BART DETERMINATION
SUPPORT DOCUMENT FOR
TESORO MARKETING AND REFINING COMPANY
ANACORTES REFINERY

Prepared by

Washington State Department of Ecology
Air Quality Program

August 2009

Revised Feb, 22, 2010

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EXECUTIVE SUMMARY

The Best Available Retrofit Technology (BART) program is part of the larger effort under the federal Clean Air Act Amendments of 1977 to eliminate human-caused visibility impairment in all mandatory federal Class I areas. Sources that are required to comply with the BART requirements are those sources that:

1. Fall within 26 specified industrial source categories.
2. Commenced operation or completed permitting between August 7, 1962 and August 7, 1977.
3. Have the potential to emit more than 250 tons per year (tpy) of one or more visibility impairing compounds.
4. Cause or contribute to visibility impairment within at least one mandatory federal Class I area.

Tesoro Refining and Marketing Company (Tesoro) operates a petroleum (a.k.a. oil) refinery on March Point near Anacortes, Washington. The petroleum refining process results in the emissions of particulate matter (PM), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and nitrogen oxides (NO_X). All of these pollutants are visibility impairing.

Petroleum (oil) refineries are one of the 26 listed source categories. Construction on the Tesoro refinery began in 1955 with commercial operation starting a year later. Additional units started operation in 1963-1964 and during a major expansion in 1971. The BART-eligible emission units at the refinery have the potential to emit more than 250 tpy of SO_2, NO_X, and PM. Fourteen of the 26 combustion units at the plant are BART-eligible. A number of the crude oil and oil product storage tanks are BART-eligible as sources of VOC. VOC emissions were not evaluated for visibility impairment or BART control technology due to the inability of the visibility model to evaluate visibility impact of VOCs. The combustion units are the major sources of visibility impairing pollutants from the oil refinery.

Modeling of visibility impairment was done following the Oregon/Idaho/Washington/EPA Region 10 BART modeling protocol.[1] Modeled visibility impacts of baseline emissions show impacts on the 8th highest day in any year (the 98th percentile value) of greater than 0.5 deciviews (dv) at five Class 1 areas. The highest impact was 1.72 dv on Olympic National Park. Modeling showed that on the most impacted days at Olympic National Park, approximately 57 percent of the visibility impairment is due to NO_X emissions and 41 percent is due to SO_2 emissions.

Tesoro prepared a BART technical analysis following Washington State's BART Guidance.[2]

The Washington State Department of Ecology (Ecology) has determined BART at the Tesoro refinery for PM/PM_{10}, SO_2, and NO_X, as depicted in Table ES-1.

[1] Modeling protocol available at http://www.deq.state.or.us/aq/haze/docs/bartprotocol.pdf.
[2] "Best Available Retrofit Technology Determinations Under the Federal Regional Haze Rule," Washington State Department of Ecology, June 12, 2007.

- BART for PM/PM_{10} (all particulates) is the use of refinery fuel gas or natural gas for fuel and the current combination of emission controls on Unit F-304.
- BART for SO_2 is the elimination of routine use of fuel oil in Unit F-103 and meeting current requirements on sulfur content of refinery fuel gas.
- BART for SO_2 for Unit F-304 is the continued use of current wet scrubber emission controls
- BART for NO_X is based on continued use of the existing burners and controls except for Unit F-103 which will install new ultra-low-NO_X burners.

The BART controls selected by Ecology will result in a visibility improvement at Olympic National Park of less than half of a deciview.

Table ES-1. ECOLOGY'S DETERMINATION OF THE EMISSION CONTROLS THAT CONSTITUTE BART

	BART Control Technology	**Emission Limitation**
F-103		
PM/PM_{10}	Ending routine use of fuel oil. Use of refinery fuel gas or natural gas as primary fuel.	Fuel oil allowed only under the following conditions: • Natural gas curtailment. • Periods with limited refinery fuel gas availability, such as start-up and shutdown of major refinery process units, while major refinery process units are not operating and producing refinery gas, and emergency conditions as necessary to maintain safe operations or equipment shutdown. Test firing on fuel oil is allowed for up to 24 hours per calendar year.
SO_2	Ending routine use of fuel oil. Use of refinery fuel gas or natural gas as primary fuel.	Same as for PM/PM_{10}.
NO_X	Ultra-low-NO_X burners	Not to exceed 59.1 tpy, rolling annual (365) total calculated daily.
All Other BART-Eligible Units		
F-104, F-304, F-654, F-6600, F-6601, F-6602, F-6650, F-6651, F-6652, F6653, F-6654, F-6655, Flare X-819, Cooling Towers 2 and 2a	Currently installed combustion and other controls.	Per applicable NWCAA regulatory orders and regulations.

1. INTRODUCTION

This document is to support Ecology's determination of the Best Available Retrofit Technology (BART) for the Tesoro Refining and Marketing Company (Tesoro) petroleum (a.k.a. oil) refinery on March Point near Anacortes, Washington.

The Tesoro refinery processes crude oil to produce refined oil products, including ultra low sulfur diesel oil, jet fuel, #6 fuel oil, and gasoline. Fourteen of the 26 process heaters, flares, and boilers, plus two cooling towers at the plant are BART-eligible. The primary emission units of concern are the process heaters, boilers, and flares. The process heaters, boilers, and flares emit SO_2 and NO_X. Direct PM emissions from BART-eligible units are low because almost all of them combust either refinery fuel gas or natural gas. Only one BART unit is currently permitted to use fuel oil.

Eleven of the 74 storage tanks are also BART-eligible sources of VOCs. The CALPUFF model used to evaluate visibility impairment cannot model VOCs. Ecology directed that VOC emissions BART-eligible storage tanks and other units not be evaluated for visibility impact or BART control technology. The BART determination for the Tesoro refinery focuses only on PM, SO_2 and NO_X.

1.1 The BART Analysis Process

Tesoro and Ecology used the United States Environmental Protection Agency's (EPA's) BART guidelines contained in Appendix Y to 40 CFR Part 51, as annotated by Ecology, to determine BART. The BART analysis protocol reflects utilization of a 5-step analysis to determine BART for SO_2, NO_X, and PM_{10}. The five steps are:

1. Identify all available retrofit control technologies.
2. Eliminate technically infeasible control technologies.
3. Evaluate the control effectiveness of remaining control technologies.
4. Evaluate impacts and document the results.
5. Evaluate visibility impacts.

The BART guidance limits the types of control technologies that need to be evaluated in the BART process to available control technologies. Available control technologies are those which have been applied in practice in the industry. The State can consider additional control techniques beyond those that are 'available', but is not required to do so. This limitation to available control technologies contrasts to the Best Available Control Technology (BACT) process where innovative technologies and techniques that have been applied to similar flue gases must be considered.

As allowed by the EPA BART guidance, Ecology has chosen to consider all five factors in its BART determinations. To be selected as BART, a control has to be available, technically feasible, cost effective, provide a visibility benefit, and have a minimal potential for adverse non-air quality impacts. Normally, the potential visibility improvement from a particular control technology is only one of the factors weighed for determining whether a control constitutes BART. However, if two available and feasible controls are essentially equivalent in cost effectiveness and non-air quality impacts, visibility improvement becomes the deciding factor for the determination of BART.

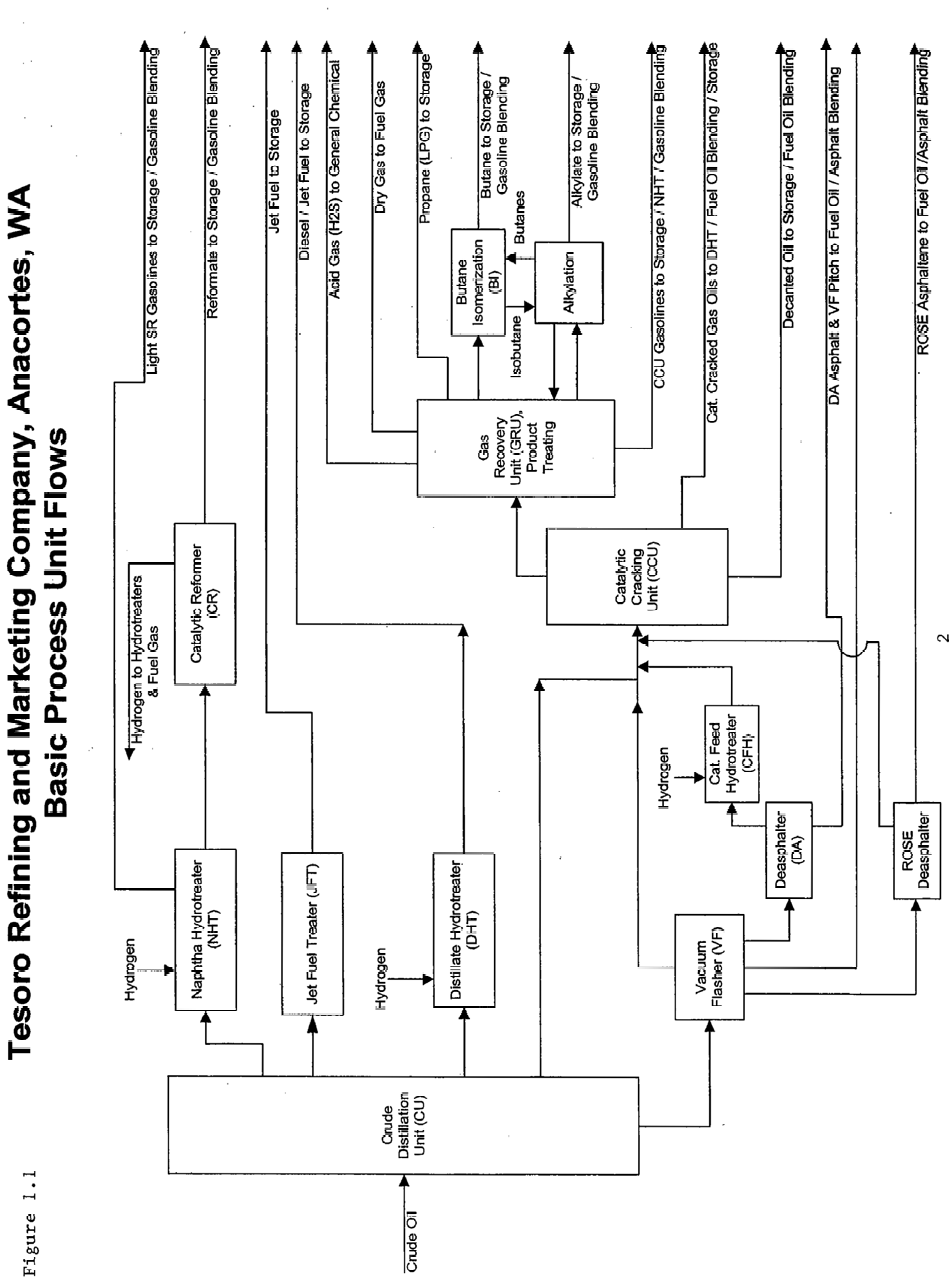
1.2 Basic Description of the Tesoro Refinery

The Tesoro refinery purchases crude oil on the open market for processing into a variety of petroleum products, including gasoline and ultra low sulfur diesel. Current refinery throughput is approximately 115,000 barrels per day of crude oil. Crude oil is heated and sent to the crude distillation unit where the crude oil is separated into various fractions based on boiling point of the hydrocarbons. The various crude fractions are sent for further processing and refining in other units of the plant. De-asphalted heavy oil from the crude unit is hydrotreated prior to being sent to the Fluid Catalytic Cracking Unit (FCCU) to be split into lighter fractions for blending. The refinery also produces heavy fuel oil (a.k.a. #6 oil or bunker C) and paving asphalts. Figure 1-1[3] is a simplified process flow diagram of the overall refinery process.

Catalyst used in the FCCU is regenerated in a separate regenerator unit. In the regenerator unit, the carbon, sulfur and other impurities are burned off the catalyst. The exhaust gas from the regenerator is routed to the two carbon monoxide boilers (F-302, CO Boiler No. 1 and F-304, CO Boiler No. 2) to be combusted and the energy recovered. Exhaust gas from the two carbon monoxide boilers is routed to a single Flue Gas Scrubber for particulate and SO_2 control.

The principle air pollution control authority for this facility is the Northwest Clean Air Agency (NWCAA).

[3] Copied from Air Operating Permit Statement of Basis, Tesoro Refining and Marketing Company, for Air Operating Permit No. 013, issued November 25, 2002.


Tesoro Refining and Marketing Company, Anacortes, WA
Basic Process Unit Flows
Crude Oil
Crude Distillation Unit (CU)
Hydrogen
Naphtha Hydrotreater (NHT)
Jet Fuel Treater (JFT)
Distillate Hydrotreater (DHT)
Vacuum Flasher (VF)
Deasphalter (DA)
ROSE Deasphalter
Cat. Feed Hydrotreater (CFH)
Catalytic Reformer (CR)
Hydrogen to Hydrotreaters & Fuel Gas
Catalytic Cracking Unit (CCU)
Gas Recovery Unit (GRU), Product Treating
Butane Isomerization (BI)
Alkylation
Isobutane
Butanes
Light SR Gasolines to Storage / Gasoline Blending
Reformate to Storage / Gasoline Blending
Jet Fuel to Storage
Diesel / Jet Fuel to Storage
Acid Gas (H2S) to General Chemical
Dry Gas to Fuel Gas
Propane (LPG) to Storage
Butane to Storage / Gasoline Blending
Alkylate to Storage / Gasoline Blending
CCU Gasolines to Storage / NHT / Gasoline Blending
Cat. Cracked Gas Oils to DHT / Fuel Oil Blending / Storage
Decanted Oil to Storage / Fuel Oil Blending
DA Asphalt & VF Pitch to Fuel Oil / Asphalt Blending
ROSE Asphaltene to Fuel Oil /Asphalt Blending
2
Figure 1.1

1.3 BART-Eligible Units at the Tesoro Refinery

Fourteen of the 26 process heaters, flares, and boilers and the two cooling towers at the Tesoro refinery are BART-eligible. This means that these 14 emission units have the potential to emit more than 250 tpy of SO_2, NO_X, and PM/PM_{10} and commenced operation within the 15-year BART period.[4] The refinery was constructed during 1955-1956 and reported to have begun commercial operation in 1956.

Table 1-1 identifies the BART-eligible units and the emissions used in the BART modeling.

Table 1-1. BART MODELING EMISSION RATES FOR BART-ELIGIBLE UNITS

Emission Unit			BART Impact Modeling Emissions (lb/hr)		
Source Designation	**Service**	**Design Heat Input (MMBtu/hr)**	**NO_X**	**SO_2**	**PM_{10}**
F-103	Crude Oil Distillation	145	53.5	160.5	9.1
F-104	Gasoline Splitter/Reboiler	53	0.8	39.8	0.4
F-304	CO Boiler No. 2	322	242.7	24.9	14.1
F-654	Catalytic Feed Hydrotreater	16.5	1.3	11.7	0.1
F-6600	Naphtha Hydrotreater	71.5	13.1	56.0	0.9
F-6601	Naphtha Hydrotreater	75	8.0	77.5	0.6
F-6602	Naphtha Hydrotreater	75	8.3	25.6	0.6
F-6650/6651	Catalytic Reformer	286	101.3	332.0	2.8
F-6652/6653	Catalytic Reformer	105	19.2	86.1	1.5
F-6654	Catalytic Reformer	35	4.0	32.2	0.3
F-6655	Catalytic Reformer	30	2.9	15.1	0.2
X-819	Flare	244	2.0	10.0	0.4
CWT #2	Cooling Water Tower		0	0	0.1
CWT #2a	Cooling Water Tower		0	0	0.1

Tesoro and Ecology reviewed the currently installed and potential controls for all BART-eligible emission units listed above. Tesoro's review was focused on the combustion units because of the contribution of these units to visibility impairment and availability of emission controls.

[4] The 15-year period ending with August 7, 1977, the date of passage of the Clean Air Act amendments of 1977.

Some of the combustion units listed above have been subject to BACT review as part of projects to upgrade or increase plant production capacity. Others have had emission controls added to comply with federal hazardous air pollutant control requirements or to reduce ambient air quality impacts of other projects at the refinery. The results of these actions are incorporated in the modeled emission rates shown in Table 1-1.

1.3 Visibility Impact of BART-Eligible Units at the Tesoro Refinery

Emission units that meet the source category, age, and potential to emit criteria are "BART-eligible." To be "subject to BART," the actual emissions from the "BART-eligible" units at the facility must "cause or contribute" to visibility impairment within at least one mandatory federal Class I area. Ecology has adopted the "cause and contribute" criteria that EPA suggested in its guideline. BART-eligible units at a source cause visibility impairment if their modeled visibility impairment is at least 1.0 deciview (dv). Similarly, the criterion for contributing to impairment means that the source causes a modeled visibility change of 0.5 dv or more.

Class I area visibility impairment and improvement modeling was performed by Tesoro using the BART modeling protocol developed by Oregon, Idaho, Washington, and EPA Region 10.[5] This protocol uses three years of metrological information to evaluate visibility impacts. As directed in the protocol, Tesoro used the highest 24-hour emission rates that occurred in the 3-year period to model its impacts on Class I areas.

Modeled visibility impacts of baseline emissions show impacts on the 8th highest day in any year (the 98th percentile value) of greater than 0.5 deciviews (dv) at five Class 1 areas. The highest impact was 1.72 dv at Olympic National Park. Modeling showed that on the most impacted days at Olympic National Park, approximately 57 percent of the visibility impairment is due to NO_X emissions and 41 percent is due to SO_2 emissions. For more information on visibility impacts of this facility, see Section 3 below.

[5] A copy of the modeling protocol is available at http://www.deq.state.or.us/aq/haze/docs/bartprotocol.pdf.

2. BART TECHNOLOGY ANALYSIS

The Tesoro BART technology analysis was based on the 5-step process defined in BART guidance and listed in Section 1.1 of this report. The first subsection below deals with an overview of the controls evaluated for combustion units, the second with, evaluation of plant-wide SO_2 controls and specific controls on individual combustion units, and the third with controls on the cooling towers. The latter two sections provide an overview of the potentially feasible emission controls evaluated by Tesoro followed by Tesoro's BART proposal.

In Tesoro's evaluation of costs in the 2008 BART analysis, they assumed that all control installations would occur at a regularly scheduled maintenance turn-around. These are the costs presented in sections 2.2 and 2.3. Tesoro subsequently submitted additional cost analyses for implementation of the BART controls on 5 units at other than a regularly scheduled maintenance turn-around. This is discussed in Section 2.4.

2.1 Controls Evaluated for Combustion Units

The Tesoro refinery has 14 fuel combustion units subject to BART. The three subsections below provide an overview of the NO_X, SO_2, and PM/PM_{10} control techniques that were evaluated by Tesoro. While the units differ in firing rate, usage, and specific design features, most of the NO_X, SO_2, and PM/PM_{10} controls could be used on all units.

2.1.1 NO_X Controls Evaluated for All Combustion Units

There are a variety of controls that can be used for reducing the quantity of NO_X emitted to the atmosphere from the process heaters and CO Boiler which are subject to BART. Specifically, the company evaluated eight different technologies, including variations of several of them. NO_X emissions control from refinery fuel gas and flue gas combustion can be achieved with eight technologies or combinations of technologies.

- Flue gas recirculation (FGR)
- Low-NO_X burners (LNBs)
  - Staged-air LNBs
  - Staged-fuel LNBs
- Ultra-low-NO_X burners (ULNBs)
- Selective non-catalytic reduction (SNCR)
  - SNCR
  - LNBs + SNCR
  - ULNBs + SNCR
- Selective catalytic reduction (SCR)
  - SCR
  - LNBs + SCR
  - ULNBs + SCR

- $LoTO_X$™ process (evaluated only for Unit F-304, CO Boiler No. 2)
- Sulfur Recovery Unit with Tail Gas Unit (SRU/TGU; evaluated for only Unit F-304, CO Boiler No. 2).

Additional control techniques were considered by Tesoro and are not listed here due to their lack of applicability to the Tesoro emission units. The following are more detailed descriptions of the NO_X control and reduction technologies evaluated by Tesoro for use at the refinery. Control techniques that are applicable to only one or two units are specifically noted.

Flue gas recirculation (FGR) generally involves mixing some of the flue gas from the heater or boiler with the air fed to the burner(s). FGR can be integrated into the construction of the unit or can be added to an existing unit. In the FGR process, approximately 15 to 30 percent of the air supplied to the burner's primary combustion zone is flue gas.[6] The flue gas reduces the peak flame temperature and the local oxygen concentrations resulting in less thermal NO_X formation. Thermal NO_X is the principal kind of NO_X produced in combustion of most gaseous and liquid fuels. FGR has been used on only a few oil refinery process heaters. These installations require extensive modification to the heater to accommodate the changed combustion characteristics and to avoid the introduction of hydrocarbon vapors that may leak from the heat transfer tubing to the flue gas.

Tesoro regards flue gas recirculation of flue gases at process heaters as an unacceptable safety risk due to the potential of formation of explosive gas mixtures in the event of a heater tube failure. Few applications have been made to refinery process heaters due to this risk. Therefore, this technology was not explored further.

Low- and ultra-low-NO_X burners come in two principle designs: staged-air and the staged-fuel burners. Both function by adjusting the mixture of fuel and air to reduce peak temperatures and minimize the production of NO_X. Some LNBs and ULNBs include flue gas recirculation in their design. Both designs generally have longer flame zones than the 'standard' burners that they replace in retrofit situations. The longer flame is not an issue in new heater installations due to the heaters being designed to accommodate the LNB or ULNB burners. Emission factors from EPA's RACT/BACT/LAER Clearinghouse range from 0.08 to 0.1 lb/MMBtu (NO_X) for LNBs and ULNBs.

LNB and ULNB retrofits are commonly installed as a result of BACT and LAER determinations or as a result of federal Consent Order requirements.

Staged-air, low-NO_X burners limit NO_X production by reducing flame oxygen concentrations in the primary combustion zone. The initial fuel combustion takes place in a fuel-rich, reducing atmosphere with a flame high temperature due to the low combustion air/fuel ratio. The low O_2 concentration limits NO_X formation.

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[6] (CPPI, 1990), (Campbell, 1991), (Martin, 1993), (Shareef, 1988)

For this burner design, retrofitting heaters with less than three feet between the burner and the opposite wall of the firebox may not be practical due to potential flame impingement on the firebox refractory materials or heat transfer tubes. Emission reductions achieved by staged-air LNBs range from 30 to 40 percent below emissions from conventional burners. Tesoro used a 40 percent NO_X reduction for its initial cost analysis review.

Staged-fuel, low-NO_X burners separate the combustion zone into two regions. The first is a lean primary region in which all the combustion air is injected with a small fraction of the fuel. This is followed by a second region where the remaining fuel is injected and combustion is completed.

Staged-fuel LNBs have several advantages over staged-air LNBs. First, the improved fuel/air mixing reduces the excess air necessary to ensure complete combustion. The lower excess air both reduces NO_X formation and improves heater efficiency. Second, for a given peak flame temperature, staged-fuel LNBs have a more compact (shorter) flame than staged-air LNBs. Up to 72 percent NO_X emissions reductions for staged-fuel LNBs have been reported over conventional burners based on vendor test data. Tesoro used a 60 percent average NO_X reduction for its initial cost analysis review. Ecology has only included information using this version of LNB in the unit-specific discussions below.

Ultra-low-NO_X burners (ULNBs) recirculate hot, oxygen-depleted flue gas from the flame or firebox back into the combustion zone. This reduces the average oxygen concentration within the flame maintaining the temperatures necessary for optimal combustion efficiency. ULNBs are physically larger than the conventional or LNB burners that might be used but compensate by having shorter flames than LNBs and are occasionally more efficient at combusting the fuel. They may require fans to provide combustion air rather than using a natural draft combustion air system. The conventional burner equipped heaters at Tesoro all use natural draft combustion air delivery systems. Burner mount modifications may be required because ULNBs usually do not fit into conventional burner mounts.

ULNBs now have the following features available:

- Compact sizes
- Shorter flame paths
- High turndown ratios

Tesoro used a 75 percent average NO_X reduction for its initial cost analysis based on EPA methods. After receiving vendor guaranteed average NO_X emission reductions ranging from 60 to 73.5 percent for specific units, Tesoro developed a vendor cost factor analysis for each unit based on the vendor guarantee and the unit-specific emission rate.

Selective Non-Catalytic Reduction (SNCR) is a post-combustion technology that involves directly injecting ammonia or urea into the hot flue gas. The reaction requires the flue temperatures required range from 1,600 to 1,750°F for ammonia and from 1,000 to 1,900°F for urea-based reagents. Other chemicals such as hydrogen, hydrogen peroxide, fuel gas, and methanol may be added to improve performance and lower the minimum threshold temperatures. The injection point must be at a location where temperature of the flue gas is within the required temperature range for enough time for the reaction to occur.

Not all of the ammonia or urea is used. Unreacted ammonia in the emissions (ammonia slip) is potentially higher in SNCR systems than in an SCR system due to higher reactant injection ratios (2:1). The degree of ammonia slip can be minimized through consistent operation of the heaters and good operational controls.

Vendors contacted by Tesoro have projected potential NO_X reductions at a maximum 25 ppm ammonia slip. SNCR systems may increase fuel gas consumption by approximately 0.3 percent in addition to the power required to vaporize aqueous ammonia. One result of the SNCR process is the formation of small amounts of nitrous oxide (N_2O), a greenhouse gas.

Ammonia used in the process is delivered and stored on site as either anhydrous ammonia or aqua-ammonia. If urea is used, it is delivered and stored as a dry material. Anhydrous and aqua-ammonia at concentrations above 19 percent ammonia require special reporting, handling, and worker safety requirements be followed. Urea is either dissolved in water and injected into the flue gas or converted to ammonia prior to injection.

SNCR may be used as the sole NO_X control technique or in combination with LNBs or ULNBs. At optimum temperatures, NO_X destruction efficiencies range from 30 to 50 percent. Tesoro used a 50 percent NO_X reduction for its initial cost analysis review.

Vendor NO_X reduction guarantees ranged from 35 to 40 percent based on Tesoro's fuel gas compositions and measured bridgewall temperatures. EPA's RACT/BACT/LAER Clearinghouse lists an emission limit of 127 ppmdv NO_X at seven percent oxygen for a SNCR used to control emissions from a Fluid Catalytic Cracking Regenerator unit followed by a CO Boiler.

NO_X tempering (steam or water injection) was proposed by Peerless Manufacturing Company as a technique that could be combined with SNCR on Units F-103 and F-304. Water or steam injection is a common NO_X control for large combustion turbines permitted prior to 2000. Peerless proposed a patented process in which water is injected into the burner flame to reduce the peak flame temperature. For each 190°F of flame temperature reduction, the NO_X is reduced by 50 percent.[7] Peerless estimated that NO_X tempering would reduce NO_X formation by 30 to 35 percent.

Flame temperature cooling is likely to reduce bridgewall (a.k.a. arch) temperatures and thus reduce the heat energy available to heat the crude oil. To overcome this reduction in heat energy, fuel use in the two units would need to increase, but this potentially reduces the

[7] EPA, 2003 and EPA, 1993.

effectiveness of tempering. Other potentially adverse effects are anticipated to occur. Finally, to date, NO_X tempering has only been used on large utility boilers. Tesoro did not analyze this technique any further.

Selective Catalytic Reduction (SCR) is a post-combustion gas treatment technique to reduce NO_X in the exhaust stream through the use of a catalyst. As with SNCR, an ammonia or urea solution is injected in the flue gas upstream of a catalyst bed where it selectively reduces the nitrogen oxide compounds in the exhaust to produce elemental nitrogen and water. The catalyst's function is to reduce the reaction temperature from the range needed for SNCR.

Catalysts have been formulated to operate at three temperature ranges, a low temperature range based on platinum, and middle and high temperature catalysts based on a mixture of vanadium, titanium, and tungsten oxides. The operating temperature of the SCR system defines the catalyst type used. A conventional (middle range) SCR catalyst functions at temperatures of 600 to 750°F (the high temperature is often given as 850°F). Low temperature catalysts operate best in the range of 470 to 510°F. High temperature catalysts operate at temperatures of 900 to 1000°F.

Other than the catalyst bed reactor, major components of an SCR system are ammonia storage sources, vaporizer, and an ammonia injection grid. Catalyst deactivation and residual ammonia slip in the flue gas are the two key drawbacks in an SCR system. Catalyst activity decreases with operating time and with catalyst fouling. Disposal of the fouled catalyst presents another environmental concern due to the toxic metals contained in the catalyst. This concern is minimized as the result of the vendors recycling used catalysts.

Ammonia slip can be held to levels below five ppm in many situations, though the vendors contacted by Tesoro projected potential NO_X reductions using a maximum slip of 25 ppm ammonia.

SCR catalysts will oxidize a small portion of the SO_2 in the flue gas to SO_3 which can combine with water vapor to form sulfuric acid mist.

Typical SCR NO_X removal efficiencies range from 70 to 90^+ percent removal, depending on the unit being controlled. Tesoro used a 90 percent NO_X removal in its cost analyses.

The **LoTOx™** process is available from BELCO under license from BOC. It uses ozone to convert NO and NO_2 to N_2O_5 which is removed from the flue gas by water where it is converted to nitric acid or is removed with a caustic scrubber and converted to a nitrate. Specifically, ozone (O_3) is generated from industrial-grade oxygen using common industrial methods. O_3 is injected into the flue gas at a suitable, low temperature. O_3 oxidizes the NO_X to N_2O_5. In a wet scrubber, the N_2O_5 combines with water vapor in the flue gas to form nitric acid (HNO_3). Following the reaction zone, multiple spray levels scrub the flue gas to absorb nitric acid mist and unreacted O_3 in the final step. The reported LoTOx™ NO_X removal efficiency is 80 percent.[8]

NO_X concentration changes in the flue gas do not adversely affect the removal efficiency of the $LoTO_X$™ process. This means the Refinery Operations staff can optimize the combustion process to achieve the most cost-efficient burner conditions without considering NO_X generation. Continuous NO_X monitors within the system provide the O_3 flow rates necessary to achieve a set stack NO_X level.
LoTOx™ systems require a downstream caustic or water based scrubber. The use of the water based scrubber would require either a use for the dilute nitric acid produced or a separate acid neutralization tank or other denitrifying wastewater treatment process. The scrubber must be compatible with the LoTOx™ system.

Currently, EDV® Wet Scrubbing systems with the LoTOx™ process for NO_X control are installed on five Fluid Catalytic Cracking Units (FCCUs). One of these began operation in 2006 and the other units were commissioned during 2007. Tesoro considered adding LoTOx™ only to unit F-304, CO Boiler No. 2.

Use of a LoTOx™ unit with caustic scrubbing liquor will also produce a sodium or calcium nitrate-, sulfate-, and sulfite-rich wastewater which must be discharged to the plant's industrial waste water system. The increased nitrates to the treatment system could have a beneficial or detrimental effect. Beneficial effects would come from reduced need to add nitrogen to the industrial treatment system for nutrient balancing of the biological treatment process. Detrimental effects could come from the need for denitrification in the final clarifier prior to discharge. Denitrification in the clarifier would result in increased total suspended solids in the effluent and could lead to violations of the refinery's discharge permit. Tesoro did not perform a detailed evaluation of potential impacts.

A Sulfur Recovery Unit with Tail Gas Treatment (SRU/TGU) can be used to accept ammonia-rich vent gas from the Sour Water Stripper's (SWS) second stage instead of burning it in F-304, CO Boiler No. 2. In this control option, the SWS vent stream would be rerouted from F-304 to a Sulfur Recovery Unit (SRU) where the ammonia would be converted to nitrogen gas rather than nitrogen oxides.

The Tesoro refinery does not operate its own SRU, but routes its H_2S acid gas stream to the SRU and sulfuric acid plant at the neighboring General Chemical facility. Due to a recent upgrade to the sulfur removal system at Tesoro and resulting increase in sulfides sent to it, the General Chemical facility has no additional sulfur processing capacity. The General Chemical facility cannot handle the ammonia-rich SWS gases.

Tesoro's proposal to remove the ammonia-rich SWS vent gas stream from F-304 and treat it in an SRU requires construction of a new and independent SRU. The SRU would provide capacity

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[8] (EPA, 2005) BELCO Product Literature.

for future reductions of sulfur in the refinery fuel gas and in the fuel oils produced by the refinery.

The various emission controls described above are summarized in Table 2-1.

Table 2-1. SUMMARY OF NO_X RETROFIT TECHNOLOGIES EVALUATED

Technology	Manufacturer Contacted	Description	EPA Removal Rate	Vendor Removal Rate
FGR	N/A	Recycles 15-30% of inert flue gas to the primary combustion zone.	30%	--
LNB	John Zink (SFG/PSFG Retrofit Kit) & Todd Combustion	Burner upgrade kit includes tile, cone extension, primary riser, four fuel gas tips.	40% staged air 60% staged fuel	28-66%
ULNB	John Zink (Coolstar Burner)	Compact size, short flame, high turndown capabilities.	75%	73%
SNCR	Peerless Manufacturing Group	19% aqueous ammonia injection into radiant and convective regions of firebox (1,600-2,200°F).	50%	35-40%
SCR	CRI Catalyst	19% aqueous ammonia injection and catalyst (470-510°F and 600-750°F), low temperature pelletized extrudate catalyst.	90%	90%
$LoTO_X$	Available through BELCO under license from BOC	Uses ozone to convert NO_X to higher oxidation state which is subsequently hydrolyzed and removed with a caustic scrubber. Cons: High power consumption, creates pressure drops and incompatible when located upstream of existing WGS due to pressure sensitive venturi scrubber. Potential for nitric acid mist.	--	80%
SRU/TGU	Generally available technologies	NO_X emissions from F-304, CO Boiler No. 2 can be reduced by discontinuing the burning of ammonia-rich SWS vent gas. Routing the vent gas to an SRU, where ammonia is converted to nitrogen gas, is an identified option.	--	30%

2.1.2 SO_2 Controls Evaluated for All Combustion Units

All BART-eligible combustion units are permitted to burn refinery fuel gas that has been treated to reduce the sulfur content or natural gas. While there are a number of add-on SO_2 control technologies available, at an oil refinery the most effective method is reduction of the fuel gas (refinery gas) sulfur content.

A review of the current information in the EPA RACT/BACT/LAER clearinghouse database indicates limited use of add-on SO_2 emission controls at oil refineries. The predominant control technology reported is "use of low sulfur fuel." The exception to this is Catalyst Regenerator/CO Boiler stacks where add-on SO_2 controls are often included. The wet scrubber on Unit F-304, CO Boiler No. 2 is discussed in section 2.2.4 below. For its analysis, Tesoro focused on additional methods to reduce the sulfur content of the fuels used in the BART-eligible heaters and boilers.

Eliminating use of high sulfur fuel oil is a proven way to reduce SO_2 emissions from an oil refinery. This involves removal of the ability to fire fuel oil from the affected process heaters and boilers. The units may then be fired exclusively with natural gas, refinery fuel gas, or lower sulfur content distillate oil. At the Tesoro plant, only one of the BART-eligible units (Unit F-103) is still capable of firing a liquid fuel oil.

Tesoro evaluated **additional flare gas recovery** to reduce the amount of untreated gas burned in the flare system. Refinery fuel gas that is not used beneficially is sent to the plant flare system for combustion and disposal. Collection and routing of the recovered gas for use in the refinery fuel gas system reduces both the quantity of the gas flared and the sulfur content of the gas to match the level of the rest of the plant. Flare gas consists of purge gas, pilot burner gas (natural gas), various off gases associated with loading operations and process vents, and occasionally off gases from other process units during upsets, start-up, and shutdown conditions.

Converting equipment to run on exclusively natural gas is another method that can be used to reduce SO_2 emissions. The equipment is disconnected from the refinery fuel gas system and reconnected directly to a natural gas supply. This reduces SO_2 emissions because the total sulfur content of the natural gas is much lower than the refinery fuel gas. To implement this option requires installation of natural gas lines to all affected heaters and boilers or conversion of the entire plant to this option. Natural gas is a fuel that must be purchased and thus increases plant costs.

Natural gas can be added to the "fuel drum" where the **refinery fuel gas is mixed with the natural gas**. Many oil refineries use this practice to meet regulatory requirements, supplement limited refinery fuel gas, or reduce fluctuations in heat content and concentrations of hydrogen, ethane, propane, and butane in the fuel gas. Mixing pipeline or retail quality natural gas into the refinery fuel gas system involves routing a natural gas pipeline to the refinery gas fuel drum for mixing with the refinery gas. Tesoro already adds natural gas to its refinery fuel gas system.

Refinery gas sulfur removal is the most common method of treating refinery fuel gas. In this process, a solvent such as mono- or di-ethylamine is used to remove hydrogen sulfide and other reduced sulfides from the fuel gas. The untreated refinery fuel gas is "washed" with the amine. The sulfides preferentially attach to the amine solvent and are removed from the refinery fuel gas. The used amine solvent is routed to a regenerator system where the sulfide is thermally removed from the amine. The sulfides are routed to a sulfur recovery unit or similar process. The cleaned amine is then returned to the stripping process.

Provision for additional refinery fuel gas sulfur removal has been done within the current fuel gas cleaning system. The sulfur removed by the system must be routed to a sulfur recovery unit or sulfuric acid plant. Currently Tesoro is contracted with General Chemical to provide this service for the refinery. However, the General Chemical facility is at capacity and cannot accept more sulfur. As a result, Tesoro would need to construct a new sulfur recovery unit.

A new **Sulfur Recovery Unit (SRU)** is required to remove additional sulfur. Tesoro has evaluated the costs to install a new, 50 ton/day SRU at their plant as part of a project proposed in 2006. The capital cost was estimated to be $58 million to meet the federal New Source Performance Standard limit for refinery gas H_2S of 152 ppmv. Annual operational costs were not evaluated.

2.1.3 PM/PM_{10} Controls for All Combustion Units

With the exception of emissions from Unit F-304, CO Boiler No. 2 discussed in section 2.2.4 below, PM/PM_{10} controls applicable to the process heaters at this facility are tied directly to the use of fuel. Using low sulfur refinery fuel gas reduces potential particulate emissions as much as possible. The refinery gas system includes process steps to remove particulates and some heavier hydrocarbons from the refinery gas prior to being sent to the various fuel burning units. While reduction of fuel oil use in Unit F-103 is primarily to reduce SO_2 emissions, reduced or even total elimination of fuel oil combustion in this unit will also reduce PM/PM_{10} emissions.

2.2 Evaluation of Controls for All Combustion Units

The subsections below evaluate plant-wide SO_2 reduction first and then the application of controls to each of the 14 combustion units subject to BART.

2.2.1 Plant-Wide SO_2 Control

The Tesoro refinery has 14 combustion units subject to BART that emit SO_2. SO_2 results from the combustion of sulfur containing fuels such as the refinery fuel gas, natural gas, and fuel oil. Tesoro evaluated reduction of SO_2 from Units F-103 and F-304 and Flare X-819 individually and in combination with all other combustion BART units. Applicability of unit specific SO_2 controls on Units F-103 and F-304 and Flare X-819 are discussed in individual subsections below.

2.2.1.1 Evaluation of Plant-Wide Control

SO_2 controls at oil refineries has been studied by EPA who concluded that controlling refinery fuel gas sulfur content is the most efficient method to reduce SO_2 emissions from an oil refinery. The use of "low sulfur fuel" is the most common SO_2 control technique applied to oil refinery process units. "Low sulfur fuel" is usually defined as refinery fuel gas meeting the New Source Performance Standard (NSPS) requirements of 40 CFR Part 60, Subpart J.

In 2007 the Tesoro refinery upgraded the refinery gas sulfur removal system. The upgrade resulted in the refinery fuel gas with an average daily H_2S concentration of 70 ppm. However, short-term concentration "spikes" above 200 ppm can occur for several reasons, including rates of 1000 ppm when the sulfur recovery units or sulfuric acid plant is out of operation. This upgrade reduced the annual emissions of SO_2 from the refinery but not the short-term emissions. The refinery gas system upgrade was not subject to the New Source Review process but was included in OAC 952a issued by NWCAA as part of an order addressing installation of a larger amine system stripper gas pipeline to the sulfuric acid plant.

Sulfur removed from refinery products and the refinery fuel gas system is sent to the sulfur recovery and sulfuric acid production system operated by General Chemical. Tesoro owns the equipment for the system and contracts with General Chemical for operation and maintenance (O&M). General Chemical is responsible for all costs and environmental compliance. Currently the General Chemical plant is at capacity and unable to accept any additional sulfur from the Tesoro refinery. As a result any additional refinery fuel gas sulfur content reductions require the construction of a new sulfur recover unit.

Any additional reduction in refinery fuel gas sulfur content will require construction of a new SRU. In conjunction with a proposal to install a new coking system, Tesoro evaluated the construction of a new 50 ton/day SRU and refinery modifications to route sulfur streams to the new unit. The capital cost is estimated to be $58 million to continuously treat all refinery gas to the level of the NSPS standard (162 ppm of H_2S). Attributing all the cost to the SO_2 reductions to all combustion units (not just the BART eligible units) results in a plant wide reduction from the 2003 – 05 average emissions of 395 tons of SO_2 with a cost effectiveness of $16,100/ton of SO_2 (not including O&M costs). Tesoro also evaluated the cost effectiveness of continuously meeting a limit of 50 ppm of H_2S (a plant wide annual decrease of 451 tons per year), with the use of a new SRU. To meet a 50 ppm H_2S concentration would reduce the cost effectiveness to $14,100/ton, also not including O&M costs.

2.2.1.2 Proposed BART for SO_2

Tesoro proposed to continue use of the current refinery fuel gas system meeting the requirements of NWCAA's OAC 952a for control of plant-wide SO_2.

2.2.2 Unit F-103, Crude Oil Distillation Heater

The Crude Oil Distillation Heater is used to heat crude oil for initial distillation steps. It has 24 burners split between two combustion cells. This 145 MMBtu/hr (average rate 103.5MMBtu/hr) heater was constructed in 1963 and utilizes natural gas, refinery fuel gas, or fuel oil. Currently fuel oil is used as backup fuel to natural gas and refinery fuel gas, though there are no permit restrictions limiting the use of fuel oil in this unit. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.2.1 NO_X Control

This heater currently uses "default" original manufacturer design burners originally installed in 1963. The current emission rates for this heater are an annual 121 tons per year (tpy) at an average concentration of 193 ppmv. After an evaluation of the technical feasibility of the NO_X controls listed in Table 2-1, Tesoro evaluated the cost effectiveness of ULNB, SCR, SNCR, ULNB plus SCR, and ULNB plus SNCR. Table 2-2 lists pertinent criteria and cost effectiveness.

Table 2-2. UNIT F-103 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis
No controls	--	121	--	--	--
SNCR	50%	61	$6376	40%	$17760
ULNB	75%	30	$3398	66.2%	$4648
ULNB + SNCR	87.5%	15	$6556	80%	$10886
SCR	90%	12	$9444	90%	$6743
ULNB + SCR	97.5%	3	$11331	97%	$8107

All of these controls are capable of being installed on this heater. Tesoro's current understanding of the characteristics of potential ULNB burners suggests that flame impingement is not an issue and adequate space exists to install SCR. Installation of SNCR will reduce the gross heat available to heat crude oil. This reduction is due to the need to evaporate the water included in the aqua-ammonia used in the proposed SNCR system. Within the heat input capacity limits of the existing burners, this evaporation of water can be overcome by burning more fuel with an accompanying increase in emissions of other pollutants.

The most significant adverse impact resulting from SCR or SNCR is an increase in the amount of refinery fuel gas used to overcome heat losses. The increase in fuel use results in incrementally higher emissions of other pollutants from the combustion unit.

2.2.2.2 SO_2 Control

Tesoro evaluated the elimination of routine use of fuel oil combustion in Unit F-103 heater. This option results in a very small cost at this time and would reduce SO_2 emissions from the unit by about eight tpy (current SO_2 emissions are 160.5 tpy). If the actual use of fuel oil in this heater were higher, even approaching the annual heat input requirements of the heater, the SO_2 reductions would be even larger. Tesoro is concerned that in the future as the costs of fuel oil and refinery fuel gas change, fuel oil use could again become cheaper than natural gas/refinery fuel gas costs.

2.2.2.3 PM/PM_{10} Control

Tesoro has evaluated ending the routine use of fuel oil in this heater as a BART technology. As noted above, the alternative has essentially no current cost to the plant and will reduce plant-wide PM emissions by about 26 percent or 7.7 tpy (the current emissions for this unit are 9.1 tpy).

2.2.2.4 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness and energy consumption and other non-air quality impacts. Based on that evaluation, they propose the installation of ULNBs as BART for NO_X on this heater.

Tesoro has also proposed BART for SO_2 and PM/PM_{10} for this heater as ending the routine use of fuel oil. Tesoro wants to retain fuel oil use in this heater to cover periods of natural gas curtailment, start-up, and shutdown of major process units in the refinery, and emergency conditions that would limit the availability of refinery fuel gas.

2.2.3 Unit F-104, Gasoline Splitter Reboiler

The Gasoline Splitter Reboiler is a heater used to heat the gasoline fraction from the Crude Distillation Unit for further distillation steps. It has six floor-mounted ULNB burners. This 53 MMBtu/hr (average rate 15.5MMBtu/hr) heater was constructed in 1972 and utilizes only refinery fuel gas.

2.2.3.1 NO_X Control

This heater currently uses ULNBs installed in 2004. The current emission rates for this heater are 4.7 tpy, at an average concentration of 48 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, the only control evaluated for cost effectiveness for this heater was SCR. The average cost effectiveness of SCR was found to exceed $100,000/ton removed. No further analyses were performed.

2.2.3.2 Proposed BART

Based on their cost evaluation, the relative newness of the existing ULNBs installed in this unit and the high cost of SCR, Tesoro proposes the currently installed ULNBs as BART for NO_X on this heater.

Tesoro's continued use of the refinery fuel gas system as plant-wide SO_2 BART applies to Unit F-104. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

2.2.4 Unit F-304, CO Boiler No. 2

The Unit F-304, CO Boiler makes use of the thermal energy in the carbon monoxide rich flue gas from the Fluid Catalytic Cracking Unit (FCCU) catalyst regenerator by combusting the gas and providing steam for many plant processes. This unit exhausts through a common stack with the other CO Boiler (F-302) which also receives off gas from the FCCU regenerator. Refinery fuel gas is used as a supplemental fuel when required. This unit is capable of operating as a conventional refinery fuel gas fired boiler when the catalyst regenerator is not operating. This 322 MMBtu/hr (average rate 184.5 MMBtu/hr) heater was constructed in 1964 and has four wall-mounted burners.

2.2.4.1 NO_X Control

This boiler currently uses "default" original manufacturers design burners as originally installed in 1964. The current emission rates for this heater are 836 tpy. After an evaluation of the technical feasibility of the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of ULNB, SCR, SNCR, ULNB plus SCR, and ULNB plus SNCR. Table 2-3 lists pertinent criteria and cost effectiveness.

Table 2-3. UNIT F-304 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Annual NO_X Emission Rate (tpy) – Vendor Removal Rates	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis
No controls	--	--	--	836	--
$LoTO_X$™[9]	80%	--	80%	167	$14873
LNB + SNCR	--	--	39%	514	$4592
SNCR	50%	$2403	35%	543	$4534
LNB	--	--	5.5%	790	$6045

Initially, Tesoro evaluated only the use of SNCR with the EPA method screen. Consultation with vendors and receipt of information on performance and price estimates resulted in the evaluation of the additional controls. All of these controls are capable of being installed on this heater.

The installation of SNCR will slightly reduce the gross heat available to provide steam. This reduction is due to the need to evaporate the water included in the aqua ammonia used in the proposed SNCR system. During normal operating rates, the heat input capacity limits of the existing burners is able to overcome this loss by burning more fuel, with an accompanying increase in emissions of other pollutants.

As noted above, the $LoTO_X$™ system has been installed on very few other CO boiler/regenerator units. The installations provide both NO_X and particulate control. The existing particulate and SO_2 control is incompatible with the acidic environment produced in the $LoTO_X$™ process and cannot be retrofitted with the ozone injection step. The vendor has advised Tesoro that if replacement of the current Flue Gas Scrubber system were not possible, the $LoTO_X$™ system would have to be installed after the Flue Gas Scrubber.[10]

As an alternative to installation after the existing Flue Gas Scrubber, it could be replaced with a new $LoTO_X$™ system and BELCO Wet Gas Scrubber. While not analyzed, the cost of removal of the 3-year old Flue Gas Scrubber and replacement with a new $LoTO_X$™ system was considered to be very costly and was not evaluated.

[9] Cost effectiveness shown is the lowest of the four analyses made. The differences in the four $LoTO_X$™ cost analyses are primarily due to the cost of oxygen to produce ozone. The range of oxygen prices is $75/ton to $180/ton.
[10] Response to questions regarding BART analysis, May 2, 2008, pp. 3-6.

2.2.4.2 SO_2 Control

The FCCU Catalyst Regenerator burns carbon contamination off of the catalyst to reactivate it. Sulfur in the catalyst contaminants is also oxidized in the catalyst regenerator step. Gases from the FCCU Catalyst Regenerator are exhausted to Units F-302 and F-304, CO Boilers.

The Flue Gas Scrubber installed on the stack for Units F-302 and F-304 (CO Boilers No. 1 and 2, respectively), provides a large decrease in SO_2 and sulfuric acid emitted. The scrubber was installed to comply with federal hazardous air pollutant (MACT) requirements for the FCCU Catalyst Regenerators. Tesoro selected the Flue Gas Scrubber over a cyclone particulate collector to meet the federal requirement because the scrubber also provided a significant SO_2 emission reduction.

2.2.4.3 PM/PM_{10} Control

Unit F-304, CO Boiler No. 2 includes a Flue Gas Scrubber to remove particulate from the exhaust form the FCCU Catalyst Regenerator. This Flue Gas Scrubber was recently installed by the plant to comply with the MACT requirements to control emissions of particulate Hazardous Air Pollutants from the FCCU Catalyst Regenerator. At that time, Tesoro evaluated installation of an alternate particulate control device but chose to install the Flue Gas Scrubber instead. The choice was based on simplified maintenance, ability to comply with MACT standard, and the ability to reduce SO_2 and SO_3 emissions from the FCCU Catalyst Regenerator and CO Boilers No. 1 and 2. While only Unit F-304 (CO Boiler No. 2) is subject to BART, both boilers exhaust through a common stack.

2.2.4.4 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit.

Based on the original evaluation, Tesoro proposed the installation of low-NOX burners and SNCR as BART for NOX on this unit. However, this initial evaluation did not reflect the cost incurred by Tesoro for being required to take the F-304 boiler offline outside the normal turnaround schedule. With these costs included in the analysis, the use of the existing burners has been determined to be BART for NOX. See Section 2.4 for more information. BART for SO2 and PM/PM10 is the existing Flue Gas scrubber

2.2.5 Unit F-6650, Catalytic Reformer Feed Heater

The Catalytic Reformer Feed Heater is used to heat the gasoline (naphtha) fraction for reforming into higher octane isomers. The heater has 10 floor-mounted burners and exhausts into two common stacks with Units F-6651, F-6652, and F-6653.[11] The heater is rated at 157 MMBtu/hr (average rate 124.7MMBtu/hr). The heater was constructed in 1971 and utilizes refinery fuel gas. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.5.1 NO_X Control

This heater currently uses "default" original manufacturers design burners as originally installed in 1971. The current emission rates for this heater are 144.7 tpy, at an average concentration of 172 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of LNB, ULNB, SCR, LNB plus SCR, and ULNB plus SCR. Table 2-4 lists pertinent criteria and cost effectiveness.

Table 2-4. UNIT F-6650 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vender Cost Factor Analysis [12]
No Controls	--	144.7	--	--	--
LNB	60%	36.2	$4938	60%	$3349
ULNB	75%	36.2	$3973	60%	$3349
SCR	90%	14.5	$8473	90%	$10776
ULNB + SCR	97.5%	3.6	$10878	96%	$10772
LNB + SCR	96%	5.8	$11030	96%	$10772

All of these controls are capable of being installed on this heater. Flame impingement from LNB and ULNB burners is not an issue; however, there is inadequate space under the heater to retrofit ULNBs.

Adequate space exists to install SCR. Installation of an SCR system is evaluated for all four heaters because all four heaters exhaust to a common plenum leading to the two common stacks. The SCR addition can be done with or without a duct burner to raise the flue gas temperature. A duct burner would be fueled by refinery fuel gas. The costs for SCR presented in Table 2-4 are for the duct burner option. The non-duct burner option has a marginally different cost (see the Tesoro BART analysis report).

[11] Refer to the Tesoro BART analysis for a more detailed description of how these heaters work together.
[12] Averaged across Units F-6650, F-6651, F-6652, and F-6653.

2.2.5.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit.

In their original BART evaluation, Tesoro proposed the installation of LNBs as BART for NOX on this heater. However, this initial evaluation did not reflect the cost incurred by Tesoro for being required to take the F-6650 heater offline outside the normal turnaround schedule. With these costs included in the analysis, the use of the existing burners has been determined to be BART for NOX. See Section 2.4 for more information

The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-6650. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

2.2.6 Unit F-6651, Catalytic Reformer Inter-Reactor Heater

The Catalytic Reformer Inter-Reactor Heater is used to heat the gasoline fraction at an intermediate point in the process of reforming gasoline into higher octane isomers. The heater has 16 floor-mounted burners in two connected fireboxes and exhausts into two common stacks with Units F-6650, F-6652, and F-6653.[13] The heater is rated at 157 MMBtu/hr (average rate 90.4MMBtu/hr). The heater was constructed in 1971 and utilizes refinery fuel gas. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.6.1 NO_X Control

This heater currently uses "default" original manufacturers design burners as originally installed in 1971. The current emission rates for this heater are 104.7 tpy, at an average concentration of 171 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of LNB, ULNB, SCR, LNB plus SCR, and ULNB plus SCR. Table 2-5 lists pertinent criteria and cost effectiveness.

[13] Refer to the Tesoro BART analysis for a more detailed description of how these heaters work together.

Table 2-5. UNIT F-6651 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis[14]
No controls	--	104.7	--	--	--
LNB	60%	42	$4614	60%	$3349
ULNB	75%	26.2	$3722	60%	$3349
SCR	90%	10.5	$11260	90%	$10776
LNB + SCR	96%	4.2	$13440	96%	$10772
ULNB + SCR	97.5%	2.6	$13257	96%	$10772

All of these controls are capable of being installed on this heater. Flame impingement from LNB and ULNB burners is not an issue; however, there is inadequate space under the heater to retrofit ULNBs.

Adequate space exists to install SCR. Installation of an SCR system is evaluated for all four heaters because all four heaters exhaust to a common plenum leading to the two common stacks. The SCR addition can be done with or without a duct burner to raise the flue gas temperature. A duct burner would be fueled by refinery fuel gas. The costs for SCR presented in Table 2-5 are for the duct burner option. The non-duct burner option has a marginally different cost (see the Tesoro BART analysis report).

2.2.6.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit.

In their original BART evaluation, Tesoro proposed the installation of LNBs as BART for NOX on this heater. However, this initial evaluation did not reflect the cost incurred by Tesoro for being required to take the F-6651 heater offline outside the normal turnaround schedule. With these costs included in the analysis, the use of the existing burners has been determined to be BART for NOX. See Section 2.4 for more information.

The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-6651. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

[14] Averaged across Units F-6650, F-6651, F-6652, and F-6653.

2.2.7 Unit F-6652, Catalytic Reformer Inter-Reactor Heater

The Catalytic Reformer Inter-Reactor Heater is used to heat the gasoline fraction at an intermediate point in the process of reforming gasoline into higher octane isomers. The heater has seven floor-mounted burners which exhaust into two common stacks with Units F-6650, F-6651, and F-6653.[15] The heater is rated at 74 MMBtu/hr (average rate 41.7 MMBtu/hr). The heater was constructed in 1971 and utilizes refinery fuel gas. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.7.1 NO_X Control

This heater currently uses "default" original manufacturers design burners as originally installed in 1971. The current emission rates for this heater are 17.1 tpy, at an average concentration of 61 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of LNB, ULNB, SCR, LNB plus SCR, and ULNB plus SCR. Table 2-6 lists pertinent criteria and cost effectiveness.

Table 2-6. UNIT F-6652 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis[16]
No controls	--	17.1	--	--	--
LNB	60%	6.8	$16818	60%	$3349
ULNB	75%	4.3	$13648	73.5%	$3349
SCR	90%	1.7	$41599	90%	$10776
LNB + SCR	96%	0.7	$49510	96%	$10772
ULNB + SCR	97.5%	0.4	$48895	96%	$10772

All of these controls are capable of being installed on this heater. Flame impingement from LNB and ULNB burners is not an issue. ULNBs were found to be a good technical fit due to adequate space under the heater. The ULNBs proposed by the manufacturer would have a NO_X emission rate of about 1/3 of their alternate LNB units at a 50 percent increase in cost.

Adequate space exists to install SCR. Installation of an SCR system is evaluated for all four heaters because all four heaters exhaust to a common plenum leading to the two common stacks. The SCR addition will require a duct burner to raise the flue gas temperature enough to

[15] Refer to the Tesoro BART analysis for a more detailed description of how these heaters work together.
[16] Averaged across Units F-6650, F-6651, F-6652, and F-6653.

consistently meet the temperature requirements of a SCR catalyst. The duct burner would be fueled by refinery fuel gas.

2.2.7.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit.

In their original BART evaluation, Tesoro proposed the installation of ULNBs as BART for NOX on this heater. However, this initial evaluation did not reflect the cost incurred by Tesoro for being required to take the F-6652 heater offline outside the normal turnaround schedule. With these costs included in the analysis, the use of the existing burners has been determined to be BART for NOX. See Section 2.4 for more information.
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The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-6652. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

2.2.8 Unit F-6653, Catalytic Reformer Inter-Reactor Heater

The Catalytic Reformer Inter-Reactor Heater is used to heat the gasoline fraction at an intermediate point in the process of reforming gasoline into higher octane isomers. The heater has three floor -mounted burners which exhaust into two common stacks with Units F-6650, F-6651, and F-6652.[17] The heater is rated at 42 MMBtu/hr (average rate 31.4 MMBtu/hr). The heater was constructed in 1971 and utilizes refinery fuel gas. The burners used are of original equipment design, emitting relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.8.1 NO_X Control

This heater currently uses "default" original manufacturer design burners as originally installed in 1971. The current emission rates for this heater are 13 tpy, at an average concentration of 61 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of LNB, ULNB, SCR, LNB plus SCR, and ULNB plus SCR. Table 2-7 lists pertinent criteria and cost effectiveness.

[17] Refer to the Tesoro BART analysis for a more detailed description of how these heaters work together.

Table 2-7. UNIT F-6653 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis [18]
No controls	--	13	--	--	--
LNB	60%	6.8	$19190	60%	$3349
ULNB	75%	3.3	$15604	73.5%	$3349
SCR	90%	1.3	$38829	90%	$10776
LNB + SCR	96%	0.7	$48396	96%	$10772
ULNB + SCR	97.5%	0.3	$47845	96%	$10772

All of these controls are capable of being installed on this heater. Flame impingement from LNB and ULNB burners is not an issue. ULNBs were found to be a good technical fit due to adequate space under the heater. The ULNBs proposed by the manufacturer would have a NO_X emission rate of about one-third of their alternate LNB units at a 50 percent increase in cost.

Adequate space exists to install SCR. Installation of an SCR system is evaluated for all four heaters because all four heaters exhaust to a common plenum leading to the two common stacks. The SCR addition will require a duct burner to raise the flue gas temperature enough to consistently meet the temperature requirements of a SCR catalyst. The duct burner would be fueled by refinery fuel gas.

2.2.8.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit.

In their original BART evaluation, Tesoro proposed the installation of ULNBs as BART for NOX on this heater. However, this initial evaluation did not reflect the cost incurred by Tesoro for being required to take the F-6653 heater offline outside the normal turnaround schedule. With these costs included in the analysis, the use of the existing burners has been determined to be BART for NOX. See Section 2.4 for more information.

The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-6653. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

[18] Averaged across Units F-6650, F-6651, F-6652, and F-6653.

2.2.9 Unit F-654, Catalyst Feed Hydrotreater Heater

The Catalyst Feed Hydrotreater Heater is used to heat the deasphalted heavy oil fraction from the crude unit prior to sulfur removal in the hydrotreater. The heater has three floor-mounted burners. The heater is rated at 16.5 MMBtu/hr (average rate 7.6 MMBtu/hr). The heater was constructed in 1964 and utilizes refinery fuel gas. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.9.1 NO_X Control

This heater currently uses "default" original manufacturers design burners as originally installed in 1964. The current emission rates for this heater are 2.6 tpy, at an average concentration of 52 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of ULNB, SCR, and ULNB plus SCR. Table 2-8 lists pertinent criteria and cost effectiveness.

Table 2-8. UNIT F-654 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis
No controls	--	2.6	--	--	--
ULNB	75%	0.7	$36131	73.5%	$43093
SCR	90%	0.3	$104352	90%	--
ULNB + SCR	97.5%	0.1	$124119	96%	--

All of these controls are capable of being installed on this heater. Adequate space exists to install ULNBs and SCR. ULNBs were found to be a good technical fit due to adequate space under the heater. A vender provided the price quotation for ULNBs that could be installed in the heater.

A screening analysis using EPA cost estimating procedures was done for installation of an SCR system. As can be seen, the cost of SCR is extremely high, primarily due to the very low uncontrolled NO_X emissions.

There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit.

2.2.9.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. Based on that evaluation, they propose the currently installed burners as BART for NO_X on this heater.

The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-654. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

2.2.10 Unit F-6600, Naphtha Hydrotreater Feed Preheater

The Naphtha Hydrotreater Feed Preheater is used to heat the naphtha fraction prior to sulfur removal in the naphtha hydrotreater. The heater has four floor-mounted burners. The heater is rated at 71.5 MMBtu/hr (average rate 46.3 MMBtu/hr). The heater was constructed in 1971 and utilizes refinery fuel gas. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.10.1 NO_X Control

This heater currently uses "default" original manufacturers design burners as originally installed in 1971. The current emission rates for this heater are 18.9 tpy, at an average concentration of 61 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of LNB, ULNB, SNCR, and ULNB plus SNCR. Table 2-9 lists pertinent criteria and cost effectiveness.

Table 2-9. UNIT F-6600 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis
No controls	--	18.9	--	--	--
LNB	60%	8	$26647	--	--
ULNB	75%	5	$21491	73.5%	$17581
SNCR	50%	9	$23779	--	--
LNB + SNCR	80%	4	$34847	--	--
ULNB + SNCR	87.5%	2	$32009	--	--

All of these controls are capable of being installed on this heater. Adequate space exists to install ULNBs and SNCR. ULNBs were found to be a good technical fit due to adequate space under the heater and lower emissions than LNBs.

A screening analysis using EPA's cost estimating procedures was done for installation of these of controls. As can be seen, the costs estimated using EPA's methods is extremely high, primarily due to the very low uncontrolled NO_X emissions. A vendor provided the price quotation for ULNBs that could be installed in the heater.

2.2.10.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit. Based on that evaluation, they propose the currently installed burners as BART for NO_X on this heater.

The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-6600. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

2.2.11 Unit F-6601, Naphtha Hydrotreater Stabilizer Column Reboiler

The Naphtha Hydrotreater Stabilizer Column Reboiler is used to heat the naphtha fraction prior to sulfur removal in the naphtha hydrotreater. The heater has four floor-mounted burners. The heater is rated at 75 MMBtu/hr (average rate 48.3 MMBtu/hr). The heater was constructed in 1971 and utilizes refinery fuel gas. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.11.1 NO_X Control

This heater currently uses "default" original manufacturers design burners as originally installed in 1971. The current emission rates for this heater are 19.8 tpy, at an average concentration of 61 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of LNB, ULNB, SNCR, and ULNB plus SNCR. Table 2-10 lists pertinent criteria and cost effectiveness.

Table 2-10. UNIT F-6601 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis
No controls	--	19.8	--	--	--
LNB	60%	8	$28538	--	--
ULNB	75%	5	$22995	73.5%	$17150
SCR	50%	2	$36638	--	--
LNB + SCR	80%	1	$52184	--	--
ULNB + SCR	87.5%	0.5	$51509	--	--

All of these controls are capable of being installed on this heater. Adequate space exists to install ULNBs and SNCR. ULNBs were found to be a good technical fit due to adequate space under the heater and have lower emission rates than LNBs.

A screening analysis using EPA's cost estimating procedures was done for installation of these of controls. As can be seen, the costs estimated using EPA's methods is extremely high, primarily due to the very low uncontrolled NO_X emissions. A vendor provided the price quotation for ULNBs that could be installed in the heater.

2.2.11.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit. Based on that evaluation, they propose the currently installed burners as BART for NO_X on this heater.

The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-6601. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

2.2.12 Unit F-6602, Naphtha Hydrotreater Feed Preheater

The Naphtha Hydrotreater Feed Preheater is used to heat the naphtha fraction prior to sulfur removal in the naphtha hydrotreater. The heater has four floor-mounted burners. The heater is rated at 75 MMBtu/hr (average rate 28 MMBtu/hr). The heater was constructed in 1971 and utilizes refinery fuel gas. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.12.1 NO_X Control

This heater currently uses "default" original manufacturers design burners as originally installed in 1971. The current emission rates for this heater are 1.3 tpy, at an average concentration of 61 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of LNB, ULNB, SNCR, and ULNB plus SNCR. Table 2-11 lists pertinent criteria and cost effectiveness.

Table 2-11. UNIT F-6602 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis
No controls	--	18.9	--	--	--
LNB	60%	8	$26647	--	--
ULNB	75%	5	$21491	73.5%	$17581
SNCR	50%	9	$23779	--	--
LNB + SNCR	80%	4	$34847	--	--
ULNB + SNCR	87.5%	2	$32009	--	--

All of these controls are capable of being installed on this heater. Adequate space exists to install ULNBs and SNCR. ULNBs were found to be a good technical fit due to adequate space under the heater.

A screening analysis using EPA's cost estimating procedures was done for installation of these of controls. As can be seen, the costs estimated using EPA's methods is extremely high, primarily to the very low uncontrolled NO_X emissions. A vendor provided the price quotation for ULNBs that could be installed in the heater.

2.2.12.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit. Based on that evaluation, they propose the currently installed burners as BART for NO_X on this heater.

The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-6602. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

2.2.13 Unit F-6654, Catalytic Reformer Stabilizer Column Reboiler

The Catalytic Reformer Stabilizer Column Reboiler is used to heat the gasoline fraction at an intermediate stage in the reforming process. The heater has three floor-mounted burners. The heater is rated at 35 MMBtu/hr (average rate 24.6 MMBtu/hr). The heater was constructed in 1971 and utilizes refinery fuel gas. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.13.1 NO_X Control

This heater currently uses "default" original manufacturers design burners as originally installed in 1971. The current emission rates for this heater are 10.2 tpy, at an average concentration of 59 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of LNB, ULNB, SNCR, and ULNB plus SNCR. Table 2-12 lists pertinent criteria and cost effectiveness.

Table 2-12. UNIT F-6654 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis
No controls	--	10.2	--	--	--
LNB	60%	4.0	$18952	--	--
ULNB	75%	2.6	$15483	73.5%	$11069
SCR	50%	5.1	$44084	--	--
LNB + SCR	80%	2.0	$53174	--	--
ULNB + SCR	87.5%	1.3	$52603	--	--

All of these controls are capable of being installed on this heater. Adequate space exists to install ULNBs and SNCR. ULNBs were found to be a good technical fit due to adequate space under the heater and to have lower emissions than LNBs.

A screening analysis using EPA's cost estimating procedures was done for installation of these of controls. As can be seen, the costs estimated using EPA's methods is extremely high, primarily to the very low uncontrolled NO_X emissions. A vendor provided the price quotation for ULNBs that could be installed in the heater.

2.2.13.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit. Based on that evaluation, they propose the currently installed burners as BART for NO_X on this heater.

The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-6654. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

2.2.14 Unit F-6655, Catalytic Reformer Stabilizer Regeneration Gas Heater

The Catalytic Reformer Stabilizer Regeneration Gas Heater is used to heat the gasoline fraction at an intermediate stage in the reforming process. The heater has three floor-mounted burners. The heater is rated at 30 MMBtu/hr (average rate 11.5 MMBtu/hr). The heater was constructed in 1971 and utilizes refinery fuel gas. The burners used are of original equipment design and emit relatively high levels of NO_X compared to current LNB or ULNB designs.

2.2.14.1 NO_X Control

This heater currently uses "default" original manufacturers design burners as originally installed in 1971. The current emission rates for this heater are 3.3 tpy, at an average concentration of 55 ppmv. After an evaluation of technical feasibility to retrofit the heater with the NO_X controls in Table 2-1, Tesoro evaluated the cost effectiveness of LNB and ULNB. Due to unit size, temperature profiles, and configuration, SCR and SNCR were not technically feasible. Table 2-13 lists pertinent criteria and cost effectiveness.

Table 2-13. F-6655 NO_X CONTROLS EVALUATED IN DETAIL

Control Technology	Emission Reduction Anticipated – EPA Method	Annual NO_X Emission Rate (tpy)	Average Cost Effectiveness ($/ton) – EPA Method	Emission Reduction Anticipated – Vendor Cost Factor Analysis	Average Cost Effectiveness ($/ton) – Vendor Cost Factor Analysis
No controls	--	3.3	--	--	--
LNB	40%	2.0	$73228	--	--
LNB	60%	1.3	$48818	28.6%	$86519
ULNB	75%	0.8	$40047	--	--

At the initial technical evaluations, all of these burner designs were viewed as being able to be installed on this heater. Upon receipt of more detailed information from the vendor, it was found that only a LNB could fit into the space in and under the heater. Flame impingement from the burners is not an issue.

A screening analysis using EPA's cost estimating procedures was done for installation of all three varieties of burners. As can be seen, the costs estimated using EPA's methods is extremely high, primarily to the very low uncontrolled NO_X emissions.

A vendor provided a price quotation for LNBS that could be installed in this application. The vendor quoted removal efficiency is based on the expected and guaranteed emission rates of the burners proposed for installation. Their control efficiency is lower than the generally accepted removal rates of LNBs.

2.2.14.2 Proposed BART

Tesoro has evaluated the technically feasible controls for cost effectiveness, energy consumption and other non-air quality impacts. There is no adverse energy, air quality, or non-air quality impacts resulting from any of these controls on this unit. Based on that evaluation, they propose the currently installed burners as BART for NO_X on this heater.

The unit is fueled by refinery fuel gas. Tesoro proposed its current use of refinery fuel gas to control SO_2 emissions from Unit F-6655. The continued use of low sulfur refinery fuel gas minimizes potential particulate emissions as much as possible and is considered BART for PM/PM10.

2.2.15 Flare X-819

Flare X-819 is used to combust process vent gases and vapors from loading operations that are not routed to the refinery gas system and gases from emergency releases of tank and process vessels. The flare operates all the time, but its primary function is to allow for the safe emergency venting of various process units in the refinery. Operation of the flare during emergency venting situations prevents hazardous conditions from occurring at the Tesoro refinery as a result of the emergency release of hydrocarbon vapors near process heaters.

The flare is a 2-stage, steam assisted flare of the "smokeless" design, rated at 244 MMBtu/hr and 2.6 million standard cubic feet per day (million scfd) of flared gas (0.5 million scfd in first stage and 2.1 million scfd in second stage). The flare was constructed in 1971 and utilizes refinery fuel gas for the pilot light fuel. While the potential to emit is considerably higher, for modeling purposes if the flare operated continuously at the modeled flare gas flow rate, it would emit 43.8 tons of SO_2 and 8.8 tons of NOx per year. Information presented indicates the flare meets the design criteria of 40 CFR 60.18 for elevated flares.

2.2.15.1 NO_X, SO_2, and PM/PM_{10} Control

There are no emission controls directly attributable to operation of flares. Reduction of routine flaring operations is the most common way to reduce non-emergency flare emissions. Tesoro already utilizes a flare gas recovery compressor and other measures to recover combustible gases and route them to the refinery fuel gas system. Adding a second compressor would recover gas from additional emergency vents that are currently routed directly to the flare system.

Tesoro evaluated addition of a second flare gas recovery compressor to reduce emissions from the flare. They estimated that this would reduce SO_2 emissions by about 10 tpy, have a capital cost of $2 million and a cost effectiveness of $21,960/ton.

2.2.15.2 Proposed BART

Tesoro proposed that BART for operations of the flare system is continued operation of the current system.

2.3 Evaluation of Controls for Cooling Water Towers 2 and 2a

The cooling water towers are used to cool returned "process cooling water" to prepare it for reintroduction to the process cooling water equipment. Current emissions of PM/PM_{10} from the cooling tower are approximately 0.2 lb/hr (0.88 tpy). The cooling towers were constructed in 1971 and include reasonable droplet drift control techniques for the time.

2.3.1 PM/PM_{10} Control

Tesoro requested an estimate for replacement of the current cooling tower drift control with a state-of-the-art system to reduce $PM//PM_{10}$ emissions from the cooling tower. This estimate was "on the order of $150,000" and would provide an 80 to 90 percent reduction in cooling tower drift emissions. Assuming the only cost involved with new drift elimination system is the capital cost, the estimated cost effectiveness is $41,781. Tesoro noted that the particulate formed by cooling towers tends to be larger in size and deposit on the area immediately around the cooling towers.

2.3.2 Proposed BART

After consideration of the cost per ton reduced and the small quantity of PM/PM_{10} that would be controlled, Tesoro proposed continued operation of the current system as BART for the cooling tower.

2.4 Compliance Schedule Based Considerations

Subsequent to the information submitted by Tesoro in 2008, Ecology and Tesoro entered discussions on the BART compliance schedule to install the emission controls proposed by Tesoro as BART. EPA Region 10 was asked to provide specific information on some aspects of the proposed compliance schedules.

The requirements for BART in 40 CFR Part 51, Subpart P include the following requirement addressing when a source is to meet the BART emission limitations.

> A requirement that each source subject to BART be required to install and operate BART as expeditiously as practicable, but in no event later than 5 years after approval of the implementation plan revision.[19]

Based on an anticipated implementation plan revision approval about December 2010, all BART controls would need to be in operation by December 2015.

The installation of the proposed controls on Unit F-103 would meet the two primary constraints on the project: it could be accomplished within the normal turn-around schedule and within five years of the anticipated approval date of the state SIP.

The work on the CO Boiler, F-304, and the 4 catalytic reformer heaters, units F-6650–6653, either had to be accomplished outside of the normal turn-around schedule or would not occur till more than five years after the Ecology anticipated date of SIP approval. For these 5 units, Tesoro initially proposed a schedule based on complying with the BART limitation 5 years after the Regional Haze implementation plan was approved by EPA, and that the implementation plan approval date would be no earlier that the end of 2012, unless that date was less than 3 years prior to the routine, scheduled turn-around. One result of this proposal is that for these units, the earliest compliance date would be 2017. The company also proposed a provision that would further extend the compliance date for these units into the future if the SIP were approved after 2014.

The extended BART compliance date request by Tesoro was presented to EPA Region 10. The region advised Ecology that the proposal did not meet the plain requirements of the regional Haze rules.

The basis for Tesoro's proposed compliance dates relates to their schedule for turn-around activities. As appears common in the petroleum refining and other industries, the various process units at the plant are taken out of service for major maintenance and upgrades on a routine cycle between 1 and 7 years for industries in Washington. The petroleum refining industry takes process units out of service for major maintenance and upgrades at five year intervals. The refinery as a whole is never taken fully out of service, though work on primary processing units like the Crude Unit and the Catalytic Reformer significantly affect the quantity of refined products produced during those times.

Corporate policy for Tesoro requires the maintenance needs, modifications, and any desired upgrades to the units involved in a particular turn-around are determined three years before the work is completed. The 3 year period allows for identification of non-routine work or upgrades, planning level cost analysis and approval from plant and corporate management, followed by financing, design, and new equipment purchases , all of which need to occur prior to contracting for the work. Permitting with the local air pollution control agency is not started until financing is approved by company management and design is far enough along to allow the permitting

[19] 40 CFR 51.308(e)(1)(iv)

process to begin. Permitting usually starts 12 to 18 months before the actual start of construction, depending on complexity of permitting.

Ecology has confirmed the outlines of this 3 year planning/construction process through contacts with other refineries and the management of the local air pollution control agency that oversees the 4 largest oil refineries in the Washington. In general this process is the same as at the other refineries, as is the 5 year period between turn-arounds.

CO Boiler 2 (F-304) and the catalytic reformer heaters (F-6650–6653) have a normal turn-around scheduled for 2012, less than 3 years after the BART order is issued, let alone the approval of the Regional Haze implementation plan, which Ecology anticipates to be the end of 2010. The next scheduled turnaround is scheduled for 2017.

As a result of Ecology's requested and EPA's confirmation that a 2017/18 BART compliance date did not comply with the requirements of the federal visibility rules, Tesoro investigated the costs to install the BART controls at a time other than the normal scheduled turn-around schedule, including accelerated installation in 2012. As a result, the cost to install the controls increases, not just in direct costs for installation of the controls, but in "lost opportunity" costs due to taking these units off-line for at an unanticipated time. The "lost opportunity costs" are a direct consequence of taking the units off line outside of the normal schedule. These costs are built into the planning and total cost of the routine turn-around schedule and as such are not an extraordinary cost in that context.

The process to retrofit an existing heater with new low NOx or Ultra low NOx heaters is not a simple process of turning the heater off, letting it cool sufficiently, unbolting the old burners and installing the new burners, and turning it back on, though that is in essence all that is done. The new burners have different flame length characteristics that need to be accounted for in revisions to the refractory brick in the heaters. The heater must be cool enough for a man to get inside to work on the refractory brick. The overall time to turn off the heater, cool it sufficiently to do the burner work, conduct test firings of the burners to assure the flame pattern is what it is supposed to be, and finally return the unit to service will take several weeks.

While the unit is off line, the remainder of the refinery either has to operate at reduced rate, or on purchased intermediate products purchased from others. The plant has inadequate storage tank capacity to handle an outage of the F304 and F-6650 – 6653 units and remain near full operating rate. The 'lost opportunity cost" is an extraordinary expense associated with the off-cycle project. As such, this becomes a site specific consideration in the cost to implement the burner retrofits on the CO Boiler and heaters[20].

[20] "The cost analysis should also take into account any site-specific design or other conditions identified above that affect the cost of a particular BART technology option." 40 CFR Part 51, Appendix Y, Section IV.4.a

For Unit F-304, installation of the BART controls off the normal schedule causes the cost effectiveness to install the originally proposed BART controls of low NO_X burners and SNCR system to rise to $10,802/ton NO_X reduced from the original $4,592/ton NO_X reduced.

Similarly the costs to install the low and ultra low NO_X burners proposed for the catalytic reformer heaters (F-6650–6653) also increases to $13,190/ton NO_X reduced from the original $3,349/ton NO_X reduced.

In this evaluation, Ecology also compared these costs for burner replacement to the costs reported by another Washington state petroleum refinery that is subject to BART. The costs reported by Tesoro are in line with the costs reported by that refinery before the "lost opportunity costs" are removed from that refinery's cost calculations. At the other refinery, the "lost opportunity costs" are primarily due to the additional time required to install low NOx burners compared to a normal turn-around on the same unit.

As a result of the increased costs to install these controls "off schedule" Tesoro proposed that BART for NO_X from these units is the existing burners.

3. VISIBILITY IMPACTS AND DEGREE OF IMPROVEMENT

The results of the Tesoro's modeling are shown in Table 3-1 for all Class I areas within 300 km of the plant plus the Columbia River Gorge National Scenic Area. The table shows the maximum day impairment due to Tesoro, the highest of the annual, 98th percentile days for the three years modeled, and the 98th percentile day of the modeled 3-year period. Also shown is the modeled visibility impairment resulting from the BART controls proposed by Tesoro. The shaded areas indicate values above the 0.5 dv threshold used to determine if a source contributes to visibility impairment.

The modeled emission rates were derived from operating records of the units and reflect the highest 24-hour emission rates within the three years that were modeled except for Unit F-304. Subsequent to the three years of the modeling period, this unit had a Flue Gas Scrubber installed and permitted with significantly lower emission rates. The emissions for Unit F-304 were scaled downward to reflect the currently-permitted emission rate for SO_2. For the other units with proposed BART controls, the effectiveness of the BART control was applied to the baseline emission rate to estimate the effect of BART on visibility impacts. The modeled emission rates are shown in Table 3-2.
Ecology modelers have reviewed the modeling performed by Tesoro and have found that the modeling complies with the Modeling Protocol and produces a reasonable result.

The modeled emission reductions proposed in the 2008 BART analysis result in substantial reduction in the visibility impairment caused by Tesoro in the most heavily impacted Class I areas modeled. At the three most heavily impacted Class I areas, Olympic National Park, North Cascades National Park, and the Alpine Lakes Wilderness, Tesoro's proposed BART controls would provide 0.2 to 0.5 dv reduction in visibility impairment in each of these areas.

Table 3-1. MODELED BASELINE AND TESORO'S PROPOSED BART CONTROL VISIBILITY IMPACTS

Class I Area	Visibility Criterion	Baseline Emissions	Proposed BART
Alpine Lakes Wilderness	Max delta deciview		
	Max 98% value (8th high)	0.917	0.733
	3 years combined 98% value (22nd high)	0.810	0.640
Glacier Peak Wilderness	Max delta deciview		
	Max 98% value (8th high)	0.908	0.679
	3 years combined 98% value (22nd high)	0.847	0.675
Goat Rocks Wilderness	Max delta deciview		
	Max 98% value (8th high)	0.293	0.239
	3 years combined 98% value (22nd high)	0.281	0.234
Mt. Adams Wilderness	Max delta deciview		
	Max 98% value (8th high)	0.255	0.197
	3 years combined 98% value (22nd high)	0.228	0.185
Mt. Rainier National Park	Max delta deciview	1	
	Max 98% value (8th high)	0.712	0.582
	3 years combined 98% value (22nd high)	0.643	0.542
North Cascades National Park	Max delta deciview		
	Max 98% value (8th high)	1.001	0.751
	3 years combined 98% value (22nd high)	0.915	0.742
Olympic National Park	Max delta deciview		
	Max 98% value (8th high)	1.722	1.248
	3 years combined 98% value (22nd high)	1.399	1.025
Pasayten Wilderness	Max delta deciview		
	Max 98% value (8th high)	0.497	0.388
	3 years combined 98% value (22nd high)	0.497	0.385
Class II area modeled per the Modeling Protocol			
Columbia River Gorge National Scenic Area	Max delta deciview		
	Max 98% value (8th high)	0.162	0.1331
	3 years combined 98% value (22nd high)	0.119	0.105

Table 3-2. MODELED EMISSION RATES

Unit	2002-2005 Rates (lb/hr)			Tesoro's Proposed BART (lb/hr)		
	SO_2	NO_X	PM_{10}	SO_2	NO_X	PM_{10}
F-103	160.5	53.5	9.1	152.5[a]	18.2[b]	1.4
F-104	39.8	0.8	0.4	39.8	0.8	0.4
F-304	24.9	242.7	14.1	24.9	148.0[b]	14.1
F-654	11.7	1.3	0.1	11.7	1.3	0.1
F-6600	56.0	13.1	0.9	56.0	13.1	0.9
F-6601	77.5	8.0	0.6	77.5	8.0	0.6
F-6602	25.6	8.3	0.6	25.6	8.3	0.6
F-6650/6651	332.0	101.3	2.8	332.0	28.3[d]	2.8
F-6652/6653	86.1	19.2	1.5	86.1	5.2[b]	1.5
F-6654	32.2	4.0	0.3	32.2	4.0	0.3
F-6655	15.1	2.9	0.2	15.1	2.9	0.2
X-819	10.0	2.0	0.4	10.0	2.0	0.4
CWT #2	0	0	0.1	0	0	0.1
CWT #2a	0	0	0.1	0	0	0.1

[a] Reflects ending fuel oil usage.
[b] Reflects reduction due to ultra-low-NO_X burners.
[c] Reflects reduction due to SNCR.
[d] Reflects reduction due to low-NO_X burners.

4. ECOLOGY'S BART DETERMINATION

Ecology has reviewed the information submitted by Tesoro. We agree with Tesoro's proposal for BART. Ecology's determination of BART for Tesoro is shown in Table 4-1. In making its determination of BART for these units, Ecology reviewed the types of controls and emission rates required under EPA national Consent Orders issued to oil refineries and BACT and BART determinations or guidance from other states.

Units F-302 and F-304 both exhaust to the same particulate/SO_2 control device, the Flue Gas Scrubber. Currently the emission limitations attributable to the individual units and on the FCCR catalyst regenerator that feeds these two units are added together and regulated at the scrubber stack. For this BART determination, Ecology proposes to continue this practice for particulate and SO_2.

Ecology believes the NO_X emission controls and resulting emission reductions originally proposed as BART by Tesoro are appropriate and cost effective to implement as part of a regularly scheduled turn-around project. These controls may ultimately be required to be installed in the future as further progress toward meeting the visibility goals. However, the increased costs to accomplish the burner and SNCR installations outside of the unit's normal maintenance cycle, we determine that BART for Unit F-304 is the current emission controls and emission limitations.

Similar to Unit F-304, Ecology believes the emission controls and resulting emission reductions originally proposed as BART by Tesoro for the Catalytic Reformer Heaters F-6650–6653 are appropriate and cost effective to implement as part of a regularly scheduled turn-around project. These controls may ultimately be required to be installed in the future as further progress toward meeting the visibility goals. However, the increased costs to accomplish the low and ultra low NO_X burner installations outside of the unit's normal maintenance cycle, we determine that BART for Unit F-304 is the current emission controls and emission limitations.

As a result of the reduced NO_X emission reductions proposed as BART by Ecology when compared to Tesoro's initial BART proposal, the visibility improvement will be considerably less than was modeled by Tesoro and depicted in Section 3. Ecology has not remodeled the visibility improvement or required Tesoro to do so. Using only the 3-year, 98th percentile day at Olympic National Park as an example, we estimate that the visibility improvement due to this proposed BART determination to be about 0.1 dv, compared to Tesoro's modeled improvement for their original proposed BART of 0.37 dv for the same day.

able 4-1. ECOLOGY'S DETERMINATION OF THE EMISSION CONTROLS THAT CONSTITUTE BART

	BART Control Technology	Emission Limitation
F-103		
PM/PM_{10}	Ending routine use of fuel oil. Use of refinery fuel gas or natural gas as primary fuel.	Fuel oil allowed only under the following conditions: • Natural gas curtailment. • Periods with limited refinery fuel gas availability, such as start-up and shutdown of major refinery process units, while major refinery process units are not operating and producing refinery gas, and emergency conditions as necessary to maintain safe operations or equipment shutdown. Test firing on fuel oil is allowed for up to 24 hours per calendar year.
SO_2	Ending routine use of fuel oil. Use of refinery fuel gas or natural gas as primary fuel.	Same as for PM/PM_{10}.
NO_X	Ultra-low-NO_X burners	Not to exceed 59.1 tpy, rolling (365 day) annual total calculated daily.
All Other BART-Eligible Units		
F-104, F-654, F-6600, F-6601, F-6602, F-6650, F-6651, F-6652, F6653, F-6654, F-6655, Flare X-819, Cooling Towers 2 and 2a	Currently installed combustion and other controls.	Per applicable NWCAA regulatory orders and regulations.

APPENDIX A. PRINCIPLE REFERENCES USED

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APPENDIX B. ACRONYMS/ABBREVIATIONS

BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
dv	Deciview(s)
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
FCCU	Fluid Catalytic Cracking Unit
FGR	Flue Gas Recirculation
LAER	Lowest Achievable Emission Rate
LNBs	Low-NO_X burners
$LoTO_X^{TM}$	Patented low temperature oxidation process for reducing NO_X in gas waste streams
MMBtu	Million British thermal units
NO_X	Nitrogen oxides
NWCAA	Northwest Clean Air Agency
PM	Particulate matter
ppm	Parts per million
ppmdv	Parts per million dry volume
ppmv	Parts per million by volume
RACT	Reasonably Available Control Technology
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SO_2	Sulfur dioxide
SRU	Sulfur Recovery Unit
SWS	Sour Water Stripper
Tesoro	Tesoro Refining and Marketing Company
TGU	Tail Gas Unit
tpy	Tons per year
ULNBs	Ultra-low-NO_X Burners
VOC(s)	Volatile organic compound(s)