F and UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with 40 CFR 60 Appendix F and UAC R307-170. 40 CFR 60 Method 11 shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, and Performance Specification 7. Notification must be made to the Director prior to conducting the performance test.

If the monitor reading is not available, the refinery fuel gas shall be sampled as close to the monitor location as safely possible at least once each day. The sample shall be analyzed for sulfur content with a detection tube capable of reading the required concentration limit.

3. In lieu of the H_2S CMS in paragraph II.B.4.g.2 above, for fuel gas combustion devices an instrument for continuously monitoring and recording the concentration by volume (dry basis, zero percent excess air) of SO_2 emissions into the atmosphere may be used. The monitor shall meet the requirements of 40 CFR 60.105.

4. The rolling three-hour average shall be calculated as the arithmetic average of three contiguous one (1)-hour averages. [40 CFR 60 Subpart J, R307-401]

II.B.5.h T-104 shall be a fixed-roof vessel with closed vent controls. The tank shall have a closed-vent system with nitrogen purge, and shall vent gases released to the TGI/TGTU or to the Sour Water Stripper/SRU flare when the TGI/TGTU is not operational. The tank shall comply with 40 CFR

60 Subpart Kb. [R307-401]

II.B.6 **Conditions on NO_x Cap Sources**

II.B.6.a Combined emissions of NO_x from the NO_x Cap Sources shall be no greater than 1.988 tons/day.

Compliance shall be determined daily by multiplying the hours of operation of a unit, feed rate to a unit, or quantity of each fuel combusted at each affected unit by the associated emission factor listed below, and summing the results. The sources, fuels, and associated emission factors for this limitation are as follows:

Sources included in emission cap	Fuel	NO_x Emission factor
Crude Unit Furnace (H-101)	Plant Gas	results of last stack test
Ultraformer Furnace (F1)	Plant Gas	results of last stack test
Regenerator Gas Heater (F15)	Plant Gas	81 lb/MMscf
FCCU/CO Boiler	FCU Coke & plant gas	NO_x CEM
DDU charge heater (F-680)	Plant gas	0.049 lb/MMBtu
DDU rerun reboiler (F-681)	Plant gas	0.052 lb/MMBtu
Cogeneration facility	Plant & natural gas	results of last stack test
GHT heater (F-701)	Plant gas	0.074 lb/MMBtu
Hydrogen Compressors (K1s)	Propane/natural gas	1.8 lb/hr

The Crude Unit stack (H-101) shall be tested every year to determine the correct emission factor for the calculations above.

The UFU stack (F1) emissions shall be stack tested every year to determine the correct emission factor for the calculations above.

The initial stack tests were done on the DDU to verify the design emission factor of 0.04 lb/MMBtu for NO_x. The new emission factors for the DDU, computed from the results of the stack tests, are 0.049 lb/MMBtu and 0.052 lb/MMBtu as specified in the above table. Subsequent testing shall be done if directed by the Director.

Both trains in the cogeneration facility were stack tested within 180 days of startup to show emissions equivalency of the trains. Subsequently, both trains shall be tested either simultaneously or seriatim at least once every two years.

The GHT heater was stack tested within 180 days of startup. Subsequent testing shall be done if directed by the Director.

All other units in the above list shall be stack-tested if directed by the Director. Tesoro may also perform a stack test on any of the above listed sources to provide information for updating the emission factors listed.

All stack tests shall conform to the following:

The applicant shall provide a notification of the test date at least 45 days prior to the test. A pretest conference between the owner/operator, the tester, and the Director shall be held at least 30 days prior to the test if directed by the Director.

The emission point shall conform to the requirements of 40 CFR 60, Appendix A, Method 1. Occupational Safety and Health Administration (OSHA) approved access shall be provided to the test location.

40 CFR 60, Appendix A, Method 7, 7A, 7B, 7C, 7D, or 7E shall be used to determine the NO_x emission rate.

40 CFR 60, Appendix A, Method 2 shall be used to determine the volumetric flow rate.
To determine mass emission rates (lbs/hr, etc.), the pollutant concentration, as determined by the appropriate methods above, shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director to give the results in the specified units of the emission limitation.

A NO_x CEM shall be used to calculate daily NO_x emissions from the FCCU/CO Boiler. Emissions shall be determined by multiplying the nitrogen dioxide concentration in the flue gas by the mass flow of the flue gas.

The NO_x concentration in the flue gas shall be determined by a CEM that meets or exceeds the requirements contained in 40 CFR 60, Appendix B, Performance Specification 2. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170. 40 CFR 60 Methods 2, 3 and 7 shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, Performance Specification 2. Notification must be made to the Director prior to conducting the performance test. Whenever the NO_x CEM is bypassed for short periods, NO_x CEM data from the previous three days will be averaged and used as an emission factor to determine emissions.

The mass flow rate of the flue gas shall be determined by a volumetric flow measurement device that meets or exceeds the requirements contained in 40 CFR 60 Appendix B. An annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170 and 40 CFR 60 Appendix B. If a new volumetric flow measurement device is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60 Appendix B. Notification must be made to the Director prior to conducting the performance test. [R307-401]

II.B.6.b Emissions of NO_x from the sources listed under the NO_x cap shall be no greater than 598 tons per rolling 12-month period. The NO_x limit at the FCCU is 174 tons per rolling 12-month period.

Compliance shall be determined on a 12-month rolling total. By the 20th day of each month, the NO_x emissions calculated to show compliance with the daily limitations for the previous month shall be summed to give a monthly emission total. This shall be added to the previous 11 months' emission totals to give the new 12-month rolling total. [R307-401]

II.B.6.c Emissions of NO_x from each K1 compressor shall be no greater than 3.20 lb/hr or 933 ppmdv

@10% oxygen and 400° F.

Compliance shall be determined by stack testing in accordance with the procedure for stack testing other NO_x sources as described above. Testing shall be done if directed by the Director.

The maximum fired heat capacity at H-101will be no greater than 174 MMbtu/hr (LHV) based on a 1-hour average. Orifice plate will be installed to limit fuel gas pressure to 20 psi such that maximum firing rate of the burner remains unchanged. [R307-401]

II.B.7 **Conditions on PM_{10} Cap Sources**

II.B.7.a Combined emissions of filterable PM_{10} and filterable $PM_{2.5}$ from the PM_{10} Cap Sources shall be no greater than 522 lbs/day. The filterable PM_{10} limit at the FCCU is 69 tons per rolling 12-month period.

Compliance shall be determined daily by multiplying the quantity of each fuel combusted at the affected units by the associated emission factor for that fuel, and summing the results. The emission factors for this limitation are as follows:

Natural gas:	5 lb/MMscf
Plant gas:	5 lb/MMscf
Cat Coke:	results of last stack test
Propane:	negligible

The FCCU/COB stack shall be stack tested every year to determine the correct emission factor for the calculations above. All other units in the above list shall be stack-tested if directed by the Director. The permitted source may also perform a stack test to provide information for updating the emission factors listed above. All stack tests shall conform to the following:

The applicant shall provide a notification of the test date at least 45 days prior to the test. A pretest conference between the owner/operator, the tester, and the Director shall be held at least 30 days prior to the test if directed by the Director.

The emission point shall conform to the requirements of 40 CFR 60, Appendix A, Method 1. OSHA approved access shall be provided to the test location. The throughput rate during compliance testing shall be no less than 90% of the rated throughput, or 90% of the highest monthly throughput achieved in the previous three years, whichever is least.

40 CFR 51, Appendix M, Methods 201 or 201a shall be used to determine front-half PM_{10} emissions in stacks in which no liquid drops are present. 40 CFR 51, Appendix M, Method 202 shall be used to determine back half condensables in such stacks.

For stacks in which liquid drops are present, methods to eliminate the liquid drops should be explored. If no reasonable method to eliminate the drops exists, then the following methods shall be used: 40 CFR 60, Appendix A, Method 5, 5a, 5d, or 5e as appropriate. The back half condensables shall also be tested using Method 202. All particulate captured in the back half shall be considered PM_{10}. For purposes of the PM_{10} SIP Cap, the back half condensables shall not be used for compliance demonstration but shall be used for inventory purposes.

40 CFR 60, Appendix A, Method 2 shall be used to determine the volumetric flow rate.

To determine mass emission rates (lbs/hr, etc.), the pollutant concentration, as determined by the appropriate methods above, shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director to give the results in the specified units of the emission limitation. [R307-401]

II.B.8 **Conditions on Tanks**

II.B.8.a For the primary seals, the accumulated area of gaps between the tank wall and the metallic shoe seal or the liquid-mounted seal shall not exceed 10 square inches per foot of tank diameter. The width of any portion of any gap shall not exceed one and one half (1½) inches. If the seal is a vapor mounted seal, the accumulated area of gaps between the tank wall and seal shall not exceed one (1) square inch per foot of tank diameter, and the width of any portion of any gap shall not exceed one-half (½) inch. This condition applies to Tanks 190, 242, 243, 244, 245, 246, 247, 308, 309, 326, and 330. [R307-327]

II.B.8.b Tanks 246 and 247 shall be used only to store heavy distillate products with a True Vapor Pressure (TVP) of less than 1.5 psia, such as Jet A fuel. [R307-401-8]

II.B.8.c For the secondary seals, the accumulated area of gaps between the tank wall and the secondary seal shall not exceed one square inch per foot of tank diameter and the width of any portion of any gap shall not exceed one-half inch. This condition applies to Tanks 190, 242, 243, 244, 245, 308, 309, 326, and 330. This condition does not apply to Tanks 246 and 247.

The secondary seals shall be properly installed and maintained according to the manufacturer's recommendations.
[R307-327]

II.B.8.d The owner/operator shall comply with all applicable parts of R307-327 - Petroleum Liquid Storage. [R307-327]

Section III: APPLICABLE FEDERAL REQUIREMENTS

In addition to the requirements of this AO, all applicable provisions of the following federal programs have been found to apply to this installation. This AO in no way releases the owner or operator from any liability for compliance with all other applicable federal, state, and local regulations including UAC R307.

NSPS (Part 60), A: General Provisions
NSPS (Part 60), Db: Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units
NSPS (Part 60), J: Standards of Performance for Petroleum Refineries
NSPS (Part 60), Ja: Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After May 14, 2007
NSPS (Part 60), K: Standards of Performance for Storage Vessels for Petroleum Liquids for Which Construction, Reconstruction, or Modification Commenced After June 11, 1973, and Prior to May 19, 1978
NSPS (Part 60), Ka: Standards of Performance for Storage Vessels for Petroleum Liquids for Which Construction, Reconstruction, or Modification Commenced After May 18, 1978, and Prior to July 23, 1984
NSPS (Part 60), Kb: Standards of Performance for Volatile Organic Liquid Storage Vessels (Including

Petroleum Liquid Storage Vessels) for Which Construction, Reconstruction, or Modification Commenced After July 23, 1984
NSPS (Part 60), GG: Standards of Performance for Stationary Gas Turbines
NSPS (Part 60), XX: Standards of Performance for Bulk Gasoline Terminals
NSPS (Part 60), GGG: Standards of Performance for Equipment Leaks of VOC in Petroleum Refineries for which Construction, Reconstruction, or Modification Commenced After January 4, 1983, and on or Before November 7, 2006
NSPS (Part 60), GGGa: Standards of Performance for Equipment Leaks of VOC in Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After November 7, 2006
NSPS (Part 60), NNN: Standards of Performance for Volatile Organic Compound (VOC) Emissions From Synthetic Organic Chemical Manufacturing Industry (SOCMI) Distillation Operations
NSPS (Part 60), QQQ: Standards of Performance for VOC Emissions From Petroleum Refinery Wastewater Systems
NESHAP (Part 61), A: General Provisions
NESHAP (Part 61), M: National Emission Standard for Asbestos
NESHAP (Part 61), FF: National Emission Standard for Benzene Waste Operations
MACT (Part 63), A: General Provisions
MACT (Part 63), CC: National Emission Standards for Hazardous Air Pollutants From Petroleum Refineries
MACT (Part 63), UUU: National Emission Standards for Hazardous Air Pollutants for Petroleum Refineries: Catalytic Cracking Units, Catalytic Reforming Units, and Sulfur Recovery Units
MACT (Part 63), EEEE: National Emission Standards for Hazardous Air Pollutants: Organic Liquids Distribution (Non-Gasoline)
MACT (Part 63), DDDDD: National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters
Title V (Part 70) major source

REVIEWER COMMENTS

The AO will be based on the following documents:

Supersedes	DAQE-AN103350065-14 dated September 5, 2014
Is Derived From	Source Submitted NOI dated June 11, 2015
Incorporates	Additional Information Received From EPA dated September 29, 2015
Incorporates	Additional Information Received dated September 23, 2015
Incorporates	Additional Information Received dated October 12, 2015
Incorporates	Additional Information Received dated November 10, 2015
Incorporates	Additional Information Received dated January 8, 2016
Incorporates	Additional Information Received dated February 1, 2016

1. Comment regarding Status of sources:
Several emission units are specifically affected by this project. Each is addressed below:

Wet Gas Scrubber and associated systems:
This is a control device on an existing unmodified unit (see below), the FCCU/CO Boiler. Although listed as a separate line item under II.A.6, it is considered as part of the FCCU for federal subpart (NSPS and NESHAP) permitting requirements and is not a separate emitting unit.

FCCU/CO Boiler:
The installation of the wet gas scrubber system does not modify the FCCU/CO Boiler under NSPS or NESHAP regulations. Although physical changes are occurring at this emission unit, they do not trigger a reconstruction under NSPS or NESHAP regulations as they do not constitute more than 50% of the cost of a new unit. No modification is occurring, as no increase in the hourly emission rate of an applicable pollutant is occurring. Also see Engineering Review Comment #2 regarding the applicability of NSR to direct ozone emissions

Ultraformer Unit F-1 Furnace:
The installation of the new burners at the F-1 Furnace requires review due to the increase in emissions of $PM/PM_{10}/PM_{2.5}$ and VOC (see "Revised Firing Rate Calculations" submitted 2/1/16).

Cogeneration Units:
The increased steam demand from the cogeneration units does not result in a modification of these units as this can be accomplished under the existing permit conditions and without any physical changes or changes in the method of operation of these units. See also Engineering Review Comments 4 and 5 regarding Emission Calculations.
[Last updated February 29, 2016]

2. Comment regarding Applicability of NSR to direct ozone emissions:
On June 4, 2015, UDAQ sent an inquiry to Region 8 of US EPA regarding the Agency's interpretation of the NSR program to direct ozone emissions. Specifically, whether or not a source which emits ozone as a pollutant is subject to the provisions of 40 CFR 52.21(b)(23)(ii).

On September 29, 2015, Region 8 responded with a letter which stated, in essence, that since ozone is listed in the previous paragraph [52.21(b)(23)(i)], which defines a significant emission rate for that pollutant as being 40 tons per year of either VOC or NO_x, then [52.21(b)(23)(ii)] does not apply.

A copy of the Region 8 letter has been included in the source file for reference. [Last updated January 14, 2016]

3. Comment regarding Federal Requirements:
Analysis of the following specific federal subparts is included in this review:

40 CFR 60 (NSPS) Subparts J and Ja:
Under the wet gas scrubber/Low-TOx sub-project, only the FCCU/CO boiler will require any physical changes. These changes primarily involve reconfiguration of the exhaust system to incorporate the new controls, some external structural work to house the scrubber and other units, and other minor electrical, plumbing, and support work as needed to accommodate the new systems. There will not be any increase in the maximum hourly emissions of any of the pollutants regulated under Subpart J, which currently applies to the FCCU/CO Boiler. However, the FCCU/CO Boiler is already subject to NSPS Ja for CO and PM emissions and will be subject to NSPS Ja for NO_x and SO_2 by January 1, 2018 after the wet gas scrubber/Low-TOx system is installed.

Although the installation of the new burners on the F-1 furnace likely qualifies under the exemption of 40 CFR 60.14(e)(5):

The addition or use of any system or device whose primary function is the reduction of air pollutants, except when an emission control system is removed or is replaced by a system which the Administrator determines to be less environmentally beneficial.

Tesoro has conservatively assumed that this sub-project results in a modification of the F-1 furnace, and thus triggering the applicability of Subpart Ja for emissions of SO_2.

Both of these subparts have already been listed as included/applicable to the refinery.

40 CFR 63 (NESHAP) Subpart UUU:
Again, the FCCU/CO Boiler is the only existing unit subject to Subpart UUU experiencing a physical change as a result of the wet gas scrubber sub-project. Subpart UUU already applies to the FCCU/CO Boiler, and no changes in that applicability will occur due to this project. There will be new monitoring requirements associated with the wet gas scrubber as a control device after installation.

This subpart has been previously included in the applicability list for the refinery.

40 CFR 63 Subpart DDDDD:
The F-1 Furnace is currently subject to the provisions of Subpart DDDDD. The installation of the new burners will not change the applicability of this subpart, nor will it trigger any new requirements. However, this subpart was not previously included in the applicability list for the refinery and will be included in this review. [Last updated February 29, 2016]

4. Comment regarding Emission Calculations:
In order to properly calculate the overall change in emissions for this combined project, each sub-project must be evaluated separately. Although both sub-projects have been combined for permitting convenience, they were submitted separately and affect separate and distinct units at

the refinery. Both sub-projects can be accomplished individually and independently.

While both sub-projects are required by the $PM_{2.5}$ SIP, and both require some amount of additional incremental steam load from the cogeneration units, these two facts do not necessarily link the two sub-projects together. Neither sub-project is reliant upon the other in terms of infrastructure, timing, finances, logistics, or resources. It is only the nature of the NSR permitting program itself that requires that both projects be permitted simultaneously. Thus, each sub-project will be evaluated separately, and then the two individual results will be summed to arrive at the final project total change.

Wet Gas Scrubber:
Installation of the wet gas scrubber and LoTOx unit will reduce emissions of SO_2, NO_x and CO at the FCCU/CO Boiler. These values, which are specific to the FCCU/CO Boiler are as follows:

Estimated current SO_2 = 671.5 tpy (subject to a 705 tpy SO_x limit, existing condition II.B.4.b)
SO_2 PTE after project = 41.06 tpy (based on a limit of 10 ppmvd on a 365-day rolling average)

Current NO_x = 174 tpy (existing condition II.B.5.b)
NO_x PTE after project = 29.48 tpy (based on a limit of 10 ppmvd on a 365-day rolling average)

Estimated current CO = 933.43 tpy (subject to a 500 ppmvd limit - 40 CFR 60 Subpart J)
CO PTE after project = 179.51 (based on a limit of 100 ppmvd on a 365-day rolling average)

Both the NO_x and SO_2 values were already included in the calculations used when setting the new plant-wide emission caps for the Tesoro refinery which become applicable on January 1, 2019. Therefore, no change in overall refinery PTE will occur as a result of this installation.

Increased utilization of the cogeneration units for the wet gas scrubber sub-project:
Estimated additional steam requirement is 17,500 lb/hr, which requires an increased firing rate of approximately 19.25 MMBtu/hr. This additional firing is within the already permitted amount authorized to Tesoro under DAQE-103350065-14, as no specific limitation on firing rate is listed in the AO beyond that listed in II.A.18 (two steam units rated at approximately 157.8 MMBtu/hr each, for a total of 315.6 MMBtu/hr), and the emission inventory for 2014 showed a combined usage of approximately 162.7 MMBtu/hr (52% of that max value). The increase in actual emissions from the cogeneration units associated with this additional steam requirement is (all values in tpy):
PM_{10} = 0.84, $PM_{2.5}$ = 0.84, NO_x = 5.97, SO_2 = 2.09, CO = 6.53, VOC = 0.43, H_2SO_4 = 0.03
These values are based on Tesoro's most recent stack test, AP-42 tables 1.4-2 and 3.1-1, NSPS Subpart Ja, and Tesoro's supplied estimates of additional fuel and steam requirements.

Haul road fugitive dust emission estimates:
Tesoro also supplied emission estimates of the increased truck traffic on Tesoro's haul roads for delivery of raw materials (oxygen, caustic, coagulant) and disposal/removal of waste products (wastewater, filter cake). These estimates are based on the maximum potential increase in vehicle traffic, although reduction in these values is possible using alternatives to vehicle transport (such as alternative wastewater treatment).
The increase in fugitive particulates from haul road vehicle traffic is as follows (all values in tpy):
PM_{10} = 0.08, $PM_{2.5}$ = 0.02
[Last updated February 11, 2016]

5. Comment regarding Emission Calculations Cont.:
The installation of the new burners on the F-1 furnace results in a slightly more complicated emission calculation. First, is the estimation of the projected emissions of the unit following completion of the project (all values in tpy)

$PM_{10} = 4.59$, $PM_{2.5} = 4.59$, $NO_x = 40.06$, $SO_2 = 4.73$, $CO = 30.81$, $VOC = 3.32$, $H_2SO_4 = 0.07$

[This is based on a firing rate of 140.7 MMBtu/hr (as supplied by Tesoro, revised 1/8/16).]

However, as this is a modified unit at an existing major source, to properly calculate the emission increase from this sub-project, the "actual to projected actual" applicability test must be employed. This test is described at 40 CFR 52.21(a)(2)(iv)(c), and incorporated by reference at R307-405-2(2).

For purposes of simplicity, the PSD version of this description was used. The nonattainment area thresholds for a modification are identical, as is the description of the test. The nonattainment area version is described and outlined at R307-403-2(1)(c). Since Tesoro is located in an area of attainment for some pollutants and nonattainment for other pollutants, and functionally the two processes are identical, only one process will be discussed.

Under the actual to projected actual test, the source calculates the difference between the projected actual emissions of the modified unit, and the baseline actual emissions of that unit. For baseline actual emissions, this is defined as the average rate the unit actually emitted the pollutant during any consecutive 24-month period selected by the owner/operator within the 10-year period immediately preceding the project. A separate 24-month period may be chosen for each pollutant.

Tesoro considered periods between May 1, 2007 and May 31, 2015, and provided the emission values chosen to UDAQ as part of the NOI submitted Nov 10, 2015. UDAQ has reviewed the 24-month baseline periods and concurs with the emission values provided.

The calculation of projected actual emissions is complicated by three mitigating factors:
1. Projected actual emissions shall exclude the portion of the emissions that an existing unit "could have accommodated during the baseline period and are also unrelated to the particular project"
2. The projected actual emissions shall exclude any emissions related to increased utilization due to product demand growth
3. The projected actual emissions may use the emission units potential to emit in lieu of the actual emission calculation

In this particular case, Tesoro was able to estimate values for both factors #1 and #2, but elected to use the calculation of actual emissions rather than potential to emit.

Technically speaking, there are two additional components to this sub-project: the new components in VOC service (pipes, valves, flanges, etc.), and the increased utilization of the cogeneration units. When including these additional components, the process is exactly the same as for the modified unit [this is called the hybrid test, and is outlined at 40 CFR 52.21(a)(2)(iv)(f)].

By definition, the baseline period, capable of accommodating emissions, and demand growth emissions of the new components would all be zero (0), since they did not previously exist. Similarly, the emissions from the increased utilization at the cogeneration units would only involve the increased firing rate, since all other emissions would cancel out.

The final calculation of emission increases can be found on the included spreadsheet [Tesoro Revised Projected Emissions, and Revised Table 3b - Projected Actual Emission Calculations]. The conclusion is emission increases as follows (all values in tpy):

$PM_{10} = 0.5$, $PM_{2.5} = 0.5$, $NO_x = 0.72$, $SO_2 = 0.25$, CO = 0.78, VOC = 2.76

However, these changes in actual emissions can be accommodated within Tesoro's existing and future (1/1/2019) emission caps with no changes.

[Last updated February 11, 2016]

6. Comment regarding NSR/PSD Applicability:
Neither sub-project triggers a major modification under either the nonattainment area NSR (NNSR) or PSD requirements. As was previously discussed (see the emission calculation and BACT review sections above) these two sub-projects do not need to be aggregated for permitting purposes. They are also not tied to any previous permitting project conducted at Tesoro. This combined project can be considered a minor modification under the NSR permitting requirements for both NNSR and PSD. [Last updated January 13, 2016]

7. Comment regarding Changes in Permit Requirements:
This project results in the following changes in the permit:

1. Update in Section II.A - the listing for the UFU F-1 Furnace has been changed to reflect the addition of the new ultra-low NO_x burners, and the new components in VOC service.

2. Update in Section II.A - an additional entry has been made, listing the new wet gas scrubber and LoTOx unit.

3. New conditions on the FCCU/CO Boiler - new requirements (emission limitations) on the FCCU/CO Boiler have been added, limiting NO_x, SO_2 and CO emissions on a 7-day and 365-day rolling average basis. A sub-condition detailing the compliance methodology has also been included.

4. A condition of the applicable plant-wide caps (emission limits) which become applicable as of January 1, 2019 has been included. This condition is based on the requirements of Section IX.H.12 of the Utah $PM_{2.5}$ SIP. The requirements of the PM_{10} Maintenance plan have not yet been incorporated.

5. Several small corrections have been made where "12-month rolling average" was used in place of "12-month rolling total"

6. Condition II.B.5.g has been updated to be clearer - moving the parenthetical from the first paragraph to a separate line item.

7. Several conditions with expired dates have been updated or removed.

8. Opacity conditions have been clarified and consolidated.

9. A condition requiring initial inspection of the newly installed control equipment was added.

10. Several conditions have been updated where limitations change as of 1/1/18 or 1/1/19.

11. With installation of the WGS, several conditions with reference to "FCCU/CO Boiler (ESP)" have been changed to "FCCU/CO Boiler".

12. One condition was updated to include reference to filterable $PM_{2.5}$ (II.B.7.a) in addition to the already present filterable PM_{10}. [Last updated February 25, 2016]

8. Comment regarding Discussion of SO_2 Emission Limit:
There are two sets of *apparently redundant* emission limitations on SO_2. These have not been included in error, but rather are included as a result of Tesoro's emission calculation methodology.

The lower limits (10 ppmvd on a rolling 365-day basis and 18 ppmvd on a rolling 7-day basis) are used to calculate the PTE of the FCCU/CO Boiler following installation of the new control system. Thus, this limit needs to be included in the AO in order to make this calculation enforceable. Tesoro also uses these limits to gauge the overall performance of the control system. The higher limits (25 ppmvd on a rolling 365-day basis and 50 ppmvd on a rolling 7-day basis) are limits associated with the $PM_{2.5}$ SIP, and have specific associated monitoring requirements [Last updated February 11, 2016]

9. Comment regarding Filterable $PM_{2.5}$ Limit:
Condition II.B.7.a now includes a limit a filterable $PM_{2.5}$. This limitation did not previously apply to the Tesoro Refinery, and serves as a transition between previous AOs (which did not limit $PM_{2.5}$) and the applicable limits of the SIP, which do not come into effect until January 1, 2019. This limitation serves merely as a stopgap measure to address comments received on previous permitting actions as well as those comments received during the SIP development process. [Last updated February 25, 2016]

ACRONYMS

The following lists commonly used acronyms and associated translations as they apply to this document:

40 CFR	Title 40 of the Code of Federal Regulations
AO	Approval Order
BACT	Best Available Control Technology
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CDS	Classification Data System (used by EPA to classify sources by size/type)
CEM	Continuous emissions monitor
CEMS	Continuous emissions monitoring system
CFR	Code of Federal Regulations
CMS	Continuous monitoring system
CO	Carbon monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent - 40 CFR Part 98, Subpart A, Table A-1
COM	Continuous opacity monitor
DAQ/UDAQ	Division of Air Quality
DAQE	This is a document tracking code for internal UDAQ use
EPA	Environmental Protection Agency
FDCP	Fugitive dust control plan
GHG	Greenhouse Gas(es) - 40 CFR 52.21 (b)(49)(i)
GWP	Global Warming Potential - 40 CFR Part 86.1818-12(a)
HAP or HAPs	Hazardous air pollutant(s)
ITA	Intent to Approve
LB/HR	Pounds per hour
MACT	Maximum Achievable Control Technology
MMBTU	Million British Thermal Units
NAA	Nonattainment Area
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOI	Notice of Intent
NO_x	Oxides of nitrogen
NSPS	New Source Performance Standard
NSR	New Source Review
PM_{10}	Particulate matter less than 10 microns in size
$PM_{2.5}$	Particulate matter less than 2.5 microns in size
PSD	Prevention of Significant Deterioration
PTE	Potential to Emit
R307	Rules Series 307
R307-401	Rules Series 307 - Section 401
SO_2	Sulfur dioxide
Title IV	Title IV of the Clean Air Act
Title V	Title V of the Clean Air Act
TPY	Tons per year
UAC	Utah Administrative Code
VOC	Volatile organic compounds

Information taken from Tesoro's 2014 Inventory submission:

East Turbine	Refinery Gas	0553	975.170	10^6 cu ft/yr	AN	Input	1,053	btu/cu ft
East HRSG	Refinery Gas	0553	485.940	10^6 cu ft/yr	AN	Input	951	btu/cu ft
West Turbine	Refinery Gas	0553	984.250	10^6 cu ft/yr	AN	Input	1,053	btu/cu ft
West HRSG	Refinery Gas	0553	943.000	10^6 cu ft/yr	AN	Input	951	btu/cu ft

Extracting only the relevant information:

We only want the HRSG info, since those are the steam producing units in this particular case.

East HRSG	Refinery Gas	485.94 10^6 cu ft/yr	950.57097 btu/cu ft	8043 hrs/yr
West HRSG	Refinery Gas	943 10^6 cu ft/yr	950.57097 btu/cu ft	8515 hrs/yr

Performing unit conversion and assuming maximum operation during total hourly operation:

East HRSG	60417.75457 cu ft/hr	=	57.431364 MMBtu/hr		
West HRSG	110745.7428 cu ft/hr	=	105.27169 MMBtu/hr		
				Each unit rated at:	157.8 MMBtu/hr
		Total =	162.70305 MMBtu/hr	Max both units:	315.6 MMBtu/hr
		% of max:	52%		

Revised Projected Emissions Calculations
Based on Tesoro's revised firing rate estimates of 1/8/16

This calculates the new projected emissions for the UFU F-1 furnace only

Taking Table 3a (page 6 of 9) from the NOI and adjusting for the new firing rate:

Firing rate: 140.7 MMBtu/hr = 129.82 Mscf/hr

Pollutant	Emission Factor	Units	Emissions (lb/hr)	Emissions (tons/yr)
NOx	0.065000	lb/MMBtu	9.15	40.06
SO2	8.310000	lb/MMscf	1.08	4.73
CO	0.050000	lb/MMBtu	7.04	30.81
PM	0.007450	lb/MMBtu	1.05	4.59
PM10	0.007450	lb/MMBtu	1.05	4.59
PM2.5	0.007450	lb/MMBtu	1.05	4.59
VOC	0.005390	lb/MMBtu	0.76	3.32
H2SO4	0.120000	lb/MMscf	0.02	0.07

Revised Emission Increase Calculations
Based on Tesoro's revised firing rate estimate of 1/8/16

This calculates both the projected actual emissions (future emissions) as well as the emission increase associated with the project
This is still only from the UFU F-1 furnace only

From Table 3b (Page 7 of 9) of the NOI and adjusting based on the new projected emissions (previous tab):

	NOx	SO2	CO	PM	PM10	PM2.5	VOC	H2SO4	
A. Baseline Actual Emissions	53.16	4.00	41.32	3.74	3.74	3.74	2.70	0.06	This line is unchanged from the original NOI
B. Capable of Accommodating	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09	This line is unchanged from the original NOI
C. Projected Emissions	40.06	4.73	30.81	4.59	4.59	4.59	3.32	0.07	From Revised Projected Emissions Tab
D. Demand Growth (D=B-A)	0.00	1.98	0.00	0.45	0.45	0.45	0.34	0.03	
E. Projected Actual Emissions (E=C-D)	40.06	2.75	30.81	4.14	4.14	4.14	2.98	0.04	
F. Emission Increase (F=E-A)	0.00	0.00	0.00	0.40	0.40	0.40	0.28	0.00	

Now to include the emissions from the other components involved in the project:

Emissions from VOC Process Components (Pipe Flanges, Valves, Pumps, etc)

	NOx	SO2	CO	PM	PM10	PM2.5	VOC	H2SO4
Total from Table 4 of the NOI	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00

Emissions from increased utilization of the Cogeneration Units

	NOx	SO2	CO	PM	PM10	PM2.5	VOC	H2SO4
Total from Table 5 of the NOI	0.720	0.250	0.780	0.100	0.100	0.100	0.051	0.004

Yielding a new grand project total of:

	NOx	SO2	CO	PM	PM10	PM2.5	VOC	H2SO4
Total project emission increase (tpy)	**0.720**	**0.250**	**0.780**	**0.500**	**0.500**	**0.500**	**2.751**	**0.004**

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EMPRO™ PremAir® Catalysts

PremAir® Direct Ozone Reduction (DOR)

PremAir® is a patented catalyst coating that transforms ground level ozone, the main component of smog, into oxygen. As air flows over a vehicle's coated radiator, PremAir® catalyzes the reaction that converts ozone into oxygen. This process capitalizes on the large volume of air that passes through a vehicle's radiator.

PremAir® NXT Next Generation DOR

With PremAir® NXT, even smaller radiators for today's downsized 4 cylinder engines can convert as much ozone to oxygen as larger radiators with standard PremAir®. This allows Automotive OEMs to earn the full emission credit for California LEV III and U.S. Tier 3 emission regulations.

PremAir® NXT delivers value through emission reduction credits

PremAir® NXT is a DOR technology which has been validated for 150,000 miles or 15 years. Tier 3 and LEV III have approved an emission reduction credit of 5 mg/mile for DOR technology. OEMs can leverage this tool in a number of ways to deliver value to manage their fleet average emissions requirements.

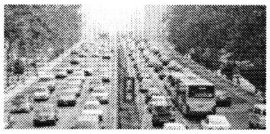
- **Optimize engine performance**
  - PremAir® NXT credits are a cost-effective alternative solution to PGM (Platinum Group Metals) content in catalytic converters and can be used to maximize engine performance at a bin classification.
- **Reduce cost**
  - As regulations demand more out of catalytic converters, additional PGM content can have decreasing emission control efficiency. PremAir® NXT credits can help optimize PGM performance to reduce total emission control costs.
- **Engineering Safety Factor for SULEV**
  - Performance at low NMOG and NOx levels is difficult to measure for both fresh and aged catalyst performance; borderline TWC aging performance can introduce risk to an OEM. PremAir® NXT credits can be leveraged to increase the safety factor at a vehicle bin classification.
- **Managing fleet vehicle mix**
  - LEV III and Tier 3 require OEMs to change their fleet percentage sales to meet the emission standards, so OEMs have to sell more SULEV vehicles while selling less ULEV 125 vehicles. High performance sedans and coupes as well as trucks and SUVs are often more profitable but meet higher emission bins. Utilizing PremAir® NXT credits can enable OEMs to mitigate the impact of new regulations on their vehicle mix.

What is ozone?

Ozone is a molecule that consists of three oxygen atoms. Naturally-occurring ozone is formed miles above the earth in the stratosphere. This ozone layer is responsible for absorbing the sun's harmful ultraviolet radiation. Unfortunately, the ozone at ground level is the major component of smog. This artificially created ozone is the cause of many adverse effects, such as irritation of and damage to lungs, eyes, noses and throats. Man-made ozone is produced by the oxidation of nitrogen oxides (NOx) and Volatile Organic Compounds (VOCs) in the presence of direct sunlight. The main sources of NOx and VOC gases are mobile emissions, industrial factories, electrical plants, chemical solvents, and gasoline vapors.

Click here for a list of car models that have been certified with Direct Ozone Reduction (PremAir).

PremAir



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Need more information?

We create chemistry

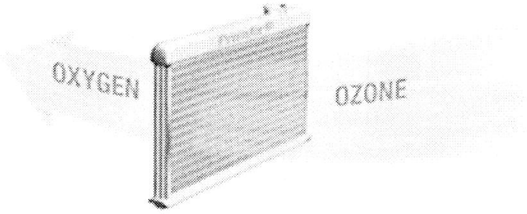
Clean Air Technology

EMPRO™ PremAir®

Ozone destruction catalysts

PremAir is the first commercial product that destroys harmful, ground-level ozone already in the air and converts it into oxygen. PremAir catalysts have been successfully installed on over 3 million automotive radiators throughout the world.

Depending upon the conditions, PremAir can destroy 75 percent or more of the ozone that touches the PremAir-coated radiator surface, converting ozone molecules (O_3) into oxygen (O_2) molecules. There is no significant impact on cooling or other performance attributes of the radiator.

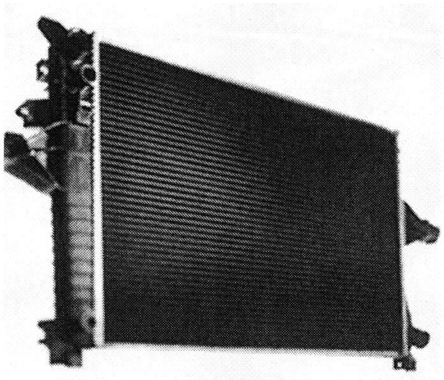


LEV III Credit Certified

Having recognized the air quality benefits of PremAir-equipped automotive radiators, the Air Resources Board in California has established programs to allow vehicle manufacturers to use PremAir in meeting emissions standards.

PremAir Green

Where regulatory compliance is not needed, PremAir Green is a cost-effective option for vehicle manufacturers to demonstrate commitment to a clean environment and a responsible environmental policy.



What is ground-level ozone?

According to the U.S. Environmental Protection Agency (EPA), in the Earth's lower atmosphere, near ground level, ozone is formed when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants and other sources react chemically in the presence of sunlight.

Ozone pollution is a special concern during summer months when the weather conditions needed to form ground-level ozone – lots of sun and hot temperatures – normally occur.

The American Lung Association reports that half of the U.S. population breathes unhealthy levels of ozone some time during the year. Millions of people living in urban areas around the world are similarly exposed.

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We are proud to introduce EMPRO as the new brand for BASF Mobile Emissions Catalysts. The EMPRO brand represents what makes BASF unique as value added solutions provider. As the global leader in catalysis, BASF has unsurpassed expertise in developing innovative emission control technologies for a wide range of applications, to enable clean air for a sustainable future. We are the Emissions Professionals.

The focus of the BASF Emissions Professional is always on innovative, cost-effective solutions to meet the needs of OEMs and engine manufacturers globally. With a creative, open, responsible and entrepreneurial approach we help make our customers meet regulations and be more profitable. That's the EMPRO way.

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For additions or changes to the content on this page, contact **Michael Locascio.**

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Selective Catalytic Reduction & Selective Catalytic Reduction on Filter (SCR, SCR.2F)

6311484, 6415602, 6446430, 6581374, 6662553, 6742330, 6826906, 7143578, 7150145, 7229597, 7438878, 7481983, 7490464, 7601662, 7704475, 7767176, 7722845, 7902107, 7919051, 7951742, 7968068, 7998423, 8119088, 8122603, 8246922, 8293182, 8293198, 8293199, 8404203, 8524185, 8544260, 8617474, 8899023, 6004524, 8961914, 8722000, 6689709, 6914026, 6125629

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7481983, 7767176, 7722845, 8293182, 8524185, 8722000, 6689709, 6914026

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Three Way Conversion Catalysts and Four Way Conversion Catalysts

5866210, 5888464, 5898014, 6044644, 6110862, 6492297, 6497851, 6764665, 6777370, 6923945, 7041263, 7022644, 7276212, 7374729, 7501098, 7517510, 7524465, 7550124, 7622096, 7678347, 7749472, 7754171, 7758834, 7795172, 7811962, 7879755, 7922988, 8007750, 8038951, 8173087, 8568675, 8815189, 8950174, 8765085, 6093378

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7271125, 7521033, 7527774, 7704915, 7981390, 8062990, 8833064, 8765085

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EvapTrap™

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United States Patent **6,818,254**
Hoke , et al. **November 16, 2004**

Stable slurries of catalytically active materials

Abstract

A method and apparatus for treating the atmosphere comprising moving a vehicle through the atmosphere, the vehicle having at least one atmosphere contacting surface and a pollutant treating composition located on said surface. A specific embodiment comprises coating a motor vehicle radiator with pollutant treating catalyst.

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Assignee:	**Engelhard Corporation** (Iselin, NJ)
Family ID:	**33425551**
Appl. No.:	**08/682,174**
Filed:	**July 16, 1996**

Related U.S. Patent Documents

Application Number	Filing Date	Patent Number	Issue Date
589182	Jan 19, 1996		
537206	Sep 29, 1995		
410445	Mar 24, 1995		
376332	Jan 20, 1995		

Current U.S. Class:	**427/421.1**; 427/429; 427/435; 427/443.2; 502/2; 502/324; 502/325; 502/339; 502/506; 502/512
Current CPC Class:	B01D 53/02 (20130101); B01D 53/8675 (20130101); B01D 53/885 (20130101); B01D 53/74 (20130101); Y10S 502/512 (20130101); B01D 2251/40 (20130101); B01D

	2251/602 (20130101); B01D 2253/102 (20130101); B01D 2253/108 (20130101); B01D 2253/11 (20130101); B01D 2253/202 (20130101); B01D 2253/25 (20130101); B01D 2253/304 (20130101); B01D 2253/306 (20130101); B01D 2257/106 (20130101); B01D 2257/302 (20130101); B01D 2257/404 (20130101); B01D 2257/502 (20130101); B01D 2257/702 (20130101); B01D 2258/06 (20130101); B01D 2259/4558 (20130101); Y10S 502/506 (20130101)
Current International Class:	B01D 53/74 (20060101); B01D 53/04 (20060101); B01D 53/86 (20060101); B01D 53/88 (20060101); B01J 023/34 (); B05D 001/02 (); B05D 001/18 (); B05D 001/28 ()
Field of Search:	;502/2,324,325,439,506,512,514 ;427/421,429,435,443.2

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Parent Case Text

RELATED APPLICATION

This is a continuation-in-part application of U.S. Ser. No. 08/589,182 filed Jan. 19, 1996 now abandoned which is a continuation-in-part of U.S. Ser. No. 08/537,206 filed Sep. 29, 1995 now abandoned which is a continuation-in-part of U.S. Ser. No. 08/410,445 filed Mar. 24, 1995 now abandoned which is a continuation-in-part of U.S. Ser. No. 08/376,332 filed Jan. 20, 1995, now abandoned all of said applications are herein incorporated by reference.

Claims

What is claimed is:

1. A method of applying a mixture to a substrate comprising the steps of: forming a mixture comprising water and a particulate catalytically-active material, the catalytically-active material comprising a manganese component having a BET N.sub.2 surface area of greater than 150 m.sup.2 /g, and wherein approximately 90% of the particles are less than 8 micrometers; adding to the mixture a dispersant comprising a compound selected from the group consisting of a polymer containing carboxylic acid groups, an ester of the polymer and a salt of the polymer; adding to the mixture a polymeric binder selected from the group consisting of an acrylic polymer and a poly(vinyl) acetate; and after adding the dispersant and polymeric binder, applying the mixture to a motor vehicle contacting surface.

2. The method of claim 1, wherein the slurry is applied by spray coating, brushing, or dipping.

3. The method of claim 2, wherein the slurry is applied by spray coating.

4. The method as recited in claim 1 wherein the atmosphere contacting surface is selected from the group consisting of the outer surface of an air conditioner condenser, a radiator, a radiator fan, an air charge cooler, a wind deflector, engine oil cooler, a transmission oil cooler and a power steering fluid cooler.

5. The method of as recited in claim 1 further comprising adjusting the pH of the mixture to at least 8.5.

6. A method of forming a slurry comprising the steps of: forming a mixture comprising water and a particulate catalytically-active material, the catalytically-active material comprising a manganese component having a BET N.sub.2 surface area of greater than 150 m.sup.2 /g, and wherein approximately 90% of the particles are less than 8 micrometers; adding to the mixture a dispersant comprising a compound selected from the group consisting of a polymer containing carboxylic acid groups, an ester of the polymer and a salt of the polymer; and adding to the mixture a polymeric binder selected from the group consisting of an acrylic polymer and a poly(vinyl) acetate.

7. The method of claim 6, wherein the dispersant is a dicarboxylic acid ester or salt derivative.

8. The method of claim 7, wherein the dispersant is a maleic acid/isobutylene copolymer.

9. The method of claim 8, wherein the dispersant is a salt of a maleic acid/isobutylene copolymer.

10. The method of claim 9, wherein the dispersant is a sodium salt of a maleic acid/isobutylene copolymer.

11. The method of claim 6, wherein the dispersant is a polymeric acrylate.

12. The method of claim 11, wherein the dispersant is a salt of a polymeric acrylate.

13. The method of claim 12, wherein the dispersant is a sodium salt of a polyacrylate/methacrylate copolymer.

14. The method of as recited in claim 6 further comprising adjusting the pH of the mixture to at least 8.5.

15. The method of claims 14, 6, 11, 12, 13, 7, 8, 9, or 10, wherein the binder is an acrylic latex binder or an ethylene vinyl acetate binder.

16. The method as recited in claims 14, 6 or 1 wherein the catalytically active material further comprises a platinum group metal component.

17. The method as recited in claim 16 further comprising the step of calcining the catalytically active material prior to adding the polymeric binder.

18. The method as recited in claim 16 further comprising the step of reducing the catalytically active material.

19. The method as recited in claims 14, 6, or 1 wherein the manganese component is MnO.sub.2.

20. The method as recited in claim 48 wherein the MnO.sub.2 is .alpha.-MnO.sub.2.

21. The method as recited in claim 20 wherein the .alpha.-MnO.sub.2 is selected from the group consisting of hollandite, cryptomelane, manjiroite and coronadite.

22. The method as recited in claim 21 wherein the .alpha.-MnO.sub.2 is cryptomelane having a surface area of about from 200 to 350 m.sup.2 /g.

23. The method as recited in claim 20 wherein the .alpha.-MnO.sub.2 comprises up to 2% by weight of silica.

24. The method of claims 14, 6 or 1 wherein the mixture further comprises thickeners, biocides, and antioxidants.

25. A composition made by the method of claims 14, 6, 11, 12, 13, 7, 8, 9, or 10.

26. The composition of claim 25, wherein the binder is an acrylic latex binder or an ethylene vinyl acetate binder.

27. The composition of claim 26 further comprising at least one additive selected from the group consisting of a thickener, a biocide, and an antioxidant.

28. A catalytic slurry for adhering to a substrate comprising: a particulate catalytically-active material comprising a manganese component having a BET N.sub.2 surface area of greater than 150 m.sup.2 /g, and wherein approximately 90% of the particles are less than 8 micrometers; a dispersant comprising a compound selected from the group consisting of a polymer containing carboxylic acid groups, an ester of the polymer and a salt of the polymer; a polymeric binder selected from the group consisting of an

acrylic polymer and a poly(vinyl) acetate; and water.

Description

BACKGROUND OF THE INVENTION

1. Field of The Invention

The present invention relates to an apparatus for cleaning the atmosphere; and more particularly to a vehicle comprising at least one atmosphere contacting surface having a pollution treating composition thereon, and a related method and composition.

2. Discussion of the Related Art

A review of literature relating to pollution control reveals that the general approach is to reactively clean waste streams entering the environment. If too much of one pollutant or another is detected or being discharged, the tendency has been to focus on the source of the pollutant, the cause of the pollutant or the waste stream containing the pollutant. For the most part gaseous streams are treated to reduce the pollutants prior to entering the atmosphere.

It has been disclosed to treat atmospheric air directed into a confined space to remove undesirable components in the air. However, there has been little effort to treat pollutants which are already in the environment; the environment has been left to its own self cleansing systems. References are known which disclose proactively cleaning the environment. U.S. Pat. No. 3,738,088 discloses an air filtering assembly for cleaning pollution from the ambient air by utilizing a vehicle as a mobile cleaning device. A variety of elements are disclosed to be used in combination with a vehicle to clean the ambient air as the vehicle is driven through the environment. In particular, there is disclosed ducting to control air stream velocity and direct the air to various filter means. The filter means can include filters and electronic precipitators. Catalyzed postfilters are disclosed to be useful to treat nonparticulate or aerosol pollution such as carbon monoxide, unburned hydrocarbons, nitrous oxide and/or sulfur oxides, and the like. German Patent DE 43 18 738 C1 also discloses a process for the physical and chemical cleaning of outside air. Motor vehicles are used as carriers of conventional filters and/or catalysts, which do not constitute operational components of the vehicle but are used to directly clean atmospheric air.

Another approach is disclosed in U.S. Pat. No. 5,147,429. There is disclosed a mobile airborne air cleaning station. In particular this patent features a dirigible for collecting air. The dirigible has a plurality of different types of air cleaning devices contained therein. The air cleaning devices disclosed include wet scrubbers, filtration machines, and cyclonic spray scrubbers.

The difficulty with the above recited devices disclosed to proactively clean the atmospheric air is that they require new and additional equipment. Even the modified vehicle disclosed in U.S. Pat. No. 3,738,088 requires ducting and filters which can include catalytic filters.

DE 40 07 965 C2 to Klaus Hager discloses a catalyst comprising copper oxides for converting ozone and a mixture of copper oxides and manganese oxides for converting carbon monoxide. The catalyst can be applied as a coating to a self heating radiator, oil coolers or charged-air coolers. The catalyst coating comprises heat resistant binders which are also gas permeable. It is indicated that the copper oxides and manganese oxides are widely used in gas mask filters and have the disadvantage of being poisoned by water vapor. However, the heating of the surfaces of the automobile during operation evaporates the water. In this way, continuous use of the catalyst is possible since no drying agent is necessary.

Manganese oxides are known to catalyze the oxidation of ozone to form oxygen. Many commercially available types of manganese compound and compositions, including alpha manganese oxide are disclosed to catalyze the reaction of ozone to form oxygen. In particular, it is known to use the cryptomelane form of alpha manganese oxide to catalyze the reaction of ozone to form oxygen.

Alpha manganese oxides are disclosed in references such as O'Young, Hydrothermal Synthesis of Manganese Oxides with Tunnel Structures, Modern Analytical Techniques for Analysis of Petroleum, presented at the Symposium on Advances in Zeolites and Pillared Clay Structures before the Division of Petroleum Chemistry, Inc. American Chemical Society New York City Meeting, Aug. 25-30, 1991 beginning at page 348. Such materials are also disclosed in U.S. Pat. No. 5,340,562 to O'Young, et al. Additionally, forms of .alpha.-MnO.sub.2 are disclosed in McKenzie, the Synthesis of Birnessite, Cryptomelane, and Some Other Oxides and Hydroxides of Manganese, Mineralogical Magazine, December 1971, Vol. 38, pp. 493-502. For the purposes of the present invention, .alpha.-MnO.sub.2 is defined to include hollandite (BaMn.sub.8 O.sub.16.xH.sub.2 O), cryptomelane (KMn.sub.8 O.sub.16.xH.sub.2 O), manjiroite (NaMn.sub.8 O.sub.16.xH.sub.2 O) and coronadite (PbMn.sub.8 O.sub.16.xH.sub.2 O). O'Young discloses these materials to have a three dimensional framework tunnel structure (U.S. Pat. No. 5,340,562 and O'Young Hydrothermal Synthesis of Manganese Oxides with Tunnel Structures both hereby incorporated by reference). For the purposes of the present invention, .alpha.-MnO.sub.2 is considered to have a 2.times.2 tunnel structure and to include hollandite, cryptomelane, manjiroite and coronadite.

SUMMARY OF THE INVENTION

The present invention relates to an apparatus, method and composition to treat the atmosphere. For the purposes of the present invention atmosphere is defined as the mass of air surrounding the earth.

The present invention is directed to an apparatus and related method for treating the atmosphere comprising a vehicle and a means such as a motor to translate the vehicle from one place to another through the atmosphere. The vehicle comprises at least one atmosphere contacting vehicle surface and a pollutant treating composition located on that surface. The atmosphere contacting surface is a surface of a component of the vehicle that is in direct contact with the atmosphere. Preferred and useful atmosphere contacting surfaces include body surfaces, wind deflector surfaces, grill surfaces, mirror backs and the surfaces of "under the hood" components. Preferred atmosphere contacting surfaces are located within the body of the motor vehicle, typically in proximity to the engine, i.e., the engine compartment. The surfaces are preferably the surfaces of cooling means which comprise an in flow path for liquids or gases through a coolant walled enclosure such as tubes or a housing and an outer surface on which is located fins to enhance heat transfer. Preferred atmosphere contacting surfaces comprise a finned outer surface and are selected from the outer surfaces of the radiator, air conditioner condenser, the surfaces of the radiator fan, engine oil cooler, transmission oil cooler, power steering fluid cooler and air charge cooler also referred to as an intercooler or after cooler. The most preferred atmosphere contacting surfaces are the outer surfaces of the air conditioner condenser and radiator due to their large surface area and relatively high ambient operating temperatures of from about 40.degree. C. to 135.degree. C. and typically up to 110.degree. C.

An advantage of the present invention is that the atmosphere contacting surface useful to support a pollution treating composition can be the surface of existing vehicle components. No additional filter, or apparatus to support a pollutant treating composition, is required. Accordingly, the apparatus and method of the present invention can be located on existing components of new cars or retrofitted onto old cars. Retrofitting may comprise coating a suitable pollutant treating composition on an existing vehicle surface which comes in contact with atmospheric air as the vehicle is driven through the atmosphere.

The present invention is directed to compositions, methods and articles to treat pollutants in air. Such pollutants may typically comprise from 0 to 400 parts, more typically 1 to 300, and yet more typically 1 to 200, parts per billion (ppb) ozone; 0 to 30 parts, and more typically 1 to 20, parts per million (ppm) carbon monoxide; and 2 to 3000 ppb unsaturated hydrocarbon compounds such as C.sub.2 to about C.sub.20 olefins and partially oxygenated hydrocarbons such as alcohols, aldehydes, esters, ethers, ketones and the like. Typical hydrocarbons which can be treated include, but are not limited to, propylene, butylene, formaldehyde and other airborne hydrocarbon gases and vapors. Other pollutants present may include nitrogen oxides and sulfur oxides. The National Ambient Air Quality Standard for ozone is 120 ppb, and for carbon monoxide is 9 ppm.

Pollutant treating compositions include catalyst compositions useful for catalyzing the conversion of pollutants present in the atmosphere to non-objectionable materials. Alternatively, adsorption compositions can be used as the pollutant treating composition to absorb pollutants which can be destroyed upon adsorption, or stored for further treatment at a later time.

Catalyst compositions can be used which can assist in the conversion of the pollutants to harmless compounds or to less harmful compounds. Useful and preferred catalyst compositions include compositions which catalyze the reaction of ozone to form oxygen, catalyze the reaction of carbon monoxide to form carbon dioxide, and/or catalyze the reaction of hydrocarbons to form water and carbon dioxide. Specific and preferred catalysts to catalyze the reaction of hydrocarbons are useful for catalyzing the reaction of low molecular weight unsaturated hydrocarbons having from two to twenty carbons and at least one double bond, such as C.sub.2 to about C.sub.8 mono-olefins. Such low molecular weight hydrocarbons have been identified as being sufficiently reactive to cause smog. Particular olefins which can be reacted include propylene and butylene. A useful and preferred catalyst can catalyze the reactions of both ozone and carbon monoxide; and preferably ozone, carbon monoxide and hydrocarbons.

Ozone--Useful and preferred catalyst compositions to treat ozone include a composition comprising manganese compounds including oxides such as Mn.sub.2 O.sub.3 and MnO.sub.2 with a preferred composition comprising .alpha.-MnO.sub.2, and cryptomelane being most preferred. Other useful and preferred compositions include a mixture of MnO.sub.2 and CuO. Specific and preferred compositions comprise hopcalite which contains CuO and MnO.sub.2 and, more preferably Carulite.RTM. which contains MnO.sub.2, CuO and Al.sub.2 O.sub.3 and sold by the Carus Chemical Co. An alternative composition comprises a refractory metal oxide support on which is dispersed a catalytically effective amount of a palladium component and preferably also includes a manganese component. Also useful is a catalyst comprising a precious metal component, preferably a platinum component on a support of coprecipitated zirconia and manganese oxide. The use of this coprecipitated support has been found to be particularly effective to enable a platinum component to be used to treat ozone. Yet another composition which can result in the conversion of ozone to oxygen comprises carbon, and palladium or platinum supported on carbon, manganese dioxide, Carulite.RTM. and/or hopcalite. Manganese supported on a refractory oxide such as alumina has also been found to be useful.

Carbon Monoxide--Useful and preferred catalyst compositions to treat carbon monoxide include a composition comprising a refractory metal oxide support on which is dispersed a catalytically effective amount of a platinum and/or palladium component, preferably a platinum component. A most preferred catalyst composition to treat carbon monoxide comprises a reduced platinum group component supported on a refractory metal oxide, preferably titania. Useful catalytic materials include precious metal components including platinum group components which include the metals and their compounds. Such metals can be selected from platinum, palladium, rhodium and ruthenium, gold and/or silver components. Platinum will also result in the catalytic reaction of ozone. Also useful is a catalyst comprising a precious metal component, preferably a platinum component on a support of coprecipitated zirconia and manganese dioxide. Preferably, this catalyst embodiment is reduced. Other useful compositions which can convert carbon monoxide to carbon dioxide include a platinum component supported on carbon or a support comprising manganese dioxide. Preferred catalysts to treat such pollutants are reduced. Another composition useful to treat carbon monoxide comprises a platinum group metal component, preferably a platinum component, a refractory oxide support, preferably alumina and titania and at least one metal component selected from a tungsten component and rhenium component, preferably in the metal oxide form.

Hydrocarbons--Useful and preferred catalyst compositions to treat unsaturated hydrocarbons including C.sub.2 to about C.sub.20 olefins and typically C.sub.2 to C.sub.8 mono-olefins such as propylene and partially oxygenated hydrocarbons as recited have been found to be the same type as recited for use in catalyzing the reaction of carbon monoxide with the preferred compositions for unsaturated hydrocarbons comprising a reduced platinum and/or palladium component and a refractory metal oxide support for the platinum component. A preferred refractory metal oxide support is titania. Other useful compositions which can convert hydrocarbons to carbon dioxide and water include a platinum component supported on carbon or a support comprising manganese dioxide. Preferred catalysts to treat such pollutants are reduced. Another composition useful to convert hydrocarbons comprises a platinum group metal component, preferably a platinum component, a refractory oxide support, preferably alumina and titania and at least one metal component selected from a tungsten component and rhenium component, preferably in the metal oxide form. A combination of a platinum component and a palladium component results in improved CO conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable.

Ozone and Carbon Monoxide--A useful and preferred catalyst which can treat both ozone and carbon monoxide comprises a support such as a refractory metal oxide support on which is dispersed a precious metal component. The refractory oxide support can comprise a support component selected from the group consisting of ceria, alumina, silica, titania, zirconia, and mixtures thereof. Also useful as a support for precious metal catalyst components is a coprecipitate of zirconia and manganese oxides. Most preferably, this support is used with a platinum component and the catalyst is in reduced form. This single catalyst has been found to effectively treat both ozone and carbon monoxide. Other useful and preferred precious metal components are comprised of precious metal components selected from palladium and also platinum components with palladium preferred. A combination of a ceria support with a palladium component results in an effective catalyst for treating both ozone and carbon monoxide. Other useful and preferred catalysts to treat both ozone and carbon monoxide include a platinum group component, preferably a platinum component and/or palladium component and more preferably a platinum component, on titania or on a combination of zirconia and silica. A combination of a platinum component and a palladium component results in improved CO conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. Other useful compositions which can convert ozone to oxygen and carbon monoxide to carbon dioxide include a platinum component supported on carbon or on a support comprising manganese dioxide. Preferred catalysts are reduced.

Ozone, Carbon Monoxide and Hydrocarbons--A useful and preferred catalyst which can treat ozone, carbon monoxide and hydrocarbons, typically low molecular weight olefins (C.sub.2 to about C.sub.20) and typically C.sub.2 to C.sub.8 mono-olefins and partially oxygenated hydrocarbons as recited comprises a support, preferably a refractory metal oxide support on which is dispersed a precious metal component. The refractory metal oxide support can comprise a support component selected from the group consisting of ceria, alumina, titania, zirconia and mixtures thereof with titania most preferred. Useful and preferred precious metal components are comprised of precious metal components selected from platinum group components including palladium and/or platinum components with platinum most preferred. It has been found that a combination of a titania support with a platinum component results in the most effective catalyst for treating ozone, carbon monoxide and low molecular weight gaseous olefin compounds. A combination of a platinum component and a palladium component results in improved CO and hydrocarbon conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. It is preferred to reduce the platinum group components with a suitable reducing agent. Other useful compositions which can convert ozone to oxygen, carbon monoxide to carbon dioxide, and hydrocarbons to carbon dioxide include a platinum component supported on carbon, a support comprising manganese dioxide, or a support comprising a coprecipitate of manganese oxides and zirconia. Preferred catalysts are reduced.

The above compositions can be applied by coating to at least one atmosphere contacting vehicle surface. Particularly preferred compositions catalyze the destruction of ozone, carbon monoxide and/or unsaturated low molecular weight olefinic compounds at ambient conditions or ambient operating conditions. Ambient conditions are the conditions of the atmosphere. By ambient operating conditions it is meant the conditions, such as temperature, of the atmosphere contacting surface during normal operation of the vehicle without the use of additional energy directed to heating the pollutant treating composition. Certain atmosphere contacting surfaces such as a grill or wind deflector can be at the same or similar temperature as the atmosphere. It has been found that preferred catalysts which catalyze the reaction of ozone can catalyze the reaction of ozone at ambient conditions in ranges as low as 5.degree. C. to 30.degree. C.

Atmosphere contacting surfaces may have higher temperatures than the ambient atmospheric temperatures due to the nature of the operation of the component underlying the surface. For example, preferred atmosphere contacting surfaces are the surfaces of the air conditioning condenser and the radiator due to their high surface area. Where vehicles use air charge coolers, these are preferred due to high surface area and operating temperatures of from ambient to 250.degree. F. Normally, during ambient operating conditions the surfaces of these components increase to higher temperature levels than the ambient environment due to the nature of their operation. After the vehicle motor has warmed up, these components are typically at temperatures which range up to about 130.degree. C. and typically from 40.degree. C. to 110.degree. C. The temperature range of these atmosphere contacting surfaces helps to enhance the conversion rates of the ozone, carbon monoxide and hydrocarbon catalysts supported on such surfaces. Air charge coolers operate at temperatures up to about 130.degree. C. and typically from 60.degree. C. to 130.degree. C.

Various of the catalyst compositions can be combined, and a combined coating applied to the atmosphere contacting surface. Alternatively, different surfaces or different parts of the same surface can be coated with different catalyst compositions.

The method and apparatus of the present invention are designed so that the pollutants can be treated at ambient atmospheric conditions or at the ambient operating conditions of the vehicle atmosphere contacting surface. The present invention is particularly useful for treating ozone by coating motor vehicle atmosphere contacting surfaces with suitable catalysts useful to destroy such pollutants even at ambient conditions, and at vehicle surface temperatures typically from at least 0.degree. C., preferably from 10.degree. C. to 105.degree. C., and more preferably from 40.degree. C. to 100.degree. C. Carbon monoxide is preferably treated at atmosphere contacting surface temperatures from 40.degree. C. to 105.degree. C. Low molecular weight hydrocarbons, typically unsaturated hydrocarbons having at least one unsaturated bond, such as C.sub.2 to about C.sub.20 olefins and typically C.sub.2 to C.sub.8 mono-olefins, are preferably treated at atmosphere contacting surface temperatures of from 40.degree. C. to 105.degree. C. The percent conversion of ozone, carbon monoxide and/or hydrocarbons depends on the temperature and space velocity of the atmospheric air relative to the atmosphere contacting surface, and the temperature of the atmosphere contacting surface.

Accordingly, the present invention, in most preferred embodiments can result in at least reducing the ozone, carbon monoxide and/or hydrocarbon levels present in the atmosphere without the addition of any mechanical features or energy source to existing vehicles, particularly motor vehicles. Additionally, the catalytic reaction takes place at the normal ambient operating conditions experienced by the surfaces of these motor vehicle elements so that no changes in the construction or method of operation of the motor vehicle are required.

While the apparatus and method of the present invention are generally directed to treating the atmosphere, it will be appreciated that variations of the apparatus are contemplated for use to treat volumes of air in enclosed spaces. For example, a motor vehicle having an atmosphere contacting surface supporting a pollutant treating composition can be used to treat the air within factories, mines and tunnels. Such apparatus can include vehicles used in such environments.

While the preferred embodiments of the present invention are directed to the destruction of pollutants at the ambient operating temperatures of the atmosphere contacting surface, it is also desirable to treat pollutants which have a catalyzed reaction temperature higher than the ambient temperature or ambient operating temperature of the atmosphere contacting surface. Such pollutants include hydrocarbons and nitrogen oxides and any carbon monoxide which bypasses or is not treated at the atmosphere contacting surface. These pollutants can be treated at higher temperatures typically in the range of at least 100.degree. C. to 450.degree. C. This can be accomplished, for example, by the use of an auxiliary heated catalyzed surface. By an auxiliary heated surface, it is meant that there are supplemental means to heat the surface. A preferred auxiliary heated surface is the surface of an electrically heated catalyzed monolith such as an electrically heated catalyzed metal honeycomb of the type known to those skilled in the art. Electricity can be provided by batteries or a generator such as are present in motor vehicles. The catalyst composition can be any well known oxidation and/or reduction catalyst, preferably a three way catalyst (TWC) comprising precious group metals such as platinum, palladium, rhodium and the like supported on refractory oxide supports. An auxiliary heated catalyzed surface can be used in combination with, and preferably downstream of, the vehicle atmosphere contacting surface to further treat the pollutants.

As previously stated, adsorption compositions can also be used to adsorb pollutants such as hydrocarbons and/or particulate matter for later oxidation or subsequent removal. Useful and preferred adsorption compositions include zeolites, other molecular sieves, carbon, and Group IIA alkaline earth metal oxides such as calcium oxide. Hydrocarbons and particulate matter can be adsorbed from 0.degree. C. to 110.degree. C. and subsequently treated by desorption followed by catalytic reaction or incineration.

It is preferred to coat areas of the vehicle that have a relatively high surface area exposed to a large flow rate of atmospheric air as the motor vehicle is driven through the environment. For land use motor vehicles, particularly preferred atmosphere contacting surfaces include the radiator, fan blades, the air conditioning condenser or heat exchanger, air charge cooler, engine oil cooler, transmission oil cooler, and wind deflectors of the type used on the roof of truck cabs.

Most preferably, the atmosphere contacting surface is a surface of a radiator. The radiator has a large surface area for enhanced cooling of internal combustion engine fluid coolants. By applying a catalyst to be supported on the radiator surface, advantage can be taken of the large honeycomb-like surface area, usually with little or no effect on the cooling function of the radiator. The high honeycomb-like surface area enables a maximization of contact of the catalyst with the air passing through the honeycomb-like design of the radiator. Additionally, radiators in many automobiles are located behind the air conditioner condenser and are thereby protected by the air conditioner condenser.

The present invention includes methods to coat pollutant treating compositions on to atmosphere contacting surfaces of motor vehicles. In particular, the present invention includes a method to coat catalyst compositions onto finned elements such as radiators, air conditioner condensers, and air charge coolers.

Calculations suggest that in motor vehicle traffic congested areas, there are a sufficient number of motor vehicles to significantly impact pollutants treated in accordance with the present invention. For example, in Southern California's South Coast Air Quality Management District, there are approximately eight million cars. It has been calculated that if each car travels 20 miles per day, all of the air in this region to an altitude of 100 feet can be cycled through radiators in one week.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side schematic view of a truck showing a grill, air conditioner condenser, electrically heated catalyst, air charge cooler, radiator, fan and engine with a wind deflector on the roof of the truck cab.

FIG. 2 is a partial schematic view of a motor vehicle showing the grill, air conditioner condenser, radiator and fan.

FIG. 3 is a front view of the radiator.

FIG. 4 is a front view of the air conditioner condenser.

FIG. 5 is a front view of a wind deflector of the type illustrated in FIG. 1.

FIG. 6 is a front view of the truck of FIG. 1.

FIG. 7 is a partial schematic sectional view of coated finned cooling element.

FIG. 8 is a photograph of the coated radiator from Examples 1 and 2.

FIGS. 9-14 and 16-17 are graphs of CO conversion versus temperature for using different catalysts in Examples 4, 9-12, 14 and 15.

FIG. 15 is a graph of propylene conversion versus temperature based on Example 14.

FIG. 18 is a graph of ozone conversion versus temperature based on Example 17.

FIG. 19 is an IR spectrum for cryptomelane.

FIG. 20 is an XRD pattern for cryptomelane shown as counts using a square root scale versus the Bragg angle, 2.theta..

FIG. 21 is a graph of CO and hydrocarbon conversion versus temperature based on Example 30.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to apparatus and methods for cleaning the atmosphere useful with vehicles having means to convey the vehicle through the atmosphere. As the vehicle moves through the atmosphere, at least one atmosphere contacting surface comprising a pollutant treating composition (e.g., a catalyst or an adsorber) located thereon contacts atmospheric air. As the atmospheric air encounters the pollutant treating composition, various pollutants including particulate matter and/or gaseous pollutants carried in the air can be catalytically reacted or adsorbed by the pollutant treating composition located on the atmosphere contacting surface.

It will be appreciated by those skilled in the art that the vehicle can be any suitable vehicle which has a translation means to propel the vehicle such as wheels, sails, belts, tracks or the like. Such means can be powered by any suitable power means including engines which use fossil fuel such as gasoline or diesel fuel, ethanol, methanol, gas engines powered by fuels such as by methane gas, wind power such as by wind driving sails or propellers, solar power or electric power such as in battery operated automobiles. Vehicles include cars, trucks, buses, trains, boats, ships, airplanes, dirigibles, balloons and the like.

The atmosphere contacting surface can be any suitable surface that encounters and contacts air as the vehicle moves through the atmosphere. Preferably in a motor vehicle, preferably cars, trucks and buses, the contact means is a surface located toward the front of the vehicle and can contact air as the vehicle proceeds in a forward direction. Useful contact surfaces should have a relatively large surface area. Preferred contact surfaces are at least partially enclosed in the vehicle. Preferred atmosphere contacting surfaces are located under the hood and are located within the body of the motor vehicle, typically in proximity to the engine, i.e., the engine compartment. The surfaces are preferably the outer surfaces of cooling means which comprise a flow path for liquids or gases through a coolant walled enclosure such as tubes or a housing and an outer surface on which is located fins to enhance heat transfer. Useful contact surfaces include the outside surfaces of means to cool fluids, including liquids and/or gases used in the vehicle such as the air conditioner condenser, the radiator, air charge cooler, engine oil cooler, transmission oil cooler, power steering fluid cooler, the fan shroud, and the radiator fan which are all located and supported within the housing of the vehicle. A useful contact surface outside of the vehicle can be the grill typically located and supported on the front of the housing, or wind deflectors commonly supported on the roof of the cabs of large trucks. It is preferred that the contacting surface is a forward facing surface, side facing surface or surface facing the top or bottom of the vehicle. The front facing surfaces face the front of the vehicle, surfaces such as the fins of the radiator and condenser elements face the side, top and bottom of the vehicle. Even surfaces directed to face away from the front and toward the back of the vehicle which contact air can be atmosphere contacting surfaces, such as the back surface of fan blades. Surfaces of airplane engines such as wings, propellers and jet engine parts including turbine rotors and/or stators can be coated.

Preferred atmosphere contacting surfaces in motor vehicles are located on engine cooling elements such as motor vehicle radiators, air conditioner condensers, air charge coolers, also known as intercoolers or after coolers, engine oil coolers and transmission oil coolers. Such elements typically have high surface area structures associated with them to have improved heat transfer. The high surface areas are useful for maximizing the contact of the atmospheric air with the pollutant treating composition. All such elements are well known in the automotive arts. Reference is made to Bosch Automotive Handbook, Second Edition, pages 301-303, 320 and 349-351, published by Robert Bosch GmbH, 1986, herein incorporated by reference. This reference illustrates a truck diesel engine with a radiator, an intercooler and a fan. Such elements may be coated with a pollutant treating surface of the present invention. The radiator and intercooler typically operate at temperatures higher than that of the atmospheric air. Reference is also made to Taylor, The Internal Combustion Engine in Theory and Practice, Vol. 1: Thermo Dynamics, Fluid Flow, Performance, Second Edition, Rev. The MIT Press, 1985 at pages 304-306 for radiator and fin design; and page 392 for after coolers. The above pages in Taylor are herein incorporated by reference.

Reference is also made to a collection of papers in 1993 Vehicle Thermal Management Systems Conference Proceedings, SAE P:263 published by the Society of Automotive Engineers, Inc., 1993. The following papers are herein incorporated by reference. SAE Paper No. 931088 beginning at page 157 entitled, Calculation and Design of Cooling Systems by Eichlseder and Raab of Steyr Damler Puchag and Charge Air Cooler for Passenger Cars by Collette of Valeo Thermique Moteur; SAE Paper No. 931092 entitled, State of the Art and Future Developments of Aluminum Radiators for Cars and Trucks by Kern and Eitel of Behr GmbH and Co. beginning at page 187; SAE Paper 931112 entitled, Air Mix vs. Coolant Flow to Control Discharge Air Temperature and Vehicle Heating Air Conditioning Systems by Rolling and Cummings of Behr of America, Inc. and Schweizer of Behr GmbH & Co. The above papers include descriptions of radiator, air conditioner and air charge cooler structures for use in the motor vehicles. Reference is additionally made to SAE Paper 931115 entitled, Engine Cooling Module Development Using Air Flow Management Techniques by El-Bourini and Chen of Calsonic Technical Center beginning at page 379 and hereby incorporated by reference. Of interest are Appendices 1 and 2 which illustrate typical radiator and condenser structures useful in motor vehicle applications. Reference is also made to SAE Paper 931125 entitled, Durability Concerns of Aluminum Air to Air Charged Coolers by Smith, Valeo Engine Cooling Inc. which discloses air charge coolers and is hereby incorporated by reference.

The present invention will be understood by those skilled in the art by reference to the accompanying FIGS. 1-7.

FIG. 1 illustrates a truck 10 schematically containing a variety of vehicle components comprising atmosphere contacting surfaces. These surfaces include the surfaces of grill 12, the air conditioner condenser 14, an air charge cooler 25, the radiator 16, and the radiator fan 18. Also shown on this truck is a wind deflector 20 having a front deflecting surface 22. It is recognized that the various components can have different relative locations on different vehicles.

Referring to FIGS. 1 to 4 the preferred contacting surfaces include the surface of the front 13 and side 15 surfaces of the air conditioner condenser 14, the front 17 and side 19 surfaces of the radiator 16, corresponding surfaces of the air charge cooler 25 and the front 21 and back 23 surfaces of the radiator fan 18. These surfaces are located within the housing 24 of the truck. They are typically under the hood 24 of the truck between the front 26 of the truck and the engine 28. The air conditioner condenser, air charge cooler, radiator and radiator fan can be directly or indirectly supported by housing 24 or a frame (not shown) within the housing.

FIG. 2 generally shows a schematic view of an automobile assembly. Corresponding elements in FIGS. 1 and 2 have common reference characters. The automobile comprises a housing 30. There is a motor vehicle front 32 having a grill 12 supported on the front of the housing 30. An air conditioner condenser 14, a radiator 16, and a radiator fan 18 can be located within the housing 30.

Referring to embodiments in FIGS. 1, 2 and 6, the contacting surface on the front and sides of least one of the grill 12, air conditioner condenser 14, the air charge cooler 25, and radiator 16; the front and back of the radiator fan 18; and the front of the wind deflector 20 can have a pollutant treating composition located thereon. The grill 12 can have a suitable grill grid type design which provides for openings 36 through which air passes as the truck 12 is operated and moves through the atmosphere. The openings are defined by the grill grid 38. The grill grid 38 has a front grill surface 40 and a side grill surface 42. The front and side grill grid surfaces 40 and 42 can be used as atmosphere contacting surfaces on which pollutant treating compositions are located.

Referring to FIGS. 1 and 4, the air conditioning condenser 14 comprises a plurality of air conditioning condenser fins 44. Additionally, there is an air conditioning fluid conduit 46 which conducts the air conditioning fluid through condenser 14. The front and side surfaces of the air conditioning fins 44, as well as the front surface of the air conditioning conduit 46 can be the atmosphere contacting surfaces on which a pollutant treating composition is located. As indicated, both the front 21 and back 23 surfaces of the radiator fan 18 can be a contacting surface to support a pollutant treating composition.

The most preferred atmosphere contacting surface is on radiator 16 as shown in FIG. 3. A typical radiator 16 has a frontal radiator surface 17 as well as a plurality of radiator corrugated plates or fins 50 located in corresponding radiator plate or fin channels 52 which pass through the radiator 16. It is preferred to coat the front surface 17 as well as the side surfaces of the radiator plates 50 and channel 52 surfaces. The radiator is most preferred because it is located within the housing 24 or 30 and is protected from the front by at least the grill 12 and preferably an air conditioner condenser 14. In addition to air entering into the hood chamber 34 as the motor vehicle moves through the atmosphere, radiator fan 18 draws air in and through the channels 52. Therefore, the radiator 16 is located and protected by the grill 12, the air conditioner condenser 19 and is in front of the radiator fan 18. Additionally, as indicated above, the radiator has a large surface area for heat transfer purposes. In accordance with the present invention, pollutant treating composition can be effectively located on, and take advantage of, such a large surface area without significantly adversely impacting on the heat transfer function of the radiator.

The above description is particularly directed to and illustrates the use of atmosphere treating surfaces on apparatus such as radiator 16 and air conditioner condenser 14. As indicated the atmosphere contacting surface can be on other suitable means to cool engine fluids including well known articles such as the above referenced air charge cooler 25 as well as engine oil coolers, transmission oil coolers and power steering oil coolers. A commonality of all such cooling means is a housing or conduit through which the fluid passes. The housing comprises a wall having an inner surface in contact with the fluid and an outer surface typically in contact with the atmosphere within the frame of the vehicle and typically within the engine compartment. In order to efficiently transfer heat from the fluid in these various apparatus, there are fins or plates extending from the outer surface of the cooling, housing or conduit.

A useful and preferred embodiment with each of these cooling means is illustrated in FIG. 7. FIG. 7 is a schematic sectional view of a coated finned cooling element 60. The element comprises a housing or conduit defined by a housing or conduit wall 62. Located within the conduit is a passageway or chamber 64 through which fluid such as oils or cooling liquids or air conditioning fluids pass. Such fluids are shown as referenced character 66. The housing wall comprises an inner surface 68 and an outer surface 70. Located and attached to the outer surface are plates or fins 72. In accordance with the present invention, there is a pollutant treating composition 74 which can be located on the outer surface 70 and the fins or plates 72. During operation air streams contact the pollutant treating composition to cause various of the pollutants to be treated.

Applicant herein incorporates by reference commonly assigned patent application entitled, "Pollution Treating Device and Methods of Making the Same", filed as U.S. Ser. No. 08/537,208. Additionally, any of the embodiments of the apparatus of the present invention and method of use thereof can optionally further incorporate a replaceable pollution treating device as disclosed therein.

Pollutant treating compositions can also be located on outer surfaces of the vehicle. As indicated, such compositions can be located on the grill 12 and in the case of the truck shown in FIGS. 1 and 6, on the wind deflector 20 frontal wind deflector surface 22. Additionally, pollution treatment compositions can be located on the front of the mirror 54 as well as any of a variety of front facing surfaces.

The use of an air charge cooler 25 represents a particularly effective atmosphere contacting surface on which pollutant treating compositions can be supported. The operating temperatures can reach as high as 250.degree. F. At such temperatures, the catalyst compositions of the present invention can more effectively treat ozone, hydrocarbons, and carbon monoxide pollutants. Particularly useful are compositions containing precious metals such as platinum, palladium, gold or silver components. Alternatively, the catalyst can include manganese compounds such as manganese dioxide and copper compounds including copper oxide such Carulite or hopcalite.

During normal operation, the vehicle moves in a forward direction with the front 26 of the vehicle 10 initially contacting the atmospheric air. Typically, vehicles move through the air at velocities of up to about 1,000 miles per hour for jet planes. Land vehicles and water vehicles typically move at velocities of up to 300 miles per hour, more typically up to 200 miles per hour with motor vehicles moving at velocities up to 100 miles per hour and typically from 5 to 75 miles per hour. Seagoing vehicles, such as boats, typically move through the water at velocities up to 30 miles per hour and typically from 2 to 20 miles per hour. In accordance with method of the present invention the relative velocity (or face velocity) between the atmosphere contacting surface and the atmosphere, as the vehicle, typically an automobile or land based vehicle, moves through the atmosphere, is from 0 to 100 miles per hour, and typically from 2 to 75 miles per hour in an automobile typically from 5 to 60 miles per hour. The face velocity is the velocity of the air relative to the pollutant treating surface.

In motor vehicles such as trucks 10 which have a radiator fan 18, the fan draws atmospheric air through the grill 12, air conditioner condenser 14, air charge cooler 25 and/or radiator 16 in addition to air which passes across these elements as the motor vehicle moves through the atmosphere. When the motor vehicle is idling the relative face velocity of air drawn into the radiator typically ranges from about 5 to 15 mph. The radiator fan moderates the flow rate of air through radiator as the motor vehicle moves through the atmosphere. When a typical car is moving through the atmosphere at speeds approaching 70 mph, the inlet face velocity of air is at about 25 mph. Depending on the design of a motor vehicle using a radiator fan, cars have a face velocity as low as when the fan is used during idle up to about 100% of the face velocity corresponding to the velocity of the motor vehicle. However, typically, the face velocity of the air relative to the atmosphere contacting surface is equal to the idle face velocity plus from 0.1 to 1.0 and more typically 0.2 to 0.8 times the velocity of the vehicle.

In accordance with the present invention, large volumes of air can be treated at relatively low temperatures. This occurs as vehicles move through the atmosphere. High surface area components of vehicles including radiators, air conditioner condensers and charge air coolers typically have a large frontal surface area which encounters the air stream. However, these devices are relatively narrow, typically ranging from about 3/4 of an inch deep up to about 2 inches deep and usually in the range of 3/4 to 1 1/2 inches deep. The linear velocity of the atmospheric air contacting the frontal surface of such devices is typically in the range of up to 20, and more typically 5 to 15 miles per hour. An indication of the amount of air being treated as it passes across the catalyzed vehicle component is commonly referred to space velocity or more precisely volume hourly space velocity (VHSV). This is measured as volume (corresponding to the volume of the catalyzed element) of air per hour which passes across the volume of the catalytic article. It is based on the cubic feet per hour of air divided by the cubic feet of catalyst substrate. The volume of the catalyst substrate is the frontal area times the depth or axial length in the direction of the air flow. Alternatively, volume hourly space velocity is the number of catalyst volumes based on the volume of the catalytic article being treated per hour. Because of the relatively short axial depth of the catalyzed elements of the present invention, the space velocities are relatively high. The volume hourly space velocities of air which can be treated in accordance with the present invention can be a million or more reciprocal hours. A face velocity of air against one of these elements at 5 miles per hour can result in a space velocity of as high as 300,000 reciprocal hours. In accordance with the present invention, the catalysts are designed to treat pollutants in the atmosphere at space velocities in ranges as high as from 250,000 to 750,000 and typically 300,000 to 600,000 reciprocal hours. This is accomplished even at the relatively low ambient temperatures and ambient operating temperatures of the vehicle elements containing pollutant treating compositions in accordance with the present invention.

The ambient operating temperature of the atmosphere contacting surfaces can vary depending on whether they are located in the proximity of heat sources within the vehicle or are the surfaces of elements which function to cool parts of the vehicle. However, contacting surfaces such as grill 12, wind deflector 20 are at ambient conditions. During typical operation, the means to cool operates at above ambient atmospheric temperature, with the contacting surfaces such as the surfaces of the air conditioner condenser 14, and radiator 16 and air charge cooler 25 can range up to 130.degree. C. and typically up to 105.degree. C. and are typically in the range of from 10.degree. C. to 105.degree. C., more typically from 40.degree. C. to 100.degree. C. and can be from 10.degree. C. to 75.degree. C. The air charge cooler 25 typically operates at temperatures of from 750 to 130.degree. C. The amount of contacting surface can vary with air conditioner condensers, radiators and air charge coolers typically having from 20 to 2,000 square feet and fan blades 18 typically having from 0.2 to up to about 40 square feet when considering front and back surfaces.

The pollutant treating composition is preferably a catalytic composition or adsorption composition. Useful and preferred catalyst compositions are compositions which can catalytically cause the reaction of targeted pollutants at the space velocity of the air as it contacts the surface, and at the temperature of the surface at the point of contact. Typically, these catalyzed reactions will be in the temperature range at the atmosphere contacting surface of from 0.degree. C. to 130.degree. C., more typically 20.degree. C. to 105.degree. C. and yet more typically from about 40.degree. C. to 100.degree. C. There is no limit on the efficiency of the reaction as long as some reaction takes place. Preferably, there is at least a 1% conversion efficiency with as high a conversion efficiency as possible. Useful conversion efficiencies are preferably at least about 5% and more preferably at least about 10%. Preferred conversions depend on the particular pollutant and pollutant treating composition. Where ozone is treated with a catalytic composition on an atmosphere contacting surface it is preferred that the conversion efficiency be greater than about from 30% to 40%, preferably greater than 50%, and more preferably greater than 70%. Preferred conversion for carbon monoxide is greater than 30% and preferably greater than 50%. Preferred conversion efficiency for hydrocarbons and partially oxygenated hydrocarbons is at least 10%, preferably at least 15%, and most preferably at least 25%. These conversion rates are particularly preferred where the atmosphere contacting surface is at ambient operating conditions of up to about 110.degree. C. These temperatures are the surface temperatures typically experienced during normal operation of atmosphere contacting surfaces of the vehicle including the surfaces of the radiator and air conditioning condenser. Where there is supplemental heating of the atmosphere contacting surface such as by having an electrically heated catalytic monolith, grid, screen, gauze or the like, it is preferred that the conversion efficiency be greater than 90% and more preferably greater than 95%. The conversion efficiency is based on the mole percent of the particular pollutants in the air which react in the presence of the catalyst composition.

Ozone treating catalyst compositions comprise manganese compounds including manganese dioxide, including non stoichiometric manganese dioxide (e.g., MnO.sub.(1.5-2.0), and/or Mn.sub.2 O.sub.3. Preferred manganese dioxides, which are nominally referred to as MnO.sub.2 have a chemical formula wherein the molar ratio of manganese to oxide is about from 1.5 to 2.0, such as Mn.sub.8 O.sub.16. Up to

100 percent by weight of manganese dioxide MnO.sub.2 can be used in catalyst compositions to treat ozone. Alternative compositions which are available comprise manganese dioxide and compounds such as copper oxide alone or copper oxide and alumina.

Useful and preferred manganese dioxides are alpha manganese dioxides nominally having a molar ratio of manganese to oxygen of from 1 to 2. Useful alpha manganese dioxides are disclosed in U.S. Pat. No. 5,340,562 to O'Young, et al.; also in O'Young, Hydrothermal Synthesis of Manganese Oxides with Tunnel Structures presented at the Symposium on Advances in Zeolites and Pillared Clay Structures presented before the Division of Petroleum Chemistry, Inc. American Chemical Society New York City Meeting, Aug. 25-30, 1991 beginning at page 342, and in McKenzie, the Synthesis of Birnessite, Cryptomelane, and Some Other Oxides and Hydroxides of Manganese, Mineralogical Magazine, December 1971, Vol. 38, pp. 493-502. For the purposes of the present invention, the preferred alpha manganese dioxide is a 2.times.2 tunnel structure which can be hollandite (BaMn.sub.8 O.sub.16.xH.sub.2 O), cryptomelane (KMn.sub.8 O.sub.16.xH.sub.2 O), manjiroite (NaMn.sub.8 O.sub.16.xH.sub.2 O) and coronadite (PbMn.sub.8 O.sub.16.xH.sub.2 O).

The manganese dioxides of the present invention preferably have a surface area, measured by BET N.sub.2 adsorption, of greater than 150 m.sup.2 /g, more preferably greater than 200 m.sup.2 /g, and more preferably greater than 220 m.sup.2 /g. The upper range can be as high as 300 m.sup.2 /g, 325 m.sup.2 /g or even 350 m.sup.2 /g. Preferred materials are in the range of 200-350 m.sup.2 /g, preferably 200-275 m.sup.2 /g and most preferably 220-250 m.sup.2 /g. The composition preferably comprises a binder as described below with preferred binders being polymeric binders. The composition can further comprise precious metal components with preferred precious metal components being the oxides of precious metal, preferably the oxides of platinum group metals and most preferably the oxides of palladium or platinum also referred to as palladium black or platinum black. The amount of palladium or platinum black can range from 0 to 25%, with useful amounts being in ranges of from about 1 to 25 and 5 to 15% by weight based on the weight of the manganese component and the precious component.

It has been found that the use of compositions comprising the cryptomelane form of alpha manganese oxide, which also contain a polymeric binder can result in greater than 50%, preferably greater than 60% and most preferably from 75-85% conversion of ozone in a concentration range of from 0 to 400 parts per billion (ppb) and an air stream moving across a radiator at space velocity of from 300,000 to 650,000 reciprocal hours. Where a portion of the cryptomelane is replaced by up to 25% and preferably from 15-25% parts by weight of palladium black (PdO), ozone conversion rates at the above conditions range from 95-100% using a powder reactor.

The preferred cryptomelane manganese dioxide has from 1.0 to 3.0 weight percent potassium, typically as K.sub.2 O, and a crystallite size ranging from 2 to 10 and preferably from less than 5 nm. It can be calcined at a temperature range of from 250.degree. C. to 550.degree. C. and preferably below 500.degree. C. and greater than 300.degree. C. for at least 1.5 hours and preferably at least 2 hours up to about 6 hours.

The preferred cryptomelane can be made in accordance described in the above referenced articles and patents to O'Young and McKenzie. The cryptomelane can be made by reacting a manganese salt including salts selected from the group consisting MnCl.sub.2, Mn(NO.sub.3).sub.2, MnSO.sub.4 and Mn(CH.sub.3 COO).sub.2 with a permanganate compound. Cryptomelane is made using potassium permanganate; hollandite is made using barium permanganate; coronadite is made using lead permanganate; and manjiroite is made using sodium permanganate. It is recognized that the alpha manganese useful in the present invention can contain one or more of hollandite, cryptomelane, manjiroite or coronadite compounds. Even when making cryptomelane minor amounts of other metal ions such as sodium may be present. Useful methods to form the alpha manganese dioxide are described in the above references which are incorporated by reference.

The preferred alpha manganese for use in accordance with the present invention is cryptomelane. The preferred cryptomelane is "clean" or substantially free of inorganic anions, particularly on the surface. Such anions could include chlorides, sulfates and nitrates which are introduced during the method to form cryptomelane. An alternate method to make the clean cryptomelane is to react a manganese carboxylate, preferably manganese acetate, with potassium permanganate. It has been found that the use of such a material which has been calcined is "clean". The use of material containing inorganic anions can result in conversion of ozone to oxygen of up to about 60%. The use of cryptomelane with a "clean" surface results in conversions of up about 80%.

It is believed that the carboxylates are burned off during the calcination process. However, inorganic anions remain on the surface even during calcination. The inorganic anions such as sulfates can be washed away with an aqueous solution or a slightly acidic aqueous solution. Preferably the alpha manganese dioxide is a "clean" alpha manganese dioxide. The cryptomelane can be washed at from about 60.degree. C. to 100.degree. C. for about one-half hour to remove a significant amount of sulfate anions. The washing also lowers the level of potassium present. The nitrate anions may be removed in a similar manner. The "clean" alpha manganese dioxide is characterized as having an IR spectrum as illustrated in FIG. 19 and in X-ray diffraction (XRD) pattern as illustrated in FIG. 20. Such a cryptomelane preferably has a surface area greater than 200 m.sup.2 /g and more preferably greater than 250 m.sup.2 /g. A review of the IR spectrum for the most preferred cryptomelane, shown in FIG. 19 is characterized by the absence of peaks assignable to carbonate, sulfate and nitrate groups. Expected peaks for carbonate groups appear in the range of from 1320 to 1520 wavenumbers; and for sulfate groups appear in the range of from 950 to 1250 wavenumbers. FIG. 20 is a powder X-ray diffraction pattern for high surface area cryptomelane prepared in Example 23. The X-ray pattern for cryptomelane useful in the present invention is characterized by broad peaks resulting from small crystallite size (.about.5-10 nm). Approximate peak positions (.+-.0.15.degree.2.theta.) and approximate relative intensities (.+-.5) for cryptomelane using CuK.sub..alpha. radiation as shown in FIG. 20 are: 2.theta./Relative Intensities--12.1/9; 18/9; 28.3/10; 37.5/100; 41.8/32; 49.7/16; 53.8/5; 60.1/13; 55.7/38; and 68.0/23.

A preferred method of making cryptomelane useful in the present invention comprises mixing an aqueous acidic manganese salt solution with a potassium permanganate solution. The acidic manganese salt solution preferably has a pH of from 0.5 to 3.0 and can be made acidic using any common acid, preferably acetic acid at a concentration of from 0.5 to 5.0 normal and more preferably from 1.0 to 2.0 normal. The mixture forms a slurry which is stirred at a temperature range of from 50.degree. C. to 110.degree. C. The slurry is filtered and the filtrate is dried at a temperature range of from 75.degree. C. to 200.degree. C. The resulting cryptomelane crystals have a surface area of typically in the range of from 200 m.sup.2 /g to 350 m.sup.2 /g.

Another useful composition comprising manganese dioxide is a composition comprising manganese dioxide and minor amounts of silica, typically up to 2%, more typically up to 1% with preferred amounts being from 0.4 to 0.8% based on the weight of the manganese dioxide and the silica. The presence of silica in the preferred amounts has been found to effect the crystalline morphology of manganese dioxide, particularly the cryptomelane form of manganese dioxide. It is speculated that the presence of minor amounts of silica, particularly in the preferred range, may provide certain advantages to the composition of the present invention. The presence of silica is believed to make the composition more hydrophobic, particularly when used as a coating on a substrate such as a coating on a radiator. Secondly, it is believed that the presence of silica in coating compositions comprising manganese dioxide increases the pH to help the compatibility of the manganese dioxide with latex binders. A preferred and useful composition for use as a coating material comprises cryptomelane and silica. Such a material comprises cryptomelane having a surface area from 200 to 340 and preferably 220 to 250 m.sup.2 /g, a weight percent of potassium of from 1 to 3% less than 0.1% sulphur and a measured loss on ignition of 13 to 18% by weight primarily due to moisture. The pH of the composition is about 3. Surface area is measured by a BET nitrogen adsorption and desorption test. As the amount of sulphur is reduced, the pH typically increases slightly. Additionally, typically the pH increases with the amount of potassium present with preferred amounts of potassium being from 1.2 to 2.8 weight percent.

Other useful compositions comprise manganese dioxide and optionally copper oxide and alumina and at least one precious metal component such as a platinum group metal supported on the manganese dioxide and where present copper oxide and alumina. Useful compositions contain up to 100, from 40 to 80 and preferably 50 to 70 weight percent manganese dioxide and 10 to 60 and typically 30 to 50 percent copper oxide. Useful compositions include hopcalite which is about 60 percent manganese dioxide and about 40 percent copper oxide; and Carulite.RTM. 200 (sold by Carus Chemical Co.) which is reported to have 60 to 75 weight percent manganese dioxide, 11 to 14 percent copper oxide and 15 to 16 percent aluminum oxide. The surface area of Carulite.RTM. is reported to be about 180 m.sup.2 /g. Calcining at 450.degree. C. reduces the surface area of the Carulite.RTM. by about fifty percent (50%) without significantly affecting activity. It is preferred to calcine manganese compounds at from 300.degree. C. to 500.degree. C. and more preferably 350.degree. C. to 450.degree. C. Calcining at 550.degree. C. causes a great loss of surface area and ozone treatment activity. Calcining the Carulite.RTM. after ball milling with acetic acid and coating on a substrate can improve adhesion of the coating to a substrate.

Other compositions to treat ozone can comprise a manganese dioxide component and precious metal components such as platinum group metal components. While both components are catalytically active, the manganese dioxide can also support the precious metal component. The platinum group metal component preferably is a palladium and/or platinum component. The amount of platinum group metal compound preferably ranges from about 0.1 to about 10 weight percent (based on the weight of the platinum group metal) of the composition. Preferably, where platinum is present it is in amounts of from 0.1 to 5 weight percent, with useful and preferred amounts on pollutant treating catalyst volume, based on the volume of the supporting article, ranging from about 0.5 to about 70 g/ft.sup.3. The amount of palladium component preferably ranges from about 2 to about 10 weight percent of the composition, with useful and preferred amounts on pollutant treating catalyst volume ranging from about 10 to about 250 g/ft.sup.3.

Various useful and preferred pollutant treating catalyst compositions, especially those containing a catalytically active component such as a precious metal catalytic component, can comprise a suitable support material such as a refractory oxide support. The preferred refractory oxide can be selected from the group consisting of silica, alumina, titania, ceria, zirconia and chromia, and mixtures thereof. More preferably, the support is at least one activated, high surface area compound selected from the group consisting of alumina, silica, titania, silica-alumina, silica-zirconia, alumina silicates, alumina zirconia, alumina-chromia and alumina-ceria. The refractory oxide can be in suitable form including bulk particulate form typically having particle sizes ranging from about 0.1 to about 100 and preferably 1 to 10 .mu.m or in sol form also having a particle size ranging from about 1 to about 50 and preferably about 1 to about 10 nm. A preferred titania sol support comprises titania having a particle size ranging from about 1 to about 10, and typically from about 2 to 5 nm.

Also useful as a preferred support is a coprecipitate of a manganese oxide and zirconia. This composition can be made as recited in U.S. Pat. No. 5,283,041 incorporated herein by reference. Briefly, this coprecipitated support material preferably comprises in a ratio based on the weight of manganese and zirconium metals from 5:95 to 95:5; preferably 10:90 to 75:25; more preferably 10:90 to 50:50; and most preferably from 15:85 to 50:50. A useful and preferred embodiment comprises a Mn:Zr weight ratio of 20:80. U.S. Pat. No. 5,283,041 describes a preferred method to make a coprecipitate of a manganese oxide component and a zirconia component. As recited in U.S. Pat. No. 5,283,041 a zirconia oxide and manganese oxide material may be prepared by mixing aqueous solutions of suitable zirconium oxide precursors such as zirconium oxynitrate, zirconium acetate, zirconium oxychloride, or zirconium oxysulfate and a suitable manganese oxide precursor such as manganese nitrate, manganese acetate, manganese dichloride or manganese dibromide, adding a sufficient amount of a base such as ammonium hydroxide to obtain a pH of 8-9, filtering the resulting precipitate, washing with water, and drying at 450.degree.-500.degree. C.

A useful support for a catalyst to treat ozone is selected from a refractory oxide support, preferably alumina and silica-alumina with a more preferred support being a silica-alumina support comprising from about 1% to 10% by weight of silica and from 90% to 99% by weight of alumina.

Useful refractory oxide supports for a catalyst comprising a platinum group metal to treat carbon monoxide are selected from alumina, titania, silica-zirconia, and manganese-zirconia. Preferred supports for a catalyst composition to treat carbon monoxide is a zirconia-silica support as recited in U.S. Pat. No. 5,145,825, a manganese-zirconia support as recited in U.S. Pat. No. 5,283,041 and high surface area alumina. Most preferred for treatment of carbon monoxide is titania. Reduced catalysts having titania supports resulted in greater carbon monoxide conversion than corresponding non reduced catalysts.

The support for catalyst to treat hydrocarbons, such as low molecular weight hydrocarbons, particularly low molecular weight olefinic hydrocarbons having about from two up to about twenty carbons and typically two to about eight carbon atoms, as well as partially oxygenated hydrocarbons is preferably selected from refractory metal oxides including alumina and titania. As with catalysts to treat carbon monoxide reduced catalysts results in greater hydrocarbon conversion. Particularly preferred is a titania support which has been found useful since it results in a catalyst composition having enhanced ozone conversion as well as significant conversion of carbon monoxide and low molecular weight olefins. Also useful are high surface area, macroporous refractory oxides, preferably alumina and titania having a surface area of greater than 150 m.sup.2 /g and preferably ranging from about 150 to 350, preferably from 200 to 300, and more preferably from 225 to 275 m.sup.2 /g; a porosity of greater than 0.5 cc/g, typically ranging from 0.5 to 4.0 and preferably about from 1 to 2 cc/g measured based on mercury porosometry; and particle sizes range from 0.1 to 10 .mu.m. A useful material is Versal GL alumina having a surface area of about 260 m.sup.2 /g, a porosity of 1.4 to 1.5 cc/g and supplied by LaRoche Industries.

A preferred refractory support for platinum group metals, preferably platinum and/or palladium for use in treating carbon monoxide and/or hydrocarbons is titania dioxide. The titania can be used in bulk powder form or in the form of titania dioxide sol. Also useful is nano particle size (nanometer) titania. The catalyst composition can be prepared by adding a platinum group metal in a liquid media preferably in the form of a solution such as platinum nitrate with the titania sol, with the sol most preferred. The obtained slurry can then be coated onto a suitable substrate such as an atmosphere treating surface such as a radiator, metal monolith substrate or ceramic substrate. The preferred platinum group metal is a platinum compound. The platinum titania sol catalyst obtained from the above procedure has high activity for carbon monoxide and/or hydrocarbon oxidation at ambient operating temperature. Metal components other than platinum components which can be combined with the titania sol include gold, palladium, rhodium, silver components and mixtures thereof. A reduced platinum group component, preferably a platinum component on titanium catalyst which is indicated to be preferred for treating carbon monoxide, has also been found to be useful and preferred for treating hydrocarbons, particularly olefinic hydrocarbons.

A preferred titania sol support comprises titania having a particle size ranging from about 1 to about 10, and typically from about 2 to 5 nm.

A preferred bulk titania has a surface area of about from 25 to 120 m.sup.2 /g, and preferably from 50 to 100 m.sup.2 /g; and a particle size of about from 0.1 to 10 .mu.m. A specific and preferred bulk titania support has a surface area of 45-50 m.sup.2 /g, a particle size of about 1 .mu.m, and is sold by DeGussa as P-25. Useful nano particle size titanium comprises having a particle size ranging from about 5 to 100 and typically greater 10 to about 50 nm.

A preferred silica-zirconia support comprises from 1 to 10 percent silica and 90 to 99 percent zirconia. Preferred support particles have high surface area, e.g. from 100 to 500 square meters per gram (m.sup.2 /g) surface area, preferably from 150 to 450 m.sup.2 /g, more preferably from 200 to 400 m.sup.2 /g, to enhance dispersion of the catalytic metal component or components thereon. The preferred refractory metal oxide support also has a high porosity with pores of up to about 145 nm radius, e.g., from about 0.75 to 1.5 cubic centimeters per gram (cm.sup.3 /g), preferably from about 0.9 to 1.2 cm.sup.3 /g, and a pore size range of at least about 50% of the porosity being provided by pores of 5 to 100 nm in radius.

A useful ozone treating catalyst comprises at least one precious metal component, preferably a palladium component dispersed on a suitable support such as a refractory oxide support. The composition comprises from 0.1 to 20.0 weight percent, and preferably 0.5 to 15 weight percent of precious metal on the support, such as a refractory oxide support, based on the weight of the precious metal (metal and not oxide) and the support. Palladium is preferably used in amounts of from 2 to 15, more preferably 5 to and yet more preferably 8 to 12 weight percent. Platinum is preferably used at 0.1 to 10, more preferably 0.1 to 5.0, and yet more preferably 2 to 5 weight percent. Palladium is most preferred to catalyze the reaction of ozone to form oxygen. The support materials can be selected from the group recited above. In preferred embodiments, there can additionally be a bulk manganese component as recited above, or a manganese component dispersed on the same or different refractory oxide support as the precious metal, preferably palladium component. There can be up to 80, preferably up to 50, more preferably from 1 to 40 and yet more preferably 5 to 35 weight percent of a manganese component based on the weight of palladium and manganese metal in the pollutant treating composition. Stated another way, there is preferably about 2 to 30 and preferably 2 to 10 weight percent of a manganese component. The catalyst loading is from 20 to 250 grams and preferably about 50 to 250 grams of palladium per cubic foot (g/ft.sup.3) of catalyst volume. The catalyst volume is the total volume of the finished catalyst composition and therefore includes the total volume of air conditioner condenser or radiator including void spaces provided by the gas flow passages. Generally, the higher loading of palladium results in a greater ozone conversion, i.e., a greater percentage of ozone decomposition in the treated air stream.

Conversions of ozone to oxygen attained with a palladium/manganese catalyst on alumina support compositions at a temperature of about 40.degree. C. to 50.degree. C. have been about 50 mole percent where the ozone concentrations range from 0.1 to 0.4 ppm and the face velocity was about 10 miles per hour. Lower conversions were attained using a platinum on alumina catalyst.

Of particular interest is the use of a support comprising the above described coprecipitated product of a manganese oxide, and zirconia which is used to support a precious metal, preferably selected from platinum and palladium, and most preferably platinum. Platinum is of particular interest in that it has been found that platinum is particularly effective when used on this coprecipitated support. The amount of platinum can range from 0.1 to 6, preferably 0.5 to 4, more preferably 1 to 4, and most preferably 2 to 4 weight percent based on metallic platinum and the coprecipitated support. The use of platinum to treat ozone has been found to be particularly effective on this support. Additionally, as discussed below, this catalyst is useful to treat carbon monoxide. Preferably the precious metal is platinum and the catalyst is reduced.

Other useful catalysts to catalytically convert ozone to oxygen are described in U.S. Pat. Nos. 4,343,776 and 4,405,507, both hereby incorporated by reference. A useful and most preferred composition is disclosed in commonly assigned U.S. Ser. No. 08/202,397 filed Feb. 25, 1994, now U.S. Pat. No. 5,422,331 and entitled, "Light Weight, Low Pressure Drop Ozone Decomposition Catalyst for. Aircraft Applications" hereby incorporated by reference. Yet other compositions which can result in the conversion of ozone to oxygen comprises carbon, and palladium or platinum supported on carbon, manganese dioxide, Carulite.RTM., and/or hopcalite. Manganese supported on a refractory oxide such as recited above has also been found to be useful.

Carbon monoxide treating catalysts preferably comprise at least one precious metal component, preferably selected from platinum and/or palladium components with platinum components being most preferred. A combination of a platinum component and a palladium component results in improved CO conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. The composition comprises from 0.01 to 20 weight percent, and preferably 0.5 to 15 weight percent of the precious metal component on a suitable support such as refractory oxide support, with the amount of precious metal being based on the weight of precious metal (metal and not the metal component) and the support. Platinum is most preferred and is preferably used in amounts of from 0.01 to 10 weight percent and more preferably 0.1 to 5 weight percent, and most preferably 1.0 to 5.0 weight percent. Palladium is useful in amounts from 2 to 15, preferably 5 to 15 and yet more preferably 8 to 12 weight percent. The preferred support is titania, with titania sol most preferred as recited above. When loaded onto a monolithic structure such as a radiator or onto other atmosphere contacting surfaces the catalyst loading is preferably about 1 to 150, and more preferably 10 to 100 grams of platinum per cubic foot (g/ft.sup.3) of catalyst volume and/or 20 to 250 and preferably 50 to 250 grams of palladium per g/ft.sup.3 of catalyst volume. When platinum and palladium are used in combination, there is from about 25 to 100 g/ft.sup.3 of platinum and 50 to 250 g/ft 3of palladium. A preferred composition comprises about 50 to 90 g/ft.sup.3 of platinum and 100 to 225 g/ft.sup.3 of palladium. Preferred catalysts are reduced. Conversions of 5 to 80 mole percent of carbon monoxide to carbon dioxide were attained using coated core samples from automotive radiator having from 1 to 6 weight percent (based on metal) of platinum on titania compositions at temperatures from 25.degree. to 90.degree. C. where the carbon monoxide concentration was 15 to 25 parts per million and the space velocity was 300,000 to 500,000 reciprocal hours. Also, conversions of 5 to 65 mole percent of carbon monoxide to carbon dioxide were attained using 1.5 to 4.0 weight percent platinum on alumina support compositions at a temperature of about up to 95.degree. C. where the carbon monoxide concentration was about 15 parts per million and the space velocity was about 300,000 reciprocal hours. Lower conversions have been attained with palladium on a ceria support.

An alternate and preferred catalyst composition to treat carbon monoxide comprises a precious metal component supported on the above described coprecipitate of a manganese oxide and zirconia. The coprecipitate is formed as described above. The preferred ratios of manganese to zirconia are 5:95 to 95:5; 10:90 to 75:25; 10:90 to 50:50; and 15:85 to 25:75 with a preferred coprecipitate having a manganese oxides to zirconia of 20:80. The percent of platinum supported on the coprecipitate based on platinum metal ranges from 0.1 to 6, preferably 0.5 to 4, more preferably 1 to 4, and most preferably 2-4 weight percent. Preferably the catalyst is reduced. The catalyst can be reduced in powder form or after it has been coated onto a supporting substrate. Other useful compositions which can convert carbon monoxide to carbon dioxide include a platinum component supported on carbon or a support comprising manganese dioxide.

Catalysts to treat hydrocarbons, typically unsaturated hydrocarbons, more typically unsaturated mono-olefins having from two to about twenty carbon atoms and, in particular, from two to eight carbon atoms, and partially oxygenated hydrocarbons of the type referred to above, comprise at least one precious metal component, preferably selected from platinum and palladium with platinum being most preferred. A combination of a platinum component and a palladium component results in improved hydrocarbons conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. Useful catalyst compositions include those described for use to treat carbon monoxide. Composition to treat hydrocarbons comprise from 0.01 to 20 wt. % and preferably 0.5 to 15 wt. % of the precious metal component on a suitable support such as a refractory oxide support, with the amount of precious metal being based on the weight of the precious metal, (not the metal component) and the support. Platinum is the most preferred and is preferably used in amounts of from 0.01 to 10 wt. % and more preferably 0.1 to 5 wt. % and most preferably 1.0 to 5 wt. %. When loaded onto a monolithic structure such as a motor vehicle radiator or on to other atmospheric contacting surfaces, the catalyst loading is preferably about 1 to 150, and more preferably 10 to 100 grams of platinum per cubic foot (g/ft.sup.3) of catalyst volume. When platinum and palladium are used in combination, there is from about 25 to 100 g/ft.sup.3 of platinum and 50 to 250 g/ft.sup.3 of palladium. A preferred composition comprises about 50 to 90 g/ft.sup.3 of platinum and 100 to 225 g/ft.sup.3 of palladium. The preferred refractory oxide support is a metal oxide refractory which is preferably selected from ceria, silica, zirconia, alumina, titania and mixtures thereof with alumina and titania being most preferred. The preferred titania is characterized by as recited above with titania sol most preferred. The preferred catalyst is reduced. Testing on a coated automotive radiator resulted in conversions of a low molecular weight mono-olefin such as propylene to water and carbon dioxide with 1.5 to 4 wt. % of platinum on an alumina or titania support have been between 15 and 25% where the propylene concentration was about 10 parts per million propylene and the space velocity was about 320,000 reciprocal hours. These catalysts were not reduced. Reduction of the catalyst improves conversion.

Catalysts useful for the oxidation of both carbon monoxide and hydrocarbons generally include those recited above as useful to treat either carbon monoxide or hydrocarbons. Most preferred catalysts which have been found to have good activity for the treatment of both carbon monoxide and hydrocarbon such as unsaturated olefins comprise platinum component supported on a preferred titania support. The composition preferably comprises a binder and can be coated on a suitable support structure in amounts of from 0.8 to 1.0 g/in. A preferred platinum concentration ranges from 2 to 6% and preferably 3 to 5% by weight of platinum metal on the titania support. Useful and preferred substrate cell densities are equivalent to about 300 to 400 cells per square inch. The catalyst is preferably reduced as a powder or on the coated article using a suitable reducing agent. Preferably the catalyst is reduced in the gas stream comprising about 7% hydrogen with the balance nitrogen at from 200.degree. to 500.degree. C. or from 1 to 12 hours. The most preferred reduction or forming temperature is 400.degree. C. for 2-6 hours. This catalyst has been found to maintain high activity in air and humidified air at elevated temperatures of up to 100.degree. C. after prolonged exposure.

Useful catalysts which can treat both ozone and carbon monoxide comprise at least one precious metal component, most preferably a precious metal selected from palladium, platinum and mixtures thereof on a suitable support such as a refractory oxide support. A combination of a platinum component and a palladium component results in improved Co conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. Useful refractory oxide supports comprise ceria, zirconia, alumina, titania, silica and mixtures thereof including a mixture of zirconia and silica as recited above. Also useful and preferred as a support are the above described coprecipitates of manganese oxides and zirconia. The composition comprises from 0.1 to 20.0, preferably 0.5 to 15, and more preferably from 1 to 10 weight percent of the precious metal component on the support based on the weight of the precious metal and the support. Palladium is preferably used in amounts from 2 to and more preferably from 3 to 8 weight percent. Platinum is preferably used in amounts of from 0.1 to 6 percent and more preferably 2 to 5 weight percent. A preferred composition is a composition wherein the refractory component comprises ceria and the precious metal component comprises palladium. This composition has resulted in relatively high ozone and carbon monoxide conversions. More particularly, testing of this composition on a coated radiator has resulted in a 21% conversion of carbon monoxide in an air stream comprising 16 ppm of carbon monoxide contacting a surface at 95.degree. C. with a face velocity of the gas stream being 5 miles per hour. The same catalyst resulted in a 55% ozone conversion where the stream contained 0.25 ppm of ozone and the treating surface was at 25.degree. C. with an air stream face velocity of 10 miles per hour. Also preferred is a composition comprising a precious metal, preferably a platinum group metal, more preferably selected from platinum and palladium components, and most preferably a platinum component and the above recited coprecipitate of manganese oxide and zirconia. This above recited precious metal containing catalyst in the form of a catalyst powder or coating on a suitable substrate is in reduced form. Preferred reduction conditions include those recited above with the most preferred condition being from 250.degree. to 350.degree. C. for from 2 to 4 hours in a reducing gas comprising 7% hydrogen and 93% nitrogen. This catalyst has been found to be particularly useful in treating both carbon monoxide and ozone. Other useful compositions to convert ozone to oxygen and carbon monoxide to carbon dioxide comprise a platinum component supported on carbon, manganese dioxide, or a refractory oxide support, and optionally having an additional manganese component.

A useful and preferred catalyst which can treat ozone, carbon monoxide and hydrocarbons, as well as partially oxygenated hydrocarbons, comprises a precious metal component, preferably a platinum component on a suitable support such as a refractory oxide support. A combination of a platinum component and a palladium component results in improved Co conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. Useful refractory oxide supports comprise ceria, zirconia, alumina, titania, silica and mixtures thereof including a mixture of zirconia and silica as recited above. Also useful is a support including the above-recited coprecipitate of manganese oxide and zirconia. The composition comprises from 0.1 to 20, preferably 0.5 to 15 and more preferably 1 to 10 wt. % of the precious metal component on the refractory support based on the weight of the precious metal and the support. Where the hydrocarbon component is sought to be converted to carbon dioxide and water, platinum is the most preferred catalyst and is preferably used in amounts of from 0.1 to 5% and more preferably 2 to 5% by weight.

In specific embodiments, there can be a combination of catalysts including the above recited catalyst as well as a catalyst which is particularly preferred for the treatment of ozone such as a catalyst comprising a manganese component. The manganese component can be optionally combined with a platinum component. The manganese and platinum can be on the same or different supports. There can be up to 80, preferably up to 50, more preferably from 1 to 40 and yet more preferably from 10 to 35 wt. % of the manganese component based on the weight of the precious metal and manganese in the pollutant treating composition. The catalyst loading is the same at that recited above with regard to the ozone catalyst. A preferred composition is a composition wherein the refractory component comprises an alumina or titania support and the precious metal component comprises a platinum component. Testing of such a composition coated onto a radiator has resulted in 68 to 72% conversion of carbon monoxide, 8 to 15% conversion of ozone and 17 to 18% conversion of propylene when contacting a surface at 95.degree. C. with a face velocity of the gas stream being about ten miles per hour (hourly space velocity of 320,000 per reciprocal hours) with air dew point at 35.degree. F. Generally, as the contacting surface temperature decreases and the space velocity or face velocity of the atmosphere air flow over the pollutant contacting surface increases, the percent conversion decreases.

Catalyst activity, particularly to treat carbon monoxide and hydrocarbons can be further enhanced by reducing the catalyst in a forming gas such as hydrogen, carbon monoxide, methane or hydrocarbon plus nitrogen gas. Alternatively, the reducing agent can be in the form of a liquid such as a hydrazine, formic acid, and formate salts such as sodium formate solution. The catalyst can be reduced as a powder or after coating onto a substrate. The reduction can be conducted in gas at from 150.sup.0-500.degree. C., preferably 200.sup.0-400.degree. C. for 1 to 12 hours, preferably 2 to 8 hours. In a preferred process, coated article or powder can be reduced in a gas comprising 7% hydrogen in nitrogen at 275.degree.-350.degree. C. for 2 to 4 hours.

An alternate composition for use in the method and apparatus of the present invention comprises a catalytically active material selected from the group consisting of precious metal components including platinum group metal components, gold components and silver components and a metal component selected from the group consisting of tungsten components and rhenium components. The relative amounts of catalytically active material to the tungsten component and /or rhenium component based on the weight of the metal are from 1 to 25, to 15 to 1.

The composition containing a tungsten component and/or a rhenium component preferably comprises tungsten and/or rhenium in the oxide form. The oxide can be obtained by forming the composition using tungsten or rhenium salts and the composition can subsequently be calcined to form tungsten and/or rhenium oxide. The composition can comprise further components such as supports including refractory oxide supports, manganese components, carbon, and coprecipitates of a manganese oxide and zirconia. Useful refractory metal oxides include alumina, silica, titania, ceria, zirconia, chromia and mixtures thereof. The composition can additionally comprise a binder material, such as metal sols including alumina or titania sols or polymeric binder which can be provided in the form of a polymeric latex binder.

In preferred compositions, there are from 0.5 to 15, preferably 1 to 10, and most preferably from 3 to 5 percent by weight of the catalytically active material. The preferred catalytically active materials are platinum group metals with platinum and palladium being more preferred and platinum being most preferred. The amount of tungsten and/or rhenium component based on the metals ranges 1 to 25, preferably 2 to 15 and most preferably 3 to 10 weight percent. The amount of binder can vary from 0 to 20 weight percent, preferably 0.5 to 20, more preferably 2 to 10 and most preferably 2 to 5 weight percent. Depending on the support material a binder is not necessary in this composition. Preferred compositions comprise from 60 to 98.5 weight percent of a refractory oxide support, from 0.5 to 15 weight percent of the catalytically active material, from 1 to 25 weight of the tungsten and/or rhenium component, and from 0 to 10 weight percent binder.

Compositions containing the tungsten component and rhenium component can be calcined under conditions as recited above. Additionally, the composition can be reduced. However, as shown in the examples below, the compositions need not be reduced and the presence of the tungsten and/or rhenium component can result in conversions of carbon monoxide and hydrocarbons comparable to compositions containing platinum group metals which have been reduced.

The pollutant treating compositions of the present invention preferably comprise a binder which acts to adhere the composition and to provide adhesion to the atmosphere contacting surface. It has been found that a preferred binder is a polymeric binder used in amounts of from 0.5 to 20, more preferably 2 to 10, and most preferably to 2 to 5 percent by weight of binder based on the weight of the composition. Preferably, the binder is a polymeric binder which can be a thermosetting or thermoplastic polymeric binder. The polymeric binder can have suitable stabilizers and age resistors known in the polymeric art. The polymer can be a plastic or elastomeric polymer. Most preferred are thermosetting, elastomeric polymers introduced as a latex into the catalyst into a slurry of the catalyst composition, preferably an aqueous slurry. Upon application of the composition and heating the binder material can crosslink providing a suitable support which enhances the integrity of the coating, its adhesion to the atmosphere contacting surface and provides structural stability under vibrations encountered in motor vehicles. The use of preferred polymeric binder enables the pollutant treating composition to adhere to the atmosphere contacting surface without the necessity of an undercoat layer. The binder can comprise water resistant additives to improve water resistance and improve adhesion. Such additives can include fluorocarbon emulsions and petroleum wax emulsions.

Useful polymeric compositions include polyethylene, polypropylene, polyolefin copolymers, polyisoprene, polybutadiene, polybutadiene copolymers, chlorinated rubber, nitrile rubber, polychloroprene, ethylene-propylene-diene elastomers, polystyrene, polyacrylate, polymethacrylate, polyacrylonitrile, poly(vinyl esters), poly(vinyl halides), polyamides, cellulosic polymers, polyimides, acrylics, vinyl acrylics and styrene acrylics, poly vinyl alcohol, thermoplastic polyesters, thermosetting polyesters, poly(phenylene oxide), poly(phenylene sulfide), fluorinated polymers such as poly(tetrafluoroethylene) polyvinylidene fluoride, poly(vinylfluoride) and chloro/fluoro copolymers such as ethylene chlorotrifluoroethylene copolymer, polyamide, phenolic resins and epoxy resins, polyurethane, and silicone polymers. A most preferred polymeric material is an acrylic polymeric latex as described in the accompanying examples.

Particularly preferred polymers and copolymers are vinyl acrylic polymers and ethylene vinyl acetate copolymers. A preferred vinyl acrylic polymer is a cross linking polymer sold by National Starch and Chemical Company as Xlink 2833. It is described as a vinyl acrylic polymer having a Tg of -15.degree. C., 45% solids, a pH of 4.5 and a viscosity of 300 cps. In particular, it is indicated to have vinyl acetate CAS No. 108-05-4 in a concentration range of less than 0.5 percent. It is indicated to be a vinyl acetate copolymer. Other preferred vinyl acetate copolymers which are sold by the National Starch and Chemical Company include Dur-O-Set E-623 and Dur-O-Set E-646. Dur-O-Set E-623 is indicated to be ethylene vinyl acetate copolymers having a Tg of 0.degree. C., 52% solids, a pH of 5.5 and a viscosity of 200 cps. Dur-O-Set E-646 is indicated to be an ethylene vinyl acetate copolymer with a Tg of -12.degree. C., 52% solids, a pH of 5.5 and a viscosity of 300 cps. A useful and preferred binder is a crosslinking acrylic copolymer sold by National Starch and Chemical Company as X-4280. It is described as a milk white aqueous emulsion having a pH of 2.6; a boiling point of 212.degree. F., a freezing point of 32.degree. F.; a specific gravity of 1.060; a viscosity of 100 cps.

An alternate and useful binding material is the use of a zirconium compound. Zirconyl acetate is preferred zirconium compound used. It is believed that zirconia acts as a high temperature stabilizer, promotes catalytic activity, and improves catalyst adhesion. Upon calcination, zirconium compounds such as zirconyl acetate are converted to ZrO.sub.2 which is believed to be the binding material. Various useful zirconium compounds include acetates, hydroxides, nitrates, etc. for generating ZrO.sub.2 in catalysts. In the case of using zirconyl acetate as a binder for the present catalysts, ZrO.sub.2 will not be formed unless the radiator coating is calcined. Since good adhesion has been attained at a "calcination" temperature of only 120.degree. C., it is believed that the zirconyl acetate has not decomposed to zirconium oxide but instead has formed a cross linked network with the pollutant treating material such as Carulite.RTM. particles and the acetates which were formed from ball milling with acetic acid. Accordingly, the use of any zirconium containing compounds in the present catalysts are not restricted only to zirconia. Additionally, the zirconium compounds can be used with other binders such as the polymeric binder recited above.

An alternate pollutant treating catalyst composition can comprise activated carbon composition. The carbon composition comprises activated carbon, a binder, such as a polymeric binder, and optionally conventional additives such as defoamers and the like. A useful activated carbon composition comprises from 75 to 85 weight percent activated carbon such as "coconut shell" carbon or carbon from wood and a binder such as an acrylic binder with a defoamer. Useful slurries comprise from 10 to 50 weight percent solids. The activated carbon can catalyze reduction of ozone to oxygen, as well as adsorb other pollutants.

Pollutant treating catalyst compositions of the present invention can be prepared in any suitable process. A preferred process is disclosed in U.S. Pat. No. 4,134,860 herein incorporated by reference. In accordance with this method, the refractory oxide support such as activated alumina, titania or activated silica alumina is jet milled, impregnated with a catalytic metal salt, preferably precious metal salt solution and calcined at a suitable temperature, typically from about 300.degree. C. to about 600.degree. C., preferably from about 350.degree. C. to about 550.degree. C., and more preferably from about 400.degree. C. to about 500.degree. C. for from about 0.5 to about 12 hours. Palladium salts are preferably a palladium nitrate or a palladium amine such as palladium tetraamine acetate, or palladium tetraamine hydroxide. Platinum salts preferably include platinum hydroxide solubilized in an amine. In specific and preferred embodiments the calcined catalyst is reduced as recited above.

In an ozone treating composition, a manganese salt, such as manganese nitrate, can then be mixed with the dried and calcined alumina supported palladium in the presence of deionized water. The amount of water added should be an amount up to the point of incipient wetness. Reference is made to the method reviewed in the above referenced and incorporated U.S. Pat. No. 4,134,860. The point of incipient wetness is the point at which the amount of liquid added is the lowest concentration at which the powdered mixture is sufficiently dry so as to absorb essentially all of the liquid. In this way a soluble manganese salt such as Mn(NO.sub.3).sub.2 in water can be added into the calcined supported catalytic precious metal. The mixture is then dried and calcined at a suitable temperature, preferably 400 to 500.degree. C. for about 0.5 to about 12 hours.

Alternatively, the supported catalytic powder (i.e., palladium supported on alumina) can be combined with a liquid, preferably water, to form a slurry to which a solution of a manganese salt, such as Mn(NO.sub.3).sub.2 is added. Preferably, the manganese component and palladium supported on a refractory support such as activated alumina, more preferably activated silica-alumina is mixed with a suitable amount of water to result in a slurry having from 15 to 40% and preferable 20 to 35 weight percent solids. The combined mixture can be coated onto a carrier such as a radiator and the radiator dried in air at suitable conditions such as 50.degree. C. to 150.degree. C. for 1 to 12 hours. The substrate which supports the coating can then be heated in an oven at suitable conditions typically from 300.degree. C. to 550.degree. C., preferably 350.degree. C. to 500.degree. C., more preferably 350.degree. C. to 450.degree. C. and most preferably from 400.degree. C. and 500.degree. C. in an oxygen containing atmosphere, preferably air for about 0.5 to about 12 hours to calcine the components and help to secure the coating to the substrate atmosphere contacting surface. Where the composition further comprises a precious metal component, it is preferably reduced after calcining.

A method of the present invention includes forming a mixture comprising a catalytically active material selected from at least one platinum group metal component, a gold component, a silver component, a manganese component and mixtures thereof and water. The catalytically active material can be on a suitable support, preferably a refractory oxide support. The mixture can be milled, and then optionally be calcined and reduced when using precious metal catalytic material. The calcining step can be conducted prior to milling and adding the polymeric binder. It is also preferred to reduce the catalytically active material prior to milling, calcining and adding the polymeric binder. The slurry comprises a carboxylic acid compound or polymer containing carboxylic acid groups or derivatives thereof in an amount to result in a pH of about from 3 to 7, typically 3 to 6. Preferably the acid comprises from 0.5 to 15 weight percent of glacial acetic acid based on the weight of the catalytically active material and acetic acid. The amount of water can be added as suited to attain a slurry of the desired solids concentration and/or viscosity. The percent solids are typically 20 to 50 and preferably 30 to 40 percent by weight. The preferred vehicle is deionized water (D.I.). The acetic acid can be added upon forming the mixture of the catalytically active material, which may have been calcined, with water. Alternatively, the acetic acid can be added with the polymeric binder. A preferred composition to treat ozone using manganese dioxide as the catalyst can be made using about 1,500 g of manganese dioxide which is mixed with 2,250 g of deionized water and 75 g of acetic acid. The mixture is combined in a 1 gallon ballmill and ballmilled for about 4 hours until approximately 90% of the particles are less than 8 micrometers. The ballmill is drained and 150 g of polymeric binder is added. The mixture is then blended on a rollmill for 30 minutes. The resulting mixture is ready for coating onto a suitable substrate such as an automobile radiator according to the methods described below.

It has been found that compatibility of the components of a slurry comprising a catalytic material and a polymeric binder, such as a latex emulsion, is desirable to maintain slurry stability and uniformity. For the purpose of the present invention compatibility means that the binder and the catalytic material remain as a mixture of separate particles in the slurry. It is believed that where the polymeric binder is a latex emulsion and the catalytic material have electrical charges which cause them to repel each other, they are compatible and the slurry is stable and has a uniform distribution of the catalytic material and the polymer latex in the liquid vehicle, e.g. aqueous fluid such as water. If the catalytic material and latex emulsion particles do not mutually repel each other, irreversible agglomeration of the latex on the catalytic material will occur. These materials are therefore incompatible and the latex comes out of the emulsion.

Compatibility of a high surface area catalyst with the organic latex binder is a key property in preparing a stable, uniform slurry. If the catalyst and latex emulsion particles do not mutually repel each other, irreversible agglomeration will occur. The result of this will be an unstable, non-uniform slurry which will produce a poorly adherent coating. Although the mutual repulsion of the catalyst and binder particles is controlled by a variety physical factors, surface charge plays a key role. Since latex emulsion particles are typically negatively charged, catalyst particles must be similarly charged. Zeta potential measurements have shown, however, that catalyst particles, such as MnO.sub.2 are only slightly negatively or even positively charged, and as a result, irreversible coagulation of the catalyst and latex occurs (i.e. catalyst and latex are not compatible). It has been found that although the above described method of adding acetic acid provides certain advantages to the slurries of the present invention, such as viscosity control, it does not enhance compatibility and may even be detrimental to aged slurry stability.

Where the catalytically material is positively or slightly negatively charged, improved compatibility can be achieved by making the slurry more basic. The pH of the slurry can be controlled depending on the acidity of the catalytic material, with preferred pH levels being at least 6, preferably at least 7, more preferably at least 8.5. Generally, the slurry should not be too caustic and a preferred upper limit is about 11. A preferred range is from 8.5 to 11.

Maintaining a pH.gtoreq.8.5 of a slurry comprising a latex emulsion and MnO.sub.2 (cryptomelane) is critical. If the pH drops below 8.5 for an extended period of time (days), the binder and catalyst will irreversibly coagulate. Despite the large negative charge on the cryptomelane particles at this pH, long term stability of cryptomelane containing slurries has been difficult to achieve. Preferred binders are poly(acrylic) acid derivative based binders with a particularly preferred binder which has long term stability under these conditions being an acrylic latex sold by National Starch as x-4280 acrylic latex. The difficulty in achieving long term compatibility even with basic slurries containing negatively charged latex and catalyst particles indicates that although surface charge is important, it is not the only factor in determining binder/catalyst compatibility. Other factors which play a role include emulsion particle size, surfactant package, etc. The present method involves raising the pH of the ball milled catalyst slurry to pH.gtoreq.8.5 and preferably 9 to enhance stability.

An alternative method to enhance slurry stability involves adding a surfactant such as a polymeric dispersant to the slurry instead of or in addition to increasing the pH. In the second case, binder/catalyst compatibility is achieved by adding a polymeric acrylate derived dispersant (ca. 3% solids basis) instead of increasing the pH. The result is the same, however, in that the catalyst particle is given a large negative charge which can repel the like charged latex particles. The dispersant can be added during the ball milling operation or after. Despite generating a large negative charge on the catalyst particles, not all dispersants work equally as well. Preferred dispersants comprise polymers containing carboxylic acid groups or derivatives thereof such as esters and salts. Preferred dispersants include Accusol 445 (from Rohm & Haas) and Colloid 226/35 (from Rhone-Poulenc). Useful dispersants and a review of dispersion technology are presented in, Additives for Dispersion Technology, published by Rhone-Poulenc, Surfactants & Specialties hereby incorporated by reference. Useful polymeric dispersants include but are not limited to polyacrylic acid partial sodium salts and anionic copolymer sodium salts sold by Rhone-Poulenc as Colloid.TM. polymeric dispersants. Again, although surface charge is an important factor in determining catalyst/binder compatibility, it is not the only factor. In general, the dispersant (particularly Colloid 226) does a good job of stabilizing the slurry since a greater variety of latex binders (e.g. acrylics, styrene acrylics, and EVA's) are compatible. Long term compatibility problems may be addressed by increasing the quantity of dispersant, raising the pH somewhat, or both.

The above recited methods enhance compatibility and result in a stable catalyst slurry. Both methods generate a large negative surface charge on the catalyst particle which in turn stabilizes the catalyst in the presence of the like charged (anionic) latex emulsion particles. For both systems, good adhesion has been observed(i.e. catalyst cannot be wiped off the face of a coated monolith) with a 10% by weight loading (solids basis) of the polymeric binder. At 5%, adhesion is not as good, so the optimum loading is probably somewhere in between.

While these methods have been shown to enhance compatability of MnO.sub.2 /latex slurries, the present invention is not limited to systems using negatively charged latex emulsions. Those skilled in the art will understand that slurry compatability can likewise be achieved using cationic latex emulsions, using cationic surfactant and/or dispersant packages to stabilize the catalyst particles.

The polymeric slurries of the present, particularly polymer latex slurries, can contain conventional additives such as thickeners, biocides, antioxidants and the like.

The pollutant treating composition can be applied to the atmosphere contacting vehicle surface by any suitable means such as spray coating, powder coating, or brushing or dipping the surface into a catalyst slurry.

The atmosphere contacting surface is preferably cleaned to remove surface dirt, particularly oils which could result in poor adhesion of the pollutant treating composition to the surface. Where possible, it is preferred to heat the substrate on which the surface is located to a high enough temperature to volatilize or burn off surface debris and oils.

Where the substrate on which there is an atmosphere contacting surface is made of a material which can withstand elevated temperatures such as an aluminum radiator, the substrate surface can be treated in such a manner as to improve adhesion to the catalyst composition, preferably the ozone carbon monoxide, and/or hydrocarbon catalyst composition. One method is to heat the aluminum substrate such as the radiator to a sufficient temperature in air for a sufficient time to form a thin layer of aluminum oxide on the surface. This helps clean the surface by removing oils which may be detrimental to adhesion. Additionally, if the surface is aluminum a sufficient layer of oxidized aluminum has been found to be able to be formed by heating the radiator in air for from 0.5 to 24 hours, preferably from 8 to 24 hours and more preferably from 12 to hours at from 350.degree. C. to 500.degree. C., preferably from 400 to 500.degree. C. and more preferably 425 to 475.degree. C. In some cases, sufficient adhesion without the use of an undercoat layer has been attained where an aluminum radiator has been heated at 450.degree. C. for 16 hours in air. This method is particularly useful when applying the coating to new surfaces such as radiators or air conditioner condensers prior to assembly in a motor vehicle either as original equipment or replacement.

Adhesion may improve by applying an undercoat or precoat to the substrate. Useful undercoats or precoats include refractory oxide supports of the type discussed above, with alumina preferred. A preferred undercoat to increase adhesion between the atmosphere contacting surface and an overcoat of an ozone catalyst composition is described in commonly assigned U.S. Pat. No. 5,422,331 herein incorporated herein by reference. The undercoat layer is disclosed as comprising a mixture of fine particulate refractory metal oxide and a sol selected from silica, alumina, zirconia and titania sols. In accordance with the method of the present invention, surfaces on existing vehicles can be coated while the substrate such as the radiator, radiator fan or air conditioner condenser is located on the vehicle. The catalyst composition can be applied directly to the surface. Where additional adhesion is desired, an undercoat can be used as recited above.

Where it is practical to separate the radiator from the vehicle, a support material such as activated alumina, silica-alumina, bulk titania, titanium sol, silica zirconia, manganese zirconia and others as recited can be formed into a slurry and coated on the substrate preferably with a silica sol to improve adhesion. The precoated substrate can subsequently be coated with soluble precious metal salts such as the platinum and/or palladium salts, and optionally manganese nitrate. The coated substrate can then be heated in an oven in air for sufficient time (0.5 to 12 hours at 350.degree. C. to 550.degree. C.) to calcine the palladium and manganese components to form the oxides thereof.

The present invention can comprise adsorption compositions supported on the atmosphere contacting surface. The adsorption compositions can be used to adsorb gaseous pollutants such as hydrocarbons and sulfur dioxide as well as particulate matter such as particulate hydrocarbon, soot, pollen, bacteria and germs. Useful supported compositions can include adsorbents such as zeolite to adsorb hydrocarbons. Useful zeolitic compositions are described in Publication No. WO 94/27709 published Dec. 8, 1994 and entitled Nitrous Oxide Decomposition Catalyst hereby incorporated by reference. Particularly preferred zeolites are Beta zeolite, and dealuminated Zeolite Y.

Carbon, preferably activated carbon, can be formed into carbon adsorption compositions comprising activated carbon and binders such as polymers as known in the art. The carbon adsorption composition can be applied to the atmosphere contacting surface. Activated carbon can adsorb hydrocarbons, volatile organic components, bacteria, pollen and the like. Yet another adsorption composition can include components which can adsorb SO.sub.3. A particularly useful SO.sub.3 adsorbent is calcium oxide. The calcium oxide is converted to calcium sulfate. The calcium oxide adsorbent compositions can also contain a vanadium or platinum catalyst which can be used to convert sulfur dioxide to sulfur trioxide which can then be adsorbed onto the calcium oxide to form calcium sulfate.

In addition to treatment of atmospheric air containing pollutants at ambient condition or ambient operating conditions, the present invention contemplates the catalytic oxidation and/or reduction of hydrocarbons, nitrogen oxides and residual carbon monoxide using conventional three way catalysts supported on electrically heated catalysts such as are known in the art. The electrically heated catalysts can be located on electrically heated catalyst monolith 56 illustrated in FIG. 1. Such electrically heated catalyst substrates are known in the art and are disclosed in references such as U.S. Pat. Nos. 5,308,591 and 5,317,869 hereby incorporated by reference. For the purposes of the present invention, the electrically heated catalyst is a metal honeycomb having a suitable thickness to fit in the flow direction, preferably of from 1/8 inch to 12 inches, and more preferably 0.5 to 3 inches. Where the electrically heated catalyst must fit into a narrow space, it can be from 0.25 to 1.5 inches thick. Preferred supports are monolithic carriers of the type having a plurality of fine, parallel gas flow passages extending therethrough from an inlet face to an outlet face of the carrier so that the passages are open to air flow entering from the front 26 and passing through the monolith 56 in the direction toward the fan 20. Preferably the passages are essentially straight from their inlet to their outlet and are defined by walls in which the catalytic material is coated as a wash coat so that the gases flowing through the passages contact the catalytic material. The flow passages of the monolithic carrier are thin wall channels which can be of any suitable cross-sectional shape and size such as trapezoidal, rectangular, square, sinusoidal, hexagonal, oval, circular or formed from metallic components which are corrugated and flat as are known in the art. Such structures may contain from about 60 to 600 or more gas inlet openings ("cells") per square inch of cross section. The monolith may be made of any suitable material and is preferably capable of being heated upon application of an electric current. A useful catalyst to apply is the three way catalyst (TWC) as recited above which can enhance the oxidation of hydrocarbons and carbon monoxide as well as the reduction of nitrogen oxides. Useful TWC catalysts are recited in U.S. Pat. Nos. 4,714,694; 4,738,947; 5,010,051; 5,057,483; and 5,139,992.

The present invention is illustrated further by the following examples which are not intended to limit the scope of this invention.

EXAMPLES

Example 1

A 1993 Nissan Altima radiator core (Nissan part number 21460-1E400) was heat treated in air to 450.degree. C. for 16 hours to clean and oxidize the surface and then a portion coated with high surface area silica-alumina undercoat (dry loading=0.23 g/in.sup.3) by pouring a water slurry containing the silica-alumina through the radiator channels, blowing out the excess with an air gun, drying at room temperature with a fan, and then calcining to 450.degree. C. The silica-alumina slurry was prepared by ball milling high surface area calcined SRS-II alumina (Davison) with acetic acid (0.5% based on alumina) and water (total solids ca. 20%) to a particle size of 90% <4 .mu.m. The ball milled material was then blended with Nalco silica sol (#91SJ06S--28% solids) in a ratio of 25%/75%. The SRS-II alumina is specified to have a structure of xSiO.sub.2.yAl.sub.2 O.sub.3.zH.sub.2 O with 92-95% by weight Al.sub.2 O.sub.3 and 4-7% by weight SiO.sub.2 after activation. BET surface area is specified to be a minimum of 260 m.sup.2 /g after calcination.

A Pd/Mn/Al.sub.2 O.sub.3 catalyst slurry (nominally 10% by weight palladium on alumina) was prepared by impregnating high surface area SRS-II alumina (Davison) to the point of incipient wetness with a water solution containing sufficient palladium tetraamine acetate. The resulting powder was dried and then calcined for 1 hour at 450.degree. C. The powder was subsequently mixed under high shear with a water solution of manganese nitrate (amount equivalent to 5.5% by weight MnO.sub.2 on the alumina powder) and sufficient dilution water to yield a slurry of 32-34% solids. The radiator was coated with the slurry, dried in air using a fan, and then calcined in air at 450.degree. C. for 16 hours. This ozone destruction catalyst contained palladium (dry loading=263 g/ft.sup.3 of radiator volume) and manganese dioxide (dry loading=142 g/ft.sup.3) on high surface area SRS-II alumina. The partially coated radiator reassembled with the coolant tanks, also referred to as headers is shown in FIG. 8.

Ozone destruction performance of the coated catalyst was determined by blowing an air stream containing a given concentration of ozone through the radiator channels at face velocities typical of driving speeds and then measuring the concentration of ozone exiting the back face of the radiator. The air used was at about 20.degree. C. and had a dew point of about 35.degree. F. Coolant fluid was circulated through the radiator at a temperature of about 50.degree. C. Ozone concentrations ranged from 0.1-0.4 ppm. Ozone conversion was measured at linear air velocities (face velocities) equivalent to 12.5 miles per hour to be 43%; at 25 mph to be 33%; at 37.5 mph to be 30% and at 49 mph to be 24%.

Example 2 (Comparative)

A portion of the same radiator used in Example 1 which was not coated with catalyst was similarly evaluated for ozone destruction performance (i.e. control experiment). No conversion of ozone was observed.

Example 3

After heat treatment for 60 hours in air at 450.degree. C., a Lincoln Town Car radiator core (part #F1VY-8005-A) was coated sequentially in 6".times.6" square patches with a variety of different ozone destruction catalyst compositions (i.e., different catalysts; catalyst loadings, binder formulations, and heat treatments). Several of the radiator patches were precoated with a high surface area alumina or silica-alumina and calcined to 450.degree. C. prior to coating with the catalyst. The actual coating was accomplished similarly to Example 1 by pouring a water slurry containing the specific catalyst formulation through the radiator channels, blowing out the excess with an air gun, and drying at room temperature with a fan. The radiator core was then dried to 120.degree. C., or dried to 120.degree. C. and then calcined to 400 to 450.degree. C. The radiator core was then reattached to its plastic tanks and ozone destruction performance of the various catalysts was determined at a radiator surface temperature of about 40.degree. C. to 50.degree. C. and a face velocity of 10 mph as described in Example 1.

Table I summarizes the variety of catalysts coated onto the radiator. Details of the catalyst slurry preparations are given below.

A Pt/Al.sub.2 O.sub.3 catalyst (nominally 2% by weight Pt on Al.sub.2 O.sub.3) was prepared by impregnating 114 g of a platinum salt solution derived from H.sub.2 Pt(OH).sub.6 solubilized in an amine, (17.9% Pt), dissolved in 520 g of water to 1000 g of Condea SBA-150 high surface area (specified to be about 150 m.sup.2 /g) alumina powder. Subsequently 49.5 g of acetic acid was added. The powder was then dried at 110.degree. C. for 1 hour and calcined at 550.degree. C. for 2 hours. A catalyst slurry was then prepared by adding 875 g of the powder to 1069 g of water and 44.6 g of acetic acid in a ball mill and milling the mixture to a particle size 90%<10 .mu.m. (Patches 1 and 4)

A carbon catalyst slurry was a formulation (29% solids) purchased from Grant Industries, Inc., Elmwood Park, N.J. The carbon is derived from coconut shell. There is an acrylic binder and a defoamer. (Patches 8 and 12)

The Carulite.RTM. 200 catalyst (CuO/MnO.sub.2) was prepared by first ball milling 1000 g of Carulite.RTM. 200 (purchased from Carus Chemical Co., Chicago, Ill.) with 1500 g of water to a particle size 90%<6 .mu.m. Carulite.RTM. 200 is specified as containing 60 to 75 weight percent MnO.sub.2, 11-14 percent CuO and 15-16 percent Al.sub.2 O.sub.3. The resulting slurry was diluted to ca. 28% solids and then mixed with either 3% (solids basis) of Nalco #1056 silica sol or 2% (solids basis) National Starch #x4260 acrylic copolymer. (Patches 5, 9 and 10)

The Pd/Mn/Al.sub.2 O.sub.3 catalyst slurry (nominally 10% by weight palladium on alumina) was prepared as described in Example 1. (Patches 2, 3 and 6)

An I.W. (incipient wetness) Pd/Mn/Al.sub.2 O.sub.3 catalyst (nominally 8% palladium and 5.5% MnO.sub.2 based on alumina) was prepared similarly by first impregnating high surface area SRS-II alumina (Davison) to the point of incipient wetness with a water solution containing palladium tetraamine acetate. After drying and then calcining the powder for two hours at 450.degree. C., the powder was reimpregnated to the point of incipient wetness with a water solution containing manganese nitrate. Again, after drying and calcination at 450.degree. C. for two hours, the powder was mixed in a ball mill with acetic acid (3% by weight of catalyst powder) and enough water to create a slurry of 35% solids. The mixture was then milled until the particle size was 90%<8 .mu.m. (Patches 7 and 11)

The SiO.sub.2 /Al.sub.2 O.sub.3 precoat slurry was prepared as described in Example 1. (Patches 3 and 11)

The Al.sub.2 O.sub.3 precoat slurry was prepared by ball milling high surface area Condea SBA-150 alumina with acetic acid (5% by weight based on alumina) and water (total solids ca. 44%) to a particle size of 90%<10 .mu.m. (Patches 9 and 12)

Results are summarized in Table I. The conversion of carbon monoxide after being on the automobile for 5,000 miles was also measured at the conditions recited in Example 1 for patch #4. At a radiator temperature of 50.degree. C. and a linear velocity of 10 mph no conversion was observed.

TABLE I CATALYST SUMMARY PATCH # CATALYST OZONE CONVERSION (%) 1 Pt/Al.sub.2 O.sub.3 12 0.67 g/in.sup.3 (23 g/ft.sup.3 Pt) No Precoat No Calcine (120.degree. C. only) 2 Pd/Mn/Al.sub.2 O.sub.3 25 0.97 g/in.sup.3 (171 g/ft.sup.3 Pd) No Precoat Calcined 450.degree. C. 3 Pd/Mn/Al.sub.2 O.sub.3 24 1.19 g/in.sup.3 (209 g/ft.sup.3 Pd) SiO.sub.2 /Pt/Al.sub.2 O.sub.3 Precoat (0.16 g/in.sup.3) Calcined 450.degree. C. 4 Pt/Al.sub.2 O.sub.3 8 0.79 g/in.sup.3 (27 g/ft.sup.3 Pt) No Precoat Calcined 450.degree. C. 5 Carulite 200 50 0.49 g/in.sup.3 3% SiO.sub.2 /Pt/Al.sub.2 O.sub.3 Binder No Precoat Calcined 400.degree. C. 6 Pd/Mn/Al.sub.2 O.sub.3 28 0.39 g/in.sup.3 (70 g/ft.sup.3 Pd) No Precoat Calcined 450.degree. C. 7 I.W. Pd/Mn/Al.sub.2 O.sub.3 50 0.69 g/in.sup.3 (95 g/ft.sup.3 Pd) No Precoat No Calcine (120.degree. C. only) 8 Carbon 22 0.80 g/in.sup.3 No Precoat No Calcine (120.degree. C. only) 9 Carulite 200 38 0.65 g/in.sup.3 3% SiO.sub.2 /Al.sub.2 O.sub.3 Binder Al.sub.2 O.sub.3 Precoat (0.25 g/in.sup.3) Calcined 450.degree. C. 10 Carulite 200 42 0.70 g/in.sup.3 2% Latex Binder No Precoat No Calcine (120.degree. C. only) 11 I.W. Pd/Mn/Al.sub.2 O.sub.3 46 0.59 g/in.sup.3 (82 g/ft.sup.3 Pd) SiO.sub.2 /Al.sub.2 O.sub.3 precoat (0.59 g/in.sup.3) No Calcine either Coat (120.degree. C. only) 12 Carbon 17 1.07 g/in.sup.3 Al.sub.2 O.sub.3 Precoat (0.52 g/in.sup.3) calcined to 450.degree. C. Topcoat not calcined (120.degree. C. only)

Example 4

A 1993 Nissan Altima radiator core (Nissan part number 21460-1E400) was heat treated in air to 400.degree. C. for 16 hours and then a portion coated with Condea high surface area SBA-150 alumina (dry loading=0.86 g/in.sup.3) by pouring a water slurry containing the alumina through the radiator channels, blowing out the excess with an air gun, drying at room temperature with a fan, and then calcining to 400.degree. C. The alumina precoat slurry was prepared as described in Example 3. The radiator was then coated sequentially in 2".times.2" square patches with seven different CO destruction catalysts (Table II). Each coating was applied by pouring a water slurry containing the specific catalyst formulation through the radiator channels, blowing out the excess with an air gun, and drying at room temperature with a fan.

The Carulite.RTM. and 2% Pt/Al.sub.2 O.sub.3 catalysts (Patch #4 and #6, respectively) were prepared according to the procedure described in Example 3. The 3% Pt/ZrO.sub.2 /SiO.sub.2 catalyst (Patch #3) was made by first calcining 510 g of zirconia/silica frit (95% ZrO.sub.2 /5% SiO.sub.2 --Magnesium Elektron XZO678/01) for 1 hour at 500.degree. C. A catalyst slurry was then prepared by adding to 480 g of deionized water, 468 g of the resulting powder, 42 g of glacial acetic acid, and 79.2 g of a platinum salt solution (18.2% Pt) derived from H.sub.2 Pt(OH).sub.6 solubilized with an amine. The resulting mixture was milled on a ball mill for 8 hours to a particle size of 90% less than 3 .mu.m.

The 3% Pt/TiO.sub.2 catalyst (Patch #7) was prepared by mixing in a conventional blender 500 g of TiO.sub.2 (Degussa P25), 500 g of deionized water, 12 g of concentrated ammonium hydroxide, and 82 g of a platinum salt solution (18.2% Pt) derived from H.sub.2 Pt(OH).sub.6 solubilized with an amine. After blending for 5 minutes to a particle size of 90% less than 5 .mu.m, 32.7 g of Nalco 1056 silica sol and sufficient deionized water to reduce the solids content to ca. 22% was added. The resulting mixture was blended on a roll mill to mix all ingredients.

The 3% Pt/Mn/ZrO.sub.2 catalyst slurry (Patch #5) was prepared by combining in a ball mill 70 g of manganese/zirconia frit comprising a coprecipitate of 20 weight percent manganese and 80 weight percent zirconium based on metal weight (Magnesium Elektron XZO719/01), 100 g of deionized water, 3.5 g of acetic acid and 11.7 g of a platinum salt solution (18.2% Pt) derived from H.sub.2 Pt(OH).sub.6 solubilized with an amine. The resulting mixture was milled for 16 hours to a particle size 90% less than 10 .mu.m.

The 2% Pt/CeO.sub.2 catalyst (Patch #1) was prepared by impregnating 490 g of alumina stabilized high surface area ceria (Rhone Poulenc) with 54.9 g of a platinum salt solution (18.2% Pt) derived from H.sub.2 Pt(OH).sub.6 solubilized with an amine and dissolved in deionized water (total volume--155mL). The powder was dried at 110.degree. C. for 6 hours and calcined at 400.degree. C. for 2 hours. A catalyst slurry was then prepared by adding 491 g of the powder to 593 g of deionized water in a ball mill and then milling the mixture for 2 hours to a particle size of 90% less than 4 .mu.m. The 4.6% Pd/CeO.sub.2 catalyst (Patch #2) was prepared similarly via incipient wetness impregnation using 209.5 g (180mL) of palladium tetraamine acetate solution.

After all seven catalysts were applied, the radiator was calcined for about 16 hours at 400.degree. C. After attaching the radiator core to the plastic tanks, CO destruction performance of the various catalysts were determined by blowing an air stream containing CO (ca. 16ppm) through the radiator channels at a 5 mph linear face velocity (315,000/h space velocity) and then measuring the concentration of CO exiting the back face of the radiator. The radiator temperature was ca. 95.degree. C., and the air stream had a dew point of approximately 35.degree. F. Results are summarized in Table II.

Ozone destruction performance was measured as described in Example 1 at 25.degree. C., 0.25 ppm ozone, and a linear face velocity of 10 mph with a flow of 135.2 L/min and an hourly space velocity of 640,000/h. The air used had a dewpoint of 35.degree. F. Results are summarized in Table II. FIG. 9 illustrates CO conversion v. temperature for Patch Nos. 3, 6 and 7.

The catalysts were also tested for the destruction of propylene by blowing an air stream containing propylene (ca. 10 ppm) through the radiator channels at a 5 mph linear face velocity, with a flow rate of 68.2 L/min and an hourly space velocity of 320,000/h, and then measuring the concentration of propylene exiting the back face of the radiator. The radiator temperature was ca. 95.degree. C., and the air stream had a dew point of approximately 35.degree. F. Results are summarized in Table II.

TABLE II CO/HC/OZONE CONVERSION SUMMARY CARBON MON- PROPYL- OXIDE OZONE ENE PATCH CONVER- CONVER- CONVER- # CATALYST SION (%).sup.1 SION (%).sup.2 SION (%).sup.3 1 2% Pt/CeO.sub.2 2 14 0 0.7 g/in.sup.3 (24 g/ft.sup.3 Pt) 2 4.6% Pd/CeO.sub.2 21 55 0 0.5 g/in.sup.3 (40 g/ft.sup.3 Pd) 3 3% Pt/ZrO.sub.2 /SiO.sub.2 67 14 2 0.5 g/in.sup.3 (26 g/ft.sup.3 Pt) 4 Carulite 200 5 56 0 0.5 g/in.sup.3 3% SiO.sub.2 /Al.sub.2 O.sub.3 binder 5 3% Pt/Mn/ZrO.sub.2 7 41 0 0.7 g/in.sup.3 (36 g/ft.sup.3 Pt) 6 2% Pt/Al.sub.2 O.sub.3 72 8 17 0.5 g/in.sup.3 (17 g/ft.sup.3 Pt) 7 3% Pt/TiO.sub.2 68 15 18 0.7 g/in.sup.3 (36 g/ft.sup.3 Pt) 3% SiO.sub.2 /Al.sub.2 O.sub.3 binder .sup.1 Test Conditions: 16 ppm CO; 95.degree. C.; 5 mph face velocity; 68.2 L/min; LHSV (hourly space velocity) = 320,000/h; Air dewpoint = 35.degree. F. .sup.2 Test Conditions: 0.25 ppm O.sub.3 ; 25.degree. C.; 10 mph face velocity; 135.2 L/min; LHSV (hourly space velocity) = 640,000/h; Air dewpoint = 35.degree. F. .sup.3 Test Conditions: 10 ppm propylene; 95.degree. C.; 5 mph face velocity; 68.2 L/min; LHSV (hourly space velocity) = 320,000/h; Air dewpoint = 35.degree. F.

Example 5

This example summarizes the technical results from on-the-road vehicle testing conducted in February and March 1995 in the Los Angeles area. The purpose of the test was to measure catalytic ozone decomposition efficiency over a catalyzed radiator under actual driving conditions. The Los Angeles (LA) area was chosen as the most appropriate test site primarily due to its measurable ozone levels during this March testing period. In addition, specific driving routes are defined in the LA area which are typical of AM and PM peak and off-peak driving. Two different catalyst compositions were evaluated: 1) Carulite.RTM. 200 (CuO/MnO.sub.2 /Al.sub.2 O.sub.3 purchased from Carus Chemical Company); and 2) Pd/Mn/Al.sub.2 O.sub.3 (77 g/ft.sup.3 Pd) prepared as described in Example 3. Both catalysts were coated in patches onto a late model Cadillac V-6 engine aluminum radiator. The radiator was an aluminum replacement for the copper-brass OEM radiator which was on a Chevrolet Caprice test vehicle. The car was outfitted with 1/4" Teflon.RTM. PTFE sampling lines located directly behind each catalyst patch and behind an uncoated portion of the radiator (control patch). Ambient (catalyst in) ozone levels were measured via a sampling line placed in front of the radiator. Ozone concentrations were measured with two Dasibi Model 1003AH ozone monitors located in the back seat of the vehicle. Temperature probes were mounted (with epoxy) directly onto each radiator test patch within a few inches of the sampling line. A single air velocity probe was mounted on the front face of the radiator midway between the two patches. Data from the ozone analyzers, temperature probes, air velocity probe, and vehicle speedometer were collected with a personal computer located in the trunk and downloaded to floppy disks.

Overall results from the test are summarized in Table III below. For each catalyst (Carulite.RTM. & Pd/Mn/Al.sub.2 O.sub.3), results for cold idle, hot idle and on-the-road driving are reported. Data were collected on two separate trips to LA in February and March of 1995. The first trip was cut short after only a few days due to low ambient ozone levels. Although somewhat higher during the second trip in March, ambient levels still only averaged approximately 40 ppb. The last three days of testing (March 17-20) had the highest ozone encountered. Peak levels were approximately 100 ppb. In general, no trend in conversion vs. ozone concentration was noted.

Except for the cold idle results, those reported in Table III are averages from at least eleven different runs (the actual range of values appear in parentheses). Only data corresponding to inlet ozone concentration greater or equal to 30 ppb were included. Freeway data was not included since ambient levels dropped to 20 ppb or lower. Only two runs were completed for the cold idle tests. By cold idle refers to data collected immediately after vehicle startup during idle before the thermostat switches on and pumps warm coolant fluid to the radiator. Overall, ozone conversions were very good for both catalysts with the highest values obtained during hot idle. This can be attributed to the higher temperatures and lower face velocities associated with idling. Cold idle gave the lowest conversion due to the lower ambient temperature of the radiator surface. Driving results were intermediate of hot and cold idle results. Although the radiator was warm, temperature was lower and face velocity higher than those encountered with hot idle conditions. In general, ozone conversions measured for Carulite.RTM. were greater than those measured for Pd/Mn/Al.sub.2 O.sub.3 (e.g. 78.1 vs. 63.0% while driving). However, for the hot idle and driving runs, the average temperature of the Carulite.RTM. catalyst was typically 40.degree. F. greater than the Pd/Mn/Al.sub.2 O.sub.3 catalyst while the average radiator face velocity was typically 1 mph lower.

Overall, the results indicate that ozone can be decomposed at high conversion rates under typical driving conditions.

TABLE III ON-ROAD OZONE CONVERSION RESULTS* OZONE CONVER- TEMPER- FACE VEHICLE SION ATURE VELOCITY SPEED (%) (.degree. F.) (mph) (mph) Pd/Mn/Al.sub.2 O.sub.3 Idle Cold 48.2 70.6 9.0 0.0 (47.2-49.2) (70.5-70.8) (8.9-9.2) Idle Hot 80.6 120.0 7.4 0.0 (70.7-89.9) (104.7-145.2) (6.1-8.4) Driving 63.0 104.3 13.2 23.3 (55.5-69.9) (99.2-109.6) (12.2-14.9) (20.5-29.7) Carulite (CuO/MnO.sub.2) Idle Cold 67.4 71.8 8.2 0.0 (67.4-67.5) (70.8-72.9) (7.5-8.9) Idle Hot 84.5 157.1 7.5 0.0 (71.4-93.5) (134.8-171.2) (6.7-8.2) Driving 78.1 143.7 12.2 19.2 (72.3-83.8) (132.9-149.6) (11.2-13.5) (13.7-24.8) *Average values. Ranges appear in parentheses.

In general, the results of motor testing are consistent with fresh activity measured in the lab prior to installation of the radiator. At room temperature (.about.25.degree. C.), 20% relative humidity (0.7% water vapor absolute), and a 10 mph equivalent face velocity, lab conversions for Pd/Mn/Al.sub.2 O.sub.3 and Carulite.RTM. were 55 and 69% respectively. Increasing the RH to 70% at room temperature (.about.25.degree. C.) (2.3% water vapor absolute) lowered conversions to 38 and 52%, respectively. Since the cold idle (70.degree. F.) conversions measured at a 9 mph face velocity were 48 and 67% respectively, it would appear that the humidity levels encountered during the testing were low.

The face velocity of air entering the radiator was low. At an average driving speed of roughly 20 mph (typical of local driving), radiator face velocity was only approximately 13 mph. Even at freeway speeds in excess of 60 mph, radiator face velocity was only ca. 25 mph. The fan significantly affects control of air flowing through the radiator. While idling, the fan typically pulled about 8 mph.

Example 6

An 8 weight percent Pd on Carulite.RTM. catalyst was prepared by impregnating 100 g Carulite.RTM. 200 powder (ground up in a blender) to the point of incipient wetness with 69.0 g of a water solution containing palladium tetraamine acetate (12.6% Pd). The powder was dried overnight at 90.degree. C. and then calcined to 450.degree. C. or 550.degree. C. for 2 hours. 92 g of the resulting calcined catalyst was then combined with 171 g of deionized water in a ball mill to create a slurry of 35% solids. After milling for 30 minutes to a particle size 90%.ltoreq.9 .mu.m, 3.1 g of National Starch x4260 acrylic latex binder (50% solids) was added, and the resulting mixture was milled for an additional 30 minutes to disperse the binder. Compositions containing 2,4 and 6 weight percent Pd on Carulite.RTM. catalysts were similarly prepared and evaluated.

The catalysts were evaluated for ozone decomposition at room temperature and 630,000/h space velocity using washcoated 300 cpsi (cells per square inch) ceramic honeycombs. The catalyst samples were prepared as recited above. Results are summarized in Table IV. As can readily be seen, the 4 and 8% Pd/Carulite.RTM. catalysts which were calcined to 450.degree. C. gave equivalent initial and 45 minute ozone conversions (ca. 62 and 60%, respectively). These results are equivalent to those of Carulite.RTM.

alone under the identical test conditions. The 2 and 4% Pd catalysts which were calcined to 550.degree. C. gave significantly lower conversions after 45 minutes (47%). This is attributed to a loss in surface area at the higher temperature of calcination. The 6% catalyst was also calcined to 550.degree. C. but did not show quite as large of an activity drop.

TABLE IV OZONE RESULTS (300 cpsi Honeycomb, 630,000/h Space Velocity) LOADING CONVERSION CONVERSION CATALYST (g/in.sup.3) (%) initial (%) 45 Minutes Pd on Carulite 200 4% Pd/Carulite 1.8 64 59 (calcined 450.degree. C.) 8% Pd/Carulite 2.0 61 60 (calcined 450.degree. C.) 2% Pd/Carulite 2.1 57 48 (calcined 550.degree. C.) 4% Pd/Carulite 1.9 57 46 (calcined 550.degree. C.) 6% Pd/Carulite 2.3 59 53 (calcined 550.degree. C.)

Example 7

A series of tests were conducted to evaluate a variety of catalyst compositions comprising a palladium component to treat air containing 0.25 ppm ozone. The air was at ambient conditions (23.degree. C.; 0.6% water). The compositions were coated onto a 300 cell per inch ceramic (cordierite) flow through honeycomb at loadings of about 2 g of washcoat per cubic inch of substrate. The coated monoliths containing the various supported palladium catalysts were loaded into a 1" diameter stainless steel pipe, and the air stream was passed perpendicular to the open face of the honeycomb at a space velocity of 630,000/h. Ozone concentration was measured inlet and outlet of the catalyst. One alumina support used was SRS-II gamma alumina (purchased from Davison) characterized as described in Example 1 (surface area approximately 300 m.sup.2 /g). Also used was a low surface area theta alumina characterized by a surface area of approximately 58 m.sup.2 /g and an average pore radius of about 80 Angstrom. E-160 alumina is a gamma alumina characterized by a surface area of about 180 m.sup.2 /g and an average pore radius of about 47 Angstrom. Ceria used had a surface area about 120 m.sup.2 /g and an average pore radius of about 28 Angstrom. Also used was dealuminated Beta zeolite with a silica to alumina ratio of approximately 250 to 1 and a surface area about 430 m.sup.2 /g. Carbon, a microporous wood carbon characterized with a surface area of about 850 m.sup.2 /g, was also used as a support. Finally, a titania purchased from Rhone-Poulenc (DT51 grade) and characterized by a surface area of approximately 15 110 m.sup.2 /g was used as a support. Results are summarized in Table V which includes the relative weight percent of various catalyst components, the loading on the honeycomb, initial ozone conversion, and conversion after 45 minutes.

TABLE V OZONE RESULTS - (300 cpsi Honeycomb, 630,000/h Space Velocity, 0.6% Water; ca. 0.25 ppm Ozone) LOADING CONVERSION CONVERSION CATALYST (g/in.sup.3) (%) initial (%) 45 Minutes I.W. 8% Pd/5% Mn/ 1.8 60 55 Al.sub.2 O.sub.3 I.W. 8% Pd/5% Mn/ 1.9 64 60 Low Surface Area Al.sub.2 O.sub.3 8% Pd/Low Surface 1.9 56 44 Area Al.sub.2 O.sub.3 8% Pd/E-160 Al.sub.2 O.sub.3 2.2 61 57 4.6% Pd/CeO.sub.2 1.99 59 58 8% Pd/BETA 1.9 38 32 Zeolite (dealuminated) 5% Pd/C 0.5 63 61 8% Pd/DT-51 TiO.sub.2 1.8 39 20

Example 8

Following is a preparation of Carulite.RTM. slurry which includes vinyl acetate latex binder and is used in coating radiators which results in excellent adhesion of the catalyst to an aluminum radiator.

1000 g of Carulite.RTM. 200, 1500 g of deionized water, and 50 g of acetic acid (5% based on Carulite.RTM.) were combined in a 1 gallon ball mill and milled for 4 hours to a particle size 90%.ltoreq.7 .mu.m. After draining the resulting slurry from the mill, 104 g (5% solids basis) of National Starch Dur-O-Set E-646 cross linking EVA copolymer (48% solids) was added. Thorough blending of the binder was achieved by rolling the slurry on a mill without milling media for several hours.

Following coating of this slurry onto a piece of aluminum substrate (e.g., radiator), excellent adhesion (i.e., coating could not be wiped off) was obtained after drying for 30 minutes at 30.degree. C. Higher temperatures of curing (up to 150.degree. C.) can be utilized if desired.

Example 9

Carbon monoxide conversion was tested by coating a variety of titania supported platinum compositions onto ceramic honeycombs as described in Example 6. Catalyst loadings were about 2 g/in.sup.3, and testing was conducted using an air stream having 16 ppm carbon monoxide (dew point 35.degree. F.) at a space velocity of 315,000/h. The catalyst compositions were reduced on the honeycomb using a forming gas having 7% H.sub.2 and 93% N.sub.2 at 300.degree. C. for 3 hours. Compositions containing TiO.sub.2 included 2 and 3 weight percent platinum component on P25 titania; and 2 and 3 weight percent platinum component on DT52 grade titania. DT51 grade titania was purchased from Rhone-Poulenc and had a surface area of approximately 110 m.sup.2 /g. DT52 grade titania was a tungsten containing titania purchased from Rhone-Poulenc and which had a surface area of approximately 210 m.sup.2 /g. P25 grade titania was purchased from Degussa and was characterized as having a particle size of approximately 1 .mu.m and a surface area of ca. 45-50 m.sup.2 /g. Results are illustrated in FIG. 10.

Example 10

Example 10 relates to the evaluation of CO conversion for compositions containing alumina, ceria and zeolite. The supports were characterized as described in Example 7. Compositions evaluated included 2 weight percent platinum on low surface area theta alumina; 2 weight percent platinum and ceria; 2 weight percent platinum on SRS-II gamma alumina, and 2 weight percent platinum on Beta zeolite. Results are illustrated in FIG. 11.

Example 11

CO conversion was measured v. temperature for compositions containing 2 weight percent platinum on SRS-II gamma alumina and on ZSM-5 zeolite which were coated onto a 1993 Nissan Altima radiator as recited in Example 4 and tested using the same procedure to test CO as used in Example 4. Results are illustrated in FIG. 9.

Example 12

0.659 g of a solution of amine solubilized platinum hydroxide solution having 17.75 weight percent platinum (based on metallic platinum) was slowly added to 20 g of an 11.7 weight percent aqueous slurry of a titania sol in a glass beaker and stirred with a magnetic stirrer. A one-inch diameter by one-inch long 400 cells per square inch (cpsi) metal monolith cored sample was dipped into the slurry. Air was blown over the coated monolith to clear the channels and the monolith was dried for three hours at 110.degree. C. At this time, the monolith was redipped into the slurry once again and the steps of air blowing the channels and drying at 110.degree. C. was repeated. The twice coated monolith was calcined at 300.degree. C. for two hours. The uncoated metal monolith weighed 12.36 g. After the first dipping, it weighed 14.06 g, after the first drying 12.6 g, after the second dipping 14.38 g and after calcination weighed 13.05 g indicating a total weight gain of 0.69 g. The coated monolith had 72 g/ft.sup.3 of platinum based on the metal and is designated as 72 Pt/Ti. The catalyst was evaluated in an air stream containing 20 ppm carbon monoxide at a gas flow rate of 36.6 liters per minute. After this initial evaluation the catalyst core was reduced in a forming gas having 7% hydrogen and 93% nitrogen at 300.degree. C. for 12 hours and the evaluation to treat an air stream containing 20 ppm carbon monoxide was repeated. The reduced coated monolith as designated as 72 Pt/Ti/R. The above recited slurry was then evaluated using a cored sample from a ceramic monolith having 400 cells per square inch (cpsi), which was precoated with 40 g per cubic foot, of 5:1 weight ratio of platinum to rhodium plus 2.0 g per cubic inch of ES-160 (alumina) and the core had 11 cells by 10 cells by 0.75 inches long monolith and designated as 33 Pt/7Rh/Al was dipped into the above recited slurry and air blown to clean the channels. This monolith was dried at 110.degree. C. for three hours and calcined at 300.degree. C. for two hours. The catalyst substrate including the first platinum and rhodium layer weighed 2.19 g. After the first dip it weighed 3.40 g and after calcination 2.38 g showing a total weight gain of 0.19 g which is equal to 0.90 g per cubic inch of the platinum/titania slurry. The dipped ceramic core contained 74 per cubic foot of platinum based on the platinum metal and designated as 74 Pt/Ti//Pt/Rh. Results are illustrated in FIG. 12.

Example 13

A platinum on titanium catalyst as described in the above referenced Example 12 has been used in an air stream containing 4 ppm propane and 4 ppm propylene. In an air stream at a space velocity of 650,000 standard hourly space velocity. The platinum and titanium catalyst had 72 g of platinum per cubic foot of total catalyst and substrate used. It was evaluated on the ceramic honeycomb as recited in Example 13. The measured results for propylene conversion were 16.7% at 65.degree. C.; 19% at 70.degree. C.; 23.8% at 75.degree. C.; 28.6% at 80.degree. C.; 35.7% at 85.degree. C.; 40.5% at 95.degree. C. and 47.6% at 105.degree. C.

Example 14

Example 14 is an illustration of a platinum component on a titania support. This Example illustrates the excellent activity of platinum supported on titania for carbon monoxide and hydrocarbon oxidation. The evaluation was carried out using a catalyst prepared from a colloidal titania sol to form a composition comprising 5.0 weight percent platinum component based on the weight of the platinum metal and titania. The platinum was added to titania in the form of amine solubilized platinum hydroxide solution. It was added to colloidal titania slurry or into titania powders to prepare a platinum and titania containing slurry. The slurry was coated onto a ceramic monolith having 400 cells per square inch (cpsi). Samples had coating amounts varying from 0.8-1.0 g/in. The coated monoliths were calcined for 300.degree. C. for 2 hours in the air and then reduced. The reduction was carried out at 300.degree. C. in a gas containing 7% hydrogen and 93% nitrogen for 12 hours. The colloidal titania slurry contained 10% by weight titania in an aqueous media. The titania had a nominal particle size of 2-5nm.

Carbon monoxide conversion was measured in an air stream containing 20 ppm CO. The flow rate of the carbon monoxide in various experiments range from space velocities of 300,000 VHSV to 650,000 VHSV at a temperature between ambient to 110.degree. C. The air used was purified air from an air cylinder and where humidity was added the air was passed through a water bath. Where humidity was studied the relative humidity was varied from 0-100% humidity at room temperature (25.degree. C.). The carbon monoxide containing air stream was passed through the ceramic monolith coated with the catalyst compositions using a space velocity of 650,000/h.

FIG. 13 represents a study using air with 20 ppm CO having to measure carbon monoxide conversion v. temperature comparing platinum supported on titania which has been reduced (Pt/Ti-R) at 300.degree. C. using a reducing gas containing 7% hydrogen and 93% nitrogen for 12 hours as recited above with a non reduced platinum supported on titania catalyst (Pt/Ti) coating. FIG. 13 illustrates a significant advantage when using a reduced catalyst.

FIG. 14 illustrates a comparison of platinum on titania which has been reduced with varying supports including platinum on tin oxide (Pt/Sn), platinum on zinc oxide (Pt/Zn) and platinum on ceria (Pt/Ce) for comparative sake. All of the samples were reduced at the above indicated conditions. The flow rate of carbon monoxide in the air was 650,000 shsv. As can be seen, the reduced platinum on colloidal titania had significantly higher conversion results than platinum on the various other support materials.

Hydrocarbon oxidation was measured using a 6 ppm propylene air mixture. The propylene air stream was passed through the catalyst monolith at a space velocity of 300,000 vhsv at a temperature which varied from room temperature to 110.degree. C. Propylene concentration was determined using a flame ionized detector before and after the catalyst. The results are summarized in FIG. 15. The support used was 5% by weight based on the weight of platinum metal and yttrium oxide Y.sub.2 O.sub.3. The comparison was between reduced and non reduced catalyst. As shown in FIG. 15 reducing the catalyst resulted in a significant improvement in propylene conversion.

The above recited platinum supported on titania catalyst was reduced in a forming gas containing 7% hydrogen and 93% nitrogen at 500.degree. C. for 1 hour. The conversion of carbon monoxide was evaluated in 0 percent relative humidity air at a flow rate of 500,000 vhsv. The evaluation was conducted to determine if the reduction of the catalyst was reversible. Initially, the catalyst was evaluated for the ability to convert carbon monoxide at 22.degree. C. As shown in FIG. 16, the catalyst initially converted about 53% of the carbon monoxide and dropped down to 30% after approximately 200 minutes. At 200 minutes the air and carbon monoxide was heated to 50.degree. C. and carbon monoxide conversion increased to 65%. The catalyst was further heated to 100.degree. C. in air and carbon monoxide and held at 100.degree. C. for one hour, and then cooled in air to room temperature (about 25.degree. C.). Initially, the conversion dropped to about 30% in the period from about 225-400 minutes. The evaluation was continued at 100.degree. C. to 1200 minutes at which time conversion was measured at about 40%. A parallel study was conducted at 50.degree. C. At about 225 minutes the conversion was about 65%. After 1200 minutes, the conversion actually rose to about 75%. This Example shows that reduction of the catalyst permanently improves the catalysis activity.

Example 15

Example 15 is used to illustrate ozone conversion at room temperature for platinum and/or palladium components supported on a manganese oxide/zirconia coprecipitate. This Example also shows a platinum catalyst which catalyzes the conversion of ozone to oxygen and, at the same time, oxidize carbon monoxide and hydrocarbons. Manganese oxide/zirconia mixed oxide powders were made having 1:1 and 1:4 weight based on Mn and Zr metals. The coprecipitate was made in accordance with the procedure disclosed in U.S. Pat. No. 5,283,041 referenced above. 3% and 6% Pt on manganese/zirconia catalysts (1:4 weight basis of Mn to Zr) were prepared as described in Example 4. SBA-150 gamma alumina (10% based on the weight of the mixed oxide powder) was added as a binder in the form of a 40% water slurry containing acetic acid (5% by weight of alumina powder) and milled to a particle size 90%<10 .mu.m. The 6% weight percent Pd catalyst was prepared by impregnating manganese/zirconia frit (1:1 weight basis of Mn to Zr) to the point of incipient wetness with a water solution containing palladium tetraamine acetate. After drying and then calcining the powder for two hours at 450.degree. C., the catalyst was mixed in a ball mill with Nalco #1056 silica sol (10% by weight of catalyst powder) and enough water to create a slurry of approximately 35% solids. The mixture was then milled until the particle size was 90%.ltoreq.10 .mu.m. Various samples were reduced using a forming gas having 7% H.sub.2 and 93% N.sub.2 at 300.degree. C. for 3 hours. Evaluations were conducted to determine the conversion of ozone on coated radiator minicores from a 1993 Altima radiator which were approximately 1/2 inch by 7/8 inch by 1 inch deep. The evaluation was conducted at room temperature using a one-inch diameter stainless steel pipe as described in Example 7 with house air (laboratory supplied air) at a 630,000/h space velocity with an inlet ozone concentration of 0.25 ppm. Results are provided on Table VI.

TABLE VI SUMMARY OF FRESH ACTIVITY OZONE RESULTS - (39 cpsi Nissan Altima core, 630,000/h Space Velocity; 25.degree.C.; 0.25 ppm ozone; House air - ca. 0.6% water) LOAD- CORE ING CONVERSION CONVERSION NO. CATALYST (g/in.sup.3) (%) Initial (%) 45 Minutes 1 3% Pt/MnO.sub.2 / 0.7 70.7 65.8 ZrO.sub.2 (1:4) (calcined at 450.degree. C.) 2 3% Pt/MnO.sub.2 / 0.7 70.5 63.7 ZrO.sub.2 (1:4) (calcined at 450.degree. C.; reduced at 300.degree. C.) 3 6% Pt/MnO.sub.2 / 0.68 68.2 62.3 ZrO.sub.2 (1:4) (calcined at 450.degree. C.) 4 6% Pt/MnO.sub.2 / 0.66 66 55.8 ZrO.sub.2 (1:4) (calcined 450.degree. C.; reduced at 300.degree. C.) 5 6% Pd/MnO.sub.2 / 0.39 38.3 21.1 ZrO.sub.2 (1:1) w. 10% Nalco 1056 6 MnO.sub.2 /ZrO.sub.2 0.41 58.3 44.9 (1:1) w. 10% Nalco 1056 7 MnO.sub.2 /ZrO.sub.2 0.37 55.8 41.2 (1:1) w. 10% Nalco 1056 8 3% Pt/ZrO.sub.2 / 0.79 27.4 10 SiO.sub.2 (calcined 450.degree. C.) 9 3% Pt/ZrO.sub.2 / 0.76 54.2 30.1 SiO.sub.2 (calcined 450.degree. C. and reduced at 300.degree. C.)

As can be seem from Table VI Cores 1 and 2 having only 3% platinum resulted in excellent ozone conversion initially and after 45 minutes both for reduced and unreduced catalyst. Cores 3 and 4 having a 6% platinum concentration also had excellent results but not quite as good as the 3% platinum results. Cores 5-7 illustrate a variety of other support materials used which resulted in conversion of ozone. Core 5 had palladium on a manganese oxide/zirconia coprecipitate and resulted in lower than expected but still significant ozone conversion. Cores 6 and 7 evaluations used the coprecipitate without precious metal and also resulted in significant ozone conversions but here again not as good as when using platinum as a catalyst. Core 8 was platinum on a zirconia/silica support which was calcined but not reduced and Core 9 was platinum on zirconia/silica support which was reduced. Both Cores 8 and 9 gave some conversion but yet not as good as the conversion obtained with platinum on the coprecipitate.

In addition, carbon monoxide conversion was evaluated on 39 cpsi radiator minicores, as recited, for 3% and 6% platinum on manganese/zirconia supports. Reduced and unreduced samples were evaluated. For illustrative purposes, platinum on zirconia/silica supports and platinum on Carulite.RTM. reduced and unreduced are also presented. As can be seen from FIG. 17, the results of 3% reduced platinum on manganese/zirconia support were higher when compared to the other embodiments.

Example 16 (Comparative)

Ozone conversion was measured over an uncoated 1995 Ford Contour radiator at room temperature and 80.degree. C. by blowing an air stream containing ozone (0.25 ppm) through the radiator channels at a 10 mph linear velocity (630,000/h space velocity) and then measuring the concentration of ozone exiting the back face of the radiator. The air stream had a dew point of approximately 35.degree. F. Heated coolant was not circulated through the radiator, but the air stream was heated as necessary with heating tape to achieve the desired radiator temperature. Additional testing was completed with an uncoated 0.75" (L)x0.5" (W)x1.0" (D) Ford Taurus radiator "mini-core" in a 1" diameter stainless steel pipe as described in Example 7. The air stream was heated with heating tape to achieve the desired radiator temperature. For both tests, no decomposition of ozone was observed up to 120.degree. C.

Example 17

Ozone conversion was measured at various temperatures for a reduced 3% Pt/TiO.sub.2 catalyst in the absence and in the presence of 15 ppm CO. Degussa P25 grade titania was used as the support and was characterized as having a particle size of approximately 1 .mu.m and a surface area of ca. 45-50 m.sup.2 /g. The catalyst was coated onto a 300 cpsi ceramic (cordierite) honeycomb and was reduced on the honeycomb using a forming gas having 7% H.sub.2 and 93% N.sub.2 at 300.degree. C. for 3 hours. Testing was accomplished as described previously in Example 7. The air stream (35.degree. F. dewpoint) was heated with heating tape to achieve the desired temperature. As can be seen in FIG. 18, an approximate 5% enhancement in absolute ozone conversion was observed from 25 to 80.degree. C. The presence of CO improves the conversion of ozone.

Example 18

100 g of Versal GL alumina obtained from LaRoche Industries Inc. was impregnated with about 28 g of Pt amine hydroxide (Pt(A)salt) diluted in water to about 80 g of solution. 5 g of acetic acid was added to fix the Pt onto the alumina surface. After mixing for half hour, the Pt impregnated catalyst was made into a slurry by adding water to make about 40% solids. The slurry was ballmilled for 2 hours. The particle size was measured to be 90% less than 10 microns. The catalyst was coated onto a 1.5" diameter by 1.0" length 400 cpsi ceramic substrate to give a washcoat loading after drying of about 0.65 g/in.sup.3. The catalyst was then dried at 100.degree. C. and calcined at 550.degree. C. for 2 hours. This catalyst was tested for C.sub.3 H.sub.6 oxidation at temperatures between 60 and 100.degree. C. in dry air as described in Example 21.

Some of calcined Pt/Al.sub.2 O.sub.3 sample described above was also reduced in 7%H2/N2 at 400.degree. C. for 1 hour. The reduction step was carried out by ramping the catalyst temperature from 25 to 400.degree. C. at a H2/N2 gas flow rate of 500 cc/min. The ramp temperature was about 5.degree. C./min. The catalyst was cooled down to room temperature and the catalyst was tested for C.sub.3 H.sub.6 oxidation as described in Example 21.

Example 19

6.8 g of ammonium tungstate was dissolved in 30 cc of water and the pH adjusted to 10 and the solution impregnated onto 50 g of Versal GL alumina (LaRoche Industries Inc.). The material was dried at 100.degree. C. and calcined for 2 hours at 550.degree. C. The approximately 10% by metal weight of W on Al.sub.2 O.sub.3 was cooled to room temperature and impregnated with 13.7 g of Pt amine hydroxide (18.3% Pt). 2.5 g of acetic acid was added and mixed well. The catalyst was then made into a slurry containing 35% solid by adding water. The slurry was then coated over a 400 cpsi, 1.5"-1.0" diameter ceramic substrate resulting, after drying, in having a catalyst washcoat loading of 0.79 g/in.sup.3. The coated catalyst was then dried and calcined at 550.degree. C. for 2 hours. The catalyst was tested calcined in C.sub.3 H.sub.6 and dry air in the temperature range 60 to 100.degree. C.

Example 20

6.8 g of perrhenic acid (36% Re in solution) was further diluted in water to make 10 g percent perrhenic acid solution. The solution was impregnated onto 25 g of Versal GL alumina. The impregnated alumina was dried and the powder calcined at 550.degree. C. for 2 hours. The impregnated 10 weight percent based metal of Re on Al.sub.2 O.sub.3 powder was then further impregnated with 6.85 g of Pt amine hydroxide solution (Pt metal in solution was 18.3%). 5 g of acetic acid was added and mixed for a half hour. A slurry was made by adding water to make 28% solid. The slurry was ballmilled for 2 hours and coated onto 1.5" diameter x 1.0" length 400 cpsi ceramic substrate to give a catalyst washcoat loading of 0.51 g/in.sup.3 after drying. The catalyst coated substrate was dried at 100.degree. C. and calcined at 550.degree. C. for 2 hours. The catalyst was tested in the calcined form using 60 ppm C.sub.3 H.sub.6 and dry air in the temperature range of 60 to 100.degree. C.

Example 21

The catalyst of Examples 18, 19 and 20 were tested in a microreactor. The size of the catalyst samples was 0.5" diameter and 0.4" length. The feed was composed of 60 ppm C.sub.3 H.sub.6 in dry air in the temperature range of 25 to 100.degree. C. The C.sub.3 H.sub.6 was measured at 60, 70, 80, 90 and 100.degree. C. at steady sate condition. Results are summarized in Table VII.

TABLE VII SUMMARY RESULTS OF C3H6 CONVERSION Catalyst Name Pt/ Pt/Al.sub.2 O.sub.3 10% W/ Pt/10% Re/ % C3H6 Pt/Al.sub.2 O.sub.3 Calcined Al.sub.2 O.sub.3 Al.sub.2 O.sub.3 Conversion Calcined and reduced Calcined Calcined @ (Ex. 18) (Ex. 18) (Ex. 19) (Ex. 20) 60.degree. C. 0 10 9 11 70.degree. C. 7 22 17 27 80.degree. C. 20 50 39 45 90.degree. C. 38 70 65 64 100.degree. C. 60 83 82 83

It is clear from the Table that addition of W or Re oxide has enhanced the activity of the Pt/Al.sub.2 O.sub.3 in the calcined form. The C.sub.3 H.sub.6 conversion of the calcined Pt/Al.sub.2 O.sub.3 was enhanced significantly when catalyst was reduced at 400.degree. C. for 1 hour. The enhanced activity was also observed for the calcined catalyst by incorporation of W or Re oxides.

Example 22

This is an example of preparing high surface area cryptomelane using MnSO.sub.4.

Molar ratios: KMnO.sub.4 : MnSO.sub.4 : acetic acid were 1:1.43: 5.72

Molarities of Mn in solutions prior to mixing were:

0.44 M KmnO.sub.4

0.50 M MnSO.sub.4

FW KMnO.sub.4 =158.04 g/mol

FW MnSO.sub.4.H.sub.2 O=169.01 g/mol

FW C.sub.2 H.sub.4 O.sub.2 =60.0 g/mol

The following steps were conducted: 1. Made a solution of 3.50 moles (553 grams) of KMnO.sub.4 in 8.05 L of D.I. water and heated to 68.degree. C. 2. Made 10.5 L of 2N acetic acid by using 1260 grams of glacial acetic acid and diluting to 10.5 L with D.I. water. Density of this solution is 1.01 g/mL. 3. Weighed out 5.00 moles (846 grams) of manganous sulfate hydrate (MnSO.sub.4.H.sub.2 O) and dissolved in 10,115 g of the above 2N acetic acid solution and heated to 40.degree. C. 4. Added the solution from 3. to the solution from 1. over 15 minutes while continuously stirring. After addition was complete, began heating the slurry according to the following heat-up rate:

1:06 pm 69.4.degree. C. 1:07 pm 71.2.degree. C. 1:11 pm 74.5.degree. C. 1:15 pm 77.3.degree. C. 1:18 pm 80.2.degree. C. 1:23 pm 83.9.degree. C. 1:25 pm 86.7.degree. C. 1:28 pm 88.9.degree. C. 5. At 1:28 pm approximately 100 mL of slurry was removed from the vessel and promptly filtered on a BUchner funnel, washed with 2 L of D.I. water, and then dried in an oven at 100.degree. C. The sample was determined to have a BET Multi-Point surface area of 259 m.sup.2 /g.

Example 23

This is an example of preparing high surface area cryptomelane using Mn(CH.sub.3 COO).sub.2.

Molar ratios: KMnO.sub.4 : Mn(CH.sub.3 CO.sub.2).sub.2 : acetic acid were 1:1.43:5.72

FW KMnO.sub.4 =158.04 g/mol Aldrich Lot #08824MG

FW Mn(CH.sub.3 CO.sub.2).sub.2.H.sub.2 O=245.09 g/mol Aldrich Lot #08722HG

FW C.sub.2 H.sub.4 O.sub.2 =60.0 g/mol 1. Made a solution of 2.0 moles (316 grams) of KMnO.sub.4 in 4.6 L of D.I. water and heated to 60.degree. C. by heating on hot plates. 2. Made up 6.0 of 2N acetic acid by using 720 grams of glacial acetic acid and diluting to 6.0 L with D.I. water. Density of this solution is 1.01 g/mL. 3. Weighed out 2.86 moles (700 grams) of manganese (II) acetate tetrahydrate [Mn(CH.sub.3 CO.sub.2).sub.2.4H2O] and dissolved in 5780 g of the above 2N acetic acid solution (in the reactor vessel). Heated to 60.degree. C. in the reactor vessel. 4. Added the solution from 1. to the solution from 3. while maintaining the slurry at 62-63.degree. C. After complete addition, gently heated the slurry according to the following:

82.0.degree. C. at 3:58 pm

86.5.degree. C. at 4:02 pm

87.0.degree. C. at 4:06 pm

87.1.degree. C. at 4:08 pm

shut off heat then quenched the slurry by pumping 10 L of D.I. water into the vessel. This cooled the slurry to 58.degree. C. at 4:13 pm. The slurry was filtered on Buchner funnels. The resulting filter cakes were reslurried in 12 L of D.I. water then stirred overnight in a 5 gallon bucket using a mechanical stirrer. The washed product was refiltered in the morning then dried in an oven at 100.degree. C. The sample was determined to have a BET Multi-Point surface area of 296 m.sup.2 /g. The resulting cryptomelane is characterized by the XRD pattern of FIG. 20. It is expected to have an IR spectrum similar to that shown in FIG. 19.

Example 24

Following is a description of the ozone testing method for determining percent ozone decomposition used in this Example. A test apparatus comprising an ozone generator, gas flow control equipment, water bubbler, chilled mirror dew point hygrometer, and ozone detector was used to measure the percent ozone destroyed by catalyst samples. Ozone was generated in situ utilizing the ozone generator in a flowing gas stream comprised of air and water vapor. The ozone concentration was measured using the ozone detector and the water content was determined utilizing the dew point hygrometer. Samples were tested as 25.degree. C. using inlet ozone concentrations of 4.5 to 7 parts per million (ppm) in a gas stream flowing at approximately 1.5 L/minute with a dew point between 15.degree. C. and 17.degree. C. Samples were tested as particles sized to -25/+45 mesh held between glass wool plugs in a 1/4" I.D. Pyrex.RTM. glass tube. Tested samples filled a 1 cm portion of the glass tube.

Sample testing generally required between 2 to 16 hours to achieve a steady state of conversion. Samples typically gave close to 100% conversion when testing began and slowly decreased to a "leveled off" conversation that remained steady for extended periods of time (48 hours). After a steady state was obtained, conversions were calculated from the equation: % ozone conversion=[(1-(ozone concentration after passing over catalyst)/(ozone concentration before passing over catalyst)]*100.

Ozone destruction testing on the sample of Example 22 showed 58% conversion.

Ozone destruction testing on the sample of Example 23 showed 85% conversion.

Example 25

This example is intended to illustrate that the method of Example 23 generated "clean" high surface area cryptomelane for which the ozone destruction performance was not further enhanced by calcination and washing. A 20 gram portion of the sample represented by Example 23 was calcined in air at 200.degree. C. for 1 hour, cooled to room temperature, then washed at 100.degree. C. in 200 mL of D.I. water by stirring the slurry for 30 minutes. The resulting product was filtered and dried at 100.degree. C. in an oven. The sample was determined to have BET Multi-Point surface area of 265 m.sup.2 /g. Ozone destruction testing on the sample showed 85% conversion. A comparison to the testing of the sample of Example 23 demonstrated that no benefit in ozone conversion was realized from the washing and calcination of the sample of Example 23.

Example 26

Samples of high surface area cryptomelane were obtained from commercial suppliers and modified by calcination and/or washing. As received and modified powders were tested for ozone decomposition performance according to the method of Example 24 and characterized by powder X-ray diffraction, infrared spectroscopy, and BET surface area measurements by nitrogen adsorption.

Example 26a

A commercially supplied sample of high surface area cryptomelane (Chemetals, Inc., Baltimore, Md.) was washed for 30 minutes in D.I. water at 60.degree. C., filtered, rinsed, and oven-dried at 100.degree. C. Ozone conversion of the as received sample was 64% compared to 79% for the washed material. Washing did not change the surface area or crystal structure of this material (223 m.sup.2 /g cryptomelane) as determined by nitrogen adsorption and powder X-ray diffraction measurements, respectively. However, infrared spectroscopy showed the disappearance of peaks at 1220 and 1320 wavenumbers in the spectrum of the washed sample indicating the removal of sulfate group anions.

Example 26b

Commercially supplied samples of high surface area cryptomelane (Chemetals, Inc., Baltimore, Md.) were calcined at 300.degree. C. for 4 hours and 400.degree. C. for 8 hours. Ozone conversion of the as received material was 44% compared to 71% for the 300.degree. C. calcined sample and 75% for the 400.degree. C. calcined sample. Calcination did not significantly change the surface area or crystal structure of the 300.degree. C. or 400.degree. C. samples (334 m.sup.2 /g cryptomelane). A trace of Mn.sub.2 O.sub.3 was detected in the 400.degree. C. sample. Calcination causes dehydroxylation of these samples. Infrared spectroscopy show a decrease in the intensity of the band between 2700 and 3700 wavenumbers assigned to surface hydroxyl groups.

Example 27

The addition Pd black (containing Pd metal and oxide) to high surface area cryptomelane is found to significantly enhance ozone decomposition performance. Samples were prepared comprising Pd black powder physically mixed with powders of (1) a commercially obtained cryptomelane (the 300.degree. C.

calcined sample described in Example 26b) and (2) the high surface area cryptomelane synthesized in Example 23 calcined at 200.degree. C. for 1 hour. The samples were prepared by mixing, in a dry state, powder of Pd black and cryptomelane in a 1:4 proportion by weight. The dry mixture was shaken until homogeneous in color. An amount of D.I. water was added to the mixture in a beaker to yield 20-30% solids content, thus forming a suspension. Aggregates in the suspension were broken up mechanically with a stirring rod. The suspension was sonicated in a Bransonic.RTM. Model 5210 ultrasonic cleaner for 10 minutes and then oven dried at 120-140.degree. C. for approximately 8 hours.

The ozone conversion for the commercially obtained cryptomelane calcined at 300.degree. C. was 71% as measured on the powder reactor (Example 26b). A sample of this product was mixed with 20 weight percent Pd black yielded 88% conversion.

The cryptomelane sample prepared as in Example 23 calcined at 200.degree. C. had 85% conversion. Performance improved to 97% with 20 weight percent Pd black added.

Example 28

1500 g of high surface area manganese dioxide (cryptomelane purchased from Chemetals) and 2250 g of deionized water were combined in a one gallon ball mill and milled for 1.5 hours to a particle size 90%.ltoreq.7 .mu.m. After draining the resulting slurry from the mill into a separate 1 gallon container, sufficient KOH (20% solution in DI water) was added to raise the pH to ca. 9.5. Additional KOH was added over the next several days to maintain a pH of 9.5. Subsequently, 294 g (10% solids basis) of National Starch x-4280 acrylic latex polymer (51% solids) was added. Thorough blending of the binder was achieved by rolling the container containing the slurry on a two roll mill. The container contained no milling media such as ceramic milling balls. Slurry made according to this process was coated onto a variety of substrates and exhibited excellent adhesion. Such substates included a porous monolithic support (eg. ceramic honeycomb) onto which the coating was applied by dipping the honeycomb into the slurry. The slurry was also spray coated onto an aluminum radiator. It was also dip coated on to small radiator minicores of the type recited above. Additionally, polyfiber filter media of the type used to filter air was coated by dipping or spraying. Typically, the samples were coated with loadings which could vary from 0.15 to 1.5 grams per cubic inch. The samples were air dried at 30.degree. C. until dry, typically for at least two hours. Excellent catalyst adhesion was attained in each case (i.e. coating could not be wiped off). Higher temperatures of drying (up to 150.degree. C.) can be utilized if desired. The latex cures during drying.

Example 29

To 96.56 g of the ball milled catalyst slurry obtained in Example 28 (before KOH addition) was added 3.20 g (3% solids basis) of Rhone-Poulenc Colloid 226 polymeric dispersant. After rolling the mixture on a roll mill for several hours, 7.31 g (10% solids basis) of National Starch x-4280 acrylic latex polymer (51% solids) was added. As in Example 28, thorough blending of the binder was achieved by rolling the container containing the slurry on a two roll mill. The container contained no milling media such as ceramic milling balls. Slurry made according to this process was coated onto a variety of substrates and exhibited excellent adhesion. Such substates included a porous monolithic support (eg. ceramic honeycomb) onto which the coating was applied by dipping the honeycomb into the slurry. The slurry was also dip coated on to small radiator minicores of the type recited above. Typically, the samples were coated with loadings which could vary from 0.15 to 1.5 grams per cubic inch. The samples were air dried at 30.degree. C. until dry, typically for at least two hours. Excellent catalyst adhesion was attained in each case (i.e. coating could not be wiped off). Higher temperatures of drying (up to 150.degree. C.) can be utilized if desired. The latex cures during drying.

Example 30

8.9 grams of D.I. water was added to 1.1 grams of TiO2 nano powder in a beaker. An ammonia/water concentrate was added to adjust the pH to 9.5. A solution of amine solubilized platinum hydroxide having 17.75 weight percent platinum (based on metallic platinum) was slowly added, with mixing to obtain 5% by weight of platinum on titania. Then a solution of palladium nitrate containing 20% by weight based on palladium metal was added, with mixing to obtain 14.3% palladium on the titania. A one-inch diameter by one-inch long 400 cells per square inch (cpsi) metal monolith cored sample was dipped into the slurry. Air was blown over the coated monolith to clear the channels and the monolith was dried for three hours at 110.degree. C. At this time, the monolith was redipped into the slurry once again and the steps of air blowing the channels and drying at 110.degree. C. was repeated. The twice coated monolith was calcined at 300.degree. C. for two hours. After this initial evaluation the catalyst core was reduced in a forming gas having 7% hydrogen and 93% nitrogen at 300.degree. C. for 12 hours. The catalyst was evaluated in an air stream containing 20 ppm carbon monoxide and 20 ppm of hydrocarbons based on C.sub.1. The hydrocarbons were evaluated in the presence of the 20 ppm CO. The hydrocarbons evaluated were ethylene C.sub.2 =; propylene C.sub.3 =; and pentene C.sub.5 =at a gas flow rate of 36.6 liters per minute which corresponds to 300,000 standard hourly space velocity (SHSV). The air stream was at 30% relative humidity (RH). Results are illustrated in FIG. 21.

* * * * *

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January 29, 2016

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY
FEB 0 1 2016
DIVISION OF AIR QUALITY

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HAND DELIVERED

Re: UPDATE – Tesoro Salt Lake City Refinery Installation of Ultra-Low NO_X Burners on Ultraformer Unit (UFU) Furnace F-1

Dear Mr. Gray:

On November 10, 2015, Tesoro Refining & Marketing Company LLC (Tesoro) submitted a Notice of Intent (NOI) application for installation of Ultra-Low NO_X Burners on the Ultraformer Unit (UFU) F-1 Furnace at the Salt Lake City Refinery. The NOI was for the purpose of achieving the NO_X reduction from the F-1 Furnace required by the PM2.5 SIP. Since the time the original application was submitted, Tesoro has determined that the projected annual firing rate of the burners will be higher than anticipated in the original submittal. This results in a very small increase in particulate and VOC emissions. An updated version of Table 3-3 of the original application is presented below to reflect the change in emissions due to the updated projected actual firing rate of the F-1 Furnace. Attachment B (Emission Calculations) has also been updated and is included as an attachment to this letter.

Table 3-3. Project Actual Emission Increase Summary

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
Emissions Unit	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
UFU Furnace F-1	0.00*	0.00	0.00	0.40	0.40	0.40	0.29	0.00
Cogeneration Units	0.72	0.25	0.78	0.10	0.10	0.10	0.05	0.00
New Process Components	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00
Total Project Emission Increase	**0.72**	**0.25**	**0.78**	**0.50**	**0.50**	**0.50**	**2.76**	**0.00**

* For the regulatory applicability purposes of this table, a zero emission increase is shown; however, this project will result in an estimated decrease in actual NO_X emissions of 13 ton/yr.

As described in Section 3.0 of the initial application, the project is not a major modification and is not subject to the PSD program. The updated projected firing rate does not change the PSD applicability of the project.

Section 4.4.2 of the initial application describes applicability of best available control technology (BACT). A BACT review is required for new emission units and existing emission units where there is a physical modification and an increase in emissions. As a result of the updated projected actual firing rate, as shown in the table above, there will be a slight increase in emissions of PM/PM_{10}/$PM_{2.5}$, and VOC from the UFU Furnace F-1. A BACT evaluation has been prepared in accordance with R307-401-5(d) and is attached to this letter. For PM/PM_{10}/$PM_{2.5}$, BACT is determined to be good combustion practices and use of gaseous fuel. For VOC, BACT is determined to be good combustion practice and proper equipment design, which is the industry standard for control of VOC emissions from refinery process heaters.

This update to the NOI application does not change the result of any applicable rules or requirements as described in the original NOI application.

Please contact me at 801-521-4966 or Michelle Bujdoso at 801-366-2036 if you need more information or have questions.

Sincerely,

William Snarr
Health Safety and Environmental Manager

Enclosures

ATTACHMENT A

Best Available Control Technology Review

Prepared for
Tesoro Refining and Marketing Company
Salt Lake City Refinery
Salt Lake City, UT

January 2016

Table of Contents

List of Tables

1.0 Executive Summary

Tesoro Refining & Marketing Company LLC's (Tesoro's) Salt Lake City (SLC) Refinery is proposing to install Ultra Low NO_X burners (ULNB) on the Ultraformer Unit (UFU) Furnace F-1. The Project will replace the existing burners in the UFU Furnace F-1 with ULNB and is being undertaken primarily to meet the $PM_{2.5}$ SIP requirements. The Project will result in an estimated actual reduction in NO_X emissions of 13 tons/yr. Further, the Project will not result in a significant emission increase or significant net emission increase in air emissions of any regulated New Source Review (NSR) pollutant from the refinery; therefore, the Project is not subject to federal NSR requirements as provided in Utah's State Implementation Plan (SIP). However, Utah Administrative Code, Air Quality Rule R307-401-3(c) requires submittal of a Notice of Intent (NOI) to "install a control apparatus or other equipment intended to control emissions of air contaminants." Additionally under R307-401-5(d), the NOI must include, "an analysis of best available control technology for the proposed source or modification" for any unit that will be both physically modified and experience an increase in emissions as a result of the project. Accordingly, Tesoro is submitting this Best Available Control Technology (BACT) analysis for the UFU, which will experience a small increase in emissions of particulate matter and volatile organic compounds as a result of the installation of the ULNB on the UFU. This BACT analysis follows the following approach:

- Step 1 – Identify All Available Control Technologies
- Step 2 – Eliminate Technically Infeasible Options
- Step 3 – Rank Remaining Control Technologies by Control Effectiveness
- Step 4 – Evaluate Most Effective Control Technologies and Document Results
- Step 5 – Select BACT

2.0 BACT Methodology

As presented in R307-401-2 (d):

""Best available control technology" means an emissions limitation (including a visible emissions standard) based on the maximum degree of reduction for each air contaminant which would be emitted from any proposed stationary source or modification which the director, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 40 CFR parts 60 and 61. If the director determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard or combination thereof, may be prescribed instead to satisfy the requirement for the application of best available control technology. Such standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and shall provide for compliance by means which achieve equivalent results."

For purposes of this analysis, the proposed BACT emissions limits have been selected using the approach set forth above.

Step 1 – Identify all Control Technologies

All available control technologies are identified. A control technology is considered available for a specific pollutant if it could practically be applied to the specific emission unit. To identify all available control technologies, the following sources were consulted:

- EPA's RACT/BACT/LAER Clearinghouse (RBLC);
- EPA's Clean Air Technology Center (CATC) website;
- Control Technology Vendors; and/or
- Other EPA/State air quality permits.

Step 2 – Eliminate Technically Infeasible Options

Each control technology identified in Step 1 is evaluated, using source-specific factors, to determine if it is technically feasible. If physical, chemical and engineering principles demonstrate that a technology could not be successfully used on the emission unit, then that technology is determined to be technically infeasible. Economics are not considered in the determination of technical feasibility. Technologies that are determined to be infeasible are eliminated from further consideration.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

All technically feasible technologies are ranked in order of overall control effectiveness. Rankings are based on the level of emission control expressed as emissions per unit of production, emissions per unit of energy used, control efficiency, or a similar measure. The control effectiveness listed will be representative of the level of emission control which can be achieved by the control technology at the operating conditions of the emission unit being reviewed. Controls are listed in order of overall control effectiveness for the pollutant under review, with the most effective control alternative at the top.

Step 4 – Evaluate Most Effective Control Technologies and Document Result

The economic, environmental, and energy impacts of each technically feasible control technology are evaluated. Step 4 is only required if the most effective control technology is not proposed as BACT.

Step 5 – Select BACT

The most effective option not rejected is BACT. Per R307-401-2(d), if technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of BACT.

3.0 BACT for Modified UFU Furnace F-1

3.1 UFU Furnace F-1 PM/PM_{10}/$PM_{2.5}$ Emissions

Particulate matter including PM less than 10 microns in diameter (PM_{10}) and PM less than 2.5 microns in diameter ($PM_{2.5}$) has the potential to be emitted from UFU Furnace F-1 as a result of incomplete combustion, particulate matter present in the combustion air, and solid and condensable materials contained in gaseous fuels. The existing UFU Furnace F-1 uses refinery fuel gas. This BACT report consolidates the BACT analysis for PM, PM_{10}, and $PM_{2.5}$ because particulate matter from gaseous fuel firing can all be considered to be fine particulate less than 1.0 micron in size.[1]

3.1.1 Step 1 – Identify All Available Control Technologies for PM/PM_{10}/$PM_{2.5}$ Emissions

Potentially available control options for PM/PM_{10}/$PM_{2.5}$ emissions from combustion at UFU Furnace F-1 are shown in the table below:

Table 3-1 PM/PM_{10}/$PM_{2.5}$ Emission Control Options for UFU Furnace F-1

Technology	Description
Add-On Control Technologies	Add-on particulate control technologies, such as a baghouse or electrostatic precipitator (ESP), are control technologies that reduce primarily filterable particulate emissions entrained in the exhaust gas stream.
Clean Fuels	Both refinery fuel gas and natural gas contain very low concentrations of ash and other forms of particulate matter, thus the use of the gaseous fuel minimizes PM/PM_{10}/$PM_{2.5}$ emissions.
Good Combustion Practices	Good combustion practices are preventative measures that minimize the release of pollutants generated from incomplete combustion of fuels into the environment. Good combustion practices may include the proper design and maintenance of equipment, good housekeeping, and good operating practices.

3.1.2 Step 2 – Technical Feasibility of PM/PM_{10}/$PM_{2.5}$ Control Options as Applied to UFU Furnace F-1

The use of add-on control technologies, such as a baghouse, electrostatic precipitator, or wet scrubber, can provide particulate matter control for solid and liquid fuel combustion applications by removing filterable PM. However, these add-on control technologies are not effective for gaseous

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[1] AP 42, Chapter 1.4 Table 1.4-2, http://www3.epa.gov/ttn/chief/ap42/ch01/final/c01s04.pdf

fuel post-combustion emissions control due to the very low filterable PM outlet concentrations and the capture limitations of the control technologies.

EPA's emissions factor information for natural gas combustion provided in AP-42, lists the filterable particulate matter concentration for natural gas combustion at 0.0015 gr/dscf exhaust, which is lower than the post-combustion outlet range achievable with add-on control devices. Additionally, it is expected that the particulate emission rates for refinery fuel gas combustion are consistent with the natural gas factors from AP-42 and also are below the post-combustion outlet range achievable with add-on control devices. Accordingly, add on controls are not proposed because they will not reduce emissions for this source fired by refinery fuel gas.

It is Tesoro's understanding that no add-on control technologies for particulate emissions have been applied to reduce particulate emissions from a gas-fired refinery process heater. Additionally, there were no applications of add-on particulate control technologies for gas fuel gas fired process heaters identified in the RBLC or any of the other references reviewed as part of this BACT analysis, as listed in Section 1.0 above. This is most likely because gaseous fuels have almost no inert materials or ash, and therefore, the "uncontrolled" filterable particulate emissions from the combustion of these gaseous fuels is as low (or lower) than a controlled filterable particulate emission rate from a solid or liquid fuel combustion source that uses an air pollution control technology such as a baghouse.

Consequently, there is no add-on control technology that is technically feasible for controlling PM/PM_{10}/ $PM_{2.5}$ emissions at UFU Furnace F-1. Adherence to good combustion practices with the use of refinery fuel gas are the only technically feasible control options for control of particulate emissions.

3.1.3 Step 3 – Rank Effectiveness of Feasible PM/PM_{10}/$PM_{2.5}$ Control Options

Tesoro will combine good combustion practices with the use of refinery fuel gas as clean fuels because those options are the only technically feasible PM/PM_{10}/$PM_{2.5}$ control options for UFU Furnace F-1. Ranking of the control measures is not necessary because both can be used in combination.

3.1.4 Step 4 – Evaluation of Most Effective PM/PM_{10}/$PM_{2.5}$ Control Options

Tesoro has selected the only technically feasible, and thus the top ranked, control options. There are no adverse energy, environmental, or economic impacts associated with implementing good combustion practices or with the use of refinery fuel gas at UFU Furnace F-1.

3.1.5 Step 5 – $PM/PM_{10}/PM_{2.5}$ BACT Selection

Good combustion practices in conjunction with the use of refinery fuel gas is the proposed BACT for particulate emissions from UFU Furnace F-1. Total particulate emissions, including PM, PM_{10} and $PM_{2.5}$, from UFU Furnace F-1 have been estimated using the AP-42 emission factor of 0.0075 lb/MMBtu for natural gas combustion, which is a representative estimate of the $PM/PM_{10}/PM_{2.5}$ emissions that may result from refinery fuel gas combustion. Per AP-42 all PM (total, condensable, and filterable) that results from gaseous fuel combustion can be considered to be less than 1.0 micrometer in diameter; therefore the PM emission factor can be used to estimate PM, PM_{10} and $PM_{2.5}$. To ensure continued operation applying good combustion techniques, Tesoro will conduct heater tune-ups in accordance with 40 C.F.R. Part 63, Subpart DDDDD. Actions taken during each tune up will follow the schedule required for this unit under NESHAP Subpart DDDDD.

3.2 UFU Furnace F-1 VOC Emissions

VOC is emitted from UFU Furnace F-1 as a result of incomplete combustion of hydrocarbons. VOC formation is dependent on the efficiency of the process heaters. Emissions are result of low operating temperature, insufficient residence time, inadequate mixing, and/or low air-to-fuel ratio in the combustion zone. Additionally, trace amounts of VOC species in the refinery fuel gas (e.g., formaldehyde and benzene) may also contribute to VOC emissions if they are not completely combusted in the unit.

3.2.1 Step 1 – Identify All Available Control Technologies for VOC Emissions

Potentially available control options for VOC emissions from UFU Furnace F-1 are shown in the table below:

Table 3-2 VOC Emission Control Options

Technology	Description
Catalytic Oxidation	Catalytic oxidation of VOC gases requires a catalyst bed located in the exhaust of the unit being controlled where VOCs are converted to CO_2 and water vapor in the presence of excess air in the combustion exhaust stream. For gaseous fired combustion units reduction efficiency can reach up to 50%. The optimal range for oxidation catalysts is approximately 850 to 1,100 °F.
Proper Burner Design and Good Combustion Practices	Good design includes process and mechanical equipment designs which are either inherently lower polluting or are designed to minimize emissions and achieve good combustion efficiency. Good combustion practice includes operational and design elements to control the amount and distribution of excess air in the flue gas. This ensures that there is enough oxygen present for complete combustion. If sufficient combustion air supply, temperature, residence time, and mixing are incorporated in the combustion design and operation, VOC emissions are minimized.

3.2.2 Step 2 – Technical Feasibility of VOC Control Options as Applied to UFU Furnace F-1

The technical feasibility of potential control options for VOC emissions are summarized in the below table.

Table 3-3 Technical Feasibility of VOC Control Options for UFU Furnace F-1

Technology	Technically Feasible?
Catalytic Oxidation	No
Proper Burner Design and Good Combustion Practices	Yes

Tesoro contacted vendors regarding VOC removal by catalytic oxidation. Vendors have indicated that saturated hydrocarbon removal can only be achieved at temperatures above 800°F, which will be above the normal operating range of the process heater, making catalytic oxidation infeasible for VOC control.

3.2.3 Step 3 – Effectiveness of Feasible VOC Control Options

Proper burner design and good combustion practices is the only technically feasible VOC control option at UFU Furnace F-1 and is therefore the top ranked control.

3.2.4 Step 4 – Evaluation of Most Effective VOC Control Options

Tesoro has selected the only technically feasible, and thus the top ranked, control option. There are no adverse energy, environmental, or economic impacts associated with implementing proper burner design and good combustion practices. The only control strategy identified for the refinery fuel gas-fired process heaters is adherence to good combustion practices. This control strategy is technically feasible and will not cause adverse energy, environmental, or economic impacts.

3.2.5 Step 5 – VOC BACT Selection

Adherence to good combustion practices is the proposed BACT for VOC emissions from UFU Furnace F-1. The UFU Furnace F-1 will implement good combustion practices, including preventative measures that minimize the release of pollutants into the environment. Good combustion practice includes operational and design elements to control the amount and distribution of excess air in the flue gas. This ensures that there is enough oxygen present for complete combustion. Since sufficient combustion air supply, temperature, residence time, and mixing are incorporated in the combustion design and operation, VOC emissions are minimized. To ensure continued operation applying good combustion techniques, Tesoro will conduct heater tune-ups in accordance with 40 C.F.R. Part 63, Subpart DDDDD. Actions taken during each tune up will follow the schedule required for this unit under NESHAP Subpart DDDDD.

The VOC emissions from UFU Furnace F-1 have been estimated using the AP-42 emission factor of 0.0054 lb/MMBtu for natural gas combustion, which is a representative estimate of the VOC emissions that may result from refinery fuel gas combustion at UFU Furnace F-1.

ATTACHMENT B

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 1 - PSD Applicability Determination and Reasonable Possiblity Requirements

	NO_X	**SO_2**	**CO**	**PM**	**PM_{10}**	**$PM_{2.5}$**	**VOC**	**H_2SO_4**
Project Emission Increases	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
F-1	0.00	0.00	0.00	0.40	0.40	0.40	0.29	0.00
Cogen	0.72	0.25	0.78	0.10	0.10	0.10	0.05	0.00
Components	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00
Total Project Emission Increase	**0.72**	**0.25**	**0.78**	**0.50**	**0.50**	**0.50**	**2.76**	**0.00**
PSD Significant Emission Rate (SER)	40	40	100	25	15	10	40	7
Is Project Emission Increase Greater than PSD Significant Emission Rate?	No	No	No	No	No	No	No	No

Reasonable Possibility Requirements

	NO_X	**SO_2**	**CO**	**PM**	**PM_{10}**	**$PM_{2.5}$**	**VOC**	**H_2SO_4**
	tpy	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
Project Emission Increase	0.72	0.25	0.78	0.50	0.50	0.50	2.76	0.00
Demand Growth Exclusion	0.00	1.98	0.00	0.46	0.46	0.46	0.33	0.03
Project Emission Increase + Demand Growth Exclusion	0.72	2.23	0.78	0.96	0.96	0.96	3.09	0.03
PSD Significant Emission Rate (SER)	40	40	100	25	15	10	40	7
Is Project Emission Increase Greater than 1/2 of the PSD Significant Emission Rate?	No	No	No	No	No	No	No	No
Is Project Emission Increase + Demand Growth Exclusion Greater than 1/2 of the PSD Significant Emission Rate?	No	No	No	No	No	No	No	No
Is Preconstruction Determination Required?	No	No	No	No	No	No	No	No
Is Recordkeeping of Annual Actual Emissions Required?	No	No	No	No	No	No	No	No

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Nov-07	3.73	0.18	2.46	0.22	0.22	0.22	0.16	0.00	9.23	59,823	83.81
Dec-07	3.34	0.13	2.21	0.20	0.20	0.20	0.14	0.00	7.48	53,547	75.02
Jan-08	4.42	0.20	2.76	0.25	0.25	0.25	0.18	2.97E-03	9.99	67,048	99.19
Feb-08	3.92	0.17	2.70	0.24	0.24	0.24	0.18	2.48E-03	9.31	65,564	88.01
Mar-08	4.69	0.23	2.77	0.25	0.25	0.25	0.18	3.50E-03	10.32	67,207	105.29
Apr-08	4.71	0.32	2.87	0.26	0.26	0.26	0.19	4.84E-03	10.23	69,596	105.70
May-08	4.77	0.32	2.95	0.27	0.27	0.27	0.19	4.87E-03	10.29	71,560	107.25
Jun-08	4.25	0.56	3.15	0.28	0.28	0.28	0.21	8.42E-03	9.65	76,467	95.45
Jul-08	4.45	0.61	3.04	0.27	0.27	0.27	0.20	9.14E-03	9.92	73,790	99.96
Aug-08	4.39	0.35	2.73	0.25	0.25	0.25	0.18	5.24E-03	9.55	66,154	98.67
Sep-08	4.13	0.27	2.56	0.23	0.23	0.23	0.17	4.02E-03	9.17	62,123	92.76
Oct-08	3.81	0.21	2.55	0.23	0.23	0.23	0.17	3.08E-03	8.24	61,939	85.54
Nov-08	4.27	0.16	2.65	0.24	0.24	0.24	0.17	2.39E-03	7.81	64,230	83.73
Dec-08	4.25	0.14	2.63	0.24	0.24	0.24	0.17	2.16E-03	7.59	63,912	78.90
Jan-09	4.87	0.22	3.02	0.27	0.27	0.27	0.20	3.28E-03	7.90	73,267	85.84
Feb-09	4.38	0.13	2.71	0.25	0.25	0.25	0.18	1.96E-03	8.42	65,848	83.95
Mar-09	4.50	0.25	2.79	0.25	0.25	0.25	0.18	3.82E-03	10.06	67,742	101.51
Apr-09	4.47	0.28	2.77	0.25	0.25	0.25	0.18	4.22E-03	9.59	67,260	90.20
May-09	5.29	0.33	3.28	0.30	0.30	0.30	0.21	4.88E-03	10.16	79,555	105.69
Jun-09	4.96	0.35	3.07	0.28	0.28	0.28	0.20	5.28E-03	10.31	74,579	101.40
Jul-09	5.02	0.45	3.11	0.28	0.28	0.28	0.20	6.73E-03	10.44	75,487	102.10
Aug-09	4.57	0.38	2.83	0.26	0.26	0.26	0.19	5.75E-03	9.52	68,763	89.28
Sep-09	4.63	0.35	2.87	0.26	0.26	0.26	0.19	5.18E-03	9.95	69,687	90.07
Oct-09	4.48	0.31	2.78	0.25	0.25	0.25	0.18	4.68E-03	9.09	67,400	87.47
Nov-09	3.61	0.27	2.61	0.24	0.24	0.24	0.17	4.10E-03	9.48	63,324	84.42
Dec-09	3.22	0.15	2.33	0.21	0.21	0.21	0.15	2.32E-03	5.65	56,538	64.12
Jan-10	4.49	0.27	3.24	0.29	0.29	0.29	0.21	4.09E-03	9.70	78,759	92.27
Feb-10	3.63	0.36	2.62	0.24	0.24	0.24	0.17	5.44E-03	9.98	63,601	85.56
Mar-10	1.09	0.02	0.79	0.07	0.07	0.07	0.05	3.25E-04	1.25	19,186	19.90
Apr-10	4.03	0.17	2.91	0.26	0.26	0.26	0.19	2.57E-03	7.05	70,673	70.77
May-10	4.56	0.35	3.29	0.30	0.30	0.30	0.22	5.31E-03	10.74	79,965	104.62
Jun-10	4.22	0.36	3.05	0.28	0.28	0.28	0.20	5.34E-03	10.39	74,092	96.31
Jul-10	4.51	0.49	3.26	0.29	0.29	0.29	0.21	7.38E-03	10.75	79,122	107.65
Aug-10	4.60	0.46	3.32	0.30	0.30	0.30	0.22	6.94E-03	10.87	80,633	106.30

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Sep-10	4.30	0.29	3.10	0.28	0.28	0.28	0.20	4.41E-03	10.57	75,363	99.00
Oct-10	4.56	0.29	3.30	0.30	0.30	0.30	0.22	4.31E-03	10.09	79,985	95.87
Nov-10	3.20	0.16	2.71	0.25	0.25	0.25	0.18	2.36E-03	7.84	65,892	72.03
Dec-10	3.53	0.24	3.00	0.27	0.27	0.27	0.20	3.63E-03	10.24	72,776	95.80
Jan-11	3.42	0.30	2.90	0.26	0.26	0.26	0.19	4.48E-03	9.00	70,446	83.78
Feb-11	2.96	0.25	2.51	0.23	0.23	0.23	0.16	3.73E-03	9.46	60,963	79.36
Mar-11	3.65	0.32	3.10	0.28	0.28	0.28	0.20	4.74E-03	10.11	75,339	94.55
Apr-11	3.61	0.31	3.07	0.28	0.28	0.28	0.20	4.65E-03	9.98	74,535	93.72
May-11	3.49	0.29	2.97	0.27	0.27	0.27	0.19	4.34E-03	9.85	71,991	94.68
Jun-11	3.42	0.26	2.91	0.26	0.26	0.26	0.19	3.84E-03	9.25	70,612	86.83
Jul-11	4.09	0.34	3.47	0.31	0.31	0.31	0.23	5.05E-03	NA	84,303	109.77
Aug-11	3.92	0.34	3.33	0.30	0.30	0.30	0.22	5.05E-03	NA	80,753	109.75
Sep-11	3.94	0.37	3.35	0.30	0.30	0.30	0.22	5.62E-03	NA	81,334	120.73
Oct-11	3.82	0.28	3.21	0.29	0.29	0.29	0.21	4.14E-03	NA	77,932	96.53
Nov-11	3.29	0.17	2.76	0.25	0.25	0.25	0.18	2.49E-03	NA	67,069	80.81
Dec-11	3.10	0.13	2.60	0.24	0.24	0.24	0.17	1.91E-03	NA	63,203	66.44
Jan-12	3.28	0.16	2.76	0.25	0.25	0.25	0.18	2.33E-03	7.57	67,010	82.15
Feb-12	3.05	0.16	2.57	0.23	0.23	0.23	0.17	2.41E-03	7.31	62,283	76.46
Mar-12	4.07	0.31	3.42	0.31	0.31	0.31	0.22	4.67E-03	9.38	83,059	105.11
Apr-12	4.12	0.30	3.46	0.31	0.31	0.31	0.23	4.45E-03	9.81	83,988	102.71
May-12	4.07	0.28	3.43	0.31	0.31	0.31	0.22	4.22E-03	9.18	83,158	100.28
Jun-12	4.45	0.35	3.75	0.34	0.34	0.34	0.25	5.26E-03	11.10	90,908	109.11
Jul-12	4.41	0.39	3.71	0.34	0.34	0.34	0.24	5.84E-03	10.17	90,090	105.43
Aug-12	4.60	0.30	3.87	0.35	0.35	0.35	0.25	4.53E-03	10.52	93,923	111.37
Sep-12	4.31	0.27	3.62	0.33	0.33	0.33	0.24	4.08E-03	10.37	87,929	106.86
Oct-12	3.96	0.21	3.33	0.30	0.30	0.30	0.22	3.21E-03	8.85	80,761	96.80
Nov-12	4.51	0.34	3.79	0.34	0.34	0.34	0.25	5.04E-03	10.08	91,973	110.42
Dec-12	3.47	0.24	3.33	0.30	0.30	0.30	0.22	3.54E-03	8.68	80,775	97.05
Jan-13	3.59	0.30	3.44	0.31	0.31	0.31	0.23	4.56E-03	8.74	83,483	96.82
Feb-13	2.93	0.27	2.80	0.25	0.25	0.25	0.18	4.07E-03	8.56	68,030	82.81
Mar-13	4.07	0.56	3.90	0.35	0.35	0.35	0.26	8.37E-03	10.47	94,614	116.13
Apr-13	2.98	0.76	2.86	0.26	0.26	0.26	0.19	1.14E-02	7.75	69,392	100.84
May-13	3.59	0.57	3.44	0.31	0.31	0.31	0.22	8.54E-03	9.48	83,391	114.61
Jun-13	4.02	0.52	3.85	0.35	0.35	0.35	0.25	7.73E-03	11.04	93,567	104.98

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Jul-13	4.20	0.43	4.02	0.36	0.36	0.36	0.26	6.50E-03	11.11	97,568	111.13
Aug-13	3.61	0.27	3.46	0.31	0.31	0.31	0.23	4.05E-03	9.69	84,032	93.20
Sep-13	3.21	0.28	3.08	0.28	0.28	0.28	0.20	4.15E-03	8.92	74,749	82.92
Oct-13	3.59	0.15	3.44	0.31	0.31	0.31	0.22	2.22E-03	9.80	83,379	87.20
Nov-13	3.58	0.11	3.11	0.28	0.28	0.28	0.20	1.66E-03	9.06	75,393	82.87
Dec-13	3.65	0.15	3.16	0.29	0.29	0.29	0.21	2.30E-03	8.71	76,790	74.68
Jan-14	4.21	0.14	3.65	0.33	0.33	0.33	0.24	2.13E-03	9.93	88,626	86.57
Feb-14	3.04	0.16	2.63	0.24	0.24	0.24	0.17	2.46E-03	8.26	63,934	69.82
Mar-14	4.07	0.26	3.53	0.32	0.32	0.32	0.23	3.89E-03	10.43	85,608	95.01
Apr-14	3.86	0.22	3.35	0.30	0.30	0.30	0.22	3.33E-03	10.67	81,325	86.00
May-14	3.97	0.24	3.44	0.31	0.31	0.31	0.23	3.54E-03	10.69	83,610	88.44
Jun-14	3.70	0.24	3.21	0.29	0.29	0.29	0.21	3.54E-03	10.44	77,808	81.59
Jul-14	4.04	0.42	3.50	0.32	0.32	0.32	0.23	6.37E-03	10.56	84,958	89.12
Aug-14	3.85	0.32	3.34	0.30	0.30	0.30	0.22	4.77E-03	10.52	81,122	81.89
Sep-14	3.67	0.24	3.19	0.29	0.29	0.29	0.21	3.56E-03	9.82	77,324	79.40
Oct-14	4.19	0.25	3.63	0.33	0.33	0.33	0.24	3.69E-03	11.14	88,221	88.58
Nov-14	3.63	0.13	3.15	0.28	0.28	0.28	0.21	2.00E-03	10.08	76,450	79.72
Dec-14	3.60	0.13	2.82	0.26	0.26	0.26	0.18	2.01E-03	8.78	68,519	80.72
Jan-15	3.73	0.07	2.93	0.26	0.26	0.26	0.19	1.09E-03	8.95	71,090	76.17
Feb-15	3.77	0.09	2.96	0.27	0.27	0.27	0.19	1.40E-03	9.95	71,783	76.11
Mar-15	0.77	0.00	0.60	0.05	0.05	0.05	0.04	4.01E-05	1.78	14,590	13.50
Apr-15	1.46	0.03	1.14	0.10	0.10	0.10	0.07	4.89E-04	4.45	27,718	22.30
May-15	4.01	0.11	3.15	0.28	0.28	0.28	0.21	1.64E-03	9.30	76,384	38.73
Baseline Period Ends:	**Oct-09**	**Jul-13**	**Mar-14**	**Mar-14**	**Mar-14**	**Mar-14**	**Mar-14**	**Jul-13**	--	--	--
Baseline Actual Emissions (tpy):	**53.16**	**4.00**	**41.32**	**3.74**	**3.74**	**3.74**	**2.70**	**0.06**	--	--	--

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Monthly Maximum Throughput During Baseline (mmbtu):	79,555	121	97,568	97,568	97,568	97,568	97,568	121	11.14	97,568	120.73
Occurs:	May-09	Sep-11	Jul-13	Jul-13	Jul-13	Jul-13	Jul-13	Sep-11	Oct-14	Jul-13	Sep-11

Emission Factor References

[1] Nov-07 through Oct-08: 11/18/04 stack test results of 89.04 lb/MMscf.
Nov-08 through Oct-09: 10/21/08 stack test results of 0.133 lb/MMBtu.
Nov-09 through Oct-10: 10/21/09 stack test results of 0.114 lb/MMBtu.
Nov-10 through Sept-11: 10/28/10 stack test results of 0.097 lb/MMBtu.
Oct-11 through Nov-12: 9/13/11 stack test results of 0.098 lb/MMBtu.
Dec-12 through Oct-13: 11/20/12 stack test results of 0.086 lb/MMBtu
Nov-13 through Nov-14: 10/13/13 stack test results of 0.095 lb/MMBtu
Dec-14 through May-15: 11/17/14 stack test results of 0.105 lb/MMBtu

[2] SO2 (tons) = Monthly average fuel gas H2S contents (ppmv) / 385.34 ft3/lb-mol * 64 lb/lb-mol * MMscf / 2000 lb/ton

[3] Emission factor of 0.0824 lb/MMBtu per AP-42 Table 1.4-1.

[4] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.

[5] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.

[6] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.

[7] Emission factor of 5.39E-03 lb/MMBtu per AP-42 Table 1.4-2.

[8] Assumed to be 1.5% of total SO2 emissions consistent with TRI reporting.

[9] Measured throughput rates, higher heating value (HHV).

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 3a - Projected Actual Emission Calculations for Ultraformer Unit Furnace F-1

Quantity	Value	Units	Reference
Projected Firing Rate:	129.89	Mscf/hr	Calculated
	140.77	MMBtu/hr (HHV)	Engineering estimate, based on projected post project firing rate
Fuel HHV:	1083.8	Btu/scf	Engineering estimate
Fuel H_2S Content:	50	ppmvd	Engineering estimate
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units (HHV)	Projected Emissions (lb/hr) [1]	Projected Emissions (tpy) [2]	Emission Factor Reference
NO_X	0.065	lb/MMBtu	9.15	40.08	Manufacturer's Emission Guarantee
SO_2	8.31	lb/MMscf	1.08	4.73	Calculated
CO	0.050	lb/MMBtu	7.04	30.83	Manufacturer's estimate
PM	0.00745	lb/MMBtu	1.05	4.59	AP-42 Table 1.4-2
PM_{10}	0.00745	lb/MMBtu	1.05	4.59	AP-42 Table 1.4-2
$PM_{2.5}$	0.00745	lb/MMBtu	1.05	4.59	AP-42 Table 1.4-2
VOC	5.39E-03	lb/MMBtu	0.76	3.32	AP-42 Table 1.4-2
H_2SO_4	0.12	lb/MMscf	1.62E-02	7.09E-02	TRI calculation (1.5% of SO2 emissions)

[1] Projected Emissions (lb/hr) = Emission Factor (lb/MMBtu) x Projected Firing Rate (MMBtu/hr) or
Projected Emissions (lb/hr) = Emission Factor (lb/MMscf) x Projected Firing Rate (Mscf/hr) / 1000 Mscf/MMscf

[2] Emission Increase (tpy) = Projected Emissions (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 3b - Projected Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X [1]	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	
	tpy	tpy	tpy	tpy	tpy	tpy	tpy	tpy	**Reference**
A. Baseline Actual Emissions	53.16	4.00	41.32	3.74	3.74	3.74	2.70	0.06	Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
B. Capable of Accommodating	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09	See below.
C. Projected Emissions	40.08	4.73	30.83	4.59	4.59	4.59	3.32	0.07	
D. Demand Growth (D=B-A)	0.00	1.98	0.00	0.46	0.46	0.46	0.33	0.03	
E. Projected Actual Emissions (E=C-D)	40.08	2.74	30.83	4.14	4.14	4.14	2.99	0.04	
F. Emission Increase (F=E-A)	0.00	0.00	0.00	0.40	0.40	0.40	0.29	0.00	

B. Capable of Accommodating	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	**Notes**
Annual Emission Limits (ton/yr)	CAP	CAP	N/A	N/A	CAP	N/A	N/A	N/A	
Representative Monthly Throughput during Baseline Period (Units/mo)	79,555	120.73	97,568	97,568	97,568	97,568	97,568	120.73	
Month that this occurred:	May-09	Sep-11	Jul-13	Jul-13	Jul-13	Jul-13	Jul-13	Sep-11	
Throughput that Unit was Capable of Accommodating (Units/year)	917,964	1,439.51	1,125,812	1,125,812	1,125,812	1,125,812	1,125,812	1,439.51	Assumes a 98% utilization factor.
Representative Emission Factor that Unit was Capable of Accommodating (lb/Units)	0.065	8.31	0.05	7.45E-03	7.45E-03	7.45E-03	5.39E-03	0.12	
Units	MMBtu	MMscf	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMscf	HHV
Emissions the Unit was Capable of Accommodating during Baseline Period (ton/yr)	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09	

[1] Due to installation of Ultra Low NO_X burners, and the corresponding decrease in NO_X emission factor, capable of accommodating emissions are less than the baseline actual emissions. Therefore, the NO_X emissions increase analysis does not include a demand growth component.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 4 - Potential Emission Calculations for Process Components

Components (service)	**UFU/Fuel Gas** Count [1]	Emission Factor [2] (kg/hr/source)	(lb/hr/source)	Control Effectiveness [3] (%)	Emissions (lbs/yr)	Emissions (Tons/yr)
Valves (gas)	216	0.0268	0.059083	96	4,472	2.24
Valves (LL)	0	0.0109	0.024030	95	-	-
Valves (HL)	0	0.00023	0.000507	0	-	-
Flanges (gas)	408	0.00025	0.00055	81	374	0.19
Flanges (LL)	0	0.00025	0.00055	81	-	-
Flanges (HL)	0	0.00025	0.00055	81	-	-
Pump Seals (LL)	0	0.114	0.25	88	-	-
Pump Seals LL (Tandem)	0	0.114	0.25	100	-	-
Pump Seal (HL)	0	0.021	0.046	0	-	-
Comp. Seals (gas)	0	0.636	1.4	100	-	-
Comp. Seals (H_2)	0	0.636	1.402	100	-	-
Process Drains (total)	0	0.073	0.161	100	-	-
Relief Valves (gas)	0	0.16	0.35	100	-	-
Total					4,846	2.42

Gas = material in a gaseous state at operating conditions
LL = light liquid = material in a liquid state in which the sum of the concentration of individual constituents with a vapor pressure over 0.3 kilopascals (kPa) at 20 oC is greater than or equal to 20 wt%.
HL = heavy liquid = not in gas/vapor service or light liquid service.
In VOC service means that the piece of equipment contains or contacts a process fluid that is at least 10 percent VOC by weight. (40 CFR 60.481)

Notes:

[1] Estimated counts based on P&ID drawings plus a 50% safety factor to be conservative.
[2] Protocol for Equipment Leak Emission Estimates, November 1995, Table 2-2. Refinery Average Emission Factors.
[3] Protocol for Equipment Leak Emission Estimates, November 1995, Table 5-3. Control Effectiveness for an LDAR Program at a Refinery Process Unit. Monitored under the Consent Decree leak definition of 500 ppm, quarterly with no chance for skip monitoring. Equivalent to HON regulation.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 5: Stack Emission Calculations for Cogeneration Units

Quantity	Value	Units	Reference
Steam Requirement:	2,100	lb/hr	Engineering estimate
Firing Requirement:	2.31	MMBtu/hr	Engineering estimate
Fuel Heat Content, HHV:	1083.8	Btu/scf	Engineering estimate for future operations
Fuel Use Requirement:	0.0021	MMscf/hr	Calculated
Fuel H_2S Content:	162	ppmvd	NSPS Ja H_2S concentration limit
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units (HHV)	Emission Increase (lb/hr) (1)	Emission Increase (tpy) (2)	Reference
NO_X	76.80	lb/MMscf	0.16	0.72	Maximum stack test result from 2009 for East Cogeneration Unit
SO_2	26.91	lb/MMscf	5.73E-02	0.25	Calculated
CO	84	lb/MMscf	0.18	0.78	AP-42 Table 3.1-1
PM	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
PM_{10}	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
$PM_{2.5}$	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
VOC	5.5	lb/MMscf	1.17E-02	5.13E-02	AP-42 Table 1.4-2
H_2SO_4	0.40	lb/MMscf	8.60E-04	3.77E-03	TRI calculation (1.5% of SO2 emissions)

Notes:

(1) Emission Increase (lb/hr) = Emission Factor (lb/MMBtu) x Fuel Use Requirement (MMBtu/hr) or
Emission Increase (lb/hr) = Emission Factor (lb/MMscf) x Fuel Use Requirement (MMscf/hr)

(2) Emission Increase (tpy) = Emission Increase (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton

NSR

RECEIVED
NOV 10 2015
DEPARTMENT OF
ENVIRONMENTAL QUALITY

TESORO

Tesoro Refining & Marketing Company LLC
474 West 900 North
Salt Lake City, UT 84103

HAND DELIVERED

November 10, 2015

Marty Gray, Major NSR Section Manager
Utah Division of Air Quality
195 North 1950 West
P.O. Box 144820
Salt Lake City, Utah 84114-4820

Re: Tesoro Salt Lake City Refinery Installation of Ultra-Low NOx Burners Ultraformer Unit F-1 Furnace NOI Submittal

Dear Mr. Gray:

Enclosed please find a Notice of Intent (NOI) application for the installation of Ultra-Low NOx Burners on the Ultraformer Unit (UFU) F-1 Furnace. This project will occur at the Tesoro Refining and Marketing Company's (Tesoro's) Salt Lake City (SLC) Refinery which operates under Approval Order (AO) DAQE-AN103350065-14.

Included is a receipt for $2300 which covers the filing fee and the base fee (Existing Major Source with a Minor Modification) for the NOI application.

Please contact me at 801-521-4966 or Michelle Bujdoso at 801-366-2036 if you need more information or have questions.

Sincerely,

William Snarr
Health, Safety and Environmental Manager

Enclosures

RECEIVED
NOV 10 2015
DEPARTMENT OF
ENVIRONMENTAL QUALITY

Installation of Ultra-Low NO_X Burners on Ultraformer Unit (UFU) Furnace F-1

Notice of Intent for an Approval Order

Prepared for
Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery

November 2015

TESORO

BARR

4700 West 77th Street
Minneapolis, MN 55435-4803
Phone: (952) 832-2600
Fax: (952) 832-2601

Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1

Notice of Intent for an Approval Order

November 2015

Table of Contents

List of Tables

List of Attachments

Attachment A	Figure A-1 – Refinery Location Map
	Figure A-2 – Refinery Plot Plan
Attachment B	Emission Calculations for Project
Attachment C	Form 1 and NOI Checklist

1.0 Introduction

This Notice of Intent (NOI) package is submitted for approval of the installation of Ultra Low NO_X burners (ULNB) on the Ultraformer Unit (UFU) Furnace F-1 (Project) at the Tesoro Refining & Marketing Company LLC's (Tesoro's) Salt Lake City (SLC) Refinery. The SLC Refinery currently operates under multiple Approval Orders (AOs), of which DAQE-AN0103350065-14 for the major process units is affected by this Project. The SLC Refinery is situated on 236 acres in Salt Lake County, approximately 1.5 miles north of Salt Lake City.

This Project will replace the existing burners in the UFU Furnace F-1 with ULNB. Similar to Tesoro's project to install a Wet Gas Scrubber and LoTOx™ system on the FCCU/CO Boiler, this project is being undertaken primarily to meet the $PM_{2.5}$ SIP requirements and will result in a significant reduction in NO_X emissions. Due to project timing, Tesoro requests that the NOI for this project be processed concurrently with the Wet Gas Scrubber and and LoTOx™ system NOI.

The Project will not result in a significant emission increase or significant net emission increase in air emissions of a regulated New Source Review (NSR) pollutant from the refinery; therefore, the Project is not subject to federal NSR requirements as provided in Utah's State Implementation Plan (SIP).

Rule R307-401-3(b) requires submittal of an NOI to "make modifications or relocate an existing installation which will or might reasonably expected to increase the amount or change the effect of, or the character of, air contaminants discharged, so that such installation may be expected to become a source or indirect source of air pollution." Rule R307-401-5 requires that the NOI must contain specific information related to the process, nature of emissions, control device(s), and regulatory applicability and compliance. This NOI includes a project description, an emissions summary, and a description of regulatory applicability and demonstration of compliance to address these requirements.

This NOI is organized as follows:

- Section 2.0 contains a project description,
- Section 3.0 contains an NSR applicability analysis,
- Section 4.0 contains a description of regulatory applicability and compliance demonstration,
- Section 5.0 contains a summary of the NOI requirements,

- Attachment A contains a site diagram,
- Attachment B contains the project emission calculations,
- Attachment C contains Form 1 and the NOI checklist.

2.0 Project Description

This section includes a general description of the facility and details of the proposed Project.

2.1 General Facility Information

The Tesoro Salt Lake City Refinery is located at 474 West 900 North, Salt Lake City, Utah. The refinery is located in a nonattainment area for $PM_{2.5}$ (including precursors NO_X, SO_2, and VOC)[1], PM_{10} (including precursors SO_2 and NO_X)[2], and SO_2. The area is also a designated maintenance area for ozone (VOC and NO_X) and CO. Attachment A includes a figure that shows the location of the refinery in Salt Lake City.

2.2 Project Description

This Project involves replacement of the UFU Furnace F-1 (A through E) burners with new burners that will have Ultra Low NO_X burner (ULNB) technology. Specifically, the Project involves the following physical changes:

- UFU Furnace F-1 (A through E) burners will be replaced with new burners with ULNB technology.
- Due to the decreased size of the burner tip orifices in the ULNB, fuel gas coalescers will be installed as recommended by API 535.
- Fuel gas piping from the coalescer to the burners, including new fuel gas control valves, will be changed to stainless steel.
- The existing air pre-heater will be replaced.
- Combustion air ducting will be modified as required to accommodate the new burners, new preheater, and new fans.
- New electronic igniters will be installed.
- The existing induced draft/forced draft fans will be replaced to match the pressure drop requirements of the air pre-heater, ducting, and furnace.
- Furnace repairs will be performed as needed.
- 2,100 lb/hr of steam injection will be used for flame temperature control.

---

[1] Utah $PM_{2.5}$ Nonattainment Provisions for Salt Lake County, Section IX.A.21, December 3, 2014.

[2] Utah PM_{10} Maintenance Provisions for Salt Lake County, Section IX.A.10, July 6, 2005.

Tesoro has estimated the existing and future firing capacities of the burners and has determined it is possible that the new burners will have a slightly greater rated maximum hourly heat input capacity than the existing burners. Therefore, the short-term potential-to-emit (PTE) of pollutants other than NO_X may increase at the UFU Furnace F-1 as a result of the Project. However, future actual firing rates and actual emissions are not expected to increase. In order to demonstrate the actual emissions due to the project will not increase, Tesoro has conservatively completed emission calculations. The emission calculations included were completed in accordance with the federal Nonattainment New Source Review (NNSR) and Prevention of Significant Deterioration (PSD) preconstruction permitting programs in Section 3.0 of this application.

2.3 Modified Emission Units

The UFU Furnace F-1 is considered a modified emission unit as a result of the burner replacements. No other emission units are modified as part of this Project.

Upon Project completion, Tesoro does not expect to see an increase in actual emissions for any pollutants at the UFU Furnace. Tesoro does not intend to increase the actual furnace firing rate as a result of the Project. The Project is being undertaken to lower the NO_X emissions from the unit.

2.4 New Emission Units

Minor piping changes involving installation of new components in VOC service will occur as part of this Project.

2.5 Affected Non-Modified Emission Units

The Project does not relieve constraints of any process units at the refinery. The firing rate at the UFU Furnace F-1 does not currently restrict production rate at the UFU. The installation of the new ULNB will not have any upstream or downstream impacts on the refinery's operation. However, a small amount of additional steam from the facility's Cogeneration Units (CG1 and CG2) will be required to assist the operation of the ULNB. Therefore, the Cogeneration Units are non-modified emissions units that will be affected by the Project.

2.6 Project Schedule

The estimated start of construction date is June 2016, pending permit approval. The UFU is expected to restart operations in November 2016, assuming permit approval by the estimated date for start of construction.

3.0 NSR Applicability Analysis

Utah rules implement the New Source Review (NSR) permitting program for major sources and major modifications. Rule R307-403 and R307-405 implement the federal Nonattainment New Source Review (NNSR) and Prevention of Significant Deterioration (PSD) preconstruction permitting programs, respectively. The Tesoro SLC Refinery is a major source as defined in Utah Rule R307-100 and in these federal permitting programs. Therefore, Tesoro has completed an applicability analysis to determine if this Project is a major modification as defined under Utah rules and the NSR permitting program.

The NSR pollutants are covered either by the PSD or NNSR permitting programs, but for purposes of determining applicability as a major modification, the significance thresholds are the same. For simplicity, Tesoro uses the PSD definitions and rules at 40 CFR 52.21 to describe the applicability analysis. The PSD rules are incorporated by reference into the Utah rules.

On June 23, 2014, the U.S. Supreme Court issued its decision in Utility Air Regulatory Group v. EPA. The Court held that EPA may not treat greenhouse gases (GHGs) as an air pollutant for purposes of determining whether a source is a major source required to obtain a PSD or title V permit. As described in the following sections, NSR is not triggered for pollutants other than greenhouse gases (GHG). Since there is not a significant emissions increase of a regulated pollutant other than GHG, GHG is not a regulated pollutant and need not be further analyzed.

3.1 "Hybrid Test" of PSD Applicability

An NSR applicability analysis has been conducted for the Project to determine if it is a "major modification" under NSR regulations. Because this project involves the proposed modification to both "existing emission units" and "new emissions units," the "hybrid test" is used to determine if a "significant emissions increase" and a "significant net emissions increase" of a "regulated NSR pollutant" will occur. The hybrid test is described as the following:[3]

> *"... A significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the emissions increases for each emissions unit, using the method specified in paragraphs (a)(2)(iv)(c) through (e) of this section as applicable with respect to each emissions unit, for each*

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[3] 40 CFR 52.21(a)(2)(iv)(f).

> *type of emissions unit equals or exceeds the significant amount for that pollutant (as defined in paragraph (b)(23) of this section)…"*

The hybrid test refers to the use of two emissions increase calculation methods listed in paragraphs 40 CFR 52.21(a)(2)(iv)(c) and (d). The methods prescribed for existing emissions units are described further below. The remainder of this section focuses on the emissions increase test.

An increase is significant if it exceeds the annual ton per year (tpy) thresholds known as the PSD significant emission rates, which are listed in Table 3-1 for only those regulated NSR pollutants that are emitted in quantifiable amounts from emission units affected by this project.

Table 3-1. NSR Significant Emission Rates

Pollutant[A]	Significant Emission Rate (tpy)
Particulate matter (PM)	25
Particulate matter less than 10 microns (PM_{10})	15
Particulate matter less than 2.5 microns ($PM_{2.5}$)[B]	10
Sulfur dioxide (SO_2)	40
Nitrogen oxides (NO_X)	40
Carbon monoxide (CO)	100
Volatile organic compounds (VOC)	40 [C]
Sulfuric Acid Mist (H_2SO_4)	7

[A] Only those NSR pollutants that are emitted in quantifiable amounts from emission units affected by this project are shown in the table. Condensable particulate matter is included within the definition of PM_{10} and $PM_{2.5}$.

[B] The significant emission rate for direct $PM_{2.5}$ emissions is 10 tpy; additionally this includes 40 tpy of SO_2 emissions and/or 40 tpy of NO_X emissions unless they are demonstrated not to be a $PM_{2.5}$ precursor.

[C] The NSR significant emission rate is assessed based on emissions of volatile organic compounds (VOC) as a precursor to ozone.

"Net emissions increase" means the amount by which the sum of the following exceeds zero:[4]

> *"(a) The increase in emissions from a particular physical change or change in the method of operation at a stationary source as calculated pursuant to paragraph (a)(2)(iv) of this section; and*
>
> *(b) Any other increases and decreases in actual emissions at the major stationary source that are contemporaneous with the particular change and are otherwise creditable. Baseline actual*

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[4] 40 CFR 52.21(b)(3)(i).

> *emissions for calculating increases and decreases under this paragraph (b)(3)(i)(b) shall be determined as provided in paragraph (b)(48) of this section, except that paragraphs (b)(48)(i)(c) and (b)(48)(ii)(d) of this section shall not apply."*

The project emissions increase is calculated as the sum of emissions increases from the existing emissions units that are impacted by this project and the new piping components. If the project emissions increase for a regulated NSR pollutant is less than the significant emission rate, NSR is not required for that pollutant. As described in the following sections, the project emissions increase is less than the significant emission rate for each regulated NSR pollutant.

3.1.1 Actual-to-Projected-Actual Test for Existing Emissions Units

To estimate the change in emissions at the UFU Furnace F-1, Tesoro has utilized the actual-to-projected-actual applicability test which is described in 40 CFR 52.21(a)(2)(iv)(c) as follows:

> *"(c) Actual-to-projected-actual applicability test for projects that only involve existing emissions units. A significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the difference between the projected actual emissions (as defined in paragraph (b)(41) of this section) and the baseline actual emissions (as defined in paragraphs (b)(48)(i) and (ii) of this section), for each existing emissions unit, equals or exceeds the significant amount for that pollutant (as defined in paragraph (b)(23) of this section)."*

Terms within this paragraph that have specific definitions include "existing emissions unit," "projected actual emissions," and "baseline actual emissions." An "existing emissions unit" is any part of a stationary source that emits any regulated NSR pollutant and has been in existence for at least two years from the date it first operated.[5] A description of "projected actual emissions" and "baseline actual emissions" are as follows.

3.1.1.1 Projected Actual Emissions

"Projected actual emissions" are calculated as:[6]

> *"... the maximum annual rate, in tons per year, at which an existing emissions unit is projected to emit a regulated NSR pollutant in any one of the 5 years (12-month period) following the date the unit resumes regular operation after the project, or in any one of the 10 years following that date, if the project involves increasing the emissions unit's design capacity or its potential to emit that regulated NSR pollutant and full utilization of the unit would result in a significant emissions increase or a significant net emissions increase at the major stationary source."*

---

[5] 40 CFR 52.21(b)(7)(ii).

[6] 40 CFR 52.21(b)(41)(i).

A source shall consider when determining projected actual emissions any relevant business or regulatory information. In addition, fugitive emissions and emissions associated with startups, shutdowns and malfunctions must be calculated, as applicable. By definition, projected actual emissions shall exclude the portion of the emissions that an existing unit could have accommodated during the baseline period and that are also unrelated to the particular project, including any increased utilization due to product demand growth.[7] A source may use the emission unit's potential to emit in lieu of the aforementioned projected actual emissions calculation.

The projected actual throughput for the UFU Furnace F-1 is based on engineering and business projections. Projected emissions are calculated based on annual throughput and firing rate following startup of the Project and emission factors representative of expected operation. The emission factors used for the projected emissions are generally also representative of the baseline period for most pollutants. For projected actual NO_X and CO emissions, emission factors are based on ULNB manufacturer's specifications.

The product demand growth exclusions, or emissions that the unit was capable of accommodating during the baseline period, are calculated based on the maximum actual firing rate experienced during any 1-month period during the 24-month baseline period. A utilization factor of 98% was used in the calculation of annualized emissions that the emission unit was "capable of accommodating" during the baseline period. The utilization factor was multiplied by the maximum monthly observed firing rate converted to an annual rate. This utilization factor accounts for normal rate reductions that occur each year due to mechanical or supply issues. Tesoro conservatively assumes that none of these normal rate reductions occurred during the month when the maximum throughput was observed. This 98% utilization factor is equivalent to assuming 175 hours of annual downtime. It is also important to note that Tesoro did not include this utilization factor in its projected post-project operating rates. The net result is a more conservative estimate of the emissions increase. The emission factors used to calculate the product demand growth exclusion are generally consistent with those used for projected emissions.

The difference between the annualized emissions that the units were capable of accommodating and the baseline actual emissions is excluded (i.e. subtracted from) the projected emissions. The emissions increase is then calculated by subtracting the baseline actual emissions from the projected

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[7] 40 CFR 52.21(b)(41)(ii)(c).

actual emissions. This approach is consistent with that outlined by EPA Region 4 regarding an applicability analysis completed by Georgia-Pacific Wood Products, LLC.[8]

3.1.1.2 Baseline Actual Emissions

"Baseline actual emissions" for an existing emissions unit are calculated as:

> *"... the average rate, in tons per year, at which the emissions unit actually emitted the pollutant during any consecutive 24-month period selected by the owner or operator within the 10-year period immediately preceding either the date the owner or operator begins actual construction of the project, or the date a complete permit application is received by the Administrator for a permit required under this section or by the reviewing authority for a permit required by a plan, whichever is earlier, except that the 10-year period shall not include any period earlier than November 15, 1990."*

For baseline actual emissions, Tesoro has defined a 24-month baseline period specific to each NSR pollutant. Tesoro has considered emissions between May 1, 2007 and May 31, 2015, for all pollutants for its baseline emissions analysis. The 24-month baseline periods are chosen because they are considered the most representative of past and current capabilities of the UFU Furnace F-1 for those pollutants (i.e., this time period is indicative of capabilities that exist today and could be utilized with variations in crude slate or intermediates). Refer to Attachment B for documentation of the baseline periods selected and the calculated baseline actual emissions.

As with projected actual emissions, baseline actual emissions shall include fugitive emissions and emissions associated with startups, shutdowns, and malfunctions.[9] The baseline emissions are adjusted downwards to address emissions that occurred during the 24-month baseline or emissions that could have exceeded a current emission limitation.[10]

Generally, baseline actual emissions are calculated according to the following hierarchy:

1. Continuous emission monitoring system (CEMS) data
2. Stack test results and measured process data
3. Standard emission factors from public sources and measured process data (i.e. EPA's AP-42)

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[8] March 18, 2010 letter from Mr. Worley of EPA Region 4 to Mr. Robinson of Georgia-Pacific Wood Products, LLC.

[9] 40 CFR 52.21(b)(48)(ii)(a).

[10] 40 CFR 52.21(b)(48)(ii)(b)-(c).

3.1.2 Actual-to-Potential Test for New Emissions Units

To estimate emissions from new process components, Tesoro utilized the actual-to-potential test for new emissions units. In 40 CFR 52.21(a)(2)(iv)(d), the actual-to-potential applicability test is described as the following:

> *"(d) Actual-to-potential test for projects that only involve construction of a new emissions unit(s). A significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the difference between the potential to emit (as defined in paragraph (b)(4) of this section) from each new emissions unit following completion of the project and the baseline actual emissions (as defined in paragraph (b)(48)(iii) of this section) of these units before the project equals or exceeds the significant amount for that pollutant (as defined in paragraph (b)(23) of this section)."*

Terms within this paragraph that have specific definitions include "new emissions unit," "potential to emit," and "baseline actual emissions." A "new emissions unit" is any part of a stationary source that emits any regulated NSR pollutant and is or will be newly constructed and has existed for less than two years from the date such emissions unit first operated.[11] A description of "potential to emit" and "baseline actual emissions" are as follows.

"Potential to emit" is defined as: [12]

> *"... the maximum capacity of a stationary source to emit a pollutant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitation or the effect it would have on emissions is federally enforceable..."*

The potential to emit for an emissions unit yet to be constructed is generally calculated as the product of its hourly maximum throughput or heat input capacity and an emission factor, which may be from EPA documents (e.g., AP-42), a manufacturer performance guarantee, existing regulatory standards (e.g., a New Source Performance Standard), or from other information sources. Federally enforceable emission limitations on the capacity of the source to emit a pollutant (e.g., air pollution control equipment, restriction on hours of operation) may be taken to reduce the unit's potential to emit.

The methodology in this section may also be applied to estimate maximum emissions from existing emission units to reduce post-project annual emission recordkeeping requirements.

---

[11] 40 CFR 52.21(b)(7)(ii).
[12] 40 CFR 52.21(b)(4).

3.1.3 Methodology for Non-Modified Existing Units

As previously described, the Cogeneration Units will not be modified but may experience an increase in emissions. The EPA recognizes in its PSD rules that non-modified existing units experiencing an emissions increase as a result of the project need to be considered in the overall emissions increase calculation. For non-modified emission units, EPA allows for calculating the emissions increase as the product of the potential increase in throughput due to the project and an emissions factor representative of "worst-case" operations. The "potential increase in utilization" approach is consistent with the 1980 NSR rules and has been maintained for existing emissions units in the existing rules through §52.21(b)(41)(ii)(d), which allows a PTE approach in lieu of future actual emissions.

3.2 Affected Units at the Salt Lake City Refinery

All existing, non-modified emission units at the Salt Lake City Refinery were reviewed to determine if the project will result in an emissions increase. Units that will or may experience an emissions increase due to the project (i.e., be affected by the project) are presented in Table 3-2.

Table 3-2. Summary of Affected Emission Units

Emission Unit	New / Existing	Modified / Non-modified
UFU Furnace F-1	Existing	Modified
Cogeneration Unit CG1 and CG2	Existing	Non-modified
New/Replaced Components	New	N/A

3.3 Calculation of Emissions

Tesoro has calculated the change in emissions expected at the emissions units affected by the Project as described further below. Details are included in Attachment B.

3.3.1 New Equipment and Piping Components in VOC Service

New equipment and piping components in VOC service will be installed as part of this Project. The emissions increase is calculated based upon the counts of new components to be added plus a safety factor for conservatism.

The USEPA Protocol for Equipment Leak Emission Estimates is used to quantify potential emissions from the new components installed as part of this Project. The final number of installed components will likely change from this estimate after additional detailed design/engineering is performed;

however, the change in VOC emissions from this activity is not appreciable and will not change the PSD applicability determination.

3.3.2 Cogeneration Units

The Project will result in additional steam demand required to control the flame temperature of the new ULNB. The emission factors are based on AP-42 emissions factors, the estimated sulfur content of the fuel gas, stack test results, and manufacturer specifications.

3.4 Project Emissions Increase Summary

Table 3-3 presents a summary of the Project emissions increase. The Project emissions increase are less than their respective NSR significant emission rates for each regulated pollutant; therefore the Project does not trigger NSR.

Table 3-3. Project Actual Emission Increase Summary[13]

Emissions Unit	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
	tpy	tpy	tpy	tpy	tpy	tpy	tpy	tpy
UFU Furnace F-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cogeneration Units	0.72	0.25	0.78	0.10	0.10	0.10	0.05	0.00
New Process Components	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00
Total Project Emission Increase	**0.72**	**0.25**	**0.78**	**0.10**	**0.10**	**0.10**	**2.47**	**0.00**

---

[13] Although NO_X emissions will decrease from the UFU Furnace F-1, the sum of the change in emissions from an emissions unit that results in a negative number is not included in the total Project's emissions.

3.4.1 "Reasonable Possibility" Requirements

On December 21, 2007, the US EPA promulgated updates to the federal PSD rules at 40 CFR 52.21(r)(6)(vi) that defines when an owner/operator of a major source is required to conduct recordkeeping and reporting when using the baseline-actual-to-projected-actual emissions increase calculation methodology. The Utah Air Quality Board has adopted the federal PSD rules as they existed in the Code of Federal Regulations on July 1, 2008, at R307-405.

A "reasonable possibility" occurs when the project is calculated to result in either:[14]

> *"(a) A projected actual emissions increase of at least 50 percent of the amount that is a "significant emissions increase," as defined under paragraph (b)(40) of this section (without reference to the amount that is a significant net emissions increase), for the regulated NSR pollutant; or*
>
> *(b) A projected actual emissions increase that, added to the amount of emissions excluded under paragraph (b)(41)(ii)(c) of this section, sums to at least 50 percent of the amount that is a "significant emissions increase," as defined under paragraph (b)(40) of this section (without reference to the amount that is a significant net emissions increase), for the regulated NSR pollutant. For a project for which a reasonable possibility occurs only within the meaning of paragraph (r)(6)(vi)(b) of this section, and not also within the meaning of paragraph (r)(6)(vi)(a) of this section, then provisions (r)(6)(ii) through (v) do not apply to the project."*

A summary of reasonable possibility applicability and requirements is shown in Table 3-4 below. Since emissions do not exceed 50% of the significance rate for any pollutant, reasonable possibility recordkeeping requirements do not apply.

---

[14] 40 CFR 52.21(r)(6)(vi)(*a*)-(*b*)

Table 3-4. Summary of Reasonable Possibility Applicability and Requirements

Pollutant	Emission Increase (tons/yr)	Significant Emission Rate (SER) (tons/yr)	Percentage of SER (%)
NO_X	0.72	40	1.8%
SO_2	0.25	40	0.6%
CO	0.78	100	0.8%
PM	0.10	25	0.4%
PM_{10}	0.10	15	0.7%
$PM_{2.5}$	0.10	10	1.0%
VOC	2.47	40	6.2%
H_2SO_4	0.00	7	0.1%

4.0 Regulatory Applicability and Compliance Demonstration

In addition to the PSD analysis detailed in Section 3.0, Tesoro has completed an applicability review of all Federal and State air quality regulations as part of the air permit application process. Table 4-1 provides a summary of the major air quality programs that were reviewed for the Project. Each regulation which requires explanation is described in the following sections. Certain aspects of the Project result in the triggering of new applicable requirements.

Table 4-1. Summary of Air Quality Regulatory Applicability for the Project

Report Section	Program Description	Regulatory Citation	Does This Project Trigger New Applicable Requirements?
---	National Ambient Air Quality Standards (NAAQS)	40 CFR 50	No
3.0	New Source Review (NSR)	40 CFR 52	No
4.1	New Source Performance Standards (NSPS)	40 CFR 60	Yes
4.2	National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR 61	No
4.2	NESHAPs for Source Categories	40 CFR 63	No
---	Risk Management Programs for Chemical Accidental Release Prevention	40 CFR 68	No
---	Title V Operating Permit	40 CFR 70	No
---	Acid Rain Requirements	40 CFR 72	No
---	Stratospheric Ozone Protection Requirements	40 CFR 82	No
---	**Utah State Rules**	**UAC R307**	---
4.1	Stationary Sources	R307-210	Yes
4.2	National Emission Standards for Hazardous Air Pollutants	R307-214	No
4.3	Ozone Nonattainment and Maintenance Areas: Control of Hydrocarbon Emissions in Petroleum Refineries	R307-326	Yes
---	Ozone Nonattainment and Maintenance Areas: Petroleum Liquid Storage	R307-327	No
4.4	Permit: New and Modified Sources	R307-401	Yes
4.5	Nonattainment and Maintenance Areas	R307-403	No
4.6	Permits: Major Sources in Attainment or Unclassified Areas (PSD)	R307-405	No

Report Section	Program Description	Regulatory Citation	Does This Project Trigger New Applicable Requirements?
4.7	Visibility	R307-406	No
4.8	Permits: Emissions Impact Analysis	R307-410	No
4.9	Permits: Ozone Offset Requirements in Davis and Salt Lake Counties	R307-420	No

4.1 R307-210: Stationary Sources

New Source Performance Standards (NSPS) are incorporated by reference into the UDAQ rules. There is no new construction of any NSPS affected facilities. Tesoro reviewed whether the Project will result in a "modification" or "reconstruction" for any NSPS affected facilities, and thus result in applicability of that NSPS. The NSPS regulation, at 40 CFR §60.14(a), defines a modification as a physical or operational change to the affected facility that is not specifically exempted and that results in an increase in the emissions rate to the atmosphere of any pollutant to which a standard applies. An increase in production rate, if that increase can be accomplished without a capital expenditure on that facility, is not considered a modification per §60.14(e)(2). "Increase in emissions rate" is defined pursuant to §60.14(b) as an increase in the maximum hourly emission rate of an applicable pollutant from the affected facility. A reconstruction occurs when the fixed capital cost of the project is 50 percent or greater than the current replacement cost of the affected facility.

The physical changes performed as part of the Project affect only the UFU Furnace F-1. Applicability to 40 CFR 60 Subpart Ja is discussed below in additional detail.

Regulatory coverage for other NSPS subparts currently applicable to the facility will not change as a result of this Project.

4.1.1 Subpart Ja: Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After May 14, 2007

NSPS Subpart Ja applies to various facilities in petroleum refineries, including process heaters as "fuel gas combustion devices." For process heaters, NSPS Ja regulates NO_X and SO_2 emissions. Tesoro has reviewed the applicability of Subpart Ja UFU Furnace F-1. Per 40 CFR 60.14(a), "*any physical or operational change to an existing facility which results in an increase in the emission rate to the atmosphere of any pollutant to which a standard applies shall be considered a modification.*" 40 CFR 60.14(e) provides exemptions for modification including "*the addition or use* *of any system or device whose primary function is the reduction of air pollutants, except when an emission control system is removed or is replaced by a system which the Administrator determines to be less environmentally beneficial*". The Project is to install ULNB on the Ultraformer Furnace F-1; the new burner's primary function is to reduce air pollution. Therefore, this NSPS exemption could apply to the Project. However, Tesoro has conservatively assumed that the Project results in a modification of UFU Furnace F-1, resulting in applicability of NSPS Subpart Ja for SO_2. In addition to the pollution control exemption above, the maximum hourly emission rate of NO_X will decrease because of installation of the ULNB.

Reconstruction is defined at 40 CFR 60.15(b) as the replacement of components of an existing facility such that the fixed capital cost of the project is 50 percent or greater than the current replacement cost of the affected facility. The cost of the Project is estimated to be approximately 28 percent of the current replacement cost of the UFU Furnace F-1; therefore, this Project does not result in reconstruction of the unit as defined under NSPS.

4.2 R307-214: National Emission Standards for Hazardous Air Pollutants

NESHAP standards from 40 CFR 61 and 40 CFR 63 are incorporated by reference into the UDAQ rules. The physical changes performed as part of the Project only affects the UFU Furnace F-1. The UFU Furnace F-1 is currently subject to 40 CFR 63 Subpart DDDDD for "National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters." Tesoro will continue to comply with the emission standards for an existing affected facility and other requirements of this rule. No new requirements will be triggered as a result of this Project.

Tesoro also considered whether a reconstruction[15] would occur, which would affect the compliance date. Reconstruction is defined at 40 CFR 63.2 as the replacement of components of a source such that the fixed capital cost of the project exceeds 50 percent of the current replacement cost of the source. The cost of the new burners is estimated to be approximately 28 percent of the current replacement cost of the UFU Furnace F-1; therefore, this Project does not result in reconstruction of the unit as defined under 40 CFR 63.2.

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[15] There are no provisions for "modification" under 40 CFR 63 as there are under 40 CFR 60.

Regulatory coverage for other subparts currently applicable to the facility will not change as a result of this Project.

4.3 R307-326: Ozone Nonattainment and Maintenance Areas: Control of Hydrocarbon Emissions in Petroleum Refineries

Rule R307-326-9 contains requirements for leaks from petroleum refinery equipment. New process components associated with the Project will be subject to the repair, recordkeeping, and reporting requirements of the rule. Following the Project, Tesoro will continue to comply with the requirements of this rule for the new process components installed as part of the Project.

4.4 R307-401: Permit: New and Modified Sources

Rule R307-401-3(b) requires submittal of an NOI to "make modifications or relocate an existing installation which will or might reasonably be expected to increase the amount or change the effect of, or the character of, air contaminants discharged, so that such installation may be expected to become a source or indirect source of air pollution." The Project may increase the amount of air contaminants discharged from the Cogeneration Units and from new process components. Rule R307-401-5 requires submittal of an NOI, which must contain specific information related to the process, nature of emissions, control device(s), and regulatory applicability and compliance. Refer to Section 5.0 for a summary of compliance with the NOI requirements.

4.4.1 Low Oxides of Nitrogen Burner Technology

Rule R307-401-4 requires installation of low oxides of nitrogen burners or equivalent oxides of nitrogen controls whenever existing fuel combustion burners are replaced, unless such equipment is not physically practical or cost effective. Tesoro is meeting this requirement by installing ULNB at the Ultraformer Furnace F-1.

4.4.2 BACT

Rule R307-401-5(d) permits the issuance of an approval order if it is determined that the pollution control for emissions is at least best available control technology (BACT). A BACT review is required for new emission units and existing emission units where there is a physical modification and an increase in emissions. The UFU Furnace F-1 is the only existing emissions unit undergoing a physical modification; however, as discussed in Section 3.0 and shown in Attachment B, there will not be an increase in emissions from this unit.

New process components will meet BACT by meeting the requirements of NSPS Subpart GGGa.

4.5 R307-403: Nonattainment and Maintenance Areas

R307-403 applies to major new sources or major modifications to be located in a nonattainment area. The proposed project is neither a new major source nor a major modification as defined in R307-101-2 since the actual emissions increase is less than the significant emission rate (SER) thresholds. Refer to Section 3.4 for a summary of this determination.

4.5.1 R307-403-5: Offsets: PM_{10} Nonattainment Area

Emission offsets are required if the combined allowable emission increase of PM_{10}, SO_2, and NO_x exceeds 25 tons per year. The combined allowable emission increase from the project is zero (0) tons per year. Therefore, no emission offsets are required.

4.6 R307-405: Permits: Major Sources in Attainment or Unclassified Areas (PSD)

This project is not a major modification and is not subject to the PSD program as described in Section 3.0. Refer to Section 3.4 for a summary of this determination. Tesoro has demonstrated compliance with all applicable requirements with the submission of this NOI. Therefore the requirements of R307-405 are not applicable to this proposed project.

4.7 R307-406: Visibility

R307-406 applies to major new sources or major modifications. This Project is not a new major source or a major modification; therefore the provisions of this rule are not applicable.

4.8 R307-410: Permits: Emissions Impact Analysis

R307-410 establishes the procedures and requirements for evaluating the emissions impact of new or modified sources. Pursuant to R307-410-4, dispersion modeling is required for increases in the total controlled emission rate of attainment pollutants (NO_X and CO for the SLC refinery) in an amount greater or equal to values given in Table 1 of the rule. For these pollutants, the thresholds given in Table 1 are equal to the SERs. Dispersion modeling is not required since the increases in emissions of NO_X and CO are less than the SERs.

4.8.1 R307-410-5: Ambient Air Impacts for Hazardous Air Pollutants

The requirements of R307-410-5 requires sources to provide documentation of increases in emissions of hazardous air pollutants prior to receiving an approval order. The rule requires each applicant's notice of intent to include the estimated maximum pounds per hour emission rate increase from each affected installation. Per R307-410-5(1)(a)(i), this rule does not apply to installations which are subject to or are scheduled to be subject to an emission standard promulgated under 42 USC 7412 at the time the NOI is submitted. As described in Section 4.2, the UFU Furnace F-1 is subject to 40 CFR 63 Subpart DDDDD. In addition, there will be not be a lb/hr emission rate increase of HAP at the Cogeneration Units. Therefore, the requirements of R307-410-5 do not apply to the Project.

4.9 R307-420: Permits: Ozone Offset Requirements in Davis and Salt Lake Counties

The SLC Refinery is located in a maintenance area for ozone. Emission offsets are required for any new major source or major modification of VOC or NO_X. The project is neither a new major source nor a major modification for VOC or NO_X, therefore offsets are not required.

5.0 Summary of NOI Requirements for Project

Table 5-1 provides a summary of how this NOI complies with the specific requirements of Rule R307-401-5(2).

Table 5-1. Summary of NOI Requirements

Requirement	Section Reference for Information Provided
(a) A description of the nature of the processes involved; the nature, procedures for handling and quantities of raw materials; the type and quantity of fuels employed; and the nature and quantity of finished product.	Section 2.2
(b) Expected composition and physical characteristics of effluent stream both before and after treatment by any control apparatus, including emission rates, volume, temperature, air contaminant types, and concentration of air contaminants.	Section 3.0
(c) Size, type and performance characteristics of any control apparatus.	N/A
(d) An analysis of best available control technology for the proposed source or modification. When determining best available control technology for a new or modified source in an ozone nonattainment or maintenance area that will emit volatile organic compounds or nitrogen oxides, the owner or operator of the source shall consider EPA Control Technique Guidance (CTG) documents and Alternative Control Technique documents that are applicable to the source. Best available control technology shall be at least as stringent as any published CTG that is applicable to the source.	Section 4.4.2
(e) Location and elevation of the emission point and other factors relating to dispersion and diffusion of the air contaminant in relation to nearby structures and window openings, and other information necessary to appraise the possible effects of the effluent.	Attachment A – location provided – other info not needed since modeling is not required.
(f) The location of planned sampling points and the tests of the completed installation to be made by the owner or operator when necessary to ascertain compliance.	Not applicable – no new testing is necessary to demonstrate compliance.

Requirement	Section Reference for Information Provided
(g) The typical operating schedule.	Section 2.2
(h) A schedule for construction.	Section 2.6
(i) Any plans, specifications and related information that are in final form at the time of submission of notice of intent.	No plans or specifications are in final form at the time of this submission.
(j) Any additional information required by:	
(i) R307-403, Permits: New and Modified Sources in Nonattainment Areas and Maintenance Areas;	(i) Section 4.5
(ii) R307-405, Permits: Major Sources in Attainment or Unclassified Areas (PSD);	(ii) Section 4.6
(iii) R307-406, Visibility;	(iii) Section 4.7
(iv) R307-410, Emissions Impact Analysis;	(iv) Section 4.8
(v) R307-420, Permits: Ozone Offset Requirements in Davis and Salt Lake Counties;	(v) Section 4.9
(vi) R307-421, Permits: PM10 Offset Requirements in Salt Lake County and Utah County.	N/A
(k) Any other information necessary to determine if the proposed source or modification will be in compliance with Title R307.	Section 4.1 (NSPS Compliance) Section 4.2 (MACT Compliance) Section 4.3 (Control of Hydrocarbons)

Attachment A

Figure A-1 – Refinery Location Map

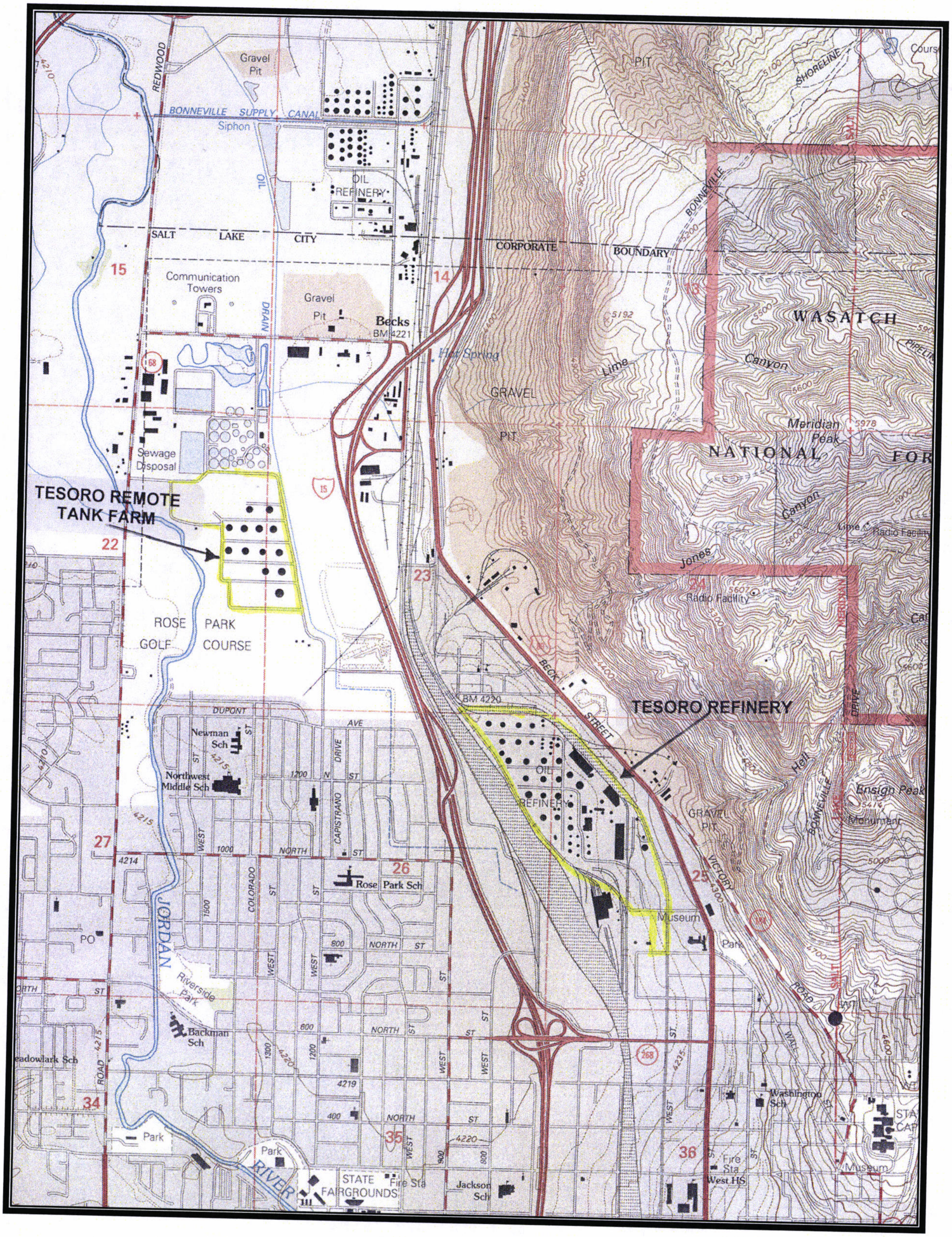
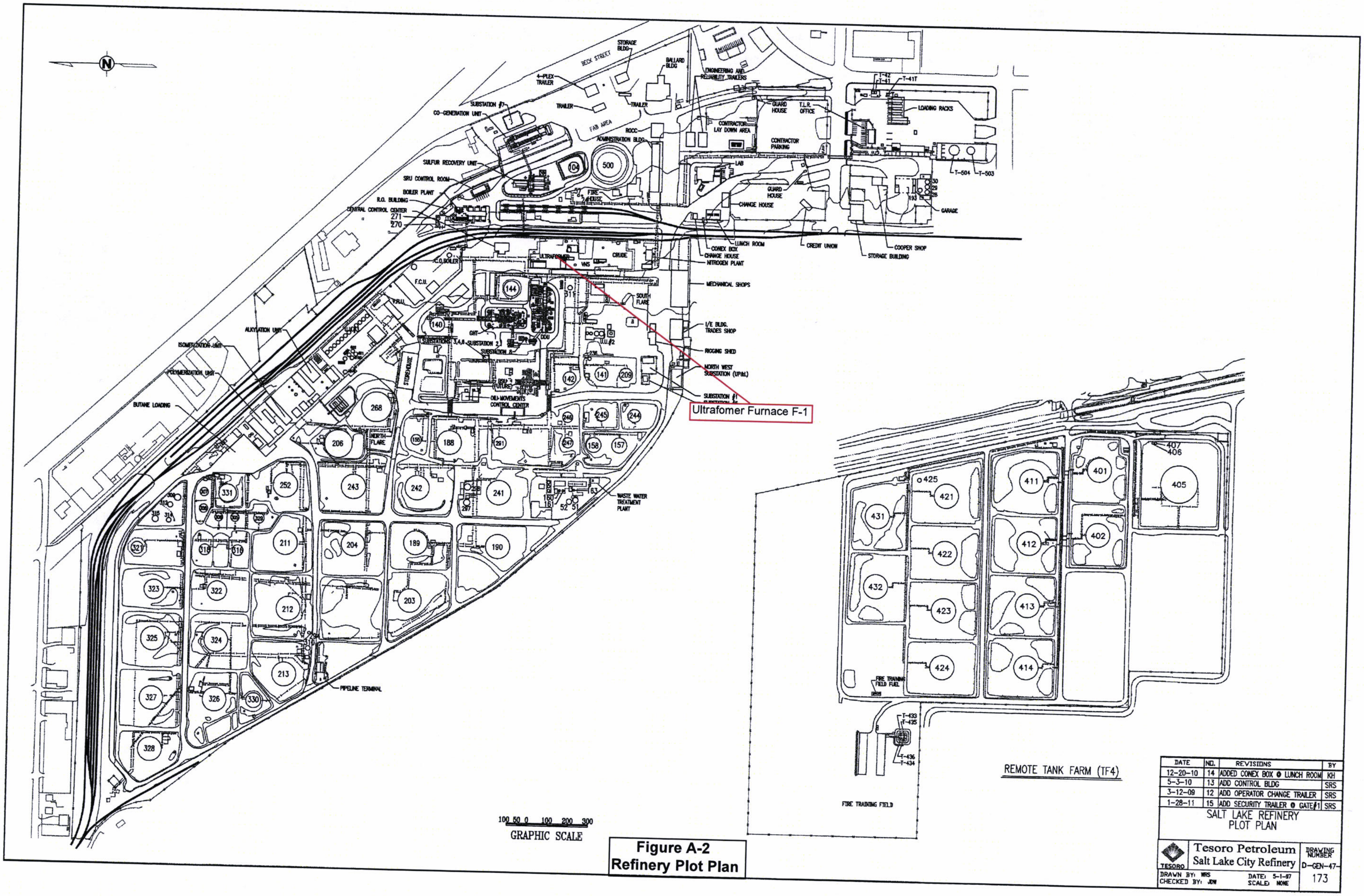


Figure A-1
Refinery Location Map

Attachment A

Figure A-2 – Refinery Plot Plan



DATE	NO.	REVISIONS	BY
12-20-10	14	ADDED CONEX BOX @ LUNCH ROOM	KH
5-3-10	13	ADD CONTROL BLDG	SRS
3-12-09	12	ADD OPERATOR CHANGE TRAILER	SRS
1-28-11	15	ADD SECURITY TRAILER @ GATE#1	SRS

SALT LAKE REFINERY
PLOT PLAN

TESORO
Tesoro Petroleum
Salt Lake City Refinery

DRAWING NUMBER
D-GEN-47-173

DRAWN BY: WRS
CHECKED BY: JDW
DATE: 5-1-97
SCALE: NONE

Figure A-2
Refinery Plot Plan

Attachment B

Emission Calculations for Project

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 1 - PSD Applicability Determination and Reasonable Possiblity Requirements

	NO_X	**SO_2**	**CO**	**PM**	**PM_{10}**	**$PM_{2.5}$**	**VOC**	**H_2SO_4**
Project Emission Increases	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
F-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cogen	0.72	0.25	0.78	0.10	0.10	0.10	0.05	0.00
Components	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00
Total Project Emission Increase	**0.72**	**0.25**	**0.78**	**0.10**	**0.10**	**0.10**	**2.47**	**0.00**
PSD Significant Emission Rate (SER)	40	40	100	25	15	10	40	7
Is Project Emission Increase Greater than PSD Significant Emission Rate?	No	No	No	No	No	No	No	No

Reasonable Possibility Requirements

	NO_X	**SO_2**	**CO**	**PM**	**PM_{10}**	**$PM_{2.5}$**	**VOC**	**H_2SO_4**
	tpy	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
Project Emission Increase	0.72	0.25	0.78	0.10	0.10	0.10	2.47	0.00
Demand Growth Exclusion	0.00	1.98	0.00	0.46	0.46	0.46	0.33	0.03
Project Emission Increase + Demand Growth Exclusion	0.72	2.23	0.78	0.56	0.56	0.56	2.81	0.03
PSD Significant Emission Rate (SER)	40	40	100	25	15	10	40	7
Is Project Emission Increase Greater than 1/2 of the PSD Significant Emission Rate?	No	No	No	No	No	No	No	No
Is Project Emission Increase + Demand Growth Exclusion Greater than 1/2 of the PSD Significant Emission Rate?	No	No	No	No	No	No	No	No
Is Preconstruction Determination Required?	No	No	No	No	No	No	No	No
Is Recordkeeping of Annual Actual Emissions Required?	No	No	No	No	No	No	No	No

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Nov-07	3.73	0.18	2.46	0.22	0.22	0.22	0.16	0.00	9.23	59,823	83.81
Dec-07	3.34	0.13	2.21	0.20	0.20	0.20	0.14	0.00	7.48	53,547	75.02
Jan-08	4.42	0.20	2.76	0.25	0.25	0.25	0.18	2.97E-03	9.99	67,048	99.19
Feb-08	3.92	0.17	2.70	0.24	0.24	0.24	0.18	2.48E-03	9.31	65,564	88.01
Mar-08	4.69	0.23	2.77	0.25	0.25	0.25	0.18	3.50E-03	10.32	67,207	105.29
Apr-08	4.71	0.32	2.87	0.26	0.26	0.26	0.19	4.84E-03	10.23	69,596	105.70
May-08	4.77	0.32	2.95	0.27	0.27	0.27	0.19	4.87E-03	10.29	71,560	107.25
Jun-08	4.25	0.56	3.15	0.28	0.28	0.28	0.21	8.42E-03	9.65	76,467	95.45
Jul-08	4.45	0.61	3.04	0.27	0.27	0.27	0.20	9.14E-03	9.92	73,790	99.96
Aug-08	4.39	0.35	2.73	0.25	0.25	0.25	0.18	5.24E-03	9.55	66,154	98.67
Sep-08	4.13	0.27	2.56	0.23	0.23	0.23	0.17	4.02E-03	9.17	62,123	92.76
Oct-08	3.81	0.21	2.55	0.23	0.23	0.23	0.17	3.08E-03	8.24	61,939	85.54
Nov-08	4.27	0.16	2.65	0.24	0.24	0.24	0.17	2.39E-03	7.81	64,230	83.73
Dec-08	4.25	0.14	2.63	0.24	0.24	0.24	0.17	2.16E-03	7.59	63,912	78.90
Jan-09	4.87	0.22	3.02	0.27	0.27	0.27	0.20	3.28E-03	7.90	73,267	85.84
Feb-09	4.38	0.13	2.71	0.25	0.25	0.25	0.18	1.96E-03	8.42	65,848	83.95
Mar-09	4.50	0.25	2.79	0.25	0.25	0.25	0.18	3.82E-03	10.06	67,742	101.51
Apr-09	4.47	0.28	2.77	0.25	0.25	0.25	0.18	4.22E-03	9.59	67,260	90.20
May-09	5.29	0.33	3.28	0.30	0.30	0.30	0.21	4.88E-03	10.16	79,555	105.69
Jun-09	4.96	0.35	3.07	0.28	0.28	0.28	0.20	5.28E-03	10.31	74,579	101.40
Jul-09	5.02	0.45	3.11	0.28	0.28	0.28	0.20	6.73E-03	10.44	75,487	102.10
Aug-09	4.57	0.38	2.83	0.26	0.26	0.26	0.19	5.75E-03	9.52	68,763	89.28
Sep-09	4.63	0.35	2.87	0.26	0.26	0.26	0.19	5.18E-03	9.95	69,687	90.07
Oct-09	4.48	0.31	2.78	0.25	0.25	0.25	0.18	4.68E-03	9.09	67,400	87.47
Nov-09	3.61	0.27	2.61	0.24	0.24	0.24	0.17	4.10E-03	9.48	63,324	84.42
Dec-09	3.22	0.15	2.33	0.21	0.21	0.21	0.15	2.32E-03	5.65	56,538	64.12
Jan-10	4.49	0.27	3.24	0.29	0.29	0.29	0.21	4.09E-03	9.70	78,759	92.27
Feb-10	3.63	0.36	2.62	0.24	0.24	0.24	0.17	5.44E-03	9.98	63,601	85.56
Mar-10	1.09	0.02	0.79	0.07	0.07	0.07	0.05	3.25E-04	1.25	19,186	19.90
Apr-10	4.03	0.17	2.91	0.26	0.26	0.26	0.19	2.57E-03	7.05	70,673	70.77
May-10	4.56	0.35	3.29	0.30	0.30	0.30	0.22	5.31E-03	10.74	79,965	104.62
Jun-10	4.22	0.36	3.05	0.28	0.28	0.28	0.20	5.34E-03	10.39	74,092	96.31
Jul-10	4.51	0.49	3.26	0.29	0.29	0.29	0.21	7.38E-03	10.75	79,122	107.65
Aug-10	4.60	0.46	3.32	0.30	0.30	0.30	0.22	6.94E-03	10.87	80,633	106.30

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Sep-10	4.30	0.29	3.10	0.28	0.28	0.28	0.20	4.41E-03	10.57	75,363	99.00
Oct-10	4.56	0.29	3.30	0.30	0.30	0.30	0.22	4.31E-03	10.09	79,985	95.87
Nov-10	3.20	0.16	2.71	0.25	0.25	0.25	0.18	2.36E-03	7.84	65,892	72.03
Dec-10	3.53	0.24	3.00	0.27	0.27	0.27	0.20	3.63E-03	10.24	72,776	95.80
Jan-11	3.42	0.30	2.90	0.26	0.26	0.26	0.19	4.48E-03	9.00	70,446	83.78
Feb-11	2.96	0.25	2.51	0.23	0.23	0.23	0.16	3.73E-03	9.46	60,963	79.36
Mar-11	3.65	0.32	3.10	0.28	0.28	0.28	0.20	4.74E-03	10.11	75,339	94.55
Apr-11	3.61	0.31	3.07	0.28	0.28	0.28	0.20	4.65E-03	9.98	74,535	93.72
May-11	3.49	0.29	2.97	0.27	0.27	0.27	0.19	4.34E-03	9.85	71,991	94.68
Jun-11	3.42	0.26	2.91	0.26	0.26	0.26	0.19	3.84E-03	9.25	70,612	86.83
Jul-11	4.09	0.34	3.47	0.31	0.31	0.31	0.23	5.05E-03	NA	84,303	109.77
Aug-11	3.92	0.34	3.33	0.30	0.30	0.30	0.22	5.05E-03	NA	80,753	109.75
Sep-11	3.94	0.37	3.35	0.30	0.30	0.30	0.22	5.62E-03	NA	81,334	120.73
Oct-11	3.82	0.28	3.21	0.29	0.29	0.29	0.21	4.14E-03	NA	77,932	96.53
Nov-11	3.29	0.17	2.76	0.25	0.25	0.25	0.18	2.49E-03	NA	67,069	80.81
Dec-11	3.10	0.13	2.60	0.24	0.24	0.24	0.17	1.91E-03	NA	63,203	66.44
Jan-12	3.28	0.16	2.76	0.25	0.25	0.25	0.18	2.33E-03	7.57	67,010	82.15
Feb-12	3.05	0.16	2.57	0.23	0.23	0.23	0.17	2.41E-03	7.31	62,283	76.46
Mar-12	4.07	0.31	3.42	0.31	0.31	0.31	0.22	4.67E-03	9.38	83,059	105.11
Apr-12	4.12	0.30	3.46	0.31	0.31	0.31	0.23	4.45E-03	9.81	83,988	102.71
May-12	4.07	0.28	3.43	0.31	0.31	0.31	0.22	4.22E-03	9.18	83,158	100.28
Jun-12	4.45	0.35	3.75	0.34	0.34	0.34	0.25	5.26E-03	11.10	90,908	109.11
Jul-12	4.41	0.39	3.71	0.34	0.34	0.34	0.24	5.84E-03	10.17	90,090	105.43
Aug-12	4.60	0.30	3.87	0.35	0.35	0.35	0.25	4.53E-03	10.52	93,923	111.37
Sep-12	4.31	0.27	3.62	0.33	0.33	0.33	0.24	4.08E-03	10.37	87,929	106.86
Oct-12	3.96	0.21	3.33	0.30	0.30	0.30	0.22	3.21E-03	8.85	80,761	96.80
Nov-12	4.51	0.34	3.79	0.34	0.34	0.34	0.25	5.04E-03	10.08	91,973	110.42
Dec-12	3.47	0.24	3.33	0.30	0.30	0.30	0.22	3.54E-03	8.68	80,775	97.05
Jan-13	3.59	0.30	3.44	0.31	0.31	0.31	0.23	4.56E-03	8.74	83,483	96.82
Feb-13	2.93	0.27	2.80	0.25	0.25	0.25	0.18	4.07E-03	8.56	68,030	82.81
Mar-13	4.07	0.56	3.90	0.35	0.35	0.35	0.26	8.37E-03	10.47	94,614	116.13
Apr-13	2.98	0.76	2.86	0.26	0.26	0.26	0.19	1.14E-02	7.75	69,392	100.84
May-13	3.59	0.57	3.44	0.31	0.31	0.31	0.22	8.54E-03	9.48	83,391	114.61
Jun-13	4.02	0.52	3.85	0.35	0.35	0.35	0.25	7.73E-03	11.04	93,567	104.98

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Jul-13	4.20	0.43	4.02	0.36	0.36	0.36	0.26	6.50E-03	11.11	97,568	111.13
Aug-13	3.61	0.27	3.46	0.31	0.31	0.31	0.23	4.05E-03	9.69	84,032	93.20
Sep-13	3.21	0.28	3.08	0.28	0.28	0.28	0.20	4.15E-03	8.92	74,749	82.92
Oct-13	3.59	0.15	3.44	0.31	0.31	0.31	0.22	2.22E-03	9.80	83,379	87.20
Nov-13	3.58	0.11	3.11	0.28	0.28	0.28	0.20	1.66E-03	9.06	75,393	82.87
Dec-13	3.65	0.15	3.16	0.29	0.29	0.29	0.21	2.30E-03	8.71	76,790	74.68
Jan-14	4.21	0.14	3.65	0.33	0.33	0.33	0.24	2.13E-03	9.93	88,626	86.57
Feb-14	3.04	0.16	2.63	0.24	0.24	0.24	0.17	2.46E-03	8.26	63,934	69.82
Mar-14	4.07	0.26	3.53	0.32	0.32	0.32	0.23	3.89E-03	10.43	85,608	95.01
Apr-14	3.86	0.22	3.35	0.30	0.30	0.30	0.22	3.33E-03	10.67	81,325	86.00
May-14	3.97	0.24	3.44	0.31	0.31	0.31	0.23	3.54E-03	10.69	83,610	88.44
Jun-14	3.70	0.24	3.21	0.29	0.29	0.29	0.21	3.54E-03	10.44	77,808	81.59
Jul-14	4.04	0.42	3.50	0.32	0.32	0.32	0.23	6.37E-03	10.56	84,958	89.12
Aug-14	3.85	0.32	3.34	0.30	0.30	0.30	0.22	4.77E-03	10.52	81,122	81.89
Sep-14	3.67	0.24	3.19	0.29	0.29	0.29	0.21	3.56E-03	9.82	77,324	79.40
Oct-14	4.19	0.25	3.63	0.33	0.33	0.33	0.24	3.69E-03	11.14	88,221	88.58
Nov-14	3.63	0.13	3.15	0.28	0.28	0.28	0.21	2.00E-03	10.08	76,450	79.72
Dec-14	3.60	0.13	2.82	0.26	0.26	0.26	0.18	2.01E-03	8.78	68,519	80.72
Jan-15	3.73	0.07	2.93	0.26	0.26	0.26	0.19	1.09E-03	8.95	71,090	76.17
Feb-15	3.77	0.09	2.96	0.27	0.27	0.27	0.19	1.40E-03	9.95	71,783	76.11
Mar-15	0.77	0.00	0.60	0.05	0.05	0.05	0.04	4.01E-05	1.78	14,590	13.50
Apr-15	1.46	0.03	1.14	0.10	0.10	0.10	0.07	4.89E-04	4.45	27,718	22.30
May-15	4.01	0.11	3.15	0.28	0.28	0.28	0.21	1.64E-03	9.30	76,384	38.73
Baseline Period Ends:	**Oct-09**	**Jul-13**	**Mar-14**	**Mar-14**	**Mar-14**	**Mar-14**	**Mar-14**	**Jul-13**	--	--	--
Baseline Actual Emissions (tpy):	**53.16**	**4.00**	**41.32**	**3.74**	**3.74**	**3.74**	**2.70**	**0.06**	--	--	--

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Monthly Maximum Throughput During Baseline (mmbtu):	79,555	121	97,568	97,568	97,568	97,568	97,568	121	11.14	97,568	120.73
Occurs:	May-09	Sep-11	Jul-13	Jul-13	Jul-13	Jul-13	Jul-13	Sep-11	Oct-14	Jul-13	Sep-11

Emission Factor References

[1] Nov-07 through Oct-08: 11/18/04 stack test results of 89.04 lb/MMscf.
Nov-08 through Oct-09: 10/21/08 stack test results of 0.133 lb/MMBtu.
Nov-09 through Oct-10: 10/21/09 stack test results of 0.114 lb/MMBtu.
Nov-10 through Sept-11: 10/28/10 stack test results of 0.097 lb/MMBtu.
Oct-11 through Nov-12: 9/13/11 stack test results of 0.098 lb/MMBtu.
Dec-12 through Oct-13: 11/20/12 stack test results of 0.086 lb/MMBtu
Nov-13 through Nov-14: 10/13/13 stack test results of 0.095 lb/MMBtu
Dec-14 through May-15: 11/17/14 stack test results of 0.105 lb/MMBtu

[2] SO2 (tons) = Monthly average fuel gas H2S contents (ppmv) / 385.34 ft3/lb-mol * 64 lb/lb-mol * MMscf / 2000 lb/ton

[3] Emission factor of 0.0824 lb/MMBtu per AP-42 Table 1.4-1.

[4] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.

[5] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.

[6] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.

[7] Emission factor of 5.39E-03 lb/MMBtu per AP-42 Table 1.4-2.

[8] Assumed to be 1.5% of total SO2 emissions consistent with TRI reporting.

[9] Measured throughput rates.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 3a - Projected Actual Emission Calculations for Ultraformer Unit Furnace F-1

Quantity	Value	Units	Reference
Projected Firing Rate:	115.26	Mscf/hr	Calculated
	124.92	MMBtu/hr	Engineering estimate, based on projected post project firing rate
Fuel HHV:	1083.8	Btu/scf	Engineering estimate
Fuel H_2S Content:	50	ppmvd	Engineering estimate
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units	Projected Emissions (lb/hr) [1]	Projected Emissions (tpy) [2]	Emission Factor Reference
NO_X	0.065	lb/MMBtu	8.12	35.56	Manufacturer's Emission Guarantee
SO_2	8.31	lb/MMscf	0.96	4.19	Calculated
CO	0.050	lb/MMBtu	6.25	27.36	Manufacturer's estimate
PM	0.00745	lb/MMBtu	0.93	4.08	AP-42 Table 1.4-2
PM_{10}	0.00745	lb/MMBtu	0.93	4.08	AP-42 Table 1.4-2
$PM_{2.5}$	0.00745	lb/MMBtu	0.93	4.08	AP-42 Table 1.4-2
VOC	5.39E-03	lb/MMBtu	0.67	2.95	AP-42 Table 1.4-2
H_2SO_4	0.12	lb/MMscf	1.44E-02	6.29E-02	TRI calculation (1.5% of SO2 emissions)

[1] Projected Emissions (lb/hr) = Emission Factor (lb/MMBtu) x Projected Firing Rate (MMBtu/hr) or
Projected Emissions (lb/hr) = Emission Factor (lb/MMscf) x Projected Firing Rate (Mscf/hr) / 1000 Mscf/MMscf

[2] Emission Increase (tpy) = Projected Emissions (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 3b - Projected Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X [1]	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
	tpy	tpy	tpy	tpy	tpy	tpy	tpy	tpy
A. Baseline Actual Emissions	53.16	4.00	41.32	3.74	3.74	3.74	2.70	0.06
B. Capable of Accommodating	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09
C. Projected Emissions	35.56	4.19	27.36	4.08	4.08	4.08	2.95	0.06
D. Demand Growth (D=B-A)	0.00	1.98	0.00	0.46	0.46	0.46	0.33	0.03
E. Projected Actual Emissions (E=C-D)	35.56	2.21	27.36	3.62	3.62	3.62	2.62	0.03
F. Emission Increase (F=E-A)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

B. Capable of Accommodating	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
Annual Emission Limits (ton/yr)	CAP	CAP	N/A	N/A	CAP	N/A	N/A	N/A
Representative Monthly Throughput during Baseline Period (Units/mo)	79,555	120.73	97,568	97,568	97,568	97,568	97,568	120.73
Month that this occurred:	May-09	Sep-11	Jul-13	Jul-13	Jul-13	Jul-13	Jul-13	Sep-11
Throughput that Unit was Capable of Accommodating (Units/year)	917,964	1,439.51	1,125,812	1,125,812	1,125,812	1,125,812	1,125,812	1,439.51
Representative Emission Factor that Unit was Capable of Accommodating (lb/Units)	0.065	8.31	0.05	7.45E-03	7.45E-03	7.45E-03	5.39E-03	0.12
Units	MMBtu	MMscf	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMscf
Emissions the Unit was Capable of Accommodating during Baseline Period (ton/yr)	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09

[1] Due to installation of Ultra Low NO_X burners, and the corresponding decrease in NO_X emission factor, capable of accommodating em than the baseline actual emissions. Therefore, the NO_X emissions increase analysis does not include a demand growth component.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 4 - Potential Emission Calculations for Process Components

Components (service)	**UFU/Fuel Gas** Count [1]	Emission Factor [2] (kg/hr/source)	(lb/hr/source)	Control Effectiveness [3] (%)	Emissions (lbs/yr)	Emissions (Tons/yr)
Valves (gas)	216	0.0268	0.059083	96	4,472	2.24
Valves (LL)	0	0.0109	0.024030	95	-	-
Valves (HL)	0	0.00023	0.000507	0	-	-
Flanges (gas)	408	0.00025	0.00055	81	374	0.19
Flanges (LL)	0	0.00025	0.00055	81	-	-
Flanges (HL)	0	0.00025	0.00055	81	-	-
Pump Seals (LL)	0	0.114	0.25	88	-	-
Pump Seals LL (Tandem)	0	0.114	0.25	100	-	-
Pump Seal (HL)	0	0.021	0.046	0	-	-
Comp. Seals (gas)	0	0.636	1.4	100	-	-
Comp. Seals (H_2)	0	0.636	1.402	100	-	-
Process Drains (total)	0	0.073	0.161	100	-	-
Relief Valves (gas)	0	0.16	0.35	100	-	-
Total					4,846	2.42

Gas = material in a gaseous state at operating conditions
LL = light liquid = material in a liquid state in which the sum of the concentration of individual constituents with a vapor pressure over 0.3 kilopascals (kPa) at 20 oC is greater than or equal to 20 wt%.
HL = heavy liquid = not in gas/vapor service or light liquid service.
In VOC service means that the piece of equipment contains or contacts a process fluid that is at least 10 percent VOC by weight. (40 CFR 60.481)

Notes:

[1] Estimated counts based on P&ID drawings plus a 50% safety factor to be conservative.

[2] Protocol for Equipment Leak Emission Estimates, November 1995, Table 2-2. Refinery Average Emission Factors.

[3] Protocol for Equipment Leak Emission Estimates, November 1995, Table 5-3. Control Effectiveness for an LDAR Program at a Refinery Process Unit. Monitored under the Consent Decree leak definition of 500 ppm, quarterly with no chance for skip monitoring. Equivalent to HON regulation.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 5: Stack Emission Calculations for Cogeneration Units

Quantity	Value	Units	Reference
Steam Requirement:	2,100	lb/hr	Engineering estimate
Firing Requirement:	2.31	MMBtu/hr	Engineering estimate
Fuel Heat Content:	1083.8	Btu/scf	Engineering estimate for future operations
Fuel Use Requirement:	0.0021	MMscf/hr	Calculated
Fuel H_2S Content:	162	ppmvd	NSPS Ja H_2S concentration limit
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units	Emission Increase (lb/hr) (1)	Emission Increase (tpy) (2)	Reference
NO_X	76.80	lb/MMscf	0.16	0.72	Maximum stack test result from 2009 for East Cogeneration Unit
SO_2	26.91	lb/MMscf	5.73E-02	0.25	Calculated
CO	84	lb/MMscf	0.18	0.78	AP-42 Table 3.1-1
PM	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
PM_{10}	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
$PM_{2.5}$	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
VOC	5.5	lb/MMscf	1.17E-02	5.13E-02	AP-42 Table 1.4-2
H_2SO_4	0.40	lb/MMscf	8.60E-04	3.77E-03	TRI calculation (1.5% of SO2 emissions)

Notes:

(1) Emission Increase (lb/hr) = Emission Factor (lb/MMBtu) x Fuel Use Requirement (MMBtu/hr) or
Emission Increase (lb/hr) = Emission Factor (lb/MMscf) x Fuel Use Requirement (MMscf/hr)

(2) Emission Increase (tpy) = Emission Increase (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton

Attachment C

Form 1 and NOI Checklist

Utah Division of Air Quality
New Source Review Section

Date

Form 1
Notice of Intent (NOI)

Application for: ☐Initial Approval Order ☒Approval Order Modification

APPROVAL ORDER MUST BE ISSUED BEFORE ANY CONSTRUCTION OR INSTALLATION CAN BEGIN. This is not a stand alone document; please refer to UAC R307-401and the published NOI guidebook for information on requirements of the specified information below. Please print or type all information requested. All outlined information requested must be accurate and completed before DAQ can determine that an NOI is complete and an engineering review can be initiated. If you have any questions, contact the Division of Air Quality at (801) 536-4000 and ask to speak with a New Source Review Engineer. Written inquiries may be addressed to: Division of Air Quality, New Source Review Section, P.O. Box 144820, Salt Lake City, Utah 84114-4820.

General Owner and Facility Information

R307-401-5(2)(k)

1. Filing Fee Paid*

2. Application Fee Paid*

3. Company name and address:
Tesoro Refining & Marketing Company LLC
474 West 900 North
Salt Lake City, UT 84103

Phone No.: (801)366-2036
Fax No.: (801)521-4965

4. Company** contact for environmental matters:
William Snarr

Phone no.: (801)521-4966
Email: William.K.Snarr@tsocorp.com

*** Company contact only; consultant or independent contractor contact information can be provided in a cover letter*

5. Facility name and address (if different from above):
Tesoro Refining & Marketing Company LLC
474 West 900 North
Salt Lake City, UT 84103

Phone no.: (801)366-2036
Fax no.: (801)521-4965

6. Owners name and address:
Tesoro Corporation
19100 Ridgewood Parkway
San Antonio, TX 78259

Phone no.:
Fax no.:

7. Property Universal Transverse Mercator coordinates (UTM), including System and Datum:
Easting: 423,400
Northing: 4,515,950
System: UTM Zone 12
Datum:

8. County where the facility is located in:
Salt Lake

9. Standard Industrial Classification Code:
2911

10. Designation of facility in an attainment, maintenance, or nonattainment area(s):

SL City CO Maint Area
SL Co Ozone Maint Area
SL Co PM10 NAA
SL Co PM2.5 NAA
SL Co SO2 NAA

11. If request for modification, AO# to be modified: DAQE#DAQE-AN103350065-14 Date: 9/5/14

12. Identify any current Approval Order(s) for the facility **not** being modified with this request:

AO#DAQE-AN103350063-14 Date3/17/14
AO#DAQE-AN0103350042-08 Date5/13/08
AO# Date
AO# Date

13. Application for:

☐New construction
☐Existing equipment operating without permit
☐Change of permit condition
☒Modification
☐Permanent site for Portable Approval Order
☐Change of location

14. Construction or modification estimated start date:6/1/16 Estimated completion date:

R307-401-5(2)(h)

15. Does this application contain justifiable confidential data? ☒Yes ☒ No

16. Current Title V (Operating Permit) Identification: Date

☒Requesting an enhanced Title V permit with this AO modification

17. Brief (50 words or less) description of project to post on DAQ web for public awareness

This Project involves installation of Ultra Low NOx Burners on the Ultraformer Unit F-1 Furnace.

Process Information

18. Appendix A: Detailed description of project including process flow diagram (See Forms 2-23)

☐Fuels and their use
☐Raw materials used
☐Operation schedules
☐Equipment used in process
☐Description of changes to process (if applicable)
☐Production rates (including daily/seasonal variances)
☐Description of product(s)
☐Stack parameters

R307-401-5(2)(a)

19. Appendix B: Site plan of facility with all emission points and elevations, building dimensions, stack parameters included

R307-401-5(2)(e)

Emissions Information

20. Appendix C: Emission Calculations that must include:
    - ☒Emissions per new/modified unit for each of the following: PM_{10}, $PM_{2.5}$, NO_x, SO_x, CO, VOC, and HAPs
    - ☒Designation of fugitive and non fugitive emissions
    - ☐Major GHG Sources: Emissions per new/modified unit for GHGs (in CO_2e short tons per year)
    - ☒References/assumptions for each Emission Factor used in calculating Criteria pollutant, HAP, and GHG emissions
    - ☒HAP emissions (in pounds per hour and tons per year) broken out by specific pollutant and summed as a total

R307-401-5(2)(b)

21. Appendix D: DAQ Form 1a or equivalent (comparison of existing emissions to proposed emission and resulting new total emissions)

22. Appendix E: Source Size determination (Minor, Synthetic Minor, Major, or PSD)
    - ☒ If an Existing Major Source: Determination of Minor, Major or PSD modification

23. Appendix F: Offset requirements (nonattainment/maintenance areas)
    - ☐Acquired required offsets

R307-401-420 & R307-401-421

Air Pollution Control Equipment Information

24. Appendix G: Best Available Control Technology (BACT) analysis for the proposed source or modification

R307-401-5(2)(d)

25. Appendix H: Detailed information on all new/modified equipment controls. It is strongly recommended using DAQ forms as they outline required information, but something equivalent to the DAQ forms is acceptable.

R307-401-5(2)(c)

26. Appendix I: Discussion of Federal/State requirement applicability (NAAQS, SIP, NSPS, NESHAP, etc)

Modeling Information

27. Appendix J: Emissions Impact Analysis (if applicable)

R307-410-4

Electronic NOI

28. A complete and accurate electronic NOI submitted

R307-401-5(1)

I hereby certify that the information and data submitted in and with this application is completely true, accurate and complete, based on reasonable inquiry made by me and to the best of my knowledge and belief.

Signature:

Title:

Name (print)	Telephone Number:	Date:

with the exception of Federal Agencies who will be billed at completion of the project

Utah Division of Air Quality

Boxes indicate where information can be found in the application.

NOTICE OF INTENT COMPLETENESS CHECKLIST

TO BE COMPLETED BY PROJECT ENGINEER WITHIN 30 DAYS OF RECEIPT OF THE NOTICE OF INTENT (NOI). CRITERIA DERIVED FROM R307-401-5, UTAH ADMINISTRATIVE CODE (UAC). ANY NEGATIVE RESPONSE WILL CAUSE APPLICATION TO BE DELAYED. ALL REFERENCES ARE TO THE UAC EXCEPT AS NOTED.

Project Name: Date:

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1. Fees Paid
   - A. Filing Fee — Y ☐ N ☐
   - B. Application Fee — Y ☐ N ☐

Cover letter

2. Source Identification Information: [R307-401-5(2)(k)]
   - A. Name, address, and telephone number (w/area code) — Y ☐ N ☐
   - B. Company submitting application — Y ☐ N ☐
   - C. Plant manager and/or Company contact — Y ☐ N ☐
   - D. Plant (if different from Company) — Y ☐ N ☐ N/A ☐
   - E. Company owner and agent — Y ☐ N ☐
   - F. Property UTM coordinates — Y ☐ N ☐
   - G. County where facility is located — Y ☐ N ☐
   - H. SIC Code(s) — Y ☐ N ☐
   - I. Facility area designation (attainment, maintenance, or nonattaiment) — Y ☐ N ☐

Form 1
General information in Sections 1.0 and 2.1

3. If modification, AO# to be modified [R307-401-5(2)(k)] — Y ☐ N ☐ N/A ☐

Form 1

   - A. Other current Approval Order(s) for facility not being modified — Y ☐ N ☐ N/A ☐
   - B. Current Title V (Operating Permit) — Y ☐ N ☐ N/A ☐

Form 1
Section 1.0

4. Purpose of application [R307-401-5(2)(a)] — Y ☐ N ☐

Form 1
Section 2.6

5. Construction schedule [R307-401-5(2)(h)] — Y ☐ N ☐ N/A ☐

6. Justifiable confidential data — Y ☐ N ☐ N/A ☐

N/A

7. Description of Source Process. [R307-401-5(2)]

   - A. Detailed description of project: [(Appendix A) (Forms 2-23)]
     1. Fuels and their use — Y ☐ N ☐
     2. Raw materials used — Y ☐ N ☐ N/A ☐
     3. Description of product(s) — Y ☐ N ☐
     4. Equipment used in process — Y ☐ N ☐
     5. Operation schedules — Y ☐ N ☐
     6. Description of changes to process — Y ☐ N ☐ N/A ☐
     7. Production rates — Y ☐ N ☐ N/A ☐

Section 2.0 and sub-sections

B. Site plan of facility with, building dimensions, stack parameters included: (Appendix B) Y ☐ N ☐
   1. Emission points and elevations Y ☐ N ☐
   2. Building dimensions Y ☐ N ☐ N/A ☐
   3. Stack parameters Y ☐ N ☐ N/A ☐

Attachment A
No stack parameters included
(no modeling analysis)

8. Emissions Related Information. [R307-401-(2)(b)]

A. Emission Calculations: (Appendix C)
   1. Emissions per new/modified unit for all pollutants: (PM$_{10}$, PM$_{2.5}$ NO$_x$, SO$_x$, CO, VOC, and HAPs) Y ☐ N ☐
   2. Designation of fugitive and non-fugitive emissions Y ☐ N ☐
   3. Major GHG Sources: (in CO2e short tons per year) Y ☐ N ☐ N/A ☐
   4. References/assumptions for each calculation and pollutant Y ☐ N ☐
   5. HAP emissions (broken out by specific pollutant in pounds per hr) Y ☐ N ☐ N/A ☐
   6. Applicable Material Safety Data Sheets Y ☐ N ☐

Section 3.0 and
subsections;
Attachment B

B. DAQ Form 1a or equivalent (Appendix D) Y ☐ N ☐

Attachment C

C. Source size determination (Appendix E)

Section 3.0 and sub-sections

   1. If Existing Major Source: Determination of Minor, Major, or PSD Modification Y ☐ N ☐ N/A ☐

D. Offset requirements (nonattainment/maintenance areas) [(R307-401-420)(R307-401-421)] (Appendix F) Y ☐ N ☐ N/A ☐
   1. Acquired required offsets Y ☐ N ☐ N/A ☐

Section 4.9
(not applicable)

9. Air Pollution Control Equipment

Not applicable.

A. Best Available Control Technology (BACT) Analysis [R307-401-5(2)(d), (Appendix G)] Y ☐ N ☐

B. Detailed information on new/modified equipment controls [R307-401-5(2)(c), (Appendix H)] Y ☐ N ☐

10. Federal/State requirement applicability [(NAAQS, SIP, NSPS, etc), (Appendix I) Y ☐ N ☐ N/A ☐

Section 4.0 and sub-sections

11. Modeling information

A. Emissions Impact Analysis [(R307-410-4), (Appendix J)] Y ☐ N ☐ N/A ☐

Section 4.8

12. Signature on application (Form 1 Notice of Intent) Y ☐ N ☐

Form 1

NSR

RECEIVED
OCT 13 2015
DEPARTMENT OF
ENVIRONMENTAL QUALITY

TESORO

Tesoro Refining & Marketing Company LLC
474 West 900 North
Salt Lake City, UT 84103
801 521 4810

October 12, 2015

HAND DELIVERED

Marty Gray, Major NSR Section Manager
Utah Division of Air Quality
195 North 1950 West
P.O. Box 144820
Sal t Lake City, Utah 84114-4820

Re: Tesoro Salt Lake City Refinery FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation NOI Update

Dear Mr. Gray:

On June 11, 2015, Tesoro Refining & Marketing Company LLC (Tesoro) submitted a Notice of Intent (NOI) application for the FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation for the Salt Lake City Refinery. Since the time the original application was submitted, Tesoro has determined that an incremental steam load of approximately 17,500 lb/hr of 300 psi steam will be required as part of the project. The additional steam load will drive the CO Boiler combustion air fan which will provide higher pressures through the flue gas train. This additional pressure is needed to overcome the pressure drop associated with installing the Wet Gas Scrubber. In addition, Tesoro is submitting estimated fugitive PM, PM_{10}, and $PM_{2.5}$ emissions associated with truck traffic on existing paved roads at the facility due to raw material (oxygen, caustic and coagulant) delivery and filter cake (associated with the wet gas scrubber's purge treatment unit) disposal. While not likely, trucks may also be utilized to dispose of wastewater. The final option for wastewater disposal has not been determined at this time; however, to be conservative, Tesoro has assumed haul trucks will be utilized to dispose of wastewater.

Emissions Summary

To account for the potential increase in emissions due to additional steam demand, Tesoro has estimated the increase in emissions at the facility's Cogeneration Units for the incremental steam consumption. For haul road truck traffic, emissions are estimated using methodology from AP-42 Section 13.2.1, Paved Roads (equation 2), January 2011.

A summary of emissions increases from the project is provided below. Detailed calculations are provided in Attachment A to this letter.

	Emissions Increase (ton/yr)							
Emissions Unit	**NO_X**	**SO_2**	**CO**	**PM**	**PM_{10}**	**$PM_{2.5}$**	**VOC**	**H_2SO_4**
Cogeneration Units	5.97	2.09	6.53	0.84	0.84	0.84	0.43	0.03
Truck Traffic				0.40	0.08	0.02		
Total	**5.97**	**2.09**	**6.53**	**1.24**	**0.92**	**0.86**	**0.43**	**0.03**
PSD Significant Emissions Rate (SER)	40	40	100	25	15	10	40	7
Exceeds PSD threshold?	No	No	No	No	No	No	No	No

This update to the NOI application does not change the result of any applicable rules or requirements as described in the original NOI application.

Please contact me at 801-521-4966 or Michelle Bujdoso at 801-366-2036 if you need more information or have questions.

Sincerely,

William Snarr
Health Safety and Environmental Manager

Enclosures

Tesoro Refining & Marketing Company LLC

Salt Lake City Refinery

FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation - UPDATE

Table 1: Stack Emission Calculations for Cogeneration Units

Quantity	Value	Units	Reference
Steam Requirement:	17,500	lb/hr	Engineering estimate
Firing Requirement:	19.25	MMBtu/hr	Engineering estimate
Fuel Heat Content:	1083.8	Btu/scf	Engineering estimate for future operations
Fuel Use Requirement:	0.0178	MMscf/hr	Calculated
Fuel H_2S Content:	162	ppmvd	NSPS Ja H_2S concentration limit (3-hour average)
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units	Emission Increase (lb/hr) (1)	Emission Increase (tpy) (2)	Reference
NO_X	76.80	lb/MMscf	1.36	5.97	Maximum stack test result from 2009 for East Cogeneration Unit
SO_2	26.91	lb/MMscf	0.48	2.09	Calculated
CO	84.00	lb/MMscf	1.49	6.53	AP-42 Table 3.1-1
PM	0.01	lb/MMBtu	0.19	0.84	Manufacturer Specification
PM_{10}	0.01	lb/MMBtu	0.19	0.84	Manufacturer Specification
$PM_{2.5}$	0.01	lb/MMBtu	0.19	0.84	Manufacturer Specification
VOC	5.50	lb/MMscf	0.10	0.43	AP-42 Table 1.4-2
H_2SO_4	0.40	lb/MMscf	0.01	0.03	TRI calculation (1.5% of SO2 emissions)

Notes:

(1) Emission Increase (lb/hr) = Emission Factor (lb/MMBtu) x Fuel Use Requirement (MMBtu/hr) or
Emission Increase (lb/hr) = Emission Factor (lb/MMscf) x Fuel Use Requirement (MMscf/hr)

(2) Emission Increase (tpy) = Emission Increase (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton

Date printed: 10/12/2015

Tesoro Refining and Marketing Company
Salt Lake City Refinery
FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation - UPDATE
Table 2: Emissions Calculations for Haul Road Truck Traffic

Increases in Emissions on Paved Roads

Emissions calculated using equation in January 2011 AP-42 Section 13.2.1, Paved Roads (equation 2).

E = [k * (sL)^0.91 * (W)^1.02] * (1-P/4*N)

Variable	Description	PM	PM$_{10}$	PM$_{2.5}$	Reference
k =	particle size multiplier	0.011	0.0022	0.00054	from AP-42 Table 13.2.1-1
sL =	Road surface silt loading, g/m^2, annual average	1.5	1.5	1.5	AP-42 Table 13.2-1-2 for < 500 ADT, assuming 6 mos. with frozen precipitation
W =	Average weight (tons) of the vehicles traveling the road	27.5	27.5	27.5	Engineering estimate
P =	days per year with at least 0.254 mm precipitation	60	60	60	from AP-42 Figure 13.2.2-1
Emission Factor =	Emission Factor (lb/vehicle miles traveled (VMT))	0.45	0.09	0.02	
	Control Efficiency from Application of Dust Suppressant	0%	0%	0%	

Truck Type	Number of Trucks per Year	Miles Traveled per Truck (round trip)	Mileage (VMT)	PM Emissions (tons)	PM$_{10}$ Emissions (tons)	PM$_{2.5}$ Emissions (tons)
Oxygen delivery	90	1.25	113	0.03	0.01	0.00
Caustic delivery	24	2.25	54	0.01	0.00	0.00
Coagulant delivery	12	1.25	15	0.00	0.00	0.00
Wastewater disposal	1260	1.25	1,575	0.35	0.07	0.02
Filter cake disposal	24	1.25	30	0.01	0.00	0.00
Increase in Haul Road Truck Traffic Emissions from Paved Roads				**0.40**	**0.08**	**0.02**

NSR

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY
JUN 11 2015
DIVISION OF AIR QUALITY

TESORO

Tesoro Refining & Marketing Company LLC
474 West 900 North
Salt Lake City, UT 84103
801 521 4810

HAND DELIVERED

June 11, 2015

Marty Gray, Major NSR Section Manager
Utah Division of Air Quality
195 North 1950 West
P.O. Box 144820
Salt Lake City, Utah 84114-4820

Re: Tesoro Salt Lake City Refinery FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation NOI Submittal

Dear Mr. Gray:

Enclosed please find a Notice of Intent (NOI) application for the FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation. This project will occur at the Tesoro Refining and Marketing Company's (Tesoro's) Salt Lake City (SLC) Refinery which operates under Approval Order (AO) DAQE-AN103350065-14.

Also included is a check for $2300 which covers the filing fee and the base fee (Existing Major Source with a Minor Modification) for the NOI application.

Please contact me at 801-521-4966 or Michelle Bujdoso at 801-366-2036 if you need more information or have questions.

Sincerely,

William Snarr
Health, Safety and Environmental Manager

Enclosures

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY

JUN 1 1 2015

DIVISION OF AIR QUALITY

FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation

Notice of Intent for an Approval Order

Prepared for
Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery

June 2015

TESORO

BARR

4700 West 77th Street
Minneapolis, MN 55435-4803
Phone: (952) 832-2600
Fax: (952) 832-2601

FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation

Notice of Intent for an Approval Order

June 2015

Table of Contents

List of Tables

List of Attachments

1.0 Introduction

This Notice of Intent (NOI) package is submitted for approval of the installation of wet gas scrubber (WGS) and LoTOx^{TM} emission control systems on the fluidized catalytic cracking unit/carbon monoxide boiler (FCCU/CO Boiler) at the Tesoro Refining &Marketing Company LLC's (Tesoro's) Salt Lake City (SLC) Refinery (hereinafter referred to as the "Project"). The SLC Refinery currently operates under multiple Approval Orders (AOs), of which DAQE-AN103350065-14 is affected by this Project. The SLC Refinery is situated on 236 acres in Salt Lake County, approximately 1.5 miles north of Salt Lake City.

This Project involves installation of WGS and LoTOx^{TM} systems to control emissions from the FCCU/CO Boiler. These emission control systems are being installed primarily to meet Utah's $PM_{2.5}$ State Implementation Plan (SIP) requirements that apply to Tesoro. The $PM_{2.5}$ SIP, as most recently amended by the Utah Air Quality Board on December 3, 2014, is incorporated by reference and made part of Utah rules pursuant to R307-110-10. Section IX.H.11.g.i. of the SIP contains requirements for petroleum refineries and specifically for fluid catalytic cracking units. In addition, source-wide limits are included specifically for Tesoro's SLC Refinery in section IX.H.11.r. These requirements are included in section 4.1 of this application.

In general, the WGS and LoTOx^{TM} technology process reduces the emissions of SO_2 and NO_X by converting these compounds to other compounds that are easily removed from the flue gas by liquid sprays within the scrubber. These same liquid sprays also remove particulates from the flue gas. The LoTOx^{TM} system injects ozone into the FCCU/CO Boiler exhaust stream within the WGS. NO_X compounds are oxidized with ozone to form compounds that are removed from the flue gas in the WGS. It is expected that a small amount of ozone (approximately 3 ppm) will not react with the NO_X compounds and will be emitted directly to the atmosphere (known as "slip"). Emissions of NO_X and $SO_2$from the FCCU/CO Boiler will be reduced due to the installation of the pollution control equipment.

Utah administrative code Rule R307-401-3(c) requires submittal of an NOI to "install a control apparatus or other equipment intended to control emissions of air contaminants." Rule R307-401-5 requires that the NOI must contain specific information related to the process, nature of emissions, control device(s), and regulatory applicability and compliance. This NOI includes a project description, an emissions summary, and a description of regulatory applicability and demonstration of compliance to address these requirements.

This NOI is organized as follows:

- Section 2.0 contains a project description,
- Section 3.0 contains the emissions summary,
- Section 4.0 contains a description of regulatory applicability and compliance demonstration,
- Section 5.0 contains a summary of the NOI requirements,
- Attachment A contains a site diagram,
- Attachment B contains the Project emission calculations,
- Attachment C contains Form 1, Form 9, and the NOI checklist.

2.0 Project Description

This section includes a general description of the facility and details of the proposed Project.

2.1 General Facility Information

The Tesoro Salt Lake City Refinery is located at 474 West 900 North, Salt Lake City, Utah. The refinery is located in a nonattainment area for $PM_{2.5}$ (including precursors NO_X, SO_2, and VOC)[1], PM_{10} (including precursors SO_2 and NO_x)[2], and SO_2. The area is also a designated maintenance area for ozone (VOC and NO_x) and CO. Attachment A includes a figure that shows the location of the refinery in Salt Lake City.

2.2 Project Description

This Project will install a Belco wet gas scrubber (WGS) and Linde LoTOx™ system. Specifically, the control system will consist of:

- A Belco spray tower for SO_2 and particulate removal,
- A Linde LoTOx™ system including an onsite ozone generator for NO_X removal, and
- A Belco purge treatment unit (PTU) for dewatering and solid waste disposal.

For control of NO_X emissions, the proposed wet scrubbing system uses Linde LLC's patented LoTOx™ process. In the LoTOx™ process, ozone is injected into the FCCU/CO Boiler exhaust gas stream within the WGS. NO_X compounds are oxidized with ozone to form compounds that are removed from the flue gas in the WGS.

SO_2 and SO_3 are removed from the FCCU/CO Boiler exhaust gas stream by contacting the exhaust gas with water, buffered with a sodium reagent (either sodium hydroxide, NaOH or soda ash or Na_2CO), in the spray tower. The reagent and reagent byproducts are liquids.

Similar to SO_X removal, particulates are also removed through liquid-gas contact in the scrubber's spray tower. Liquid containing these compounds is collected and purged from the scrubber. It is then processed by a Purge Treatment Unit (PTU), which separates and dewaters the particulate. The

---

[1] Utah State Implementation Plan Control Measures for Area and Point Sources, Fine Particulate Matter, $PM_{2.5}$ SIP for the Salt Lake City, UT Nonattainment Area Section IX. Part A.21, December 3, 2014

[2] Utah PM_{10} Maintenance Provisions for Salt Lake County, Section IX.A.10, July 6, 2005.

system is designed to discharge a neutral pH liquid stream. The final effluent is low in total suspended solids (TSS), and contains up to 10% total dissolved solids (TDS) from sodium sulfate and sodium nitrate.

A small increase in fugitive dust emissions will occur due to increased truck traffic to deliver raw materials and haul waste byproducts associated with the WGS and LoTOx™ system. In addition, there is an increase in electrical demand resulting from onsite ozone generation and pumping loads; however, all incremental electricity will be provided by off-site generation, since on-site generation is fully utilized by existing process facilities within the refinery.

2.3 Affected Non-Modified Emission Units

The emission unit controlled by the Project is the FCCU/CO Boiler (PS# 4). However, the unit itself will not be modified and NO_X SO_2, $PM_{2.5}$, PM_{10}, and PM emissions will not increase after the Project.

2.4 Emission Units Not Affected by Project

Tesoro has evaluated the Project impacts to other portions of the refinery and has determined that no non-modified emission units are affected by the Project. The Project does not relieve constraints of any other process units.

2.5 Project Schedule

The estimated start of construction is May 2016, pending permit approval. The system is expected to begin operations in October 2017, assuming permit approval by the estimated date for start of construction.

3.0 Emissions Summary

The Utah Department of Environmental Quality Division of Air Quality (UDAQ) requires a comparison of the emissions before and after the Project. There will be no increase in potential or actual emissions at the FCCU/CO Boiler (PM, PM_{10}, $PM_{2.5}$, NO_X, SO_2, CO). There will be a small amount of ozone emissions resulting from ozone slip in the LoTOx^{TM} system (approximately 3 ppm) after the installation of the control system.

Attachment B contains detailed emission calculations which summarize the potential emissions of the FCCU/CO Boiler before and after the Project. These emission calculations reflect new emission limitations that will apply or are being proposed (refer to Section 3.2).

3.1 R307-403 and R307-405 Emissions Determination

Pollutant-specific emission calculations must be completed to determine whether a major modification will occur under R307-403 for nonattainment and maintenance areas and under R307-405 for attainment areas. Since the Project does not result in an increase in actual emissions for the affected unit (the FCCU/CO Boiler) or for any other emission units, a major modification will not occur. Refer to Sections 4.6 and 4.7 for determinations of the applicability of New Source Review (NSR).

3.2 Calculation of Emissions

As previously discussed, NO_X and SO_2 emissions from the FCCU/CO Boiler will decrease as part of the Project. The annual emissions decreases are described and quantified as follows to reflect new applicable and proposed limitations. In addition to the annual limits described below, short term limits are also proposed. A summary of all emissions limits is provided in Section 3.4. A summary of the annual potential emissions of SO_2, NO_X, and CO from the FCCU/CO Boiler before and after the project is presented in Table 3-1 below.

- Potential SO_2 emissions before the Project are based on the existing SO_X limit at the FCCU/CO Boiler of 705 tons per rolling 12-month period and the conversion factor of 1.05 to convert from SO_X to SO_2. Potential SO_2 emissions after the Project are calculated using a proposed SO_2 emission limit of 10 ppmvd @ 0% excess air on a 365-day rolling average.

- Potential NO_X emissions before the Project are based on the existing NO_X limit at the FCCU/CO Boiler of 174 tons per year. Potential NO_X emissions after the Project are calculated using a proposed NO_X emission limit of 10 ppmvd @ 0% excess air on a 365-day rolling average.

- Potential CO emissions before the Project are based on the existing CO limit of 500 ppmvd. Potential CO emissions after the Project are calculated using a proposed CO emission limit of 100 ppmvd @ 0% excess air on a 365-day rolling average.
- Potential emissions of other pollutants will not change because there are no new applicable or proposed limits. The $PM_{2.5}$ SIP contains a limit of 1.0 pounds PM per 1000 pounds coke burned on a 3-hour average basis; however, the same PM limit already applies per 40 CFR 60 (NSPS) Subpart J.

Table 3-1. Summary of FCCU/CO Boiler Potential to Emit (PTE) Before and After Project

Pollutant	Before Project (tons/yr)	After Project (tons/yr)
SO_2	671.43	41.06
NO_X	174.00	29.48
CO	933.43	179.51

3.3 Hazardous Air Pollutant (HAP) Emissions

There are no increases in actual or potential emissions of HAPs as a result of the Project. The WGS may result in a decrease in HAP emissions such as heavy metals in particulate form or volatile organic compounds that are soluble in water; however, these potential decreases have not been quantified.

3.4 Existing and Proposed Emissions Limits

Proposed new emission limits are presented in Table 3-2 for the FCCU/CO Boiler. Section 4.1 also provides the refinery-wide limits that are required by the $PM_{2.5}$ SIP. Tesoro will use continuous emission monitoring systems (CEMS) to demonstrate compliance with the proposed NO_X, SO_2, and CO limits for the FCCU/CO Boiler.

Table 3-2. Proposed FCCU/CO Boiler Emission Limits

Pollutant	Limit	Averaging Period	Date Applicable
NO_X	10 ppmvd at 0% O_2	Rolling 365-day	January 1, 2018
NO_X	20 ppmvd at 0% O_2	Rolling 7-day	January 1, 2018
SO_2	10 ppmvd at 0% O_2	Rolling 365-day	January 1, 2018
SO_2	18 ppmvd at 0% O_2	Rolling 7-day	January 1, 2018
SO_2	25 ppmvd at 0% O_2	Rolling 365-day	January 1, 2018
SO_2	50 ppmvd at 0% O_2	Rolling 7-day	January 1, 2018
CO	100 ppmvd at 0% O_2	Rolling 365-day	October 1, 2015

Table 3-3. Proposed Source-Wide Emission Limits

Pollutant	Limit	Averaging Period	Date Applicable
$PM_{2.5}$ (filterable)	0.42 ton/day	1-day	January 1, 2019
$PM_{2.5}$ (filterable)	110 ton/yr	Rolling 12-month	January 1, 2019
NO_X	1.988 ton/day	1-day	January 1, 2019
NO_X	475 ton/yr	Rolling 12-month	January 1, 2019
SO_2	3.1 ton/day	1-day	January 1, 2019
SO_2	300 ton/yr	Rolling 12-month	January 1, 2019

4.0 Regulatory Applicability and Compliance Demonstration

Tesoro has completed an applicability review of all Federal and State air quality regulations as part of the air permit application process. Table 4-1 provides a summary of the major air quality programs that were reviewed for the Project. Each regulation which requires explanation is described in the following sections.

Table 4-1. Summary of Air Quality Regulatory Applicability for the Project

Report Section	Program Description	Regulatory Citation	Does This Project Trigger New Applicable Requirements?
---	**Utah State Rules**	**R307**	---
4.1	General Requirements: State Implementation Plan	R307-110	Yes
4.2	Stationary Sources	R307-210	No
4.3	National Emission Standards for Hazardous Air Pollutants	R307-214	No
4.4	Ozone Nonattainment and Maintenance Areas: Control of Hydrocarbon Emissions in Petroleum Refineries	R307-326	No
---	Ozone Nonattainment and Maintenance Areas: Petroleum Liquid Storage	R307-327	No
4.5	Permit: New and Modified Sources	R307-401	Yes
4.6	Nonattainment and Maintenance Areas	R307-403	No
4.7	Permits: Major Sources in Attainment or Unclassified Areas (PSD)	R307-405	No
4.8	Visibility	R307-406	No
4.9	Permits: Emissions Impact Analysis	R307-410	No
---	Permits: Fees for Approval Orders	R307-414	No
4.10	Permits: Ozone Offset Requirements in Davis and Salt Lake Counties	R307-420	No
4.11	Permits: PM_{10} Offset Requirements in Salt Lake County and Utah County	R307-421	No
4.12	Consent Decree - United States, et.al. v. BP Exploration & Oil, et. al., Civil Action No. 2:96 CV 095 RL	---	No
---	**Federal Rules**	40 CFR	---

Report Section	Program Description	Regulatory Citation	Does This Project Trigger New Applicable Requirements?
---	National Ambient Air Quality Standards (NAAQS)	40 CFR 50	No
4.6, 4.7	New Source Review (NSR)	40 CFR 52	No
4.2	New Source Performance Standards (NSPS)	40 CFR 60	Yes
4.3	National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR 61	No
4.3	NESHAPs for Source Categories	40 CFR 63	No
---	Risk Management Programs for Chemical Accidental Release Prevention	40 CFR 68	No
---	Title V Operating Permit	40 CFR 70	No
---	Acid Rain Requirements	40 CFR 72	No
---	Stratospheric Ozone Protection Requirements	40 CFR 82	No

4.1 Rule R307-110. General Requirements: State Implementation Plan

The $PM_{2.5}$ State Implementation Plan (SIP), as most recently amended by the Utah Air Quality Board on December 3, 2014, is incorporated by reference and made part of Utah rules pursuant to R307-110-10. The limits described below are summarized in Section 3.4 of this application. Section IX.H.11.g.i of the $PM_{2.5}$ SIP contains the following requirements for petroleum refineries.

Petroleum Refineries.

i. Limits at Fluid Catalytic Cracking Units

A. FCCU SO_2 Emissions

I. By no later than January 1, 2018, each owner or operator of an FCCU shall comply with an SO_2 emission limit of 25 ppmvd @ 0% excess air on a 365-day rolling average basis and 50 ppmvd @ 0% excess air on a 7-day rolling average basis.

II. Compliance with this limit shall be determined by following 40 C.F.R. §60.105a(g).

B. FCCU PM Emissions

I. By no later than January 1, 2018, each owner or operator of an FCCU shall comply with an emission limit of 1.0 pounds PM per 1000 pounds coke burned on a 3-hour average basis.

II. Compliance with this limit shall be determined by following the stack test protocol specified in 40 C.F.R. §60.106(b) to measure PM emissions on the FCCU. Each owner operator shall conduct stack tests once every five years at each FCCU.

III. By no later than January 1, 2019, each owner or operator of an FCCU shall install, operate and maintain a continuous parameter monitor system (CPMS) to measure and record operating parameters for determination of source-wide $PM_{2.5}$ emissions as appropriate.

In addition, the following source-wide requirements apply specifically to the Tesoro SLC Refinery per Section IX.H.11.r.

r. Tesoro Refining and Marketing Company: Salt Lake City Refinery

i. Source-wide PM2.5

By no later than January 1, 2019, combined emissions of filterable PM2.5 shall not exceed 0.42 tons per day (tpd) and 110 tons per rolling 12-month period.

PM2.5 emissions shall be determined daily by applying the listed emission factors or emission factors determined from the most current performance test to the relevant quantities of fuel combusted. Unless adjusted by performance testing as discussed above, the default emission factors to be used are as follows:

Natural gas – 1.9 lb/MMscf (filterable), 5.7 lb/MMscf (condensable)

Plant gas – 1.9 lb/MMscf (filterable), 5.7 lb/MMscf (condensable)

Daily gas consumption by all boilers and furnaces shall be measured by meters that can delineate the flow of gas to the indicated emission points.

The equations used to determine emissions for the boilers and furnaces shall be as follows:

*Emission Factor (lb/MMscf) * Gas Consumption (MMscf/24 hrs)/(2,000 lb/ton)*

By no later than January 1, 2019, Tesoro shall conduct stack testing to establish the ratio of condensable PM2.5 from the FCCU wet gas scrubber stack. At that time the condensable fraction will be added and a new source-wide limitation shall be established in the AO.

Total 24-hour PM2.5 (filterable + condensable) emissions shall be calculated by adding the results of the above filterable PM2.5 equations for natural gas and plant gas combustion to the values for the FCCU wet gas scrubber stack and to the estimate for the SRU/TGTU/TGI. Results shall be tabulated every day, and records shall be kept which include the meter readings (in the appropriate units) and the calculated emissions.

ii. Source-wide NOx

By no later than January 1, 2019, combined emissions of NOx shall not exceed 1.988 tons per day (tpd) and 475 tons per rolling 12-month period.

Compliance shall be determined daily by multiplying the hours of operation of a unit, feed rate to a unit, or quantity of each fuel combusted at each affected unit by the associated emission factor, and summing the results.

A NOx CEM shall be used to calculate daily NOx emissions from the FCCU wet gas scrubber stack. Emissions shall be determined by multiplying the nitrogen dioxide concentration in the flue gas by the mass flow of the flue gas. The NOx concentration in the flue gas shall be determined by a CEM.

The emission factors for all other emission units are based on the results of the most recent stack test for that unit.

Total daily NOx emissions shall be calculated by adding the emissions for each emitting unit. Results shall be tabulated every day, and records shall be kept which include the meter readings (in the appropriate units) and the calculated emissions.

iii. Source-wide SO2

By no later than January 1, 2019, combined emissions of SO2 shall not exceed 3.1 tons per day (tpd) and 300 tons per rolling 12-month period.

Daily SO2 emissions from the FCCU wet gas scrubber stack shall be determined by multiplying the SO2 concentration in the flue gas by the mass flow of the flue gas. The SO2 concentration in the flue gas shall be determined by a CEM.

Daily SO2 emissions from other affected units shall be determined by multiplying the quantity of each fuel used daily (24 hour usage) at each affected unit by the appropriate emission factor below.

Emission factors (EF) for the various fuels shall be as follows:

Natural gas: EF = 0.60 lb/MMscf

Propane: EF = 0.60 lb/MMscf

Plant fuel gas: the emission factor shall be calculated from the H2S measurement or from the SO2 measurement obtained by direct testing/monitoring.

The emission factor, where appropriate, shall be calculated as follows:

EF (lb SO2/MMscf gas) = [(24 hr avg. ppmdv H2S) /10^6] [(64 lb SO2/lb mole)] [(10^6

scf/MMscf)/(379 scf/lb mole)]

Where mixtures of fuel are used in a Unit, the above factors shall be weighted according to the use of each fuel.

Total daily SO2 emissions shall be calculated by adding the daily results of the above SO2 emissions equations for natural gas, plant fuel gas, and propane combustion to the wet gas scrubber stack. Results shall be tabulated every day, and records shall be kept which include the CEM readings for H2S (averaged for each one-hour period), all meter readings (in the appropriate units), and the calculated emissions.

Tesoro requests that the requirements from the SIP be incorporated into the Approval Order issued for this Project.

4.2 R307-210: Stationary Sources

New Source Performance Standards (NSPS) are incorporated by reference into the UDAQ rules. There is no new construction of any NSPS affected facilities. Tesoro reviewed whether the Project will result in a "modification" or "reconstruction" for any NSPS affected facilities, and thus result in applicability of that NSPS. The NSPS regulation, at 40 CFR §60.14(a), defines a modification as a physical or operational change to the affected facility that is not specifically exempted and that results in an increase in the emissions rate to the atmosphere of any pollutant to which a standard applies. An increase in production rate, if that increase can be accomplished without a capital expenditure on that facility, is not considered a modification per §60.14(e)(2). "Increase in emissions rate" is defined pursuant to §60.14(b) as an increase in the maximum hourly emission rate of an applicable pollutant from the affected facility. A reconstruction occurs when the fixed capital cost of the Project is 50 percent or greater than the current replacement cost of the affected facility.

The FCCU/CO Boiler is the only emissions unit that will require physical changes as part of the Project and is currently an affected facility under NSPS Subpart J. Tesoro reviewed the physical changes performed as part of the Project to determine if NSPS Subpart Ja is triggered for the FCCU/CO Boiler. There will not be any increase in maximum hourly emissions of any pollutant regulated by NSPS Subpart Ja (PM, NO_X, SO_2 and CO). Therefore, the FCCU/CO Boiler is not considered to be "modified" according to NSPS regulations. In addition, the estimated cost of changes being made to the FCCU/CO Boiler as part of the Project are less than 50% of the replacement cost of the affected facility; therefore, "reconstruction" is also not triggered.

Tesoro is evaluating applicability of wastewater system modifications related to the Project to determine whether modification is triggered under NSPS Subpart QQQ and is uncertain at this time whether a modification to an affected facility will occur as part of the Project. Tesoro will review the detailed drawings when they are available and in the event that modification is triggered under Subpart QQQ, Tesoro will provide the required notifications to UDAQ.

The Project will not affect applicability of any other NSPS subparts.

4.3 R307-214: National Emission Standards for Hazardous Air Pollutants

NESHAP standards from 40 CFR 61 and 40 CFR 63 are incorporated by reference into the UDAQ rules. The physical changes performed as part of the Project affect only the FCCU/CO Boiler; which is currently subject to 40 CFR 63 Subpart UUU for "National Emission Standards for Hazardous Air Pollutants for Petroleum Refineries: Catalytic Cracking Units, Catalytic Reforming Units, and Sulfur Recovery Units." Catalytic cracking units are regulated as emission points under this subpart. Tesoro will continue to comply with the emission standards and other requirements of this rule following the Project.

4.4 R307-326: Ozone Nonattainment and Maintenance Areas: Control of Hydrocarbon Emissions in Petroleum Refineries

Rule R307-326-7 contains requirements for flue gas from catalytic cracker catalyst regeneration units. The FCCU/CO Boiler is currently subject and will remain subject to this requirement after the Project. Tesoro will continue to comply with the requirements of this rule following the Project.

4.5 R307-401: Permit: New and Modified Sources

Rule R307-401-3(c) requires submittal of an NOI to "install a control apparatus or other equipment intended to control emissions of air contaminants." Since the Project is installation of emission control systems, an NOI must be submitted. Rule R307-401-5 requires submittal of an NOI, which must contain specific information related to the process, nature of emissions, control device(s), and regulatory applicability and compliance. Refer to Section 5.0 for a summary of compliance with the NOI requirements.

4.5.1 State BACT

R307-401-5(d) permits the issuance of an approval order if it is determined that the pollution control for emissions is at least best available control technology (BACT). A BACT review is required for new emission units and existing emission units where there is a physical modification and an increase in emissions. Because emissions are not increasing at the FCCU/CO Boiler a BACT review is not required.

4.6 R307-403: Nonattainment and Maintenance Areas

R307-403 applies to major new sources or major modifications to be located in a nonattainment area. The refinery is located in a nonattainment area for $PM_{2.5}$ (including precursors SO_2, NO_X, and VOC), PM_{10} (including precursors SO_2 and NO_x), and SO_2. The area is also a designated maintenance area for ozone (VOC and NO_x) and CO. The proposed Project is neither a new major source nor a major modification as defined in R307-101-2 since the actual emissions increase is zero, which is less than the significant emission rate (SER) threshold for each applicable pollutant.

Emission offsets are required if the combined allowable emission increase of PM_{10}, SO_2, and NO_x exceeds 25 tons per year per R307-403-5. Since the combined allowable emission increase from the Project is zero tons per year of these pollutants, no emission offsets are required.

4.7 R307-405: Permits: Major Sources in Attainment or Unclassified Areas (PSD)

R307-405 applies to major new sources or major modifications located in an attainment, unclassified, and maintenance areas. This rule requires review of all regulated NSR pollutants except those pollutants in nonattainment with the ambient air quality standards ($PM_{2.5}$, PM_{10}, and SO_2). The proposed Project is neither a new major source nor a major modification as defined in R307-405-3 since the emissions increase for all applicable pollutants is zero, which is less than the SER threshold for each applicable pollutant. Tesoro has demonstrated compliance with all applicable requirements with the submission of this NOI. Therefore the requirements of R307-405 are not applicable to this proposed Project.

4.8 R307-406: Visibility

The installation of the emission control systems results in a reduction in pollutants (NO_X, SO_2, and PM) that cause or contribute to visibility impairment. As a result, Tesoro believes that the Project will not cause an "Adverse Impact on Visibility" as defined in the rule and no further review is required.

4.9 R307-410: Permits: Emissions Impact Analysis

R307-410 establishes the procedures and requirements for evaluating the emissions impact of new or modified sources. Pursuant to R307-410-4, dispersion modeling is required for increases in the total controlled emission rate of attainment pollutants (NO_x and CO for the SLC refinery) in an amount greater or equal to values given in Table 1 of the rule. For these pollutants, the thresholds given in Table 1 are equal to the SERs. Dispersion modeling is not required since there is not an increase in emissions of NO_x or CO.

The requirements of R307-410-5 for documentation of ambient air impacts for hazardous air pollutants do not apply since the Project does not result in an increase in emissions of hazardous air pollutants.

4.10 R307-420: Permits: Ozone Offset Requirements in Davis and Salt Lake Counties

The SLC Refinery is located in a maintenance area for ozone. Emission offsets are required for any new major source or major modification of VOC or NO_x. R307-420-2 defines a significant emission increase at a level of 25 tpy VOC rather than 40 tpy VOC. The Project is neither a new major source nor a major modification for VOC (considering the lower threshold) or NO_x; therefore, offsets are not required.

4.11 R307-421: Permits: PM_{10} Offset Requirements in Salt Lake County and Utah County

Emission offsets are required if the combined allowable emission increase of SO_2 and NO_x exceeds 25 tons per year. The combined allowable emission increase of these pollutants from the Project is 0 tons per year. Therefore, no emission offsets are required.

4.12 Consent Decree - United States, et.al. v. BP Exploration & Oil, et. al., Civil Action No. 2:96 CV 095 RL

On August 29, 2001 BP Exploration entered into a Consent Decree with the US EPA covering eight refineries including the Salt Lake City and Mandan refineries. When Tesoro purchased the Salt Lake and Mandan refineries from BP, Tesoro assumed responsibility for the provisions of the consent decree as they related to the two facilities. This Project is not being undertaken to comply with any provisions of this consent decree. Tesoro will continue to comply with the provisions of the consent decree, if applicable, after implementation of the Project.

5.0 Summary of NOI Requirements for Project

Table 5-1 provides a summary of how this NOI complies with the specific requirements of Rule R307-401-5(2).

Table 5-1. Summary of NOI Requirements

Requirement	Section Reference for Information Provided
(a) A description of the nature of the processes involved; the nature, procedures for handling and quantities of raw materials; the type and quantity of fuels employed; and the nature and quantity of finished product.	Section 2.2
(b) Expected composition and physical characteristics of effluent stream both before and after treatment by any control apparatus, including emission rates, volume, temperature, air contaminant types, and concentration of air contaminants.	Section 3.2, Attachment B
(c) Size, type and performance characteristics of any control apparatus.	Attachment C, Form 9.
(d) An analysis of best available control technology for the proposed source or modification. When determining best available control technology for a new or modified source in an ozone nonattainment or maintenance area that will emit volatile organic compounds or nitrogen oxides, the owner or operator of the source shall consider EPA Control Technique Guidance (CTG) documents and Alternative Control Technique documents that are applicable to the source. Best available control technology shall be at least as stringent as any published CTG that is applicable to the source.	N/A. The Project does not include installation of a new or modified source.
(e) Location and elevation of the emission point and other factors relating to dispersion and diffusion of the air contaminant in relation to nearby structures and window openings, and other information necessary to appraise the possible effects of the effluent.	Attachment A – location provided – other info not needed since modeling is not required.
(f) The location of planned sampling points and the tests of the completed installation to be made by the owner or operator when necessary to ascertain compliance.	Not applicable – no new testing is necessary to demonstrate compliance.
(g) The typical operating schedule.	Section 2.2

Requirement	Section Reference for Information Provided
(h) A schedule for construction.	Section 2.5
(i) Any plans, specifications and related information that are in final form at the time of submission of notice of intent.	No plans or specifications are in final form at the time of this submission.
(j) Any additional information required by:	
(i) R307-403, Permits: New and Modified Sources in Nonattainment Areas and Maintenance Areas;	(i) Section 4.6
(ii) R307-405, Permits: Major Sources in Attainment or Unclassified Areas (PSD);	(ii) Section 4.7
(iii) R307-406, Visibility;	(iii) Section 4.8
(iv) R307-410, Emissions Impact Analysis;	(iv) Section 4.9
(v) R307-420, Permits: Ozone Offset Requirements in Davis and Salt Lake Counties;	(v) Section 0
(vi) R307-421, Permits: PM_{10} Offset Requirements in Salt Lake County and Utah County.	(vi) Section 4.11
(k) Any other information necessary to determine if the proposed source or modification will be in compliance with Title R307.	Section 4.2 (NSPS Compliance) Section 4.3 (MACT Compliance) Section 4.4 (Control of Hydrocarbons)

Attachment A

Refinery Location Map and Site Diagram

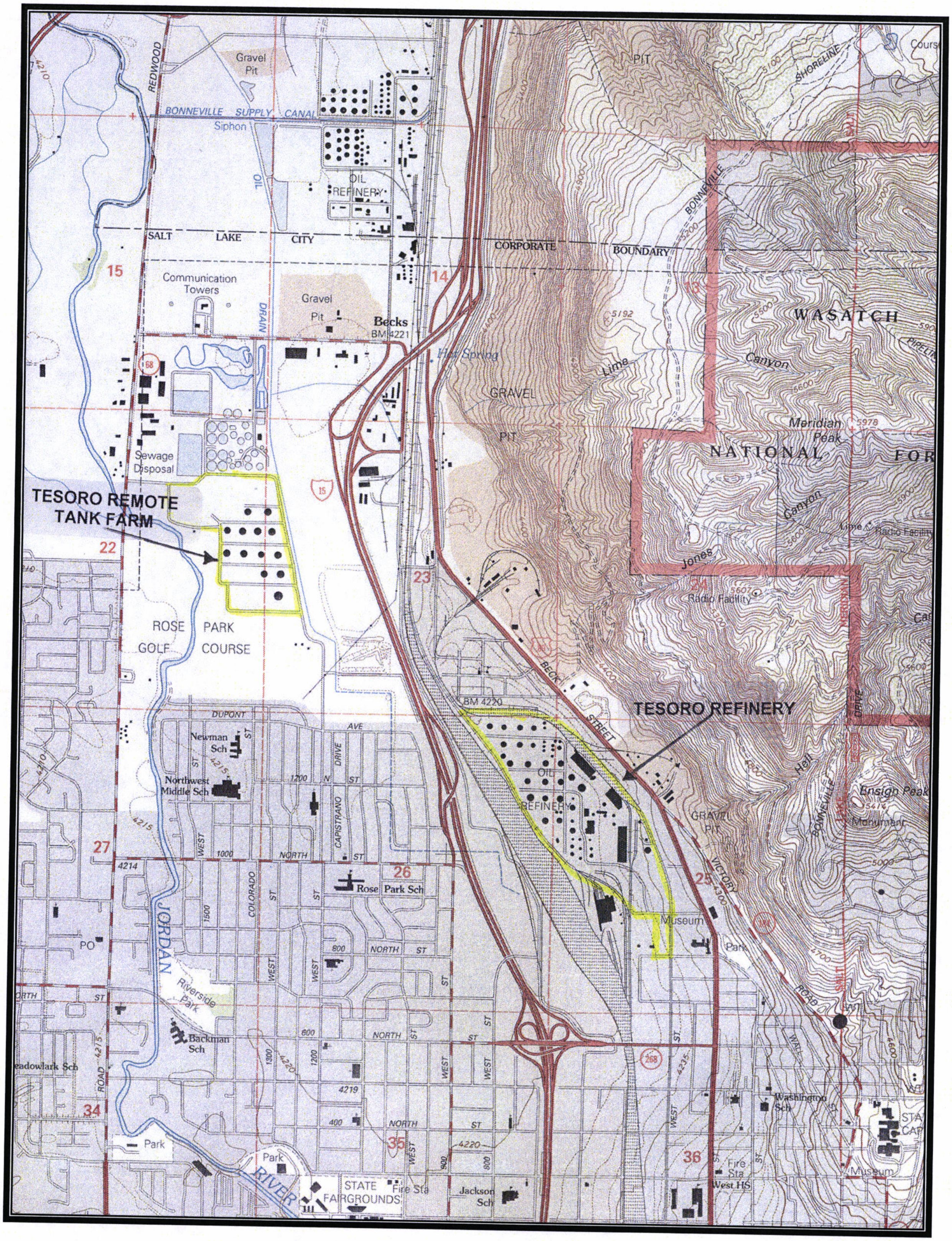
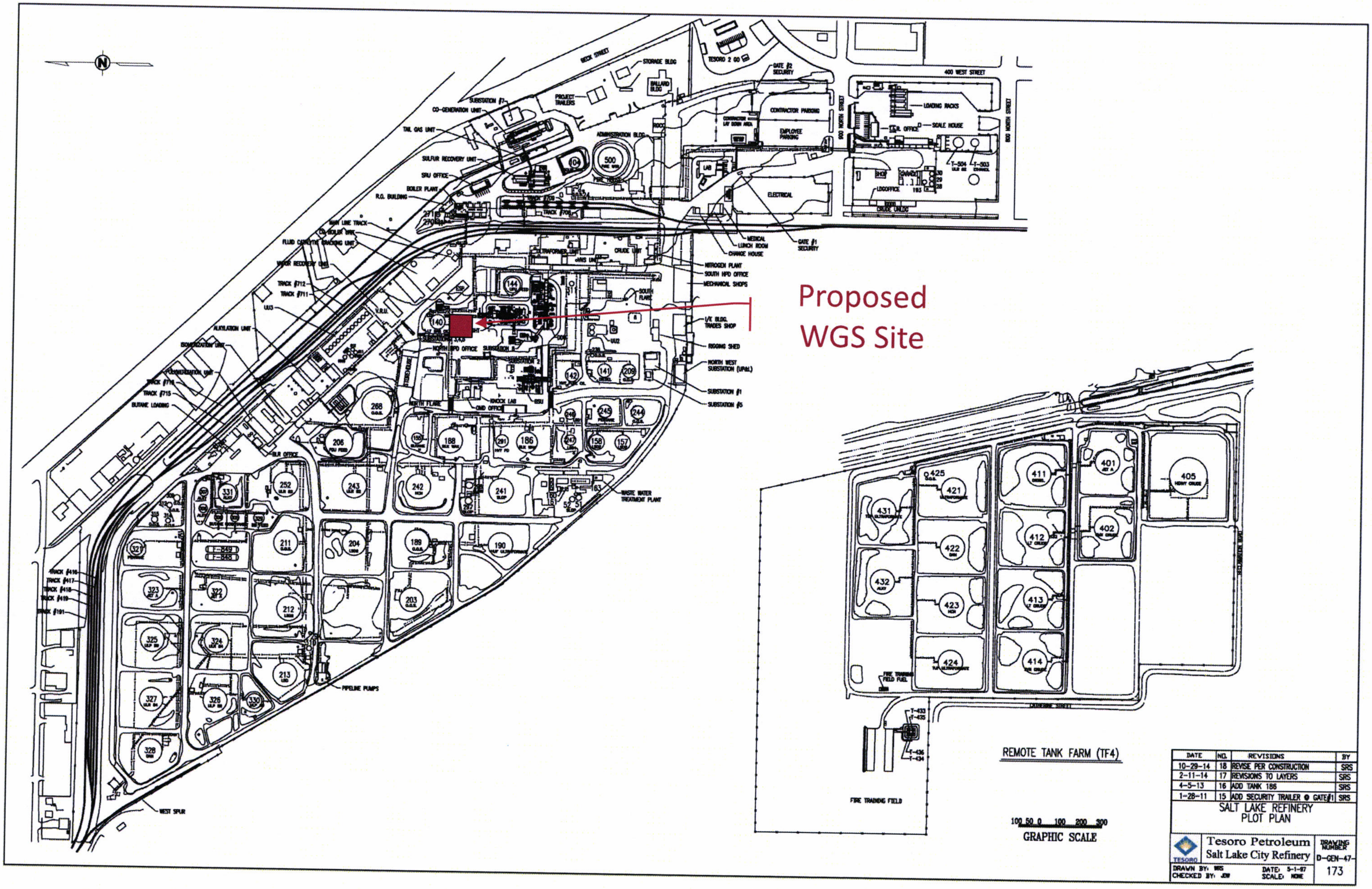


Figure A-1
Refinery Location Map

Tesoro Salt Lake Refinery – Refinery Map



DATE	NO.	REVISIONS	BY
10-29-14	18	REVISE PER CONSTRUCTION	SRS
2-11-14	17	REVISIONS TO LAYERS	SRS
4-5-13	16	ADD TANK 186	SRS
1-28-11	15	ADD SECURITY TRAILER @ GATE#1	SRS

SALT LAKE REFINERY
PLOT PLAN

Tesoro Petroleum
Salt Lake City Refinery

DRAWING NUMBER D-GEN-47-173

DRAWN BY: WRS
CHECKED BY: JDW
DATE: 5-1-97
SCALE: NONE

Attachment B

Emission Calculations for Project

Tesoro Refining and Marketing Company
Salt Lake City Refinery
FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation
Table 1 - FCCU/CO Boiler PTE Summary

	Potential to Emit (tpy)		
Pollutant	Before Project	After Project	Notes
SO_2	671.43	41.06	Note 1.
NO_X	174.00	29.48	Note 2.
CO	933.43	179.51	Note 3.

Notes:

(1) The FCCU is currently subject to a 705 ton/year limit on SO_x emissions from the FCCU stack (refer to Approval Order DAQE-AN103350065-14 condition II.B.4.b). The SO_2 PTE before the project is calculated by dividing the 705 ton/year SO_X limit by 1.05. The 1.05 factor is based on actual stack test data showing that approximately 5% of SO_X is SO_3 and the remaining amount is SO_2. After the project, Tesoro is proposing an SO_2 limit of 10 ppmvd at 0% oxygen on a 365-day rolling average; refer to Table 2 for calculation details.

(2) The FCCU is currently subject to a 174 ton/year limit on NO_X emissions from the FCCU stack. Refer to Approval Order DAQE-AN103350065-14 condition II.B.5.b. After the project, Tesoro is proposing a NO_X limit of 10 ppmvd at 0% oxygen on a 365-day rolling average; refer to Table 2 for calculation details.

(3) The FCCU is currently subject to a CO limit of 500 ppmvd (refer to Table 3 for calculation). After the project, Tesoro is proposing a CO limit of 100 ppmvd at 0% oxygen on a 365-day rolling average; refer to Table 2 for calculation details.

Tesoro Refining and Marketing Company
Salt Lake City Refinery
FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation
Table 2 - FCCU/CO Boiler Emission Calculations after Project

FCCU stack flow rate at design O_2 concentration(1), SCFM (wet)	100,000
FCCU stack moisture content(1) (%)	9%
FCCU stack design O_2 concentration(1) (%)	3.5%
FCCU stack flow rate at design O_2 concentration (calculated), SCFM (dry)	91,000
FCCU stack flow rate at 0% O_2 concentration (calculated), SCFM (dry)	87,500

Pollutant	Concentration at 0% O_2, ppmvd	Molecular Weight	Stack emission rate, lb/hr	Stack emission rate, tpy	Notes
SO_2	10	64.07	9.37	41.06	Note 2.
NO_X	10	46.00	6.73	29.48	Note 2.
CO	100	28.01	40.98	179.51	Note 2.

Notes:

(1) Flow rate, moisture content, and O_2 concentration from "*Design Basis, Tesoro SLC Wet Gas Scrubber, Draft – 3/24/15* ".

(2) SO_2, NO_X, and CO emissions based on proposed concentration limits.

Tesoro Refining and Marketing Company
Salt Lake City Refinery
FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation
Table 3 - FCCU/CO Boiler CO Emission Calculation (before project)

FCCU stack flow rate[1], SCFM (wet)	100,000
Stack moisture content[1] (%)	9%
FCCU stack flow rate (calculated), SCFM (dry)	91,000

Pollutant	Concentration at Design O_2, ppmvd	Molecular Weight	Stack emission rate, lb/hr	Stack emission rate, tpy	Notes
CO	500	28.01	213.11	933.43	Note 2.

Notes:

(1) Flow rate and moisture content from "*Design Basis, Tesoro SLC Wet Gas Scrubber, Draft – 3/24/15* ".

(2) Current CO limit per 40 CFR 60 Subpart J.

Attachment C

Form 1, Form 9, and NOI Checklist

Utah Division of Air Quality
New Source Review Section

Date

Form 1
Notice of Intent (NOI)

Application for: ☒Initial Approval Order ☐Approval Order Modification

APPROVAL ORDER MUST BE ISSUED BEFORE ANY CONSTRUCTION OR INSTALLATION CAN BEGIN. This is not a stand alone document; please refer to UAC R307-401and the published NOI guidebook for information on requirements of the specified information below. Please print or type all information requested. All outlined information requested must be accurate and completed before DAQ can determine that an NOI is complete and an engineering review can be initiated. If you have any questions, contact the Division of Air Quality at (801) 536-4000 and ask to speak with a New Source Review Engineer. Written inquiries may be addressed to: Division of Air Quality, New Source Review Section, P.O. Box 144820, Salt Lake City, Utah 84114-4820.

General Owner and Facility Information

R307-401-5(2)(k)

1. Filing Fee Paid*	2. Application Fee Paid*
3. Company name and address: Tesoro Refining & Marketing Company LLC 474 West 900 North Salt Lake City, UT 84103 Phone No.: (801)366-2036 Fax No.: (801)521-4965	4. Company** contact for environmental matters: William Snarr Phone no.: (801)521-4966 Email: William.K.Snarr@tsocorp.com *** Company contact only; consultant or independent contractor contact information can be provided in a cover letter*
5. Facility name and address (if different from above): Tesoro Refining & Marketing Company LLC 474 West 900 North Salt Lake City, UT 84103 Phone no.: (801)366-2036 Fax no.: (801)521-4965	6. Owners name and address: Tesoro Corporation 19100 Ridgewood Parkway San Antonio, TX 78259 Phone no.: Fax no.:
7. Property Universal Transverse Mercator coordinates (UTM), including System and Datum: Easting: 423,400 Northing: 4,515,950 System: UTM Zone 12 Datum:	8. County where the facility is located in: Salt Lake 9. Standard Industrial Classification Code: 2911

10. Designation of facility in an attainment, maintenance, or nonattainment area(s):

SL City CO Maint Area
SL Co Ozone Maint Area
SL Co PM10 NAA
SL Co PM2.5 NAA
SL Co SO2 NAA

11. If request for modification, AO# to be modified: DAQE#DAQE-AN103350065-14 Date: 9/5/14

12. Identify any current Approval Order(s) for the facility **not** being modified with this request:

AO#DAQE-AN103350063-14 Date3/17/14
AO#DAQE-AN0103350042-08 Date5/13/08
AO# Date
AO# Date

13. Application for:

☒New construction
☐Existing equipment operating without permit
☐Change of permit condition
☐Modification
☐Permanent site for Portable Approval Order
☐Change of location

14. Construction or modification estimated start date:5/1/16 Estimated completion date:10/31/17

R307-401-5(2)(h)

15. Does this application contain justifiable confidential data? ☐Yes ☒ No

16. Current Title V (Operating Permit) Identification: Date

☐Requesting an enhanced Title V permit with this AO modification

17. Brief (50 words or less) description of project to post on DAQ web for public awareness

This Project involves installation of WGS and LoTOxTM emissions control systems on the FCCU exhaust stack. These emission control systems are being installed primarily to meet Utah's PM2.5 State Implementation Plan (SIP) requirements that apply to Tesoro.

Process Information

18. Appendix A: Detailed description of project including process flow diagram (See Forms 2-23)

☐Fuels and their use
☐Raw materials used
☐Operation schedules
☐Equipment used in process
☐Description of changes to process (if applicable)
☐Production rates (including daily/seasonal variances)
☐Description of product(s)
☒Stack parameters

R307-401-5(2)(a)

19. Appendix B: Site plan of facility with all emission points and elevations, building dimensions, stack parameters included

R307-401-5(2)(e)

Emissions Information

20. Appendix C: Emission Calculations that must include:
☒Emissions per new/modified unit for each of the following: PM_{10}, $PM_{2.5}$, NO_x, SO_x, CO, VOC, and HAPs
☒Designation of fugitive and non fugitive emissions
☐Major GHG Sources: Emissions per new/modified unit for GHGs (in CO_2e short tons per year)
☒References/assumptions for each Emission Factor used in calculating Criteria pollutant, HAP, and GHG emissions
☐HAP emissions (in pounds per hour and tons per year) broken out by specific pollutant and summed as a total
R307-401-5(2)(b)

21. Appendix D: DAQ Form 1a or equivalent (comparison of existing emissions to proposed emission and resulting new total emissions)

22. Appendix E: Source Size determination (Minor, Synthetic Minor, Major, or PSD)
☒ If an Existing Major Source: Determination of Minor, Major or PSD modification

23. Appendix F: Offset requirements (nonattainment/maintenance areas)
☐Acquired required offsets
R307-401-420 & R307-401-421

Air Pollution Control Equipment Information

24. Appendix G: Best Available Control Technology (BACT) analysis for the proposed source or modification
R307-401-5(2)(d)

25. Appendix H: Detailed information on all new/modified equipment controls. It is strongly recommended using DAQ forms as they outline required information, but something equivalent to the DAQ forms is acceptable.
R307-401-5(2)(c)

26. Appendix I: Discussion of Federal/State requirement applicability (NAAQS, SIP, NSPS, NESHAP, etc)

Modeling Information

27. Appendix J: Emissions Impact Analysis (if applicable)
R307-410-4

Electronic NOI

28. A complete and accurate electronic NOI submitted
R307-401-5(1)

I hereby certify that the information and data submitted in and with this application is completely true, accurate and complete, based on reasonable inquiry made by me and to the best of my knowledge and belief.

Signature: Karma M. Thomson Title: VP, SAlT Lake City Refinery

Name (print) Karma M Thomson	Telephone Number: 801 521 4813	Date: June 11, 2015

with the exception of Federal Agencies who will be billed at completion of the project

Utah Division of Air Quality

Boxes indicate where information can be found in the application.

NOTICE OF INTENT COMPLETENESS CHECKLIST

TO BE COMPLETED BY PROJECT ENGINEER WITHIN 30 DAYS OF RECEIPT OF THE NOTICE OF INTENT (NOI). CRITERIA DERIVED FROM R307-401-5, UTAH ADMINISTRATIVE CODE (UAC). ANY NEGATIVE RESPONSE WILL CAUSE APPLICATION TO BE DELAYED. ALL REFERENCES ARE TO THE UAC EXCEPT AS NOTED.

Project Name: FCU/COB WGS LoTOx Install Date: 6/11/15

1. Fees Paid
   A. Filing Fee Y ☐ N ☐
   B. Application Fee Y ☐ N ☐

Cover letter

2. Source Identification Information: [R307-401-5(2)(k)]
   A. Name, address, and telephone number (w/area code) Y ☐ N ☐
   B. Company submitting application Y ☐ N ☐
   C. Plant manager and/or Company contact Y ☐ N ☐
   D. Plant (if different from Company) Y ☐ N ☐ N/A ☐
   E. Company owner and agent Y ☐ N ☐
   F. Property UTM coordinates Y ☐ N ☐
   G. County where facility is located Y ☐ N ☐
   H. SIC Code(s) Y ☐ N ☐
   I. Facility area designation (attainment, maintenance, or nonattaiment) Y ☐ N ☐

Form 1
General information in Sections 1.0 and 2.1

3. If modification, AO# to be modified [R307-401-5(2)(k)] Y ☐ N ☐ N/A ☐

Form 1

   A. Other current Approval Order(s) for facility not being modified Y ☐ N ☐ N/A ☐
   B. Current Title V (Operating Permit) Y ☐ N ☐ N/A ☐

4. Purpose of application [R307-401-5(2)(a)] Y ☐ N ☐

Form 1
Section 1.0

5. Construction schedule [R307-401-5(2)(h)] Y ☐ N ☐ N/A ☐

Form 1
Section 2.5

6. Justifiable confidential data Y ☐ N ☐ N/A ☐

N/A

7. Description of Source Process. [R307-401-5(2)]

   A. Detailed description of project: [(Appendix A) (Forms 2-23)]
      1. Fuels and their use Y ☐ N ☐
      2. Raw materials used Y ☐ N ☐ N/A ☐
      3. Description of product(s) Y ☐ N ☐
      4. Equipment used in process Y ☐ N ☐
      5. Operation schedules Y ☐ N ☐
      6. Description of changes to process Y ☐ N ☐ N/A ☐
      7. Production rates Y ☐ N ☐ N/A ☐

Section 2.0 and sub-sections

B. Site plan of facility with, building dimensions, stack parameters included: (Appendix B) Y ☐ N ☐
   1. Emission points and elevations Y ☐ N ☐
   2. Building dimensions Y ☐ N ☐ N/A ☐
   3. Stack parameters Y ☐ N ☐ N/A ☐

Attachment A
No stack parameters included
(no modeling analysis)

8. Emissions Related Information. [R307-401-(2)(b)]

A. Emission Calculations: (Appendix C)
   1. Emissions per new/modified unit for all pollutants: (PM_{10}, $PM_{2.5}$ NO_x, SO_x, CO, VOC, and HAPs) Y ☐ N ☐
   2. Designation of fugitive and non-fugitive emissions Y ☐ N ☐
   3. Major GHG Sources: (in CO2e short tons per year) Y ☐ N ☐ N/A ☐
   4. References/assumptions for each calculation and pollutant Y ☐ N ☐
   5. HAP emissions (broken out by specific pollutant in pounds per hr) Y ☐ N ☐ N/A ☐
   6. Applicable Material Safety Data Sheets Y ☐ N ☐

Section 3.0 and subsections; Attachment B

B. DAQ Form 1a or equivalent (Appendix D) Y ☐ N ☐

Attachment C

C. Source size determination (Appendix E)
   1. If Existing Major Source: Determination of Minor, Major, or PSD Modification Y ☐ N ☐ N/A ☐

Section 3.0 and sub-sections

D. Offset requirements (nonattainment/maintenance areas) [(R307-401-420)(R307-401-421)] (Appendix F) Y ☐ N ☐ N/A ☐
   1. Acquired required offsets Y ☐ N ☐ N/A ☐

Sections 4.10, 4.11 (not applicable)

9. Air Pollution Control Equipment

Sections 2.2 and 4.5, Form 9

A. Best Available Control Technology (BACT) Analysis [R307-401-5(2)(d), (Appendix G)] Y ☐ N ☐

B. Detailed information on new/modified equipment controls [R307-401-5(2)(c), (Appendix H)] Y ☐ N ☐

10. Federal/State requirement applicability [(NAAQS, SIP, NSPS, etc), (Appendix I) Y ☐ N ☐ N/A ☐

11. Modeling information

Section 4.0 and sub-sections

A. Emissions Impact Analysis [(R307-410-4), (Appendix J)] Y ☐ N ☐ N/A ☐

Section 4.9

12. Signature on application (Form 1 Notice of Intent) Y ☐ N ☐

Form 1

Utah Division of Air Quality
New Source Review Section

Form 9
Scrubbers & Wet Collectors

Company Tesoro Refining and Marketing Company
Site/Source Salt Lake City Refinery
Date May 1, 2015

Equipment Information

1. Provide diagram of internal components (attachment) TBD

2. Manufacturer: Belco
Model no. TBD

3. Date installed: October 1, 2017

4. Emission Equipment served: FCCU

5. Type of pollutant(s) controlled:
Particulate (type) Filterable (PM, PM_{10}, and $PM_{2.5}$) and condensable
SO_x SO_2, SO_3
Odor
Other NO_X

6. Type of Scrubber: TBD
☒ Spray Chamber
☐ Cyclone
☐ Orifice
☐ Venturi
☐ Packed Tower Type
☐ Mechanical

7. Gas Stream Characteristics

Flow rate (acfm)		Gas Stream Temperature (°F)		Particulate Grain Loading (grains/scf)	
Design Maximum	Average Expected	Inlet	Outlet	Inlet	Outlet
100,000 scfm	95,000 scfm	480°F	134°F	1.35	0.0051

8. Particulate size: TBD microns (mean geometric diameter)

Scrubbing Liquid Characteristics

9. Scrubbing Liquid
PH 14 Range 14 - 14

Composition	Wt. %
1.	
2.	
3.	
4.	
5.	
6.	

10. Liquid Injection Rate (gpm)

Design Maximum	Average Expected
80	70-80

11. Pressure at Spray Nozzle: TBD (psia)

12. Pressure Drop thru Scrubber TBD (inches of water)

Data for Venturi Scrubber

13. Throat Dimensions (Specify Units) n/a

14. Throat Velocity (ft/sec) n/a

Data for Packed Towers

15. Type of Packing n/a

16. Superficial Gas Velocity through Bed n/a

Form 9 Scrubbers & Wet Collectors - Continued

Data Stack/Exhaust Exit

17. Height: 180 feet	18. Temperature of exhaust stream: 134 °F	19. Inside dimensions: 8 feet diameter or ____ feet x ____ feet

20. Monitoring Equipment

Type	Manufacturer	Model	Range	Units
Gas Pressure	TBD	TBD	TBD	inches of water column
Water Flow	TBD	TBD	TBD	gallons per minute
Water Pressure	TBD	TBD	TBD	pounds per square inch

Settling Ponds

21. Dimensions of settling pond:
Width:
Length: n/a
Depth:

22. Flow rate through settling pond: n/a

23. Residence time of water in pond: n/a

Emissions Calculations (PTE)

24. Calculated emissions for this device Refer to Attachment B of application.

PM_{10} ____ Lbs/hr ____ Tons/yr $PM_{2.5}$ ____ Lbs/hr ____ Tons/yr
NO_x ____ Lbs/hr ____ Tons/yr SO_x ____ Lbs/hr ____ Tons/yr
CO ____ Lbs/hr ____ Tons/yr VOC ____ Lbs/hr ____ Tons/yr
HAPs ____ Lbs/hr (speciate) ____ Tons/yr (speciate)
Submit calculations as an appendix.

Instructions – Form 9 Scrubbers & Wet Collectors

NOTE:
1. **Submit this form in conjunction with Form 1 and Form 2.**
2. Call the Division of Air Quality (DAQ) at **(801) 536-4000** if you have problems or questions in filling out this form. Ask to speak with a New Source Review engineer. We will be glad to help!

1. Supply an assembly drawing, dimensioned and to scale of the interior dimensions and features of the equipment. Please include inlet and outlet liquid and gas flow directions and temperatures, and demister section.
2. Specify the manufacturer and model number of equipment.
3. Please indicate the date that the equipment was installed.
4. Specify what type of equipment or process the scrubber is being used for.
5. Specify what pollutant is being controlled by the scrubber/wet collector.
6. Specify the type of scrubber.
7. Supply the specifications for the gas stream including the flow rate at the design maximum and expected average, inlet and outlet temperatures, and particulate grain loading at inlet and outlet.
8. Supply the particulate mean geometric diameter.
9. Supply the composition of the scrubbing liquid used in the equipment.
10. Indicate what the liquid injection rate is for the design maximum and the expected average in gallons per minute.
11. Indicate the pressure at the spray nozzle.
12. Identify what the pressure drop through the scrubber is.
13. Indicate what the throat dimensions are for a venturi scrubber.
14. Indicate what the throat velocity is for a venturi scrubber.
15. Indicate what the type of packing is in a packed tower.
16. Specify what the gas velocity is through the bed in a packed tower.
17. Indicate what the stack height is of the scrubber.
18. Indicate the temperature of the exhaust gas.
19. Supply the inside dimensions of the stack.
20. Supply specifications of any monitoring equipment which is used in the system.
21. Specify the dimensions of the settling pond.
22. Indicate the flow rate of the water through the settling pond.
23. Supply the residence time of the water in the settling pond.
24. Supply calculations for all criteria pollutants and HAPs. Use AP42 or Manufacturers data to complete your calculations.

RE: Questions on WGS NOI

1 message

Drechsel, Chris S <Christopher.S.Drechsel@tsocorp.com> Wed, Sep 16, 2015 at 3:49 PM
To: John Jenks <jjenks@utah.gov>, "Bujdoso, Michelle D" <Michelle.D.Bujdoso@tsocorp.com>

John – I will review and provide feedback on your questions below. I'll also give you a call to discuss the other items.

As another option, I'll be in SLC next Monday – Weds. Would you have any time for a face-to-face to review these items and the other topics I wanted to discuss?

Thanks. Chris.

From: John Jenks [mailto:jjenks@utah.gov]
Sent: Wednesday, September 16, 2015 2:40 PM
To: Bujdoso, Michelle D; Drechsel, Chris S
Subject: Questions on WGS NOI

Michelle,

I've got a few questions on the WGS NOI. Hopefully they are pretty easy, and I can wrap this project up for you guys in the next couple of days.

yes as back up to WGS

1. I just want to verify that the existing particulate controls (cyclones/ESP) are remaining in place on the FCC? The NOI doesn't specify anything about changes, so I assume so.

2. In addition, although there is a reference to increased fugitive dust emissions (road dust) from vehicle traffic, this will be absorbed by the existing plant wide caps, and there will be no increase in overall particulates?

not specifically calculated but accounted for

There isn't a lot of discussion on particulates in the NOI generally, so I had to infer part of the engineering review, but one question that is liable to come up during any potential comment or challenge would be why there is no drop in particulate emissions since ultimately the spray tower's function is to remove particulates (treated NOx compounds for example).

3. There are three existing conditions II.B.4.b, II.B.5.b and II.B.6.a that have current limitations on the FCCU in

terms of tons/year, but are built into the existing plant-wide caps. I'm easily able to write a new condition(s) for the required limits found in Table 3-2 from the NOI, but those limits are ppmvd values. Once the new plant-wide limits (found in Table 3-3) are also included, those FCCU yearly limits from the existing conditions no longer seem valid or applicable.

need to stay PSD concern / re EPA although could move to make clear

I'd like to propose putting in a sunset clause on those limits such that they expire once the new plant-wide caps come into play. This project obviously has to go out to public comment anyway, so it doesn't extend the permitting process. Thoughts?

no see above

4. You've included a specific CO limitation as well as calculations showing a CO reduction, but no explanation was included as to why this was included. In order to include this information I'll need to include some explanation within the engineering review so there is a justification for the limit and a reason for demonstrating the reduction. Even if the justification was "a voluntary emission reduction" that would suffice. Otherwise, management won't allow me to include the limitation as there would be no basis for it.

included as CO change

5. Monitoring: Currently there are CEMs and/or stack testing in place for demonstrating compliance with the SO2/NOx/particulate limits at the FCCU/CO boiler (see II.B.4.c.1, II.B.5.a and II.B.6.a, respectively. Will these same methods remain in place and in use following the installation of the WGS? Or will anything need to change?

keep

6. Finally, I'm not currently including the PM10 SIP requirements, since that SIP isn't going to be final until at least December (and not published in the State Bulletin until January), and I hope to be well finished with this project before then. However, it is possible that we'll get comments asking why those provisions haven't been included.

now include since new NOI

Chris, I did receive your phone call, hopefully this brings you up to speed on where I am with the WGS project. I am available anytime the rest of this week if you would like to schedule another call for further discussions on your other topics.

- John

--

John D. Jenks

Environmental Engineer

Utah Division of Air Quality

P: (801) 536-4459

F: (801) 536-4099

Tesoro/UDAQ Air Permitting Update Meeting

September 23, 2015

I. **WGS NOI Application:**
  A. Discuss UDAQ email questions
  B. Steam use application update letter
  C. Ozone applicability EPA Region 8 request

II. **Ultraformer ULNB NOI Application**

III. **Tesoro Logistics Truck Loading Rack Tank NOI Application**

IV. **Further Discussion/Questions**

I've got a few questions on the WGS NOI. Hopefully they are pretty easy, and I can wrap this project up for you guys in the next couple of days.

1. I just want to verify that the existing particulate controls (cyclones/ESP) are remaining in place on the FCC? The NOI doesn't specify anything about changes, so I assume so.

2. In addition, although there is a reference to increased fugitive dust emissions (road dust) from vehicle traffic, this will be absorbed by the existing plant wide caps, and there will be no increase in overall particulates?

There isn't a lot of discussion on particulates in the NOI generally, so I had to infer part of the engineering review, but one question that is liable to come up during any potential comment or challenge would be why there is no drop in particulate emissions since ultimately the spray tower's function is to remove particulates (treated NOx compounds for example).

3. There are three existing conditions II.B.4.b, II.B.5.b and II.B.6.a that have current limitations on the FCCU in terms of tons/year, but are built into the existing plant-wide caps. I'm easily able to write a new condition(s) for the required limits found in Table 3-2 from the NOI, but those limits are ppmvd values. Once the new plant-wide limits (found in Table 3-3) are also included, those FCCU yearly limits from the existing conditions no longer seem valid or applicable.

I'd like to propose putting in a sunset clause on those limits such that they expire once the new plant-wide caps come into play. This project obviously has to go out to public comment anyway, so it doesn't extend the permitting process. Thoughts?

4. You've included a specific CO limitation as well as calculations showing a CO reduction, but no explanation was included as to why this was included. In order to include this information I'll need to include some explanation within the engineering review so there is a justification for the limit and a reason for demonstrating the reduction. Even if the justification was "a voluntary emission reduction" that would suffice. Otherwise, management won't allow me to include the limitation as there would be no basis for it.

5. Monitoring: Currently there are CEMs and/or stack testing in place for demonstrating compliance with the SO2/NOx/particulate limits at the FCCU/CO boiler (see II.B.4.c.1, II.B.5.a and II.B.6.a, respectively. Will these same methods remain in place and in use following the installation of the WGS? Or will anything need to change?

6. Finally, I'm not currently including the PM10 SIP requirements, since that SIP isn't going to be final until at least December (and not published in the State Bulletin until January), and I hope to be well finished with this project before then. However, it is possible that we'll get comments asking why those provisions haven't been included.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
Denver, CO 80202-1129
Phone 800-227-8917
www.epa.gov/region08

September 29, 2015

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY
OCT - 5 2015
DIVISION OF AIR QUALITY

Ref: 8P-AR

Bryce Bird, Director
Division of Air Quality
Utah Dept. of Environmental Quality
P.O. Box 144820
Salt Lake City, Utah 84114-4820

RE: Response to Your Inquiry Regarding Direct Ozone Emissions

Dear Mr. Bird:

This letter is in response to your inquiry letter of June 4, 2015, regarding interpretation of Prevention of Significant Deterioration (PSD) regulations as they pertain to direct emissions of ozone. You explained that you are anticipating receipt of a New Source Review (NSR) permit application shortly for a project involving installation of a wet gas scrubber unit at a local refinery. The purpose of the new unit is to reduce nitrogen oxide emissions. Since the unit will be using ozone injection to accomplish this reduction, direct emissions of ozone from the scrubber stack are highly probable. You asked how the definition of "significant" in the PSD regulations at 40 CFR 52.21(b)(23)(ii) pertains to direct emissions of ozone. The definition of "significant" provides that with regard to a regulated NSR pollutant that is not listed in paragraph (b)(23)(i), any emissions rate is significant.

Since paragraph (b)(23)(i) specifically lists the pollutant ozone and defines a significant emissions rate for ozone as 40 tons per year of volatile organic compounds or nitrogen oxides, we do not interpret paragraph (b)(23)(ii) to apply to ozone or direct ozone emissions.

If you have any further questions, please feel free to contact me at (303) 312-6416, or your staff may contact Mike Owens at (303) 312-6440.

Sincerely,

Carl Daly

Carl Daly, Director
Air Program

1896

State of Utah

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

Department of
Environmental Quality

Alan Matheson
Acting Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

FILE

DAQE-009-15

June 4, 2015

Carl Daly
US EPA Region 8
1595 Wynkoop Street
Denver, CO 80202-1129

Dear Mr. Daly:

This letter requests an official letter documenting the Agency's interpretation of the applicability of the New Source Review (NSR) program to direct emissions of ozone. The Utah Division of Air Quality (DAQ) is shortly expecting to receive an application for a wet gas scrubber unit at a local refinery. This scrubber will be equipped with a Low-TOx system, which uses ozone injection to reduce emissions of NO_x from the effluent stream. As with any system which relies on injection of a reagent, some unreacted reagent (ozone "slip") will occur. Thus, direct emissions of ozone from the scrubber stack are highly probable.

DAQ's request for interpretation specifically applies to the definition of "significant" under the Prevention of Significant Deterioration regulations at 40 CFR 52.21(b)(23)(ii). Paragraph (b)(23)(ii) provides that with regard to a regulated NSR pollutant that is not listed in paragraph (b))(23)(i), any emissions rate is significant. We are aware of the draft letter from OAQPS Director, Stephen Page regarding the Archer Daniel Midland case, but have been unable to obtain a copy of the final version of this document.

As the refinery application in question is being submitted in partial fulfillment of the refinery's obligations under both Utah's State Implementation Plan and the refinery's pending consent decree with EPA, obtaining documentation of the agency's position on this issue would be of great assistance in DAQ's efforts to issue a timely and accurate NSR permit.

Sincerely,

Bryce C. Bird
Director

BCB:JJ:jc

195 North 1950 West • Salt Lake City, UT
Mailing Address: P.O. Box 144820 • Salt Lake City, UT 84114-4820
Telephone (801) 536-4000 • Fax (801)536-4099 • T.D.D. (801) 536-4414
www.deq.utah.gov
Printed on 100% recycled paper

NEW SOURCE REVIEW SECTION

SITE ID # AND PROJECT #: N/A
COMPANY NAME: EPA
REGARDING: Request an official letter documenting the Agency's interpretation of the applicability of the New Source Review (NSR) program to direct emissions of ozone

THE ATTACHED DOCUMENT IS CATEGORIZED AS: (PLEASE CHOOSE ONE)

	NEWSPAPER NOTICE (NN)	Office Tech signs cover letter of Newspaper Notice
	INTENT TO APPROVE (ITA)	Cover letter and ITA signed by associated Section Manager Electronic Copy of ITA sent to Ron Reece
	APPROVAL ORDER (AO)	Copy of purple sheet and cover letter of AO to Teri Weiss
	EXPERIMENTAL AO	Copy of purple sheet and cover letter of AO to Teri Weiss
✓	CORRESPONDENCE	Signatory varies
	SOIL REMEDIATION	If associated fee, send copy of purple sheet and letter to Teri Weiss
	SALES TAX EXEMPTION (TAX)	
	SMALL SOURCE EXEMPTION	Copy of purple sheet and letter to Teri Weiss
	EMISSIONS BANKING LETTER	Copy of letter to Camron Harry
	NAME CHANGE	Copy of purple sheet and letter to Teri Weiss

COPIES TO BE SENT TO THE FOLLOWING PARTIES: (PLEASE CHECK AS THEY APPLY)

√	Manila File Folder (working file)	√	Greens Folder
	Health Department (see letter for which)		EPA – Mike Owens
	Compliance (associated Section Manager)		Finance – Teri Weiss
	Name Change Letters: Deborah McMurtrie Susan Weisenberg Dave Beatty		Brett Wilding, Utah State Tax Commission, Technical Research Unit
	Offsets Used? Copy of document(s) to Camron Harry		Enter final Name Change Letters in /engineer/aoname
	Copy To:		Enter in /engineer/aocond & in AO Log: (AOs, AO not needed, Replacement in Kind)
	NEWSPAPER NOTICE – COPIES TO: Cities, Counties, Gov. Agencies, & etc./& a copy of Public Official letter with self-addressed envelope E-Mail To: dvd.kvd@juno.com, Jodie Swanson, Lori Walker, Debbie Oberndorfer, Bill Sinclair, Beverly Rasmussen & Jen Burge, Donna Spangler, Ron Reece, and Kelly Beck <u>E-Mail copy & Fax to Newspaper Agencies</u>		PSD PROJECTS: Copy the NOI, Engineering Review, ITA, NOTICE & AO Send to: Mike Owens, EPA Don Banks, Bureau of Land Management Chris Hocket, U.S. Forest Service Chris Shaver, National Park Service TITLE V: Check w/ NSR Engineer for which document(s) to be copied.

REVIEWED BY AND DOCUMENT SIGN OFF DATES:

Completeness determination	John Jenks JDJ
Section Manager sign off	Marty Gray MG
Branch Manager sign off	Reginald Olsen

RDO
5/28/15

UTAH DIVISION OF AIR QUALITY
SOURCE PLAN REVIEW

William Snarr
Tesoro Refining & Marketing Company LLC
474 W 900 N
Salt Lake City, UT 84103

Project Number: N103350066

RE:	Installation of a Wet Gas Scrubber and Ultra-Low NO_x Burners Salt Lake County; CDS A; MACT (Part 63), Nonattainment or Maintenance Area, Title V (Part 70) major source, PM_{10} SIP / Maint Plan, $PM_{2.5}$ Moderate Area SIP, Major criteria source, NESHAP (Part 61), Major HAP source, NSPS (Part 60)
Review Engineer:	John Jenks
Date:	February 29, 2016
Notice of Intent Submitted:	June 11, 2015
Plant Contact:	Michelle Bujdoso
Phone Number:	(801) 366-2036
Fax Number:	(801) 521-4965 Email: Michelle.D.Bujdoso@tsocorp.com
Source Location:	474 West 900 North, Salt Lake City, UT Salt Lake County 4,515,950 m Northing, 423,400 m Easting, UTM Zone 12 UTM Datum: NAD27

DAQ requests that a company/corporation official read the attached draft/proposed Plan Review with Recommended Approval Order Conditions. If this person does not understand or does not agree with the conditions, the review engineer should be contacted within five days after receipt of the Plan Review. If this person agrees with the Plan Review and Recommended Approval Order Conditions, this person should sign below and return (FAX # 801-536-4099) within 10 days after receipt of the conditions. If the review engineer is not contacted within 10 days, the review engineer shall assume that the company/corporation official agrees with this Plan Review and will process the Plan Review towards final approval. A public comment period will be required before the Approval Order can be issued.

Applicant Contact ____
(Signature & Date)

OPTIONAL: In order for this Source Plan Review and associated Approval Order conditions to be administratively included in your Operating Permit (Application), the Responsible Official as defined in R307-415-3, must sign the statement below and the signature above is not necessary. THIS IS STRICTLY OPTIONAL!

If you do not desire this Plan Review to be administratively included in your Operating Permit (Application), only the Applicant Contact signature above is required. Failure to have the Responsible Official sign below will not delay the Approval Order, but will require a separate update to your Operating Permit Application or a request for modification of your Operating Permit, signed by the Responsible Official, in accordance with R307--415-5a through 5e or R307-415-7a through 7i.

> **"Based on reasonable inquiry, I certify that the information provided for this Approval Order has been true, accurate and complete and request that this Approval Order be administratively amended to the Operating Permit (Application)."**

Responsible Official ______________________________________

(Signature & Date)

Print Name of Responsible Official ______________________________

ABSTRACT

On June 11, 2015, Tesoro Refining & Marketing Company LLC (Tesoro) submitted a NOI to construct and operate a wet gas scrubber and LoTOx project to control emissions from the FCCU/CO Boiler at the Tesoro Refinery in Salt Lake City (Refinery). The Refinery is located in Salt Lake City, Salt Lake County, which is a nonattainment area for PM10, PM2.5 and SO2, and a maintenance area for ozone and CO. This project was submitted in partial fulfillment of the PM2.5 requirements found in Sections IX.H.11.g.i and IX.H.12.r of the Utah SIP.

The project involves the installation of an ozone generation system to react with and remove NOx from the FCCU/CO boiler exhaust stream. The exhaust gases are then passed through a new spray tower, which removes the NOx compounds, as well as SO2/SO3 and particulates. The removed compounds are retained in the spray tower's liquid medium - water, buffered with a sodium hydroxide reagent. The liquid is then processed in a purge treatment unit, which separates and dewaters the solids. This results in a final effluent stream that is low in total suspended solids.

Although there will be a small increase in fugitive dust emissions from increased truck traffic to deliver raw materials and haul away waste byproducts associated with the project, no change in plant-wide particulate emissions is anticipated as a result of this project.

This project was supplemented on October 12, 2015, with the submission of additional information. Tesoro determined that approximately 17,500 lb/hr of additional steam generation would be needed to drive the combustion air fan, providing the higher pressures needed in the flue gas train. There would be a slight increase in actual emissions from the existing cogeneration units at the refinery, the largest being approximately 6 tpy of NOx, although this increase would be within Tesoro's existing permitted emission caps. Tesoro also provided information regarding truck haul road emissions as part of this submission. The fugitive dust emissions from the haul roads amount to less than 0.1 tons of total particulates (either PM10 or PM2.5).

Finally, on November 10, 2015, Tesoro submitted a separate NOI for the installation of ultra-low NOx burners on the ultraformer unit (UFU) F-1 furnace. Also submitted in partial fulfillment of the PM2.5 requirements of the Utah SIP, this project is scheduled to be installed at roughly the same time as the wet gas scrubber project. Therefore, Tesoro has requested that the two projects be processed concurrently. Since both projects affect equipment covered by the same existing AO (DAQE-AN103350065-14), both NOIs have been combined into a single AO modification for purposes of convenience and project timing.

The installation of the new burners on the UFU yields no change in established source-wide permitted emissions (no change in Tesoro's emission caps), as this installation was already included and anticipated in Tesoro's emission caps as required by January 1, 2019. Only the UFU will be directly physically changed by this portion of the project. A slight increase in actual emissions (<1 tpy) of PM/PM10/PM2.5 and VOC is expected from the UFU Furnace F-1. In addition, some additional steam from the cogeneration units will be required to assist the operation of the new burners. The total increase in actual emissions from increased utilization of the cogeneration units is less than 1 tpy of any pollutant (the largest being 0.78 tpy of CO). Like the emission increases associated with the wet gas scrubber steam demand, these emission increases are included in Tesoro's existing emission caps.

Any increase in emissions associated with increased utilization of the cogeneration units can be accomplished under existing permit requirements and without a physical change or change in the method of operation of those units; therefore, a review of BACT is not required for the cogeneration units. The F-

1 Furnace is being physically changed by the installation of the new burners, and will experience a small increase in emissions of both particulates and VOC; therefore, a BACT review is required for this emissions unit.

The source is subject to federal NSPS, NESHAP and MACT requirements, and is defined as a major contributing source in both the Salt Lake County PM10 Maintenance and Salt Lake City PM2.5 Nonattainment Area sections of the SIP. The SIP has established emission caps for PM10, PM2.5, SO2 and NOx. The new and project-affected equipment will be included in these emission caps which shall remain at their present values. Total PTE from the entire refinery is estimated at the following tons per year values: PM10 = 282, PM2.5 (a subset of PM10) = 154, NOx = 638, SO2 = 1637, CO = 1,376, VOC = 793.

SOURCE SPECIFIC DESIGNATIONS

Applicable Programs:

NSPS (Part 60), Subpart A: General Provisions applies to North Flare
NSPS (Part 60), Subpart A: General Provisions applies to South Flare
NSPS (Part 60), Subpart Db: Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units applies to CG1 and CG2
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to F-15
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to F-680 and F-681
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to F-701
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to FCCU/CO Boiler
NSPS (Part 60), Subpart J: Standards of Performance for Petroleum Refineries applies to H-101
NSPS (Part 60), Subpart Ja: Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After May 14, 2007 applies to F-1
NSPS (Part 60), Subpart K: Standards of Performance for Storage Vessels for Petroleum Liquids for Which Construction, Reconstruction, or Modification Commenced After June 11, 1973, and Prior to May 19, 1978 applies to Permitted Source
NSPS (Part 60), Subpart Ka: Standards of Performance for Storage Vessels for Petroleum Liquids for Which Construction, Reconstruction, or Modification Commenced After May 18, 1978, and Prior to July 23, 1984 applies to Permitted Source
NSPS (Part 60), Subpart Kb: Standards of Performance for Volatile Organic Liquid Storage Vessels (Including Petroleum Liquid Storage Vessels) for Which Construction, Reconstruction, or Modification Commenced After July 23, 1984 applies to Tank 327: Storage vessel - gasoline
NSPS (Part 60), Subpart GG: Standards of Performance for Stationary Gas Turbines applies to CG1 and CG2
NSPS (Part 60), Subpart XX: Standards of Performance for Bulk Gasoline Terminals applies to Permitted Source
NSPS (Part 60), Subpart GGG: Standards of Performance for Equipment Leaks of VOC in Petroleum Refineries for which Construction, Reconstruction, or Modification Commenced After January 4, 1983, and on or Before November 7, 2006 applies to Permitted Source
NSPS (Part 60), Subpart GGGa: Standards of Performance for Equipment Leaks of VOC in Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After November 7, 2006 applies to Permitted Source
NSPS (Part 60), Subpart NNN: Standards of Performance for Volatile Organic Compound (VOC) Emissions From Synthetic Organic Chemical Manufacturing Industry (SOCMI) Distillation Operations

applies to Permitted Source
NSPS (Part 60), Subpart QQQ: Standards of Performance for VOC Emissions From Petroleum Refinery Wastewater Systems applies to Permitted Source
NESHAP (Part 61), Subpart A: General Provisions applies to Permitted Source
NESHAP (Part 61), Subpart M: National Emission Standard for Asbestos applies to Permitted Source
NESHAP (Part 61), Subpart FF: National Emission Standard for Benzene Waste Operations applies to Permitted Source
MACT (Part 63), Subpart A: General Provisions applies to Permitted Source
MACT (Part 63), Subpart CC: National Emission Standards for Hazardous Air Pollutants From Petroleum Refineries applies to Permitted Source
MACT (Part 63), Subpart UUU: National Emission Standards for Hazardous Air Pollutants for Petroleum Refineries: Catalytic Cracking Units, Catalytic Reforming Units, and Sulfur Recovery Units applies to Permitted Source
MACT (Part 63), Subpart EEEE: National Emission Standards for Hazardous Air Pollutants: Organic Liquids Distribution (Non-Gasoline) applies to Permitted Source
MACT (Part 63), Subpart DDDDD: National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters applies to Permitted Source
Major HAP source applies to Permitted Source
Major criteria source applies to Permitted Source
PM_{10} SIP / Maint Plan applies to Permitted Source
Title V (Part 70) major source applies to Permitted Source
Salt Lake City CO Maintenance Area applies to Permitted Source
Salt Lake County O3 Maintenance Area applies to Permitted Source
Salt Lake County PM_{10} NAA applies to Permitted Source
Salt Lake County $PM_{2.5}$ NAA applies to Permitted Source
Salt Lake County SO_2 NAA applies to Permitted Source

Permit History:

When issued, the approval order shall supersede or will be based on the following documents:

Supersedes	DAQE-AN103350065-14 dated September 5, 2014
Is Derived From	Source Submitted NOI dated June 11, 2015
Incorporates	Additional Information Received From EPA dated September 29, 2015
Incorporates	Additional Information Received dated September 23, 2015
Incorporates	Additional Information Received dated October 12, 2015
Incorporates	Additional Information Received dated November 10, 2015
Incorporates	Additional Information Received dated January 8, 2016
Incorporates	Additional Information Received dated February 1, 2016

SUMMARY OF NOTICE OF INTENT INFORMATION

Description of Proposal:

On June 11, 2015, Tesoro Refining & Marketing Company LLC (Tesoro) submitted a NOI to construct and operate a wet gas scrubber and LoTOx project to control emissions from the FCCU/CO Boiler at the Tesoro Refinery in Salt Lake City (Refinery). The Refinery is located in Salt Lake City, Salt Lake County, which is a nonattainment area for PM_{10}, $PM_{2.5}$ and SO_2, and a maintenance area for ozone and

CO. This project was submitted in partial fulfillment of the $PM_{2.5}$ requirements found in Sections IX.H.11.g.i and IX.H.12.r of the Utah SIP.

The project involves the installation of an ozone generation system to react with and remove NO_x from the FCCU/CO boiler exhaust stream. The exhaust gases are then passed through a new spray tower, which removes the NO_x compounds, as well as SO_2/SO_3 and particulates. The removed compounds are retained in the spray tower's liquid medium - water, buffered with a sodium hydroxide reagent. The liquid is then processed in a purge treatment unit, which separates and dewaters the solids. This results in a final effluent stream that is low in total suspended solids.

Although there will be a small increase in fugitive dust emissions from increased truck traffic to deliver raw materials and haul away waste byproducts associated with the project, no change in plant-wide particulate emissions is anticipated as a result of this project. There is the potential for a small amount of unreacted ozone being released as "slip" from the treatment process. The total amount of ozone released is expected to be quite small (likely less than 5 tpy).

This project was supplemented on October 12, 2015, with the submission of additional information. Tesoro determined that approximately 17,500 lb/hr of additional steam generation would be needed to drive the combustion air fan, providing the higher pressures needed in the flue gas train. There would be a slight increase in actual emissions from the existing cogeneration units at the refinery, the largest being approximately 6 tpy of NO_x, although this increase would be within Tesoro's existing permitted emission caps. Tesoro provided updated information regarding truck haul road emissions as part of this submission. The fugitive dust emissions from the haul roads amounts to less than 0.1 tons of total particulates (either PM_{10} or $PM_{2.5}$).On November 10, 2015, Tesoro submitted a separate NOI for the installation of ultra-low NO_x burners on the ultraformer unit (UFU) F-1furnace. Also submitted in partial fulfillment of the $PM_{2.5}$ requirements of the Utah SIP, this project is scheduled to be installed at approximately the same time as the wet gas scrubber project. Therefore, Tesoro has requested that the two projects be processed concurrently. Since both projects affect equipment covered by the same existing AO (DAQE-AN103350065-14), both NOIs have been combined into a single AO change for purposes of convenience and project timing.

The installation of the new burners on the UFU yields no change in established source-wide permitted emissions. The installation of these burners was already included and anticipated in Tesoro's $PM_{2.5}$ SIP-required emission caps, which come into effect on January 1, 2019. However, these emission caps will be added to this AO as a separate and distinct permit requirement.

Only the UFU will be directly physically modified by this portion of the project. A slight increase in actual emissions (<1 tpy) of $PM/PM_{10}/PM_{2.5}$ and VOC is expected from the UFU Furnace F-1. In addition, some additional steam from the cogeneration units will be required to assist the operation of the new burners. The total increase in actual emissions from increased utilization of the cogeneration units is less than 1 tpy of any pollutant (the largest being 0.78 tpy of CO). Like the emission increases associated with the wet gas scrubber steam demand, these emission increases are included in Tesoro's existing and future (1/1/2019) emission caps.

The changes anticipated by this combined permitting project are:
1. Adding one entry to Section II.A to list the new wet gas scrubber and Lo-TOx unit
2. Updating the entry in Section II.A referring to the UFU F-1 Furnace to reflect the new burners
3. Adding new requirements in Section II.B on the FCCU/CO Boiler based on the expected performance of the wet gas scrubber

4. Adding new requirements to reflect the new emission caps from SIP Sections IX.H.2 and IX.H.12
5. Adding 40 CFR 63, Subpart DDDDD to the list of applicable subparts as it was previously left out.

Summary of Emission Totals:

The emissions listed below are an estimate of the total potential emissions from the source. Some rounding of emissions is possible.

Estimated Criteria Pollutant Potential Emissions		
CO_2 Equivalent	1.00	tons/yr
Carbon Monoxide	1376.00	tons/yr
Nitrogen Oxides	638.00	tons/yr
Particulate Matter - PM_{10}	282.00	tons/yr
Particulate Matter - $PM_{2.5}$	154.00	tons/yr
Sulfur Dioxide	1637.00	tons/yr
Volatile Organic Compounds	793.00	tons/yr

Review of Best Available Control Technology:

1. BACT Review
As a combined project with two distinct sections, the requirement to review BACT applies separately to each sub-project.

Wet Gas Scrubber Project:
The wet gas scrubber and LoTOx unit are being installed entirely as pollution control devices. The only emission "increase" associated with the installation is the release of ozone as part of the NO_x control process. Although every effort is made to balance the amount of ozone required to control NO_x, some amount of additional ozone is required as no process can be truly isometric in practice. Some portion of this ozone can pass through the process unreacted and be emitted in what is called "slip". This is very similar to the passage of ammonia slip used in the SCR process.

In fact, within the NSR permitting process the way this ozone would be reviewed must be handled exactly as would the ammonia slip from an SCR treatment process. In other words, not as a separate pollutant emission, but as an unfortunate by-product of the treatment process. Nevertheless, UDAQ has conducted a search for potential applicable control technology for direct ozone emissions and found only a single process which claims to reduce ozone emissions directly.

The PremAir and PremAir NXT direct ozone reduction catalysts from BASF are based on an earlier design by Engelhard (BASF bought Engelhard in 2006). These catalysts are designed for use in vehicle radiators and reduce ozone into oxygen. Unfortunately, this technology is not currently transferable to control the ozone slip emissions generated in the Tesoro wet gas scrubber. As is explained in the process description, the wet gas scrubber is being installed primarily to control SO_2 (and other sulfur oxide and acid gas) emissions. This system was chosen because of the high initial particulate loading, and the ability to control multiple sulfur-based pollutants simultaneously. This type of system has also been demonstrated as highly effective in controlling emissions from FCCU regenerators; especially when combined with a

LoTOx unit for controlling NO_x emissions.

In the LoTOx system, the ozone is injected prior to the packed bed scrubber, in order to ensure good mixing and elevated temperatures (which speeds the reduction). Attempting to install an ozone reducing catalyst in this section would lead to fouling of that catalyst due to the high particulate loading. Unfortunately, attempting to install the catalyst after the packed bed yields a different problem. The catalyst has been shown to have greatly lowered effectiveness in high humidity environments, and can be actively poisoned by chemical salts.

Given that the exhaust stream following the packed bed will approach 100% relative humidity, UDAQ asserts that this technology is not transferable at this time. UDAQ was unable to find any other direct ozone emission-controlling technology which could be applied to this process.

Operating under the assumption that the wet gas scrubber/LoTOx unit operates as an emission control device, and the ozone used in the process is considered "slip", no existing emissions will increase as a result of this sub-project, no new emissions will be generated, and several existing pollutants will experience a decrease in emissions.

Thus, no additional BACT is required for this sub-project. [Last updated February 11, 2016]

2. BACT Review cont.
From the definition of BACT found at R307-401-2:

"Best available control technology" means an emissions limitation (including a visible emissions standard) based on the maximum degree of reduction for each air contaminant which would be emitted from any **proposed stationary source or modification** which the director, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant... [emphasis added]

In this particular case, the installation of the new wet gas scrubber/LoTOx system is not a new (proposed) stationary source, as the refinery is already existing; nor does it qualify as a modification, since by definition a modification requires there to be an increase in emissions (see the definition of "modification" in R307-101-2).

Even if the emissions of ozone are treated as a separate emission, there are no new emissions of any other air contaminants besides ozone, and so BACT would only need to be reviewed for control of that single pollutant. Ozone is not a regulated NSR pollutant. No other processes are being physically modified or experiencing an increase in emissions of any air contaminant. Thus, BACT for this sub-project is no additional controls beyond installation of the wet gas scrubber and LoTOx unit as described. [Last updated February 11, 2016]

3. BACT Review cont.
Installation of the Ultra-Low NO_x Burners on the Ultraformer Unit F-1 Furnace:

As with the wet gas scrubber/LoTOx system, the new ultra-low NO_x burners are being installed to reduce the NO_x emissions from the F-1 Furnace; ultra-low NO_x burners are inherently lower in NO_x emissions than standard or "regular" low-NO_x burners. However, a slight increase in actual emissions (< 1 tpy) of $PM/PM_{10}/PM_{2.5}$ and VOC is expected from the UFU Furnace F-1.

This results in two changes which need to be considered in the BACT review process. Steam from the existing cogeneration units is used to control the flame temperature of the new burners. This places additional steam demand on the cogeneration units, making them affected units under NSR. The new burners make the F-1 Furnace a modified unit.

Since the cogeneration units are not being physically changed in any way, no BACT review is required for these units. While the emissions from these two units are included in the overall NSR analysis, the lack of a physical change means that no BACT review is necessary. The F-1 furnace is being physically changed by the installation of the new burners, and will experience a small increase in emissions of both particulates and VOC (see the emission calculation section for further details).

The total estimated increase in actual particulate and VOC emissions for the F-1 furnace is less than 1 ton per year each (0.4 tpy of PM_{10}, 0.4 tpy of $PM_{2.5}$ and 0.3 tpy of VOC). The source of the emissions is gaseous fuel combustion - a combination of refinery fuel gas and natural gas. At this level of emissions, UDAQ is unaware of any add-on controls for additional reduction of particulate emissions beyond good combustion control and use of gaseous fuel. The same holds true for VOC emissions - although additional VOC control could be obtained with thermal oxidation, this leads to additional emissions in the form of CO, CO_2, NO_x and particulates from combustion. In addition, there are no economically viable add-on controls, as outlined below.

Tesoro evaluated several possible additional control measures:
For particulate emissions - the use of baghouses, ESPs, or wet scrubber technology;
and for VOC control - the use of catalytic oxidation.
None of these control options were found to be technically or economically feasible. The expected emission rates achievable by any of the add-on particulate controls is actually larger than the emission rate expected from just the new burners alone, making the use of add-on controls superfluous. Tesoro was unable to identify any available add-on controls for the CO emissions. Although catalytic reduction technology has been applied to CO emissions, it has not been utilized in this context - for emission increases on such a small scale.

Therefore, the NSR section recommends that the existing project to install ultra-low NO_x burners proceed without changes and be accepted without additional add-on controls as BACT. Proper design, implementation of good combustion practices, and use of gaseous fuels is considered BACT. [Last updated February 25, 2016]

4. BACT Review Cont.
Control of Fugitive Dust.
No BACT Review for fugitive dust is required, as no physical change is taking place. The increase in fugitive dust emissions are the direct result of increased vehicle traffic on Tesoro's internal haul roads. These roads are already paved and swept/washed as needed under Tesoro's existing dust control plan in order to meet the opacity requirements of R307-309. The increased vehicle traffic does not change the control technique applicable to reduce fugitive dust emissions. As Tesoro is already employing the most effective control strategy available, and no changes or improvements are possible, no additional review of BACT for this "process" is required.

Thus, the NSR section recommends that BACT continue to remain sweeping/washing the existing paved roads as needed. [Last updated February 29, 2016]

Modeling Results:

This combined project results in no increase in total permitted emissions of any pollutant. Under the provisions of R307-410-4 and R307-410-5, no modeling is required. Similarly, the only modification occurring under the federal provisions of 40 CFR 51, 40 CFR 60, 40 CFR 61 or 40 CFR 63 would be the small increase in actual emissions of particulates and VOC resulting from the installation of the new ultra-low NO_x burners at the UFU. These increases are less than 1 ton per year for each pollutant, well below the federal modeling thresholds.

With regard to the direct emissions of ozone (the ozone "slip" emissions), no model has been approved for modeling direct ozone emissions, and no modeling threshold exists.

Therefore, no modeling is required for this project.
[Last updated January 14, 2016]

RECOMMENDED APPROVAL ORDER CONDITIONS

The intent is to issue an air quality Approval Order (AO) authorizing the project with the following recommended conditions and that failure to comply with any of the conditions may constitute a violation of the AO. The AO will be issued to and will apply to the following:

Name of Permittee:	**Permitted Location:**
Tesoro Refining & Marketing Company LLC 474 W 900 N Salt Lake City, UT 84103	Salt Lake City Refinery 474 West 900 North Salt Lake City, UT 84103

UTM coordinates: 423,400 m Easting, 4,515,950 m Northing, UTM Zone 12
SIC code: 2911 (Petroleum Refining)

Section I: GENERAL PROVISIONS

I.1 All definitions, terms, abbreviations, and references used in this AO conform to those used in the UAC R307 and 40 CFR. Unless noted otherwise, references cited in these AO conditions refer to those rules. [R307-101]

I.2 The limits set forth in this AO shall not be exceeded without prior approval. [R307-401]

I.3 Modifications to the equipment or processes approved by this AO that could affect the emissions covered by this AO must be reviewed and approved. [R307-401-1]

I.4 All records referenced in this AO, which are required to be kept by the owner/operator, shall be made available to the Director or Director's representative upon request, and the records shall include the two-year period prior to the date of the request. Records shall be kept for a minimum of five (5) years. Records for the Consent Decree, Civil Action No. 2:96 CV 095 RL shall be kept for the life of the Consent Decree. [R307-415-6a]

I.5 A. The owner/operator shall comply with R307-150 Series. Inventories.

B. The owner/operator shall maintain records of annual actual emissions of NO_x, SO_2, VOC, and H_2SO_4 on a calendar year basis in accordance with 40 CFR 52.21(r)(6). These records will be maintained for the following emission units:

Crude Unit Furnace H-101
FCCU/CO Boiler
Ultraformer Unit Furnace F-1
UFU Regeneration Heater F-15
DDU Charge Heater F-680
DDU Rerun Boiler F-681
SRU/TGTU/TGI
GHT Unit F-701
Ultraformer Compressors K1s
Cogeneration Unit Turbines
Cogeneration Unit HRSGs

DDU Reactor (SSM events)
VRU Vessels (SSM events)
FGDU/SWS (SRU) Flare
Cooling Tower UU3
LPG Rack
Gasoline and Diesel Truck Loadout Rack
Storage Tanks (186, 188, 204, 212, 213, 242, 243, 252, 321, 324, 325, 326, 327, 330, 331, 503, 504)
New and Replaced Components. [R307-150, R307-405-19]

I.6 The owner/operator shall comply with UAC R307-107. General Requirements: Breakdowns. [R307-107]

Section II: SPECIAL PROVISIONS

II.A The approved installations shall consist of the following equipment:

II.A.1 **Permitted Source**
Permitted Source

II.A.2 **H-101**
Crude Unit Furnace, with ultra-low NO_x burners and one (1) stack, PS #1

II.A.3 **F-1**
Ultraformer Unit (UFU) Furnace, with ultra-low NO_x burners and four (4) stacks, PS #2

II.A.4 **F-15**
UFU Regeneration Heater, with low NO_x burners and one (1) stack, PS #3

II.A.5 **FCCU/CO Boiler**
Fluid catalytic Cracking Unit (FCCU) Regenerator, Carbon Monoxide Boiler (Heat Recovery Unit), with $CONO_x$ oxygen injection, ammonia injection, electrostatic precipitator (ESP), wet gas scrubber/LoTOx system (WGS), and one (1) stack, PS #4

II.A.6 **F-680 and F-681**
Distillate Desulfurization Unit (DDU) charge heater and rerun boiler, combined rating approx. 37.8 MMBtu/hr, equipped with "ultra-ultra" low NO_x burners. Heaters share common convection section and stack, PS #5.

II.A.7 **K1s**
Hydrogen Compressors (Ultraformer compressors), with catalytic converters and two (2) stacks, PS #6

II.A.8 **South Flare**
Flare covering Crude/UFU Unit/DDU,
Flare gas header routed to FGR system, PS #7

II.A.9 **North Flare**
Flare covering FCCU/VRU/Alkylation Unit/GHT,
Flare gas header routed to FGR system, PS #8

II.A.10 **Modular FGR System (FGR)**
Flare gas recovery compressors (electrically driven) and associated equipment

II.A.11 **CO Boiler Bypass**
CO Boiler Bypass, with one (1) stack, PS #9

II.A.12 **SRU/TGI/TGTU**
Sulfur Recovery Unit/Tail Gas Incinerator/Tail Gas Treatment Unit, PS #10

II.A.13 **FGDU/SWS**
Fuel Gas Desulfurization Unit/Sour Water Stripper (FGDU/SWS) Flare (this unit is physically integrated with the Sulfur Recovery Unit (SRU)), PS #11

II.A.14 **T-104**
Sour Water Storage Tank

II.A.15 **Emergency/Standby Sources**
Waste Water Treatment Plant (WWTP) Generator, Electrical Generators, Plant Air Compressors, Miscellaneous Air Compressors, Fire Water Pumps, B-1 Air Preheater, Package Boilers

II.A.16 **F-701**
Gasoline Hydrotreater (GHT) Unit with 8.0 MMBtu/hr process heater

II.A.17 **BSU**
Benzene Saturation Unit (BSU):

3,000 bpd Bensat reactor and 10,000 bpd reformate splitter.

II.A.18 **CG1 and CG2**
Cogeneration Unit: two cogeneration trains (CG1 and CG2), each with one 11.8 MW (based on an annual average) turbine with SoLoNO$_x$ controls and one heat recovery steam generating unit rated at approx 157.8 MMBtu/hr (HHV). Both rates based on an annual average.

II.A.19 **Loading/Unloading Racks**

II.A.20 **Tank 140: Storage vessel - petroleum liquids**
Storage tank with internal floating roof and primary seals

II.A.21 **Tank 141: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.22 **Tank 142: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.23 **Tank 144: Storage vessel - petroleum liquids**
Storage tank with external floating roof, primary and secondary seals

II.A.24 **Tank 157: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.25 **Tank 158: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.26 **Tank 186: Storage vessel - petroleum liquids**
Storage tank with internal floating roof, primary and secondary seals

II.A.27 **Tank 188: Storage vessel - petroleum liquids**
Storage tank with internal floating roof, primary and secondary seals

II.A.28 **Tank 189: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.29 **Tank 190: Storage vessel - petroleum liquids**
Storage tank with external floating roof, primary and secondary seals

II.A.30 **Tank 201: Storage vessel - amine**
Storage tank with fixed roof

II.A.31 **Tank 203: Storage vessel - stormwater**
Storage tank with fixed roof

II.A.32 **Tank 204: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.33 **Tank 206: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.34 **Tank 212: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.35 **Tank 213: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.36 **Tank 236: Storage vessel - petroleum liquids**
Storage tank with fixed roof

II.A.37 **Tank 241: Storage vessel - surge tank**
Storage tank with external floating roof, primary and secondary seals

II.A.38 **Tank 242: Storage vessel - petroleum liquids**
Storage tank with external floating roof, primary and secondary seals

II.A.39 **Tank 243: Storage vessel - petroleum liquids**
Storage tank with external floating roof, primary and secondary seals

II.A.40 **Tank 244: Storage vessel - petroleum liquids**
Storage tank with external floating roof, primary and secondary seals

II.A.41	**Tank 245: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.42	**Tank 246: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.43	**Tank 247: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.44	**Tank 252: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.45	**Tank 270: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.46	**Tank 271: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.47	**Tank 291: Storage vessel - petroleum liquids** Storage tank with fixed roof to be retrofitted with internal floating roof
II.A.48	**Tank 297: Storage vessel - petroleum liquids** Storage tank with internal floating roof and primary seals
II.A.49	**Tank 298: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.50	**Tank 307: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.51	**Tank 308: Storage vessel - chemicals** Storage tank with external floating roof, primary and secondary seals
II.A.52	**Tank 309: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.53	**Tank 310: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.54	**Tank 311: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.55	**Tank 312: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.56	**Tank 313: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.57	**Tank 314: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.58	**Tank 315: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.59	**Tank 321: Storage vessel - petroleum liquids** Storage tank with internal floating roof and primary seals
II.A.60	**Tank 322: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.61	**Tank 323: Storage vessel - petroleum liquids** Storage tank with fixed roof
II.A.62	**Tank 324: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.63	**Tank 325: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.64	**Tank 326: Storage vessel - petroleum liquids** Storage tank with external floating roof, primary and secondary seals
II.A.65	**Tank 327: Storage vessel - gasoline**

Storage tank with external floating roof, primary and secondary seals, and slotted guide pole controls

II.A.66 Tank 328: Storage vessel - petroleum liquids
Storage tank with external floating roof, primary and secondary seals

II.A.67 Tank 330: Storage vessel - petroleum liquids
Storage tank with external floating roof, primary and secondary seals

II.A.68 Tank 331: Storage vessel - petroleum liquids
Storage tank with internal floating roof, primary and secondary seals

II.A.69 SO_2 Cap Sources
Sources included in emissions cap: includes F-701, CG1 and CG2, H-101, FCCU/CO Boiler, K1s, F-1, F-15 , F-680 and F-681

II.A.70 NO_x Cap Sources
Sources included in emissions cap: includes F-701, CG1 and CG2, H-101, FCCU/CO Boiler, K1s, F-1, F-15 , F-680 and F-681

II.A.71 PM_{10} Cap Sources
Sources included in emissions cap: includes F-701, CG1 and CG2, H-101, FCCU/CO Boiler, K1s, F-1, F-15 , F-680 and F-681

II.B Requirements and Limitations

II.B.1 Conditions on Permitted Source

II.B.1.a Visible emissions from the stacks of combustion units without controls shall be no greater than 10 percent (%) opacity. Compliance shall be determined using opacity observations performed in accordance with 40 CFR 60, Appendix A, Method 9. [R307-401]

II.B.1.b Tesoro shall limit operation of the emergency/standby package boilers listed in Section II.A.14 to an annual capacity factor of 10% (0.10) or less for natural gas as specified in 40 CFR 60 Subpart Db. [R307-401]

II.B.1.c Visible emissions from the FCCU/CO Boiler and fugitive emissions shall not exceed 20% opacity. Compliance shall be determined using opacity observations performed in accordance with 40 CFR 60, Appendix A, Method 9.

Visible emissions from process flares, fugitive dust, and the FCCU (when going through the bypass stack) shall not exceed 20% opacity. Compliance shall be determined using opacity observations performed in accordance with 40 CFR 60, Appendix A, Method 9. [40 CFR 60, R307-401-8]

II.B.1.d Tesoro shall submit to the Director a projection of planned and required process shutdowns for the upcoming calendar year by January 15 of each year. [R307-401]

II.B.1.e Tesoro shall control the sulfur pit emissions by continuing to route sulfur pit emissions to the incinerator at the SRU. [R307-401]

II.B.1.f Tesoro shall supply no more than one-third of its potential electrical output capacity on an annual basis to any utility power distribution system for sale (on a gross basis). Records of capacity and annual electrical sales shall be maintained. [R307-401]

II.B.1.g Tesoro shall install and operate a flare gas recovery system designed to limit hydrocarbon flaring from each of the North Flare and South Flare to levels below the values listed in 40 CFR 60.103a(c), except during periods of startup, shut down, or malfunction. [40 CFR 60 Subpart Ja, SIP Section IX.H.11]

II.B.1.h Plant-wide Emission Limits:

By no later than January 1, 2019, combined emissions of:

1. Total (Filterable+Condensable) PM_{10} shall not exceed 2.25 tons per day,
2. Filterable $PM_{2.5}$ shall not exceed 0.42 tons per day and 110 tons per rolling 12-month period,
3. NO_x shall not exceed 1.988 tons per day and 475 tons per rolling 12-month period, and
4. SO_2 shall not exceed 3.1 tons per day and 300 tons per rolling 12-month period

For purposes of this requirement, a "day" is defined as a period of 24-hours commencing at midnight and ending at the following midnight. Compliance with the emission limits shall be determined as outlined in Section IX.H.2 and Section IX.H.12 of the SIP, as adopted by the Air Quality Board on December 2, 2015. [SIP Section IX.H.12, SIP Section IX.H.2]

II.B.1.i Tesoro shall notify the Director in writing within 30 days after the new ultra-low NO_x burners (II.A.3) and wet gas scrubber/LoTOx system (II.A.5) are installed and operational, as an initial compliance inspection is required. To ensure proper credit when notifying the Director, send your correspondence to the Director, attn: Compliance Section.

Approval orders issued by the Director in accordance with the provisions of R307-401 will be reviewed eighteen months after the date of issuance to determine the status of construction, installation, modification, relocation or establishment. If a continuous program of construction, installation, modification, relocation or establishment is not proceeding, the Director may revoke the approval order. [R307-401-18]

II.B.2 **Conditions on Crude Unit Furnace (H-101)**

II.B.2.a Emissions of NO_x shall not exceed 0.054 lb/MMBtu on a 3-hour average basis.

Compliance shall be demonstrated by means of annual NO_x emissions testing as directed in 40 CFR 60 Appendix A, Test Method 7, 7A, 7B, 7C, 7D or 7E.
[R307-401]

II.B.3 **Conditions on FCCU/CO Boiler and CO Boiler Bypass**

II.B.3.a As of January 1, 2018, emissions of NO_x and SO_2 shall not exceed the following values:

1. 10 ppmvd NO_x at 0% O_2 on a 365-day rolling average basis
2. 20 ppmvd NO_x at 0% O_2 on a 7-day rolling average basis
3. 10 ppmvd SO_2 at 0% O_2 on a 365-day rolling average basis
4. 18 ppmvd SO_2 at 0% O_2 on a 7-day rolling average basis

For the 365-day NO_x and SO_2 limits, the first complete 365-day rolling average shall be calculated on January 1, 2019, based on monitoring data from January 1, 2019, and the 364 days prior to January 1, 2019.

NO_x and SO_2 emissions during periods of startup, shutdown, or malfunction of the FCCU, or malfunction of the associated NO_x or SO_2 control equipment, if any, shall not be used in determining compliance with the 7-day NO_x and SO_2 limits established above provided that during such periods Tesoro, to the extent practicable, maintains and operates the FCCU, including associated air pollution control equipment, in a manner consistent with good air pollution control practices for minimizing emissions. The 365-day NO_x and SO_2 limits shall apply at all times.

Tesoro shall use NO_x, SO_2, and O_2 CEMS to monitor performance of the FCCU. CEMS shall be used to demonstrate compliance with the 7-day and 365-day NO_x emission limits established above. Tesoro shall make CEMS data available to UDAQ or EPA within thirty (30) days of a written request. Tesoro shall install, certify, calibrate, maintain, and operate all CEMS at the FCCU required by this paragraph in accordance with the provisions of 40 C.F.R. § 60.13 that are applicable to CEMS (excluding those provisions applicable only to COMS) and Part 60 Appendices A and F, and the applicable performance specification test of 40 C.F.R. Part 60 Appendix B.
[R307-401]

II.B.3.b By no later than January 1, 2018, Tesoro shall comply with an SO_2 emission limit of 25 ppmvd @ 0% excess air on a 365-day rolling average basis and 50 ppmvd @ 0% excess air on a 7-day rolling average basis.

Compliance with this limit shall be determined by following 40 C.F.R. §60.105a(g). [SIP Section IX.H.11.g.i]

II.B.3.c By no later than January 1, 2018, Tesoro shall comply with an emission limit of 1.0 pounds PM per 1000 pounds coke burned on a 3-hour average basis.

Compliance with this limit shall be determined by following the stack test protocol specified in 40 C.F.R. §60.106(b) to measure PM emissions on the FCCU. Stack tests shall be conducted once every five years.

By no later than January 1, 2019, each owner or operator of an FCCU shall install, operate, and maintain a continuous parameter monitor system (CPMS) to measure and record operating parameters for determination of source-wide $PM_{2.5}$ emissions as appropriate. [SIP Section IX.H.11.g.i]

II.B.3.d By no later than October 1, 2015, Tesoro shall comply with the following CO limits at the FCCU: (1) a short-term FCCU CO emission limit of 500 ppmvd CO @ 0% O_2 (one-hour block average); and (2) a long-term FCCU CO emission limit of 100 ppmvd CO @ 0% O_2 (365-day rolling average). For 365-day CO emission limit, the first complete 365-day rolling average shall be calculated on October 1, 2015, based on monitoring data from October 1, 2015 and the 364 Days prior to October 1, 2015.

CO emissions during periods of startup, shutdown, or malfunction of the FCCU, or malfunction of the associated CO control equipment, if any, shall not be used in determining compliance with the 7-day FCCU CO emission limit established above, provided that during such periods Tesoro, to the extent practicable, maintains and operates the FCCU, including associated air pollution control equipment, in a manner consistent with good air pollution control practices for minimizing emissions. The 365-day CO emission limit established above, shall apply at all times.

Tesoro shall use a CO and O_2 CEMS to monitor the performance of the FCCU. Tesoro shall make CEMS data available to UDAQ or EPA within thirty (30) days of a written request. Tesoro shall install, certify, calibrate, maintain, and operate all CEMS at the FCCU required by this Paragraph in accordance with the provisions of 40 C.F.R. § 60.13 that are applicable to CEMS (excluding those provisions applicable only to COMS) and Part 60 Appendices A and F, and the applicable performance specification test of 40 C.F.R. Part 60 Appendix B. [R307-401]

II.B.3.e The FCCU Catalyst Regenerator is an "affected facility" as that term is used in 40 C.F.R. Part 60, Subparts A and J for PM, SO_2, and CO. On and after October 1, 2015, until January 1, 2018, the FCCU Catalyst Regenerator shall continue to be subject to and shall comply with 40 C.F.R. Part 60, Subparts A and J for SO_2. [40 CFR 60 Subpart J]

II.B.3.f Beginning on October 1, 2015, the FCCU shall become an "affected facility" as that term is used in 40 C.F.R. Part 60, Subpart Ja for PM and CO in lieu of Subpart J. Beginning on January 1, 2018, the FCCU shall become an "affected facility" as that term is used in 40 C.F.R. Part 60, Subpart Ja for NO_x, and Subpart Ja for SO_2 in lieu of Subpart J. On and after January 1, 2018, Tesoro shall comply with all applicable requirements in 40 C.F.R. Part 60, Subpart Ja at the FCCU. [40 CFR 60 Subpart J, 40 CFR 60 Subpart Ja]

II.B.4 **<u>Conditions on SRU/TGI/TGTU</u>**

II.B.4.a Gaseous emissions from the SRU shall be treated by the TGTU during normal operations prior to final treatment at the TGI. [R307-401-8]

II.B.4.b The SO_2 limit at the SRU/TGI/TGTU is 1.68 tons/day. Compliance with the daily limitation shall be determined as follows:

Daily sulfur dioxide emissions from the SRU/TGI/TGTU shall be determined by multiplying the SO_2 concentration in the flue gas by the mass flow of the flue gas.

Emissions of SO_2 from the SRU/TGI/TGTU shall not exceed 60 tons per rolling 12-month period. Compliance shall be determined on a 12-month rolling total. Within 20 days of the beginning of each calendar month, the SO_2 emission totals calculated to demonstrate compliance with the daily limitations shall be totaled for the previous month. The monthly total shall be added to the totals from the previous 11 months to determine the new 12-month rolling total. [R307-401]

II.B.4.b.1 The SO_2 concentration in the flue gas shall be determined by a CEM that meets or exceeds the requirements contained in 40 CFR 60, Appendix B, Performance Specification 2. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170. 40 CFR 60 Methods 2, 3 and 6 shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, Performance Specification 2. Notification must be made to the Director prior to conducting the performance test. Whenever the SO_2 CEM is bypassed for short periods, SO_2 CEM data from the previous three days will be averaged and used as an emission factor to determine emissions.

The mass flow rate of the flue gas shall be determined by a volumetric flow measurement device that meets or exceeds the requirements contained in 40 CFR 60 Appendix B. An annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170 and 40 CFR 60 Appendix B. If a new volumetric flow measurement device is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 52 Appendix E. Notification must be made to the Director prior to conducting the performance test.

Tesoro shall comply with a 95% recovery efficiency requirement for all periods of operation except during periods of startup, shutdown, or malfunction of the SRU/TGI/TGTU. The 95% recovery efficiency will be determined on a daily basis; however, compliance will be determined on a rolling 30-day average basis. Tesoro shall determine the percent recovery by measuring the flow rate and concentration of H_2S in the feed streams going to the SRU and by measuring the SO_2 emissions with the CEMS at the SRU incinerator. The feed streams shall include the overhead stream from the Fuel Gas Desulfurization unit (Amine unit) regenerator and the overhead stream from the Sour Water Stripper. The flow rate will be determined continuously; the H_2S concentration shall be determined at least once every three years (samples may be collected as manual grabs or through remote monitoring). The flow rate and H_2S concentration values will be used to determine the daily feed rate. SRU efficiency results shall be reported to the Director a minimum of once per year.
[R307-401]

II.B.5 **Conditions on SO_2 Cap Sources**

II.B.5.a Combined emissions of SO_2 from the SO_2 Cap Sources shall not exceed the following limits:

November 1 through end of February: 3.699 tons/day

March 1 through October 31: 4.374 tons/day

Compliance with the daily limitation shall be determined by summing the emissions calculated in conditions II.B.4.a.1 and II.B.4.a.2 below.
[R307-401]

II.B.5.a.1 Daily SO_2 emissions from the FCCU/CO Boiler stack shall be determined by multiplying the sulfur dioxide concentration in the flue gas by the mass flow of the flue gas.

The SO_2 concentration in the flue gas shall be determined by a CEM that meets or exceeds the requirements contained in 40 CFR 60, Appendix B, Performance Specification 2. The monitor span shall be 350 ppm. No later than January 1, 2018 the span shall be 200 ppm. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with 40 CFR 60, Appendix F and UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with 40 CFR 60 Appendix F and UAC R307-170. 40 CFR 60 Methods 2, 3 and 6 shall be used to determine relative accuracy. If a new SO_2 monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, Performance Specification 2. Notification must be made to the Director prior to conducting the performance test. Whenever the SO_2 CEM is unavailable for short periods (i.e. CO boiler or CO Boiler emergency bypass, FCCU start-up and shutdowns), SO_2 CEM data from the previous three days will be averaged and used as an emission factor to determine emissions from the FCCU.

The mass flow rate of the flue gas shall be determined by a volumetric flow measurement device that meets or exceeds the requirements contained in 40 CFR 60 Appendix B. An annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170 and 40 CFR 60 Appendix B. If a new volumetric flow measurement device is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 52 Appendix E. Notification must be made to the Director prior to conducting the performance test.

SO_2 emissions from the FCCU regenerator shall be calculated by subtracting the emissions attributable to the CO Boiler from the mass emissions. Emissions attributable to combustion of plant gas in the CO Boiler shall be calculated by multiplying the quantity of fuel used in the CO boiler by the emission factor for plant gas as determined below. [R307-401]

II.B.5.a.2 Daily SO_2 emissions from other affected units shall be determined by multiplying the quantity of each fuel used daily (24 hour usage) at each affected unit by the appropriate emission factor below. The values shall be summed to show the total daily SO_2 emission.

Emission factors (EF) for the various fuels shall be as follows:

Natural gas: EF = 0.60 lb/MMscf
Propane: EF = 0.60 lb/MMscf
Plant fuel gas: the emission factor shall be calculated from the H_2S measurement or from the SO_2 measurement obtained in section II.B.5.g of this permit. The emission factor, where appropriate, shall be calculated as follows:

EF (lb SO_2/MMscf gas) = [(24 hr avg. ppmdv H_2S) /10^6] [(64 lb SO_2/lb mole)] [(10^6 scf/MMscf)/(379 scf/lb mole)]

Where mixtures of fuel are used in a Unit, the above factors shall be weighted according to the use of each fuel. [R307-401]

II.B.5.b Emissions of SO_2 from the permitted source shall not exceed 1,637 tons per rolling 12-month period. The SO_x limit at the FCCU is 705 tons per rolling 12-month period.

Compliance shall be determined on a 12-month rolling total. Within 20 days of the beginning of each calendar month, the SO_2 emission totals calculated to demonstrate compliance with the daily (24-hr) limitations shall be totaled for the previous month. The monthly total shall be added to the totals from the previous 11 months to determine the new 12-month rolling total. [R307-401]

II.B.5.c Until January 1, 2018, the SO_x emissions from the FCCU regenerator shall not exceed 9.8 lbs/1000 lbs coke burned, based on a seven-day average.

The following monitoring protocol has been approved by EPA staff in accordance with 40 CFR 60.106(i)(12), in letters from EPA dated August 29, 1997, May 12, 2003, June 20, 2005 and August 8, 2008, and may not be modified without prior EPA approval. [40 CFR 60 Subpart J]

II.B.5.c.1 Until January 1, 2018, each day, the daily SO_x emissions from the FCCU regenerator, as calculated below, shall be multiplied by a factor of 1.05 and divided by the amount of coke burned in the FCCU regenerator during the same period. The result shall be added to the calculated values for the previous six days and the total divided by seven to determine the seven-day average.

The weight of coke burned in the FCCU regenerator shall be determined by a mass balance calculation utilizing the measured airflow to the regenerator, and the volume percent CO and O_2 measured in the regenerator flue gas, in accordance with the procedure documented in correspondence to the DAQ dated November 3, 1995.

This monitoring method is valid only if the following process conditions and procedures are met.

(a) Sulfur content of the feed to the FCCU is not greater than 0.85 wt%, based on a seven-day average.

The sulfur content of the feed shall be determined by obtaining and analyzing a minimum of three grab-samples per seven-day period.

(b) Temperature of the FCCU regenerator is between 1182° Fahrenheit and 1419° Fahrenheit, based on an 8-hour average.

The temperature of the FCCU regenerator shall be determined using a suitable temperature-sensing device. The device shall be calibrated according to manufacturer's specifications.

(c) The oxygen concentration in the FCCU regenerator is less than or equal to 3.4 % by volume, based on an 8-hour average.

A CEM shall be used to determine the oxygen concentration in the regenerator flue gas. The monitor shall meet or exceed the requirements specified in 40 CFR 60, Appendix B, and Performance Specification 3. The monitor span shall be 1.5-2.0 times the allowable level. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170. 40 CFR 60 Method 3B shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, and Performance Specification 3. Notification must be made to the Director prior to conducting the performance test.

(d) The CO concentration in the FCCU regenerator is less than or equal to 4.4% by volume based on an 8-hour average.

A CEM shall be used to determine the CO concentration in the regenerator flue gas. The monitor shall meet or exceed the requirements specified in 40 CFR 60, Appendix B, and Performance Specification 4, and 40 CFR 60, Appendix F. The monitor span shall be 1.5-2.0 times the allowable level. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170. 40 CFR 60 Method 10 or 10A shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, and Performance Specification 4. Notification must be made to the Director prior to conducting the performance test.

If Tesoro intentionally changes the FCCU's operating parameters (FCCU's feed sulfur content, the regenerator temperature, the regenerator oxygen concentration, or the regenerator CO concentration) to a value outside the listed ranges, compliance with the sulfur oxides limitation shall be demonstrated in accordance with 40 CFR 60.106(i). Performance of such compliance demonstrations shall begin within two weeks of first recording the change in operating parameters.

Tesoro may then conduct performance tests as required to establish a new set of parameters for the above alternate monitoring procedure, in accordance with 40 CFR 60.106(i)(12). Tesoro must submit the new parameters and associated test data for approval by the EPA before use.

An unintentional variation of any of the operating parameters associated with this monitoring method beyond the range allowed by this method shall constitute a violation of this monitoring condition, unless the variation can be positively identified as the result of an unavoidable breakdown. [40 CFR 60 Subpart J, R307-401]

II.B.5.d Until January 1, 2018, the following information shall be maintained and made available upon request:

1. The monitoring record of the lbs SO_x /1000 lb coke burned
2. Results of the sulfur analysis of the feed, including sample dates, times, and sulfur concentration
3. The monitoring record of the temperature sensor, the date of each calibration of the sensor and any corrective actions required or performed
4. The monitoring record of the oxygen CEM and any calibration or maintenance activity on the monitor
5. The monitoring record of the CO CEM and any calibration or maintenance activity on the monitor
6. The date, time, and description of any change in the listed FCCU operating parameters, whether or not such change was intentional
7. All information associated with the performance of 40 CFR 60.106(i)(12), Compliance Demonstration, if such demonstration is performed. [40 CFR 60 Subpart J, R307-401]

II.B.5.e Until January 1, 2018, if any of the listed operating parameters are intentionally changed, Tesoro shall submit written notification of the change and confirmation of the initiation of the 40 CFR

60.106(i)(12), Compliance Demonstration, within 14 days of first recording the change. The notification shall be submitted to the Director and to EPA.

If any of the listed operating parameters are unintentionally exceeded, Tesoro shall submit a report of the exceedance to the Director on the next quarterly monitoring report. The report shall include a description of the exceedance, an estimate of any excess emissions, the time of the exceedance, and the actions taken to correct the situation. [40 CFR 60 Subpart J, R307-401]

II.B.5.f Until January 1, 2019, the following sources shall not be regulated for SO_2 or NO_x emissions nor shall they be included in the emission limitation totals herein:

1. North flare (FCCU/VRU/GHT/Alky Flare)
2. South flare (Crude/UFU/DDU Flare). [R307-401, SIP Section IX.H.12]

II.B.5.g The H_2S content of fuel gas combusted at any affected unit shall not exceed 0.10 grains H_2S/dscf (162 ppmdv), based on a rolling three-hour average. Compliance with this limitation shall be determined as follows:

1. For natural gas, compliance is assumed while the fuel comes from a public utility.

2. For plant gas, the H_2S content of the fuel gas shall be measured with a CMS that meets or exceeds the requirements contained in 40 CFR 60, Appendix B, Specification 7. The monitor shall be installed in a location representative of the H_2S content in the fuel gas system. The location shall be approved in writing by the Director prior to installation. The current approved location of the H_2S monitor is on the outlet of fuel-gas blending vessel V-917. The span of the monitor shall be 300 ppm. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with 40 CFR 60 Appendix F and UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with 40 CFR 60 Appendix F and UAC R307-170. 40 CFR 60 Method 11 shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, and Performance Specification 7. Notification must be made to the Director prior to conducting the performance test.

If the monitor reading is not available, the refinery fuel gas shall be sampled as close to the monitor location as safely possible at least once each day. The sample shall be analyzed for sulfur content with a detection tube capable of reading the required concentration limit.

3. In lieu of the H_2S CMS in paragraph II.B.4.g.2 above, for fuel gas combustion devices an instrument for continuously monitoring and recording the concentration by volume (dry basis, zero percent excess air) of SO_2 emissions into the atmosphere may be used. The monitor shall meet the requirements of 40 CFR 60.105.

4. The rolling three-hour average shall be calculated as the arithmetic average of three contiguous one (1)-hour averages. [40 CFR 60 Subpart J, R307-401]

II.B.5.h T-104 shall be a fixed-roof vessel with closed vent controls. The tank shall have a closed-vent system with nitrogen purge, and shall vent gases released to the TGI/TGTU or to the Sour Water Stripper/SRU flare when the TGI/TGTU is not operational. The tank shall comply with 40 CFR

60 Subpart Kb. [R307-401]

II.B.6 **Conditions on NO_x Cap Sources**

II.B.6.a Combined emissions of NO_x from the NO_x Cap Sources shall be no greater than 1.988 tons/day.

Compliance shall be determined daily by multiplying the hours of operation of a unit, feed rate to a unit, or quantity of each fuel combusted at each affected unit by the associated emission factor listed below, and summing the results. The sources, fuels, and associated emission factors for this limitation are as follows:

Sources included in emission cap	Fuel	NO_x Emission factor
Crude Unit Furnace (H-101)	Plant Gas	results of last stack test
Ultraformer Furnace (F1)	Plant Gas	results of last stack test
Regenerator Gas Heater (F15)	Plant Gas	81 lb/MMscf
FCCU/CO Boiler	FCU Coke & plant gas	NO_x CEM
DDU charge heater (F-680)	Plant gas	0.049 lb/MMBtu
DDU rerun reboiler (F-681)	Plant gas	0.052 lb/MMBtu
Cogeneration facility	Plant & natural gas	results of last stack test
GHT heater (F-701)	Plant gas	0.074 lb/MMBtu
Hydrogen Compressors (K1s)	Propane/natural gas	1.8 lb/hr

The Crude Unit stack (H-101) shall be tested every year to determine the correct emission factor for the calculations above.

The UFU stack (F1) emissions shall be stack tested every year to determine the correct emission factor for the calculations above.

The initial stack tests were done on the DDU to verify the design emission factor of 0.04 lb/MMBtu for NO_x. The new emission factors for the DDU, computed from the results of the stack tests, are 0.049 lb/MMBtu and 0.052 lb/MMBtu as specified in the above table. Subsequent testing shall be done if directed by the Director.

Both trains in the cogeneration facility were stack tested within 180 days of startup to show emissions equivalency of the trains. Subsequently, both trains shall be tested either simultaneously or seriatim at least once every two years.

The GHT heater was stack tested within 180 days of startup. Subsequent testing shall be done if directed by the Director.

All other units in the above list shall be stack-tested if directed by the Director. Tesoro may also perform a stack test on any of the above listed sources to provide information for updating the emission factors listed.

All stack tests shall conform to the following:

The applicant shall provide a notification of the test date at least 45 days prior to the test. A pretest conference between the owner/operator, the tester, and the Director shall be held at least 30 days prior to the test if directed by the Director.

The emission point shall conform to the requirements of 40 CFR 60, Appendix A, Method 1. Occupational Safety and Health Administration (OSHA) approved access shall be provided to the test location.

40 CFR 60, Appendix A, Method 7, 7A, 7B, 7C, 7D, or 7E shall be used to determine the NO_x emission rate.

40 CFR 60, Appendix A, Method 2 shall be used to determine the volumetric flow rate.
To determine mass emission rates (lbs/hr, etc.), the pollutant concentration, as determined by the appropriate methods above, shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director to give the results in the specified units of the emission limitation.

A NO_x CEM shall be used to calculate daily NO_x emissions from the FCCU/CO Boiler. Emissions shall be determined by multiplying the nitrogen dioxide concentration in the flue gas by the mass flow of the flue gas.

The NO_x concentration in the flue gas shall be determined by a CEM that meets or exceeds the requirements contained in 40 CFR 60, Appendix B, Performance Specification 2. Daily zero (0-20% of span value) and span (50-100% of span value) calibration drift tests shall be conducted in accordance with UAC R307-170. Quarterly cylinder gas audits and an annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170. 40 CFR 60 Methods 2, 3 and 7 shall be used to determine relative accuracy. If a new monitor is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60, Appendix B, Performance Specification 2. Notification must be made to the Director prior to conducting the performance test. Whenever the NO_x CEM is bypassed for short periods, NO_x CEM data from the previous three days will be averaged and used as an emission factor to determine emissions.

The mass flow rate of the flue gas shall be determined by a volumetric flow measurement device that meets or exceeds the requirements contained in 40 CFR 60 Appendix B. An annual relative accuracy test audit shall be conducted in accordance with the procedures outlined in UAC R307-170 and 40 CFR 60 Appendix B. If a new volumetric flow measurement device is installed, an initial performance test shall be performed within 30 days of installation. The performance test shall be conducted and data reduced in accordance with the test methods and procedures contained in 40 CFR 60 Appendix B. Notification must be made to the Director prior to conducting the performance test. [R307-401]

II.B.6.b Emissions of NO_x from the sources listed under the NO_x cap shall be no greater than 598 tons per rolling 12-month period. The NO_x limit at the FCCU is 174 tons per rolling 12-month period.

Compliance shall be determined on a 12-month rolling total. By the 20th day of each month, the NO_x emissions calculated to show compliance with the daily limitations for the previous month shall be summed to give a monthly emission total. This shall be added to the previous 11 months' emission totals to give the new 12-month rolling total. [R307-401]

II.B.6.c Emissions of NO_x from each K1 compressor shall be no greater than 3.20 lb/hr or 933 ppmdv

@10% oxygen and 400° F.

Compliance shall be determined by stack testing in accordance with the procedure for stack testing other NO_x sources as described above. Testing shall be done if directed by the Director.

The maximum fired heat capacity at H-101will be no greater than 174 MMbtu/hr (LHV) based on a 1-hour average. Orifice plate will be installed to limit fuel gas pressure to 20 psi such that maximum firing rate of the burner remains unchanged. [R307-401]

II.B.7 **Conditions on PM_{10} Cap Sources**

II.B.7.a Combined emissions of filterable PM_{10} and filterable $PM_{2.5}$ from the PM_{10} Cap Sources shall be no greater than 522 lbs/day. The filterable PM_{10} limit at the FCCU is 69 tons per rolling 12-month period.

Compliance shall be determined daily by multiplying the quantity of each fuel combusted at the affected units by the associated emission factor for that fuel, and summing the results. The emission factors for this limitation are as follows:

Natural gas:	5 lb/MMscf
Plant gas:	5 lb/MMscf
Cat Coke:	results of last stack test
Propane:	negligible

The FCCU/COB stack shall be stack tested every year to determine the correct emission factor for the calculations above. All other units in the above list shall be stack-tested if directed by the Director. The permitted source may also perform a stack test to provide information for updating the emission factors listed above. All stack tests shall conform to the following:

The applicant shall provide a notification of the test date at least 45 days prior to the test. A pretest conference between the owner/operator, the tester, and the Director shall be held at least 30 days prior to the test if directed by the Director.

The emission point shall conform to the requirements of 40 CFR 60, Appendix A, Method 1. OSHA approved access shall be provided to the test location. The throughput rate during compliance testing shall be no less than 90% of the rated throughput, or 90% of the highest monthly throughput achieved in the previous three years, whichever is least.

40 CFR 51, Appendix M, Methods 201 or 201a shall be used to determine front-half PM_{10} emissions in stacks in which no liquid drops are present. 40 CFR 51, Appendix M, Method 202 shall be used to determine back half condensables in such stacks.

For stacks in which liquid drops are present, methods to eliminate the liquid drops should be explored. If no reasonable method to eliminate the drops exists, then the following methods shall be used: 40 CFR 60, Appendix A, Method 5, 5a, 5d, or 5e as appropriate. The back half condensables shall also be tested using Method 202. All particulate captured in the back half shall be considered PM_{10}. For purposes of the PM_{10} SIP Cap, the back half condensables shall not be used for compliance demonstration but shall be used for inventory purposes.

40 CFR 60, Appendix A, Method 2 shall be used to determine the volumetric flow rate.

To determine mass emission rates (lbs/hr, etc.), the pollutant concentration, as determined by the appropriate methods above, shall be multiplied by the volumetric flow rate and any necessary conversion factors determined by the Director to give the results in the specified units of the emission limitation. [R307-401]

II.B.8 **Conditions on Tanks**

II.B.8.a For the primary seals, the accumulated area of gaps between the tank wall and the metallic shoe seal or the liquid-mounted seal shall not exceed 10 square inches per foot of tank diameter. The width of any portion of any gap shall not exceed one and one half (1½) inches. If the seal is a vapor mounted seal, the accumulated area of gaps between the tank wall and seal shall not exceed one (1) square inch per foot of tank diameter, and the width of any portion of any gap shall not exceed one-half (½) inch. This condition applies to Tanks 190, 242, 243, 244, 245, 246, 247, 308, 309, 326, and 330. [R307-327]

II.B.8.b Tanks 246 and 247 shall be used only to store heavy distillate products with a True Vapor Pressure (TVP) of less than 1.5 psia, such as Jet A fuel. [R307-401-8]

II.B.8.c For the secondary seals, the accumulated area of gaps between the tank wall and the secondary seal shall not exceed one square inch per foot of tank diameter and the width of any portion of any gap shall not exceed one-half inch. This condition applies to Tanks 190, 242, 243, 244, 245, 308, 309, 326, and 330. This condition does not apply to Tanks 246 and 247.

The secondary seals shall be properly installed and maintained according to the manufacturer's recommendations.
[R307-327]

II.B.8.d The owner/operator shall comply with all applicable parts of R307-327 - Petroleum Liquid Storage. [R307-327]

Section III: APPLICABLE FEDERAL REQUIREMENTS

In addition to the requirements of this AO, all applicable provisions of the following federal programs have been found to apply to this installation. This AO in no way releases the owner or operator from any liability for compliance with all other applicable federal, state, and local regulations including UAC R307.

NSPS (Part 60), A: General Provisions
NSPS (Part 60), Db: Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units
NSPS (Part 60), J: Standards of Performance for Petroleum Refineries
NSPS (Part 60), Ja: Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After May 14, 2007
NSPS (Part 60), K: Standards of Performance for Storage Vessels for Petroleum Liquids for Which Construction, Reconstruction, or Modification Commenced After June 11, 1973, and Prior to May 19, 1978
NSPS (Part 60), Ka: Standards of Performance for Storage Vessels for Petroleum Liquids for Which Construction, Reconstruction, or Modification Commenced After May 18, 1978, and Prior to July 23, 1984
NSPS (Part 60), Kb: Standards of Performance for Volatile Organic Liquid Storage Vessels (Including

Petroleum Liquid Storage Vessels) for Which Construction, Reconstruction, or Modification Commenced After July 23, 1984
NSPS (Part 60), GG: Standards of Performance for Stationary Gas Turbines
NSPS (Part 60), XX: Standards of Performance for Bulk Gasoline Terminals
NSPS (Part 60), GGG: Standards of Performance for Equipment Leaks of VOC in Petroleum Refineries for which Construction, Reconstruction, or Modification Commenced After January 4, 1983, and on or Before November 7, 2006
NSPS (Part 60), GGGa: Standards of Performance for Equipment Leaks of VOC in Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After November 7, 2006
NSPS (Part 60), NNN: Standards of Performance for Volatile Organic Compound (VOC) Emissions From Synthetic Organic Chemical Manufacturing Industry (SOCMI) Distillation Operations
NSPS (Part 60), QQQ: Standards of Performance for VOC Emissions From Petroleum Refinery Wastewater Systems
NESHAP (Part 61), A: General Provisions
NESHAP (Part 61), M: National Emission Standard for Asbestos
NESHAP (Part 61), FF: National Emission Standard for Benzene Waste Operations
MACT (Part 63), A: General Provisions
MACT (Part 63), CC: National Emission Standards for Hazardous Air Pollutants From Petroleum Refineries
MACT (Part 63), UUU: National Emission Standards for Hazardous Air Pollutants for Petroleum Refineries: Catalytic Cracking Units, Catalytic Reforming Units, and Sulfur Recovery Units
MACT (Part 63), EEEE: National Emission Standards for Hazardous Air Pollutants: Organic Liquids Distribution (Non-Gasoline)
MACT (Part 63), DDDDD: National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters
Title V (Part 70) major source

REVIEWER COMMENTS

The AO will be based on the following documents:

Supersedes	DAQE-AN103350065-14 dated September 5, 2014
Is Derived From	Source Submitted NOI dated June 11, 2015
Incorporates	Additional Information Received From EPA dated September 29, 2015
Incorporates	Additional Information Received dated September 23, 2015
Incorporates	Additional Information Received dated October 12, 2015
Incorporates	Additional Information Received dated November 10, 2015
Incorporates	Additional Information Received dated January 8, 2016
Incorporates	Additional Information Received dated February 1, 2016

1. Comment regarding Status of sources:
Several emission units are specifically affected by this project. Each is addressed below:

    Wet Gas Scrubber and associated systems:
    This is a control device on an existing unmodified unit (see below), the FCCU/CO Boiler. Although listed as a separate line item under II.A.6, it is considered as part of the FCCU for federal subpart (NSPS and NESHAP) permitting requirements and is not a separate emitting unit.

    FCCU/CO Boiler:
    The installation of the wet gas scrubber system does not modify the FCCU/CO Boiler under NSPS or NESHAP regulations. Although physical changes are occurring at this emission unit, they do not trigger a reconstruction under NSPS or NESHAP regulations as they do not constitute more than 50% of the cost of a new unit. No modification is occurring, as no increase in the hourly emission rate of an applicable pollutant is occurring. Also see Engineering Review Comment #2 regarding the applicability of NSR to direct ozone emissions

    Ultraformer Unit F-1 Furnace:
    The installation of the new burners at the F-1 Furnace requires review due to the increase in emissions of $PM/PM_{10}/PM_{2.5}$ and VOC (see "Revised Firing Rate Calculations" submitted 2/1/16).

    Cogeneration Units:
    The increased steam demand from the cogeneration units does not result in a modification of these units as this can be accomplished under the existing permit conditions and without any physical changes or changes in the method of operation of these units. See also Engineering Review Comments 4 and 5 regarding Emission Calculations.
    [Last updated February 29, 2016]

2. Comment regarding Applicability of NSR to direct ozone emissions:
On June 4, 2015, UDAQ sent an inquiry to Region 8 of US EPA regarding the Agency's interpretation of the NSR program to direct ozone emissions. Specifically, whether or not a source which emits ozone as a pollutant is subject to the provisions of 40 CFR 52.21(b)(23)(ii).

    On September 29, 2015, Region 8 responded with a letter which stated, in essence, that since ozone is listed in the previous paragraph [52.21(b)(23)(i)], which defines a significant emission rate for that pollutant as being 40 tons per year of either VOC or NO_x, then [52.21(b)(23)(ii)] does not apply.

A copy of the Region 8 letter has been included in the source file for reference. [Last updated January 14, 2016]

3. Comment regarding Federal Requirements:
Analysis of the following specific federal subparts is included in this review:

40 CFR 60 (NSPS) Subparts J and Ja:
Under the wet gas scrubber/Low-TOx sub-project, only the FCCU/CO boiler will require any physical changes. These changes primarily involve reconfiguration of the exhaust system to incorporate the new controls, some external structural work to house the scrubber and other units, and other minor electrical, plumbing, and support work as needed to accommodate the new systems. There will not be any increase in the maximum hourly emissions of any of the pollutants regulated under Subpart J, which currently applies to the FCCU/CO Boiler. However, the FCCU/CO Boiler is already subject to NSPS Ja for CO and PM emissions and will be subject to NSPS Ja for NO_x and SO_2 by January 1, 2018 after the wet gas scrubber/Low-TOx system is installed.

Although the installation of the new burners on the F-1 furnace likely qualifies under the exemption of 40 CFR 60.14(e)(5):

The addition or use of any system or device whose primary function is the reduction of air pollutants, except when an emission control system is removed or is replaced by a system which the Administrator determines to be less environmentally beneficial.

Tesoro has conservatively assumed that this sub-project results in a modification of the F-1 furnace, and thus triggering the applicability of Subpart Ja for emissions of SO_2.

Both of these subparts have already been listed as included/applicable to the refinery.

40 CFR 63 (NESHAP) Subpart UUU:
Again, the FCCU/CO Boiler is the only existing unit subject to Subpart UUU experiencing a physical change as a result of the wet gas scrubber sub-project. Subpart UUU already applies to the FCCU/CO Boiler, and no changes in that applicability will occur due to this project. There will be new monitoring requirements associated with the wet gas scrubber as a control device after installation.

This subpart has been previously included in the applicability list for the refinery.

40 CFR 63 Subpart DDDDD:
The F-1 Furnace is currently subject to the provisions of Subpart DDDDD. The installation of the new burners will not change the applicability of this subpart, nor will it trigger any new requirements. However, this subpart was not previously included in the applicability list for the refinery and will be included in this review. [Last updated February 29, 2016]

4. Comment regarding Emission Calculations:
In order to properly calculate the overall change in emissions for this combined project, each sub-project must be evaluated separately. Although both sub-projects have been combined for permitting convenience, they were submitted separately and affect separate and distinct units at

the refinery. Both sub-projects can be accomplished individually and independently.

While both sub-projects are required by the $PM_{2.5}$ SIP, and both require some amount of additional incremental steam load from the cogeneration units, these two facts do not necessarily link the two sub-projects together. Neither sub-project is reliant upon the other in terms of infrastructure, timing, finances, logistics, or resources. It is only the nature of the NSR permitting program itself that requires that both projects be permitted simultaneously. Thus, each sub-project will be evaluated separately, and then the two individual results will be summed to arrive at the final project total change.

Wet Gas Scrubber:
Installation of the wet gas scrubber and LoTOx unit will reduce emissions of SO_2, NO_x and CO at the FCCU/CO Boiler. These values, which are specific to the FCCU/CO Boiler are as follows:

Estimated current SO_2 = 671.5 tpy (subject to a 705 tpy SO_x limit, existing condition II.B.4.b)
SO_2 PTE after project = 41.06 tpy (based on a limit of 10 ppmvd on a 365-day rolling average)

Current NO_x = 174 tpy (existing condition II.B.5.b)
NO_x PTE after project = 29.48 tpy (based on a limit of 10 ppmvd on a 365-day rolling average)

Estimated current CO = 933.43 tpy (subject to a 500 ppmvd limit - 40 CFR 60 Subpart J)
CO PTE after project = 179.51 (based on a limit of 100 ppmvd on a 365-day rolling average)

Both the NO_x and SO_2 values were already included in the calculations used when setting the new plant-wide emission caps for the Tesoro refinery which become applicable on January 1, 2019. Therefore, no change in overall refinery PTE will occur as a result of this installation.

Increased utilization of the cogeneration units for the wet gas scrubber sub-project:
Estimated additional steam requirement is 17,500 lb/hr, which requires an increased firing rate of approximately 19.25 MMBtu/hr. This additional firing is within the already permitted amount authorized to Tesoro under DAQE-103350065-14, as no specific limitation on firing rate is listed in the AO beyond that listed in II.A.18 (two steam units rated at approximately 157.8 MMBtu/hr each, for a total of 315.6 MMBtu/hr), and the emission inventory for 2014 showed a combined usage of approximately 162.7 MMBtu/hr (52% of that max value). The increase in actual emissions from the cogeneration units associated with this additional steam requirement is (all values in tpy):
PM_{10} = 0.84, $PM_{2.5}$ = 0.84, NO_x = 5.97, SO_2 = 2.09, CO = 6.53, VOC = 0.43, H_2SO_4 = 0.03
These values are based on Tesoro's most recent stack test, AP-42 tables 1.4-2 and 3.1-1, NSPS Subpart Ja, and Tesoro's supplied estimates of additional fuel and steam requirements.

Haul road fugitive dust emission estimates:
Tesoro also supplied emission estimates of the increased truck traffic on Tesoro's haul roads for delivery of raw materials (oxygen, caustic, coagulant) and disposal/removal of waste products (wastewater, filter cake). These estimates are based on the maximum potential increase in vehicle traffic, although reduction in these values is possible using alternatives to vehicle transport (such as alternative wastewater treatment).
The increase in fugitive particulates from haul road vehicle traffic is as follows (all values in tpy):
PM_{10} = 0.08, $PM_{2.5}$ = 0.02
[Last updated February 11, 2016]

5. Comment regarding Emission Calculations Cont.:
The installation of the new burners on the F-1 furnace results in a slightly more complicated emission calculation. First, is the estimation of the projected emissions of the unit following completion of the project (all values in tpy)

$PM_{10} = 4.59$, $PM_{2.5} = 4.59$, $NO_x = 40.06$, $SO_2 = 4.73$, $CO = 30.81$, $VOC = 3.32$, $H_2SO_4 = 0.07$

[This is based on a firing rate of 140.7 MMBtu/hr (as supplied by Tesoro, revised 1/8/16).]

However, as this is a modified unit at an existing major source, to properly calculate the emission increase from this sub-project, the "actual to projected actual" applicability test must be employed. This test is described at 40 CFR 52.21(a)(2)(iv)(c), and incorporated by reference at R307-405-2(2).

For purposes of simplicity, the PSD version of this description was used. The nonattainment area thresholds for a modification are identical, as is the description of the test. The nonattainment area version is described and outlined at R307-403-2(1)(c). Since Tesoro is located in an area of attainment for some pollutants and nonattainment for other pollutants, and functionally the two processes are identical, only one process will be discussed.

Under the actual to projected actual test, the source calculates the difference between the projected actual emissions of the modified unit, and the baseline actual emissions of that unit. For baseline actual emissions, this is defined as the average rate the unit actually emitted the pollutant during any consecutive 24-month period selected by the owner/operator within the 10-year period immediately preceding the project. A separate 24-month period may be chosen for each pollutant.

Tesoro considered periods between May 1, 2007 and May 31, 2015, and provided the emission values chosen to UDAQ as part of the NOI submitted Nov 10, 2015. UDAQ has reviewed the 24-month baseline periods and concurs with the emission values provided.

The calculation of projected actual emissions is complicated by three mitigating factors:
1. Projected actual emissions shall exclude the portion of the emissions that an existing unit "could have accommodated during the baseline period and are also unrelated to the particular project"
2. The projected actual emissions shall exclude any emissions related to increased utilization due to product demand growth
3. The projected actual emissions may use the emission units potential to emit in lieu of the actual emission calculation

In this particular case, Tesoro was able to estimate values for both factors #1 and #2, but elected to use the calculation of actual emissions rather than potential to emit.

Technically speaking, there are two additional components to this sub-project: the new components in VOC service (pipes, valves, flanges, etc.), and the increased utilization of the cogeneration units. When including these additional components, the process is exactly the same as for the modified unit [this is called the hybrid test, and is outlined at 40 CFR 52.21(a)(2)(iv)(f)].

By definition, the baseline period, capable of accommodating emissions, and demand growth emissions of the new components would all be zero (0), since they did not previously exist. Similarly, the emissions from the increased utilization at the cogeneration units would only involve the increased firing rate, since all other emissions would cancel out.

The final calculation of emission increases can be found on the included spreadsheet [Tesoro Revised Projected Emissions, and Revised Table 3b - Projected Actual Emission Calculations]. The conclusion is emission increases as follows (all values in tpy):

$PM_{10} = 0.5$, $PM_{2.5} = 0.5$, $NO_x = 0.72$, $SO_2 = 0.25$, $CO = 0.78$, $VOC = 2.76$

However, these changes in actual emissions can be accommodated within Tesoro's existing and future (1/1/2019) emission caps with no changes.

[Last updated February 11, 2016]

6. Comment regarding NSR/PSD Applicability:
Neither sub-project triggers a major modification under either the nonattainment area NSR (NNSR) or PSD requirements. As was previously discussed (see the emission calculation and BACT review sections above) these two sub-projects do not need to be aggregated for permitting purposes. They are also not tied to any previous permitting project conducted at Tesoro. This combined project can be considered a minor modification under the NSR permitting requirements for both NNSR and PSD. [Last updated January 13, 2016]

7. Comment regarding Changes in Permit Requirements:
This project results in the following changes in the permit:

1. Update in Section II.A - the listing for the UFU F-1 Furnace has been changed to reflect the addition of the new ultra-low NO_x burners, and the new components in VOC service.

2. Update in Section II.A - an additional entry has been made, listing the new wet gas scrubber and LoTOx unit.

3. New conditions on the FCCU/CO Boiler - new requirements (emission limitations) on the FCCU/CO Boiler have been added, limiting NO_x, SO_2 and CO emissions on a 7-day and 365-day rolling average basis. A sub-condition detailing the compliance methodology has also been included.

4. A condition of the applicable plant-wide caps (emission limits) which become applicable as of January 1, 2019 has been included. This condition is based on the requirements of Section IX.H.12 of the Utah $PM_{2.5}$ SIP. The requirements of the PM_{10} Maintenance plan have not yet been incorporated.

5. Several small corrections have been made where "12-month rolling average" was used in place of "12-month rolling total"

6. Condition II.B.5.g has been updated to be clearer - moving the parenthetical from the first paragraph to a separate line item.

7. Several conditions with expired dates have been updated or removed.

8. Opacity conditions have been clarified and consolidated.

9. A condition requiring initial inspection of the newly installed control equipment was added.

10. Several conditions have been updated where limitations change as of 1/1/18 or 1/1/19.

11. With installation of the WGS, several conditions with reference to "FCCU/CO Boiler (ESP)" have been changed to "FCCU/CO Boiler".

12. One condition was updated to include reference to filterable $PM_{2.5}$ (II.B.7.a) in addition to the already present filterable PM_{10}. [Last updated February 25, 2016]

8. Comment regarding Discussion of SO_2 Emission Limit:
There are two sets of *apparently redundant* emission limitations on SO_2. These have not been included in error, but rather are included as a result of Tesoro's emission calculation methodology.

The lower limits (10 ppmvd on a rolling 365-day basis and 18 ppmvd on a rolling 7-day basis) are used to calculate the PTE of the FCCU/CO Boiler following installation of the new control system. Thus, this limit needs to be included in the AO in order to make this calculation enforceable. Tesoro also uses these limits to gauge the overall performance of the control system. The higher limits (25 ppmvd on a rolling 365-day basis and 50 ppmvd on a rolling 7-day basis) are limits associated with the $PM_{2.5}$ SIP, and have specific associated monitoring requirements [Last updated February 11, 2016]

9. Comment regarding Filterable $PM_{2.5}$ Limit:
Condition II.B.7.a now includes a limit a filterable $PM_{2.5}$. This limitation did not previously apply to the Tesoro Refinery, and serves as a transition between previous AOs (which did not limit $PM_{2.5}$) and the applicable limits of the SIP, which do not come into effect until January 1, 2019. This limitation serves merely as a stopgap measure to address comments received on previous permitting actions as well as those comments received during the SIP development process. [Last updated February 25, 2016]

ACRONYMS

The following lists commonly used acronyms and associated translations as they apply to this document:

40 CFR	Title 40 of the Code of Federal Regulations
AO	Approval Order
BACT	Best Available Control Technology
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CDS	Classification Data System (used by EPA to classify sources by size/type)
CEM	Continuous emissions monitor
CEMS	Continuous emissions monitoring system
CFR	Code of Federal Regulations
CMS	Continuous monitoring system
CO	Carbon monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent - 40 CFR Part 98, Subpart A, Table A-1
COM	Continuous opacity monitor
DAQ/UDAQ	Division of Air Quality
DAQE	This is a document tracking code for internal UDAQ use
EPA	Environmental Protection Agency
FDCP	Fugitive dust control plan
GHG	Greenhouse Gas(es) - 40 CFR 52.21 (b)(49)(i)
GWP	Global Warming Potential - 40 CFR Part 86.1818-12(a)
HAP or HAPs	Hazardous air pollutant(s)
ITA	Intent to Approve
LB/HR	Pounds per hour
MACT	Maximum Achievable Control Technology
MMBTU	Million British Thermal Units
NAA	Nonattainment Area
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOI	Notice of Intent
NO_x	Oxides of nitrogen
NSPS	New Source Performance Standard
NSR	New Source Review
PM_{10}	Particulate matter less than 10 microns in size
$PM_{2.5}$	Particulate matter less than 2.5 microns in size
PSD	Prevention of Significant Deterioration
PTE	Potential to Emit
R307	Rules Series 307
R307-401	Rules Series 307 - Section 401
SO_2	Sulfur dioxide
Title IV	Title IV of the Clean Air Act
Title V	Title V of the Clean Air Act
TPY	Tons per year
UAC	Utah Administrative Code
VOC	Volatile organic compounds

Information taken from Tesoro's 2014 Inventory submission:

East Turbine	Refinery Gas	0553	975.170	10^6 cu ft/yr	AN	Input	1,053	btu/cu ft
East HRSG	Refinery Gas	0553	485.940	10^6 cu ft/yr	AN	Input	951	btu/cu ft
West Turbine	Refinery Gas	0553	984.250	10^6 cu ft/yr	AN	Input	1,053	btu/cu ft
West HRSG	Refinery Gas	0553	943.000	10^6 cu ft/yr	AN	Input	951	btu/cu ft

Extracting only the relevant information:

We only want the HRSG info, since those are the steam producing units in this particular case.

East HRSG	Refinery Gas	485.94 10^6 cu ft/yr	950.57097 btu/cu ft	8043 hrs/yr
West HRSG	Refinery Gas	943 10^6 cu ft/yr	950.57097 btu/cu ft	8515 hrs/yr

Performing unit conversion and assuming maximum operation during total hourly operation:

East HRSG	60417.75457 cu ft/hr	=	57.431364 MMBtu/hr
West HRSG	110745.7428 cu ft/hr	=	105.27169 MMBtu/hr
		Total =	162.70305 MMBtu/hr
		% of max:	52%

Each unit rated at: 157.8 MMBtu/hr

Max both units: 315.6 MMBtu/hr

Revised Projected Emissions Calculations
Based on Tesoro's revised firing rate estimates of 1/8/16

This calculates the new projected emissions for the UFU F-1 furnace only

Taking Table 3a (page 6 of 9) from the NOI and adjusting for the new firing rate:

Firing rate: 140.7 MMBtu/hr = 129.82 Mscf/hr

Pollutant	Emission Factor	Units	Emissions (lb/hr)	Emissions (tons/yr)
NOx	0.065000	lb/MMBtu	9.15	40.06
SO2	8.310000	lb/MMscf	1.08	4.73
CO	0.050000	lb/MMBtu	7.04	30.81
PM	0.007450	lb/MMBtu	1.05	4.59
PM10	0.007450	lb/MMBtu	1.05	4.59
PM2.5	0.007450	lb/MMBtu	1.05	4.59
VOC	0.005390	lb/MMBtu	0.76	3.32
H2SO4	0.120000	lb/MMscf	0.02	0.07

Revised Emission Increase Calculations
Based on Tesoro's revised firing rate estimate of 1/8/16

This calculates both the projected actual emissions (future emissions) as well as the emission increase associated with the project
This is still only from the UFU F-1 furnace only

From Table 3b (Page 7 of 9) of the NOI and adjusting based on the new projected emissions (previous tab):

	NOx	SO2	CO	PM	PM10	PM2.5	VOC	H2SO4	
A. Baseline Actual Emissions	53.16	4.00	41.32	3.74	3.74	3.74	2.70	0.06	This line is unchanged from the original NOI
B. Capable of Accommodating	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09	This line is unchanged from the original NOI
C. Projected Emissions	40.06	4.73	30.81	4.59	4.59	4.59	3.32	0.07	From Revised Projected Emissions Tab
D. Demand Growth (D=B-A)	0.00	1.98	0.00	0.45	0.45	0.45	0.34	0.03	
E. Projected Actual Emissions (E=C-D)	40.06	2.75	30.81	4.14	4.14	4.14	2.98	0.04	
F. Emission Increase (F=E-A)	0.00	0.00	0.00	0.40	0.40	0.40	0.28	0.00	

Now to include the emissions from the other components involved in the project:

Emissions from VOC Process Components (Pipe Flanges, Valves, Pumps, etc)

	NOx	SO2	CO	PM	PM10	PM2.5	VOC	H2SO4
Total from Table 4 of the NOI	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00

Emissions from increased utilization of the Cogeneration Units

	NOx	SO2	CO	PM	PM10	PM2.5	VOC	H2SO4
Total from Table 5 of the NOI	0.720	0.250	0.780	0.100	0.100	0.100	0.051	0.004

Yielding a new grand project total of:

	NOx	SO2	CO	PM	PM10	PM2.5	VOC	H2SO4
Total project emission increase (tpy)	**0.720**	**0.250**	**0.780**	**0.500**	**0.500**	**0.500**	**2.751**	**0.004**

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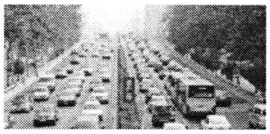
PremAir® NXT is a DOR technology which has been validated for 150,000 miles or 15 years. Tier 3 and LEV III have approved an emission reduction credit of 5 mg/mile for DOR technology. OEMs can leverage this tool in a number of ways to deliver value to manage their fleet average emissions requirements.

- **Optimize engine performance**
  - PremAir® NXT credits are a cost-effective alternative solution to PGM (Platinum Group Metals) content in catalytic converters and can be used to maximize engine performance at a bin classification.
- **Reduce cost**
  - As regulations demand more out of catalytic converters, additional PGM content can have decreasing emission control efficiency. PremAir® NXT credits can help optimize PGM performance to reduce total emission control costs.
- **Engineering Safety Factor for SULEV**
  - Performance at low NMOG and NOx levels is difficult to measure for both fresh and aged catalyst performance; borderline TWC aging performance can introduce risk to an OEM. PremAir® NXT credits can be leveraged to increase the safety factor at a vehicle bin classification.
- **Managing fleet vehicle mix**
  - LEV III and Tier 3 require OEMs to change their fleet percentage sales to meet the emission standards, so OEMs have to sell more SULEV vehicles while selling less ULEV 125 vehicles. High performance sedans and coupes as well as trucks and SUVs are often more profitable but meet higher emission bins. Utilizing PremAir® NXT credits can enable OEMs to mitigate the impact of new regulations on their vehicle mix.

What is ozone?

Ozone is a molecule that consists of three oxygen atoms. Naturally-occurring ozone is formed miles above the earth in the stratosphere. This ozone layer is responsible for absorbing the sun's harmful ultraviolet radiation. Unfortunately, the ozone at ground level is the major component of smog. This artificially created ozone is the cause of many adverse effects, such as irritation of and damage to lungs, eyes, noses and throats. Man-made ozone is produced by the oxidation of nitrogen oxides (NOx) and Volatile Organic Compounds (VOCs) in the presence of direct sunlight. The main sources of NOx and VOC gases are mobile emissions, industrial factories, electrical plants, chemical solvents, and gasoline vapors.

Click here for a list of car models that have been certified with Direct Ozone Reduction (PremAir).



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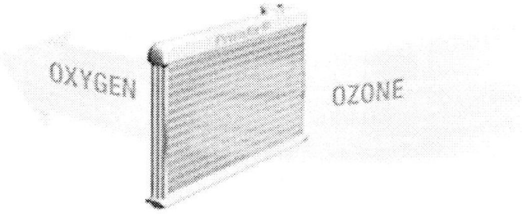
PremAir is the first commercial product that destroys harmful, ground-level ozone already in the air and converts it into oxygen. PremAir catalysts have been successfully installed on over 3 million automotive radiators throughout the world.

Depending upon the conditions, PremAir can destroy 75 percent or more of the ozone that touches the PremAir-coated radiator surface, converting ozone molecules (O_3) into oxygen (O_2) molecules. There is no significant impact on cooling or other performance attributes of the radiator.

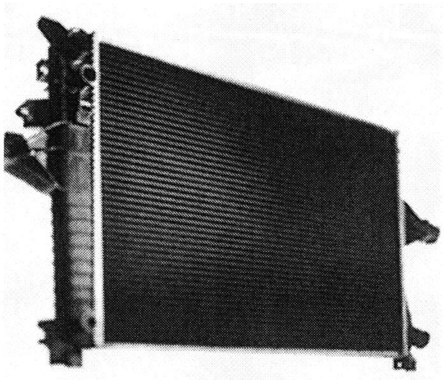


LEV III Credit Certified

Having recognized the air quality benefits of PremAir-equipped automotive radiators, the Air Resources Board in California has established programs to allow vehicle manufacturers to use PremAir in meeting emissions standards.

PremAir Green

Where regulatory compliance is not needed, PremAir Green is a cost-effective option for vehicle manufacturers to demonstrate commitment to a clean environment and a responsible environmental policy.



What is ground-level ozone?

According to the U.S. Environmental Protection Agency (EPA), in the Earth's lower atmosphere, near ground level, ozone is formed when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants and other sources react chemically in the presence of sunlight.

Ozone pollution is a special concern during summer months when the weather conditions needed to form ground-level ozone – lots of sun and hot temperatures – normally occur.

The American Lung Association reports that half of the U.S. population breathes unhealthy levels of ozone some time during the year. Millions of people living in urban areas around the world are similarly exposed.

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The focus of the BASF Emissions Professional is always on innovative, cost-effective solutions to meet the needs of OEMs and engine manufacturers globally. With a creative, open, responsible and entrepreneurial approach we help make our customers meet regulations and be more profitable. That's the EMPRO way.

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Diesel Oxidation Catalysts (DOC)

5987882, 6006516, 6422008, 7078004, 7576031, 7875573, 7947238, 8148290, 8211392, 8246922, 8252258, 8329607, 8449852, 8568675, 8637426

Lean NOx Traps (LNT)

6375910, 6497848, 7022646, 7490464, 7919051, 8022010, 8173574, 8784759, 8776499

Selective Catalytic Reduction & Selective Catalytic Reduction on Filter (SCR, SCR.2F)

6311484, 6415602, 6446430, 6581374, 6662553, 6742330, 6826906, 7143578, 7150145, 7229597, 7438878, 7481983, 7490464, 7601662, 7704475, 7767176, 7722845, 7902107, 7919051, 7951742, 7968068, 7998423, 8119088, 8122603, 8246922, 8293182, 8293198, 8293199, 8404203, 8524185, 8544260, 8617474, 8899023, 6004524, 8961914, 8722000, 6689709, 6914026, 6125629

AMX

7481983, 7767176, 7722845, 8293182, 8524185, 8722000, 6689709, 6914026

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5866210, 5888464, 5898014, 6044644, 6110862, 6492297, 6497851, 6764665, 6777370, 6923945, 7041263, 7022644, 7276212, 7374729, 7501098, 7517510, 7524465, 7550124, 7622096, 7678347, 7749472, 7754171, 7758834, 7795172, 7811962, 7879755, 7922988, 8007750, 8038951, 8173087, 8568675, 8815189, 8950174, 8765085, 6093378

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United States Patent **6,818,254**

Hoke , et al. **November 16, 2004**

Stable slurries of catalytically active materials

Abstract

A method and apparatus for treating the atmosphere comprising moving a vehicle through the atmosphere, the vehicle having at least one atmosphere contacting surface and a pollutant treating composition located on said surface. A specific embodiment comprises coating a motor vehicle radiator with pollutant treating catalyst.

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Assignee:	**Engelhard Corporation** (Iselin, NJ)
Family ID:	**33425551**
Appl. No.:	**08/682,174**
Filed:	**July 16, 1996**

Related U.S. Patent Documents

Application Number	Filing Date	Patent Number	Issue Date
589182	Jan 19, 1996		
537206	Sep 29, 1995		
410445	Mar 24, 1995		
376332	Jan 20, 1995		

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Current CPC Class:	B01D 53/02 (20130101); B01D 53/8675 (20130101); B01D 53/885 (20130101); B01D 53/74 (20130101); Y10S 502/512 (20130101); B01D 2251/40 (20130101); B01D

	2251/602 (20130101); B01D 2253/102 (20130101); B01D 2253/108 (20130101); B01D 2253/11 (20130101); B01D 2253/202 (20130101); B01D 2253/25 (20130101); B01D 2253/304 (20130101); B01D 2253/306 (20130101); B01D 2257/106 (20130101); B01D 2257/302 (20130101); B01D 2257/404 (20130101); B01D 2257/502 (20130101); B01D 2257/702 (20130101); B01D 2258/06 (20130101); B01D 2259/4558 (20130101); Y10S 502/506 (20130101)
Current International Class:	B01D 53/74 (20060101); B01D 53/04 (20060101); B01D 53/86 (20060101); B01D 53/88 (20060101); B01J 023/34 (); B05D 001/02 (); B05D 001/18 (); B05D 001/28 ()
Field of Search:	;502/2,324,325,439,506,512,514 ;427/421,429,435,443.2

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Primary Examiner: Langel; Wayne A.
Attorney, Agent or Firm: Lindenfeldar; Russell G.

Parent Case Text

RELATED APPLICATION

This is a continuation-in-part application of U.S. Ser. No. 08/589,182 filed Jan. 19, 1996 now abandoned which is a continuation-in-part of U.S. Ser. No. 08/537,206 filed Sep. 29, 1995 now abandoned which is a continuation-in-part of U.S. Ser. No. 08/410,445 filed Mar. 24, 1995 now abandoned which is a continuation-in-part of U.S. Ser. No. 08/376,332 filed Jan. 20, 1995, now abandoned all of said applications are herein incorporated by reference.

Claims

What is claimed is:

1. A method of applying a mixture to a substrate comprising the steps of: forming a mixture comprising water and a particulate catalytically-active material, the catalytically-active material comprising a manganese component having a BET N.sub.2 surface area of greater than 150 m.sup.2 /g, and wherein approximately 90% of the particles are less than 8 micrometers; adding to the mixture a dispersant comprising a compound selected from the group consisting of a polymer containing carboxylic acid groups, an ester of the polymer and a salt of the polymer; adding to the mixture a polymeric binder selected from the group consisting of an acrylic polymer and a poly(vinyl) acetate; and after adding the dispersant and polymeric binder, applying the mixture to a motor vehicle contacting surface.

2. The method of claim 1, wherein the slurry is applied by spray coating, brushing, or dipping.

3. The method of claim 2, wherein the slurry is applied by spray coating.

4. The method as recited in claim 1 wherein the atmosphere contacting surface is selected from the group consisting of the outer surface of an air conditioner condenser, a radiator, a radiator fan, an air charge cooler, a wind deflector, engine oil cooler, a transmission oil cooler and a power steering fluid cooler.

5. The method of as recited in claim 1 further comprising adjusting the pH of the mixture to at least 8.5.

6. A method of forming a slurry comprising the steps of: forming a mixture comprising water and a particulate catalytically-active material, the catalytically-active material comprising a manganese component having a BET N.sub.2 surface area of greater than 150 m.sup.2 /g, and wherein approximately 90% of the particles are less than 8 micrometers; adding to the mixture a dispersant comprising a compound selected from the group consisting of a polymer containing carboxylic acid groups, an ester of the polymer and a salt of the polymer; and adding to the mixture a polymeric binder selected from the group consisting of an acrylic polymer and a poly(vinyl) acetate.

7. The method of claim 6, wherein the dispersant is a dicarboxylic acid ester or salt derivative.

8. The method of claim 7, wherein the dispersant is a maleic acid/isobutylene copolymer.

9. The method of claim 8, wherein the dispersant is a salt of a maleic acid/isobutylene copolymer.

10. The method of claim 9, wherein the dispersant is a sodium salt of a maleic acid/isobutylene copolymer.

11. The method of claim 6, wherein the dispersant is a polymeric acrylate.

12. The method of claim 11, wherein the dispersant is a salt of a polymeric acrylate.

13. The method of claim 12, wherein the dispersant is a sodium salt of a polyacrylate/methacrylate copolymer.

14. The method of as recited in claim 6 further comprising adjusting the pH of the mixture to at least 8.5.

15. The method of claims 14, 6, 11, 12, 13, 7, 8, 9, or 10, wherein the binder is an acrylic latex binder or an ethylene vinyl acetate binder.

16. The method as recited in claims 14, 6 or 1 wherein the catalytically active material further comprises a platinum group metal component.

17. The method as recited in claim 16 further comprising the step of calcining the catalytically active material prior to adding the polymeric binder.

18. The method as recited in claim 16 further comprising the step of reducing the catalytically active material.

19. The method as recited in claims 14, 6, or 1 wherein the manganese component is MnO.sub.2.

20. The method as recited in claim 48 wherein the MnO.sub.2 is .alpha.-MnO.sub.2.

21. The method as recited in claim 20 wherein the .alpha.-MnO.sub.2 is selected from the group consisting of hollandite, cryptomelane, manjiroite and coronadite.

22. The method as recited in claim 21 wherein the .alpha.-MnO.sub.2 is cryptomelane having a surface area of about from 200 to 350 m.sup.2 /g.

23. The method as recited in claim 20 wherein the .alpha.-MnO.sub.2 comprises up to 2% by weight of silica.

24. The method of claims 14, 6 or 1 wherein the mixture further comprises thickeners, biocides, and antioxidants.

25. A composition made by the method of claims 14, 6, 11, 12, 13, 7, 8, 9, or 10.

26. The composition of claim 25, wherein the binder is an acrylic latex binder or an ethylene vinyl acetate binder.

27. The composition of claim 26 further comprising at least one additive selected from the group consisting of a thickener, a biocide, and an antioxidant.

28. A catalytic slurry for adhering to a substrate comprising: a particulate catalytically-active material comprising a manganese component having a BET N.sub.2 surface area of greater than 150 m.sup.2 /g, and wherein approximately 90% of the particles are less than 8 micrometers; a dispersant comprising a compound selected from the group consisting of a polymer containing carboxylic acid groups, an ester of the polymer and a salt of the polymer; a polymeric binder selected from the group consisting of an

acrylic polymer and a poly(vinyl) acetate; and water.

Description

BACKGROUND OF THE INVENTION

1. Field of The Invention

The present invention relates to an apparatus for cleaning the atmosphere; and more particularly to a vehicle comprising at least one atmosphere contacting surface having a pollution treating composition thereon, and a related method and composition.

2. Discussion of the Related Art

A review of literature relating to pollution control reveals that the general approach is to reactively clean waste streams entering the environment. If too much of one pollutant or another is detected or being discharged, the tendency has been to focus on the source of the pollutant, the cause of the pollutant or the waste stream containing the pollutant. For the most part gaseous streams are treated to reduce the pollutants prior to entering the atmosphere.

It has been disclosed to treat atmospheric air directed into a confined space to remove undesirable components in the air. However, there has been little effort to treat pollutants which are already in the environment; the environment has been left to its own self cleansing systems. References are known which disclose proactively cleaning the environment. U.S. Pat. No. 3,738,088 discloses an air filtering assembly for cleaning pollution from the ambient air by utilizing a vehicle as a mobile cleaning device. A variety of elements are disclosed to be used in combination with a vehicle to clean the ambient air as the vehicle is driven through the environment. In particular, there is disclosed ducting to control air stream velocity and direct the air to various filter means. The filter means can include filters and electronic precipitators. Catalyzed postfilters are disclosed to be useful to treat nonparticulate or aerosol pollution such as carbon monoxide, unburned hydrocarbons, nitrous oxide and/or sulfur oxides, and the like. German Patent DE 43 18 738 C1 also discloses a process for the physical and chemical cleaning of outside air. Motor vehicles are used as carriers of conventional filters and/or catalysts, which do not constitute operational components of the vehicle but are used to directly clean atmospheric air.

Another approach is disclosed in U.S. Pat. No. 5,147,429. There is disclosed a mobile airborne air cleaning station. In particular this patent features a dirigible for collecting air. The dirigible has a plurality of different types of air cleaning devices contained therein. The air cleaning devices disclosed include wet scrubbers, filtration machines, and cyclonic spray scrubbers.

The difficulty with the above recited devices disclosed to proactively clean the atmospheric air is that they require new and additional equipment. Even the modified vehicle disclosed in U.S. Pat. No. 3,738,088 requires ducting and filters which can include catalytic filters.

DE 40 07 965 C2 to Klaus Hager discloses a catalyst comprising copper oxides for converting ozone and a mixture of copper oxides and manganese oxides for converting carbon monoxide. The catalyst can be applied as a coating to a self heating radiator, oil coolers or charged-air coolers. The catalyst coating comprises heat resistant binders which are also gas permeable. It is indicated that the copper oxides and manganese oxides are widely used in gas mask filters and have the disadvantage of being poisoned by water vapor. However, the heating of the surfaces of the automobile during operation evaporates the water. In this way, continuous use of the catalyst is possible since no drying agent is necessary.

Manganese oxides are known to catalyze the oxidation of ozone to form oxygen. Many commercially available types of manganese compound and compositions, including alpha manganese oxide are disclosed to catalyze the reaction of ozone to form oxygen. In particular, it is known to use the cryptomelane form of alpha manganese oxide to catalyze the reaction of ozone to form oxygen.

Alpha manganese oxides are disclosed in references such as O'Young, Hydrothermal Synthesis of Manganese Oxides with Tunnel Structures, Modern Analytical Techniques for Analysis of Petroleum, presented at the Symposium on Advances in Zeolites and Pillared Clay Structures before the Division of Petroleum Chemistry, Inc. American Chemical Society New York City Meeting, Aug. 25-30, 1991 beginning at page 348. Such materials are also disclosed in U.S. Pat. No. 5,340,562 to O'Young, et al. Additionally, forms of .alpha.-MnO.sub.2 are disclosed in McKenzie, the Synthesis of Birnessite, Cryptomelane, and Some Other Oxides and Hydroxides of Manganese, Mineralogical Magazine, December 1971, Vol. 38, pp. 493-502. For the purposes of the present invention, .alpha.-MnO.sub.2 is defined to include hollandite (BaMn.sub.8 O.sub.16.xH.sub.2 O), cryptomelane (KMn.sub.8 O.sub.16.xH.sub.2 O), manjiroite (NaMn.sub.8 O.sub.16.xH.sub.2 O) and coronadite (PbMn.sub.8 O.sub.16.xH.sub.2 O). O'Young discloses these materials to have a three dimensional framework tunnel structure (U.S. Pat. No. 5,340,562 and O'Young Hydrothermal Synthesis of Manganese Oxides with Tunnel Structures both hereby incorporated by reference). For the purposes of the present invention, .alpha.-MnO.sub.2 is considered to have a 2.times.2 tunnel structure and to include hollandite, cryptomelane, manjiroite and coronadite.

SUMMARY OF THE INVENTION

The present invention relates to an apparatus, method and composition to treat the atmosphere. For the purposes of the present invention atmosphere is defined as the mass of air surrounding the earth.

The present invention is directed to an apparatus and related method for treating the atmosphere comprising a vehicle and a means such as a motor to translate the vehicle from one place to another through the atmosphere. The vehicle comprises at least one atmosphere contacting vehicle surface and a pollutant treating composition located on that surface. The atmosphere contacting surface is a surface of a component of the vehicle that is in direct contact with the atmosphere. Preferred and useful atmosphere contacting surfaces include body surfaces, wind deflector surfaces, grill surfaces, mirror backs and the surfaces of "under the hood" components. Preferred atmosphere contacting surfaces are located within the body of the motor vehicle, typically in proximity to the engine, i.e., the engine compartment. The surfaces are preferably the surfaces of cooling means which comprise an in flow path for liquids or gases through a coolant walled enclosure such as tubes or a housing and an outer surface on which is located fins to enhance heat transfer. Preferred atmosphere contacting surfaces comprise a finned outer surface and are selected from the outer surfaces of the radiator, air conditioner condenser, the surfaces of the radiator fan, engine oil cooler, transmission oil cooler, power steering fluid cooler and air charge cooler also referred to as an intercooler or after cooler. The most preferred atmosphere contacting surfaces are the outer surfaces of the air conditioner condenser and radiator due to their large surface area and relatively high ambient operating temperatures of from about 40.degree. C. to 135.degree. C. and typically up to 110.degree. C.

An advantage of the present invention is that the atmosphere contacting surface useful to support a pollution treating composition can be the surface of existing vehicle components. No additional filter, or apparatus to support a pollutant treating composition, is required. Accordingly, the apparatus and method of the present invention can be located on existing components of new cars or retrofitted onto old cars. Retrofitting may comprise coating a suitable pollutant treating composition on an existing vehicle surface which comes in contact with atmospheric air as the vehicle is driven through the atmosphere.

The present invention is directed to compositions, methods and articles to treat pollutants in air. Such pollutants may typically comprise from 0 to 400 parts, more typically 1 to 300, and yet more typically 1 to 200, parts per billion (ppb) ozone; 0 to 30 parts, and more typically 1 to 20, parts per million (ppm) carbon monoxide; and 2 to 3000 ppb unsaturated hydrocarbon compounds such as C.sub.2 to about C.sub.20 olefins and partially oxygenated hydrocarbons such as alcohols, aldehydes, esters, ethers, ketones and the like. Typical hydrocarbons which can be treated include, but are not limited to, propylene, butylene, formaldehyde and other airborne hydrocarbon gases and vapors. Other pollutants present may include nitrogen oxides and sulfur oxides. The National Ambient Air Quality Standard for ozone is 120 ppb, and for carbon monoxide is 9 ppm.

Pollutant treating compositions include catalyst compositions useful for catalyzing the conversion of pollutants present in the atmosphere to non-objectionable materials. Alternatively, adsorption compositions can be used as the pollutant treating composition to absorb pollutants which can be destroyed upon adsorption, or stored for further treatment at a later time.

Catalyst compositions can be used which can assist in the conversion of the pollutants to harmless compounds or to less harmful compounds. Useful and preferred catalyst compositions include compositions which catalyze the reaction of ozone to form oxygen, catalyze the reaction of carbon monoxide to form carbon dioxide, and/or catalyze the reaction of hydrocarbons to form water and carbon dioxide. Specific and preferred catalysts to catalyze the reaction of hydrocarbons are useful for catalyzing the reaction of low molecular weight unsaturated hydrocarbons having from two to twenty carbons and at least one double bond, such as C.sub.2 to about C.sub.8 mono-olefins. Such low molecular weight hydrocarbons have been identified as being sufficiently reactive to cause smog. Particular olefins which can be reacted include propylene and butylene. A useful and preferred catalyst can catalyze the reactions of both ozone and carbon monoxide; and preferably ozone, carbon monoxide and hydrocarbons.

Ozone--Useful and preferred catalyst compositions to treat ozone include a composition comprising manganese compounds including oxides such as Mn.sub.2 O.sub.3 and MnO.sub.2 with a preferred composition comprising .alpha.-MnO.sub.2, and cryptomelane being most preferred. Other useful and preferred compositions include a mixture of MnO.sub.2 and CuO. Specific and preferred compositions comprise hopcalite which contains CuO and MnO.sub.2 and, more preferably Carulite.RTM. which contains MnO.sub.2, CuO and Al.sub.2 O.sub.3 and sold by the Carus Chemical Co. An alternative composition comprises a refractory metal oxide support on which is dispersed a catalytically effective amount of a palladium component and preferably also includes a manganese component. Also useful is a catalyst comprising a precious metal component, preferably a platinum component on a support of coprecipitated zirconia and manganese oxide. The use of this coprecipitated support has been found to be particularly effective to enable a platinum component to be used to treat ozone. Yet another composition which can result in the conversion of ozone to oxygen comprises carbon, and palladium or platinum supported on carbon, manganese dioxide, Carulite.RTM. and/or hopcalite. Manganese supported on a refractory oxide such as alumina has also been found to be useful.

Carbon Monoxide--Useful and preferred catalyst compositions to treat carbon monoxide include a composition comprising a refractory metal oxide support on which is dispersed a catalytically effective amount of a platinum and/or palladium component, preferably a platinum component. A most preferred catalyst composition to treat carbon monoxide comprises a reduced platinum group component supported on a refractory metal oxide, preferably titania. Useful catalytic materials include precious metal components including platinum group components which include the metals and their compounds. Such metals can be selected from platinum, palladium, rhodium and ruthenium, gold and/or silver components. Platinum will also result in the catalytic reaction of ozone. Also useful is a catalyst comprising a precious metal component, preferably a platinum component on a support of coprecipitated zirconia and manganese dioxide. Preferably, this catalyst embodiment is reduced. Other useful compositions which can convert carbon monoxide to carbon dioxide include a platinum component supported on carbon or a support comprising manganese dioxide. Preferred catalysts to treat such pollutants are reduced. Another composition useful to treat carbon monoxide comprises a platinum group metal component, preferably a platinum component, a refractory oxide support, preferably alumina and titania and at least one metal component selected from a tungsten component and rhenium component, preferably in the metal oxide form.

Hydrocarbons--Useful and preferred catalyst compositions to treat unsaturated hydrocarbons including C.sub.2 to about C.sub.20 olefins and typically C.sub.2 to C.sub.8 mono-olefins such as propylene and partially oxygenated hydrocarbons as recited have been found to be the same type as recited for use in catalyzing the reaction of carbon monoxide with the preferred compositions for unsaturated hydrocarbons comprising a reduced platinum and/or palladium component and a refractory metal oxide support for the platinum component. A preferred refractory metal oxide support is titania. Other useful compositions which can convert hydrocarbons to carbon dioxide and water include a platinum component supported on carbon or a support comprising manganese dioxide. Preferred catalysts to treat such pollutants are reduced. Another composition useful to convert hydrocarbons comprises a platinum group metal component, preferably a platinum component, a refractory oxide support, preferably alumina and titania and at least one metal component selected from a tungsten component and rhenium component, preferably in the metal oxide form. A combination of a platinum component and a palladium component results in improved CO conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable.

Ozone and Carbon Monoxide--A useful and preferred catalyst which can treat both ozone and carbon monoxide comprises a support such as a refractory metal oxide support on which is dispersed a precious metal component. The refractory oxide support can comprise a support component selected from the group consisting of ceria, alumina, silica, titania, zirconia, and mixtures thereof. Also useful as a support for precious metal catalyst components is a coprecipitate of zirconia and manganese oxides. Most preferably, this support is used with a platinum component and the catalyst is in reduced form. This single catalyst has been found to effectively treat both ozone and carbon monoxide. Other useful and preferred precious metal components are comprised of precious metal components selected from palladium and also platinum components with palladium preferred. A combination of a ceria support with a palladium component results in an effective catalyst for treating both ozone and carbon monoxide. Other useful and preferred catalysts to treat both ozone and carbon monoxide include a platinum group component, preferably a platinum component and/or palladium component and more preferably a platinum component, on titania or on a combination of zirconia and silica. A combination of a platinum component and a palladium component results in improved CO conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. Other useful compositions which can convert ozone to oxygen and carbon monoxide to carbon dioxide include a platinum component supported on carbon or on a support comprising manganese dioxide. Preferred catalysts are reduced.

Ozone, Carbon Monoxide and Hydrocarbons--A useful and preferred catalyst which can treat ozone, carbon monoxide and hydrocarbons, typically low molecular weight olefins (C.sub.2 to about C.sub.20) and typically C.sub.2 to C.sub.8 mono-olefins and partially oxygenated hydrocarbons as recited comprises a support, preferably a refractory metal oxide support on which is dispersed a precious metal component. The refractory metal oxide support can comprise a support component selected from the group consisting of ceria, alumina, titania, zirconia and mixtures thereof with titania most preferred. Useful and preferred precious metal components are comprised of precious metal components selected from platinum group components including palladium and/or platinum components with platinum most preferred. It has been found that a combination of a titania support with a platinum component results in the most effective catalyst for treating ozone, carbon monoxide and low molecular weight gaseous olefin compounds. A combination of a platinum component and a palladium component results in improved CO and hydrocarbon conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. It is preferred to reduce the platinum group components with a suitable reducing agent. Other useful compositions which can convert ozone to oxygen, carbon monoxide to carbon dioxide, and hydrocarbons to carbon dioxide include a platinum component supported on carbon, a support comprising manganese dioxide, or a support comprising a coprecipitate of manganese oxides and zirconia. Preferred catalysts are reduced.

The above compositions can be applied by coating to at least one atmosphere contacting vehicle surface. Particularly preferred compositions catalyze the destruction of ozone, carbon monoxide and/or unsaturated low molecular weight olefinic compounds at ambient conditions or ambient operating conditions. Ambient conditions are the conditions of the atmosphere. By ambient operating conditions it is meant the conditions, such as temperature, of the atmosphere contacting surface during normal operation of the vehicle without the use of additional energy directed to heating the pollutant treating composition. Certain atmosphere contacting surfaces such as a grill or wind deflector can be at the same or similar temperature as the atmosphere. It has been found that preferred catalysts which catalyze the reaction of ozone can catalyze the reaction of ozone at ambient conditions in ranges as low as 5.degree. C. to 30.degree. C.

Atmosphere contacting surfaces may have higher temperatures than the ambient atmospheric temperatures due to the nature of the operation of the component underlying the surface. For example, preferred atmosphere contacting surfaces are the surfaces of the air conditioning condenser and the radiator due to their high surface area. Where vehicles use air charge coolers, these are preferred due to high surface area and operating temperatures of from ambient to 250.degree. F. Normally, during ambient operating conditions the surfaces of these components increase to higher temperature levels than the ambient environment due to the nature of their operation. After the vehicle motor has warmed up, these components are typically at temperatures which range up to about 130.degree. C. and typically from 40.degree. C. to 110.degree. C. The temperature range of these atmosphere contacting surfaces helps to enhance the conversion rates of the ozone, carbon monoxide and hydrocarbon catalysts supported on such surfaces. Air charge coolers operate at temperatures up to about 130.degree. C. and typically from 60.degree. C. to 130.degree. C.

Various of the catalyst compositions can be combined, and a combined coating applied to the atmosphere contacting surface. Alternatively, different surfaces or different parts of the same surface can be coated with different catalyst compositions.

The method and apparatus of the present invention are designed so that the pollutants can be treated at ambient atmospheric conditions or at the ambient operating conditions of the vehicle atmosphere contacting surface. The present invention is particularly useful for treating ozone by coating motor vehicle atmosphere contacting surfaces with suitable catalysts useful to destroy such pollutants even at ambient conditions, and at vehicle surface temperatures typically from at least 0.degree. C., preferably from 10.degree. C. to 105.degree. C., and more preferably from 40.degree. C. to 100.degree. C. Carbon monoxide is preferably treated at atmosphere contacting surface temperatures from 40.degree. C. to 105.degree. C. Low molecular weight hydrocarbons, typically unsaturated hydrocarbons having at least one unsaturated bond, such as C.sub.2 to about C.sub.20 olefins and typically C.sub.2 to C.sub.8 mono-olefins, are preferably treated at atmosphere contacting surface temperatures of from 40.degree. C. to 105.degree. C. The percent conversion of ozone, carbon monoxide and/or hydrocarbons depends on the temperature and space velocity of the atmospheric air relative to the atmosphere contacting surface, and the temperature of the atmosphere contacting surface.

Accordingly, the present invention, in most preferred embodiments can result in at least reducing the ozone, carbon monoxide and/or hydrocarbon levels present in the atmosphere without the addition of any mechanical features or energy source to existing vehicles, particularly motor vehicles. Additionally, the catalytic reaction takes place at the normal ambient operating conditions experienced by the surfaces of these motor vehicle elements so that no changes in the construction or method of operation of the motor vehicle are required.

While the apparatus and method of the present invention are generally directed to treating the atmosphere, it will be appreciated that variations of the apparatus are contemplated for use to treat volumes of air in enclosed spaces. For example, a motor vehicle having an atmosphere contacting surface supporting a pollutant treating composition can be used to treat the air within factories, mines and tunnels. Such apparatus can include vehicles used in such environments.

While the preferred embodiments of the present invention are directed to the destruction of pollutants at the ambient operating temperatures of the atmosphere contacting surface, it is also desirable to treat pollutants which have a catalyzed reaction temperature higher than the ambient temperature or ambient operating temperature of the atmosphere contacting surface. Such pollutants include hydrocarbons and nitrogen oxides and any carbon monoxide which bypasses or is not treated at the atmosphere contacting surface. These pollutants can be treated at higher temperatures typically in the range of at least 100.degree. C. to 450.degree. C. This can be accomplished, for example, by the use of an auxiliary heated catalyzed surface. By an auxiliary heated surface, it is meant that there are supplemental means to heat the surface. A preferred auxiliary heated surface is the surface of an electrically heated catalyzed monolith such as an electrically heated catalyzed metal honeycomb of the type known to those skilled in the art. Electricity can be provided by batteries or a generator such as are present in motor vehicles. The catalyst composition can be any well known oxidation and/or reduction catalyst, preferably a three way catalyst (TWC) comprising precious group metals such as platinum, palladium, rhodium and the like supported on refractory oxide supports. An auxiliary heated catalyzed surface can be used in combination with, and preferably downstream of, the vehicle atmosphere contacting surface to further treat the pollutants.

As previously stated, adsorption compositions can also be used to adsorb pollutants such as hydrocarbons and/or particulate matter for later oxidation or subsequent removal. Useful and preferred adsorption compositions include zeolites, other molecular sieves, carbon, and Group IIA alkaline earth metal oxides such as calcium oxide. Hydrocarbons and particulate matter can be adsorbed from 0.degree. C. to 110.degree. C. and subsequently treated by desorption followed by catalytic reaction or incineration.

It is preferred to coat areas of the vehicle that have a relatively high surface area exposed to a large flow rate of atmospheric air as the motor vehicle is driven through the environment. For land use motor vehicles, particularly preferred atmosphere contacting surfaces include the radiator, fan blades, the air conditioning condenser or heat exchanger, air charge cooler, engine oil cooler, transmission oil cooler, and wind deflectors of the type used on the roof of truck cabs.

Most preferably, the atmosphere contacting surface is a surface of a radiator. The radiator has a large surface area for enhanced cooling of internal combustion engine fluid coolants. By applying a catalyst to be supported on the radiator surface, advantage can be taken of the large honeycomb-like surface area, usually with little or no effect on the cooling function of the radiator. The high honeycomb-like surface area enables a maximization of contact of the catalyst with the air passing through the honeycomb-like design of the radiator. Additionally, radiators in many automobiles are located behind the air conditioner condenser and are thereby protected by the air conditioner condenser.

The present invention includes methods to coat pollutant treating compositions on to atmosphere contacting surfaces of motor vehicles. In particular, the present invention includes a method to coat catalyst compositions onto finned elements such as radiators, air conditioner condensers, and air charge coolers.

Calculations suggest that in motor vehicle traffic congested areas, there are a sufficient number of motor vehicles to significantly impact pollutants treated in accordance with the present invention. For example, in Southern California's South Coast Air Quality Management District, there are approximately eight million cars. It has been calculated that if each car travels 20 miles per day, all of the air in this region to an altitude of 100 feet can be cycled through radiators in one week.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side schematic view of a truck showing a grill, air conditioner condenser, electrically heated catalyst, air charge cooler, radiator, fan and engine with a wind deflector on the roof of the truck cab.

FIG. 2 is a partial schematic view of a motor vehicle showing the grill, air conditioner condenser, radiator and fan.

FIG. 3 is a front view of the radiator.

FIG. 4 is a front view of the air conditioner condenser.

FIG. 5 is a front view of a wind deflector of the type illustrated in FIG. 1.

FIG. 6 is a front view of the truck of FIG. 1.

FIG. 7 is a partial schematic sectional view of coated finned cooling element.

FIG. 8 is a photograph of the coated radiator from Examples 1 and 2.

FIGS. 9-14 and 16-17 are graphs of CO conversion versus temperature for using different catalysts in Examples 4, 9-12, 14 and 15.

FIG. 15 is a graph of propylene conversion versus temperature based on Example 14.

FIG. 18 is a graph of ozone conversion versus temperature based on Example 17.

FIG. 19 is an IR spectrum for cryptomelane.

FIG. 20 is an XRD pattern for cryptomelane shown as counts using a square root scale versus the Bragg angle, 2.theta..

FIG. 21 is a graph of CO and hydrocarbon conversion versus temperature based on Example 30.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to apparatus and methods for cleaning the atmosphere useful with vehicles having means to convey the vehicle through the atmosphere. As the vehicle moves through the atmosphere, at least one atmosphere contacting surface comprising a pollutant treating composition (e.g., a catalyst or an adsorber) located thereon contacts atmospheric air. As the atmospheric air encounters the pollutant treating composition, various pollutants including particulate matter and/or gaseous pollutants carried in the air can be catalytically reacted or adsorbed by the pollutant treating composition located on the atmosphere contacting surface.

It will be appreciated by those skilled in the art that the vehicle can be any suitable vehicle which has a translation means to propel the vehicle such as wheels, sails, belts, tracks or the like. Such means can be powered by any suitable power means including engines which use fossil fuel such as gasoline or diesel fuel, ethanol, methanol, gas engines powered by fuels such as by methane gas, wind power such as by wind driving sails or propellers, solar power or electric power such as in battery operated automobiles. Vehicles include cars, trucks, buses, trains, boats, ships, airplanes, dirigibles, balloons and the like.

The atmosphere contacting surface can be any suitable surface that encounters and contacts air as the vehicle moves through the atmosphere. Preferably in a motor vehicle, preferably cars, trucks and buses, the contact means is a surface located toward the front of the vehicle and can contact air as the vehicle proceeds in a forward direction. Useful contact surfaces should have a relatively large surface area. Preferred contact surfaces are at least partially enclosed in the vehicle. Preferred atmosphere contacting surfaces are located under the hood and are located within the body of the motor vehicle, typically in proximity to the engine, i.e., the engine compartment. The surfaces are preferably the outer surfaces of cooling means which comprise a flow path for liquids or gases through a coolant walled enclosure such as tubes or a housing and an outer surface on which is located fins to enhance heat transfer. Useful contact surfaces include the outside surfaces of means to cool fluids, including liquids and/or gases used in the vehicle such as the air conditioner condenser, the radiator, air charge cooler, engine oil cooler, transmission oil cooler, power steering fluid cooler, the fan shroud, and the radiator fan which are all located and supported within the housing of the vehicle. A useful contact surface outside of the vehicle can be the grill typically located and supported on the front of the housing, or wind deflectors commonly supported on the roof of the cabs of large trucks. It is preferred that the contacting surface is a forward facing surface, side facing surface or surface facing the top or bottom of the vehicle. The front facing surfaces face the front of the vehicle, surfaces such as the fins of the radiator and condenser elements face the side, top and bottom of the vehicle. Even surfaces directed to face away from the front and toward the back of the vehicle which contact air can be atmosphere contacting surfaces, such as the back surface of fan blades. Surfaces of airplane engines such as wings, propellers and jet engine parts including turbine rotors and/or stators can be coated.

Preferred atmosphere contacting surfaces in motor vehicles are located on engine cooling elements such as motor vehicle radiators, air conditioner condensers, air charge coolers, also known as intercoolers or after coolers, engine oil coolers and transmission oil coolers. Such elements typically have high surface area structures associated with them to have improved heat transfer. The high surface areas are useful for maximizing the contact of the atmospheric air with the pollutant treating composition. All such elements are well known in the automotive arts. Reference is made to Bosch Automotive Handbook, Second Edition, pages 301-303, 320 and 349-351, published by Robert Bosch GmbH, 1986, herein incorporated by reference. This reference illustrates a truck diesel engine with a radiator, an intercooler and a fan. Such elements may be coated with a pollutant treating surface of the present invention. The radiator and intercooler typically operate at temperatures higher than that of the atmospheric air. Reference is also made to Taylor, The Internal Combustion Engine in Theory and Practice, Vol. 1: Thermo Dynamics, Fluid Flow, Performance, Second Edition, Rev. The MIT Press, 1985 at pages 304-306 for radiator and fin design; and page 392 for after coolers. The above pages in Taylor are herein incorporated by reference.

Reference is also made to a collection of papers in 1993 Vehicle Thermal Management Systems Conference Proceedings, SAE P:263 published by the Society of Automotive Engineers, Inc., 1993. The following papers are herein incorporated by reference. SAE Paper No. 931088 beginning at page 157 entitled, Calculation and Design of Cooling Systems by Eichlseder and Raab of Steyr Damler Puchag and Charge Air Cooler for Passenger Cars by Collette of Valeo Thermique Moteur; SAE Paper No. 931092 entitled, State of the Art and Future Developments of Aluminum Radiators for Cars and Trucks by Kern and Eitel of Behr GmbH and Co. beginning at page 187; SAE Paper 931112 entitled, Air Mix vs. Coolant Flow to Control Discharge Air Temperature and Vehicle Heating Air Conditioning Systems by Rolling and Cummings of Behr of America, Inc. and Schweizer of Behr GmbH & Co. The above papers include descriptions of radiator, air conditioner and air charge cooler structures for use in the motor vehicles. Reference is additionally made to SAE Paper 931115 entitled, Engine Cooling Module Development Using Air Flow Management Techniques by El-Bourini and Chen of Calsonic Technical Center beginning at page 379 and hereby incorporated by reference. Of interest are Appendices 1 and 2 which illustrate typical radiator and condenser structures useful in motor vehicle applications. Reference is also made to SAE Paper 931125 entitled, Durability Concerns of Aluminum Air to Air Charged Coolers by Smith, Valeo Engine Cooling Inc. which discloses air charge coolers and is hereby incorporated by reference.

The present invention will be understood by those skilled in the art by reference to the accompanying FIGS. 1-7.

FIG. 1 illustrates a truck 10 schematically containing a variety of vehicle components comprising atmosphere contacting surfaces. These surfaces include the surfaces of grill 12, the air conditioner condenser 14, an air charge cooler 25, the radiator 16, and the radiator fan 18. Also shown on this truck is a wind deflector 20 having a front deflecting surface 22. It is recognized that the various components can have different relative locations on different vehicles.

Referring to FIGS. 1 to 4 the preferred contacting surfaces include the surface of the front 13 and side 15 surfaces of the air conditioner condenser 14, the front 17 and side 19 surfaces of the radiator 16, corresponding surfaces of the air charge cooler 25 and the front 21 and back 23 surfaces of the radiator fan 18. These surfaces are located within the housing 24 of the truck. They are typically under the hood 24 of the truck between the front 26 of the truck and the engine 28. The air conditioner condenser, air charge cooler, radiator and radiator fan can be directly or indirectly supported by housing 24 or a frame (not shown) within the housing.

FIG. 2 generally shows a schematic view of an automobile assembly. Corresponding elements in FIGS. 1 and 2 have common reference characters. The automobile comprises a housing 30. There is a motor vehicle front 32 having a grill 12 supported on the front of the housing 30. An air conditioner condenser 14, a radiator 16, and a radiator fan 18 can be located within the housing 30.

Referring to embodiments in FIGS. 1, 2 and 6, the contacting surface on the front and sides of least one of the grill 12, air conditioner condenser 14, the air charge cooler 25, and radiator 16; the front and back of the radiator fan 18; and the front of the wind deflector 20 can have a pollutant treating composition located thereon. The grill 12 can have a suitable grill grid type design which provides for openings 36 through which air passes as the truck 12 is operated and moves through the atmosphere. The openings are defined by the grill grid 38. The grill grid 38 has a front grill surface 40 and a side grill surface 42. The front and side grill grid surfaces 40 and 42 can be used as atmosphere contacting surfaces on which pollutant treating compositions are located.

Referring to FIGS. 1 and 4, the air conditioning condenser 14 comprises a plurality of air conditioning condenser fins 44. Additionally, there is an air conditioning fluid conduit 46 which conducts the air conditioning fluid through condenser 14. The front and side surfaces of the air conditioning fins 44, as well as the front surface of the air conditioning conduit 46 can be the atmosphere contacting surfaces on which a pollutant treating composition is located. As indicated, both the front 21 and back 23 surfaces of the radiator fan 18 can be a contacting surface to support a pollutant treating composition.

The most preferred atmosphere contacting surface is on radiator 16 as shown in FIG. 3. A typical radiator 16 has a frontal radiator surface 17 as well as a plurality of radiator corrugated plates or fins 50 located in corresponding radiator plate or fin channels 52 which pass through the radiator 16. It is preferred to coat the front surface 17 as well as the side surfaces of the radiator plates 50 and channel 52 surfaces. The radiator is most preferred because it is located within the housing 24 or 30 and is protected from the front by at least the grill 12 and preferably an air conditioner condenser 14. In addition to air entering into the hood chamber 34 as the motor vehicle moves through the atmosphere, radiator fan 18 draws air in and through the channels 52. Therefore, the radiator 16 is located and protected by the grill 12, the air conditioner condenser 19 and is in front of the radiator fan 18. Additionally, as indicated above, the radiator has a large surface area for heat transfer purposes. In accordance with the present invention, pollutant treating composition can be effectively located on, and take advantage of, such a large surface area without significantly adversely impacting on the heat transfer function of the radiator.

The above description is particularly directed to and illustrates the use of atmosphere treating surfaces on apparatus such as radiator 16 and air conditioner condenser 14. As indicated the atmosphere contacting surface can be on other suitable means to cool engine fluids including well known articles such as the above referenced air charge cooler 25 as well as engine oil coolers, transmission oil coolers and power steering oil coolers. A commonality of all such cooling means is a housing or conduit through which the fluid passes. The housing comprises a wall having an inner surface in contact with the fluid and an outer surface typically in contact with the atmosphere within the frame of the vehicle and typically within the engine compartment. In order to efficiently transfer heat from the fluid in these various apparatus, there are fins or plates extending from the outer surface of the cooling, housing or conduit.

A useful and preferred embodiment with each of these cooling means is illustrated in FIG. 7. FIG. 7 is a schematic sectional view of a coated finned cooling element 60. The element comprises a housing or conduit defined by a housing or conduit wall 62. Located within the conduit is a passageway or chamber 64 through which fluid such as oils or cooling liquids or air conditioning fluids pass. Such fluids are shown as referenced character 66. The housing wall comprises an inner surface 68 and an outer surface 70. Located and attached to the outer surface are plates or fins 72. In accordance with the present invention, there is a pollutant treating composition 74 which can be located on the outer surface 70 and the fins or plates 72. During operation air streams contact the pollutant treating composition to cause various of the pollutants to be treated.

Applicant herein incorporates by reference commonly assigned patent application entitled, "Pollution Treating Device and Methods of Making the Same", filed as U.S. Ser. No. 08/537,208. Additionally, any of the embodiments of the apparatus of the present invention and method of use thereof can optionally further incorporate a replaceable pollution treating device as disclosed therein.

Pollutant treating compositions can also be located on outer surfaces of the vehicle. As indicated, such compositions can be located on the grill 12 and in the case of the truck shown in FIGS. 1 and 6, on the wind deflector 20 frontal wind deflector surface 22. Additionally, pollution treatment compositions can be located on the front of the mirror 54 as well as any of a variety of front facing surfaces.

The use of an air charge cooler 25 represents a particularly effective atmosphere contacting surface on which pollutant treating compositions can be supported. The operating temperatures can reach as high as 250.degree. F. At such temperatures, the catalyst compositions of the present invention can more effectively treat ozone, hydrocarbons, and carbon monoxide pollutants. Particularly useful are compositions containing precious metals such as platinum, palladium, gold or silver components. Alternatively, the catalyst can include manganese compounds such as manganese dioxide and copper compounds including copper oxide such Carulite or hopcalite.

During normal operation, the vehicle moves in a forward direction with the front 26 of the vehicle 10 initially contacting the atmospheric air. Typically, vehicles move through the air at velocities of up to about 1,000 miles per hour for jet planes. Land vehicles and water vehicles typically move at velocities of up to 300 miles per hour, more typically up to 200 miles per hour with motor vehicles moving at velocities up to 100 miles per hour and typically from 5 to 75 miles per hour. Seagoing vehicles, such as boats, typically move through the water at velocities up to 30 miles per hour and typically from 2 to 20 miles per hour. In accordance with method of the present invention the relative velocity (or face velocity) between the atmosphere contacting surface and the atmosphere, as the vehicle, typically an automobile or land based vehicle, moves through the atmosphere, is from 0 to 100 miles per hour, and typically from 2 to 75 miles per hour in an automobile typically from 5 to 60 miles per hour. The face velocity is the velocity of the air relative to the pollutant treating surface.

In motor vehicles such as trucks 10 which have a radiator fan 18, the fan draws atmospheric air through the grill 12, air conditioner condenser 14, air charge cooler 25 and/or radiator 16 in addition to air which passes across these elements as the motor vehicle moves through the atmosphere. When the motor vehicle is idling the relative face velocity of air drawn into the radiator typically ranges from about 5 to 15 mph. The radiator fan moderates the flow rate of air through radiator as the motor vehicle moves through the atmosphere. When a typical car is moving through the atmosphere at speeds approaching 70 mph, the inlet face velocity of air is at about 25 mph. Depending on the design of a motor vehicle using a radiator fan, cars have a face velocity as low as when the fan is used during idle up to about 100% of the face velocity corresponding to the velocity of the motor vehicle. However, typically, the face velocity of the air relative to the atmosphere contacting surface is equal to the idle face velocity plus from 0.1 to 1.0 and more typically 0.2 to 0.8 times the velocity of the vehicle.

In accordance with the present invention, large volumes of air can be treated at relatively low temperatures. This occurs as vehicles move through the atmosphere. High surface area components of vehicles including radiators, air conditioner condensers and charge air coolers typically have a large frontal surface area which encounters the air stream. However, these devices are relatively narrow, typically ranging from about 3/4 of an inch deep up to about 2 inches deep and usually in the range of 3/4 to 1 1/2 inches deep. The linear velocity of the atmospheric air contacting the frontal surface of such devices is typically in the range of up to 20, and more typically 5 to 15 miles per hour. An indication of the amount of air being treated as it passes across the catalyzed vehicle component is commonly referred to space velocity or more precisely volume hourly space velocity (VHSV). This is measured as volume (corresponding to the volume of the catalyzed element) of air per hour which passes across the volume of the catalytic article. It is based on the cubic feet per hour of air divided by the cubic feet of catalyst substrate. The volume of the catalyst substrate is the frontal area times the depth or axial length in the direction of the air flow. Alternatively, volume hourly space velocity is the number of catalyst volumes based on the volume of the catalytic article being treated per hour. Because of the relatively short axial depth of the catalyzed elements of the present invention, the space velocities are relatively high. The volume hourly space velocities of air which can be treated in accordance with the present invention can be a million or more reciprocal hours. A face velocity of air against one of these elements at 5 miles per hour can result in a space velocity of as high as 300,000 reciprocal hours. In accordance with the present invention, the catalysts are designed to treat pollutants in the atmosphere at space velocities in ranges as high as from 250,000 to 750,000 and typically 300,000 to 600,000 reciprocal hours. This is accomplished even at the relatively low ambient temperatures and ambient operating temperatures of the vehicle elements containing pollutant treating compositions in accordance with the present invention.

The ambient operating temperature of the atmosphere contacting surfaces can vary depending on whether they are located in the proximity of heat sources within the vehicle or are the surfaces of elements which function to cool parts of the vehicle. However, contacting surfaces such as grill 12, wind deflector 20 are at ambient conditions. During typical operation, the means to cool operates at above ambient atmospheric temperature, with the contacting surfaces such as the surfaces of the air conditioner condenser 14, and radiator 16 and air charge cooler 25 can range up to 130.degree. C. and typically up to 105.degree. C. and are typically in the range of from 10.degree. C. to 105.degree. C., more typically from 40.degree. C. to 100.degree. C. and can be from 10.degree. C. to 75.degree. C. The air charge cooler 25 typically operates at temperatures of from 750 to 130.degree. C. The amount of contacting surface can vary with air conditioner condensers, radiators and air charge coolers typically having from 20 to 2,000 square feet and fan blades 18 typically having from 0.2 to up to about 40 square feet when considering front and back surfaces.

The pollutant treating composition is preferably a catalytic composition or adsorption composition. Useful and preferred catalyst compositions are compositions which can catalytically cause the reaction of targeted pollutants at the space velocity of the air as it contacts the surface, and at the temperature of the surface at the point of contact. Typically, these catalyzed reactions will be in the temperature range at the atmosphere contacting surface of from 0.degree. C. to 130.degree. C., more typically 20.degree. C. to 105.degree. C. and yet more typically from about 40.degree. C. to 100.degree. C. There is no limit on the efficiency of the reaction as long as some reaction takes place. Preferably, there is at least a 1% conversion efficiency with as high a conversion efficiency as possible. Useful conversion efficiencies are preferably at least about 5% and more preferably at least about 10%. Preferred conversions depend on the particular pollutant and pollutant treating composition. Where ozone is treated with a catalytic composition on an atmosphere contacting surface it is preferred that the conversion efficiency be greater than about from 30% to 40%, preferably greater than 50%, and more preferably greater than 70%. Preferred conversion for carbon monoxide is greater than 30% and preferably greater than 50%. Preferred conversion efficiency for hydrocarbons and partially oxygenated hydrocarbons is at least 10%, preferably at least 15%, and most preferably at least 25%. These conversion rates are particularly preferred where the atmosphere contacting surface is at ambient operating conditions of up to about 110.degree. C. These temperatures are the surface temperatures typically experienced during normal operation of atmosphere contacting surfaces of the vehicle including the surfaces of the radiator and air conditioning condenser. Where there is supplemental heating of the atmosphere contacting surface such as by having an electrically heated catalytic monolith, grid, screen, gauze or the like, it is preferred that the conversion efficiency be greater than 90% and more preferably greater than 95%. The conversion efficiency is based on the mole percent of the particular pollutants in the air which react in the presence of the catalyst composition.

Ozone treating catalyst compositions comprise manganese compounds including manganese dioxide, including non stoichiometric manganese dioxide (e.g., MnO.sub.(1.5-2.0), and/or Mn.sub.2 O.sub.3. Preferred manganese dioxides, which are nominally referred to as MnO.sub.2 have a chemical formula wherein the molar ratio of manganese to oxide is about from 1.5 to 2.0, such as Mn.sub.8 O.sub.16. Up to

100 percent by weight of manganese dioxide MnO.sub.2 can be used in catalyst compositions to treat ozone. Alternative compositions which are available comprise manganese dioxide and compounds such as copper oxide alone or copper oxide and alumina.

Useful and preferred manganese dioxides are alpha manganese dioxides nominally having a molar ratio of manganese to oxygen of from 1 to 2. Useful alpha manganese dioxides are disclosed in U.S. Pat. No. 5,340,562 to O'Young, et al.; also in O'Young, Hydrothermal Synthesis of Manganese Oxides with Tunnel Structures presented at the Symposium on Advances in Zeolites and Pillared Clay Structures presented before the Division of Petroleum Chemistry, Inc. American Chemical Society New York City Meeting, Aug. 25-30, 1991 beginning at page 342, and in McKenzie, the Synthesis of Birnessite, Cryptomelane, and Some Other Oxides and Hydroxides of Manganese, Mineralogical Magazine, December 1971, Vol. 38, pp. 493-502. For the purposes of the present invention, the preferred alpha manganese dioxide is a 2.times.2 tunnel structure which can be hollandite (BaMn.sub.8 O.sub.16.xH.sub.2 O), cryptomelane (KMn.sub.8 O.sub.16.xH.sub.2 O), manjiroite (NaMn.sub.8 O.sub.16.xH.sub.2 O) and coronadite (PbMn.sub.8 O.sub.16.xH.sub.2 O).

The manganese dioxides of the present invention preferably have a surface area, measured by BET N.sub.2 adsorption, of greater than 150 m.sup.2 /g, more preferably greater than 200 m.sup.2 /g, and more preferably greater than 220 m.sup.2 /g. The upper range can be as high as 300 m.sup.2 /g, 325 m.sup.2 /g or even 350 m.sup.2 /g. Preferred materials are in the range of 200-350 m.sup.2 /g, preferably 200-275 m.sup.2 /g and most preferably 220-250 m.sup.2 /g. The composition preferably comprises a binder as described below with preferred binders being polymeric binders. The composition can further comprise precious metal components with preferred precious metal components being the oxides of precious metal, preferably the oxides of platinum group metals and most preferably the oxides of palladium or platinum also referred to as palladium black or platinum black. The amount of palladium or platinum black can range from 0 to 25%, with useful amounts being in ranges of from about 1 to 25 and 5 to 15% by weight based on the weight of the manganese component and the precious component.

It has been found that the use of compositions comprising the cryptomelane form of alpha manganese oxide, which also contain a polymeric binder can result in greater than 50%, preferably greater than 60% and most preferably from 75-85% conversion of ozone in a concentration range of from 0 to 400 parts per billion (ppb) and an air stream moving across a radiator at space velocity of from 300,000 to 650,000 reciprocal hours. Where a portion of the cryptomelane is replaced by up to 25% and preferably from 15-25% parts by weight of palladium black (PdO), ozone conversion rates at the above conditions range from 95-100% using a powder reactor.

The preferred cryptomelane manganese dioxide has from 1.0 to 3.0 weight percent potassium, typically as K.sub.2 O, and a crystallite size ranging from 2 to 10 and preferably from less than 5 nm. It can be calcined at a temperature range of from 250.degree. C. to 550.degree. C. and preferably below 500.degree. C. and greater than 300.degree. C. for at least 1.5 hours and preferably at least 2 hours up to about 6 hours.

The preferred cryptomelane can be made in accordance described in the above referenced articles and patents to O'Young and McKenzie. The cryptomelane can be made by reacting a manganese salt including salts selected from the group consisting MnCl.sub.2, Mn(NO.sub.3).sub.2, MnSO.sub.4 and Mn(CH.sub.3 COO).sub.2 with a permanganate compound. Cryptomelane is made using potassium permanganate; hollandite is made using barium permanganate; coronadite is made using lead permanganate; and manjiroite is made using sodium permanganate. It is recognized that the alpha manganese useful in the present invention can contain one or more of hollandite, cryptomelane, manjiroite or coronadite compounds. Even when making cryptomelane minor amounts of other metal ions such as sodium may be present. Useful methods to form the alpha manganese dioxide are described in the above references which are incorporated by reference.

The preferred alpha manganese for use in accordance with the present invention is cryptomelane. The preferred cryptomelane is "clean" or substantially free of inorganic anions, particularly on the surface. Such anions could include chlorides, sulfates and nitrates which are introduced during the method to form cryptomelane. An alternate method to make the clean cryptomelane is to react a manganese carboxylate, preferably manganese acetate, with potassium permanganate. It has been found that the use of such a material which has been calcined is "clean". The use of material containing inorganic anions can result in conversion of ozone to oxygen of up to about 60%. The use of cryptomelane with a "clean" surface results in conversions of up about 80%.

It is believed that the carboxylates are burned off during the calcination process. However, inorganic anions remain on the surface even during calcination. The inorganic anions such as sulfates can be washed away with an aqueous solution or a slightly acidic aqueous solution. Preferably the alpha manganese dioxide is a "clean" alpha manganese dioxide. The cryptomelane can be washed at from about 60.degree. C. to 100.degree. C. for about one-half hour to remove a significant amount of sulfate anions. The washing also lowers the level of potassium present. The nitrate anions may be removed in a similar manner. The "clean" alpha manganese dioxide is characterized as having an IR spectrum as illustrated in FIG. 19 and in X-ray diffraction (XRD) pattern as illustrated in FIG. 20. Such a cryptomelane preferably has a surface area greater than 200 m.sup.2 /g and more preferably greater than 250 m.sup.2 /g. A review of the IR spectrum for the most preferred cryptomelane, shown in FIG. 19 is characterized by the absence of peaks assignable to carbonate, sulfate and nitrate groups. Expected peaks for carbonate groups appear in the range of from 1320 to 1520 wavenumbers; and for sulfate groups appear in the range of from 950 to 1250 wavenumbers. FIG. 20 is a powder X-ray diffraction pattern for high surface area cryptomelane prepared in Example 23. The X-ray pattern for cryptomelane useful in the present invention is characterized by broad peaks resulting from small crystallite size (.about.5-10 nm). Approximate peak positions (.+-.0.15.degree.2.theta.) and approximate relative intensities (.+-.5) for cryptomelane using CuK.sub..alpha. radiation as shown in FIG. 20 are: 2.theta./Relative Intensities--12.1/9; 18/9; 28.3/10; 37.5/100; 41.8/32; 49.7/16; 53.8/5; 60.1/13; 55.7/38; and 68.0/23.

A preferred method of making cryptomelane useful in the present invention comprises mixing an aqueous acidic manganese salt solution with a potassium permanganate solution. The acidic manganese salt solution preferably has a pH of from 0.5 to 3.0 and can be made acidic using any common acid, preferably acetic acid at a concentration of from 0.5 to 5.0 normal and more preferably from 1.0 to 2.0 normal. The mixture forms a slurry which is stirred at a temperature range of from 50.degree. C. to 110.degree. C. The slurry is filtered and the filtrate is dried at a temperature range of from 75.degree. C. to 200.degree. C. The resulting cryptomelane crystals have a surface area of typically in the range of from 200 m.sup.2 /g to 350 m.sup.2 /g.

Another useful composition comprising manganese dioxide is a composition comprising manganese dioxide and minor amounts of silica, typically up to 2%, more typically up to 1% with preferred amounts being from 0.4 to 0.8% based on the weight of the manganese dioxide and the silica. The presence of silica in the preferred amounts has been found to effect the crystalline morphology of manganese dioxide, particularly the cryptomelane form of manganese dioxide. It is speculated that the presence of minor amounts of silica, particularly in the preferred range, may provide certain advantages to the composition of the present invention. The presence of silica is believed to make the composition more hydrophobic, particularly when used as a coating on a substrate such as a coating on a radiator. Secondly, it is believed that the presence of silica in coating compositions comprising manganese dioxide increases the pH to help the compatibility of the manganese dioxide with latex binders. A preferred and useful composition for use as a coating material comprises cryptomelane and silica. Such a material comprises cryptomelane having a surface area from 200 to 340 and preferably 220 to 250 m.sup.2 /g, a weight percent of potassium of from 1 to 3% less than 0.1% sulphur and a measured loss on ignition of 13 to 18% by weight primarily due to moisture. The pH of the composition is about 3. Surface area is measured by a BET nitrogen adsorption and desorption test. As the amount of sulphur is reduced, the pH typically increases slightly. Additionally, typically the pH increases with the amount of potassium present with preferred amounts of potassium being from 1.2 to 2.8 weight percent.

Other useful compositions comprise manganese dioxide and optionally copper oxide and alumina and at least one precious metal component such as a platinum group metal supported on the manganese dioxide and where present copper oxide and alumina. Useful compositions contain up to 100, from 40 to 80 and preferably 50 to 70 weight percent manganese dioxide and 10 to 60 and typically 30 to 50 percent copper oxide. Useful compositions include hopcalite which is about 60 percent manganese dioxide and about 40 percent copper oxide; and Carulite.RTM. 200 (sold by Carus Chemical Co.) which is reported to have 60 to 75 weight percent manganese dioxide, 11 to 14 percent copper oxide and 15 to 16 percent aluminum oxide. The surface area of Carulite.RTM. is reported to be about 180 m.sup.2 /g. Calcining at 450.degree. C. reduces the surface area of the Carulite.RTM. by about fifty percent (50%) without significantly affecting activity. It is preferred to calcine manganese compounds at from 300.degree. C. to 500.degree. C. and more preferably 350.degree. C. to 450.degree. C. Calcining at 550.degree. C. causes a great loss of surface area and ozone treatment activity. Calcining the Carulite.RTM. after ball milling with acetic acid and coating on a substrate can improve adhesion of the coating to a substrate.

Other compositions to treat ozone can comprise a manganese dioxide component and precious metal components such as platinum group metal components. While both components are catalytically active, the manganese dioxide can also support the precious metal component. The platinum group metal component preferably is a palladium and/or platinum component. The amount of platinum group metal compound preferably ranges from about 0.1 to about 10 weight percent (based on the weight of the platinum group metal) of the composition. Preferably, where platinum is present it is in amounts of from 0.1 to 5 weight percent, with useful and preferred amounts on pollutant treating catalyst volume, based on the volume of the supporting article, ranging from about 0.5 to about 70 g/ft.sup.3. The amount of palladium component preferably ranges from about 2 to about 10 weight percent of the composition, with useful and preferred amounts on pollutant treating catalyst volume ranging from about 10 to about 250 g/ft.sup.3.

Various useful and preferred pollutant treating catalyst compositions, especially those containing a catalytically active component such as a precious metal catalytic component, can comprise a suitable support material such as a refractory oxide support. The preferred refractory oxide can be selected from the group consisting of silica, alumina, titania, ceria, zirconia and chromia, and mixtures thereof. More preferably, the support is at least one activated, high surface area compound selected from the group consisting of alumina, silica, titania, silica-alumina, silica-zirconia, alumina silicates, alumina zirconia, alumina-chromia and alumina-ceria. The refractory oxide can be in suitable form including bulk particulate form typically having particle sizes ranging from about 0.1 to about 100 and preferably 1 to 10 .mu.m or in sol form also having a particle size ranging from about 1 to about 50 and preferably about 1 to about 10 nm. A preferred titania sol support comprises titania having a particle size ranging from about 1 to about 10, and typically from about 2 to 5 nm.

Also useful as a preferred support is a coprecipitate of a manganese oxide and zirconia. This composition can be made as recited in U.S. Pat. No. 5,283,041 incorporated herein by reference. Briefly, this coprecipitated support material preferably comprises in a ratio based on the weight of manganese and zirconium metals from 5:95 to 95:5; preferably 10:90 to 75:25; more preferably 10:90 to 50:50; and most preferably from 15:85 to 50:50. A useful and preferred embodiment comprises a Mn:Zr weight ratio of 20:80. U.S. Pat. No. 5,283,041 describes a preferred method to make a coprecipitate of a manganese oxide component and a zirconia component. As recited in U.S. Pat. No. 5,283,041 a zirconia oxide and manganese oxide material may be prepared by mixing aqueous solutions of suitable zirconium oxide precursors such as zirconium oxynitrate, zirconium acetate, zirconium oxychloride, or zirconium oxysulfate and a suitable manganese oxide precursor such as manganese nitrate, manganese acetate, manganese dichloride or manganese dibromide, adding a sufficient amount of a base such as ammonium hydroxide to obtain a pH of 8-9, filtering the resulting precipitate, washing with water, and drying at 450.degree.-500.degree. C.

A useful support for a catalyst to treat ozone is selected from a refractory oxide support, preferably alumina and silica-alumina with a more preferred support being a silica-alumina support comprising from about 1% to 10% by weight of silica and from 90% to 99% by weight of alumina.

Useful refractory oxide supports for a catalyst comprising a platinum group metal to treat carbon monoxide are selected from alumina, titania, silica-zirconia, and manganese-zirconia. Preferred supports for a catalyst composition to treat carbon monoxide is a zirconia-silica support as recited in U.S. Pat. No. 5,145,825, a manganese-zirconia support as recited in U.S. Pat. No. 5,283,041 and high surface area alumina. Most preferred for treatment of carbon monoxide is titania. Reduced catalysts having titania supports resulted in greater carbon monoxide conversion than corresponding non reduced catalysts.

The support for catalyst to treat hydrocarbons, such as low molecular weight hydrocarbons, particularly low molecular weight olefinic hydrocarbons having about from two up to about twenty carbons and typically two to about eight carbon atoms, as well as partially oxygenated hydrocarbons is preferably selected from refractory metal oxides including alumina and titania. As with catalysts to treat carbon monoxide reduced catalysts results in greater hydrocarbon conversion. Particularly preferred is a titania support which has been found useful since it results in a catalyst composition having enhanced ozone conversion as well as significant conversion of carbon monoxide and low molecular weight olefins. Also useful are high surface area, macroporous refractory oxides, preferably alumina and titania having a surface area of greater than 150 m.sup.2 /g and preferably ranging from about 150 to 350, preferably from 200 to 300, and more preferably from 225 to 275 m.sup.2 /g; a porosity of greater than 0.5 cc/g, typically ranging from 0.5 to 4.0 and preferably about from 1 to 2 cc/g measured based on mercury porosometry; and particle sizes range from 0.1 to 10 .mu.m. A useful material is Versal GL alumina having a surface area of about 260 m.sup.2 /g, a porosity of 1.4 to 1.5 cc/g and supplied by LaRoche Industries.

A preferred refractory support for platinum group metals, preferably platinum and/or palladium for use in treating carbon monoxide and/or hydrocarbons is titania dioxide. The titania can be used in bulk powder form or in the form of titania dioxide sol. Also useful is nano particle size (nanometer) titania. The catalyst composition can be prepared by adding a platinum group metal in a liquid media preferably in the form of a solution such as platinum nitrate with the titania sol, with the sol most preferred. The obtained slurry can then be coated onto a suitable substrate such as an atmosphere treating surface such as a radiator, metal monolith substrate or ceramic substrate. The preferred platinum group metal is a platinum compound. The platinum titania sol catalyst obtained from the above procedure has high activity for carbon monoxide and/or hydrocarbon oxidation at ambient operating temperature. Metal components other than platinum components which can be combined with the titania sol include gold, palladium, rhodium, silver components and mixtures thereof. A reduced platinum group component, preferably a platinum component on titanium catalyst which is indicated to be preferred for treating carbon monoxide, has also been found to be useful and preferred for treating hydrocarbons, particularly olefinic hydrocarbons.

A preferred titania sol support comprises titania having a particle size ranging from about 1 to about 10, and typically from about 2 to 5 nm.

A preferred bulk titania has a surface area of about from 25 to 120 m.sup.2 /g, and preferably from 50 to 100 m.sup.2 /g; and a particle size of about from 0.1 to 10 .mu.m. A specific and preferred bulk titania support has a surface area of 45-50 m.sup.2 /g, a particle size of about 1 .mu.m, and is sold by DeGussa as P-25. Useful nano particle size titanium comprises having a particle size ranging from about 5 to 100 and typically greater 10 to about 50 nm.

A preferred silica-zirconia support comprises from 1 to 10 percent silica and 90 to 99 percent zirconia. Preferred support particles have high surface area, e.g. from 100 to 500 square meters per gram (m.sup.2 /g) surface area, preferably from 150 to 450 m.sup.2 /g, more preferably from 200 to 400 m.sup.2 /g, to enhance dispersion of the catalytic metal component or components thereon. The preferred refractory metal oxide support also has a high porosity with pores of up to about 145 nm radius, e.g., from about 0.75 to 1.5 cubic centimeters per gram (cm.sup.3 /g), preferably from about 0.9 to 1.2 cm.sup.3 /g, and a pore size range of at least about 50% of the porosity being provided by pores of 5 to 100 nm in radius.

A useful ozone treating catalyst comprises at least one precious metal component, preferably a palladium component dispersed on a suitable support such as a refractory oxide support. The composition comprises from 0.1 to 20.0 weight percent, and preferably 0.5 to 15 weight percent of precious metal on the support, such as a refractory oxide support, based on the weight of the precious metal (metal and not oxide) and the support. Palladium is preferably used in amounts of from 2 to 15, more preferably 5 to and yet more preferably 8 to 12 weight percent. Platinum is preferably used at 0.1 to 10, more preferably 0.1 to 5.0, and yet more preferably 2 to 5 weight percent. Palladium is most preferred to catalyze the reaction of ozone to form oxygen. The support materials can be selected from the group recited above. In preferred embodiments, there can additionally be a bulk manganese component as recited above, or a manganese component dispersed on the same or different refractory oxide support as the precious metal, preferably palladium component. There can be up to 80, preferably up to 50, more preferably from 1 to 40 and yet more preferably 5 to 35 weight percent of a manganese component based on the weight of palladium and manganese metal in the pollutant treating composition. Stated another way, there is preferably about 2 to 30 and preferably 2 to 10 weight percent of a manganese component. The catalyst loading is from 20 to 250 grams and preferably about 50 to 250 grams of palladium per cubic foot (g/ft.sup.3) of catalyst volume. The catalyst volume is the total volume of the finished catalyst composition and therefore includes the total volume of air conditioner condenser or radiator including void spaces provided by the gas flow passages. Generally, the higher loading of palladium results in a greater ozone conversion, i.e., a greater percentage of ozone decomposition in the treated air stream.

Conversions of ozone to oxygen attained with a palladium/manganese catalyst on alumina support compositions at a temperature of about 40.degree. C. to 50.degree. C. have been about 50 mole percent where the ozone concentrations range from 0.1 to 0.4 ppm and the face velocity was about 10 miles per hour. Lower conversions were attained using a platinum on alumina catalyst.

Of particular interest is the use of a support comprising the above described coprecipitated product of a manganese oxide, and zirconia which is used to support a precious metal, preferably selected from platinum and palladium, and most preferably platinum. Platinum is of particular interest in that it has been found that platinum is particularly effective when used on this coprecipitated support. The amount of platinum can range from 0.1 to 6, preferably 0.5 to 4, more preferably 1 to 4, and most preferably 2 to 4 weight percent based on metallic platinum and the coprecipitated support. The use of platinum to treat ozone has been found to be particularly effective on this support. Additionally, as discussed below, this catalyst is useful to treat carbon monoxide. Preferably the precious metal is platinum and the catalyst is reduced.

Other useful catalysts to catalytically convert ozone to oxygen are described in U.S. Pat. Nos. 4,343,776 and 4,405,507, both hereby incorporated by reference. A useful and most preferred composition is disclosed in commonly assigned U.S. Ser. No. 08/202,397 filed Feb. 25, 1994, now U.S. Pat. No. 5,422,331 and entitled, "Light Weight, Low Pressure Drop Ozone Decomposition Catalyst for. Aircraft Applications" hereby incorporated by reference. Yet other compositions which can result in the conversion of ozone to oxygen comprises carbon, and palladium or platinum supported on carbon, manganese dioxide, Carulite.RTM., and/or hopcalite. Manganese supported on a refractory oxide such as recited above has also been found to be useful.

Carbon monoxide treating catalysts preferably comprise at least one precious metal component, preferably selected from platinum and/or palladium components with platinum components being most preferred. A combination of a platinum component and a palladium component results in improved CO conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. The composition comprises from 0.01 to 20 weight percent, and preferably 0.5 to 15 weight percent of the precious metal component on a suitable support such as refractory oxide support, with the amount of precious metal being based on the weight of precious metal (metal and not the metal component) and the support. Platinum is most preferred and is preferably used in amounts of from 0.01 to 10 weight percent and more preferably 0.1 to 5 weight percent, and most preferably 1.0 to 5.0 weight percent. Palladium is useful in amounts from 2 to 15, preferably 5 to 15 and yet more preferably 8 to 12 weight percent. The preferred support is titania, with titania sol most preferred as recited above. When loaded onto a monolithic structure such as a radiator or onto other atmosphere contacting surfaces the catalyst loading is preferably about 1 to 150, and more preferably 10 to 100 grams of platinum per cubic foot (g/ft.sup.3) of catalyst volume and/or 20 to 250 and preferably 50 to 250 grams of palladium per g/ft.sup.3 of catalyst volume. When platinum and palladium are used in combination, there is from about 25 to 100 g/ft.sup.3 of platinum and 50 to 250 g/ft 3of palladium. A preferred composition comprises about 50 to 90 g/ft.sup.3 of platinum and 100 to 225 g/ft.sup.3 of palladium. Preferred catalysts are reduced. Conversions of 5 to 80 mole percent of carbon monoxide to carbon dioxide were attained using coated core samples from automotive radiator having from 1 to 6 weight percent (based on metal) of platinum on titania compositions at temperatures from 25.degree. to 90.degree. C. where the carbon monoxide concentration was 15 to 25 parts per million and the space velocity was 300,000 to 500,000 reciprocal hours. Also, conversions of 5 to 65 mole percent of carbon monoxide to carbon dioxide were attained using 1.5 to 4.0 weight percent platinum on alumina support compositions at a temperature of about up to 95.degree. C. where the carbon monoxide concentration was about 15 parts per million and the space velocity was about 300,000 reciprocal hours. Lower conversions have been attained with palladium on a ceria support.

An alternate and preferred catalyst composition to treat carbon monoxide comprises a precious metal component supported on the above described coprecipitate of a manganese oxide and zirconia. The coprecipitate is formed as described above. The preferred ratios of manganese to zirconia are 5:95 to 95:5; 10:90 to 75:25; 10:90 to 50:50; and 15:85 to 25:75 with a preferred coprecipitate having a manganese oxides to zirconia of 20:80. The percent of platinum supported on the coprecipitate based on platinum metal ranges from 0.1 to 6, preferably 0.5 to 4, more preferably 1 to 4, and most preferably 2-4 weight percent. Preferably the catalyst is reduced. The catalyst can be reduced in powder form or after it has been coated onto a supporting substrate. Other useful compositions which can convert carbon monoxide to carbon dioxide include a platinum component supported on carbon or a support comprising manganese dioxide.

Catalysts to treat hydrocarbons, typically unsaturated hydrocarbons, more typically unsaturated mono-olefins having from two to about twenty carbon atoms and, in particular, from two to eight carbon atoms, and partially oxygenated hydrocarbons of the type referred to above, comprise at least one precious metal component, preferably selected from platinum and palladium with platinum being most preferred. A combination of a platinum component and a palladium component results in improved hydrocarbons conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. Useful catalyst compositions include those described for use to treat carbon monoxide. Composition to treat hydrocarbons comprise from 0.01 to 20 wt. % and preferably 0.5 to 15 wt. % of the precious metal component on a suitable support such as a refractory oxide support, with the amount of precious metal being based on the weight of the precious metal, (not the metal component) and the support. Platinum is the most preferred and is preferably used in amounts of from 0.01 to 10 wt. % and more preferably 0.1 to 5 wt. % and most preferably 1.0 to 5 wt. %. When loaded onto a monolithic structure such as a motor vehicle radiator or on to other atmospheric contacting surfaces, the catalyst loading is preferably about 1 to 150, and more preferably 10 to 100 grams of platinum per cubic foot (g/ft.sup.3) of catalyst volume. When platinum and palladium are used in combination, there is from about 25 to 100 g/ft.sup.3 of platinum and 50 to 250 g/ft.sup.3 of palladium. A preferred composition comprises about 50 to 90 g/ft.sup.3 of platinum and 100 to 225 g/ft.sup.3 of palladium. The preferred refractory oxide support is a metal oxide refractory which is preferably selected from ceria, silica, zirconia, alumina, titania and mixtures thereof with alumina and titania being most preferred. The preferred titania is characterized by as recited above with titania sol most preferred. The preferred catalyst is reduced. Testing on a coated automotive radiator resulted in conversions of a low molecular weight mono-olefin such as propylene to water and carbon dioxide with 1.5 to 4 wt. % of platinum on an alumina or titania support have been between 15 and 25% where the propylene concentration was about 10 parts per million propylene and the space velocity was about 320,000 reciprocal hours. These catalysts were not reduced. Reduction of the catalyst improves conversion.

Catalysts useful for the oxidation of both carbon monoxide and hydrocarbons generally include those recited above as useful to treat either carbon monoxide or hydrocarbons. Most preferred catalysts which have been found to have good activity for the treatment of both carbon monoxide and hydrocarbon such as unsaturated olefins comprise platinum component supported on a preferred titania support. The composition preferably comprises a binder and can be coated on a suitable support structure in amounts of from 0.8 to 1.0 g/in. A preferred platinum concentration ranges from 2 to 6% and preferably 3 to 5% by weight of platinum metal on the titania support. Useful and preferred substrate cell densities are equivalent to about 300 to 400 cells per square inch. The catalyst is preferably reduced as a powder or on the coated article using a suitable reducing agent. Preferably the catalyst is reduced in the gas stream comprising about 7% hydrogen with the balance nitrogen at from 200.degree. to 500.degree. C. or from 1 to 12 hours. The most preferred reduction or forming temperature is 400.degree. C. for 2-6 hours. This catalyst has been found to maintain high activity in air and humidified air at elevated temperatures of up to 100.degree. C. after prolonged exposure.

Useful catalysts which can treat both ozone and carbon monoxide comprise at least one precious metal component, most preferably a precious metal selected from palladium, platinum and mixtures thereof on a suitable support such as a refractory oxide support. A combination of a platinum component and a palladium component results in improved Co conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. Useful refractory oxide supports comprise ceria, zirconia, alumina, titania, silica and mixtures thereof including a mixture of zirconia and silica as recited above. Also useful and preferred as a support are the above described coprecipitates of manganese oxides and zirconia. The composition comprises from 0.1 to 20.0, preferably 0.5 to 15, and more preferably from 1 to 10 weight percent of the precious metal component on the support based on the weight of the precious metal and the support. Palladium is preferably used in amounts from 2 to and more preferably from 3 to 8 weight percent. Platinum is preferably used in amounts of from 0.1 to 6 percent and more preferably 2 to 5 weight percent. A preferred composition is a composition wherein the refractory component comprises ceria and the precious metal component comprises palladium. This composition has resulted in relatively high ozone and carbon monoxide conversions. More particularly, testing of this composition on a coated radiator has resulted in a 21% conversion of carbon monoxide in an air stream comprising 16 ppm of carbon monoxide contacting a surface at 95.degree. C. with a face velocity of the gas stream being 5 miles per hour. The same catalyst resulted in a 55% ozone conversion where the stream contained 0.25 ppm of ozone and the treating surface was at 25.degree. C. with an air stream face velocity of 10 miles per hour. Also preferred is a composition comprising a precious metal, preferably a platinum group metal, more preferably selected from platinum and palladium components, and most preferably a platinum component and the above recited coprecipitate of manganese oxide and zirconia. This above recited precious metal containing catalyst in the form of a catalyst powder or coating on a suitable substrate is in reduced form. Preferred reduction conditions include those recited above with the most preferred condition being from 250.degree. to 350.degree. C. for from 2 to 4 hours in a reducing gas comprising 7% hydrogen and 93% nitrogen. This catalyst has been found to be particularly useful in treating both carbon monoxide and ozone. Other useful compositions to convert ozone to oxygen and carbon monoxide to carbon dioxide comprise a platinum component supported on carbon, manganese dioxide, or a refractory oxide support, and optionally having an additional manganese component.

A useful and preferred catalyst which can treat ozone, carbon monoxide and hydrocarbons, as well as partially oxygenated hydrocarbons, comprises a precious metal component, preferably a platinum component on a suitable support such as a refractory oxide support. A combination of a platinum component and a palladium component results in improved Co conversion at an increase in cost and is most preferred where greater conversion is desired and cost increase is acceptable. Useful refractory oxide supports comprise ceria, zirconia, alumina, titania, silica and mixtures thereof including a mixture of zirconia and silica as recited above. Also useful is a support including the above-recited coprecipitate of manganese oxide and zirconia. The composition comprises from 0.1 to 20, preferably 0.5 to 15 and more preferably 1 to 10 wt. % of the precious metal component on the refractory support based on the weight of the precious metal and the support. Where the hydrocarbon component is sought to be converted to carbon dioxide and water, platinum is the most preferred catalyst and is preferably used in amounts of from 0.1 to 5% and more preferably 2 to 5% by weight.

In specific embodiments, there can be a combination of catalysts including the above recited catalyst as well as a catalyst which is particularly preferred for the treatment of ozone such as a catalyst comprising a manganese component. The manganese component can be optionally combined with a platinum component. The manganese and platinum can be on the same or different supports. There can be up to 80, preferably up to 50, more preferably from 1 to 40 and yet more preferably from 10 to 35 wt. % of the manganese component based on the weight of the precious metal and manganese in the pollutant treating composition. The catalyst loading is the same at that recited above with regard to the ozone catalyst. A preferred composition is a composition wherein the refractory component comprises an alumina or titania support and the precious metal component comprises a platinum component. Testing of such a composition coated onto a radiator has resulted in 68 to 72% conversion of carbon monoxide, 8 to 15% conversion of ozone and 17 to 18% conversion of propylene when contacting a surface at 95.degree. C. with a face velocity of the gas stream being about ten miles per hour (hourly space velocity of 320,000 per reciprocal hours) with air dew point at 35.degree. F. Generally, as the contacting surface temperature decreases and the space velocity or face velocity of the atmosphere air flow over the pollutant contacting surface increases, the percent conversion decreases.

Catalyst activity, particularly to treat carbon monoxide and hydrocarbons can be further enhanced by reducing the catalyst in a forming gas such as hydrogen, carbon monoxide, methane or hydrocarbon plus nitrogen gas. Alternatively, the reducing agent can be in the form of a liquid such as a hydrazine, formic acid, and formate salts such as sodium formate solution. The catalyst can be reduced as a powder or after coating onto a substrate. The reduction can be conducted in gas at from 150.sup.0-500.degree. C., preferably 200.sup.0-400.degree. C. for 1 to 12 hours, preferably 2 to 8 hours. In a preferred process, coated article or powder can be reduced in a gas comprising 7% hydrogen in nitrogen at 275.degree.-350.degree. C. for 2 to 4 hours.

An alternate composition for use in the method and apparatus of the present invention comprises a catalytically active material selected from the group consisting of precious metal components including platinum group metal components, gold components and silver components and a metal component selected from the group consisting of tungsten components and rhenium components. The relative amounts of catalytically active material to the tungsten component and /or rhenium component based on the weight of the metal are from 1 to 25, to 15 to 1.

The composition containing a tungsten component and/or a rhenium component preferably comprises tungsten and/or rhenium in the oxide form. The oxide can be obtained by forming the composition using tungsten or rhenium salts and the composition can subsequently be calcined to form tungsten and/or rhenium oxide. The composition can comprise further components such as supports including refractory oxide supports, manganese components, carbon, and coprecipitates of a manganese oxide and zirconia. Useful refractory metal oxides include alumina, silica, titania, ceria, zirconia, chromia and mixtures thereof. The composition can additionally comprise a binder material, such as metal sols including alumina or titania sols or polymeric binder which can be provided in the form of a polymeric latex binder.

In preferred compositions, there are from 0.5 to 15, preferably 1 to 10, and most preferably from 3 to 5 percent by weight of the catalytically active material. The preferred catalytically active materials are platinum group metals with platinum and palladium being more preferred and platinum being most preferred. The amount of tungsten and/or rhenium component based on the metals ranges 1 to 25, preferably 2 to 15 and most preferably 3 to 10 weight percent. The amount of binder can vary from 0 to 20 weight percent, preferably 0.5 to 20, more preferably 2 to 10 and most preferably 2 to 5 weight percent. Depending on the support material a binder is not necessary in this composition. Preferred compositions comprise from 60 to 98.5 weight percent of a refractory oxide support, from 0.5 to 15 weight percent of the catalytically active material, from 1 to 25 weight of the tungsten and/or rhenium component, and from 0 to 10 weight percent binder.

Compositions containing the tungsten component and rhenium component can be calcined under conditions as recited above. Additionally, the composition can be reduced. However, as shown in the examples below, the compositions need not be reduced and the presence of the tungsten and/or rhenium component can result in conversions of carbon monoxide and hydrocarbons comparable to compositions containing platinum group metals which have been reduced.

The pollutant treating compositions of the present invention preferably comprise a binder which acts to adhere the composition and to provide adhesion to the atmosphere contacting surface. It has been found that a preferred binder is a polymeric binder used in amounts of from 0.5 to 20, more preferably 2 to 10, and most preferably to 2 to 5 percent by weight of binder based on the weight of the composition. Preferably, the binder is a polymeric binder which can be a thermosetting or thermoplastic polymeric binder. The polymeric binder can have suitable stabilizers and age resistors known in the polymeric art. The polymer can be a plastic or elastomeric polymer. Most preferred are thermosetting, elastomeric polymers introduced as a latex into the catalyst into a slurry of the catalyst composition, preferably an aqueous slurry. Upon application of the composition and heating the binder material can crosslink providing a suitable support which enhances the integrity of the coating, its adhesion to the atmosphere contacting surface and provides structural stability under vibrations encountered in motor vehicles. The use of preferred polymeric binder enables the pollutant treating composition to adhere to the atmosphere contacting surface without the necessity of an undercoat layer. The binder can comprise water resistant additives to improve water resistance and improve adhesion. Such additives can include fluorocarbon emulsions and petroleum wax emulsions.

Useful polymeric compositions include polyethylene, polypropylene, polyolefin copolymers, polyisoprene, polybutadiene, polybutadiene copolymers, chlorinated rubber, nitrile rubber, polychloroprene, ethylene-propylene-diene elastomers, polystyrene, polyacrylate, polymethacrylate, polyacrylonitrile, poly(vinyl esters), poly(vinyl halides), polyamides, cellulosic polymers, polyimides, acrylics, vinyl acrylics and styrene acrylics, poly vinyl alcohol, thermoplastic polyesters, thermosetting polyesters, poly(phenylene oxide), poly(phenylene sulfide), fluorinated polymers such as poly(tetrafluoroethylene) polyvinylidene fluoride, poly(vinylfluoride) and chloro/fluoro copolymers such as ethylene chlorotrifluoroethylene copolymer, polyamide, phenolic resins and epoxy resins, polyurethane, and silicone polymers. A most preferred polymeric material is an acrylic polymeric latex as described in the accompanying examples.

Particularly preferred polymers and copolymers are vinyl acrylic polymers and ethylene vinyl acetate copolymers. A preferred vinyl acrylic polymer is a cross linking polymer sold by National Starch and Chemical Company as Xlink 2833. It is described as a vinyl acrylic polymer having a Tg of -15.degree. C., 45% solids, a pH of 4.5 and a viscosity of 300 cps. In particular, it is indicated to have vinyl acetate CAS No. 108-05-4 in a concentration range of less than 0.5 percent. It is indicated to be a vinyl acetate copolymer. Other preferred vinyl acetate copolymers which are sold by the National Starch and Chemical Company include Dur-O-Set E-623 and Dur-O-Set E-646. Dur-O-Set E-623 is indicated to be ethylene vinyl acetate copolymers having a Tg of 0.degree. C., 52% solids, a pH of 5.5 and a viscosity of 200 cps. Dur-O-Set E-646 is indicated to be an ethylene vinyl acetate copolymer with a Tg of -12.degree. C., 52% solids, a pH of 5.5 and a viscosity of 300 cps. A useful and preferred binder is a crosslinking acrylic copolymer sold by National Starch and Chemical Company as X-4280. It is described as a milk white aqueous emulsion having a pH of 2.6; a boiling point of 212.degree. F., a freezing point of 32.degree. F.; a specific gravity of 1.060; a viscosity of 100 cps.

An alternate and useful binding material is the use of a zirconium compound. Zirconyl acetate is preferred zirconium compound used. It is believed that zirconia acts as a high temperature stabilizer, promotes catalytic activity, and improves catalyst adhesion. Upon calcination, zirconium compounds such as zirconyl acetate are converted to ZrO.sub.2 which is believed to be the binding material. Various useful zirconium compounds include acetates, hydroxides, nitrates, etc. for generating ZrO.sub.2 in catalysts. In the case of using zirconyl acetate as a binder for the present catalysts, ZrO.sub.2 will not be formed unless the radiator coating is calcined. Since good adhesion has been attained at a "calcination" temperature of only 120.degree. C., it is believed that the zirconyl acetate has not decomposed to zirconium oxide but instead has formed a cross linked network with the pollutant treating material such as Carulite.RTM. particles and the acetates which were formed from ball milling with acetic acid. Accordingly, the use of any zirconium containing compounds in the present catalysts are not restricted only to zirconia. Additionally, the zirconium compounds can be used with other binders such as the polymeric binder recited above.

An alternate pollutant treating catalyst composition can comprise activated carbon composition. The carbon composition comprises activated carbon, a binder, such as a polymeric binder, and optionally conventional additives such as defoamers and the like. A useful activated carbon composition comprises from 75 to 85 weight percent activated carbon such as "coconut shell" carbon or carbon from wood and a binder such as an acrylic binder with a defoamer. Useful slurries comprise from 10 to 50 weight percent solids. The activated carbon can catalyze reduction of ozone to oxygen, as well as adsorb other pollutants.

Pollutant treating catalyst compositions of the present invention can be prepared in any suitable process. A preferred process is disclosed in U.S. Pat. No. 4,134,860 herein incorporated by reference. In accordance with this method, the refractory oxide support such as activated alumina, titania or activated silica alumina is jet milled, impregnated with a catalytic metal salt, preferably precious metal salt solution and calcined at a suitable temperature, typically from about 300.degree. C. to about 600.degree. C., preferably from about 350.degree. C. to about 550.degree. C., and more preferably from about 400.degree. C. to about 500.degree. C. for from about 0.5 to about 12 hours. Palladium salts are preferably a palladium nitrate or a palladium amine such as palladium tetraamine acetate, or palladium tetraamine hydroxide. Platinum salts preferably include platinum hydroxide solubilized in an amine. In specific and preferred embodiments the calcined catalyst is reduced as recited above.

In an ozone treating composition, a manganese salt, such as manganese nitrate, can then be mixed with the dried and calcined alumina supported palladium in the presence of deionized water. The amount of water added should be an amount up to the point of incipient wetness. Reference is made to the method reviewed in the above referenced and incorporated U.S. Pat. No. 4,134,860. The point of incipient wetness is the point at which the amount of liquid added is the lowest concentration at which the powdered mixture is sufficiently dry so as to absorb essentially all of the liquid. In this way a soluble manganese salt such as Mn(NO.sub.3).sub.2 in water can be added into the calcined supported catalytic precious metal. The mixture is then dried and calcined at a suitable temperature, preferably 400 to 500.degree. C. for about 0.5 to about 12 hours.

Alternatively, the supported catalytic powder (i.e., palladium supported on alumina) can be combined with a liquid, preferably water, to form a slurry to which a solution of a manganese salt, such as Mn(NO.sub.3).sub.2 is added. Preferably, the manganese component and palladium supported on a refractory support such as activated alumina, more preferably activated silica-alumina is mixed with a suitable amount of water to result in a slurry having from 15 to 40% and preferable 20 to 35 weight percent solids. The combined mixture can be coated onto a carrier such as a radiator and the radiator dried in air at suitable conditions such as 50.degree. C. to 150.degree. C. for 1 to 12 hours. The substrate which supports the coating can then be heated in an oven at suitable conditions typically from 300.degree. C. to 550.degree. C., preferably 350.degree. C. to 500.degree. C., more preferably 350.degree. C. to 450.degree. C. and most preferably from 400.degree. C. and 500.degree. C. in an oxygen containing atmosphere, preferably air for about 0.5 to about 12 hours to calcine the components and help to secure the coating to the substrate atmosphere contacting surface. Where the composition further comprises a precious metal component, it is preferably reduced after calcining.

A method of the present invention includes forming a mixture comprising a catalytically active material selected from at least one platinum group metal component, a gold component, a silver component, a manganese component and mixtures thereof and water. The catalytically active material can be on a suitable support, preferably a refractory oxide support. The mixture can be milled, and then optionally be calcined and reduced when using precious metal catalytic material. The calcining step can be conducted prior to milling and adding the polymeric binder. It is also preferred to reduce the catalytically active material prior to milling, calcining and adding the polymeric binder. The slurry comprises a carboxylic acid compound or polymer containing carboxylic acid groups or derivatives thereof in an amount to result in a pH of about from 3 to 7, typically 3 to 6. Preferably the acid comprises from 0.5 to 15 weight percent of glacial acetic acid based on the weight of the catalytically active material and acetic acid. The amount of water can be added as suited to attain a slurry of the desired solids concentration and/or viscosity. The percent solids are typically 20 to 50 and preferably 30 to 40 percent by weight. The preferred vehicle is deionized water (D.I.). The acetic acid can be added upon forming the mixture of the catalytically active material, which may have been calcined, with water. Alternatively, the acetic acid can be added with the polymeric binder. A preferred composition to treat ozone using manganese dioxide as the catalyst can be made using about 1,500 g of manganese dioxide which is mixed with 2,250 g of deionized water and 75 g of acetic acid. The mixture is combined in a 1 gallon ballmill and ballmilled for about 4 hours until approximately 90% of the particles are less than 8 micrometers. The ballmill is drained and 150 g of polymeric binder is added. The mixture is then blended on a rollmill for 30 minutes. The resulting mixture is ready for coating onto a suitable substrate such as an automobile radiator according to the methods described below.

It has been found that compatibility of the components of a slurry comprising a catalytic material and a polymeric binder, such as a latex emulsion, is desirable to maintain slurry stability and uniformity. For the purpose of the present invention compatibility means that the binder and the catalytic material remain as a mixture of separate particles in the slurry. It is believed that where the polymeric binder is a latex emulsion and the catalytic material have electrical charges which cause them to repel each other, they are compatible and the slurry is stable and has a uniform distribution of the catalytic material and the polymer latex in the liquid vehicle, e.g. aqueous fluid such as water. If the catalytic material and latex emulsion particles do not mutually repel each other, irreversible agglomeration of the latex on the catalytic material will occur. These materials are therefore incompatible and the latex comes out of the emulsion.

Compatibility of a high surface area catalyst with the organic latex binder is a key property in preparing a stable, uniform slurry. If the catalyst and latex emulsion particles do not mutually repel each other, irreversible agglomeration will occur. The result of this will be an unstable, non-uniform slurry which will produce a poorly adherent coating. Although the mutual repulsion of the catalyst and binder particles is controlled by a variety physical factors, surface charge plays a key role. Since latex emulsion particles are typically negatively charged, catalyst particles must be similarly charged. Zeta potential measurements have shown, however, that catalyst particles, such as MnO.sub.2 are only slightly negatively or even positively charged, and as a result, irreversible coagulation of the catalyst and latex occurs (i.e. catalyst and latex are not compatible). It has been found that although the above described method of adding acetic acid provides certain advantages to the slurries of the present invention, such as viscosity control, it does not enhance compatibility and may even be detrimental to aged slurry stability.

Where the catalytically material is positively or slightly negatively charged, improved compatibility can be achieved by making the slurry more basic. The pH of the slurry can be controlled depending on the acidity of the catalytic material, with preferred pH levels being at least 6, preferably at least 7, more preferably at least 8.5. Generally, the slurry should not be too caustic and a preferred upper limit is about 11. A preferred range is from 8.5 to 11.

Maintaining a pH.gtoreq.8.5 of a slurry comprising a latex emulsion and MnO.sub.2 (cryptomelane) is critical. If the pH drops below 8.5 for an extended period of time (days), the binder and catalyst will irreversibly coagulate. Despite the large negative charge on the cryptomelane particles at this pH, long term stability of cryptomelane containing slurries has been difficult to achieve. Preferred binders are poly(acrylic) acid derivative based binders with a particularly preferred binder which has long term stability under these conditions being an acrylic latex sold by National Starch as x-4280 acrylic latex. The difficulty in achieving long term compatibility even with basic slurries containing negatively charged latex and catalyst particles indicates that although surface charge is important, it is not the only factor in determining binder/catalyst compatibility. Other factors which play a role include emulsion particle size, surfactant package, etc. The present method involves raising the pH of the ball milled catalyst slurry to pH.gtoreq.8.5 and preferably 9 to enhance stability.

An alternative method to enhance slurry stability involves adding a surfactant such as a polymeric dispersant to the slurry instead of or in addition to increasing the pH. In the second case, binder/catalyst compatibility is achieved by adding a polymeric acrylate derived dispersant (ca. 3% solids basis) instead of increasing the pH. The result is the same, however, in that the catalyst particle is given a large negative charge which can repel the like charged latex particles. The dispersant can be added during the ball milling operation or after. Despite generating a large negative charge on the catalyst particles, not all dispersants work equally as well. Preferred dispersants comprise polymers containing carboxylic acid groups or derivatives thereof such as esters and salts. Preferred dispersants include Accusol 445 (from Rohm & Haas) and Colloid 226/35 (from Rhone-Poulenc). Useful dispersants and a review of dispersion technology are presented in, Additives for Dispersion Technology, published by Rhone-Poulenc, Surfactants & Specialties hereby incorporated by reference. Useful polymeric dispersants include but are not limited to polyacrylic acid partial sodium salts and anionic copolymer sodium salts sold by Rhone-Poulenc as Colloid.TM. polymeric dispersants. Again, although surface charge is an important factor in determining catalyst/binder compatibility, it is not the only factor. In general, the dispersant (particularly Colloid 226) does a good job of stabilizing the slurry since a greater variety of latex binders (e.g. acrylics, styrene acrylics, and EVA's) are compatible. Long term compatibility problems may be addressed by increasing the quantity of dispersant, raising the pH somewhat, or both.

The above recited methods enhance compatibility and result in a stable catalyst slurry. Both methods generate a large negative surface charge on the catalyst particle which in turn stabilizes the catalyst in the presence of the like charged (anionic) latex emulsion particles. For both systems, good adhesion has been observed(i.e. catalyst cannot be wiped off the face of a coated monolith) with a 10% by weight loading (solids basis) of the polymeric binder. At 5%, adhesion is not as good, so the optimum loading is probably somewhere in between.

While these methods have been shown to enhance compatability of MnO.sub.2 /latex slurries, the present invention is not limited to systems using negatively charged latex emulsions. Those skilled in the art will understand that slurry compatability can likewise be achieved using cationic latex emulsions, using cationic surfactant and/or dispersant packages to stabilize the catalyst particles.

The polymeric slurries of the present, particularly polymer latex slurries, can contain conventional additives such as thickeners, biocides, antioxidants and the like.

The pollutant treating composition can be applied to the atmosphere contacting vehicle surface by any suitable means such as spray coating, powder coating, or brushing or dipping the surface into a catalyst slurry.

The atmosphere contacting surface is preferably cleaned to remove surface dirt, particularly oils which could result in poor adhesion of the pollutant treating composition to the surface. Where possible, it is preferred to heat the substrate on which the surface is located to a high enough temperature to volatilize or burn off surface debris and oils.

Where the substrate on which there is an atmosphere contacting surface is made of a material which can withstand elevated temperatures such as an aluminum radiator, the substrate surface can be treated in such a manner as to improve adhesion to the catalyst composition, preferably the ozone carbon monoxide, and/or hydrocarbon catalyst composition. One method is to heat the aluminum substrate such as the radiator to a sufficient temperature in air for a sufficient time to form a thin layer of aluminum oxide on the surface. This helps clean the surface by removing oils which may be detrimental to adhesion. Additionally, if the surface is aluminum a sufficient layer of oxidized aluminum has been found to be able to be formed by heating the radiator in air for from 0.5 to 24 hours, preferably from 8 to 24 hours and more preferably from 12 to hours at from 350.degree. C. to 500.degree. C., preferably from 400 to 500.degree. C. and more preferably 425 to 475.degree. C. In some cases, sufficient adhesion without the use of an undercoat layer has been attained where an aluminum radiator has been heated at 450.degree. C. for 16 hours in air. This method is particularly useful when applying the coating to new surfaces such as radiators or air conditioner condensers prior to assembly in a motor vehicle either as original equipment or replacement.

Adhesion may improve by applying an undercoat or precoat to the substrate. Useful undercoats or precoats include refractory oxide supports of the type discussed above, with alumina preferred. A preferred undercoat to increase adhesion between the atmosphere contacting surface and an overcoat of an ozone catalyst composition is described in commonly assigned U.S. Pat. No. 5,422,331 herein incorporated herein by reference. The undercoat layer is disclosed as comprising a mixture of fine particulate refractory metal oxide and a sol selected from silica, alumina, zirconia and titania sols. In accordance with the method of the present invention, surfaces on existing vehicles can be coated while the substrate such as the radiator, radiator fan or air conditioner condenser is located on the vehicle. The catalyst composition can be applied directly to the surface. Where additional adhesion is desired, an undercoat can be used as recited above.

Where it is practical to separate the radiator from the vehicle, a support material such as activated alumina, silica-alumina, bulk titania, titanium sol, silica zirconia, manganese zirconia and others as recited can be formed into a slurry and coated on the substrate preferably with a silica sol to improve adhesion. The precoated substrate can subsequently be coated with soluble precious metal salts such as the platinum and/or palladium salts, and optionally manganese nitrate. The coated substrate can then be heated in an oven in air for sufficient time (0.5 to 12 hours at 350.degree. C. to 550.degree. C.) to calcine the palladium and manganese components to form the oxides thereof.

The present invention can comprise adsorption compositions supported on the atmosphere contacting surface. The adsorption compositions can be used to adsorb gaseous pollutants such as hydrocarbons and sulfur dioxide as well as particulate matter such as particulate hydrocarbon, soot, pollen, bacteria and germs. Useful supported compositions can include adsorbents such as zeolite to adsorb hydrocarbons. Useful zeolitic compositions are described in Publication No. WO 94/27709 published Dec. 8, 1994 and entitled Nitrous Oxide Decomposition Catalyst hereby incorporated by reference. Particularly preferred zeolites are Beta zeolite, and dealuminated Zeolite Y.

Carbon, preferably activated carbon, can be formed into carbon adsorption compositions comprising activated carbon and binders such as polymers as known in the art. The carbon adsorption composition can be applied to the atmosphere contacting surface. Activated carbon can adsorb hydrocarbons, volatile organic components, bacteria, pollen and the like. Yet another adsorption composition can include components which can adsorb SO.sub.3. A particularly useful SO.sub.3 adsorbent is calcium oxide. The calcium oxide is converted to calcium sulfate. The calcium oxide adsorbent compositions can also contain a vanadium or platinum catalyst which can be used to convert sulfur dioxide to sulfur trioxide which can then be adsorbed onto the calcium oxide to form calcium sulfate.

In addition to treatment of atmospheric air containing pollutants at ambient condition or ambient operating conditions, the present invention contemplates the catalytic oxidation and/or reduction of hydrocarbons, nitrogen oxides and residual carbon monoxide using conventional three way catalysts supported on electrically heated catalysts such as are known in the art. The electrically heated catalysts can be located on electrically heated catalyst monolith 56 illustrated in FIG. 1. Such electrically heated catalyst substrates are known in the art and are disclosed in references such as U.S. Pat. Nos. 5,308,591 and 5,317,869 hereby incorporated by reference. For the purposes of the present invention, the electrically heated catalyst is a metal honeycomb having a suitable thickness to fit in the flow direction, preferably of from 1/8 inch to 12 inches, and more preferably 0.5 to 3 inches. Where the electrically heated catalyst must fit into a narrow space, it can be from 0.25 to 1.5 inches thick. Preferred supports are monolithic carriers of the type having a plurality of fine, parallel gas flow passages extending therethrough from an inlet face to an outlet face of the carrier so that the passages are open to air flow entering from the front 26 and passing through the monolith 56 in the direction toward the fan 20. Preferably the passages are essentially straight from their inlet to their outlet and are defined by walls in which the catalytic material is coated as a wash coat so that the gases flowing through the passages contact the catalytic material. The flow passages of the monolithic carrier are thin wall channels which can be of any suitable cross-sectional shape and size such as trapezoidal, rectangular, square, sinusoidal, hexagonal, oval, circular or formed from metallic components which are corrugated and flat as are known in the art. Such structures may contain from about 60 to 600 or more gas inlet openings ("cells") per square inch of cross section. The monolith may be made of any suitable material and is preferably capable of being heated upon application of an electric current. A useful catalyst to apply is the three way catalyst (TWC) as recited above which can enhance the oxidation of hydrocarbons and carbon monoxide as well as the reduction of nitrogen oxides. Useful TWC catalysts are recited in U.S. Pat. Nos. 4,714,694; 4,738,947; 5,010,051; 5,057,483; and 5,139,992.

The present invention is illustrated further by the following examples which are not intended to limit the scope of this invention.

EXAMPLES

Example 1

A 1993 Nissan Altima radiator core (Nissan part number 21460-1E400) was heat treated in air to 450.degree. C. for 16 hours to clean and oxidize the surface and then a portion coated with high surface area silica-alumina undercoat (dry loading=0.23 g/in.sup.3) by pouring a water slurry containing the silica-alumina through the radiator channels, blowing out the excess with an air gun, drying at room temperature with a fan, and then calcining to 450.degree. C. The silica-alumina slurry was prepared by ball milling high surface area calcined SRS-II alumina (Davison) with acetic acid (0.5% based on alumina) and water (total solids ca. 20%) to a particle size of 90% <4 .mu.m. The ball milled material was then blended with Nalco silica sol (#91SJ06S--28% solids) in a ratio of 25%/75%. The SRS-II alumina is specified to have a structure of xSiO.sub.2.yAl.sub.2 O.sub.3.zH.sub.2 O with 92-95% by weight Al.sub.2 O.sub.3 and 4-7% by weight SiO.sub.2 after activation. BET surface area is specified to be a minimum of 260 m.sup.2 /g after calcination.

A Pd/Mn/Al.sub.2 O.sub.3 catalyst slurry (nominally 10% by weight palladium on alumina) was prepared by impregnating high surface area SRS-II alumina (Davison) to the point of incipient wetness with a water solution containing sufficient palladium tetraamine acetate. The resulting powder was dried and then calcined for 1 hour at 450.degree. C. The powder was subsequently mixed under high shear with a water solution of manganese nitrate (amount equivalent to 5.5% by weight MnO.sub.2 on the alumina powder) and sufficient dilution water to yield a slurry of 32-34% solids. The radiator was coated with the slurry, dried in air using a fan, and then calcined in air at 450.degree. C. for 16 hours. This ozone destruction catalyst contained palladium (dry loading=263 g/ft.sup.3 of radiator volume) and manganese dioxide (dry loading=142 g/ft.sup.3) on high surface area SRS-II alumina. The partially coated radiator reassembled with the coolant tanks, also referred to as headers is shown in FIG. 8.

Ozone destruction performance of the coated catalyst was determined by blowing an air stream containing a given concentration of ozone through the radiator channels at face velocities typical of driving speeds and then measuring the concentration of ozone exiting the back face of the radiator. The air used was at about 20.degree. C. and had a dew point of about 35.degree. F. Coolant fluid was circulated through the radiator at a temperature of about 50.degree. C. Ozone concentrations ranged from 0.1-0.4 ppm. Ozone conversion was measured at linear air velocities (face velocities) equivalent to 12.5 miles per hour to be 43%; at 25 mph to be 33%; at 37.5 mph to be 30% and at 49 mph to be 24%.

Example 2 (Comparative)

A portion of the same radiator used in Example 1 which was not coated with catalyst was similarly evaluated for ozone destruction performance (i.e. control experiment). No conversion of ozone was observed.

Example 3

After heat treatment for 60 hours in air at 450.degree. C., a Lincoln Town Car radiator core (part #F1VY-8005-A) was coated sequentially in 6".times.6" square patches with a variety of different ozone destruction catalyst compositions (i.e., different catalysts; catalyst loadings, binder formulations, and heat treatments). Several of the radiator patches were precoated with a high surface area alumina or silica-alumina and calcined to 450.degree. C. prior to coating with the catalyst. The actual coating was accomplished similarly to Example 1 by pouring a water slurry containing the specific catalyst formulation through the radiator channels, blowing out the excess with an air gun, and drying at room temperature with a fan. The radiator core was then dried to 120.degree. C., or dried to 120.degree. C. and then calcined to 400 to 450.degree. C. The radiator core was then reattached to its plastic tanks and ozone destruction performance of the various catalysts was determined at a radiator surface temperature of about 40.degree. C. to 50.degree. C. and a face velocity of 10 mph as described in Example 1.

Table I summarizes the variety of catalysts coated onto the radiator. Details of the catalyst slurry preparations are given below.

A Pt/Al.sub.2 O.sub.3 catalyst (nominally 2% by weight Pt on Al.sub.2 O.sub.3) was prepared by impregnating 114 g of a platinum salt solution derived from H.sub.2 Pt(OH).sub.6 solubilized in an amine, (17.9% Pt), dissolved in 520 g of water to 1000 g of Condea SBA-150 high surface area (specified to be about 150 m.sup.2 /g) alumina powder. Subsequently 49.5 g of acetic acid was added. The powder was then dried at 110.degree. C. for 1 hour and calcined at 550.degree. C. for 2 hours. A catalyst slurry was then prepared by adding 875 g of the powder to 1069 g of water and 44.6 g of acetic acid in a ball mill and milling the mixture to a particle size 90%<10 .mu.m. (Patches 1 and 4)

A carbon catalyst slurry was a formulation (29% solids) purchased from Grant Industries, Inc., Elmwood Park, N.J. The carbon is derived from coconut shell. There is an acrylic binder and a defoamer. (Patches 8 and 12)

The Carulite.RTM. 200 catalyst (CuO/MnO.sub.2) was prepared by first ball milling 1000 g of Carulite.RTM. 200 (purchased from Carus Chemical Co., Chicago, Ill.) with 1500 g of water to a particle size 90%<6 .mu.m. Carulite.RTM. 200 is specified as containing 60 to 75 weight percent MnO.sub.2, 11-14 percent CuO and 15-16 percent Al.sub.2 O.sub.3. The resulting slurry was diluted to ca. 28% solids and then mixed with either 3% (solids basis) of Nalco #1056 silica sol or 2% (solids basis) National Starch #x4260 acrylic copolymer. (Patches 5, 9 and 10)

The Pd/Mn/Al.sub.2 O.sub.3 catalyst slurry (nominally 10% by weight palladium on alumina) was prepared as described in Example 1. (Patches 2, 3 and 6)

An I.W. (incipient wetness) Pd/Mn/Al.sub.2 O.sub.3 catalyst (nominally 8% palladium and 5.5% MnO.sub.2 based on alumina) was prepared similarly by first impregnating high surface area SRS-II alumina (Davison) to the point of incipient wetness with a water solution containing palladium tetraamine acetate. After drying and then calcining the powder for two hours at 450.degree. C., the powder was reimpregnated to the point of incipient wetness with a water solution containing manganese nitrate. Again, after drying and calcination at 450.degree. C. for two hours, the powder was mixed in a ball mill with acetic acid (3% by weight of catalyst powder) and enough water to create a slurry of 35% solids. The mixture was then milled until the particle size was 90%<8 .mu.m. (Patches 7 and 11)

The SiO.sub.2 /Al.sub.2 O.sub.3 precoat slurry was prepared as described in Example 1. (Patches 3 and 11)

The Al.sub.2 O.sub.3 precoat slurry was prepared by ball milling high surface area Condea SBA-150 alumina with acetic acid (5% by weight based on alumina) and water (total solids ca. 44%) to a particle size of 90%<10 .mu.m. (Patches 9 and 12)

Results are summarized in Table I. The conversion of carbon monoxide after being on the automobile for 5,000 miles was also measured at the conditions recited in Example 1 for patch #4. At a radiator temperature of 50.degree. C. and a linear velocity of 10 mph no conversion was observed.

TABLE I CATALYST SUMMARY PATCH # CATALYST OZONE CONVERSION (%) 1 Pt/Al.sub.2 O.sub.3 12 0.67 g/in.sup.3 (23 g/ft.sup.3 Pt) No Precoat No Calcine (120.degree. C. only) 2 Pd/Mn/Al.sub.2 O.sub.3 25 0.97 g/in.sup.3 (171 g/ft.sup.3 Pd) No Precoat Calcined 450.degree. C. 3 Pd/Mn/Al.sub.2 O.sub.3 24 1.19 g/in.sup.3 (209 g/ft.sup.3 Pd) SiO.sub.2 /Pt/Al.sub.2 O.sub.3 Precoat (0.16 g/in.sup.3) Calcined 450.degree. C. 4 Pt/Al.sub.2 O.sub.3 8 0.79 g/in.sup.3 (27 g/ft.sup.3 Pt) No Precoat Calcined 450.degree. C. 5 Carulite 200 50 0.49 g/in.sup.3 3% SiO.sub.2 /Pt/Al.sub.2 O.sub.3 Binder No Precoat Calcined 400.degree. C. 6 Pd/Mn/Al.sub.2 O.sub.3 28 0.39 g/in.sup.3 (70 g/ft.sup.3 Pd) No Precoat Calcined 450.degree. C. 7 I.W. Pd/Mn/Al.sub.2 O.sub.3 50 0.69 g/in.sup.3 (95 g/ft.sup.3 Pd) No Precoat No Calcine (120.degree. C. only) 8 Carbon 22 0.80 g/in.sup.3 No Precoat No Calcine (120.degree. C. only) 9 Carulite 200 38 0.65 g/in.sup.3 3% SiO.sub.2 /Al.sub.2 O.sub.3 Binder Al.sub.2 O.sub.3 Precoat (0.25 g/in.sup.3) Calcined 450.degree. C. 10 Carulite 200 42 0.70 g/in.sup.3 2% Latex Binder No Precoat No Calcine (120.degree. C. only) 11 I.W. Pd/Mn/Al.sub.2 O.sub.3 46 0.59 g/in.sup.3 (82 g/ft.sup.3 Pd) SiO.sub.2 /Al.sub.2 O.sub.3 precoat (0.59 g/in.sup.3) No Calcine either Coat (120.degree. C. only) 12 Carbon 17 1.07 g/in.sup.3 Al.sub.2 O.sub.3 Precoat (0.52 g/in.sup.3) calcined to 450.degree. C. Topcoat not calcined (120.degree. C. only)

Example 4

A 1993 Nissan Altima radiator core (Nissan part number 21460-1E400) was heat treated in air to 400.degree. C. for 16 hours and then a portion coated with Condea high surface area SBA-150 alumina (dry loading=0.86 g/in.sup.3) by pouring a water slurry containing the alumina through the radiator channels, blowing out the excess with an air gun, drying at room temperature with a fan, and then calcining to 400.degree. C. The alumina precoat slurry was prepared as described in Example 3. The radiator was then coated sequentially in 2".times.2" square patches with seven different CO destruction catalysts (Table II). Each coating was applied by pouring a water slurry containing the specific catalyst formulation through the radiator channels, blowing out the excess with an air gun, and drying at room temperature with a fan.

The Carulite.RTM. and 2% Pt/Al.sub.2 O.sub.3 catalysts (Patch #4 and #6, respectively) were prepared according to the procedure described in Example 3. The 3% Pt/ZrO.sub.2 /SiO.sub.2 catalyst (Patch #3) was made by first calcining 510 g of zirconia/silica frit (95% ZrO.sub.2 /5% SiO.sub.2 --Magnesium Elektron XZO678/01) for 1 hour at 500.degree. C. A catalyst slurry was then prepared by adding to 480 g of deionized water, 468 g of the resulting powder, 42 g of glacial acetic acid, and 79.2 g of a platinum salt solution (18.2% Pt) derived from H.sub.2 Pt(OH).sub.6 solubilized with an amine. The resulting mixture was milled on a ball mill for 8 hours to a particle size of 90% less than 3 .mu.m.

The 3% Pt/TiO.sub.2 catalyst (Patch #7) was prepared by mixing in a conventional blender 500 g of TiO.sub.2 (Degussa P25), 500 g of deionized water, 12 g of concentrated ammonium hydroxide, and 82 g of a platinum salt solution (18.2% Pt) derived from H.sub.2 Pt(OH).sub.6 solubilized with an amine. After blending for 5 minutes to a particle size of 90% less than 5 .mu.m, 32.7 g of Nalco 1056 silica sol and sufficient deionized water to reduce the solids content to ca. 22% was added. The resulting mixture was blended on a roll mill to mix all ingredients.

The 3% Pt/Mn/ZrO.sub.2 catalyst slurry (Patch #5) was prepared by combining in a ball mill 70 g of manganese/zirconia frit comprising a coprecipitate of 20 weight percent manganese and 80 weight percent zirconium based on metal weight (Magnesium Elektron XZO719/01), 100 g of deionized water, 3.5 g of acetic acid and 11.7 g of a platinum salt solution (18.2% Pt) derived from H.sub.2 Pt(OH).sub.6 solubilized with an amine. The resulting mixture was milled for 16 hours to a particle size 90% less than 10 .mu.m.

The 2% Pt/CeO.sub.2 catalyst (Patch #1) was prepared by impregnating 490 g of alumina stabilized high surface area ceria (Rhone Poulenc) with 54.9 g of a platinum salt solution (18.2% Pt) derived from H.sub.2 Pt(OH).sub.6 solubilized with an amine and dissolved in deionized water (total volume--155mL). The powder was dried at 110.degree. C. for 6 hours and calcined at 400.degree. C. for 2 hours. A catalyst slurry was then prepared by adding 491 g of the powder to 593 g of deionized water in a ball mill and then milling the mixture for 2 hours to a particle size of 90% less than 4 .mu.m. The 4.6% Pd/CeO.sub.2 catalyst (Patch #2) was prepared similarly via incipient wetness impregnation using 209.5 g (180mL) of palladium tetraamine acetate solution.

After all seven catalysts were applied, the radiator was calcined for about 16 hours at 400.degree. C. After attaching the radiator core to the plastic tanks, CO destruction performance of the various catalysts were determined by blowing an air stream containing CO (ca. 16ppm) through the radiator channels at a 5 mph linear face velocity (315,000/h space velocity) and then measuring the concentration of CO exiting the back face of the radiator. The radiator temperature was ca. 95.degree. C., and the air stream had a dew point of approximately 35.degree. F. Results are summarized in Table II.

Ozone destruction performance was measured as described in Example 1 at 25.degree. C., 0.25 ppm ozone, and a linear face velocity of 10 mph with a flow of 135.2 L/min and an hourly space velocity of 640,000/h. The air used had a dewpoint of 35.degree. F. Results are summarized in Table II. FIG. 9 illustrates CO conversion v. temperature for Patch Nos. 3, 6 and 7.

The catalysts were also tested for the destruction of propylene by blowing an air stream containing propylene (ca. 10 ppm) through the radiator channels at a 5 mph linear face velocity, with a flow rate of 68.2 L/min and an hourly space velocity of 320,000/h, and then measuring the concentration of propylene exiting the back face of the radiator. The radiator temperature was ca. 95.degree. C., and the air stream had a dew point of approximately 35.degree. F. Results are summarized in Table II.

TABLE II CO/HC/OZONE CONVERSION SUMMARY CARBON MON- PROPYL- OXIDE OZONE ENE PATCH CONVER- CONVER- CONVER- # CATALYST SION (%).sup.1 SION (%).sup.2 SION (%).sup.3 1 2% Pt/CeO.sub.2 2 14 0 0.7 g/in.sup.3 (24 g/ft.sup.3 Pt) 2 4.6% Pd/CeO.sub.2 21 55 0 0.5 g/in.sup.3 (40 g/ft.sup.3 Pd) 3 3% Pt/ZrO.sub.2 /SiO.sub.2 67 14 2 0.5 g/in.sup.3 (26 g/ft.sup.3 Pt) 4 Carulite 200 5 56 0 0.5 g/in.sup.3 3% SiO.sub.2 /Al.sub.2 O.sub.3 binder 5 3% Pt/Mn/ZrO.sub.2 7 41 0 0.7 g/in.sup.3 (36 g/ft.sup.3 Pt) 6 2% Pt/Al.sub.2 O.sub.3 72 8 17 0.5 g/in.sup.3 (17 g/ft.sup.3 Pt) 7 3% Pt/TiO.sub.2 68 15 18 0.7 g/in.sup.3 (36 g/ft.sup.3 Pt) 3% SiO.sub.2 /Al.sub.2 O.sub.3 binder .sup.1 Test Conditions: 16 ppm CO; 95.degree. C.; 5 mph face velocity; 68.2 L/min; LHSV (hourly space velocity) = 320,000/h; Air dewpoint = 35.degree. F. .sup.2 Test Conditions: 0.25 ppm O.sub.3 ; 25.degree. C.; 10 mph face velocity; 135.2 L/min; LHSV (hourly space velocity) = 640,000/h; Air dewpoint = 35.degree. F. .sup.3 Test Conditions: 10 ppm propylene; 95.degree. C.; 5 mph face velocity; 68.2 L/min; LHSV (hourly space velocity) = 320,000/h; Air dewpoint = 35.degree. F.

Example 5

This example summarizes the technical results from on-the-road vehicle testing conducted in February and March 1995 in the Los Angeles area. The purpose of the test was to measure catalytic ozone decomposition efficiency over a catalyzed radiator under actual driving conditions. The Los Angeles (LA) area was chosen as the most appropriate test site primarily due to its measurable ozone levels during this March testing period. In addition, specific driving routes are defined in the LA area which are typical of AM and PM peak and off-peak driving. Two different catalyst compositions were evaluated: 1) Carulite.RTM. 200 (CuO/MnO.sub.2 /Al.sub.2 O.sub.3 purchased from Carus Chemical Company); and 2) Pd/Mn/Al.sub.2 O.sub.3 (77 g/ft.sup.3 Pd) prepared as described in Example 3. Both catalysts were coated in patches onto a late model Cadillac V-6 engine aluminum radiator. The radiator was an aluminum replacement for the copper-brass OEM radiator which was on a Chevrolet Caprice test vehicle. The car was outfitted with 1/4" Teflon.RTM. PTFE sampling lines located directly behind each catalyst patch and behind an uncoated portion of the radiator (control patch). Ambient (catalyst in) ozone levels were measured via a sampling line placed in front of the radiator. Ozone concentrations were measured with two Dasibi Model 1003AH ozone monitors located in the back seat of the vehicle. Temperature probes were mounted (with epoxy) directly onto each radiator test patch within a few inches of the sampling line. A single air velocity probe was mounted on the front face of the radiator midway between the two patches. Data from the ozone analyzers, temperature probes, air velocity probe, and vehicle speedometer were collected with a personal computer located in the trunk and downloaded to floppy disks.

Overall results from the test are summarized in Table III below. For each catalyst (Carulite.RTM. & Pd/Mn/Al.sub.2 O.sub.3), results for cold idle, hot idle and on-the-road driving are reported. Data were collected on two separate trips to LA in February and March of 1995. The first trip was cut short after only a few days due to low ambient ozone levels. Although somewhat higher during the second trip in March, ambient levels still only averaged approximately 40 ppb. The last three days of testing (March 17-20) had the highest ozone encountered. Peak levels were approximately 100 ppb. In general, no trend in conversion vs. ozone concentration was noted.

Except for the cold idle results, those reported in Table III are averages from at least eleven different runs (the actual range of values appear in parentheses). Only data corresponding to inlet ozone concentration greater or equal to 30 ppb were included. Freeway data was not included since ambient levels dropped to 20 ppb or lower. Only two runs were completed for the cold idle tests. By cold idle refers to data collected immediately after vehicle startup during idle before the thermostat switches on and pumps warm coolant fluid to the radiator. Overall, ozone conversions were very good for both catalysts with the highest values obtained during hot idle. This can be attributed to the higher temperatures and lower face velocities associated with idling. Cold idle gave the lowest conversion due to the lower ambient temperature of the radiator surface. Driving results were intermediate of hot and cold idle results. Although the radiator was warm, temperature was lower and face velocity higher than those encountered with hot idle conditions. In general, ozone conversions measured for Carulite.RTM. were greater than those measured for Pd/Mn/Al.sub.2 O.sub.3 (e.g. 78.1 vs. 63.0% while driving). However, for the hot idle and driving runs, the average temperature of the Carulite.RTM. catalyst was typically 40.degree. F. greater than the Pd/Mn/Al.sub.2 O.sub.3 catalyst while the average radiator face velocity was typically 1 mph lower.

Overall, the results indicate that ozone can be decomposed at high conversion rates under typical driving conditions.

TABLE III ON-ROAD OZONE CONVERSION RESULTS* OZONE CONVER- TEMPER- FACE VEHICLE SION ATURE VELOCITY SPEED (%) (.degree. F.) (mph) (mph) Pd/Mn/Al.sub.2 O.sub.3 Idle Cold 48.2 70.6 9.0 0.0 (47.2-49.2) (70.5-70.8) (8.9-9.2) Idle Hot 80.6 120.0 7.4 0.0 (70.7-89.9) (104.7-145.2) (6.1-8.4) Driving 63.0 104.3 13.2 23.3 (55.5-69.9) (99.2-109.6) (12.2-14.9) (20.5-29.7) Carulite (CuO/MnO.sub.2) Idle Cold 67.4 71.8 8.2 0.0 (67.4-67.5) (70.8-72.9) (7.5-8.9) Idle Hot 84.5 157.1 7.5 0.0 (71.4-93.5) (134.8-171.2) (6.7-8.2) Driving 78.1 143.7 12.2 19.2 (72.3-83.8) (132.9-149.6) (11.2-13.5) (13.7-24.8) *Average values. Ranges appear in parentheses.

In general, the results of motor testing are consistent with fresh activity measured in the lab prior to installation of the radiator. At room temperature (.about.25.degree. C.), 20% relative humidity (0.7% water vapor absolute), and a 10 mph equivalent face velocity, lab conversions for Pd/Mn/Al.sub.2 O.sub.3 and Carulite.RTM. were 55 and 69% respectively. Increasing the RH to 70% at room temperature (.about.25.degree. C.) (2.3% water vapor absolute) lowered conversions to 38 and 52%, respectively. Since the cold idle (70.degree. F.) conversions measured at a 9 mph face velocity were 48 and 67% respectively, it would appear that the humidity levels encountered during the testing were low.

The face velocity of air entering the radiator was low. At an average driving speed of roughly 20 mph (typical of local driving), radiator face velocity was only approximately 13 mph. Even at freeway speeds in excess of 60 mph, radiator face velocity was only ca. 25 mph. The fan significantly affects control of air flowing through the radiator. While idling, the fan typically pulled about 8 mph.

Example 6

An 8 weight percent Pd on Carulite.RTM. catalyst was prepared by impregnating 100 g Carulite.RTM. 200 powder (ground up in a blender) to the point of incipient wetness with 69.0 g of a water solution containing palladium tetraamine acetate (12.6% Pd). The powder was dried overnight at 90.degree. C. and then calcined to 450.degree. C. or 550.degree. C. for 2 hours. 92 g of the resulting calcined catalyst was then combined with 171 g of deionized water in a ball mill to create a slurry of 35% solids. After milling for 30 minutes to a particle size 90%.ltoreq.9 .mu.m, 3.1 g of National Starch x4260 acrylic latex binder (50% solids) was added, and the resulting mixture was milled for an additional 30 minutes to disperse the binder. Compositions containing 2,4 and 6 weight percent Pd on Carulite.RTM. catalysts were similarly prepared and evaluated.

The catalysts were evaluated for ozone decomposition at room temperature and 630,000/h space velocity using washcoated 300 cpsi (cells per square inch) ceramic honeycombs. The catalyst samples were prepared as recited above. Results are summarized in Table IV. As can readily be seen, the 4 and 8% Pd/Carulite.RTM. catalysts which were calcined to 450.degree. C. gave equivalent initial and 45 minute ozone conversions (ca. 62 and 60%, respectively). These results are equivalent to those of Carulite.RTM.

alone under the identical test conditions. The 2 and 4% Pd catalysts which were calcined to 550.degree. C. gave significantly lower conversions after 45 minutes (47%). This is attributed to a loss in surface area at the higher temperature of calcination. The 6% catalyst was also calcined to 550.degree. C. but did not show quite as large of an activity drop.

TABLE IV OZONE RESULTS (300 cpsi Honeycomb, 630,000/h Space Velocity) LOADING CONVERSION CONVERSION CATALYST (g/in.sup.3) (%) initial (%) 45 Minutes Pd on Carulite 200 4% Pd/Carulite 1.8 64 59 (calcined 450.degree. C.) 8% Pd/Carulite 2.0 61 60 (calcined 450.degree. C.) 2% Pd/Carulite 2.1 57 48 (calcined 550.degree. C.) 4% Pd/Carulite 1.9 57 46 (calcined 550.degree. C.) 6% Pd/Carulite 2.3 59 53 (calcined 550.degree. C.)

Example 7

A series of tests were conducted to evaluate a variety of catalyst compositions comprising a palladium component to treat air containing 0.25 ppm ozone. The air was at ambient conditions (23.degree. C.; 0.6% water). The compositions were coated onto a 300 cell per inch ceramic (cordierite) flow through honeycomb at loadings of about 2 g of washcoat per cubic inch of substrate. The coated monoliths containing the various supported palladium catalysts were loaded into a 1" diameter stainless steel pipe, and the air stream was passed perpendicular to the open face of the honeycomb at a space velocity of 630,000/h. Ozone concentration was measured inlet and outlet of the catalyst. One alumina support used was SRS-II gamma alumina (purchased from Davison) characterized as described in Example 1 (surface area approximately 300 m.sup.2 /g). Also used was a low surface area theta alumina characterized by a surface area of approximately 58 m.sup.2 /g and an average pore radius of about 80 Angstrom. E-160 alumina is a gamma alumina characterized by a surface area of about 180 m.sup.2 /g and an average pore radius of about 47 Angstrom. Ceria used had a surface area about 120 m.sup.2 /g and an average pore radius of about 28 Angstrom. Also used was dealuminated Beta zeolite with a silica to alumina ratio of approximately 250 to 1 and a surface area about 430 m.sup.2 /g. Carbon, a microporous wood carbon characterized with a surface area of about 850 m.sup.2 /g, was also used as a support. Finally, a titania purchased from Rhone-Poulenc (DT51 grade) and characterized by a surface area of approximately 15 110 m.sup.2 /g was used as a support. Results are summarized in Table V which includes the relative weight percent of various catalyst components, the loading on the honeycomb, initial ozone conversion, and conversion after 45 minutes.

TABLE V OZONE RESULTS - (300 cpsi Honeycomb, 630,000/h Space Velocity, 0.6% Water; ca. 0.25 ppm Ozone) LOADING CONVERSION CONVERSION CATALYST (g/in.sup.3) (%) initial (%) 45 Minutes I.W. 8% Pd/5% Mn/ 1.8 60 55 Al.sub.2 O.sub.3 I.W. 8% Pd/5% Mn/ 1.9 64 60 Low Surface Area Al.sub.2 O.sub.3 8% Pd/Low Surface 1.9 56 44 Area Al.sub.2 O.sub.3 8% Pd/E-160 Al.sub.2 O.sub.3 2.2 61 57 4.6% Pd/CeO.sub.2 1.99 59 58 8% Pd/BETA 1.9 38 32 Zeolite (dealuminated) 5% Pd/C 0.5 63 61 8% Pd/DT-51 TiO.sub.2 1.8 39 20

Example 8

Following is a preparation of Carulite.RTM. slurry which includes vinyl acetate latex binder and is used in coating radiators which results in excellent adhesion of the catalyst to an aluminum radiator.

1000 g of Carulite.RTM. 200, 1500 g of deionized water, and 50 g of acetic acid (5% based on Carulite.RTM.) were combined in a 1 gallon ball mill and milled for 4 hours to a particle size 90%.ltoreq.7 .mu.m. After draining the resulting slurry from the mill, 104 g (5% solids basis) of National Starch Dur-O-Set E-646 cross linking EVA copolymer (48% solids) was added. Thorough blending of the binder was achieved by rolling the slurry on a mill without milling media for several hours.

Following coating of this slurry onto a piece of aluminum substrate (e.g., radiator), excellent adhesion (i.e., coating could not be wiped off) was obtained after drying for 30 minutes at 30.degree. C. Higher temperatures of curing (up to 150.degree. C.) can be utilized if desired.

Example 9

Carbon monoxide conversion was tested by coating a variety of titania supported platinum compositions onto ceramic honeycombs as described in Example 6. Catalyst loadings were about 2 g/in.sup.3, and testing was conducted using an air stream having 16 ppm carbon monoxide (dew point 35.degree. F.) at a space velocity of 315,000/h. The catalyst compositions were reduced on the honeycomb using a forming gas having 7% H.sub.2 and 93% N.sub.2 at 300.degree. C. for 3 hours. Compositions containing TiO.sub.2 included 2 and 3 weight percent platinum component on P25 titania; and 2 and 3 weight percent platinum component on DT52 grade titania. DT51 grade titania was purchased from Rhone-Poulenc and had a surface area of approximately 110 m.sup.2 /g. DT52 grade titania was a tungsten containing titania purchased from Rhone-Poulenc and which had a surface area of approximately 210 m.sup.2 /g. P25 grade titania was purchased from Degussa and was characterized as having a particle size of approximately 1 .mu.m and a surface area of ca. 45-50 m.sup.2 /g. Results are illustrated in FIG. 10.

Example 10

Example 10 relates to the evaluation of CO conversion for compositions containing alumina, ceria and zeolite. The supports were characterized as described in Example 7. Compositions evaluated included 2 weight percent platinum on low surface area theta alumina; 2 weight percent platinum and ceria; 2 weight percent platinum on SRS-II gamma alumina, and 2 weight percent platinum on Beta zeolite. Results are illustrated in FIG. 11.

Example 11

CO conversion was measured v. temperature for compositions containing 2 weight percent platinum on SRS-II gamma alumina and on ZSM-5 zeolite which were coated onto a 1993 Nissan Altima radiator as recited in Example 4 and tested using the same procedure to test CO as used in Example 4. Results are illustrated in FIG. 9.

Example 12

0.659 g of a solution of amine solubilized platinum hydroxide solution having 17.75 weight percent platinum (based on metallic platinum) was slowly added to 20 g of an 11.7 weight percent aqueous slurry of a titania sol in a glass beaker and stirred with a magnetic stirrer. A one-inch diameter by one-inch long 400 cells per square inch (cpsi) metal monolith cored sample was dipped into the slurry. Air was blown over the coated monolith to clear the channels and the monolith was dried for three hours at 110.degree. C. At this time, the monolith was redipped into the slurry once again and the steps of air blowing the channels and drying at 110.degree. C. was repeated. The twice coated monolith was calcined at 300.degree. C. for two hours. The uncoated metal monolith weighed 12.36 g. After the first dipping, it weighed 14.06 g, after the first drying 12.6 g, after the second dipping 14.38 g and after calcination weighed 13.05 g indicating a total weight gain of 0.69 g. The coated monolith had 72 g/ft.sup.3 of platinum based on the metal and is designated as 72 Pt/Ti. The catalyst was evaluated in an air stream containing 20 ppm carbon monoxide at a gas flow rate of 36.6 liters per minute. After this initial evaluation the catalyst core was reduced in a forming gas having 7% hydrogen and 93% nitrogen at 300.degree. C. for 12 hours and the evaluation to treat an air stream containing 20 ppm carbon monoxide was repeated. The reduced coated monolith as designated as 72 Pt/Ti/R. The above recited slurry was then evaluated using a cored sample from a ceramic monolith having 400 cells per square inch (cpsi), which was precoated with 40 g per cubic foot, of 5:1 weight ratio of platinum to rhodium plus 2.0 g per cubic inch of ES-160 (alumina) and the core had 11 cells by 10 cells by 0.75 inches long monolith and designated as 33 Pt/7Rh/Al was dipped into the above recited slurry and air blown to clean the channels. This monolith was dried at 110.degree. C. for three hours and calcined at 300.degree. C. for two hours. The catalyst substrate including the first platinum and rhodium layer weighed 2.19 g. After the first dip it weighed 3.40 g and after calcination 2.38 g showing a total weight gain of 0.19 g which is equal to 0.90 g per cubic inch of the platinum/titania slurry. The dipped ceramic core contained 74 per cubic foot of platinum based on the platinum metal and designated as 74 Pt/Ti//Pt/Rh. Results are illustrated in FIG. 12.

Example 13

A platinum on titanium catalyst as described in the above referenced Example 12 has been used in an air stream containing 4 ppm propane and 4 ppm propylene. In an air stream at a space velocity of 650,000 standard hourly space velocity. The platinum and titanium catalyst had 72 g of platinum per cubic foot of total catalyst and substrate used. It was evaluated on the ceramic honeycomb as recited in Example 13. The measured results for propylene conversion were 16.7% at 65.degree. C.; 19% at 70.degree. C.; 23.8% at 75.degree. C.; 28.6% at 80.degree. C.; 35.7% at 85.degree. C.; 40.5% at 95.degree. C. and 47.6% at 105.degree. C.

Example 14

Example 14 is an illustration of a platinum component on a titania support. This Example illustrates the excellent activity of platinum supported on titania for carbon monoxide and hydrocarbon oxidation. The evaluation was carried out using a catalyst prepared from a colloidal titania sol to form a composition comprising 5.0 weight percent platinum component based on the weight of the platinum metal and titania. The platinum was added to titania in the form of amine solubilized platinum hydroxide solution. It was added to colloidal titania slurry or into titania powders to prepare a platinum and titania containing slurry. The slurry was coated onto a ceramic monolith having 400 cells per square inch (cpsi). Samples had coating amounts varying from 0.8-1.0 g/in. The coated monoliths were calcined for 300.degree. C. for 2 hours in the air and then reduced. The reduction was carried out at 300.degree. C. in a gas containing 7% hydrogen and 93% nitrogen for 12 hours. The colloidal titania slurry contained 10% by weight titania in an aqueous media. The titania had a nominal particle size of 2-5nm.

Carbon monoxide conversion was measured in an air stream containing 20 ppm CO. The flow rate of the carbon monoxide in various experiments range from space velocities of 300,000 VHSV to 650,000 VHSV at a temperature between ambient to 110.degree. C. The air used was purified air from an air cylinder and where humidity was added the air was passed through a water bath. Where humidity was studied the relative humidity was varied from 0-100% humidity at room temperature (25.degree. C.). The carbon monoxide containing air stream was passed through the ceramic monolith coated with the catalyst compositions using a space velocity of 650,000/h.

FIG. 13 represents a study using air with 20 ppm CO having to measure carbon monoxide conversion v. temperature comparing platinum supported on titania which has been reduced (Pt/Ti-R) at 300.degree. C. using a reducing gas containing 7% hydrogen and 93% nitrogen for 12 hours as recited above with a non reduced platinum supported on titania catalyst (Pt/Ti) coating. FIG. 13 illustrates a significant advantage when using a reduced catalyst.

FIG. 14 illustrates a comparison of platinum on titania which has been reduced with varying supports including platinum on tin oxide (Pt/Sn), platinum on zinc oxide (Pt/Zn) and platinum on ceria (Pt/Ce) for comparative sake. All of the samples were reduced at the above indicated conditions. The flow rate of carbon monoxide in the air was 650,000 shsv. As can be seen, the reduced platinum on colloidal titania had significantly higher conversion results than platinum on the various other support materials.

Hydrocarbon oxidation was measured using a 6 ppm propylene air mixture. The propylene air stream was passed through the catalyst monolith at a space velocity of 300,000 vhsv at a temperature which varied from room temperature to 110.degree. C. Propylene concentration was determined using a flame ionized detector before and after the catalyst. The results are summarized in FIG. 15. The support used was 5% by weight based on the weight of platinum metal and yttrium oxide Y.sub.2 O.sub.3. The comparison was between reduced and non reduced catalyst. As shown in FIG. 15 reducing the catalyst resulted in a significant improvement in propylene conversion.

The above recited platinum supported on titania catalyst was reduced in a forming gas containing 7% hydrogen and 93% nitrogen at 500.degree. C. for 1 hour. The conversion of carbon monoxide was evaluated in 0 percent relative humidity air at a flow rate of 500,000 vhsv. The evaluation was conducted to determine if the reduction of the catalyst was reversible. Initially, the catalyst was evaluated for the ability to convert carbon monoxide at 22.degree. C. As shown in FIG. 16, the catalyst initially converted about 53% of the carbon monoxide and dropped down to 30% after approximately 200 minutes. At 200 minutes the air and carbon monoxide was heated to 50.degree. C. and carbon monoxide conversion increased to 65%. The catalyst was further heated to 100.degree. C. in air and carbon monoxide and held at 100.degree. C. for one hour, and then cooled in air to room temperature (about 25.degree. C.). Initially, the conversion dropped to about 30% in the period from about 225-400 minutes. The evaluation was continued at 100.degree. C. to 1200 minutes at which time conversion was measured at about 40%. A parallel study was conducted at 50.degree. C. At about 225 minutes the conversion was about 65%. After 1200 minutes, the conversion actually rose to about 75%. This Example shows that reduction of the catalyst permanently improves the catalysis activity.

Example 15

Example 15 is used to illustrate ozone conversion at room temperature for platinum and/or palladium components supported on a manganese oxide/zirconia coprecipitate. This Example also shows a platinum catalyst which catalyzes the conversion of ozone to oxygen and, at the same time, oxidize carbon monoxide and hydrocarbons. Manganese oxide/zirconia mixed oxide powders were made having 1:1 and 1:4 weight based on Mn and Zr metals. The coprecipitate was made in accordance with the procedure disclosed in U.S. Pat. No. 5,283,041 referenced above. 3% and 6% Pt on manganese/zirconia catalysts (1:4 weight basis of Mn to Zr) were prepared as described in Example 4. SBA-150 gamma alumina (10% based on the weight of the mixed oxide powder) was added as a binder in the form of a 40% water slurry containing acetic acid (5% by weight of alumina powder) and milled to a particle size 90%<10 .mu.m. The 6% weight percent Pd catalyst was prepared by impregnating manganese/zirconia frit (1:1 weight basis of Mn to Zr) to the point of incipient wetness with a water solution containing palladium tetraamine acetate. After drying and then calcining the powder for two hours at 450.degree. C., the catalyst was mixed in a ball mill with Nalco #1056 silica sol (10% by weight of catalyst powder) and enough water to create a slurry of approximately 35% solids. The mixture was then milled until the particle size was 90%.ltoreq.10 .mu.m. Various samples were reduced using a forming gas having 7% H.sub.2 and 93% N.sub.2 at 300.degree. C. for 3 hours. Evaluations were conducted to determine the conversion of ozone on coated radiator minicores from a 1993 Altima radiator which were approximately 1/2 inch by 7/8 inch by 1 inch deep. The evaluation was conducted at room temperature using a one-inch diameter stainless steel pipe as described in Example 7 with house air (laboratory supplied air) at a 630,000/h space velocity with an inlet ozone concentration of 0.25 ppm. Results are provided on Table VI.

TABLE VI SUMMARY OF FRESH ACTIVITY OZONE RESULTS - (39 cpsi Nissan Altima core, 630,000/h Space Velocity; 25.degree.C.; 0.25 ppm ozone; House air - ca. 0.6% water) LOAD- CORE ING CONVERSION CONVERSION NO. CATALYST (g/in.sup.3) (%) Initial (%) 45 Minutes 1 3% Pt/MnO.sub.2 / 0.7 70.7 65.8 ZrO.sub.2 (1:4) (calcined at 450.degree. C.) 2 3% Pt/MnO.sub.2 / 0.7 70.5 63.7 ZrO.sub.2 (1:4) (calcined at 450.degree. C.; reduced at 300.degree. C.) 3 6% Pt/MnO.sub.2 / 0.68 68.2 62.3 ZrO.sub.2 (1:4) (calcined at 450.degree. C.) 4 6% Pt/MnO.sub.2 / 0.66 66 55.8 ZrO.sub.2 (1:4) (calcined 450.degree. C.; reduced at 300.degree. C.) 5 6% Pd/MnO.sub.2 / 0.39 38.3 21.1 ZrO.sub.2 (1:1) w. 10% Nalco 1056 6 MnO.sub.2 /ZrO.sub.2 0.41 58.3 44.9 (1:1) w. 10% Nalco 1056 7 MnO.sub.2 /ZrO.sub.2 0.37 55.8 41.2 (1:1) w. 10% Nalco 1056 8 3% Pt/ZrO.sub.2 / 0.79 27.4 10 SiO.sub.2 (calcined 450.degree. C.) 9 3% Pt/ZrO.sub.2 / 0.76 54.2 30.1 SiO.sub.2 (calcined 450.degree. C. and reduced at 300.degree. C.)

As can be seem from Table VI Cores 1 and 2 having only 3% platinum resulted in excellent ozone conversion initially and after 45 minutes both for reduced and unreduced catalyst. Cores 3 and 4 having a 6% platinum concentration also had excellent results but not quite as good as the 3% platinum results. Cores 5-7 illustrate a variety of other support materials used which resulted in conversion of ozone. Core 5 had palladium on a manganese oxide/zirconia coprecipitate and resulted in lower than expected but still significant ozone conversion. Cores 6 and 7 evaluations used the coprecipitate without precious metal and also resulted in significant ozone conversions but here again not as good as when using platinum as a catalyst. Core 8 was platinum on a zirconia/silica support which was calcined but not reduced and Core 9 was platinum on zirconia/silica support which was reduced. Both Cores 8 and 9 gave some conversion but yet not as good as the conversion obtained with platinum on the coprecipitate.

In addition, carbon monoxide conversion was evaluated on 39 cpsi radiator minicores, as recited, for 3% and 6% platinum on manganese/zirconia supports. Reduced and unreduced samples were evaluated. For illustrative purposes, platinum on zirconia/silica supports and platinum on Carulite.RTM. reduced and unreduced are also presented. As can be seen from FIG. 17, the results of 3% reduced platinum on manganese/zirconia support were higher when compared to the other embodiments.

Example 16 (Comparative)

Ozone conversion was measured over an uncoated 1995 Ford Contour radiator at room temperature and 80.degree. C. by blowing an air stream containing ozone (0.25 ppm) through the radiator channels at a 10 mph linear velocity (630,000/h space velocity) and then measuring the concentration of ozone exiting the back face of the radiator. The air stream had a dew point of approximately 35.degree. F. Heated coolant was not circulated through the radiator, but the air stream was heated as necessary with heating tape to achieve the desired radiator temperature. Additional testing was completed with an uncoated 0.75" (L)x0.5" (W)x1.0" (D) Ford Taurus radiator "mini-core" in a 1" diameter stainless steel pipe as described in Example 7. The air stream was heated with heating tape to achieve the desired radiator temperature. For both tests, no decomposition of ozone was observed up to 120.degree. C.

Example 17

Ozone conversion was measured at various temperatures for a reduced 3% Pt/TiO.sub.2 catalyst in the absence and in the presence of 15 ppm CO. Degussa P25 grade titania was used as the support and was characterized as having a particle size of approximately 1 .mu.m and a surface area of ca. 45-50 m.sup.2 /g. The catalyst was coated onto a 300 cpsi ceramic (cordierite) honeycomb and was reduced on the honeycomb using a forming gas having 7% H.sub.2 and 93% N.sub.2 at 300.degree. C. for 3 hours. Testing was accomplished as described previously in Example 7. The air stream (35.degree. F. dewpoint) was heated with heating tape to achieve the desired temperature. As can be seen in FIG. 18, an approximate 5% enhancement in absolute ozone conversion was observed from 25 to 80.degree. C. The presence of CO improves the conversion of ozone.

Example 18

100 g of Versal GL alumina obtained from LaRoche Industries Inc. was impregnated with about 28 g of Pt amine hydroxide (Pt(A)salt) diluted in water to about 80 g of solution. 5 g of acetic acid was added to fix the Pt onto the alumina surface. After mixing for half hour, the Pt impregnated catalyst was made into a slurry by adding water to make about 40% solids. The slurry was ballmilled for 2 hours. The particle size was measured to be 90% less than 10 microns. The catalyst was coated onto a 1.5" diameter by 1.0" length 400 cpsi ceramic substrate to give a washcoat loading after drying of about 0.65 g/in.sup.3. The catalyst was then dried at 100.degree. C. and calcined at 550.degree. C. for 2 hours. This catalyst was tested for C.sub.3 H.sub.6 oxidation at temperatures between 60 and 100.degree. C. in dry air as described in Example 21.

Some of calcined Pt/Al.sub.2 O.sub.3 sample described above was also reduced in 7%H2/N2 at 400.degree. C. for 1 hour. The reduction step was carried out by ramping the catalyst temperature from 25 to 400.degree. C. at a H2/N2 gas flow rate of 500 cc/min. The ramp temperature was about 5.degree. C./min. The catalyst was cooled down to room temperature and the catalyst was tested for C.sub.3 H.sub.6 oxidation as described in Example 21.

Example 19

6.8 g of ammonium tungstate was dissolved in 30 cc of water and the pH adjusted to 10 and the solution impregnated onto 50 g of Versal GL alumina (LaRoche Industries Inc.). The material was dried at 100.degree. C. and calcined for 2 hours at 550.degree. C. The approximately 10% by metal weight of W on Al.sub.2 O.sub.3 was cooled to room temperature and impregnated with 13.7 g of Pt amine hydroxide (18.3% Pt). 2.5 g of acetic acid was added and mixed well. The catalyst was then made into a slurry containing 35% solid by adding water. The slurry was then coated over a 400 cpsi, 1.5"-1.0" diameter ceramic substrate resulting, after drying, in having a catalyst washcoat loading of 0.79 g/in.sup.3. The coated catalyst was then dried and calcined at 550.degree. C. for 2 hours. The catalyst was tested calcined in C.sub.3 H.sub.6 and dry air in the temperature range 60 to 100.degree. C.

Example 20

6.8 g of perrhenic acid (36% Re in solution) was further diluted in water to make 10 g percent perrhenic acid solution. The solution was impregnated onto 25 g of Versal GL alumina. The impregnated alumina was dried and the powder calcined at 550.degree. C. for 2 hours. The impregnated 10 weight percent based metal of Re on Al.sub.2 O.sub.3 powder was then further impregnated with 6.85 g of Pt amine hydroxide solution (Pt metal in solution was 18.3%). 5 g of acetic acid was added and mixed for a half hour. A slurry was made by adding water to make 28% solid. The slurry was ballmilled for 2 hours and coated onto 1.5" diameter x 1.0" length 400 cpsi ceramic substrate to give a catalyst washcoat loading of 0.51 g/in.sup.3 after drying. The catalyst coated substrate was dried at 100.degree. C. and calcined at 550.degree. C. for 2 hours. The catalyst was tested in the calcined form using 60 ppm C.sub.3 H.sub.6 and dry air in the temperature range of 60 to 100.degree. C.

Example 21

The catalyst of Examples 18, 19 and 20 were tested in a microreactor. The size of the catalyst samples was 0.5" diameter and 0.4" length. The feed was composed of 60 ppm C.sub.3 H.sub.6 in dry air in the temperature range of 25 to 100.degree. C. The C.sub.3 H.sub.6 was measured at 60, 70, 80, 90 and 100.degree. C. at steady sate condition. Results are summarized in Table VII.

TABLE VII SUMMARY RESULTS OF C3H6 CONVERSION Catalyst Name Pt/ Pt/Al.sub.2 O.sub.3 10% W/ Pt/10% Re/ % C3H6 Pt/Al.sub.2 O.sub.3 Calcined Al.sub.2 O.sub.3 Al.sub.2 O.sub.3 Conversion Calcined and reduced Calcined Calcined @ (Ex. 18) (Ex. 18) (Ex. 19) (Ex. 20) 60.degree. C. 0 10 9 11 70.degree. C. 7 22 17 27 80.degree. C. 20 50 39 45 90.degree. C. 38 70 65 64 100.degree. C. 60 83 82 83

It is clear from the Table that addition of W or Re oxide has enhanced the activity of the Pt/Al.sub.2 O.sub.3 in the calcined form. The C.sub.3 H.sub.6 conversion of the calcined Pt/Al.sub.2 O.sub.3 was enhanced significantly when catalyst was reduced at 400.degree. C. for 1 hour. The enhanced activity was also observed for the calcined catalyst by incorporation of W or Re oxides.

Example 22

This is an example of preparing high surface area cryptomelane using MnSO.sub.4.

Molar ratios: KMnO.sub.4 : MnSO.sub.4 : acetic acid were 1:1.43: 5.72

Molarities of Mn in solutions prior to mixing were:

0.44 M KmnO.sub.4

0.50 M MnSO.sub.4

FW KMnO.sub.4 =158.04 g/mol

FW MnSO.sub.4.H.sub.2 O=169.01 g/mol

FW C.sub.2 H.sub.4 O.sub.2 =60.0 g/mol

The following steps were conducted: 1. Made a solution of 3.50 moles (553 grams) of KMnO.sub.4 in 8.05 L of D.I. water and heated to 68.degree. C. 2. Made 10.5 L of 2N acetic acid by using 1260 grams of glacial acetic acid and diluting to 10.5 L with D.I. water. Density of this solution is 1.01 g/mL. 3. Weighed out 5.00 moles (846 grams) of manganous sulfate hydrate (MnSO.sub.4.H.sub.2 O) and dissolved in 10,115 g of the above 2N acetic acid solution and heated to 40.degree. C. 4. Added the solution from 3. to the solution from 1. over 15 minutes while continuously stirring. After addition was complete, began heating the slurry according to the following heat-up rate:

1:06 pm 69.4.degree. C. 1:07 pm 71.2.degree. C. 1:11 pm 74.5.degree. C. 1:15 pm 77.3.degree. C. 1:18 pm 80.2.degree. C. 1:23 pm 83.9.degree. C. 1:25 pm 86.7.degree. C. 1:28 pm 88.9.degree. C. 5. At 1:28 pm approximately 100 mL of slurry was removed from the vessel and promptly filtered on a BUchner funnel, washed with 2 L of D.I. water, and then dried in an oven at 100.degree. C. The sample was determined to have a BET Multi-Point surface area of 259 m.sup.2 /g.

Example 23

This is an example of preparing high surface area cryptomelane using Mn(CH.sub.3 COO).sub.2.

Molar ratios: KMnO.sub.4 : Mn(CH.sub.3 CO.sub.2).sub.2 : acetic acid were 1:1.43:5.72

FW KMnO.sub.4 =158.04 g/mol Aldrich Lot #08824MG

FW Mn(CH.sub.3 CO.sub.2).sub.2.H.sub.2 O=245.09 g/mol Aldrich Lot #08722HG

FW C.sub.2 H.sub.4 O.sub.2 =60.0 g/mol 1. Made a solution of 2.0 moles (316 grams) of KMnO.sub.4 in 4.6 L of D.I. water and heated to 60.degree. C. by heating on hot plates. 2. Made up 6.0 of 2N acetic acid by using 720 grams of glacial acetic acid and diluting to 6.0 L with D.I. water. Density of this solution is 1.01 g/mL. 3. Weighed out 2.86 moles (700 grams) of manganese (II) acetate tetrahydrate [Mn(CH.sub.3 CO.sub.2).sub.2.4H2O] and dissolved in 5780 g of the above 2N acetic acid solution (in the reactor vessel). Heated to 60.degree. C. in the reactor vessel. 4. Added the solution from 1. to the solution from 3. while maintaining the slurry at 62-63.degree. C. After complete addition, gently heated the slurry according to the following:

82.0.degree. C. at 3:58 pm

86.5.degree. C. at 4:02 pm

87.0.degree. C. at 4:06 pm

87.1.degree. C. at 4:08 pm

shut off heat then quenched the slurry by pumping 10 L of D.I. water into the vessel. This cooled the slurry to 58.degree. C. at 4:13 pm. The slurry was filtered on Buchner funnels. The resulting filter cakes were reslurried in 12 L of D.I. water then stirred overnight in a 5 gallon bucket using a mechanical stirrer. The washed product was refiltered in the morning then dried in an oven at 100.degree. C. The sample was determined to have a BET Multi-Point surface area of 296 m.sup.2 /g. The resulting cryptomelane is characterized by the XRD pattern of FIG. 20. It is expected to have an IR spectrum similar to that shown in FIG. 19.

Example 24

Following is a description of the ozone testing method for determining percent ozone decomposition used in this Example. A test apparatus comprising an ozone generator, gas flow control equipment, water bubbler, chilled mirror dew point hygrometer, and ozone detector was used to measure the percent ozone destroyed by catalyst samples. Ozone was generated in situ utilizing the ozone generator in a flowing gas stream comprised of air and water vapor. The ozone concentration was measured using the ozone detector and the water content was determined utilizing the dew point hygrometer. Samples were tested as 25.degree. C. using inlet ozone concentrations of 4.5 to 7 parts per million (ppm) in a gas stream flowing at approximately 1.5 L/minute with a dew point between 15.degree. C. and 17.degree. C. Samples were tested as particles sized to -25/+45 mesh held between glass wool plugs in a 1/4" I.D. Pyrex.RTM. glass tube. Tested samples filled a 1 cm portion of the glass tube.

Sample testing generally required between 2 to 16 hours to achieve a steady state of conversion. Samples typically gave close to 100% conversion when testing began and slowly decreased to a "leveled off" conversation that remained steady for extended periods of time (48 hours). After a steady state was obtained, conversions were calculated from the equation: % ozone conversion=[(1-(ozone concentration after passing over catalyst)/(ozone concentration before passing over catalyst)]*100.

Ozone destruction testing on the sample of Example 22 showed 58% conversion.

Ozone destruction testing on the sample of Example 23 showed 85% conversion.

Example 25

This example is intended to illustrate that the method of Example 23 generated "clean" high surface area cryptomelane for which the ozone destruction performance was not further enhanced by calcination and washing. A 20 gram portion of the sample represented by Example 23 was calcined in air at 200.degree. C. for 1 hour, cooled to room temperature, then washed at 100.degree. C. in 200 mL of D.I. water by stirring the slurry for 30 minutes. The resulting product was filtered and dried at 100.degree. C. in an oven. The sample was determined to have BET Multi-Point surface area of 265 m.sup.2 /g. Ozone destruction testing on the sample showed 85% conversion. A comparison to the testing of the sample of Example 23 demonstrated that no benefit in ozone conversion was realized from the washing and calcination of the sample of Example 23.

Example 26

Samples of high surface area cryptomelane were obtained from commercial suppliers and modified by calcination and/or washing. As received and modified powders were tested for ozone decomposition performance according to the method of Example 24 and characterized by powder X-ray diffraction, infrared spectroscopy, and BET surface area measurements by nitrogen adsorption.

Example 26a

A commercially supplied sample of high surface area cryptomelane (Chemetals, Inc., Baltimore, Md.) was washed for 30 minutes in D.I. water at 60.degree. C., filtered, rinsed, and oven-dried at 100.degree. C. Ozone conversion of the as received sample was 64% compared to 79% for the washed material. Washing did not change the surface area or crystal structure of this material (223 m.sup.2 /g cryptomelane) as determined by nitrogen adsorption and powder X-ray diffraction measurements, respectively. However, infrared spectroscopy showed the disappearance of peaks at 1220 and 1320 wavenumbers in the spectrum of the washed sample indicating the removal of sulfate group anions.

Example 26b

Commercially supplied samples of high surface area cryptomelane (Chemetals, Inc., Baltimore, Md.) were calcined at 300.degree. C. for 4 hours and 400.degree. C. for 8 hours. Ozone conversion of the as received material was 44% compared to 71% for the 300.degree. C. calcined sample and 75% for the 400.degree. C. calcined sample. Calcination did not significantly change the surface area or crystal structure of the 300.degree. C. or 400.degree. C. samples (334 m.sup.2 /g cryptomelane). A trace of Mn.sub.2 O.sub.3 was detected in the 400.degree. C. sample. Calcination causes dehydroxylation of these samples. Infrared spectroscopy show a decrease in the intensity of the band between 2700 and 3700 wavenumbers assigned to surface hydroxyl groups.

Example 27

The addition Pd black (containing Pd metal and oxide) to high surface area cryptomelane is found to significantly enhance ozone decomposition performance. Samples were prepared comprising Pd black powder physically mixed with powders of (1) a commercially obtained cryptomelane (the 300.degree. C.

calcined sample described in Example 26b) and (2) the high surface area cryptomelane synthesized in Example 23 calcined at 200.degree. C. for 1 hour. The samples were prepared by mixing, in a dry state, powder of Pd black and cryptomelane in a 1:4 proportion by weight. The dry mixture was shaken until homogeneous in color. An amount of D.I. water was added to the mixture in a beaker to yield 20-30% solids content, thus forming a suspension. Aggregates in the suspension were broken up mechanically with a stirring rod. The suspension was sonicated in a Bransonic.RTM. Model 5210 ultrasonic cleaner for 10 minutes and then oven dried at 120-140.degree. C. for approximately 8 hours.

The ozone conversion for the commercially obtained cryptomelane calcined at 300.degree. C. was 71% as measured on the powder reactor (Example 26b). A sample of this product was mixed with 20 weight percent Pd black yielded 88% conversion.

The cryptomelane sample prepared as in Example 23 calcined at 200.degree. C. had 85% conversion. Performance improved to 97% with 20 weight percent Pd black added.

Example 28

1500 g of high surface area manganese dioxide (cryptomelane purchased from Chemetals) and 2250 g of deionized water were combined in a one gallon ball mill and milled for 1.5 hours to a particle size 90%.ltoreq.7 .mu.m. After draining the resulting slurry from the mill into a separate 1 gallon container, sufficient KOH (20% solution in DI water) was added to raise the pH to ca. 9.5. Additional KOH was added over the next several days to maintain a pH of 9.5. Subsequently, 294 g (10% solids basis) of National Starch x-4280 acrylic latex polymer (51% solids) was added. Thorough blending of the binder was achieved by rolling the container containing the slurry on a two roll mill. The container contained no milling media such as ceramic milling balls. Slurry made according to this process was coated onto a variety of substrates and exhibited excellent adhesion. Such substates included a porous monolithic support (eg. ceramic honeycomb) onto which the coating was applied by dipping the honeycomb into the slurry. The slurry was also spray coated onto an aluminum radiator. It was also dip coated on to small radiator minicores of the type recited above. Additionally, polyfiber filter media of the type used to filter air was coated by dipping or spraying. Typically, the samples were coated with loadings which could vary from 0.15 to 1.5 grams per cubic inch. The samples were air dried at 30.degree. C. until dry, typically for at least two hours. Excellent catalyst adhesion was attained in each case (i.e. coating could not be wiped off). Higher temperatures of drying (up to 150.degree. C.) can be utilized if desired. The latex cures during drying.

Example 29

To 96.56 g of the ball milled catalyst slurry obtained in Example 28 (before KOH addition) was added 3.20 g (3% solids basis) of Rhone-Poulenc Colloid 226 polymeric dispersant. After rolling the mixture on a roll mill for several hours, 7.31 g (10% solids basis) of National Starch x-4280 acrylic latex polymer (51% solids) was added. As in Example 28, thorough blending of the binder was achieved by rolling the container containing the slurry on a two roll mill. The container contained no milling media such as ceramic milling balls. Slurry made according to this process was coated onto a variety of substrates and exhibited excellent adhesion. Such substates included a porous monolithic support (eg. ceramic honeycomb) onto which the coating was applied by dipping the honeycomb into the slurry. The slurry was also dip coated on to small radiator minicores of the type recited above. Typically, the samples were coated with loadings which could vary from 0.15 to 1.5 grams per cubic inch. The samples were air dried at 30.degree. C. until dry, typically for at least two hours. Excellent catalyst adhesion was attained in each case (i.e. coating could not be wiped off). Higher temperatures of drying (up to 150.degree. C.) can be utilized if desired. The latex cures during drying.

Example 30

8.9 grams of D.I. water was added to 1.1 grams of TiO2 nano powder in a beaker. An ammonia/water concentrate was added to adjust the pH to 9.5. A solution of amine solubilized platinum hydroxide having 17.75 weight percent platinum (based on metallic platinum) was slowly added, with mixing to obtain 5% by weight of platinum on titania. Then a solution of palladium nitrate containing 20% by weight based on palladium metal was added, with mixing to obtain 14.3% palladium on the titania. A one-inch diameter by one-inch long 400 cells per square inch (cpsi) metal monolith cored sample was dipped into the slurry. Air was blown over the coated monolith to clear the channels and the monolith was dried for three hours at 110.degree. C. At this time, the monolith was redipped into the slurry once again and the steps of air blowing the channels and drying at 110.degree. C. was repeated. The twice coated monolith was calcined at 300.degree. C. for two hours. After this initial evaluation the catalyst core was reduced in a forming gas having 7% hydrogen and 93% nitrogen at 300.degree. C. for 12 hours. The catalyst was evaluated in an air stream containing 20 ppm carbon monoxide and 20 ppm of hydrocarbons based on C.sub.1. The hydrocarbons were evaluated in the presence of the 20 ppm CO. The hydrocarbons evaluated were ethylene C.sub.2 =; propylene C.sub.3 =; and pentene C.sub.5 =at a gas flow rate of 36.6 liters per minute which corresponds to 300,000 standard hourly space velocity (SHSV). The air stream was at 30% relative humidity (RH). Results are illustrated in FIG. 21.

* * * * *

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January 29, 2016

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY
FEB 0 1 2016
DIVISION OF AIR QUALITY

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HAND DELIVERED

Re: UPDATE – Tesoro Salt Lake City Refinery Installation of Ultra-Low NO_X Burners on Ultraformer Unit (UFU) Furnace F-1

Dear Mr. Gray:

On November 10, 2015, Tesoro Refining & Marketing Company LLC (Tesoro) submitted a Notice of Intent (NOI) application for installation of Ultra-Low NO_X Burners on the Ultraformer Unit (UFU) F-1 Furnace at the Salt Lake City Refinery. The NOI was for the purpose of achieving the NO_X reduction from the F-1 Furnace required by the PM2.5 SIP. Since the time the original application was submitted, Tesoro has determined that the projected annual firing rate of the burners will be higher than anticipated in the original submittal. This results in a very small increase in particulate and VOC emissions. An updated version of Table 3-3 of the original application is presented below to reflect the change in emissions due to the updated projected actual firing rate of the F-1 Furnace. Attachment B (Emission Calculations) has also been updated and is included as an attachment to this letter.

Table 3-3. Project Actual Emission Increase Summary

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
Emissions Unit	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
UFU Furnace F-1	0.00*	0.00	0.00	0.40	0.40	0.40	0.29	0.00
Cogeneration Units	0.72	0.25	0.78	0.10	0.10	0.10	0.05	0.00
New Process Components	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00
Total Project Emission Increase	**0.72**	**0.25**	**0.78**	**0.50**	**0.50**	**0.50**	**2.76**	**0.00**

* For the regulatory applicability purposes of this table, a zero emission increase is shown; however, this project will result in an estimated decrease in actual NO_X emissions of 13 ton/yr.

As described in Section 3.0 of the initial application, the project is not a major modification and is not subject to the PSD program. The updated projected firing rate does not change the PSD applicability of the project.

Section 4.4.2 of the initial application describes applicability of best available control technology (BACT). A BACT review is required for new emission units and existing emission units where there is a physical modification and an increase in emissions. As a result of the updated projected actual firing rate, as shown in the table above, there will be a slight increase in emissions of $PM/PM_{10}/PM_{2.5}$, and VOC from the UFU Furnace F-1. A BACT evaluation has been prepared in accordance with R307-401-5(d) and is attached to this letter. For $PM/PM_{10}/PM_{2.5}$, BACT is determined to be good combustion practices and use of gaseous fuel. For VOC, BACT is determined to be good combustion practice and proper equipment design, which is the industry standard for control of VOC emissions from refinery process heaters.

This update to the NOI application does not change the result of any applicable rules or requirements as described in the original NOI application.

Please contact me at 801-521-4966 or Michelle Bujdoso at 801-366-2036 if you need more information or have questions.

Sincerely,

William Snarr
Health Safety and Environmental Manager

Enclosures

ATTACHMENT A

Best Available Control Technology Review

Prepared for
Tesoro Refining and Marketing Company
Salt Lake City Refinery
Salt Lake City, UT

January 2016

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List of Tables

1.0 Executive Summary

Tesoro Refining & Marketing Company LLC's (Tesoro's) Salt Lake City (SLC) Refinery is proposing to install Ultra Low NO_X burners (ULNB) on the Ultraformer Unit (UFU) Furnace F-1. The Project will replace the existing burners in the UFU Furnace F-1 with ULNB and is being undertaken primarily to meet the $PM_{2.5}$ SIP requirements. The Project will result in an estimated actual reduction in NO_X emissions of 13 tons/yr. Further, the Project will not result in a significant emission increase or significant net emission increase in air emissions of any regulated New Source Review (NSR) pollutant from the refinery; therefore, the Project is not subject to federal NSR requirements as provided in Utah's State Implementation Plan (SIP). However, Utah Administrative Code, Air Quality Rule R307-401-3(c) requires submittal of a Notice of Intent (NOI) to "install a control apparatus or other equipment intended to control emissions of air contaminants." Additionally under R307-401-5(d), the NOI must include, "an analysis of best available control technology for the proposed source or modification" for any unit that will be both physically modified and experience an increase in emissions as a result of the project. Accordingly, Tesoro is submitting this Best Available Control Technology (BACT) analysis for the UFU, which will experience a small increase in emissions of particulate matter and volatile organic compounds as a result of the installation of the ULNB on the UFU. This BACT analysis follows the following approach:

- Step 1 – Identify All Available Control Technologies
- Step 2 – Eliminate Technically Infeasible Options
- Step 3 – Rank Remaining Control Technologies by Control Effectiveness
- Step 4 – Evaluate Most Effective Control Technologies and Document Results
- Step 5 – Select BACT

2.0 BACT Methodology

As presented in R307-401-2 (d):

"*"Best available control technology" means an emissions limitation (including a visible emissions standard) based on the maximum degree of reduction for each air contaminant which would be emitted from any proposed stationary source or modification which the director, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 40 CFR parts 60 and 61. If the director determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard or combination thereof, may be prescribed instead to satisfy the requirement for the application of best available control technology. Such standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and shall provide for compliance by means which achieve equivalent results.*"

For purposes of this analysis, the proposed BACT emissions limits have been selected using the approach set forth above.

Step 1 – Identify all Control Technologies

All available control technologies are identified. A control technology is considered available for a specific pollutant if it could practically be applied to the specific emission unit. To identify all available control technologies, the following sources were consulted:

- EPA's RACT/BACT/LAER Clearinghouse (RBLC);
- EPA's Clean Air Technology Center (CATC) website;
- Control Technology Vendors; and/or
- Other EPA/State air quality permits.

Step 2 – Eliminate Technically Infeasible Options

Each control technology identified in Step 1 is evaluated, using source-specific factors, to determine if it is technically feasible. If physical, chemical and engineering principles demonstrate that a technology could not be successfully used on the emission unit, then that technology is determined to be technically infeasible. Economics are not considered in the determination of technical feasibility. Technologies that are determined to be infeasible are eliminated from further consideration.

Step 3 – Rank Remaining Control Technologies by Control Effectiveness

All technically feasible technologies are ranked in order of overall control effectiveness. Rankings are based on the level of emission control expressed as emissions per unit of production, emissions per unit of energy used, control efficiency, or a similar measure. The control effectiveness listed will be representative of the level of emission control which can be achieved by the control technology at the operating conditions of the emission unit being reviewed. Controls are listed in order of overall control effectiveness for the pollutant under review, with the most effective control alternative at the top.

Step 4 – Evaluate Most Effective Control Technologies and Document Result

The economic, environmental, and energy impacts of each technically feasible control technology are evaluated. Step 4 is only required if the most effective control technology is not proposed as BACT.

Step 5 – Select BACT

The most effective option not rejected is BACT. Per R307-401-2(d), if technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of BACT.

3.0 BACT for Modified UFU Furnace F-1

3.1 UFU Furnace F-1 PM/PM_{10}/$PM_{2.5}$ Emissions

Particulate matter including PM less than 10 microns in diameter (PM_{10}) and PM less than 2.5 microns in diameter ($PM_{2.5}$) has the potential to be emitted from UFU Furnace F-1 as a result of incomplete combustion, particulate matter present in the combustion air, and solid and condensable materials contained in gaseous fuels. The existing UFU Furnace F-1 uses refinery fuel gas. This BACT report consolidates the BACT analysis for PM, $PM_{10,}$ and $PM_{2.5}$ because particulate matter from gaseous fuel firing can all be considered to be fine particulate less than 1.0 micron in size.[1]

3.1.1 Step 1 – Identify All Available Control Technologies for PM/PM_{10}/$PM_{2.5}$ Emissions

Potentially available control options for PM/PM_{10}/$PM_{2.5}$ emissions from combustion at UFU Furnace F-1 are shown in the table below:

Table 3-1 PM/PM_{10}/$PM_{2.5}$ Emission Control Options for UFU Furnace F-1

Technology	Description
Add-On Control Technologies	Add-on particulate control technologies, such as a baghouse or electrostatic precipitator (ESP), are control technologies that reduce primarily filterable particulate emissions entrained in the exhaust gas stream.
Clean Fuels	Both refinery fuel gas and natural gas contain very low concentrations of ash and other forms of particulate matter, thus the use of the gaseous fuel minimizes PM/PM_{10}/$PM_{2.5}$ emissions.
Good Combustion Practices	Good combustion practices are preventative measures that minimize the release of pollutants generated from incomplete combustion of fuels into the environment. Good combustion practices may include the proper design and maintenance of equipment, good housekeeping, and good operating practices.

3.1.2 Step 2 – Technical Feasibility of PM/PM_{10}/$PM_{2.5}$ Control Options as Applied to UFU Furnace F-1

The use of add-on control technologies, such as a baghouse, electrostatic precipitator, or wet scrubber, can provide particulate matter control for solid and liquid fuel combustion applications by removing filterable PM. However, these add-on control technologies are not effective for gaseous

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[1] AP 42, Chapter 1.4 Table 1.4-2, http://www3.epa.gov/ttn/chief/ap42/ch01/final/c01s04.pdf

fuel post-combustion emissions control due to the very low filterable PM outlet concentrations and the capture limitations of the control technologies.

EPA's emissions factor information for natural gas combustion provided in AP-42, lists the filterable particulate matter concentration for natural gas combustion at 0.0015 gr/dscf exhaust, which is lower than the post-combustion outlet range achievable with add-on control devices. Additionally, it is expected that the particulate emission rates for refinery fuel gas combustion are consistent with the natural gas factors from AP-42 and also are below the post-combustion outlet range achievable with add-on control devices. Accordingly, add on controls are not proposed because they will not reduce emissions for this source fired by refinery fuel gas.

It is Tesoro's understanding that no add-on control technologies for particulate emissions have been applied to reduce particulate emissions from a gas-fired refinery process heater. Additionally, there were no applications of add-on particulate control technologies for gas fuel gas fired process heaters identified in the RBLC or any of the other references reviewed as part of this BACT analysis, as listed in Section 1.0 above. This is most likely because gaseous fuels have almost no inert materials or ash, and therefore, the "uncontrolled" filterable particulate emissions from the combustion of these gaseous fuels is as low (or lower) than a controlled filterable particulate emission rate from a solid or liquid fuel combustion source that uses an air pollution control technology such as a baghouse.

Consequently, there is no add-on control technology that is technically feasible for controlling PM/PM_{10}/ $PM_{2.5}$ emissions at UFU Furnace F-1. Adherence to good combustion practices with the use of refinery fuel gas are the only technically feasible control options for control of particulate emissions.

3.1.3 Step 3 – Rank Effectiveness of Feasible PM/PM_{10}/$PM_{2.5}$ Control Options

Tesoro will combine good combustion practices with the use of refinery fuel gas as clean fuels because those options are the only technically feasible PM/PM_{10}/$PM_{2.5}$ control options for UFU Furnace F-1. Ranking of the control measures is not necessary because both can be used in combination.

3.1.4 Step 4 – Evaluation of Most Effective PM/PM_{10}/$PM_{2.5}$ Control Options

Tesoro has selected the only technically feasible, and thus the top ranked, control options. There are no adverse energy, environmental, or economic impacts associated with implementing good combustion practices or with the use of refinery fuel gas at UFU Furnace F-1.

3.1.5 Step 5 – $PM/PM_{10}/PM_{2.5}$ BACT Selection

Good combustion practices in conjunction with the use of refinery fuel gas is the proposed BACT for particulate emissions from UFU Furnace F-1. Total particulate emissions, including PM, PM_{10} and $PM_{2.5}$, from UFU Furnace F-1 have been estimated using the AP-42 emission factor of 0.0075 lb/MMBtu for natural gas combustion, which is a representative estimate of the $PM/PM_{10}/PM_{2.5}$ emissions that may result from refinery fuel gas combustion. Per AP-42 all PM (total, condensable, and filterable) that results from gaseous fuel combustion can be considered to be less than 1.0 micrometer in diameter; therefore the PM emission factor can be used to estimate PM, PM_{10} and $PM_{2.5}$. To ensure continued operation applying good combustion techniques, Tesoro will conduct heater tune-ups in accordance with 40 C.F.R. Part 63, Subpart DDDDD. Actions taken during each tune up will follow the schedule required for this unit under NESHAP Subpart DDDDD.

3.2 UFU Furnace F-1 VOC Emissions

VOC is emitted from UFU Furnace F-1 as a result of incomplete combustion of hydrocarbons. VOC formation is dependent on the efficiency of the process heaters. Emissions are result of low operating temperature, insufficient residence time, inadequate mixing, and/or low air-to-fuel ratio in the combustion zone. Additionally, trace amounts of VOC species in the refinery fuel gas (e.g., formaldehyde and benzene) may also contribute to VOC emissions if they are not completely combusted in the unit.

3.2.1 Step 1 – Identify All Available Control Technologies for VOC Emissions

Potentially available control options for VOC emissions from UFU Furnace F-1 are shown in the table below:

Table 3-2 VOC Emission Control Options

Technology	Description
Catalytic Oxidation	Catalytic oxidation of VOC gases requires a catalyst bed located in the exhaust of the unit being controlled where VOCs are converted to CO_2 and water vapor in the presence of excess air in the combustion exhaust stream. For gaseous fired combustion units reduction efficiency can reach up to 50%. The optimal range for oxidation catalysts is approximately 850 to 1,100 °F.
Proper Burner Design and Good Combustion Practices	Good design includes process and mechanical equipment designs which are either inherently lower polluting or are designed to minimize emissions and achieve good combustion efficiency. Good combustion practice includes operational and design elements to control the amount and distribution of excess air in the flue gas. This ensures that there is enough oxygen present for complete combustion. If sufficient combustion air supply, temperature, residence time, and mixing are incorporated in the combustion design and operation, VOC emissions are minimized.

3.2.2 Step 2 – Technical Feasibility of VOC Control Options as Applied to UFU Furnace F-1

The technical feasibility of potential control options for VOC emissions are summarized in the below table.

Table 3-3 Technical Feasibility of VOC Control Options for UFU Furnace F-1

Technology	Technically Feasible?
Catalytic Oxidation	No
Proper Burner Design and Good Combustion Practices	Yes

Tesoro contacted vendors regarding VOC removal by catalytic oxidation. Vendors have indicated that saturated hydrocarbon removal can only be achieved at temperatures above 800°F, which will be above the normal operating range of the process heater, making catalytic oxidation infeasible for VOC control.

3.2.3 Step 3 – Effectiveness of Feasible VOC Control Options

Proper burner design and good combustion practices is the only technically feasible VOC control option at UFU Furnace F-1 and is therefore the top ranked control.

3.2.4 Step 4 – Evaluation of Most Effective VOC Control Options

Tesoro has selected the only technically feasible, and thus the top ranked, control option. There are no adverse energy, environmental, or economic impacts associated with implementing proper burner design and good combustion practices. The only control strategy identified for the refinery fuel gas-fired process heaters is adherence to good combustion practices. This control strategy is technically feasible and will not cause adverse energy, environmental, or economic impacts.

3.2.5 Step 5 – VOC BACT Selection

Adherence to good combustion practices is the proposed BACT for VOC emissions from UFU Furnace F-1. The UFU Furnace F-1 will implement good combustion practices, including preventative measures that minimize the release of pollutants into the environment. Good combustion practice includes operational and design elements to control the amount and distribution of excess air in the flue gas. This ensures that there is enough oxygen present for complete combustion. Since sufficient combustion air supply, temperature, residence time, and mixing are incorporated in the combustion design and operation, VOC emissions are minimized. To ensure continued operation applying good combustion techniques, Tesoro will conduct heater tune-ups in accordance with 40 C.F.R. Part 63, Subpart DDDDD. Actions taken during each tune up will follow the schedule required for this unit under NESHAP Subpart DDDDD.

The VOC emissions from UFU Furnace F-1 have been estimated using the AP-42 emission factor of 0.0054 lb/MMBtu for natural gas combustion, which is a representative estimate of the VOC emissions that may result from refinery fuel gas combustion at UFU Furnace F-1.

ATTACHMENT B

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 1 - PSD Applicability Determination and Reasonable Possiblity Requirements

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
Project Emission Increases	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
F-1	0.00	0.00	0.00	0.40	0.40	0.40	0.29	0.00
Cogen	0.72	0.25	0.78	0.10	0.10	0.10	0.05	0.00
Components	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00
Total Project Emission Increase	**0.72**	**0.25**	**0.78**	**0.50**	**0.50**	**0.50**	**2.76**	**0.00**
PSD Significant Emission Rate (SER)	40	40	100	25	15	10	40	7
Is Project Emission Increase Greater than PSD Significant Emission Rate?	No	No	No	No	No	No	No	No

Reasonable Possibility Requirements

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
	tpy	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
Project Emission Increase	0.72	0.25	0.78	0.50	0.50	0.50	2.76	0.00
Demand Growth Exclusion	0.00	1.98	0.00	0.46	0.46	0.46	0.33	0.03
Project Emission Increase + Demand Growth Exclusion	0.72	2.23	0.78	0.96	0.96	0.96	3.09	0.03
PSD Significant Emission Rate (SER)	40	40	100	25	15	10	40	7
Is Project Emission Increase Greater than 1/2 of the PSD Significant Emission Rate?	No	No	No	No	No	No	No	No
Is Project Emission Increase + Demand Growth Exclusion Greater than 1/2 of the PSD Significant Emission Rate?	No	No	No	No	No	No	No	No
Is Preconstruction Determination Required?	No	No	No	No	No	No	No	No
Is Recordkeeping of Annual Actual Emissions Required?	No	No	No	No	No	No	No	No

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

Date	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Nov-07	3.73	0.18	2.46	0.22	0.22	0.22	0.16	0.00	9.23	59,823	83.81
Dec-07	3.34	0.13	2.21	0.20	0.20	0.20	0.14	0.00	7.48	53,547	75.02
Jan-08	4.42	0.20	2.76	0.25	0.25	0.25	0.18	2.97E-03	9.99	67,048	99.19
Feb-08	3.92	0.17	2.70	0.24	0.24	0.24	0.18	2.48E-03	9.31	65,564	88.01
Mar-08	4.69	0.23	2.77	0.25	0.25	0.25	0.18	3.50E-03	10.32	67,207	105.29
Apr-08	4.71	0.32	2.87	0.26	0.26	0.26	0.19	4.84E-03	10.23	69,596	105.70
May-08	4.77	0.32	2.95	0.27	0.27	0.27	0.19	4.87E-03	10.29	71,560	107.25
Jun-08	4.25	0.56	3.15	0.28	0.28	0.28	0.21	8.42E-03	9.65	76,467	95.45
Jul-08	4.45	0.61	3.04	0.27	0.27	0.27	0.20	9.14E-03	9.92	73,790	99.96
Aug-08	4.39	0.35	2.73	0.25	0.25	0.25	0.18	5.24E-03	9.55	66,154	98.67
Sep-08	4.13	0.27	2.56	0.23	0.23	0.23	0.17	4.02E-03	9.17	62,123	92.76
Oct-08	3.81	0.21	2.55	0.23	0.23	0.23	0.17	3.08E-03	8.24	61,939	85.54
Nov-08	4.27	0.16	2.65	0.24	0.24	0.24	0.17	2.39E-03	7.81	64,230	83.73
Dec-08	4.25	0.14	2.63	0.24	0.24	0.24	0.17	2.16E-03	7.59	63,912	78.90
Jan-09	4.87	0.22	3.02	0.27	0.27	0.27	0.20	3.28E-03	7.90	73,267	85.84
Feb-09	4.38	0.13	2.71	0.25	0.25	0.25	0.18	1.96E-03	8.42	65,848	83.95
Mar-09	4.50	0.25	2.79	0.25	0.25	0.25	0.18	3.82E-03	10.06	67,742	101.51
Apr-09	4.47	0.28	2.77	0.25	0.25	0.25	0.18	4.22E-03	9.59	67,260	90.20
May-09	5.29	0.33	3.28	0.30	0.30	0.30	0.21	4.88E-03	10.16	79,555	105.69
Jun-09	4.96	0.35	3.07	0.28	0.28	0.28	0.20	5.28E-03	10.31	74,579	101.40
Jul-09	5.02	0.45	3.11	0.28	0.28	0.28	0.20	6.73E-03	10.44	75,487	102.10
Aug-09	4.57	0.38	2.83	0.26	0.26	0.26	0.19	5.75E-03	9.52	68,763	89.28
Sep-09	4.63	0.35	2.87	0.26	0.26	0.26	0.19	5.18E-03	9.95	69,687	90.07
Oct-09	4.48	0.31	2.78	0.25	0.25	0.25	0.18	4.68E-03	9.09	67,400	87.47
Nov-09	3.61	0.27	2.61	0.24	0.24	0.24	0.17	4.10E-03	9.48	63,324	84.42
Dec-09	3.22	0.15	2.33	0.21	0.21	0.21	0.15	2.32E-03	5.65	56,538	64.12
Jan-10	4.49	0.27	3.24	0.29	0.29	0.29	0.21	4.09E-03	9.70	78,759	92.27
Feb-10	3.63	0.36	2.62	0.24	0.24	0.24	0.17	5.44E-03	9.98	63,601	85.56
Mar-10	1.09	0.02	0.79	0.07	0.07	0.07	0.05	3.25E-04	1.25	19,186	19.90
Apr-10	4.03	0.17	2.91	0.26	0.26	0.26	0.19	2.57E-03	7.05	70,673	70.77
May-10	4.56	0.35	3.29	0.30	0.30	0.30	0.22	5.31E-03	10.74	79,965	104.62
Jun-10	4.22	0.36	3.05	0.28	0.28	0.28	0.20	5.34E-03	10.39	74,092	96.31
Jul-10	4.51	0.49	3.26	0.29	0.29	0.29	0.21	7.38E-03	10.75	79,122	107.65
Aug-10	4.60	0.46	3.32	0.30	0.30	0.30	0.22	6.94E-03	10.87	80,633	106.30

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Sep-10	4.30	0.29	3.10	0.28	0.28	0.28	0.20	4.41E-03	10.57	75,363	99.00
Oct-10	4.56	0.29	3.30	0.30	0.30	0.30	0.22	4.31E-03	10.09	79,985	95.87
Nov-10	3.20	0.16	2.71	0.25	0.25	0.25	0.18	2.36E-03	7.84	65,892	72.03
Dec-10	3.53	0.24	3.00	0.27	0.27	0.27	0.20	3.63E-03	10.24	72,776	95.80
Jan-11	3.42	0.30	2.90	0.26	0.26	0.26	0.19	4.48E-03	9.00	70,446	83.78
Feb-11	2.96	0.25	2.51	0.23	0.23	0.23	0.16	3.73E-03	9.46	60,963	79.36
Mar-11	3.65	0.32	3.10	0.28	0.28	0.28	0.20	4.74E-03	10.11	75,339	94.55
Apr-11	3.61	0.31	3.07	0.28	0.28	0.28	0.20	4.65E-03	9.98	74,535	93.72
May-11	3.49	0.29	2.97	0.27	0.27	0.27	0.19	4.34E-03	9.85	71,991	94.68
Jun-11	3.42	0.26	2.91	0.26	0.26	0.26	0.19	3.84E-03	9.25	70,612	86.83
Jul-11	4.09	0.34	3.47	0.31	0.31	0.31	0.23	5.05E-03	NA	84,303	109.77
Aug-11	3.92	0.34	3.33	0.30	0.30	0.30	0.22	5.05E-03	NA	80,753	109.75
Sep-11	3.94	0.37	3.35	0.30	0.30	0.30	0.22	5.62E-03	NA	81,334	120.73
Oct-11	3.82	0.28	3.21	0.29	0.29	0.29	0.21	4.14E-03	NA	77,932	96.53
Nov-11	3.29	0.17	2.76	0.25	0.25	0.25	0.18	2.49E-03	NA	67,069	80.81
Dec-11	3.10	0.13	2.60	0.24	0.24	0.24	0.17	1.91E-03	NA	63,203	66.44
Jan-12	3.28	0.16	2.76	0.25	0.25	0.25	0.18	2.33E-03	7.57	67,010	82.15
Feb-12	3.05	0.16	2.57	0.23	0.23	0.23	0.17	2.41E-03	7.31	62,283	76.46
Mar-12	4.07	0.31	3.42	0.31	0.31	0.31	0.22	4.67E-03	9.38	83,059	105.11
Apr-12	4.12	0.30	3.46	0.31	0.31	0.31	0.23	4.45E-03	9.81	83,988	102.71
May-12	4.07	0.28	3.43	0.31	0.31	0.31	0.22	4.22E-03	9.18	83,158	100.28
Jun-12	4.45	0.35	3.75	0.34	0.34	0.34	0.25	5.26E-03	11.10	90,908	109.11
Jul-12	4.41	0.39	3.71	0.34	0.34	0.34	0.24	5.84E-03	10.17	90,090	105.43
Aug-12	4.60	0.30	3.87	0.35	0.35	0.35	0.25	4.53E-03	10.52	93,923	111.37
Sep-12	4.31	0.27	3.62	0.33	0.33	0.33	0.24	4.08E-03	10.37	87,929	106.86
Oct-12	3.96	0.21	3.33	0.30	0.30	0.30	0.22	3.21E-03	8.85	80,761	96.80
Nov-12	4.51	0.34	3.79	0.34	0.34	0.34	0.25	5.04E-03	10.08	91,973	110.42
Dec-12	3.47	0.24	3.33	0.30	0.30	0.30	0.22	3.54E-03	8.68	80,775	97.05
Jan-13	3.59	0.30	3.44	0.31	0.31	0.31	0.23	4.56E-03	8.74	83,483	96.82
Feb-13	2.93	0.27	2.80	0.25	0.25	0.25	0.18	4.07E-03	8.56	68,030	82.81
Mar-13	4.07	0.56	3.90	0.35	0.35	0.35	0.26	8.37E-03	10.47	94,614	116.13
Apr-13	2.98	0.76	2.86	0.26	0.26	0.26	0.19	1.14E-02	7.75	69,392	100.84
May-13	3.59	0.57	3.44	0.31	0.31	0.31	0.22	8.54E-03	9.48	83,391	114.61
Jun-13	4.02	0.52	3.85	0.35	0.35	0.35	0.25	7.73E-03	11.04	93,567	104.98

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

Date	NO_X tons [1]	SO_2 tons [2]	CO tons [3]	PM tons [4]	PM_{10} tons [5]	$PM_{2.5}$ tons [6]	VOC tons [7]	H_2SO_4 tons [8]	UFU MBPD [9]	Fuel Gas Firing MMBtu [9]	Fuel Gas Firing MMscf [9]
Jul-13	4.20	0.43	4.02	0.36	0.36	0.36	0.26	6.50E-03	11.11	97,568	111.13
Aug-13	3.61	0.27	3.46	0.31	0.31	0.31	0.23	4.05E-03	9.69	84,032	93.20
Sep-13	3.21	0.28	3.08	0.28	0.28	0.28	0.20	4.15E-03	8.92	74,749	82.92
Oct-13	3.59	0.15	3.44	0.31	0.31	0.31	0.22	2.22E-03	9.80	83,379	87.20
Nov-13	3.58	0.11	3.11	0.28	0.28	0.28	0.20	1.66E-03	9.06	75,393	82.87
Dec-13	3.65	0.15	3.16	0.29	0.29	0.29	0.21	2.30E-03	8.71	76,790	74.68
Jan-14	4.21	0.14	3.65	0.33	0.33	0.33	0.24	2.13E-03	9.93	88,626	86.57
Feb-14	3.04	0.16	2.63	0.24	0.24	0.24	0.17	2.46E-03	8.26	63,934	69.82
Mar-14	4.07	0.26	3.53	0.32	0.32	0.32	0.23	3.89E-03	10.43	85,608	95.01
Apr-14	3.86	0.22	3.35	0.30	0.30	0.30	0.22	3.33E-03	10.67	81,325	86.00
May-14	3.97	0.24	3.44	0.31	0.31	0.31	0.23	3.54E-03	10.69	83,610	88.44
Jun-14	3.70	0.24	3.21	0.29	0.29	0.29	0.21	3.54E-03	10.44	77,808	81.59
Jul-14	4.04	0.42	3.50	0.32	0.32	0.32	0.23	6.37E-03	10.56	84,958	89.12
Aug-14	3.85	0.32	3.34	0.30	0.30	0.30	0.22	4.77E-03	10.52	81,122	81.89
Sep-14	3.67	0.24	3.19	0.29	0.29	0.29	0.21	3.56E-03	9.82	77,324	79.40
Oct-14	4.19	0.25	3.63	0.33	0.33	0.33	0.24	3.69E-03	11.14	88,221	88.58
Nov-14	3.63	0.13	3.15	0.28	0.28	0.28	0.21	2.00E-03	10.08	76,450	79.72
Dec-14	3.60	0.13	2.82	0.26	0.26	0.26	0.18	2.01E-03	8.78	68,519	80.72
Jan-15	3.73	0.07	2.93	0.26	0.26	0.26	0.19	1.09E-03	8.95	71,090	76.17
Feb-15	3.77	0.09	2.96	0.27	0.27	0.27	0.19	1.40E-03	9.95	71,783	76.11
Mar-15	0.77	0.00	0.60	0.05	0.05	0.05	0.04	4.01E-05	1.78	14,590	13.50
Apr-15	1.46	0.03	1.14	0.10	0.10	0.10	0.07	4.89E-04	4.45	27,718	22.30
May-15	4.01	0.11	3.15	0.28	0.28	0.28	0.21	1.64E-03	9.30	76,384	38.73
Baseline Period Ends:	**Oct-09**	**Jul-13**	**Mar-14**	**Mar-14**	**Mar-14**	**Mar-14**	**Mar-14**	**Jul-13**	--	--	--
Baseline Actual Emissions (tpy):	**53.16**	**4.00**	**41.32**	**3.74**	**3.74**	**3.74**	**2.70**	**0.06**	--	--	--

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Monthly Maximum Throughput During Baseline (mmbtu):	79,555	121	97,568	97,568	97,568	97,568	97,568	121	11.14	97,568	120.73
Occurs:	May-09	Sep-11	Jul-13	Jul-13	Jul-13	Jul-13	Jul-13	Sep-11	Oct-14	Jul-13	Sep-11

Emission Factor References

[1] Nov-07 through Oct-08: 11/18/04 stack test results of 89.04 lb/MMscf.
Nov-08 through Oct-09: 10/21/08 stack test results of 0.133 lb/MMBtu.
Nov-09 through Oct-10: 10/21/09 stack test results of 0.114 lb/MMBtu.
Nov-10 through Sept-11: 10/28/10 stack test results of 0.097 lb/MMBtu.
Oct-11 through Nov-12: 9/13/11 stack test results of 0.098 lb/MMBtu.
Dec-12 through Oct-13: 11/20/12 stack test results of 0.086 lb/MMBtu
Nov-13 through Nov-14: 10/13/13 stack test results of 0.095 lb/MMBtu
Dec-14 through May-15: 11/17/14 stack test results of 0.105 lb/MMBtu

[2] SO2 (tons) = Monthly average fuel gas H2S contents (ppmv) / 385.34 ft3/lb-mol * 64 lb/lb-mol * MMscf / 2000 lb/ton

[3] Emission factor of 0.0824 lb/MMBtu per AP-42 Table 1.4-1.

[4] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.

[5] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.

[6] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.

[7] Emission factor of 5.39E-03 lb/MMBtu per AP-42 Table 1.4-2.

[8] Assumed to be 1.5% of total SO2 emissions consistent with TRI reporting.

[9] Measured throughput rates, higher heating value (HHV).

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 3a - Projected Actual Emission Calculations for Ultraformer Unit Furnace F-1

Quantity	Value	Units	Reference
Projected Firing Rate:	129.89	Mscf/hr	Calculated
	140.77	MMBtu/hr (HHV)	Engineering estimate, based on projected post project firing rate
Fuel HHV:	1083.8	Btu/scf	Engineering estimate
Fuel H_2S Content:	50	ppmvd	Engineering estimate
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units (HHV)	Projected Emissions (lb/hr) [1]	Projected Emissions (tpy) [2]	Emission Factor Reference
NO_X	0.065	lb/MMBtu	9.15	40.08	Manufacturer's Emission Guarantee
SO_2	8.31	lb/MMscf	1.08	4.73	Calculated
CO	0.050	lb/MMBtu	7.04	30.83	Manufacturer's estimate
PM	0.00745	lb/MMBtu	1.05	4.59	AP-42 Table 1.4-2
PM_{10}	0.00745	lb/MMBtu	1.05	4.59	AP-42 Table 1.4-2
$PM_{2.5}$	0.00745	lb/MMBtu	1.05	4.59	AP-42 Table 1.4-2
VOC	5.39E-03	lb/MMBtu	0.76	3.32	AP-42 Table 1.4-2
H_2SO_4	0.12	lb/MMscf	1.62E-02	7.09E-02	TRI calculation (1.5% of SO2 emissions)

[1] Projected Emissions (lb/hr) = Emission Factor (lb/MMBtu) x Projected Firing Rate (MMBtu/hr) or
Projected Emissions (lb/hr) = Emission Factor (lb/MMscf) x Projected Firing Rate (Mscf/hr) / 1000 Mscf/MMscf

[2] Emission Increase (tpy) = Projected Emissions (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 3b - Projected Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X [1]	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	
	tpy	tpy	tpy	tpy	tpy	tpy	tpy	tpy	**Reference**
A. Baseline Actual Emissions	53.16	4.00	41.32	3.74	3.74	3.74	2.70	0.06	Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
B. Capable of Accommodating	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09	See below.
C. Projected Emissions	40.08	4.73	30.83	4.59	4.59	4.59	3.32	0.07	
D. Demand Growth (D=B-A)	0.00	1.98	0.00	0.46	0.46	0.46	0.33	0.03	
E. Projected Actual Emissions (E=C-D)	40.08	2.74	30.83	4.14	4.14	4.14	2.99	0.04	
F. Emission Increase (F=E-A)	0.00	0.00	0.00	0.40	0.40	0.40	0.29	0.00	

B. Capable of Accommodating	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	Notes
Annual Emission Limits (ton/yr)	CAP	CAP	N/A	N/A	CAP	N/A	N/A	N/A	
Representative Monthly Throughput during Baseline Period (Units/mo)	79,555	120.73	97,568	97,568	97,568	97,568	97,568	120.73	
Month that this occurred:	May-09	Sep-11	Jul-13	Jul-13	Jul-13	Jul-13	Jul-13	Sep-11	
Throughput that Unit was Capable of Accommodating (Units/year)	917,964	1,439.51	1,125,812	1,125,812	1,125,812	1,125,812	1,125,812	1,439.51	Assumes a 98% utilization factor.
Representative Emission Factor that Unit was Capable of Accommodating (lb/Units)	0.065	8.31	0.05	7.45E-03	7.45E-03	7.45E-03	5.39E-03	0.12	
Units	MMBtu	MMscf	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMscf	HHV
Emissions the Unit was Capable of Accommodating during Baseline Period (ton/yr)	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09	

[1] Due to installation of Ultra Low NO_X burners, and the corresponding decrease in NO_X emission factor, capable of accommodating emissions are less than the baseline actual emissions. Therefore, the NO_X emissions increase analysis does not include a demand growth component.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 4 - Potential Emission Calculations for Process Components

Components (service)	**UFU/Fuel Gas** Count [1]	Emission Factor [2] (kg/hr/source)	Emission Factor [2] (lb/hr/source)	Control Effectiveness [3] (%)	Emissions (lbs/yr)	Emissions (Tons/yr)
Valves (gas)	216	0.0268	0.059083	96	4,472	2.24
Valves (LL)	0	0.0109	0.024030	95	-	-
Valves (HL)	0	0.00023	0.000507	0	-	-
Flanges (gas)	408	0.00025	0.00055	81	374	0.19
Flanges (LL)	0	0.00025	0.00055	81	-	-
Flanges (HL)	0	0.00025	0.00055	81	-	-
Pump Seals (LL)	0	0.114	0.25	88	-	-
Pump Seals LL (Tandem)	0	0.114	0.25	100	-	-
Pump Seal (HL)	0	0.021	0.046	0	-	-
Comp. Seals (gas)	0	0.636	1.4	100	-	-
Comp. Seals (H_2)	0	0.636	1.402	100	-	-
Process Drains (total)	0	0.073	0.161	100	-	-
Relief Valves (gas)	0	0.16	0.35	100	-	-
Total					4,846	2.42

Gas = material in a gaseous state at operating conditions
LL = light liquid = material in a liquid state in which the sum of the concentration of individual constituents with a vapor pressure over 0.3 kilopascals (kPa) at 20 oC is greater than or equal to 20 wt%.
HL = heavy liquid = not in gas/vapor service or light liquid service.
In VOC service means that the piece of equipment contains or contacts a process fluid that is at least 10 percent VOC by weight. (40 CFR 60.481)

Notes:

[1] Estimated counts based on P&ID drawings plus a 50% safety factor to be conservative.

[2] Protocol for Equipment Leak Emission Estimates, November 1995, Table 2-2. Refinery Average Emission Factors.

[3] Protocol for Equipment Leak Emission Estimates, November 1995, Table 5-3. Control Effectiveness for an LDAR Program at a Refinery Process Unit. Monitored under the Consent Decree leak definition of 500 ppm, quarterly with no chance for skip monitoring. Equivalent to HON regulation.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 5: Stack Emission Calculations for Cogeneration Units

Quantity	Value	Units	Reference
Steam Requirement:	2,100	lb/hr	Engineering estimate
Firing Requirement:	2.31	MMBtu/hr	Engineering estimate
Fuel Heat Content, HHV:	1083.8	Btu/scf	Engineering estimate for future operations
Fuel Use Requirement:	0.0021	MMscf/hr	Calculated
Fuel H_2S Content:	162	ppmvd	NSPS Ja H_2S concentration limit
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units (HHV)	Emission Increase (lb/hr) (1)	Emission Increase (tpy) (2)	Reference
NO_X	76.80	lb/MMscf	0.16	0.72	Maximum stack test result from 2009 for East Cogeneration Unit
SO_2	26.91	lb/MMscf	5.73E-02	0.25	Calculated
CO	84	lb/MMscf	0.18	0.78	AP-42 Table 3.1-1
PM	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
PM_{10}	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
$PM_{2.5}$	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
VOC	5.5	lb/MMscf	1.17E-02	5.13E-02	AP-42 Table 1.4-2
H_2SO_4	0.40	lb/MMscf	8.60E-04	3.77E-03	TRI calculation (1.5% of SO2 emissions)

Notes:

(1) Emission Increase (lb/hr) = Emission Factor (lb/MMBtu) x Fuel Use Requirement (MMBtu/hr) or
Emission Increase (lb/hr) = Emission Factor (lb/MMscf) x Fuel Use Requirement (MMscf/hr)

(2) Emission Increase (tpy) = Emission Increase (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton

NSR

RECEIVED
NOV 10 2015
DEPARTMENT OF
ENVIRONMENTAL QUALITY

TESORO

Tesoro Refining & Marketing Company LLC
474 West 900 North
Salt Lake City, UT 84103

HAND DELIVERED

November 10, 2015

Marty Gray, Major NSR Section Manager
Utah Division of Air Quality
195 North 1950 West
P.O. Box 144820
Salt Lake City, Utah 84114-4820

Re: Tesoro Salt Lake City Refinery Installation of Ultra-Low NOx Burners Ultraformer Unit F-1 Furnace NOI Submittal

Dear Mr. Gray:

Enclosed please find a Notice of Intent (NOI) application for the installation of Ultra-Low NOx Burners on the Ultraformer Unit (UFU) F-1 Furnace. This project will occur at the Tesoro Refining and Marketing Company's (Tesoro's) Salt Lake City (SLC) Refinery which operates under Approval Order (AO) DAQE-AN103350065-14.

Included is a receipt for $2300 which covers the filing fee and the base fee (Existing Major Source with a Minor Modification) for the NOI application.

Please contact me at 801-521-4966 or Michelle Bujdoso at 801-366-2036 if you need more information or have questions.

Sincerely,

William Snarr
Health, Safety and Environmental Manager

Enclosures

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NOV 10 2015
DEPARTMENT OF
ENVIRONMENTAL QUALITY

Installation of Ultra-Low NO_X Burners on Ultraformer Unit (UFU) Furnace F-1

Notice of Intent for an Approval Order

Prepared for
Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery

November 2015

TESORO

BARR

4700 West 77th Street
Minneapolis, MN 55435-4803
Phone: (952) 832-2600
Fax: (952) 832-2601

Installation of Ultra-Low NO_X Burners on Ultraformer Unit (UFU) Furnace F-1

Notice of Intent for an Approval Order

November 2015

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List of Attachments

1.0 Introduction

This Notice of Intent (NOI) package is submitted for approval of the installation of Ultra Low NO_X burners (ULNB) on the Ultraformer Unit (UFU) Furnace F-1 (Project) at the Tesoro Refining & Marketing Company LLC's (Tesoro's) Salt Lake City (SLC) Refinery. The SLC Refinery currently operates under multiple Approval Orders (AOs), of which DAQE-AN0103350065-14 for the major process units is affected by this Project. The SLC Refinery is situated on 236 acres in Salt Lake County, approximately 1.5 miles north of Salt Lake City.

This Project will replace the existing burners in the UFU Furnace F-1 with ULNB. Similar to Tesoro's project to install a Wet Gas Scrubber and LoTOx™ system on the FCCU/CO Boiler, this project is being undertaken primarily to meet the $PM_{2.5}$ SIP requirements and will result in a significant reduction in NO_X emissions. Due to project timing, Tesoro requests that the NOI for this project be processed concurrently with the Wet Gas Scrubber and and LoTOx™ system NOI.

The Project will not result in a significant emission increase or significant net emission increase in air emissions of a regulated New Source Review (NSR) pollutant from the refinery; therefore, the Project is not subject to federal NSR requirements as provided in Utah's State Implementation Plan (SIP).

Rule R307-401-3(b) requires submittal of an NOI to "make modifications or relocate an existing installation which will or might reasonably expected to increase the amount or change the effect of, or the character of, air contaminants discharged, so that such installation may be expected to become a source or indirect source of air pollution." Rule R307-401-5 requires that the NOI must contain specific information related to the process, nature of emissions, control device(s), and regulatory applicability and compliance. This NOI includes a project description, an emissions summary, and a description of regulatory applicability and demonstration of compliance to address these requirements.

This NOI is organized as follows:

- Section 2.0 contains a project description,
- Section 3.0 contains an NSR applicability analysis,
- Section 4.0 contains a description of regulatory applicability and compliance demonstration,
- Section 5.0 contains a summary of the NOI requirements,

- Attachment A contains a site diagram,
- Attachment B contains the project emission calculations,
- Attachment C contains Form 1 and the NOI checklist.

2.0 Project Description

This section includes a general description of the facility and details of the proposed Project.

2.1 General Facility Information

The Tesoro Salt Lake City Refinery is located at 474 West 900 North, Salt Lake City, Utah. The refinery is located in a nonattainment area for $PM_{2.5}$ (including precursors NO_X, SO_2, and VOC)[1], PM_{10} (including precursors SO_2 and NO_X)[2], and SO_2. The area is also a designated maintenance area for ozone (VOC and NO_X) and CO. Attachment A includes a figure that shows the location of the refinery in Salt Lake City.

2.2 Project Description

This Project involves replacement of the UFU Furnace F-1 (A through E) burners with new burners that will have Ultra Low NO_X burner (ULNB) technology. Specifically, the Project involves the following physical changes:

- UFU Furnace F-1 (A through E) burners will be replaced with new burners with ULNB technology.
- Due to the decreased size of the burner tip orifices in the ULNB, fuel gas coalescers will be installed as recommended by API 535.
- Fuel gas piping from the coalescer to the burners, including new fuel gas control valves, will be changed to stainless steel.
- The existing air pre-heater will be replaced.
- Combustion air ducting will be modified as required to accommodate the new burners, new preheater, and new fans.
- New electronic igniters will be installed.
- The existing induced draft/forced draft fans will be replaced to match the pressure drop requirements of the air pre-heater, ducting, and furnace.
- Furnace repairs will be performed as needed.
- 2,100 lb/hr of steam injection will be used for flame temperature control.

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[1] Utah $PM_{2.5}$ Nonattainment Provisions for Salt Lake County, Section IX.A.21, December 3, 2014.

[2] Utah PM_{10} Maintenance Provisions for Salt Lake County, Section IX.A.10, July 6, 2005.

Tesoro has estimated the existing and future firing capacities of the burners and has determined it is possible that the new burners will have a slightly greater rated maximum hourly heat input capacity than the existing burners. Therefore, the short-term potential-to-emit (PTE) of pollutants other than NO_X may increase at the UFU Furnace F-1 as a result of the Project. However, future actual firing rates and actual emissions are not expected to increase. In order to demonstrate the actual emissions due to the project will not increase, Tesoro has conservatively completed emission calculations. The emission calculations included were completed in accordance with the federal Nonattainment New Source Review (NNSR) and Prevention of Significant Deterioration (PSD) preconstruction permitting programs in Section 3.0 of this application.

2.3 Modified Emission Units

The UFU Furnace F-1 is considered a modified emission unit as a result of the burner replacements. No other emission units are modified as part of this Project.

Upon Project completion, Tesoro does not expect to see an increase in actual emissions for any pollutants at the UFU Furnace. Tesoro does not intend to increase the actual furnace firing rate as a result of the Project. The Project is being undertaken to lower the NO_X emissions from the unit.

2.4 New Emission Units

Minor piping changes involving installation of new components in VOC service will occur as part of this Project.

2.5 Affected Non-Modified Emission Units

The Project does not relieve constraints of any process units at the refinery. The firing rate at the UFU Furnace F-1 does not currently restrict production rate at the UFU. The installation of the new ULNB will not have any upstream or downstream impacts on the refinery's operation. However, a small amount of additional steam from the facility's Cogeneration Units (CG1 and CG2) will be required to assist the operation of the ULNB. Therefore, the Cogeneration Units are non-modified emissions units that will be affected by the Project.

2.6 Project Schedule

The estimated start of construction date is June 2016, pending permit approval. The UFU is expected to restart operations in November 2016, assuming permit approval by the estimated date for start of construction.

3.0 NSR Applicability Analysis

Utah rules implement the New Source Review (NSR) permitting program for major sources and major modifications. Rule R307-403 and R307-405 implement the federal Nonattainment New Source Review (NNSR) and Prevention of Significant Deterioration (PSD) preconstruction permitting programs, respectively. The Tesoro SLC Refinery is a major source as defined in Utah Rule R307-100 and in these federal permitting programs. Therefore, Tesoro has completed an applicability analysis to determine if this Project is a major modification as defined under Utah rules and the NSR permitting program.

The NSR pollutants are covered either by the PSD or NNSR permitting programs, but for purposes of determining applicability as a major modification, the significance thresholds are the same. For simplicity, Tesoro uses the PSD definitions and rules at 40 CFR 52.21 to describe the applicability analysis. The PSD rules are incorporated by reference into the Utah rules.

On June 23, 2014, the U.S. Supreme Court issued its decision in Utility Air Regulatory Group v. EPA. The Court held that EPA may not treat greenhouse gases (GHGs) as an air pollutant for purposes of determining whether a source is a major source required to obtain a PSD or title V permit. As described in the following sections, NSR is not triggered for pollutants other than greenhouse gases (GHG). Since there is not a significant emissions increase of a regulated pollutant other than GHG, GHG is not a regulated pollutant and need not be further analyzed.

3.1 "Hybrid Test" of PSD Applicability

An NSR applicability analysis has been conducted for the Project to determine if it is a "major modification" under NSR regulations. Because this project involves the proposed modification to both "existing emission units" and "new emissions units," the "hybrid test" is used to determine if a "significant emissions increase" and a "significant net emissions increase" of a "regulated NSR pollutant" will occur. The hybrid test is described as the following:[3]

> "... *A significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the emissions increases for each emissions unit, using the method specified in paragraphs (a)(2)(iv)(c) through (e) of this section as applicable with respect to each emissions unit, for each*

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[3] 40 CFR 52.21(a)(2)(iv)(f).

type of emissions unit equals or exceeds the significant amount for that pollutant (as defined in paragraph (b)(23) of this section)..."

The hybrid test refers to the use of two emissions increase calculation methods listed in paragraphs 40 CFR 52.21(a)(2)(iv)(c) and (d). The methods prescribed for existing emissions units are described further below. The remainder of this section focuses on the emissions increase test.

An increase is significant if it exceeds the annual ton per year (tpy) thresholds known as the PSD significant emission rates, which are listed in Table 3-1 for only those regulated NSR pollutants that are emitted in quantifiable amounts from emission units affected by this project.

Table 3-1. NSR Significant Emission Rates

Pollutant[A]	Significant Emission Rate (tpy)
Particulate matter (PM)	25
Particulate matter less than 10 microns (PM_{10})	15
Particulate matter less than 2.5 microns ($PM_{2.5}$)[B]	10
Sulfur dioxide (SO_2)	40
Nitrogen oxides (NO_X)	40
Carbon monoxide (CO)	100
Volatile organic compounds (VOC)	40 [C]
Sulfuric Acid Mist (H_2SO_4)	7

[A] Only those NSR pollutants that are emitted in quantifiable amounts from emission units affected by this project are shown in the table. Condensable particulate matter is included within the definition of PM_{10} and $PM_{2.5}$.

[B] The significant emission rate for direct $PM_{2.5}$ emissions is 10 tpy; additionally this includes 40 tpy of SO_2 emissions and/or 40 tpy of NO_X emissions unless they are demonstrated not to be a $PM_{2.5}$ precursor.

[C] The NSR significant emission rate is assessed based on emissions of volatile organic compounds (VOC) as a precursor to ozone.

"Net emissions increase" means the amount by which the sum of the following exceeds zero:[4]

> *"(a) The increase in emissions from a particular physical change or change in the method of operation at a stationary source as calculated pursuant to paragraph (a)(2)(iv) of this section; and*
>
> *(b) Any other increases and decreases in actual emissions at the major stationary source that are contemporaneous with the particular change and are otherwise creditable. Baseline actual*

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[4] 40 CFR 52.21(b)(3)(i).

> *emissions for calculating increases and decreases under this paragraph (b)(3)(i)(b) shall be determined as provided in paragraph (b)(48) of this section, except that paragraphs (b)(48)(i)(c) and (b)(48)(ii)(d) of this section shall not apply."*

The project emissions increase is calculated as the sum of emissions increases from the existing emissions units that are impacted by this project and the new piping components. If the project emissions increase for a regulated NSR pollutant is less than the significant emission rate, NSR is not required for that pollutant. As described in the following sections, the project emissions increase is less than the significant emission rate for each regulated NSR pollutant.

3.1.1 Actual-to-Projected-Actual Test for Existing Emissions Units

To estimate the change in emissions at the UFU Furnace F-1, Tesoro has utilized the actual-to-projected-actual applicability test which is described in 40 CFR 52.21(a)(2)(iv)(c) as follows:

> *"(c) Actual-to-projected-actual applicability test for projects that only involve existing emissions units. A significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the difference between the projected actual emissions (as defined in paragraph (b)(41) of this section) and the baseline actual emissions (as defined in paragraphs (b)(48)(i) and (ii) of this section), for each existing emissions unit, equals or exceeds the significant amount for that pollutant (as defined in paragraph (b)(23) of this section)."*

Terms within this paragraph that have specific definitions include "existing emissions unit," "projected actual emissions," and "baseline actual emissions." An "existing emissions unit" is any part of a stationary source that emits any regulated NSR pollutant and has been in existence for at least two years from the date it first operated.[5] A description of "projected actual emissions" and "baseline actual emissions" are as follows.

3.1.1.1 Projected Actual Emissions

"Projected actual emissions" are calculated as:[6]

> *"... the maximum annual rate, in tons per year, at which an existing emissions unit is projected to emit a regulated NSR pollutant in any one of the 5 years (12-month period) following the date the unit resumes regular operation after the project, or in any one of the 10 years following that date, if the project involves increasing the emissions unit's design capacity or its potential to emit that regulated NSR pollutant and full utilization of the unit would result in a significant emissions increase or a significant net emissions increase at the major stationary source."*

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[5] 40 CFR 52.21(b)(7)(ii).

[6] 40 CFR 52.21(b)(41)(i).

A source shall consider when determining projected actual emissions any relevant business or regulatory information. In addition, fugitive emissions and emissions associated with startups, shutdowns and malfunctions must be calculated, as applicable. By definition, projected actual emissions shall exclude the portion of the emissions that an existing unit could have accommodated during the baseline period and that are also unrelated to the particular project, including any increased utilization due to product demand growth.[7] A source may use the emission unit's potential to emit in lieu of the aforementioned projected actual emissions calculation.

The projected actual throughput for the UFU Furnace F-1 is based on engineering and business projections. Projected emissions are calculated based on annual throughput and firing rate following startup of the Project and emission factors representative of expected operation. The emission factors used for the projected emissions are generally also representative of the baseline period for most pollutants. For projected actual NO_X and CO emissions, emission factors are based on ULNB manufacturer's specifications.

The product demand growth exclusions, or emissions that the unit was capable of accommodating during the baseline period, are calculated based on the maximum actual firing rate experienced during any 1-month period during the 24-month baseline period. A utilization factor of 98% was used in the calculation of annualized emissions that the emission unit was "capable of accommodating" during the baseline period. The utilization factor was multiplied by the maximum monthly observed firing rate converted to an annual rate. This utilization factor accounts for normal rate reductions that occur each year due to mechanical or supply issues. Tesoro conservatively assumes that none of these normal rate reductions occurred during the month when the maximum throughput was observed. This 98% utilization factor is equivalent to assuming 175 hours of annual downtime. It is also important to note that Tesoro did not include this utilization factor in its projected post-project operating rates. The net result is a more conservative estimate of the emissions increase. The emission factors used to calculate the product demand growth exclusion are generally consistent with those used for projected emissions.

The difference between the annualized emissions that the units were capable of accommodating and the baseline actual emissions is excluded (i.e. subtracted from) the projected emissions. The emissions increase is then calculated by subtracting the baseline actual emissions from the projected

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[7] 40 CFR 52.21(b)(41)(ii)(c).

actual emissions. This approach is consistent with that outlined by EPA Region 4 regarding an applicability analysis completed by Georgia-Pacific Wood Products, LLC.[8]

3.1.1.2 Baseline Actual Emissions

"Baseline actual emissions" for an existing emissions unit are calculated as:

> *"... the average rate, in tons per year, at which the emissions unit actually emitted the pollutant during any consecutive 24-month period selected by the owner or operator within the 10-year period immediately preceding either the date the owner or operator begins actual construction of the project, or the date a complete permit application is received by the Administrator for a permit required under this section or by the reviewing authority for a permit required by a plan, whichever is earlier, except that the 10-year period shall not include any period earlier than November 15, 1990."*

For baseline actual emissions, Tesoro has defined a 24-month baseline period specific to each NSR pollutant. Tesoro has considered emissions between May 1, 2007 and May 31, 2015, for all pollutants for its baseline emissions analysis. The 24-month baseline periods are chosen because they are considered the most representative of past and current capabilities of the UFU Furnace F-1 for those pollutants (i.e., this time period is indicative of capabilities that exist today and could be utilized with variations in crude slate or intermediates). Refer to Attachment B for documentation of the baseline periods selected and the calculated baseline actual emissions.

As with projected actual emissions, baseline actual emissions shall include fugitive emissions and emissions associated with startups, shutdowns, and malfunctions.[9] The baseline emissions are adjusted downwards to address emissions that occurred during the 24-month baseline or emissions that could have exceeded a current emission limitation.[10]

Generally, baseline actual emissions are calculated according to the following hierarchy:

1. Continuous emission monitoring system (CEMS) data
2. Stack test results and measured process data
3. Standard emission factors from public sources and measured process data (i.e. EPA's AP-42)

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[8] March 18, 2010 letter from Mr. Worley of EPA Region 4 to Mr. Robinson of Georgia-Pacific Wood Products, LLC.

[9] 40 CFR 52.21(b)(48)(ii)(a).

[10] 40 CFR 52.21(b)(48)(ii)(b)-(c).

3.1.2 Actual-to-Potential Test for New Emissions Units

To estimate emissions from new process components, Tesoro utilized the actual-to-potential test for new emissions units. In 40 CFR 52.21(a)(2)(iv)(d), the actual-to-potential applicability test is described as the following:

> *"(d) Actual-to-potential test for projects that only involve construction of a new emissions unit(s). A significant emissions increase of a regulated NSR pollutant is projected to occur if the sum of the difference between the potential to emit (as defined in paragraph (b)(4) of this section) from each new emissions unit following completion of the project and the baseline actual emissions (as defined in paragraph (b)(48)(iii) of this section) of these units before the project equals or exceeds the significant amount for that pollutant (as defined in paragraph (b)(23) of this section)."*

Terms within this paragraph that have specific definitions include "new emissions unit," "potential to emit," and "baseline actual emissions." A "new emissions unit" is any part of a stationary source that emits any regulated NSR pollutant and is or will be newly constructed and has existed for less than two years from the date such emissions unit first operated.[11] A description of "potential to emit" and "baseline actual emissions" are as follows.

"Potential to emit" is defined as: [12]

> *"... the maximum capacity of a stationary source to emit a pollutant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitation or the effect it would have on emissions is federally enforceable..."*

The potential to emit for an emissions unit yet to be constructed is generally calculated as the product of its hourly maximum throughput or heat input capacity and an emission factor, which may be from EPA documents (e.g., AP-42), a manufacturer performance guarantee, existing regulatory standards (e.g., a New Source Performance Standard), or from other information sources. Federally enforceable emission limitations on the capacity of the source to emit a pollutant (e.g., air pollution control equipment, restriction on hours of operation) may be taken to reduce the unit's potential to emit.

The methodology in this section may also be applied to estimate maximum emissions from existing emission units to reduce post-project annual emission recordkeeping requirements.

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[11] 40 CFR 52.21(b)(7)(ii).

[12] 40 CFR 52.21(b)(4).

3.1.3 Methodology for Non-Modified Existing Units

As previously described, the Cogeneration Units will not be modified but may experience an increase in emissions. The EPA recognizes in its PSD rules that non-modified existing units experiencing an emissions increase as a result of the project need to be considered in the overall emissions increase calculation. For non-modified emission units, EPA allows for calculating the emissions increase as the product of the potential increase in throughput due to the project and an emissions factor representative of "worst-case" operations. The "potential increase in utilization" approach is consistent with the 1980 NSR rules and has been maintained for existing emissions units in the existing rules through §52.21(b)(41)(ii)(d), which allows a PTE approach in lieu of future actual emissions.

3.2 Affected Units at the Salt Lake City Refinery

All existing, non-modified emission units at the Salt Lake City Refinery were reviewed to determine if the project will result in an emissions increase. Units that will or may experience an emissions increase due to the project (i.e., be affected by the project) are presented in Table 3-2.

Table 3-2. Summary of Affected Emission Units

Emission Unit	New / Existing	Modified / Non-modified
UFU Furnace F-1	Existing	Modified
Cogeneration Unit CG1 and CG2	Existing	Non-modified
New/Replaced Components	New	N/A

3.3 Calculation of Emissions

Tesoro has calculated the change in emissions expected at the emissions units affected by the Project as described further below. Details are included in Attachment B.

3.3.1 New Equipment and Piping Components in VOC Service

New equipment and piping components in VOC service will be installed as part of this Project. The emissions increase is calculated based upon the counts of new components to be added plus a safety factor for conservatism.

The USEPA Protocol for Equipment Leak Emission Estimates is used to quantify potential emissions from the new components installed as part of this Project. The final number of installed components will likely change from this estimate after additional detailed design/engineering is performed;

however, the change in VOC emissions from this activity is not appreciable and will not change the PSD applicability determination.

3.3.2 Cogeneration Units

The Project will result in additional steam demand required to control the flame temperature of the new ULNB. The emission factors are based on AP-42 emissions factors, the estimated sulfur content of the fuel gas, stack test results, and manufacturer specifications.

3.4 Project Emissions Increase Summary

Table 3-3 presents a summary of the Project emissions increase. The Project emissions increase are less than their respective NSR significant emission rates for each regulated pollutant; therefore the Project does not trigger NSR.

Table 3-3. Project Actual Emission Increase Summary[13]

Emissions Unit	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
	tpy	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
UFU Furnace F-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cogeneration Units	0.72	0.25	0.78	0.10	0.10	0.10	0.05	0.00
New Process Components	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00
Total Project Emission Increase	**0.72**	**0.25**	**0.78**	**0.10**	**0.10**	**0.10**	**2.47**	**0.00**

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[13] Although NO_X emissions will decrease from the UFU Furnace F-1, the sum of the change in emissions from an emissions unit that results in a negative number is not included in the total Project's emissions.

3.4.1 "Reasonable Possibility" Requirements

On December 21, 2007, the US EPA promulgated updates to the federal PSD rules at 40 CFR 52.21(r)(6)(vi) that defines when an owner/operator of a major source is required to conduct recordkeeping and reporting when using the baseline-actual-to-projected-actual emissions increase calculation methodology. The Utah Air Quality Board has adopted the federal PSD rules as they existed in the Code of Federal Regulations on July 1, 2008, at R307-405.

A "reasonable possibility" occurs when the project is calculated to result in either:[14]

> *"(a) A projected actual emissions increase of at least 50 percent of the amount that is a "significant emissions increase," as defined under paragraph (b)(40) of this section (without reference to the amount that is a significant net emissions increase), for the regulated NSR pollutant; or*
>
> *(b) A projected actual emissions increase that, added to the amount of emissions excluded under paragraph (b)(41)(ii)(c) of this section, sums to at least 50 percent of the amount that is a "significant emissions increase," as defined under paragraph (b)(40) of this section (without reference to the amount that is a significant net emissions increase), for the regulated NSR pollutant. For a project for which a reasonable possibility occurs only within the meaning of paragraph (r)(6)(vi)(b) of this section, and not also within the meaning of paragraph (r)(6)(vi)(a) of this section, then provisions (r)(6)(ii) through (v) do not apply to the project."*

A summary of reasonable possibility applicability and requirements is shown in Table 3-4 below. Since emissions do not exceed 50% of the significance rate for any pollutant, reasonable possibility recordkeeping requirements do not apply.

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[14] 40 CFR 52.21(r)(6)(vi)(*a*)-(*b*)

Table 3-4. Summary of Reasonable Possibility Applicability and Requirements

Pollutant	Emission Increase (tons/yr)	Significant Emission Rate (SER) (tons/yr)	Percentage of SER (%)
NO_X	0.72	40	1.8%
SO_2	0.25	40	0.6%
CO	0.78	100	0.8%
PM	0.10	25	0.4%
PM_{10}	0.10	15	0.7%
$PM_{2.5}$	0.10	10	1.0%
VOC	2.47	40	6.2%
H_2SO_4	0.00	7	0.1%

4.0 Regulatory Applicability and Compliance Demonstration

In addition to the PSD analysis detailed in Section 3.0, Tesoro has completed an applicability review of all Federal and State air quality regulations as part of the air permit application process. Table 4-1 provides a summary of the major air quality programs that were reviewed for the Project. Each regulation which requires explanation is described in the following sections. Certain aspects of the Project result in the triggering of new applicable requirements.

Table 4-1. Summary of Air Quality Regulatory Applicability for the Project

Report Section	Program Description	Regulatory Citation	Does This Project Trigger New Applicable Requirements?
---	National Ambient Air Quality Standards (NAAQS)	40 CFR 50	No
3.0	New Source Review (NSR)	40 CFR 52	No
4.1	New Source Performance Standards (NSPS)	40 CFR 60	Yes
4.2	National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR 61	No
4.2	NESHAPs for Source Categories	40 CFR 63	No
---	Risk Management Programs for Chemical Accidental Release Prevention	40 CFR 68	No
---	Title V Operating Permit	40 CFR 70	No
---	Acid Rain Requirements	40 CFR 72	No
---	Stratospheric Ozone Protection Requirements	40 CFR 82	No
---	**Utah State Rules**	**UAC R307**	---
4.1	Stationary Sources	R307-210	Yes
4.2	National Emission Standards for Hazardous Air Pollutants	R307-214	No
4.3	Ozone Nonattainment and Maintenance Areas: Control of Hydrocarbon Emissions in Petroleum Refineries	R307-326	Yes
---	Ozone Nonattainment and Maintenance Areas: Petroleum Liquid Storage	R307-327	No
4.4	Permit: New and Modified Sources	R307-401	Yes
4.5	Nonattainment and Maintenance Areas	R307-403	No
4.6	Permits: Major Sources in Attainment or Unclassified Areas (PSD)	R307-405	No

Report Section	Program Description	Regulatory Citation	Does This Project Trigger New Applicable Requirements?
4.7	Visibility	R307-406	No
4.8	Permits: Emissions Impact Analysis	R307-410	No
4.9	Permits: Ozone Offset Requirements in Davis and Salt Lake Counties	R307-420	No

4.1 R307-210: Stationary Sources

New Source Performance Standards (NSPS) are incorporated by reference into the UDAQ rules. There is no new construction of any NSPS affected facilities. Tesoro reviewed whether the Project will result in a "modification" or "reconstruction" for any NSPS affected facilities, and thus result in applicability of that NSPS. The NSPS regulation, at 40 CFR §60.14(a), defines a modification as a physical or operational change to the affected facility that is not specifically exempted and that results in an increase in the emissions rate to the atmosphere of any pollutant to which a standard applies. An increase in production rate, if that increase can be accomplished without a capital expenditure on that facility, is not considered a modification per §60.14(e)(2). "Increase in emissions rate" is defined pursuant to §60.14(b) as an increase in the maximum hourly emission rate of an applicable pollutant from the affected facility. A reconstruction occurs when the fixed capital cost of the project is 50 percent or greater than the current replacement cost of the affected facility.

The physical changes performed as part of the Project affect only the UFU Furnace F-1. Applicability to 40 CFR 60 Subpart Ja is discussed below in additional detail.

Regulatory coverage for other NSPS subparts currently applicable to the facility will not change as a result of this Project.

4.1.1 Subpart Ja: Standards of Performance for Petroleum Refineries for Which Construction, Reconstruction, or Modification Commenced After May 14, 2007

NSPS Subpart Ja applies to various facilities in petroleum refineries, including process heaters as "fuel gas combustion devices." For process heaters, NSPS Ja regulates NO_X and SO_2 emissions. Tesoro has reviewed the applicability of Subpart Ja UFU Furnace F-1. Per 40 CFR 60.14(a), "*any physical or operational change to an existing facility which results in an increase in the emission rate to the atmosphere of any pollutant to which a standard applies shall be considered a modification.*" 40 CFR 60.14(e) provides exemptions for modification including "*the addition or use* *of any system or device whose primary function is the reduction of air pollutants, except when an emission control system is removed or is replaced by a system which the Administrator determines to be less environmentally beneficial*". The Project is to install ULNB on the Ultraformer Furnace F-1; the new burner's primary function is to reduce air pollution. Therefore, this NSPS exemption could apply to the Project. However, Tesoro has conservatively assumed that the Project results in a modification of UFU Furnace F-1, resulting in applicability of NSPS Subpart Ja for SO_2. In addition to the pollution control exemption above, the maximum hourly emission rate of NO_X will decrease because of installation of the ULNB.

Reconstruction is defined at 40 CFR 60.15(b) as the replacement of components of an existing facility such that the fixed capital cost of the project is 50 percent or greater than the current replacement cost of the affected facility. The cost of the Project is estimated to be approximately 28 percent of the current replacement cost of the UFU Furnace F-1; therefore, this Project does not result in reconstruction of the unit as defined under NSPS.

4.2 R307-214: National Emission Standards for Hazardous Air Pollutants

NESHAP standards from 40 CFR 61 and 40 CFR 63 are incorporated by reference into the UDAQ rules. The physical changes performed as part of the Project only affects the UFU Furnace F-1. The UFU Furnace F-1 is currently subject to 40 CFR 63 Subpart DDDDD for "National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters." Tesoro will continue to comply with the emission standards for an existing affected facility and other requirements of this rule. No new requirements will be triggered as a result of this Project.

Tesoro also considered whether a reconstruction[15] would occur, which would affect the compliance date. Reconstruction is defined at 40 CFR 63.2 as the replacement of components of a source such that the fixed capital cost of the project exceeds 50 percent of the current replacement cost of the source. The cost of the new burners is estimated to be approximately 28 percent of the current replacement cost of the UFU Furnace F-1; therefore, this Project does not result in reconstruction of the unit as defined under 40 CFR 63.2.

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[15] There are no provisions for "modification" under 40 CFR 63 as there are under 40 CFR 60.

Regulatory coverage for other subparts currently applicable to the facility will not change as a result of this Project.

4.3 R307-326: Ozone Nonattainment and Maintenance Areas: Control of Hydrocarbon Emissions in Petroleum Refineries

Rule R307-326-9 contains requirements for leaks from petroleum refinery equipment. New process components associated with the Project will be subject to the repair, recordkeeping, and reporting requirements of the rule. Following the Project, Tesoro will continue to comply with the requirements of this rule for the new process components installed as part of the Project.

4.4 R307-401: Permit: New and Modified Sources

Rule R307-401-3(b) requires submittal of an NOI to "make modifications or relocate an existing installation which will or might reasonably be expected to increase the amount or change the effect of, or the character of, air contaminants discharged, so that such installation may be expected to become a source or indirect source of air pollution." The Project may increase the amount of air contaminants discharged from the Cogeneration Units and from new process components. Rule R307-401-5 requires submittal of an NOI, which must contain specific information related to the process, nature of emissions, control device(s), and regulatory applicability and compliance. Refer to Section 5.0 for a summary of compliance with the NOI requirements.

4.4.1 Low Oxides of Nitrogen Burner Technology

Rule R307-401-4 requires installation of low oxides of nitrogen burners or equivalent oxides of nitrogen controls whenever existing fuel combustion burners are replaced, unless such equipment is not physically practical or cost effective. Tesoro is meeting this requirement by installing ULNB at the Ultraformer Furnace F-1.

4.4.2 BACT

Rule R307-401-5(d) permits the issuance of an approval order if it is determined that the pollution control for emissions is at least best available control technology (BACT). A BACT review is required for new emission units and existing emission units where there is a physical modification and an increase in emissions. The UFU Furnace F-1 is the only existing emissions unit undergoing a physical modification; however, as discussed in Section 3.0 and shown in Attachment B, there will not be an increase in emissions from this unit.

New process components will meet BACT by meeting the requirements of NSPS Subpart GGGa.

4.5 R307-403: Nonattainment and Maintenance Areas

R307-403 applies to major new sources or major modifications to be located in a nonattainment area. The proposed project is neither a new major source nor a major modification as defined in R307-101-2 since the actual emissions increase is less than the significant emission rate (SER) thresholds. Refer to Section 3.4 for a summary of this determination.

4.5.1 R307-403-5: Offsets: PM_{10} Nonattainment Area

Emission offsets are required if the combined allowable emission increase of PM_{10}, SO_2, and NO_x exceeds 25 tons per year. The combined allowable emission increase from the project is zero (0) tons per year. Therefore, no emission offsets are required.

4.6 R307-405: Permits: Major Sources in Attainment or Unclassified Areas (PSD)

This project is not a major modification and is not subject to the PSD program as described in Section 3.0. Refer to Section 3.4 for a summary of this determination. Tesoro has demonstrated compliance with all applicable requirements with the submission of this NOI. Therefore the requirements of R307-405 are not applicable to this proposed project.

4.7 R307-406: Visibility

R307-406 applies to major new sources or major modifications. This Project is not a new major source or a major modification; therefore the provisions of this rule are not applicable.

4.8 R307-410: Permits: Emissions Impact Analysis

R307-410 establishes the procedures and requirements for evaluating the emissions impact of new or modified sources. Pursuant to R307-410-4, dispersion modeling is required for increases in the total controlled emission rate of attainment pollutants (NO_X and CO for the SLC refinery) in an amount greater or equal to values given in Table 1 of the rule. For these pollutants, the thresholds given in Table 1 are equal to the SERs. Dispersion modeling is not required since the increases in emissions of NO_X and CO are less than the SERs.

4.8.1 R307-410-5: Ambient Air Impacts for Hazardous Air Pollutants

The requirements of R307-410-5 requires sources to provide documentation of increases in emissions of hazardous air pollutants prior to receiving an approval order. The rule requires each applicant's notice of intent to include the estimated maximum pounds per hour emission rate increase from each affected installation. Per R307-410-5(1)(a)(i), this rule does not apply to installations which are subject to or are scheduled to be subject to an emission standard promulgated under 42 USC 7412 at the time the NOI is submitted. As described in Section 4.2, the UFU Furnace F-1 is subject to 40 CFR 63 Subpart DDDDD. In addition, there will be not be a lb/hr emission rate increase of HAP at the Cogeneration Units. Therefore, the requirements of R307-410-5 do not apply to the Project.

4.9 R307-420: Permits: Ozone Offset Requirements in Davis and Salt Lake Counties

The SLC Refinery is located in a maintenance area for ozone. Emission offsets are required for any new major source or major modification of VOC or NO_X. The project is neither a new major source nor a major modification for VOC or NO_X, therefore offsets are not required.

5.0 Summary of NOI Requirements for Project

Table 5-1 provides a summary of how this NOI complies with the specific requirements of Rule R307-401-5(2).

Table 5-1. Summary of NOI Requirements

Requirement	Section Reference for Information Provided
(a) A description of the nature of the processes involved; the nature, procedures for handling and quantities of raw materials; the type and quantity of fuels employed; and the nature and quantity of finished product.	Section 2.2
(b) Expected composition and physical characteristics of effluent stream both before and after treatment by any control apparatus, including emission rates, volume, temperature, air contaminant types, and concentration of air contaminants.	Section 3.0
(c) Size, type and performance characteristics of any control apparatus.	N/A
(d) An analysis of best available control technology for the proposed source or modification. When determining best available control technology for a new or modified source in an ozone nonattainment or maintenance area that will emit volatile organic compounds or nitrogen oxides, the owner or operator of the source shall consider EPA Control Technique Guidance (CTG) documents and Alternative Control Technique documents that are applicable to the source. Best available control technology shall be at least as stringent as any published CTG that is applicable to the source.	Section 4.4.2
(e) Location and elevation of the emission point and other factors relating to dispersion and diffusion of the air contaminant in relation to nearby structures and window openings, and other information necessary to appraise the possible effects of the effluent.	Attachment A – location provided – other info not needed since modeling is not required.
(f) The location of planned sampling points and the tests of the completed installation to be made by the owner or operator when necessary to ascertain compliance.	Not applicable – no new testing is necessary to demonstrate compliance.

Requirement	Section Reference for Information Provided
(g) The typical operating schedule.	Section 2.2
(h) A schedule for construction.	Section 2.6
(i) Any plans, specifications and related information that are in final form at the time of submission of notice of intent.	No plans or specifications are in final form at the time of this submission.
(j) Any additional information required by:	
(i) R307-403, Permits: New and Modified Sources in Nonattainment Areas and Maintenance Areas;	(i) Section 4.5
(ii) R307-405, Permits: Major Sources in Attainment or Unclassified Areas (PSD);	(ii) Section 4.6
(iii) R307-406, Visibility;	(iii) Section 4.7
(iv) R307-410, Emissions Impact Analysis;	(iv) Section 4.8
(v) R307-420, Permits: Ozone Offset Requirements in Davis and Salt Lake Counties;	(v) Section 4.9
(vi) R307-421, Permits: PM10 Offset Requirements in Salt Lake County and Utah County.	N/A
(k) Any other information necessary to determine if the proposed source or modification will be in compliance with Title R307.	Section 4.1 (NSPS Compliance) Section 4.2 (MACT Compliance) Section 4.3 (Control of Hydrocarbons)

Attachment A

Figure A-1 – Refinery Location Map

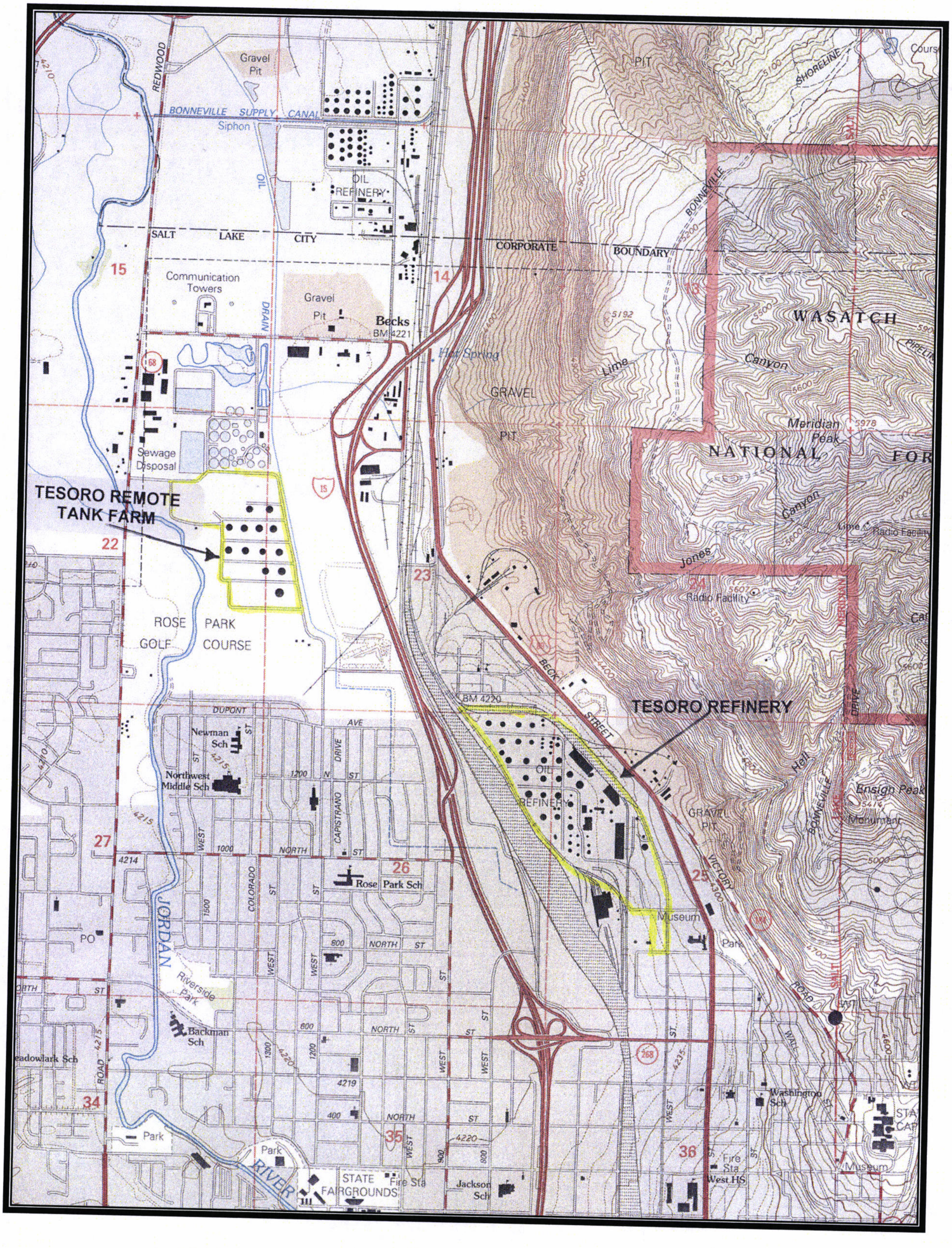
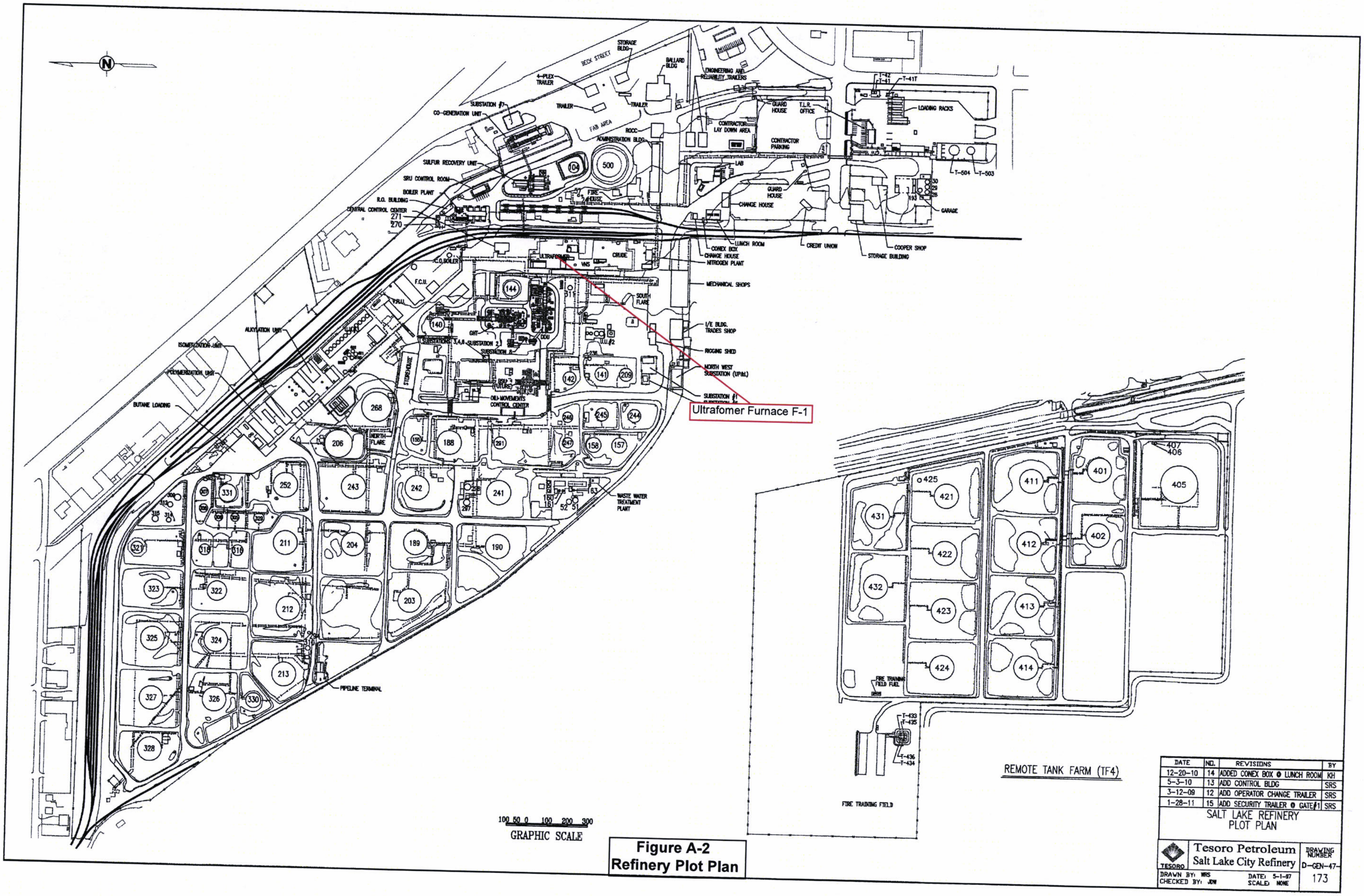


Figure A-1
Refinery Location Map

Attachment A

Figure A-2 – Refinery Plot Plan



DATE	NO.	REVISIONS	BY
12-20-10	14	ADDED CONEX BOX @ LUNCH ROOM	KH
5-3-10	13	ADD CONTROL BLDG	SRS
3-12-09	12	ADD OPERATOR CHANGE TRAILER	SRS
1-28-11	15	ADD SECURITY TRAILER @ GATE#1	SRS

SALT LAKE REFINERY
PLOT PLAN

TESORO
Tesoro Petroleum
Salt Lake City Refinery

DRAWING NUMBER
D-GEN-47-173

DRAWN BY: WRS
CHECKED BY: JDW
DATE: 5-1-97
SCALE: NONE

Figure A-2
Refinery Plot Plan

Attachment B

Emission Calculations for Project

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 1 - PSD Applicability Determination and Reasonable Possiblity Requirements

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
Project Emission Increases	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
F-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cogen	0.72	0.25	0.78	0.10	0.10	0.10	0.05	0.00
Components	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00
Total Project Emission Increase	**0.72**	**0.25**	**0.78**	**0.10**	**0.10**	**0.10**	**2.47**	**0.00**
PSD Significant Emission Rate (SER)	40	40	100	25	15	10	40	7
Is Project Emission Increase Greater than PSD Significant Emission Rate?	No	No	No	No	No	No	No	No

Reasonable Possibility Requirements

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
	tpy	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**	**tpy**
Project Emission Increase	0.72	0.25	0.78	0.10	0.10	0.10	2.47	0.00
Demand Growth Exclusion	0.00	1.98	0.00	0.46	0.46	0.46	0.33	0.03
Project Emission Increase + Demand Growth Exclusion	0.72	2.23	0.78	0.56	0.56	0.56	2.81	0.03
PSD Significant Emission Rate (SER)	40	40	100	25	15	10	40	7
Is Project Emission Increase Greater than 1/2 of the PSD Significant Emission Rate?	No	No	No	No	No	No	No	No
Is Project Emission Increase + Demand Growth Exclusion Greater than 1/2 of the PSD Significant Emission Rate?	No	No	No	No	No	No	No	No
Is Preconstruction Determination Required?	No	No	No	No	No	No	No	No
Is Recordkeeping of Annual Actual Emissions Required?	No	No	No	No	No	No	No	No

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Nov-07	3.73	0.18	2.46	0.22	0.22	0.22	0.16	0.00	9.23	59,823	83.81
Dec-07	3.34	0.13	2.21	0.20	0.20	0.20	0.14	0.00	7.48	53,547	75.02
Jan-08	4.42	0.20	2.76	0.25	0.25	0.25	0.18	2.97E-03	9.99	67,048	99.19
Feb-08	3.92	0.17	2.70	0.24	0.24	0.24	0.18	2.48E-03	9.31	65,564	88.01
Mar-08	4.69	0.23	2.77	0.25	0.25	0.25	0.18	3.50E-03	10.32	67,207	105.29
Apr-08	4.71	0.32	2.87	0.26	0.26	0.26	0.19	4.84E-03	10.23	69,596	105.70
May-08	4.77	0.32	2.95	0.27	0.27	0.27	0.19	4.87E-03	10.29	71,560	107.25
Jun-08	4.25	0.56	3.15	0.28	0.28	0.28	0.21	8.42E-03	9.65	76,467	95.45
Jul-08	4.45	0.61	3.04	0.27	0.27	0.27	0.20	9.14E-03	9.92	73,790	99.96
Aug-08	4.39	0.35	2.73	0.25	0.25	0.25	0.18	5.24E-03	9.55	66,154	98.67
Sep-08	4.13	0.27	2.56	0.23	0.23	0.23	0.17	4.02E-03	9.17	62,123	92.76
Oct-08	3.81	0.21	2.55	0.23	0.23	0.23	0.17	3.08E-03	8.24	61,939	85.54
Nov-08	4.27	0.16	2.65	0.24	0.24	0.24	0.17	2.39E-03	7.81	64,230	83.73
Dec-08	4.25	0.14	2.63	0.24	0.24	0.24	0.17	2.16E-03	7.59	63,912	78.90
Jan-09	4.87	0.22	3.02	0.27	0.27	0.27	0.20	3.28E-03	7.90	73,267	85.84
Feb-09	4.38	0.13	2.71	0.25	0.25	0.25	0.18	1.96E-03	8.42	65,848	83.95
Mar-09	4.50	0.25	2.79	0.25	0.25	0.25	0.18	3.82E-03	10.06	67,742	101.51
Apr-09	4.47	0.28	2.77	0.25	0.25	0.25	0.18	4.22E-03	9.59	67,260	90.20
May-09	5.29	0.33	3.28	0.30	0.30	0.30	0.21	4.88E-03	10.16	79,555	105.69
Jun-09	4.96	0.35	3.07	0.28	0.28	0.28	0.20	5.28E-03	10.31	74,579	101.40
Jul-09	5.02	0.45	3.11	0.28	0.28	0.28	0.20	6.73E-03	10.44	75,487	102.10
Aug-09	4.57	0.38	2.83	0.26	0.26	0.26	0.19	5.75E-03	9.52	68,763	89.28
Sep-09	4.63	0.35	2.87	0.26	0.26	0.26	0.19	5.18E-03	9.95	69,687	90.07
Oct-09	4.48	0.31	2.78	0.25	0.25	0.25	0.18	4.68E-03	9.09	67,400	87.47
Nov-09	3.61	0.27	2.61	0.24	0.24	0.24	0.17	4.10E-03	9.48	63,324	84.42
Dec-09	3.22	0.15	2.33	0.21	0.21	0.21	0.15	2.32E-03	5.65	56,538	64.12
Jan-10	4.49	0.27	3.24	0.29	0.29	0.29	0.21	4.09E-03	9.70	78,759	92.27
Feb-10	3.63	0.36	2.62	0.24	0.24	0.24	0.17	5.44E-03	9.98	63,601	85.56
Mar-10	1.09	0.02	0.79	0.07	0.07	0.07	0.05	3.25E-04	1.25	19,186	19.90
Apr-10	4.03	0.17	2.91	0.26	0.26	0.26	0.19	2.57E-03	7.05	70,673	70.77
May-10	4.56	0.35	3.29	0.30	0.30	0.30	0.22	5.31E-03	10.74	79,965	104.62
Jun-10	4.22	0.36	3.05	0.28	0.28	0.28	0.20	5.34E-03	10.39	74,092	96.31
Jul-10	4.51	0.49	3.26	0.29	0.29	0.29	0.21	7.38E-03	10.75	79,122	107.65
Aug-10	4.60	0.46	3.32	0.30	0.30	0.30	0.22	6.94E-03	10.87	80,633	106.30

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

Date	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Sep-10	4.30	0.29	3.10	0.28	0.28	0.28	0.20	4.41E-03	10.57	75,363	99.00
Oct-10	4.56	0.29	3.30	0.30	0.30	0.30	0.22	4.31E-03	10.09	79,985	95.87
Nov-10	3.20	0.16	2.71	0.25	0.25	0.25	0.18	2.36E-03	7.84	65,892	72.03
Dec-10	3.53	0.24	3.00	0.27	0.27	0.27	0.20	3.63E-03	10.24	72,776	95.80
Jan-11	3.42	0.30	2.90	0.26	0.26	0.26	0.19	4.48E-03	9.00	70,446	83.78
Feb-11	2.96	0.25	2.51	0.23	0.23	0.23	0.16	3.73E-03	9.46	60,963	79.36
Mar-11	3.65	0.32	3.10	0.28	0.28	0.28	0.20	4.74E-03	10.11	75,339	94.55
Apr-11	3.61	0.31	3.07	0.28	0.28	0.28	0.20	4.65E-03	9.98	74,535	93.72
May-11	3.49	0.29	2.97	0.27	0.27	0.27	0.19	4.34E-03	9.85	71,991	94.68
Jun-11	3.42	0.26	2.91	0.26	0.26	0.26	0.19	3.84E-03	9.25	70,612	86.83
Jul-11	4.09	0.34	3.47	0.31	0.31	0.31	0.23	5.05E-03	NA	84,303	109.77
Aug-11	3.92	0.34	3.33	0.30	0.30	0.30	0.22	5.05E-03	NA	80,753	109.75
Sep-11	3.94	0.37	3.35	0.30	0.30	0.30	0.22	5.62E-03	NA	81,334	120.73
Oct-11	3.82	0.28	3.21	0.29	0.29	0.29	0.21	4.14E-03	NA	77,932	96.53
Nov-11	3.29	0.17	2.76	0.25	0.25	0.25	0.18	2.49E-03	NA	67,069	80.81
Dec-11	3.10	0.13	2.60	0.24	0.24	0.24	0.17	1.91E-03	NA	63,203	66.44
Jan-12	3.28	0.16	2.76	0.25	0.25	0.25	0.18	2.33E-03	7.57	67,010	82.15
Feb-12	3.05	0.16	2.57	0.23	0.23	0.23	0.17	2.41E-03	7.31	62,283	76.46
Mar-12	4.07	0.31	3.42	0.31	0.31	0.31	0.22	4.67E-03	9.38	83,059	105.11
Apr-12	4.12	0.30	3.46	0.31	0.31	0.31	0.23	4.45E-03	9.81	83,988	102.71
May-12	4.07	0.28	3.43	0.31	0.31	0.31	0.22	4.22E-03	9.18	83,158	100.28
Jun-12	4.45	0.35	3.75	0.34	0.34	0.34	0.25	5.26E-03	11.10	90,908	109.11
Jul-12	4.41	0.39	3.71	0.34	0.34	0.34	0.24	5.84E-03	10.17	90,090	105.43
Aug-12	4.60	0.30	3.87	0.35	0.35	0.35	0.25	4.53E-03	10.52	93,923	111.37
Sep-12	4.31	0.27	3.62	0.33	0.33	0.33	0.24	4.08E-03	10.37	87,929	106.86
Oct-12	3.96	0.21	3.33	0.30	0.30	0.30	0.22	3.21E-03	8.85	80,761	96.80
Nov-12	4.51	0.34	3.79	0.34	0.34	0.34	0.25	5.04E-03	10.08	91,973	110.42
Dec-12	3.47	0.24	3.33	0.30	0.30	0.30	0.22	3.54E-03	8.68	80,775	97.05
Jan-13	3.59	0.30	3.44	0.31	0.31	0.31	0.23	4.56E-03	8.74	83,483	96.82
Feb-13	2.93	0.27	2.80	0.25	0.25	0.25	0.18	4.07E-03	8.56	68,030	82.81
Mar-13	4.07	0.56	3.90	0.35	0.35	0.35	0.26	8.37E-03	10.47	94,614	116.13
Apr-13	2.98	0.76	2.86	0.26	0.26	0.26	0.19	1.14E-02	7.75	69,392	100.84
May-13	3.59	0.57	3.44	0.31	0.31	0.31	0.22	8.54E-03	9.48	83,391	114.61
Jun-13	4.02	0.52	3.85	0.35	0.35	0.35	0.25	7.73E-03	11.04	93,567	104.98

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
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	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Jul-13	4.20	0.43	4.02	0.36	0.36	0.36	0.26	6.50E-03	11.11	97,568	111.13
Aug-13	3.61	0.27	3.46	0.31	0.31	0.31	0.23	4.05E-03	9.69	84,032	93.20
Sep-13	3.21	0.28	3.08	0.28	0.28	0.28	0.20	4.15E-03	8.92	74,749	82.92
Oct-13	3.59	0.15	3.44	0.31	0.31	0.31	0.22	2.22E-03	9.80	83,379	87.20
Nov-13	3.58	0.11	3.11	0.28	0.28	0.28	0.20	1.66E-03	9.06	75,393	82.87
Dec-13	3.65	0.15	3.16	0.29	0.29	0.29	0.21	2.30E-03	8.71	76,790	74.68
Jan-14	4.21	0.14	3.65	0.33	0.33	0.33	0.24	2.13E-03	9.93	88,626	86.57
Feb-14	3.04	0.16	2.63	0.24	0.24	0.24	0.17	2.46E-03	8.26	63,934	69.82
Mar-14	4.07	0.26	3.53	0.32	0.32	0.32	0.23	3.89E-03	10.43	85,608	95.01
Apr-14	3.86	0.22	3.35	0.30	0.30	0.30	0.22	3.33E-03	10.67	81,325	86.00
May-14	3.97	0.24	3.44	0.31	0.31	0.31	0.23	3.54E-03	10.69	83,610	88.44
Jun-14	3.70	0.24	3.21	0.29	0.29	0.29	0.21	3.54E-03	10.44	77,808	81.59
Jul-14	4.04	0.42	3.50	0.32	0.32	0.32	0.23	6.37E-03	10.56	84,958	89.12
Aug-14	3.85	0.32	3.34	0.30	0.30	0.30	0.22	4.77E-03	10.52	81,122	81.89
Sep-14	3.67	0.24	3.19	0.29	0.29	0.29	0.21	3.56E-03	9.82	77,324	79.40
Oct-14	4.19	0.25	3.63	0.33	0.33	0.33	0.24	3.69E-03	11.14	88,221	88.58
Nov-14	3.63	0.13	3.15	0.28	0.28	0.28	0.21	2.00E-03	10.08	76,450	79.72
Dec-14	3.60	0.13	2.82	0.26	0.26	0.26	0.18	2.01E-03	8.78	68,519	80.72
Jan-15	3.73	0.07	2.93	0.26	0.26	0.26	0.19	1.09E-03	8.95	71,090	76.17
Feb-15	3.77	0.09	2.96	0.27	0.27	0.27	0.19	1.40E-03	9.95	71,783	76.11
Mar-15	0.77	0.00	0.60	0.05	0.05	0.05	0.04	4.01E-05	1.78	14,590	13.50
Apr-15	1.46	0.03	1.14	0.10	0.10	0.10	0.07	4.89E-04	4.45	27,718	22.30
May-15	4.01	0.11	3.15	0.28	0.28	0.28	0.21	1.64E-03	9.30	76,384	38.73
Baseline Period Ends:	**Oct-09**	**Jul-13**	**Mar-14**	**Mar-14**	**Mar-14**	**Mar-14**	**Mar-14**	**Jul-13**	--	--	--
Baseline Actual Emissions (tpy):	**53.16**	**4.00**	**41.32**	**3.74**	**3.74**	**3.74**	**2.70**	**0.06**	--	--	--

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 2 - Baseline Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4	UFU	Fuel Gas Firing	
	tons	tons	tons	tons	tons	tons	tons	tons	MBPD	MMBtu	MMscf
Date	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[9]	[9]
Monthly Maximum Throughput During Baseline (mmbtu):	79,555	121	97,568	97,568	97,568	97,568	97,568	121	11.14	97,568	120.73
Occurs:	May-09	Sep-11	Jul-13	Jul-13	Jul-13	Jul-13	Jul-13	Sep-11	Oct-14	Jul-13	Sep-11

Emission Factor References

[1] Nov-07 through Oct-08: 11/18/04 stack test results of 89.04 lb/MMscf.
Nov-08 through Oct-09: 10/21/08 stack test results of 0.133 lb/MMBtu.
Nov-09 through Oct-10: 10/21/09 stack test results of 0.114 lb/MMBtu.
Nov-10 through Sept-11: 10/28/10 stack test results of 0.097 lb/MMBtu.
Oct-11 through Nov-12: 9/13/11 stack test results of 0.098 lb/MMBtu.
Dec-12 through Oct-13: 11/20/12 stack test results of 0.086 lb/MMBtu
Nov-13 through Nov-14: 10/13/13 stack test results of 0.095 lb/MMBtu
Dec-14 through May-15: 11/17/14 stack test results of 0.105 lb/MMBtu
[2] SO2 (tons) = Monthly average fuel gas H2S contents (ppmv) / 385.34 ft3/lb-mol * 64 lb/lb-mol * MMscf / 2000 lb/ton
[3] Emission factor of 0.0824 lb/MMBtu per AP-42 Table 1.4-1.
[4] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.
[5] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.
[6] Emission factor of 7.45E-03 lb/MMBtu per AP-42 Table 1.4-2.
[7] Emission factor of 5.39E-03 lb/MMBtu per AP-42 Table 1.4-2.
[8] Assumed to be 1.5% of total SO2 emissions consistent with TRI reporting.
[9] Measured throughput rates.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 3a - Projected Actual Emission Calculations for Ultraformer Unit Furnace F-1

Quantity	Value	Units	Reference
Projected Firing Rate:	115.26	Mscf/hr	Calculated
	124.92	MMBtu/hr	Engineering estimate, based on projected post project firing rate
Fuel HHV:	1083.8	Btu/scf	Engineering estimate
Fuel H_2S Content:	50	ppmvd	Engineering estimate
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units	Projected Emissions (lb/hr) [1]	Projected Emissions (tpy) [2]	Emission Factor Reference
NO_X	0.065	lb/MMBtu	8.12	35.56	Manufacturer's Emission Guarantee
SO_2	8.31	lb/MMscf	0.96	4.19	Calculated
CO	0.050	lb/MMBtu	6.25	27.36	Manufacturer's estimate
PM	0.00745	lb/MMBtu	0.93	4.08	AP-42 Table 1.4-2
PM_{10}	0.00745	lb/MMBtu	0.93	4.08	AP-42 Table 1.4-2
$PM_{2.5}$	0.00745	lb/MMBtu	0.93	4.08	AP-42 Table 1.4-2
VOC	5.39E-03	lb/MMBtu	0.67	2.95	AP-42 Table 1.4-2
H_2SO_4	0.12	lb/MMscf	1.44E-02	6.29E-02	TRI calculation (1.5% of SO2 emissions)

[1] Projected Emissions (lb/hr) = Emission Factor (lb/MMBtu) x Projected Firing Rate (MMBtu/hr) or
Projected Emissions (lb/hr) = Emission Factor (lb/MMscf) x Projected Firing Rate (Mscf/hr) / 1000 Mscf/MMscf

[2] Emission Increase (tpy) = Projected Emissions (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 3b - Projected Actual Emission Calculations for Ultraformer Unit Furnace F-1

	NO_X [1]	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
	tpy	tpy	tpy	tpy	tpy	tpy	tpy	tpy
A. Baseline Actual Emissions	53.16	4.00	41.32	3.74	3.74	3.74	2.70	0.06
B. Capable of Accommodating	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09
C. Projected Emissions	35.56	4.19	27.36	4.08	4.08	4.08	2.95	0.06
D. Demand Growth (D=B-A)	0.00	1.98	0.00	0.46	0.46	0.46	0.33	0.03
E. Projected Actual Emissions (E=C-D)	35.56	2.21	27.36	3.62	3.62	3.62	2.62	0.03
F. Emission Increase (F=E-A)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

B. Capable of Accommodating	NO_X	SO_2	CO	PM	PM_{10}	$PM_{2.5}$	VOC	H_2SO_4
Annual Emission Limits (ton/yr)	CAP	CAP	N/A	N/A	CAP	N/A	N/A	N/A
Representative Monthly Throughput during Baseline Period (Units/mo)	79,555	120.73	97,568	97,568	97,568	97,568	97,568	120.73
Month that this occurred:	May-09	Sep-11	Jul-13	Jul-13	Jul-13	Jul-13	Jul-13	Sep-11
Throughput that Unit was Capable of Accommodating (Units/year)	917,964	1,439.51	1,125,812	1,125,812	1,125,812	1,125,812	1,125,812	1,439.51
Representative Emission Factor that Unit was Capable of Accommodating (lb/Units)	0.065	8.31	0.05	7.45E-03	7.45E-03	7.45E-03	5.39E-03	0.12
Units	MMBtu	MMscf	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMscf
Emissions the Unit was Capable of Accommodating during Baseline Period (ton/yr)	29.83	5.98	28.15	4.19	4.19	4.19	3.04	0.09

[1] Due to installation of Ultra Low NO_X burners, and the corresponding decrease in NO_X emission factor, capable of accommodating em than the baseline actual emissions. Therefore, the NO_X emissions increase analysis does not include a demand growth component.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 4 - Potential Emission Calculations for Process Components

Components (service)	**UFU/Fuel Gas** Count [1]	Emission Factor [2] (kg/hr/source)	(lb/hr/source)	Control Effectiveness [3] (%)	Emissions (lbs/yr)	Emissions (Tons/yr)
Valves (gas)	216	0.0268	0.059083	96	4,472	2.24
Valves (LL)	0	0.0109	0.024030	95	-	-
Valves (HL)	0	0.00023	0.000507	0	-	-
Flanges (gas)	408	0.00025	0.00055	81	374	0.19
Flanges (LL)	0	0.00025	0.00055	81	-	-
Flanges (HL)	0	0.00025	0.00055	81	-	-
Pump Seals (LL)	0	0.114	0.25	88	-	-
Pump Seals LL (Tandem)	0	0.114	0.25	100	-	-
Pump Seal (HL)	0	0.021	0.046	0	-	-
Comp. Seals (gas)	0	0.636	1.4	100	-	-
Comp. Seals (H_2)	0	0.636	1.402	100	-	-
Process Drains (total)	0	0.073	0.161	100	-	-
Relief Valves (gas)	0	0.16	0.35	100	-	-
Total					4,846	2.42

Gas = material in a gaseous state at operating conditions
LL = light liquid = material in a liquid state in which the sum of the concentration of individual constituents with a vapor pressure over 0.3 kilopascals (kPa) at 20 oC is greater than or equal to 20 wt%.
HL = heavy liquid = not in gas/vapor service or light liquid service.
In VOC service means that the piece of equipment contains or contacts a process fluid that is at least 10 percent VOC by weight. (40 CFR 60.481)

Notes:

[1] Estimated counts based on P&ID drawings plus a 50% safety factor to be conservative.

[2] Protocol for Equipment Leak Emission Estimates, November 1995, Table 2-2. Refinery Average Emission Factors.

[3] Protocol for Equipment Leak Emission Estimates, November 1995, Table 5-3. Control Effectiveness for an LDAR Program at a Refinery Process Unit. Monitored under the Consent Decree leak definition of 500 ppm, quarterly with no chance for skip monitoring. Equivalent to HON regulation.

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
Installation of Ultra-Low NOx Burners on Ultraformer Unit (UFU) Furnace F-1
Table 5: Stack Emission Calculations for Cogeneration Units

Quantity	Value	Units	Reference
Steam Requirement:	2,100	lb/hr	Engineering estimate
Firing Requirement:	2.31	MMBtu/hr	Engineering estimate
Fuel Heat Content:	1083.8	Btu/scf	Engineering estimate for future operations
Fuel Use Requirement:	0.0021	MMscf/hr	Calculated
Fuel H_2S Content:	162	ppmvd	NSPS Ja H_2S concentration limit
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units	Emission Increase (lb/hr) (1)	Emission Increase (tpy) (2)	Reference
NO_X	76.80	lb/MMscf	0.16	0.72	Maximum stack test result from 2009 for East Cogeneration Unit
SO_2	26.91	lb/MMscf	5.73E-02	0.25	Calculated
CO	84	lb/MMscf	0.18	0.78	AP-42 Table 3.1-1
PM	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
PM_{10}	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
$PM_{2.5}$	0.01	lb/MMBtu	2.31E-02	0.10	Manufacturer Specification
VOC	5.5	lb/MMscf	1.17E-02	5.13E-02	AP-42 Table 1.4-2
H_2SO_4	0.40	lb/MMscf	8.60E-04	3.77E-03	TRI calculation (1.5% of SO2 emissions)

Notes:

(1) Emission Increase (lb/hr) = Emission Factor (lb/MMBtu) x Fuel Use Requirement (MMBtu/hr) or
Emission Increase (lb/hr) = Emission Factor (lb/MMscf) x Fuel Use Requirement (MMscf/hr)

(2) Emission Increase (tpy) = Emission Increase (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton

Attachment C

Form 1 and NOI Checklist

Utah Division of Air Quality
New Source Review Section

Date

Form 1
Notice of Intent (NOI)

Application for: ☐ Initial Approval Order ☒ Approval Order Modification

APPROVAL ORDER MUST BE ISSUED BEFORE ANY CONSTRUCTION OR INSTALLATION CAN BEGIN. This is not a stand alone document; please refer to UAC R307-401and the published NOI guidebook for information on requirements of the specified information below. Please print or type all information requested. All outlined information requested must be accurate and completed before DAQ can determine that an NOI is complete and an engineering review can be initiated. If you have any questions, contact the Division of Air Quality at (801) 536-4000 and ask to speak with a New Source Review Engineer. Written inquiries may be addressed to: Division of Air Quality, New Source Review Section, P.O. Box 144820, Salt Lake City, Utah 84114-4820.

General Owner and Facility Information

R307-401-5(2)(k)

1. Filing Fee Paid*	2. Application Fee Paid*
3. Company name and address: Tesoro Refining & Marketing Company LLC 474 West 900 North Salt Lake City, UT 84103 Phone No.: (801)366-2036 Fax No.: (801)521-4965	4. Company** contact for environmental matters: William Snarr Phone no.: (801)521-4966 Email: William.K.Snarr@tsocorp.com *** Company contact only; consultant or independent contractor contact information can be provided in a cover letter*
5. Facility name and address (if different from above): Tesoro Refining & Marketing Company LLC 474 West 900 North Salt Lake City, UT 84103 Phone no.: (801)366-2036 Fax no.: (801)521-4965	6. Owners name and address: Tesoro Corporation 19100 Ridgewood Parkway San Antonio, TX 78259 Phone no.: Fax no.:
7. Property Universal Transverse Mercator coordinates (UTM), including System and Datum: Easting: 423,400 Northing: 4,515,950 System: UTM Zone 12 Datum:	8. County where the facility is located in: Salt Lake 9. Standard Industrial Classification Code: 2911

10. Designation of facility in an attainment, maintenance, or nonattainment area(s):

SL City CO Maint Area
SL Co Ozone Maint Area
SL Co PM10 NAA
SL Co PM2.5 NAA
SL Co SO2 NAA

11. If request for modification, AO# to be modified: DAQE#DAQE-AN103350065-14 Date: 9/5/14

12. Identify any current Approval Order(s) for the facility **not** being modified with this request:

AO#DAQE-AN103350063-14 Date3/17/14
AO#DAQE-AN0103350042-08 Date5/13/08
AO# Date
AO# Date

13. Application for:

☐New construction
☐Existing equipment operating without permit
☐Change of permit condition
☒Modification
☐Permanent site for Portable Approval Order
☐Change of location

14. Construction or modification estimated start date:6/1/16 Estimated completion date:

R307-401-5(2)(h)

15. Does this application contain justifiable confidential data? ☒Yes ☒ No

16. Current Title V (Operating Permit) Identification: Date

☒Requesting an enhanced Title V permit with this AO modification

17. Brief (50 words or less) description of project to post on DAQ web for public awareness

This Project involves installation of Ultra Low NOx Burners on the Ultraformer Unit F-1 Furnace.

Process Information

18. Appendix A: Detailed description of project including process flow diagram (See Forms 2-23)

☐Fuels and their use
☐Raw materials used
☐Operation schedules
☐Equipment used in process
☐Description of changes to process (if applicable)
☐Production rates (including daily/seasonal variances)
☐Description of product(s)
☐Stack parameters

R307-401-5(2)(a)

19. Appendix B: Site plan of facility with all emission points and elevations, building dimensions, stack parameters included

R307-401-5(2)(e)

Emissions Information

20. Appendix C: Emission Calculations that must include:
    - ☒Emissions per new/modified unit for each of the following: PM_{10}, $PM_{2.5}$, NO_x, SO_x, CO, VOC, and HAPs
    - ☒Designation of fugitive and non fugitive emissions
    - ☐Major GHG Sources: Emissions per new/modified unit for GHGs (in CO_2e short tons per year)
    - ☒References/assumptions for each Emission Factor used in calculating Criteria pollutant, HAP, and GHG emissions
    - ☒HAP emissions (in pounds per hour and tons per year) broken out by specific pollutant and summed as a total

R307-401-5(2)(b)

21. Appendix D: DAQ Form 1a or equivalent (comparison of existing emissions to proposed emission and resulting new total emissions)

22. Appendix E: Source Size determination (Minor, Synthetic Minor, Major, or PSD)
    - ☒ If an Existing Major Source: Determination of Minor, Major or PSD modification

23. Appendix F: Offset requirements (nonattainment/maintenance areas)
    - ☐Acquired required offsets

R307-401-420 & R307-401-421

Air Pollution Control Equipment Information

24. Appendix G: Best Available Control Technology (BACT) analysis for the proposed source or modification

R307-401-5(2)(d)

25. Appendix H: Detailed information on all new/modified equipment controls. It is strongly recommended using DAQ forms as they outline required information, but something equivalent to the DAQ forms is acceptable.

R307-401-5(2)(c)

26. Appendix I: Discussion of Federal/State requirement applicability (NAAQS, SIP, NSPS, NESHAP, etc)

Modeling Information

27. Appendix J: Emissions Impact Analysis (if applicable)

R307-410-4

Electronic NOI

28. A complete and accurate electronic NOI submitted

R307-401-5(1)

I hereby certify that the information and data submitted in and with this application is completely true, accurate and complete, based on reasonable inquiry made by me and to the best of my knowledge and belief.

Signature: Title:

Name (print)	Telephone Number:	Date:

**with the exception of Federal Agencies who will be billed at completion of the project*

Utah Division of Air Quality

Boxes indicate where information can be found in the application.

NOTICE OF INTENT COMPLETENESS CHECKLIST

TO BE COMPLETED BY PROJECT ENGINEER WITHIN 30 DAYS OF RECEIPT OF THE NOTICE OF INTENT (NOI). CRITERIA DERIVED FROM R307-401-5, UTAH ADMINISTRATIVE CODE (UAC). ANY NEGATIVE RESPONSE WILL CAUSE APPLICATION TO BE DELAYED. ALL REFERENCES ARE TO THE UAC EXCEPT AS NOTED.

Project Name: Date:

1. Fees Paid				
A. Filing Fee	Cover letter	Y ☐	N ☐	
B. Application Fee		Y ☐	N ☐	
2. Source Identification Information: [R307-401-5(2)(k)]				
A. Name, address, and telephone number (w/area code)		Y ☐	N ☐	
B. Company submitting application		Y ☐	N ☐	
C. Plant manager and/or Company contact		Y ☐	N ☐	
D. Plant (if different from Company)		Y ☐	N ☐	N/A ☐
E. Company owner and agent	Form 1 General information in Sections 1.0 and 2.1	Y ☐	N ☐	
F. Property UTM coordinates		Y ☐	N ☐	
G. County where facility is located		Y ☐	N ☐	
H. SIC Code(s)		Y ☐	N ☐	
I. Facility area designation (attainment, maintenance, or nonattaiment)		Y ☐	N ☐	
3. If modification, AO# to be modified [R307-401-5(2)(k)]	Form 1	Y ☐	N ☐	N/A ☐
A. Other current Approval Order(s) for facility not being modified		Y ☐	N ☐	N/A ☐
B. Current Title V (Operating Permit)		Y ☐	N ☐	N/A ☐
4. Purpose of application [R307-401-5(2)(a)]	Form 1 Section 1.0	Y ☐	N ☐	
5. Construction schedule [R307-401-5(2)(h)]	Form 1 Section 2.6	Y ☐	N ☐	N/A ☐
6. Justifiable confidential data	N/A	Y ☐	N ☐	N/A ☐
7. Description of Source Process. [R307-401-5(2)]				
A. Detailed description of project: [(Appendix A) (Forms 2-23)]				
1. Fuels and their use		Y ☐	N ☐	
2. Raw materials used		Y ☐	N ☐	N/A ☐
3. Description of product(s)	Section 2.0 and sub-sections	Y ☐	N ☐	
4. Equipment used in process		Y ☐	N ☐	
5. Operation schedules		Y ☐	N ☐	
6. Description of changes to process		Y ☐	N ☐	N/A ☐
7. Production rates		Y ☐	N ☐	N/A ☐

B. Site plan of facility with, building dimensions, stack parameters included: (Appendix B) Y ☐ N ☐

1. Emission points and elevations Y ☐ N ☐
2. Building dimensions Y ☐ N ☐ N/A ☐
3. Stack parameters Y ☐ N ☐ N/A ☐

Attachment A
No stack parameters included
(no modeling analysis)

8. Emissions Related Information. [R307-401-(2)(b)]

A. Emission Calculations: (Appendix C)

Section 3.0 and subsections; Attachment B

1. Emissions per new/modified unit for all pollutants: (PM_{10}, $PM_{2.5}$ NO_x, SO_x, CO, VOC, and HAPs) Y ☐ N ☐
2. Designation of fugitive and non-fugitive emissions Y ☐ N ☐
3. Major GHG Sources: (in CO2e short tons per year) Y ☐ N ☐ N/A ☐
4. References/assumptions for each calculation and pollutant Y ☐ N ☐
5. HAP emissions (broken out by specific pollutant in pounds per hr) Y ☐ N ☐ N/A ☐
6. Applicable Material Safety Data Sheets Y ☐ N ☐

B. DAQ Form 1a or equivalent (Appendix D) Y ☐ N ☐

Attachment C

C. Source size determination (Appendix E)

Section 3.0 and sub-sections

1. If Existing Major Source: Determination of Minor, Major, or PSD Modification Y ☐ N ☐ N/A ☐

D. Offset requirements (nonattainment/maintenance areas) [(R307-401-420)(R307-401-421)] (Appendix F) Y ☐ N ☐ N/A ☐

1. Acquired required offsets Y ☐ N ☐ N/A ☐

Section 4.9
(not applicable)

9. Air Pollution Control Equipment

Not applicable.

A. Best Available Control Technology (BACT) Analysis [R307-401-5(2)(d), (Appendix G)] Y ☐ N ☐

B. Detailed information on new/modified equipment controls [R307-401-5(2)(c), (Appendix H)] Y ☐ N ☐

10. Federal/State requirement applicability [(NAAQS, SIP, NSPS, etc), (Appendix I) Y ☐ N ☐ N/A ☐

Section 4.0 and sub-sections

11. Modeling information

A. Emissions Impact Analysis [(R307-410-4), (Appendix J)] Y ☐ N ☐ N/A ☐

Section 4.8

12. Signature on application (Form 1 Notice of Intent) Y ☐ N ☐

Form 1

NSR

RECEIVED
OCT 13 2015
DEPARTMENT OF
ENVIRONMENTAL QUALITY

TESORO

Tesoro Refining & Marketing Company LLC
474 West 900 North
Salt Lake City, UT 84103
801 521 4810

October 12, 2015

Marty Gray, Major NSR Section Manager
Utah Division of Air Quality
195 North 1950 West
P.O. Box 144820
Sal t Lake City, Utah 84114-4820

HAND DELIVERED

Re: Tesoro Salt Lake City Refinery FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation NOI Update

Dear Mr. Gray:

On June 11, 2015, Tesoro Refining & Marketing Company LLC (Tesoro) submitted a Notice of Intent (NOI) application for the FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation for the Salt Lake City Refinery. Since the time the original application was submitted, Tesoro has determined that an incremental steam load of approximately 17,500 lb/hr of 300 psi steam will be required as part of the project. The additional steam load will drive the CO Boiler combustion air fan which will provide higher pressures through the flue gas train. This additional pressure is needed to overcome the pressure drop associated with installing the Wet Gas Scrubber. In addition, Tesoro is submitting estimated fugitive PM, PM_{10}, and $PM_{2.5}$ emissions associated with truck traffic on existing paved roads at the facility due to raw material (oxygen, caustic and coagulant) delivery and filter cake (associated with the wet gas scrubber's purge treatment unit) disposal. While not likely, trucks may also be utilized to dispose of wastewater. The final option for wastewater disposal has not been determined at this time; however, to be conservative, Tesoro has assumed haul trucks will be utilized to dispose of wastewater.

Emissions Summary

To account for the potential increase in emissions due to additional steam demand, Tesoro has estimated the increase in emissions at the facility's Cogeneration Units for the incremental steam consumption. For haul road truck traffic, emissions are estimated using methodology from AP-42 Section 13.2.1, Paved Roads (equation 2), January 2011.

A summary of emissions increases from the project is provided below. Detailed calculations are provided in Attachment A to this letter.

	Emissions Increase (ton/yr)							
Emissions Unit	**NO_X**	**SO_2**	**CO**	**PM**	**PM_{10}**	**$PM_{2.5}$**	**VOC**	**H_2SO_4**
Cogeneration Units	5.97	2.09	6.53	0.84	0.84	0.84	0.43	0.03
Truck Traffic				0.40	0.08	0.02		
Total	**5.97**	**2.09**	**6.53**	**1.24**	**0.92**	**0.86**	**0.43**	**0.03**
PSD Significant Emissions Rate (SER)	40	40	100	25	15	10	40	7
Exceeds PSD threshold?	No	No	No	No	No	No	No	No

This update to the NOI application does not change the result of any applicable rules or requirements as described in the original NOI application.

Please contact me at 801-521-4966 or Michelle Bujdoso at 801-366-2036 if you need more information or have questions.

Sincerely,

William Snarr
Health Safety and Environmental Manager

Enclosures

Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery
FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation - UPDATE
Table 1: Stack Emission Calculations for Cogeneration Units

Quantity	Value	Units	Reference
Steam Requirement:	17,500	lb/hr	Engineering estimate
Firing Requirement:	19.25	MMBtu/hr	Engineering estimate
Fuel Heat Content:	1083.8	Btu/scf	Engineering estimate for future operations
Fuel Use Requirement:	0.0178	MMscf/hr	Calculated
Fuel H_2S Content:	162	ppmvd	NSPS Ja H_2S concentration limit (3-hour average)
Hours of Operation:	8760	hr/yr	

Pollutant	Emission Factor	Units	Emission Increase (lb/hr) (1)	Emission Increase (tpy) (2)	Reference
NO_X	76.80	lb/MMscf	1.36	5.97	Maximum stack test result from 2009 for East Cogeneration Unit
SO_2	26.91	lb/MMscf	0.48	2.09	Calculated
CO	84.00	lb/MMscf	1.49	6.53	AP-42 Table 3.1-1
PM	0.01	lb/MMBtu	0.19	0.84	Manufacturer Specification
PM_{10}	0.01	lb/MMBtu	0.19	0.84	Manufacturer Specification
$PM_{2.5}$	0.01	lb/MMBtu	0.19	0.84	Manufacturer Specification
VOC	5.50	lb/MMscf	0.10	0.43	AP-42 Table 1.4-2
H_2SO_4	0.40	lb/MMscf	0.01	0.03	TRI calculation (1.5% of SO2 emissions)

Notes:

(1) Emission Increase (lb/hr) = Emission Factor (lb/MMBtu) x Fuel Use Requirement (MMBtu/hr) or
Emission Increase (lb/hr) = Emission Factor (lb/MMscf) x Fuel Use Requirement (MMscf/hr)

(2) Emission Increase (tpy) = Emission Increase (lb/hr) x Hours of Operation (hr/yr) / 2000 lb/ton

Date printed: 10/12/2015

Tesoro Refining and Marketing Company
Salt Lake City Refinery
FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation - UPDATE

Table 2: Emissions Calculations for Haul Road Truck Traffic

Increases in Emissions on Paved Roads

Emissions calculated using equation in January 2011 AP-42 Section 13.2.1, Paved Roads (equation 2).

E = [k * (sL)^0.91 * (W)^1.02] * (1-P/4*N)

Variable	Description	PM	PM_{10}	$PM_{2.5}$	Reference
k =	particle size multiplier	0.011	0.0022	0.00054	from AP-42 Table 13.2.1-1
sL =	Road surface silt loading, g/m^2, annual average	1.5	1.5	1.5	AP-42 Table 13.2-1-2 for < 500 ADT, assuming 6 mos. with frozen precipitation
W =	Average weight (tons) of the vehicles traveling the road	27.5	27.5	27.5	Engineering estimate
P =	days per year with at least 0.254 mm precipitation	60	60	60	from AP-42 Figure 13.2.2-1
Emission Factor =	Emission Factor (lb/vehicle miles traveled (VMT))	0.45	0.09	0.02	
	Control Efficiency from Application of Dust Suppressant	0%	0%	0%	

Truck Type	Number of Trucks per Year	Miles Traveled per Truck (round trip)	Mileage (VMT)	PM Emissions (tons)	PM_{10} Emissions (tons)	$PM_{2.5}$ Emissions (tons)
Oxygen delivery	90	1.25	113	0.03	0.01	0.00
Caustic delivery	24	2.25	54	0.01	0.00	0.00
Coagulant delivery	12	1.25	15	0.00	0.00	0.00
Wastewater disposal	1260	1.25	1,575	0.35	0.07	0.02
Filter cake disposal	24	1.25	30	0.01	0.00	0.00
Increase in Haul Road Truck Traffic Emissions from Paved Roads				**0.40**	**0.08**	**0.02**

NSR

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY

JUN 1 1 2015

DIVISION OF AIR QUALITY

TESORO

Tesoro Refining & Marketing Company LLC
474 West 900 North
Salt Lake City, UT 84103
801 521 4810

HAND DELIVERED

June 11, 2015

Marty Gray, Major NSR Section Manager
Utah Division of Air Quality
195 North 1950 West
P.O. Box 144820
Salt Lake City, Utah 84114-4820

Re: Tesoro Salt Lake City Refinery FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation NOI Submittal

Dear Mr. Gray:

Enclosed please find a Notice of Intent (NOI) application for the FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation. This project will occur at the Tesoro Refining and Marketing Company's (Tesoro's) Salt Lake City (SLC) Refinery which operates under Approval Order (AO) DAQE-AN103350065-14.

Also included is a check for $2300 which covers the filing fee and the base fee (Existing Major Source with a Minor Modification) for the NOI application.

Please contact me at 801-521-4966 or Michelle Bujdoso at 801-366-2036 if you need more information or have questions.

Sincerely,

William Snarr
Health, Safety and Environmental Manager

Enclosures

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY

JUN 11 2015

DIVISION OF AIR QUALITY

FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation

Notice of Intent for an Approval Order

Prepared for
Tesoro Refining & Marketing Company LLC
Salt Lake City Refinery

June 2015

TESORO

BARR

4700 West 77th Street
Minneapolis, MN 55435-4803
Phone: (952) 832-2600
Fax: (952) 832-2601

FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation

Notice of Intent for an Approval Order

June 2015

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1.0 Introduction

This Notice of Intent (NOI) package is submitted for approval of the installation of wet gas scrubber (WGS) and LoTOx^{TM} emission control systems on the fluidized catalytic cracking unit/carbon monoxide boiler (FCCU/CO Boiler) at the Tesoro Refining &Marketing Company LLC's (Tesoro's) Salt Lake City (SLC) Refinery (hereinafter referred to as the "Project"). The SLC Refinery currently operates under multiple Approval Orders (AOs), of which DAQE-AN103350065-14 is affected by this Project. The SLC Refinery is situated on 236 acres in Salt Lake County, approximately 1.5 miles north of Salt Lake City.

This Project involves installation of WGS and LoTOx^{TM} systems to control emissions from the FCCU/CO Boiler. These emission control systems are being installed primarily to meet Utah's $PM_{2.5}$ State Implementation Plan (SIP) requirements that apply to Tesoro. The $PM_{2.5}$ SIP, as most recently amended by the Utah Air Quality Board on December 3, 2014, is incorporated by reference and made part of Utah rules pursuant to R307-110-10. Section IX.H.11.g.i. of the SIP contains requirements for petroleum refineries and specifically for fluid catalytic cracking units. In addition, source-wide limits are included specifically for Tesoro's SLC Refinery in section IX.H.11.r. These requirements are included in section 4.1 of this application.

In general, the WGS and LoTOx^{TM} technology process reduces the emissions of SO_2 and NO_X by converting these compounds to other compounds that are easily removed from the flue gas by liquid sprays within the scrubber. These same liquid sprays also remove particulates from the flue gas. The LoTOx^{TM} system injects ozone into the FCCU/CO Boiler exhaust stream within the WGS. NO_X compounds are oxidized with ozone to form compounds that are removed from the flue gas in the WGS. It is expected that a small amount of ozone (approximately 3 ppm) will not react with the NO_X compounds and will be emitted directly to the atmosphere (known as "slip"). Emissions of NO_X and $SO_2$from the FCCU/CO Boiler will be reduced due to the installation of the pollution control equipment.

Utah administrative code Rule R307-401-3(c) requires submittal of an NOI to "install a control apparatus or other equipment intended to control emissions of air contaminants." Rule R307-401-5 requires that the NOI must contain specific information related to the process, nature of emissions, control device(s), and regulatory applicability and compliance. This NOI includes a project description, an emissions summary, and a description of regulatory applicability and demonstration of compliance to address these requirements.

This NOI is organized as follows:

- Section 2.0 contains a project description,
- Section 3.0 contains the emissions summary,
- Section 4.0 contains a description of regulatory applicability and compliance demonstration,
- Section 5.0 contains a summary of the NOI requirements,
- Attachment A contains a site diagram,
- Attachment B contains the Project emission calculations,
- Attachment C contains Form 1, Form 9, and the NOI checklist.

2.0 Project Description

This section includes a general description of the facility and details of the proposed Project.

2.1 General Facility Information

The Tesoro Salt Lake City Refinery is located at 474 West 900 North, Salt Lake City, Utah. The refinery is located in a nonattainment area for $PM_{2.5}$ (including precursors NO_X, SO_2, and VOC)[1], PM_{10} (including precursors SO_2 and NO_x)[2], and SO_2. The area is also a designated maintenance area for ozone (VOC and NO_x) and CO. Attachment A includes a figure that shows the location of the refinery in Salt Lake City.

2.2 Project Description

This Project will install a Belco wet gas scrubber (WGS) and Linde LoTOx™ system. Specifically, the control system will consist of:

- A Belco spray tower for SO_2 and particulate removal,
- A Linde LoTOx™ system including an onsite ozone generator for NO_X removal, and
- A Belco purge treatment unit (PTU) for dewatering and solid waste disposal.

For control of NO_X emissions, the proposed wet scrubbing system uses Linde LLC's patented LoTOx™ process. In the LoTOx™ process, ozone is injected into the FCCU/CO Boiler exhaust gas stream within the WGS. NO_X compounds are oxidized with ozone to form compounds that are removed from the flue gas in the WGS.

SO_2 and SO_3 are removed from the FCCU/CO Boiler exhaust gas stream by contacting the exhaust gas with water, buffered with a sodium reagent (either sodium hydroxide, NaOH or soda ash or Na_2CO), in the spray tower. The reagent and reagent byproducts are liquids.

Similar to SO_X removal, particulates are also removed through liquid-gas contact in the scrubber's spray tower. Liquid containing these compounds is collected and purged from the scrubber. It is then processed by a Purge Treatment Unit (PTU), which separates and dewaters the particulate. The

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[1] Utah State Implementation Plan Control Measures for Area and Point Sources, Fine Particulate Matter, $PM_{2.5}$ SIP for the Salt Lake City, UT Nonattainment Area Section IX. Part A.21, December 3, 2014

[2] Utah PM_{10} Maintenance Provisions for Salt Lake County, Section IX.A.10, July 6, 2005.

system is designed to discharge a neutral pH liquid stream. The final effluent is low in total suspended solids (TSS), and contains up to 10% total dissolved solids (TDS) from sodium sulfate and sodium nitrate.

A small increase in fugitive dust emissions will occur due to increased truck traffic to deliver raw materials and haul waste byproducts associated with the WGS and LoTOx™ system. In addition, there is an increase in electrical demand resulting from onsite ozone generation and pumping loads; however, all incremental electricity will be provided by off-site generation, since on-site generation is fully utilized by existing process facilities within the refinery.

2.3 Affected Non-Modified Emission Units

The emission unit controlled by the Project is the FCCU/CO Boiler (PS# 4). However, the unit itself will not be modified and NO_X SO_2, $PM_{2.5}$, PM_{10}, and PM emissions will not increase after the Project.

2.4 Emission Units Not Affected by Project

Tesoro has evaluated the Project impacts to other portions of the refinery and has determined that no non-modified emission units are affected by the Project. The Project does not relieve constraints of any other process units.

2.5 Project Schedule

The estimated start of construction is May 2016, pending permit approval. The system is expected to begin operations in October 2017, assuming permit approval by the estimated date for start of construction.

3.0 Emissions Summary

The Utah Department of Environmental Quality Division of Air Quality (UDAQ) requires a comparison of the emissions before and after the Project. There will be no increase in potential or actual emissions at the FCCU/CO Boiler (PM, PM_{10}, $PM_{2.5}$, NO_X, SO_2, CO). There will be a small amount of ozone emissions resulting from ozone slip in the LoTOx^{TM} system (approximately 3 ppm) after the installation of the control system.

Attachment B contains detailed emission calculations which summarize the potential emissions of the FCCU/CO Boiler before and after the Project. These emission calculations reflect new emission limitations that will apply or are being proposed (refer to Section 3.2).

3.1 R307-403 and R307-405 Emissions Determination

Pollutant-specific emission calculations must be completed to determine whether a major modification will occur under R307-403 for nonattainment and maintenance areas and under R307-405 for attainment areas. Since the Project does not result in an increase in actual emissions for the affected unit (the FCCU/CO Boiler) or for any other emission units, a major modification will not occur. Refer to Sections 4.6 and 4.7 for determinations of the applicability of New Source Review (NSR).

3.2 Calculation of Emissions

As previously discussed, NO_X and SO_2 emissions from the FCCU/CO Boiler will decrease as part of the Project. The annual emissions decreases are described and quantified as follows to reflect new applicable and proposed limitations. In addition to the annual limits described below, short term limits are also proposed. A summary of all emissions limits is provided in Section 3.4. A summary of the annual potential emissions of SO_2, NO_X, and CO from the FCCU/CO Boiler before and after the project is presented in Table 3-1 below.

- Potential SO_2 emissions before the Project are based on the existing SO_X limit at the FCCU/CO Boiler of 705 tons per rolling 12-month period and the conversion factor of 1.05 to convert from SO_X to SO_2. Potential SO_2 emissions after the Project are calculated using a proposed SO_2 emission limit of 10 ppmvd @ 0% excess air on a 365-day rolling average.

- Potential NO_X emissions before the Project are based on the existing NO_X limit at the FCCU/CO Boiler of 174 tons per year. Potential NO_X emissions after the Project are calculated using a proposed NO_X emission limit of 10 ppmvd @ 0% excess air on a 365-day rolling average.

- Potential CO emissions before the Project are based on the existing CO limit of 500 ppmvd. Potential CO emissions after the Project are calculated using a proposed CO emission limit of 100 ppmvd @ 0% excess air on a 365-day rolling average.
- Potential emissions of other pollutants will not change because there are no new applicable or proposed limits. The $PM_{2.5}$ SIP contains a limit of 1.0 pounds PM per 1000 pounds coke burned on a 3-hour average basis; however, the same PM limit already applies per 40 CFR 60 (NSPS) Subpart J.

Table 3-1. Summary of FCCU/CO Boiler Potential to Emit (PTE) Before and After Project

Pollutant	**Before Project**	**After Project**
	(tons/yr)	**(tons/yr)**
SO_2	671.43	41.06
NO_X	174.00	29.48
CO	933.43	179.51

3.3 Hazardous Air Pollutant (HAP) Emissions

There are no increases in actual or potential emissions of HAPs as a result of the Project. The WGS may result in a decrease in HAP emissions such as heavy metals in particulate form or volatile organic compounds that are soluble in water; however, these potential decreases have not been quantified.

3.4 Existing and Proposed Emissions Limits

Proposed new emission limits are presented in Table 3-2 for the FCCU/CO Boiler. Section 4.1 also provides the refinery-wide limits that are required by the $PM_{2.5}$ SIP. Tesoro will use continuous emission monitoring systems (CEMS) to demonstrate compliance with the proposed NO_X, SO_2, and CO limits for the FCCU/CO Boiler.

Table 3-2. Proposed FCCU/CO Boiler Emission Limits

Pollutant	Limit	Averaging Period	Date Applicable
NO_X	10 ppmvd at 0% O_2	Rolling 365-day	January 1, 2018
NO_X	20 ppmvd at 0% O_2	Rolling 7-day	January 1, 2018
SO_2	10 ppmvd at 0% O_2	Rolling 365-day	January 1, 2018
SO_2	18 ppmvd at 0% O_2	Rolling 7-day	January 1, 2018
SO_2	25 ppmvd at 0% O_2	Rolling 365-day	January 1, 2018
SO_2	50 ppmvd at 0% O_2	Rolling 7-day	January 1, 2018
CO	100 ppmvd at 0% O_2	Rolling 365-day	October 1, 2015

Table 3-3. Proposed Source-Wide Emission Limits

Pollutant	Limit	Averaging Period	Date Applicable
$PM_{2.5}$ (filterable)	0.42 ton/day	1-day	January 1, 2019
$PM_{2.5}$ (filterable)	110 ton/yr	Rolling 12-month	January 1, 2019
NO_X	1.988 ton/day	1-day	January 1, 2019
NO_X	475 ton/yr	Rolling 12-month	January 1, 2019
SO_2	3.1 ton/day	1-day	January 1, 2019
SO_2	300 ton/yr	Rolling 12-month	January 1, 2019

4.0 Regulatory Applicability and Compliance Demonstration

Tesoro has completed an applicability review of all Federal and State air quality regulations as part of the air permit application process. Table 4-1 provides a summary of the major air quality programs that were reviewed for the Project. Each regulation which requires explanation is described in the following sections.

Table 4-1. Summary of Air Quality Regulatory Applicability for the Project

Report Section	Program Description	Regulatory Citation	Does This Project Trigger New Applicable Requirements?
---	**Utah State Rules**	**R307**	---
4.1	General Requirements: State Implementation Plan	R307-110	Yes
4.2	Stationary Sources	R307-210	No
4.3	National Emission Standards for Hazardous Air Pollutants	R307-214	No
4.4	Ozone Nonattainment and Maintenance Areas: Control of Hydrocarbon Emissions in Petroleum Refineries	R307-326	No
---	Ozone Nonattainment and Maintenance Areas: Petroleum Liquid Storage	R307-327	No
4.5	Permit: New and Modified Sources	R307-401	Yes
4.6	Nonattainment and Maintenance Areas	R307-403	No
4.7	Permits: Major Sources in Attainment or Unclassified Areas (PSD)	R307-405	No
4.8	Visibility	R307-406	No
4.9	Permits: Emissions Impact Analysis	R307-410	No
---	Permits: Fees for Approval Orders	R307-414	No
4.10	Permits: Ozone Offset Requirements in Davis and Salt Lake Counties	R307-420	No
4.11	Permits: PM_{10} Offset Requirements in Salt Lake County and Utah County	R307-421	No
4.12	Consent Decree - United States, et.al. v. BP Exploration & Oil, et. al., Civil Action No. 2:96 CV 095 RL	---	No
---	**Federal Rules**	40 CFR	---

Report Section	Program Description	Regulatory Citation	Does This Project Trigger New Applicable Requirements?
---	National Ambient Air Quality Standards (NAAQS)	40 CFR 50	No
4.6, 4.7	New Source Review (NSR)	40 CFR 52	No
4.2	New Source Performance Standards (NSPS)	40 CFR 60	Yes
4.3	National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR 61	No
4.3	NESHAPs for Source Categories	40 CFR 63	No
---	Risk Management Programs for Chemical Accidental Release Prevention	40 CFR 68	No
---	Title V Operating Permit	40 CFR 70	No
---	Acid Rain Requirements	40 CFR 72	No
---	Stratospheric Ozone Protection Requirements	40 CFR 82	No

4.1 Rule R307-110. General Requirements: State Implementation Plan

The $PM_{2.5}$ State Implementation Plan (SIP), as most recently amended by the Utah Air Quality Board on December 3, 2014, is incorporated by reference and made part of Utah rules pursuant to R307-110-10. The limits described below are summarized in Section 3.4 of this application. Section IX.H.11.g.i of the $PM_{2.5}$ SIP contains the following requirements for petroleum refineries.

Petroleum Refineries.

i. Limits at Fluid Catalytic Cracking Units

A. FCCU SO_2 Emissions

I. By no later than January 1, 2018, each owner or operator of an FCCU shall comply with an SO_2 emission limit of 25 ppmvd @ 0% excess air on a 365-day rolling average basis and 50 ppmvd @ 0% excess air on a 7-day rolling average basis.

II. Compliance with this limit shall be determined by following 40 C.F.R. §60.105a(g).

B. FCCU PM Emissions

I. By no later than January 1, 2018, each owner or operator of an FCCU shall comply with an emission limit of 1.0 pounds PM per 1000 pounds coke burned on a 3-hour average basis.

II. Compliance with this limit shall be determined by following the stack test protocol specified in 40 C.F.R. §60.106(b) to measure PM emissions on the FCCU. Each owner operator shall conduct stack tests once every five years at each FCCU.

III. By no later than January 1, 2019, each owner or operator of an FCCU shall install, operate and maintain a continuous parameter monitor system (CPMS) to measure and record operating parameters for determination of source-wide $PM_{2.5}$ emissions as appropriate.

In addition, the following source-wide requirements apply specifically to the Tesoro SLC Refinery per Section IX.H.11.r.

r. Tesoro Refining and Marketing Company: Salt Lake City Refinery

i. Source-wide PM2.5

By no later than January 1, 2019, combined emissions of filterable PM2.5 shall not exceed 0.42 tons per day (tpd) and 110 tons per rolling 12-month period.

PM2.5 emissions shall be determined daily by applying the listed emission factors or emission factors determined from the most current performance test to the relevant quantities of fuel combusted. Unless adjusted by performance testing as discussed above, the default emission factors to be used are as follows:

Natural gas – 1.9 lb/MMscf (filterable), 5.7 lb/MMscf (condensable)

Plant gas – 1.9 lb/MMscf (filterable), 5.7 lb/MMscf (condensable)

Daily gas consumption by all boilers and furnaces shall be measured by meters that can delineate the flow of gas to the indicated emission points.

The equations used to determine emissions for the boilers and furnaces shall be as follows:

*Emission Factor (lb/MMscf) * Gas Consumption (MMscf/24 hrs)/(2,000 lb/ton)*

By no later than January 1, 2019, Tesoro shall conduct stack testing to establish the ratio of condensable PM2.5 from the FCCU wet gas scrubber stack. At that time the condensable fraction will be added and a new source-wide limitation shall be established in the AO.

Total 24-hour PM2.5 (filterable + condensable) emissions shall be calculated by adding the results of the above filterable PM2.5 equations for natural gas and plant gas combustion to the values for the FCCU wet gas scrubber stack and to the estimate for the SRU/TGTU/TGI. Results shall be tabulated every day, and records shall be kept which include the meter readings (in the appropriate units) and the calculated emissions.

ii. Source-wide NOx

By no later than January 1, 2019, combined emissions of NOx shall not exceed 1.988 tons per day (tpd) and 475 tons per rolling 12-month period.

Compliance shall be determined daily by multiplying the hours of operation of a unit, feed rate to a unit, or quantity of each fuel combusted at each affected unit by the associated emission factor, and summing the results.

A NOx CEM shall be used to calculate daily NOx emissions from the FCCU wet gas scrubber stack. Emissions shall be determined by multiplying the nitrogen dioxide concentration in the flue gas by the mass flow of the flue gas. The NOx concentration in the flue gas shall be determined by a CEM.

The emission factors for all other emission units are based on the results of the most recent stack test for that unit.

Total daily NOx emissions shall be calculated by adding the emissions for each emitting unit. Results shall be tabulated every day, and records shall be kept which include the meter readings (in the appropriate units) and the calculated emissions.

iii. Source-wide SO2

By no later than January 1, 2019, combined emissions of SO2 shall not exceed 3.1 tons per day (tpd) and 300 tons per rolling 12-month period.

Daily SO2 emissions from the FCCU wet gas scrubber stack shall be determined by multiplying the SO2 concentration in the flue gas by the mass flow of the flue gas. The SO2 concentration in the flue gas shall be determined by a CEM.

Daily SO2 emissions from other affected units shall be determined by multiplying the quantity of each fuel used daily (24 hour usage) at each affected unit by the appropriate emission factor below.

Emission factors (EF) for the various fuels shall be as follows:

Natural gas: EF = 0.60 lb/MMscf

Propane: EF = 0.60 lb/MMscf

Plant fuel gas: the emission factor shall be calculated from the H2S measurement or from the SO2 measurement obtained by direct testing/monitoring.

The emission factor, where appropriate, shall be calculated as follows:

EF (lb SO2/MMscf gas) = [(24 hr avg. ppmdv H2S) /10^6] [(64 lb SO2/lb mole)] [(10^6 scf/MMscf)/(379 scf/lb mole)]

Where mixtures of fuel are used in a Unit, the above factors shall be weighted according to the use of each fuel.

Total daily SO2 emissions shall be calculated by adding the daily results of the above SO2 emissions equations for natural gas, plant fuel gas, and propane combustion to the wet gas scrubber stack. Results shall be tabulated every day, and records shall be kept which include the CEM readings for H2S (averaged for each one-hour period), all meter readings (in the appropriate units), and the calculated emissions.

Tesoro requests that the requirements from the SIP be incorporated into the Approval Order issued for this Project.

4.2 R307-210: Stationary Sources

New Source Performance Standards (NSPS) are incorporated by reference into the UDAQ rules. There is no new construction of any NSPS affected facilities. Tesoro reviewed whether the Project will result in a "modification" or "reconstruction" for any NSPS affected facilities, and thus result in applicability of that NSPS. The NSPS regulation, at 40 CFR §60.14(a), defines a modification as a physical or operational change to the affected facility that is not specifically exempted and that results in an increase in the emissions rate to the atmosphere of any pollutant to which a standard applies. An increase in production rate, if that increase can be accomplished without a capital expenditure on that facility, is not considered a modification per §60.14(e)(2). "Increase in emissions rate" is defined pursuant to §60.14(b) as an increase in the maximum hourly emission rate of an applicable pollutant from the affected facility. A reconstruction occurs when the fixed capital cost of the Project is 50 percent or greater than the current replacement cost of the affected facility.

The FCCU/CO Boiler is the only emissions unit that will require physical changes as part of the Project and is currently an affected facility under NSPS Subpart J. Tesoro reviewed the physical changes performed as part of the Project to determine if NSPS Subpart Ja is triggered for the FCCU/CO Boiler. There will not be any increase in maximum hourly emissions of any pollutant regulated by NSPS Subpart Ja (PM, NO_X, SO_2 and CO). Therefore, the FCCU/CO Boiler is not considered to be "modified" according to NSPS regulations. In addition, the estimated cost of changes being made to the FCCU/CO Boiler as part of the Project are less than 50% of the replacement cost of the affected facility; therefore, "reconstruction" is also not triggered.

Tesoro is evaluating applicability of wastewater system modifications related to the Project to determine whether modification is triggered under NSPS Subpart QQQ and is uncertain at this time whether a modification to an affected facility will occur as part of the Project. Tesoro will review the detailed drawings when they are available and in the event that modification is triggered under Subpart QQQ, Tesoro will provide the required notifications to UDAQ.

The Project will not affect applicability of any other NSPS subparts.

4.3 R307-214: National Emission Standards for Hazardous Air Pollutants

NESHAP standards from 40 CFR 61 and 40 CFR 63 are incorporated by reference into the UDAQ rules. The physical changes performed as part of the Project affect only the FCCU/CO Boiler; which is currently subject to 40 CFR 63 Subpart UUU for "National Emission Standards for Hazardous Air Pollutants for Petroleum Refineries: Catalytic Cracking Units, Catalytic Reforming Units, and Sulfur Recovery Units." Catalytic cracking units are regulated as emission points under this subpart. Tesoro will continue to comply with the emission standards and other requirements of this rule following the Project.

4.4 R307-326: Ozone Nonattainment and Maintenance Areas: Control of Hydrocarbon Emissions in Petroleum Refineries

Rule R307-326-7 contains requirements for flue gas from catalytic cracker catalyst regeneration units. The FCCU/CO Boiler is currently subject and will remain subject to this requirement after the Project. Tesoro will continue to comply with the requirements of this rule following the Project.

4.5 R307-401: Permit: New and Modified Sources

Rule R307-401-3(c) requires submittal of an NOI to "install a control apparatus or other equipment intended to control emissions of air contaminants." Since the Project is installation of emission control systems, an NOI must be submitted. Rule R307-401-5 requires submittal of an NOI, which must contain specific information related to the process, nature of emissions, control device(s), and regulatory applicability and compliance. Refer to Section 5.0 for a summary of compliance with the NOI requirements.

4.5.1 State BACT

R307-401-5(d) permits the issuance of an approval order if it is determined that the pollution control for emissions is at least best available control technology (BACT). A BACT review is required for new emission units and existing emission units where there is a physical modification and an increase in emissions. Because emissions are not increasing at the FCCU/CO Boiler a BACT review is not required.

4.6 R307-403: Nonattainment and Maintenance Areas

R307-403 applies to major new sources or major modifications to be located in a nonattainment area. The refinery is located in a nonattainment area for $PM_{2.5}$ (including precursors SO_2, NO_X, and VOC), PM_{10} (including precursors SO_2 and NO_x), and SO_2. The area is also a designated maintenance area for ozone (VOC and NO_x) and CO. The proposed Project is neither a new major source nor a major modification as defined in R307-101-2 since the actual emissions increase is zero, which is less than the significant emission rate (SER) threshold for each applicable pollutant.

Emission offsets are required if the combined allowable emission increase of PM_{10}, SO_2, and NO_x exceeds 25 tons per year per R307-403-5. Since the combined allowable emission increase from the Project is zero tons per year of these pollutants, no emission offsets are required.

4.7 R307-405: Permits: Major Sources in Attainment or Unclassified Areas (PSD)

R307-405 applies to major new sources or major modifications located in an attainment, unclassified, and maintenance areas. This rule requires review of all regulated NSR pollutants except those pollutants in nonattainment with the ambient air quality standards ($PM_{2.5}$, PM_{10}, and SO_2). The proposed Project is neither a new major source nor a major modification as defined in R307-405-3 since the emissions increase for all applicable pollutants is zero, which is less than the SER threshold for each applicable pollutant. Tesoro has demonstrated compliance with all applicable requirements with the submission of this NOI. Therefore the requirements of R307-405 are not applicable to this proposed Project.

4.8 R307-406: Visibility

The installation of the emission control systems results in a reduction in pollutants (NO_X, SO_2, and PM) that cause or contribute to visibility impairment. As a result, Tesoro believes that the Project will not cause an "Adverse Impact on Visibility" as defined in the rule and no further review is required.

4.9 R307-410: Permits: Emissions Impact Analysis

R307-410 establishes the procedures and requirements for evaluating the emissions impact of new or modified sources. Pursuant to R307-410-4, dispersion modeling is required for increases in the total controlled emission rate of attainment pollutants (NO_x and CO for the SLC refinery) in an amount greater or equal to values given in Table 1 of the rule. For these pollutants, the thresholds given in Table 1 are equal to the SERs. Dispersion modeling is not required since there is not an increase in emissions of NO_x or CO.

The requirements of R307-410-5 for documentation of ambient air impacts for hazardous air pollutants do not apply since the Project does not result in an increase in emissions of hazardous air pollutants.

4.10R307-420: Permits: Ozone Offset Requirements in Davis and Salt Lake Counties

The SLC Refinery is located in a maintenance area for ozone. Emission offsets are required for any new major source or major modification of VOC or NO_x. R307-420-2 defines a significant emission increase at a level of 25 tpy VOC rather than 40 tpy VOC. The Project is neither a new major source nor a major modification for VOC (considering the lower threshold) or NO_x; therefore, offsets are not required.

4.11 R307-421: Permits: PM_{10} Offset Requirements in Salt Lake County and Utah County

Emission offsets are required if the combined allowable emission increase of SO_2 and NO_x exceeds 25 tons per year. The combined allowable emission increase of these pollutants from the Project is 0 tons per year. Therefore, no emission offsets are required.

4.12 Consent Decree - United States, et.al. v. BP Exploration & Oil, et. al., Civil Action No. 2:96 CV 095 RL

On August 29, 2001 BP Exploration entered into a Consent Decree with the US EPA covering eight refineries including the Salt Lake City and Mandan refineries. When Tesoro purchased the Salt Lake and Mandan refineries from BP, Tesoro assumed responsibility for the provisions of the consent decree as they related to the two facilities. This Project is not being undertaken to comply with any provisions of this consent decree. Tesoro will continue to comply with the provisions of the consent decree, if applicable, after implementation of the Project.

5.0 Summary of NOI Requirements for Project

Table 5-1 provides a summary of how this NOI complies with the specific requirements of Rule R307-401-5(2).

Table 5-1. Summary of NOI Requirements

Requirement	Section Reference for Information Provided
(a) A description of the nature of the processes involved; the nature, procedures for handling and quantities of raw materials; the type and quantity of fuels employed; and the nature and quantity of finished product.	Section 2.2
(b) Expected composition and physical characteristics of effluent stream both before and after treatment by any control apparatus, including emission rates, volume, temperature, air contaminant types, and concentration of air contaminants.	Section 3.2, Attachment B
(c) Size, type and performance characteristics of any control apparatus.	Attachment C, Form 9.
(d) An analysis of best available control technology for the proposed source or modification. When determining best available control technology for a new or modified source in an ozone nonattainment or maintenance area that will emit volatile organic compounds or nitrogen oxides, the owner or operator of the source shall consider EPA Control Technique Guidance (CTG) documents and Alternative Control Technique documents that are applicable to the source. Best available control technology shall be at least as stringent as any published CTG that is applicable to the source.	N/A. The Project does not include installation of a new or modified source.
(e) Location and elevation of the emission point and other factors relating to dispersion and diffusion of the air contaminant in relation to nearby structures and window openings, and other information necessary to appraise the possible effects of the effluent.	Attachment A – location provided – other info not needed since modeling is not required.
(f) The location of planned sampling points and the tests of the completed installation to be made by the owner or operator when necessary to ascertain compliance.	Not applicable – no new testing is necessary to demonstrate compliance.
(g) The typical operating schedule.	Section 2.2

Requirement	Section Reference for Information Provided
(h) A schedule for construction.	Section 2.5
(i) Any plans, specifications and related information that are in final form at the time of submission of notice of intent.	No plans or specifications are in final form at the time of this submission.
(j) Any additional information required by:	
(i) R307-403, Permits: New and Modified Sources in Nonattainment Areas and Maintenance Areas;	(i) Section 4.6
(ii) R307-405, Permits: Major Sources in Attainment or Unclassified Areas (PSD);	(ii) Section 4.7
(iii) R307-406, Visibility;	(iii) Section 4.8
(iv) R307-410, Emissions Impact Analysis;	(iv) Section 4.9
(v) R307-420, Permits: Ozone Offset Requirements in Davis and Salt Lake Counties;	(v) Section 0
(vi) R307-421, Permits: PM_{10} Offset Requirements in Salt Lake County and Utah County.	(vi) Section 4.11
(k) Any other information necessary to determine if the proposed source or modification will be in compliance with Title R307.	Section 4.2 (NSPS Compliance) Section 4.3 (MACT Compliance) Section 4.4 (Control of Hydrocarbons)

Attachment A

Refinery Location Map and Site Diagram

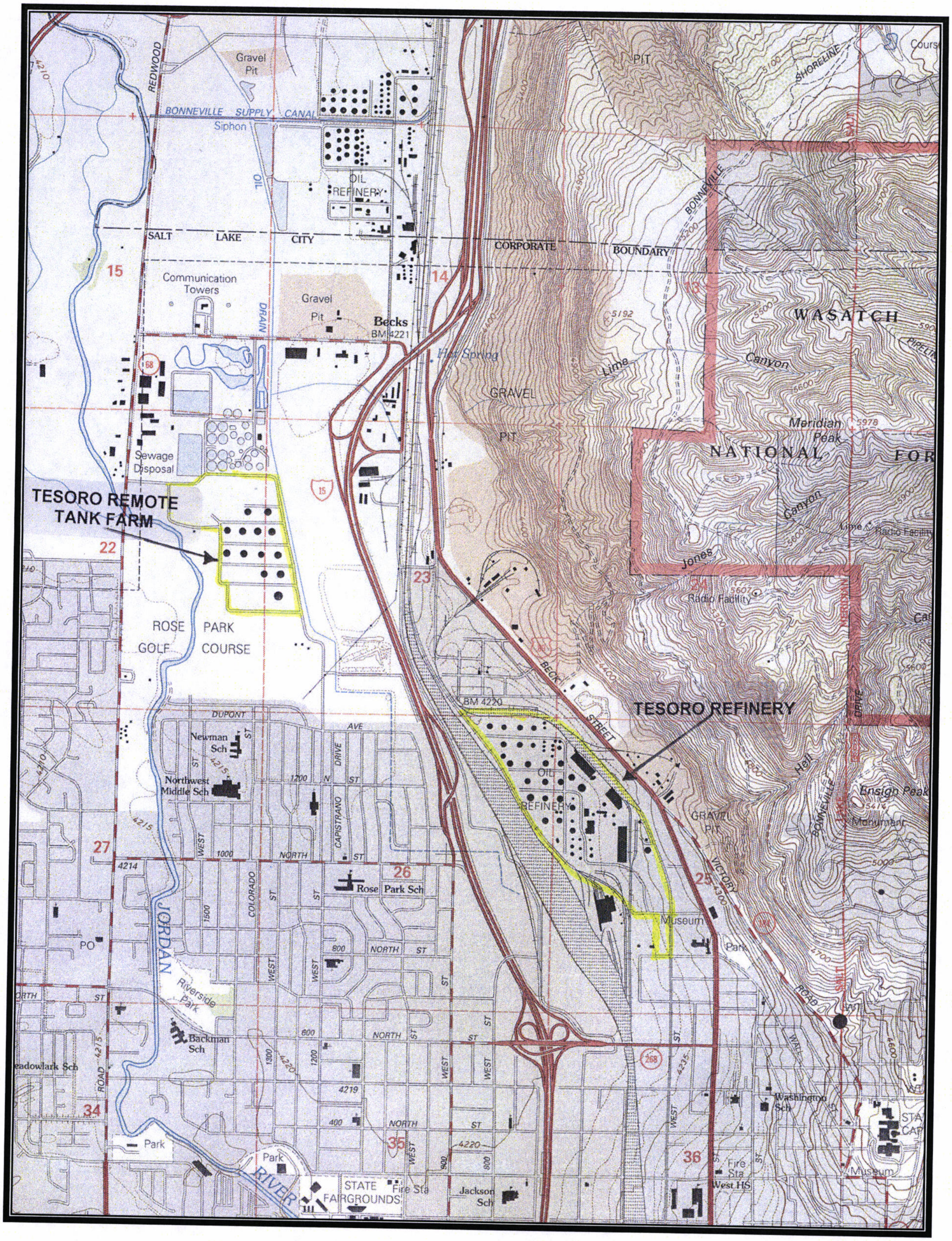
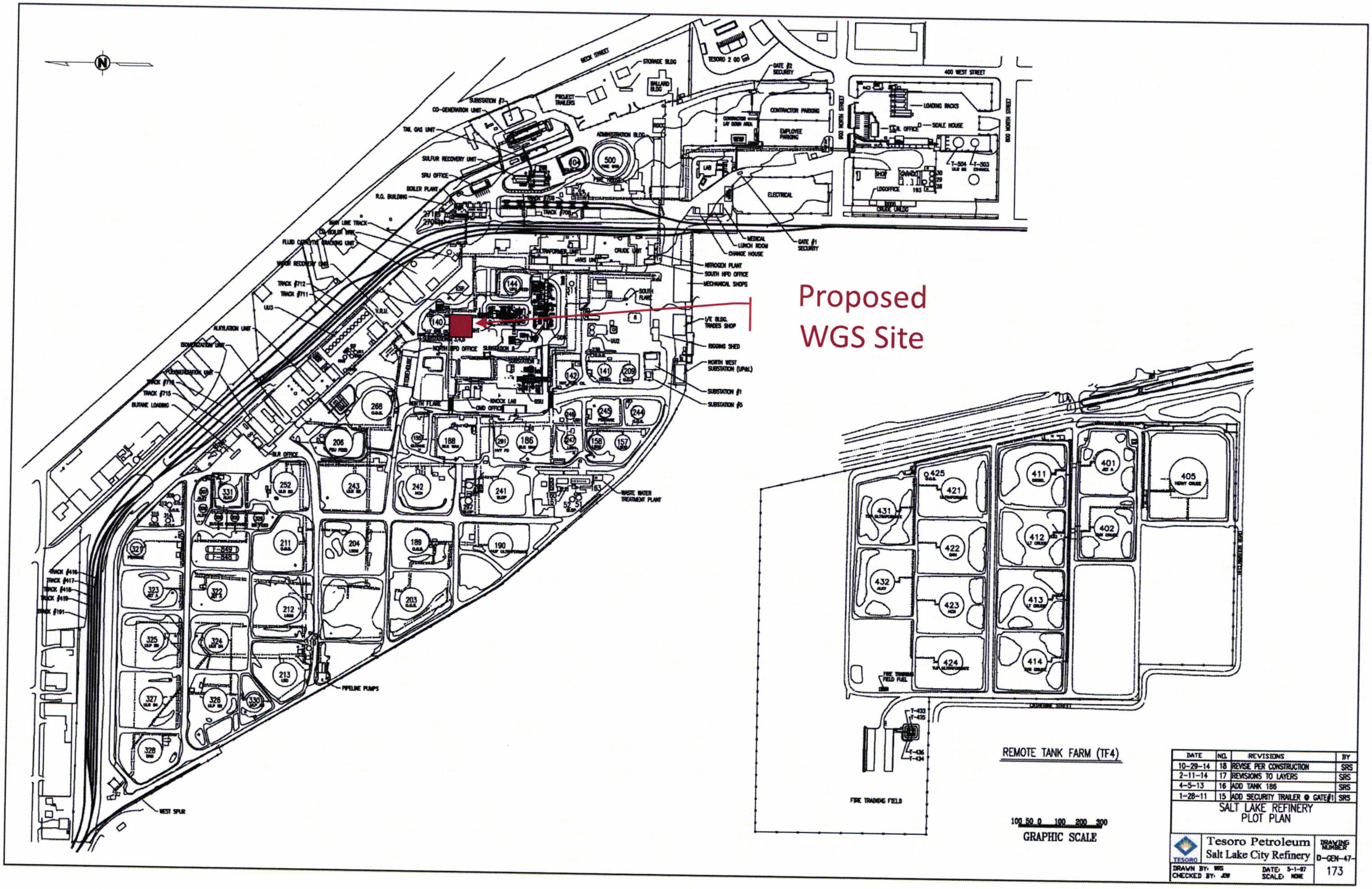


Figure A-1
Refinery Location Map

Tesoro Salt Lake Refinery – Refinery Map



Attachment B

Emission Calculations for Project

Tesoro Refining and Marketing Company
Salt Lake City Refinery
FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation
Table 1 - FCCU/CO Boiler PTE Summary

Pollutant	Potential to Emit (tpy)		Notes
	Before Project	After Project	
SO_2	671.43	41.06	Note 1.
NO_X	174.00	29.48	Note 2.
CO	933.43	179.51	Note 3.

Notes:

(1) The FCCU is currently subject to a 705 ton/year limit on SO_x emissions from the FCCU stack (refer to Approval Order DAQE-AN103350065-14 condition II.B.4.b). The SO_2 PTE before the project is calculated by dividing the 705 ton/year SO_X limit by 1.05. The 1.05 factor is based on actual stack test data showing that approximately 5% of SO_X is SO_3 and the remaining amount is SO_2. After the project, Tesoro is proposing an SO_2 limit of 10 ppmvd at 0% oxygen on a 365-day rolling average; refer to Table 2 for calculation details.

(2) The FCCU is currently subject to a 174 ton/year limit on NO_X emissions from the FCCU stack. Refer to Approval Order DAQE-AN103350065-14 condition II.B.5.b. After the project, Tesoro is proposing a NO_X limit of 10 ppmvd at 0% oxygen on a 365-day rolling average; refer to Table 2 for calculation details.

(3) The FCCU is currently subject to a CO limit of 500 ppmvd (refer to Table 3 for calculation). After the project, Tesoro is proposing a CO limit of 100 ppmvd at 0% oxygen on a 365-day rolling average; refer to Table 2 for calculation details.

Tesoro Refining and Marketing Company
Salt Lake City Refinery
FCCU/CO Boiler Wet Gas Scrubber and LoTOx™ Installation
Table 2 - FCCU/CO Boiler Emission Calculations after Project

FCCU stack flow rate at design O_2 concentration(1), SCFM (wet)	100,000
FCCU stack moisture content(1) (%)	9%
FCCU stack design O_2 concentration(1) (%)	3.5%
FCCU stack flow rate at design O_2 concentration (calculated), SCFM (dry)	91,000
FCCU stack flow rate at 0% O_2 concentration (calculated), SCFM (dry)	87,500

Pollutant	Concentration at 0% O_2, ppmvd	Molecular Weight	Stack emission rate, lb/hr	Stack emission rate, tpy	Notes
SO_2	10	64.07	9.37	41.06	Note 2.
NO_X	10	46.00	6.73	29.48	Note 2.
CO	100	28.01	40.98	179.51	Note 2.

Notes:

(1) Flow rate, moisture content, and O_2 concentration from "*Design Basis, Tesoro SLC Wet Gas Scrubber, Draft – 3/24/15* ".

(2) SO_2, NO_X, and CO emissions based on proposed concentration limits.

Tesoro Refining and Marketing Company
Salt Lake City Refinery
FCCU/CO Boiler Wet Gas Scrubber and LoTOx^{TM} Installation
Table 3 - FCCU/CO Boiler CO Emission Calculation (before project)

FCCU stack flow rate(1), SCFM (wet)	100,000
Stack moisture content(1) (%)	9%
FCCU stack flow rate (calculated), SCFM (dry)	91,000

Pollutant	Concentration at Design O_2, ppmvd	Molecular Weight	Stack emission rate, lb/hr	Stack emission rate, tpy	Notes
CO	500	28.01	213.11	933.43	Note 2.

Notes:

(1) Flow rate and moisture content from "*Design Basis, Tesoro SLC Wet Gas Scrubber, Draft – 3/24/15* ".

(2) Current CO limit per 40 CFR 60 Subpart J.

Attachment C

Form 1, Form 9, and NOI Checklist

Utah Division of Air Quality
New Source Review Section

Date

Form 1
Notice of Intent (NOI)

Application for: ☒Initial Approval Order ☐Approval Order Modification

APPROVAL ORDER MUST BE ISSUED BEFORE ANY CONSTRUCTION OR INSTALLATION CAN BEGIN. This is not a stand alone document; please refer to UAC R307-401and the published NOI guidebook for information on requirements of the specified information below. Please print or type all information requested. All outlined information requested must be accurate and completed before DAQ can determine that an NOI is complete and an engineering review can be initiated. If you have any questions, contact the Division of Air Quality at (801) 536-4000 and ask to speak with a New Source Review Engineer. Written inquiries may be addressed to: Division of Air Quality, New Source Review Section, P.O. Box 144820, Salt Lake City, Utah 84114-4820.

General Owner and Facility Information

R307-401-5(2)(k)

1. Filing Fee Paid*	2. Application Fee Paid*
3. Company name and address: Tesoro Refining & Marketing Company LLC 474 West 900 North Salt Lake City, UT 84103 Phone No.: (801)366-2036 Fax No.: (801)521-4965	4. Company** contact for environmental matters: William Snarr Phone no.: (801)521-4966 Email: William.K.Snarr@tsocorp.com *** Company contact only; consultant or independent contractor contact information can be provided in a cover letter*
5. Facility name and address (if different from above): Tesoro Refining & Marketing Company LLC 474 West 900 North Salt Lake City, UT 84103 Phone no.: (801)366-2036 Fax no.: (801)521-4965	6. Owners name and address: Tesoro Corporation 19100 Ridgewood Parkway San Antonio, TX 78259 Phone no.: Fax no.:
7. Property Universal Transverse Mercator coordinates (UTM), including System and Datum: Easting: 423,400 Northing: 4,515,950 System: UTM Zone 12 Datum:	8. County where the facility is located in: Salt Lake 9. Standard Industrial Classification Code: 2911

10. Designation of facility in an attainment, maintenance, or nonattainment area(s):

SL City CO Maint Area
SL Co Ozone Maint Area
SL Co PM10 NAA
SL Co PM2.5 NAA
SL Co SO2 NAA

11. If request for modification, AO# to be modified: DAQE#DAQE-AN103350065-14 Date: 9/5/14

12. Identify any current Approval Order(s) for the facility **not** being modified with this request:

AO#DAQE-AN103350063-14 Date3/17/14
AO#DAQE-AN0103350042-08 Date5/13/08
AO# Date
AO# Date

13. Application for:

☒New construction
☐Existing equipment operating without permit
☐Change of permit condition
☐Modification
☐Permanent site for Portable Approval Order
☐Change of location

14. Construction or modification estimated start date:5/1/16 Estimated completion date:10/31/17

R307-401-5(2)(h)

15. Does this application contain justifiable confidential data? ☐Yes ☒ No

16. Current Title V (Operating Permit) Identification: Date

☐Requesting an enhanced Title V permit with this AO modification

17. Brief (50 words or less) description of project to post on DAQ web for public awareness

This Project involves installation of WGS and LoTOxTM emissions control systems on the FCCU exhaust stack. These emission control systems are being installed primarily to meet Utah's PM2.5 State Implementation Plan (SIP) requirements that apply to Tesoro.

Process Information

18. Appendix A: Detailed description of project including process flow diagram (See Forms 2-23)

☐Fuels and their use
☐Raw materials used
☐Operation schedules
☐Equipment used in process
☐Description of changes to process (if applicable)
☐Production rates (including daily/seasonal variances)
☐Description of product(s)
☒Stack parameters

R307-401-5(2)(a)

19. Appendix B: Site plan of facility with all emission points and elevations, building dimensions, stack parameters included

R307-401-5(2)(e)

Emissions Information

20. Appendix C: Emission Calculations that must include:
☒Emissions per new/modified unit for each of the following: PM_{10}, $PM_{2.5}$, NO_x, SO_x, CO, VOC, and HAPs
☒Designation of fugitive and non fugitive emissions
☐Major GHG Sources: Emissions per new/modified unit for GHGs (in CO_2e short tons per year)
☒References/assumptions for each Emission Factor used in calculating Criteria pollutant, HAP, and GHG emissions
☐HAP emissions (in pounds per hour and tons per year) broken out by specific pollutant and summed as a total
R307-401-5(2)(b)

21. Appendix D: DAQ Form 1a or equivalent (comparison of existing emissions to proposed emission and resulting new total emissions)

22. Appendix E: Source Size determination (Minor, Synthetic Minor, Major, or PSD)
☒ If an Existing Major Source: Determination of Minor, Major or PSD modification

23. Appendix F: Offset requirements (nonattainment/maintenance areas)
☐Acquired required offsets
R307-401-420 & R307-401-421

Air Pollution Control Equipment Information

24. Appendix G: Best Available Control Technology (BACT) analysis for the proposed source or modification
R307-401-5(2)(d)

25. Appendix H: Detailed information on all new/modified equipment controls. It is strongly recommended using DAQ forms as they outline required information, but something equivalent to the DAQ forms is acceptable.
R307-401-5(2)(c)

26. Appendix I: Discussion of Federal/State requirement applicability (NAAQS, SIP, NSPS, NESHAP, etc)

Modeling Information

27. Appendix J: Emissions Impact Analysis (if applicable)
R307-410-4

Electronic NOI

28. A complete and accurate electronic NOI submitted
R307-401-5(1)

I hereby certify that the information and data submitted in and with this application is completely true, accurate and complete, based on reasonable inquiry made by me and to the best of my knowledge and belief.

Signature: Karma M. Thomson Title: VP, SAlT Lake City Refinery

Name (print) Karma M Thomson
Telephone Number: 801 521 4813
Date: June 11, 2015

*with the exception of Federal Agencies who will be billed at completion of the project

Utah Division of Air Quality

Boxes indicate where information can be found in the application.

NOTICE OF INTENT COMPLETENESS CHECKLIST

TO BE COMPLETED BY PROJECT ENGINEER WITHIN 30 DAYS OF RECEIPT OF THE NOTICE OF INTENT (NOI). CRITERIA DERIVED FROM R307-401-5, UTAH ADMINISTRATIVE CODE (UAC). ANY NEGATIVE RESPONSE WILL CAUSE APPLICATION TO BE DELAYED. ALL REFERENCES ARE TO THE UAC EXCEPT AS NOTED.

Project Name: FCU/COB WGS LoTOx Install Date: 6/11/15

1. Fees Paid
   - A. Filing Fee Y ☐ N ☐
   - B. Application Fee Y ☐ N ☐

Cover letter

2. Source Identification Information: [R307-401-5(2)(k)]
   - A. Name, address, and telephone number (w/area code) Y ☐ N ☐
   - B. Company submitting application Y ☐ N ☐
   - C. Plant manager and/or Company contact Y ☐ N ☐
   - D. Plant (if different from Company) Y ☐ N ☐ N/A ☐
   - E. Company owner and agent Y ☐ N ☐
   - F. Property UTM coordinates Y ☐ N ☐
   - G. County where facility is located Y ☐ N ☐
   - H. SIC Code(s) Y ☐ N ☐
   - I. Facility area designation (attainment, maintenance, or nonattaiment) Y ☐ N ☐

Form 1
General information in Sections 1.0 and 2.1

3. If modification, AO# to be modified [R307-401-5(2)(k)] Y ☐ N ☐ N/A ☐

Form 1

   - A. Other current Approval Order(s) for facility not being modified Y ☐ N ☐ N/A ☐
   - B. Current Title V (Operating Permit) Y ☐ N ☐ N/A ☐

4. Purpose of application [R307-401-5(2)(a)] Y ☐ N ☐

Form 1
Section 1.0

5. Construction schedule [R307-401-5(2)(h)] Y ☐ N ☐ N/A ☐

Form 1
Section 2.5

6. Justifiable confidential data Y ☐ N ☐ N/A ☐

N/A

7. Description of Source Process. [R307-401-5(2)]
   - A. Detailed description of project: [(Appendix A) (Forms 2-23)]
     1. Fuels and their use Y ☐ N ☐
     2. Raw materials used Y ☐ N ☐ N/A ☐
     3. Description of product(s) Y ☐ N ☐
     4. Equipment used in process Y ☐ N ☐
     5. Operation schedules Y ☐ N ☐
     6. Description of changes to process Y ☐ N ☐ N/A ☐
     7. Production rates Y ☐ N ☐ N/A ☐

Section 2.0 and sub-sections

B. Site plan of facility with, building dimensions, stack parameters included: (Appendix B) Y ☐ N ☐

1. Emission points and elevations Y ☐ N ☐
2. Building dimensions Y ☐ N ☐ N/A ☐
3. Stack parameters Y ☐ N ☐ N/A ☐

Attachment A
No stack parameters included
(no modeling analysis)

8. Emissions Related Information. [R307-401-(2)(b)]

A. Emission Calculations: (Appendix C)

1. Emissions per new/modified unit for all pollutants: (PM_{10}, $PM_{2.5}$ NO_x, SO_x, CO, VOC, and HAPs) Y ☐ N ☐
2. Designation of fugitive and non-fugitive emissions Y ☐ N ☐
3. Major GHG Sources: (in CO2e short tons per year) Y ☐ N ☐ N/A ☐
4. References/assumptions for each calculation and pollutant Y ☐ N ☐
5. HAP emissions (broken out by specific pollutant in pounds per hr) Y ☐ N ☐ N/A ☐
6. Applicable Material Safety Data Sheets Y ☐ N ☐

Section 3.0 and subsections; Attachment B

B. DAQ Form 1a or equivalent (Appendix D) Y ☐ N ☐

Attachment C

C. Source size determination (Appendix E)

Section 3.0 and sub-sections

1. If Existing Major Source: Determination of Minor, Major, or PSD Modification Y ☐ N ☐ N/A ☐

D. Offset requirements (nonattainment/maintenance areas) [(R307-401-420)(R307-401-421)] (Appendix F) Y ☐ N ☐ N/A ☐

1. Acquired required offsets Y ☐ N ☐ N/A ☐

Sections 4.10, 4.11 (not applicable)

9. Air Pollution Control Equipment

Sections 2.2 and 4.5, Form 9

A. Best Available Control Technology (BACT) Analysis [R307-401-5(2)(d), (Appendix G)] Y ☐ N ☐

B. Detailed information on new/modified equipment controls [R307-401-5(2)(c), (Appendix H)] Y ☐ N ☐

10. Federal/State requirement applicability [(NAAQS, SIP, NSPS, etc), (Appendix I) Y ☐ N ☐ N/A ☐

11. Modeling information

Section 4.0 and sub-sections

A. Emissions Impact Analysis [(R307-410-4), (Appendix J)] Y ☐ N ☐ N/A ☐

Section 4.9

12. Signature on application (Form 1 Notice of Intent) Y ☐ N ☐

Form 1

Utah Division of Air Quality
New Source Review Section

Form 9
Scrubbers & Wet Collectors

Company Tesoro Refining and Marketing Company
Site/Source Salt Lake City Refinery
Date May 1, 2015

Equipment Information

1. Provide diagram of internal components (attachment) TBD

2. Manufacturer: Belco
Model no. TBD

3. Date installed: October 1, 2017

4. Emission Equipment served: FCCU

5. Type of pollutant(s) controlled:
Particulate (type) Filterable (PM, PM_{10}, and $PM_{2.5}$) and condensable
SO_x SO_2, SO_3
Odor
Other NO_X

6. Type of Scrubber: TBD
☒ Spray Chamber ☐ Venturi
☐ Cyclone ☐ Packed Tower Type
☐ Orifice ☐ Mechanical

7. Gas Stream Characteristics

Flow rate (acfm)		Gas Stream Temperature (°F)		Particulate Grain Loading (grains/scf)	
Design Maximum	Average Expected	Inlet	Outlet	Inlet	Outlet
100,000 scfm	95,000 scfm	480°F	134°F	1.35	0.0051

8. Particulate size: TBD microns (mean geometric diameter)

Scrubbing Liquid Characteristics

9. Scrubbing Liquid
PH 14 Range 14 - 14

Composition	Wt. %
1.	
2.	
3.	
4.	
5.	
6.	

10. Liquid Injection Rate (gpm)

Design Maximum	Average Expected
80	70-80

11. Pressure at Spray Nozzle: TBD (psia)

12. Pressure Drop thru Scrubber TBD (inches of water)

Data for Venturi Scrubber

13. Throat Dimensions (Specify Units)
n/a

14. Throat Velocity (ft/sec)
n/a

Data for Packed Towers

15. Type of Packing
n/a

16. Superficial Gas Velocity through Bed
n/a

Form 9 Scrubbers & Wet Collectors - Continued

Data Stack/Exhaust Exit

17. Height: 180 feet	18. Temperature of exhaust stream: 134 °F	19. Inside dimensions: 8 feet diameter or _____ feet x _____ feet

20. Monitoring Equipment

Type	Manufacturer	Model	Range	Units
Gas Pressure	TBD	TBD	TBD	inches of water column
Water Flow	TBD	TBD	TBD	gallons per minute
Water Pressure	TBD	TBD	TBD	pounds per square inch

Settling Ponds

21. Dimensions of settling pond:
Width:
Length: n/a
Depth:

22. Flow rate through settling pond: n/a

23. Residence time of water in pond: n/a

Emissions Calculations (PTE)

24. Calculated emissions for this device Refer to Attachment B of application.

PM_{10}	Lbs/hr	Tons/yr	$PM_{2.5}$	Lbs/hr	Tons/yr
NO_x	Lbs/hr	Tons/yr	SO_x	Lbs/hr	Tons/yr
CO	Lbs/hr	Tons/yr	VOC	Lbs/hr	Tons/yr

HAPs_____Lbs/hr (speciate)_____Tons/yr (speciate)

Submit calculations as an appendix.

Instructions – Form 9 Scrubbers & Wet Collectors

NOTE:
1. **Submit this form in conjunction with Form 1 and Form 2.**
2. Call the Division of Air Quality (DAQ) at **(801) 536-4000** if you have problems or questions in filling out this form. Ask to speak with a New Source Review engineer. We will be glad to help!

1. Supply an assembly drawing, dimensioned and to scale of the interior dimensions and features of the equipment. Please include inlet and outlet liquid and gas flow directions and temperatures, and demister section.
2. Specify the manufacturer and model number of equipment.
3. Please indicate the date that the equipment was installed.
4. Specify what type of equipment or process the scrubber is being used for.
5. Specify what pollutant is being controlled by the scrubber/wet collector.
6. Specify the type of scrubber.
7. Supply the specifications for the gas stream including the flow rate at the design maximum and expected average, inlet and outlet temperatures, and particulate grain loading at inlet and outlet.
8. Supply the particulate mean geometric diameter.
9. Supply the composition of the scrubbing liquid used in the equipment.
10. Indicate what the liquid injection rate is for the design maximum and the expected average in gallons per minute.
11. Indicate the pressure at the spray nozzle.
12. Identify what the pressure drop through the scrubber is.
13. Indicate what the throat dimensions are for a venturi scrubber.
14. Indicate what the throat velocity is for a venturi scrubber.
15. Indicate what the type of packing is in a packed tower.
16. Specify what the gas velocity is through the bed in a packed tower.
17. Indicate what the stack height is of the scrubber.
18. Indicate the temperature of the exhaust gas.
19. Supply the inside dimensions of the stack.
20. Supply specifications of any monitoring equipment which is used in the system.
21. Specify the dimensions of the settling pond.
22. Indicate the flow rate of the water through the settling pond.
23. Supply the residence time of the water in the settling pond.
24. Supply calculations for all criteria pollutants and HAPs. Use AP42 or Manufacturers data to complete your calculations.

John Jenks <jjenks@utah.gov>

RE: Questions on WGS NOI

1 message

Drechsel, Chris S <Christopher.S.Drechsel@tsocorp.com> Wed, Sep 16, 2015 at 3:49 PM
To: John Jenks <jjenks@utah.gov>, "Bujdoso, Michelle D" <Michelle.D.Bujdoso@tsocorp.com>

John – I will review and provide feedback on your questions below. I'll also give you a call to discuss the other items.

As another option, I'll be in SLC next Monday – Weds. Would you have any time for a face-to-face to review these items and the other topics I wanted to discuss?

Thanks. Chris.

From: John Jenks [mailto:jjenks@utah.gov]
Sent: Wednesday, September 16, 2015 2:40 PM
To: Bujdoso, Michelle D; Drechsel, Chris S
Subject: Questions on WGS NOI

Michelle,

I've got a few questions on the WGS NOI. Hopefully they are pretty easy, and I can wrap this project up for you guys in the next couple of days.

yes as back up to WGS

1. I just want to verify that the existing particulate controls (cyclones/ESP) are remaining in place on the FCC? The NOI doesn't specify anything about changes, so I assume so.

2. In addition, although there is a reference to increased fugitive dust emissions (road dust) from vehicle traffic, this will be absorbed by the existing plant wide caps, and there will be no increase in overall particulates?

not specifically calculated but accounted for

There isn't a lot of discussion on particulates in the NOI generally, so I had to infer part of the engineering review, but one question that is liable to come up during any potential comment or challenge would be why there is no drop in particulate emissions since ultimately the spray tower's function is to remove particulates (treated NOx compounds for example).

3. There are three existing conditions II.B.4.b, II.B.5.b and II.B.6.a that have current limitations on the FCCU in

terms of tons/year, but are built into the existing plant-wide caps. I'm easily able to write a new condition(s) for the required limits found in Table 3-2 from the NOI, but those limits are ppmvd values. Once the new plant-wide limits (found in Table 3-3) are also included, those FCCU yearly limits from the existing conditions no longer seem valid or applicable.

need to stay PSD concern / re EPA although could move to make clear

I'd like to propose putting in a sunset clause on those limits such that they expire once the new plant-wide caps come into play. This project obviously has to go out to public comment anyway, so it doesn't extend the permitting process. Thoughts?

no see above

4. You've included a specific CO limitation as well as calculations showing a CO reduction, but no explanation was included as to why this was included. In order to include this information I'll need to include some explanation within the engineering review so there is a justification for the limit and a reason for demonstrating the reduction. Even if the justification was "a voluntary emission reduction" that would suffice. Otherwise, management won't allow me to include the limitation as there would be no basis for it.

included as CO change

5. Monitoring: Currently there are CEMs and/or stack testing in place for demonstrating compliance with the SO2/NOx/particulate limits at the FCCU/CO boiler (see II.B.4.c.1, II.B.5.a and II.B.6.a, respectively. Will these same methods remain in place and in use following the installation of the WGS? Or will anything need to change?

keep

6. Finally, I'm not currently including the PM10 SIP requirements, since that SIP isn't going to be final until at least December (and not published in the State Bulletin until January), and I hope to be well finished with this project before then. However, it is possible that we'll get comments asking why those provisions haven't been included.

now include since new NoI

Chris, I did receive your phone call, hopefully this brings you up to speed on where I am with the WGS project. I am available anytime the rest of this week if you would like to schedule another call for further discussions on your other topics.

- John

--

John D. Jenks

Environmental Engineer

Utah Division of Air Quality

P: (801) 536-4459

F: (801) 536-4099

Tesoro/UDAQ Air Permitting Update Meeting

September 23, 2015

I. **WGS NOI Application:**

  A. Discuss UDAQ email questions

  B. Steam use application update letter

  C. Ozone applicability EPA Region 8 request

II. **Ultraformer ULNB NOI Application**

III. **Tesoro Logistics Truck Loading Rack Tank NOI Application**

IV. **Further Discussion/Questions**

I've got a few questions on the WGS NOI. Hopefully they are pretty easy, and I can wrap this project up for you guys in the next couple of days.

1. I just want to verify that the existing particulate controls (cyclones/ESP) are remaining in place on the FCC? The NOI doesn't specify anything about changes, so I assume so.

2. In addition, although there is a reference to increased fugitive dust emissions (road dust) from vehicle traffic, this will be absorbed by the existing plant wide caps, and there will be no increase in overall particulates?

There isn't a lot of discussion on particulates in the NOI generally, so I had to infer part of the engineering review, but one question that is liable to come up during any potential comment or challenge would be why there is no drop in particulate emissions since ultimately the spray tower's function is to remove particulates (treated NOx compounds for example).

3. There are three existing conditions II.B.4.b, II.B.5.b and II.B.6.a that have current limitations on the FCCU in terms of tons/year, but are built into the existing plant-wide caps. I'm easily able to write a new condition(s) for the required limits found in Table 3-2 from the NOI, but those limits are ppmvd values. Once the new plant-wide limits (found in Table 3-3) are also included, those FCCU yearly limits from the existing conditions no longer seem valid or applicable.

I'd like to propose putting in a sunset clause on those limits such that they expire once the new plant-wide caps come into play. This project obviously has to go out to public comment anyway, so it doesn't extend the permitting process. Thoughts?

4. You've included a specific CO limitation as well as calculations showing a CO reduction, but no explanation was included as to why this was included. In order to include this information I'll need to include some explanation within the engineering review so there is a justification for the limit and a reason for demonstrating the reduction. Even if the justification was "a voluntary emission reduction" that would suffice. Otherwise, management won't allow me to include the limitation as there would be no basis for it.

5. Monitoring: Currently there are CEMs and/or stack testing in place for demonstrating compliance with the SO2/NOx/particulate limits at the FCCU/CO boiler (see II.B.4.c.1, II.B.5.a and II.B.6.a, respectively. Will these same methods remain in place and in use following the installation of the WGS? Or will anything need to change?

6. Finally, I'm not currently including the PM10 SIP requirements, since that SIP isn't going to be final until at least December (and not published in the State Bulletin until January), and I hope to be well finished with this project before then. However, it is possible that we'll get comments asking why those provisions haven't been included.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
Denver, CO 80202-1129
Phone 800-227-8917
www.epa.gov/region08

September 29, 2015

UTAH DEPARTMENT OF
ENVIRONMENTAL QUALITY
OCT - 5 2015
DIVISION OF AIR QUALITY

Ref: 8P-AR

Bryce Bird, Director
Division of Air Quality
Utah Dept. of Environmental Quality
P.O. Box 144820
Salt Lake City, Utah 84114-4820

RE: Response to Your Inquiry Regarding Direct Ozone Emissions

Dear Mr. Bird:

This letter is in response to your inquiry letter of June 4, 2015, regarding interpretation of Prevention of Significant Deterioration (PSD) regulations as they pertain to direct emissions of ozone. You explained that you are anticipating receipt of a New Source Review (NSR) permit application shortly for a project involving installation of a wet gas scrubber unit at a local refinery. The purpose of the new unit is to reduce nitrogen oxide emissions. Since the unit will be using ozone injection to accomplish this reduction, direct emissions of ozone from the scrubber stack are highly probable. You asked how the definition of "significant" in the PSD regulations at 40 CFR 52.21(b)(23)(ii) pertains to direct emissions of ozone. The definition of "significant" provides that with regard to a regulated NSR pollutant that is not listed in paragraph (b)(23)(i), any emissions rate is significant.

Since paragraph (b)(23)(i) specifically lists the pollutant ozone and defines a significant emissions rate for ozone as 40 tons per year of volatile organic compounds or nitrogen oxides, we do not interpret paragraph (b)(23)(ii) to apply to ozone or direct ozone emissions.

If you have any further questions, please feel free to contact me at (303) 312-6416, or your staff may contact Mike Owens at (303) 312-6440.

Sincerely,

Carl Daly

Carl Daly, Director
Air Program

State of Utah
GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

Department of
Environmental Quality

Alan Matheson
Acting Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

FILE

DAQE-009-15

June 4, 2015

Carl Daly
US EPA Region 8
1595 Wynkoop Street
Denver, CO 80202-1129

Dear Mr. Daly:

This letter requests an official letter documenting the Agency's interpretation of the applicability of the New Source Review (NSR) program to direct emissions of ozone. The Utah Division of Air Quality (DAQ) is shortly expecting to receive an application for a wet gas scrubber unit at a local refinery. This scrubber will be equipped with a Low-TOx system, which uses ozone injection to reduce emissions of NO_x from the effluent stream. As with any system which relies on injection of a reagent, some unreacted reagent (ozone "slip") will occur. Thus, direct emissions of ozone from the scrubber stack are highly probable.

DAQ's request for interpretation specifically applies to the definition of "significant" under the Prevention of Significant Deterioration regulations at 40 CFR 52.21(b)(23)(ii). Paragraph (b)(23)(ii) provides that with regard to a regulated NSR pollutant that is not listed in paragraph (b))(23)(i), any emissions rate is significant. We are aware of the draft letter from OAQPS Director, Stephen Page regarding the Archer Daniel Midland case, but have been unable to obtain a copy of the final version of this document.

As the refinery application in question is being submitted in partial fulfillment of the refinery's obligations under both Utah's State Implementation Plan and the refinery's pending consent decree with EPA, obtaining documentation of the agency's position on this issue would be of great assistance in DAQ's efforts to issue a timely and accurate NSR permit.

Sincerely,

Bryce C. Bird
Director

BCB:JJ:jc

195 North 1950 West • Salt Lake City, UT
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www.deq.utah.gov
Printed on 100% recycled paper

NEW SOURCE REVIEW SECTION

SITE ID # AND PROJECT #: N/A
COMPANY NAME: EPA
REGARDING: Request an official letter documenting the Agency's interpretation of the applicability of the New Source Review (NSR) program to direct emissions of ozone

THE ATTACHED DOCUMENT IS CATEGORIZED AS: (PLEASE CHOOSE ONE)

	NEWSPAPER NOTICE (NN)	Office Tech signs cover letter of Newspaper Notice
	INTENT TO APPROVE (ITA)	Cover letter and ITA signed by associated Section Manager Electronic Copy of ITA sent to Ron Reece
	APPROVAL ORDER (AO)	Copy of purple sheet and cover letter of AO to Teri Weiss
	EXPERIMENTAL AO	Copy of purple sheet and cover letter of AO to Teri Weiss
✓	CORRESPONDENCE	Signatory varies
	SOIL REMEDIATION	If associated fee, send copy of purple sheet and letter to Teri Weiss
	SALES TAX EXEMPTION (TAX)	
	SMALL SOURCE EXEMPTION	Copy of purple sheet and letter to Teri Weiss
	EMISSIONS BANKING LETTER	Copy of letter to Camron Harry
	NAME CHANGE	Copy of purple sheet and letter to Teri Weiss

COPIES TO BE SENT TO THE FOLLOWING PARTIES: (PLEASE CHECK AS THEY APPLY)

√	Manila File Folder (working file)	√	Greens Folder
	Health Department (see letter for which)		EPA – Mike Owens
	Compliance (associated Section Manager)		Finance – Teri Weiss
	Name Change Letters: Deborah McMurtrie Susan Weisenberg Dave Beatty		Brett Wilding, Utah State Tax Commission, Technical Research Unit
	Offsets Used? Copy of document(s) to Camron Harry		Enter final Name Change Letters in /engineer/aoname
	Copy To:		Enter in /engineer/aocond & in AO Log: (AOs, AO not needed, Replacement in Kind)
	NEWSPAPER NOTICE – COPIES TO: Cities, Counties, Gov. Agencies, & etc./& a copy of Public Official letter with self-addressed envelope E-Mail To: dvd.kvd@juno.com, Jodie Swanson, Lori Walker, Debbie Oberndorfer, Bill Sinclair, Beverly Rasmussen & Jen Burge, Donna Spangler, Ron Reece, and Kelly Beck <u>E-Mail copy & Fax to Newspaper Agencies</u>		PSD PROJECTS: Copy the NOI, Engineering Review, ITA, NOTICE & AO Send to: Mike Owens, EPA Don Banks, Bureau of Land Management Chris Hocket, U.S. Forest Service Chris Shaver, National Park Service TITLE V: Check w/ NSR Engineer for which document(s) to be copied.

REVIEWED BY AND DOCUMENT SIGN OFF DATES:

Completeness determination	John Jenks JDJ
Section Manager sign off	Marty Gray MG
Branch Manager sign off	Reginald Olsen

RDO
5/28/15