BEFORE THE ENVIRONMENTAL APPEALS BOARD
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C.

	)
In re:	)
	)
Shell Gulf of Mexico, Inc.	)
Permit No. R10OCS/PSD-AK-09-01	)
	)
and	)
	)
Shell Offshore, Inc.	)
Permit No. R10OCS/PSD-AK-2010-01	)
	)
	)

EXHIBITS IN SUPPORT OF PETITION FOR REVIEW

NATURAL RESOURCES DEFENSE COUNCIL, NATIVE VILLAGE OF POINT HOPE, RESISTING ENVIRONMENTAL DESTRUCTION ON INDIGENOUS LANDS (REDOIL), ALASKA WILDERNESS LEAGUE, AUDUBON ALASKA, CENTER FOR BIOLOGICAL DIVERSITY, NORTHERN ALASKA ENVIRONMENTAL CENTER, OCEAN CONSERVANCY, OCEANA, PACIFIC ENVIRONMENT, and SIERRA CLUB

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
SEATTLE, WASHINGTON

STATEMENT OF BASIS
FOR PROPOSED
OUTER CONTINENTAL SHELF
PREVENTION OF SIGNIFICANT DETERIORATION
PERMIT NO. R10OCS/PSD-AK-09-01

SHELL GULF OF MEXICO INC.
FRONTIER DISCOVERER DRILLSHIP
CHUKCHI SEA EXPLORATION DRILLING PROGRAM

Date of Proposed Permit: January 8, 2010

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1. INTRODUCTION, PROJECT DESCRIPTION AND PUBLIC PARTICIPATION

1.1 Introduction

Pursuant to Section 328 of the Clean Air Act (CAA), 42 U.S.C. § 7627, the United States Environmental Protection Agency (EPA) promulgated air quality regulations applicable to Outer Continental Shelf (OCS) sources, which regulations are set forth in Title 40, Code of Federal Regulations (C.F.R.), Part 55. Under these regulations, an OCS source that is a major stationary source and which proposes to locate on the OCS is required to obtain a Prevention of Significant Deterioration (PSD) permit before beginning construction. The requirements of the PSD program were established under Part C of Title I of the CAA, 42 U.S.C. § 7470-7492, and are found at 40 C.F.R. § 52.21.

Under these programs, Shell Gulf of Mexico Inc (Shell)[1] has applied for a major source permit to authorize mobilization and operation of the Frontier Discoverer drillship (Discoverer) and its associated fleet at various drill sites in the Chukchi Sea outer continental shelf (OCS) off the North Slope of Alaska in connection with an exploratory oil and gas drilling program (exploration drilling program).

EPA initially proposed a draft OCS/PSD permit for Shell's exploration drilling program in the Chukchi Sea for public comment on August 20, 2009 (August 2009 proposed permit), with an extended public comment period running through October 20, 2009. EPA conducted government-to-government consultation as requested by affected Native Villages, informational meetings, and public hearings in Barrow and Anchorage, Alaska during the week of September 21, 2009. After reviewing the comments received on the August 2009 proposed permit, EPA has decided to issue a new modified proposed permit and is initiating a new public comment period to ensure the public has an opportunity to review and comment on the new modified permit.[2]

As with the August 2009 proposed permit, this new modified proposed permit will allow Shell to operate the Frontier Discoverer drillship and associated fleet for a multi-year exploration drilling program within Shell's current lease blocks in lease sale 193 on the Chukchi Sea OCS, beyond

[1] Although the permit application was initially submitted by Shell Offshore Inc., the applicant has since clarified that Shell Gulf of Mexico Inc. is the only entity with rights to conduct activities under the leases and is responsible for compliance with all regulations and orders for activities on the leases. Shell Gulf of Mexico Inc. has confirmed that it stands by all statements made in the permit application. As a result, EPA is issuing the permit to Shell Gulf of Mexico Inc.

[2] As discussed in Section 1.3.1, because EPA is reproposing the permit in its entirety and will not be taking any further action on the August 20, 2009 initial proposed permit, EPA will not be responding to comments on the August 20, 2009 proposed permit. To the extent a commenters believes that comments provided during the comment period for the August 20, 2009 proposed permit have not been addressed by the new modified proposed permit or new modified Statement of Basis, the commenter should resubmit those specific un-addressed comments during the current comment period for this new modified proposed permit.

25 miles from Alaska's seaward boundary. Because the drillship operations would be a "major" source of air pollutants, the permit requires that the operations meet PSD program requirements.

<u>Major changes made to the new modified proposed permit since the August 2009 proposed permit include</u>:

- Overall, emissions of all PSD pollutants allowed under the new modified proposed permit are lower, with substantial reductions of particulate matter emissions (from 184 tons per year (tpy) to 52 tpy for fine particulate matter) and sulfur dioxide (from 181 tpy to less than 2 tpy) as compared to the August 2009 proposed permit.

Table 1.1 - Permitted Air Pollutant Emissions from Discoverer and Associated Fleet as OCS Source at all Locations

Air Pollutant	Initial Proposed Emissions (tpy)	Revised Emissions (tpy)
Carbon Monoxide (CO)	762	449
Nitrogen Oxides (NO_x)	1965	1188
Particulate Matter Less than 2.5 ($PM_{2.5}$)	184	52
Particulate Matter Less than 10 (PM_{10})	210	58
Sulfur Dioxide (SO_2)	181	2
Volatile Organic Compounds (VOC)	166	87

- The permit proposes two alternatives for when the Discoverer is considered an "OCS source" under the permit and when the emission limitations and other operating restrictions apply. In the August 2009 proposed permit and in this proposal, EPA seeks comment on considering the Discoverer to be an OCS source when it is attached by a single anchor to the seabed. EPA is also soliciting comment on an alternative proposal to consider the Discoverer to be an OCS source when it is sufficiently secure and stable to commence exploratory activity at a drill site.
- The proposed permit requires the use ultra-low sulfur diesel fuel in all vessels in the associated fleet when such a vessel is within 25 miles of the Discoverer and the Discoverer is operating as an OCS source. This change results in a decrease in emissions of SO_2 from 181 tpy to less than 3 tpy.
- The proposed permit requires the use of an anchor handler/icebreaker equipped with selective catalytic reduction controls on the main diesel engines, resulting in much lower emissions of NO_x.
- For the oil spill response vessel, the daily fuel limit for the two propulsion engines is increased. For the two generator engines on the vessel, the daily fuel limit is decreased. The proposed permit requires catalytic diesel particulate filters on the propulsion and generator engines. The net result is a small increase in emissions of NO_x from the vessel, but substantial decreases in particulate matter emissions and SO_2 emissions, and moderate decreases in CO and VOC emissions from this vessel.
- The logging winch engines on the Discoverer have been replaced with newer engines, one of which is a newer Tier 3 engine that is larger in horsepower than the engine it replaced.

- The permit requires oxidation catalysts on the compressor diesel engines on the Discoverer (all new Tier 3 engines), which reduces emissions of particulate matter, VOC, and CO.
- The hours of operation of the emergency generator on the Discoverer are increased from 20 minutes to two hours a month to be consistent with U.S. Coast Guard requirements.
- The fuel limits for the cementing units and logging winch engines on the Discoverer are decreased to offset the small increase in the emissions from the emergency generator.
- The proposed permit requires tighter restrictions on the waste throughput limit for the incinerator on the Discoverer, which are tied to the use of the Discoverer's HPU engines, resulting in an overall reduction of emissions from the incinerator and the HPU engines as compared to the August 2009 proposed permit. The permit also requires development and implementation of a waste segregation plan.
- For the main generator engines on the Discoverer and for the icebreaker engines, the permit requires a compliance assurance regime based on the monitoring of engine loads instead of monitoring of fuel usage.
- Certain restrictions on the locations of the icebreakers in relation to the Discoverer while traveling on non-icebreaking activities are eliminated and replaced with requirements to record the duration, purpose and operating loads at such locations.
- The number of operating loads required for the stack testing of the newer and smaller engines and the boilers on the Discoverer and the non-propulsion engines on the icebreakers is reduced.
- Monitoring of the ammonia emissions from controls on the Discoverer's main generator engines is changed from continuous monitoring to stack testing.

Again, the net result of the changes in this new modified proposed permit as compared to the August 2009 proposed permit is a reduction of all PSD pollutants emitted by Shell's exploration drilling program, with a substantial reduction of particulate matter emissions and SO_2.

Application Chronology[3]

November 2008-August 2008

Date	Document Description
11/12/2008	Modeling Protocol for Chukchi and Beaufort Sea Exploration Drilling Program
12/11/2008	Letter from Susan Childs, Shell Offshore, Inc. to Richard Albright, EPA regarding Preconstruction Permit Application for Frontier Discoverer Drill Vessel in Chukchi Sea, beyond the 25-mile Alaska Seaward Boundary
01/15/2009	E-mail from Tim Martin, Air Sciences, Inc. to Herman Wong, EPA regarding the Discoverer Chukchi Source Contribution
01/16/2009	Letter from EPA to Shell Regarding the Incompleteness Determination for the Chukchi PSD Permit Application
01/26/2009	E-mail from Tim Martin, Air Sciences, Inc. to Herman Wong, EPA regarding the Shell Chukchi Icebreaker Characterization

[3] The Administrative Record also contains numerous emails and correspondence between Shell and its consultants and EPA clarifying various aspects of Shell's application.

Neither the definition of "OCS source" in Section 328 of the CAA nor the definition in 40 C.F.R. § 55.2 expressly excludes or even mentions an exclusion for emissions from nonroad engines, although EPA makes clear that emissions from engines being used for propulsion are not included within the definition of "OSC source" for those vessels that become an OCS source by attaching to an existing OCS facility. See 40 C.F.R. § 55.2, (definition of OCS source). Indeed, in describing the emission sources included in the definition of "OCS source," both the statutory and regulatory definition broadly include "any equipment, activity, or facility which – emits or has the potential to emit any air pollutant…." CAA Section 328(a)(4)(C); 40 C.F.R. § 55.2.

In describing how emissions from vessels that are not themselves an OCS source are to be considered, both the statute and EPA's regulation refer broadly to "vessel" emissions, again without exclusion. In explaining that only the stationary aspects (i.e., excluding engines when being used for propulsion in the situation described above) of a vessel would be regulated as part of the "OCS source," EPA stated in contrast that "*All* vessel emissions related to OCS source activity will be accounted for by including vessel emissions in the "potential to emit" of an OCS source." 57 Fed. Reg. at 40794 (emphasis added). Simply put, the exclusion of nonroad engines from the general definition of "stationary source" in Section 302(z) of the CAA is overridden by the more specific provisions in Section 328 of the CAA and 40 C.F.R. § 55.2.

In determining the PTE for Shell's Chukchi Sea exploration drilling program, EPA included the potential emissions from the Discoverer while operating as an OCS source, as well as the potential emissions from the Associated Fleet – the ice breaker, the anchor handler/icebreaker, the supply ship, and the OSR fleet – when operating within 25 miles of the Discoverer while the Discoverer is an OCS source.

There are other vessels that will be associated with Shell's exploratory drilling program, such as an oil tanker, a barge, and shallow water landing craft. Based on Shell's application submittals, none of these vessels will be operating within 25 miles of the Discoverer while the Discoverer is an OCS source. Emissions from these other vessels are therefore not included in determining the potential to emit of Shell's exploration drilling program in connection with applying the requirements of the OCS or PSD program.

2.4.3 "Potential to Emit" of the "OCS Source"

Because Shell has applied for a major source permit authorizing operation of the Discoverer and its Associated Fleet at any of Shell's current leases in Lease Sale 193 of the Chukchi Sea, the PTE from the project is calculated based on emissions from any point within the area of operation authorized under the permit during any consecutive 12-month period.

Table 2.1 lists the final PTE for each regulated NSR pollutant from the project, as well as the significant emission rate for each regulated NSR pollutant. Appendix A contains detailed emissions calculations used to determine PTE for emissions of CO, NO_x, $PM_{2.5}$, PM_{10}, SO_2, VOC and lead, the regulated NSR pollutants that are NAAQS pollutants or precursors to NAAQS pollutants and are therefore relevant to the ambient air quality impact analysis discussed in Section 5. The PTE estimates for the remaining regulated NSR pollutants are set forth in Air Sciences 6/16/09; Air Sciences 6/19/09; Air Sciences 6/30/09; Air Sciences 12/18/09-Incinerator; Shell 12/9/09 Supp. App.; Shell 12/13/Supp. App.

Table 2.1 - Potential to Emit for Regulated NSR Pollutants

Pollutant	Potential to Emit, tpy	Significant Emission Rate, tpy
CO	449	100
NO_x	1188	40
PM	260*	25
$PM_{2.5}$ (precursors NO_x and SO_2)	52	10 (40 for NO_x or SO_2)
PM_{10}	58	15
SO_2	2	40
VOC	87	40
Lead	0.11	0.6
Ozone (precursors VOC and NO_x)	NA	40 for VOC or NO_x
Fluorides	0	3
Sulfuric acid mist	0.404	7
Hydrogen sulfide	0	10
Total reduced sulfur	0	10
Reduced sulfur compounds	0	10
Municipal waste combustor organics	3.26×10^{-7}	3.5×10^{-6}
Municipal waste combustor metals	0.112	15
Municipal waste combustor acid gases	3.59	40
Municipal solid waste landfill emissions	NA	50
Title VI, Class I or II substance	< 1	**

*Emissions of PM have been reduced substantially below this amount as a result of the additional restrictions and controls in this proposed permit that have reduced PM_{10} and $PM2_{2.5}$ emissions, but this estimate for PM has not been recalculated since the August 2009 proposed permit.

** In 1996, EPA proposed a significant emission rate of 100 tpy for this category of pollutant and received no adverse comments on this issue. EPA subsequently concluded that PSD review is not necessary for this category of pollutants where they would be potentially emitted at substantially less than 100 tpy (EPA 2/24/98; EPA 5/19/98).

Because exploration drilling programs are not included in the list of source categories subject to a 100-tpy applicability threshold, the requirements of the PSD program apply if the project PTE is at least 250 tpy. From Table 2-1, it is evident that Shell's Chukchi exploration drilling program is a major PSD source because emissions of CO and NO_x (and potentially PM) exceed the major source applicability threshold of 250 tpy. In addition, emissions of CO, NO_x, PM, $PM_{2.5}$ (including the precursors NO_x and SO_2), PM_{10}, and ozone precursors (VOC and NO_x) exceed the significant emission rate for each such pollutant. Emissions of SO_2 have been reduced below the significant emission rate as a result of the imposition of BACT on SO_2 emission sources on the Discoverer and Shell's recent request for a limit requiring the use of ultra-low sulfur diesel fuel in the Associated Fleet (discussed in Section 3.3 below). Absent the BACT requirement on SO_2 emission sources on Discoverer, emissions of SO_2 from Shell's exploration drilling program would exceed the significant emission rate. Consequently, pursuant to 40 C.F.R.

§ 52.21(j)(2), Shell is required to apply BACT on the OCS source for CO, NO_x, PM, $PM_{2.5}$ (including the precursors NO_x and SO_2), PM_{10}, SO_2 and ozone precursors (VOC and NO_x). Section 4 contains a discussion of the BACT analysis for each of these pollutants. Additionally, and consistent with 40 C.F.R. §§ 52.21(k) and (m), these potential to emit values are used in the analysis of ambient air quality and demonstration that this source will not cause or contribute to a violation of any NAAQS or PSD increment. Section 5 contains a discussion of the air quality impact analysis.

2.5 Title V

As specified in 40 C.F.R. § 55.13(f)(2), the requirements of the Title V operating permit program, as set forth at 40 C.F.R. Part 71 (Part 71), apply to OCS sources located beyond 25 miles of states' seaward boundaries. Because the PTE for this project is greater than 100 tons per year for several criteria pollutants, it is a major source under Title V and Part 71 and must apply for an operating permit as provided in 40 C.F.R. § 71.5(a)(1)(i) within 12 months of first becoming an OCS on Shell's current leases in the Chukchi Sea).

2.6 New Source Performance Standards (NSPS)

As discussed above, applicable NSPS apply to OCS sources. See 40 C.F.R. § 55.13(c). In addition, the PSD regulations require each major stationary source or major modification to meet applicable NSPS. See 40 C.F.R. § 52.21(j)(1). A specific NSPS subpart applies to a source based on source category, equipment capacity and the date when the equipment commenced construction or modification. The Discoverer contains emission units in four NSPS source categories: compression-ignition, internal-combustion engines; boilers; incinerators; and fuel tanks.

NSPS IIII, 40 C.F.R. Part 60, Subpart IIII, applies to stationary compression-ignition internal combustion (IC) engines, with the earliest applicability date being for units that were modified, or reconstructed after July 11, 2005 and the applicability date for newly manufactured engines that are not fire-pump engines being April 1, 2006. All diesel engines on board the Discoverer (FD-1 to FD-20), with the exception of the diesel MLC compressor engines (FD-9 to FD-11) and the Caterpillar C7 Logging Winch Engine (FD-19), were manufactured before April 1, 2006 (Air Sciences 7/16/09; Air Sciences 12/10/09), and therefore are not subject to NSPS IIII. The diesel MLC compressor engines (FD-9 to FD-11), and the Caterpillar C7 Logging Winch Engine (FD-19) are Tier 3[8] engines to which NSPS IIII applies.

NSPS Dc, 40 C.F.R. Part 60, Subpart Dc, applies to boilers with a capacity of at least 10 MMBtu/hr. Since the two Discoverer boilers (FD-21 and FD-22) are rated at less than 10 MMBtu/hr, NSPS Dc does not apply.

NSPS CCCC, 40 C.F.R. Part 60, Subpart CCCC, applies to commercial and solid waste incinerators (CISWI) constructed after November 30, 1999. The incinerator on board the

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[8] As discussed in Section 4.2 below, EPA set new emission standards for nonroad diesel engines using a 3-tiered progression to lower emission standards. Each tier involves a phase-in by horsepower rating over several years. Tier 3 in NSPS IIII is the most stringent of the 3 tiers.

3. PROJECT EMISSIONS AND PERMIT TERMS AND CONDITIONS

3.1 Overview

Shell intends to implement their Chukchi Sea exploration drilling program through the use of the Frontier Discoverer drillship and the Associated Fleet.

As discussed above, determining a project's PTE is essential for determining the applicability of PSD, as well as the scope of PSD review, in particular, the pollutants that are subject to application of BACT, analysis of ambient air quality impacts from the project, analysis of air quality and visibility impact on Class I areas, and analysis of impacts on soils and vegetation. As discussed in Section 2, PTE reflects a source's maximum emissions of a pollutant from a source operating at its design capacity, including consideration of any physical or operational limitations on design capacity such as air pollution control equipment, emission limitations, and other capacity limiting restrictions that effectively and enforceably limit emissions capacity. See 40 C.F.R. §§ 52.21(b)(4) and 55.2. In the case of OCS sources, emissions from vessels servicing or associated with an OCS source are included in the "potential to emit" for an OCS source while physically attached to the OCS source and while en route to or from the source when within 25 miles of the source.

The detailed emissions calculations for the Chukchi Sea exploration drilling program are contained in Appendix A and in Air Sciences 6/16/09; Air Sciences 6/19/09; Air Sciences 6/30/09; Air Sciences 12/18/09-Incinerator; Shell 12/9/09 Supp. App.; Shell 12/13/Supp. App. In developing the emission inventory, EPA relied extensively on emissions data that were representative of the subject emission unit. For most emission units on board the Discoverer, EPA used emissions data from either the manufacturer or from literature that provided equivalent emissions data, such as data from similar emission units. In a very few instances, where representative data were not available, EPA relied on AP-42 to calculate projected emissions (EPA 1995 AP-42 and updates).

The emission inventory reflects application of emission limitations representing best available control technology or "BACT." As discussed in Section 4.1, a new major stationary source is required to apply BACT for each pollutant subject to regulation under the Clean Air Act that it would have the potential to emit in significant amounts. 40 C.F.R. § 52.21(j). Based on the emission inventory for the OCS source presented in Table 2-1, the emissions of NO_x, PM, $PM_{2.5}$, PM_{10}, SO_2,[9] VOC and CO have a PTE exceeding their respective significant emission rates. Therefore, BACT must be determined for each emission unit on the Discoverer or that is part of the OCS source that emits these pollutants. Section 4 contains a detailed discussion of the BACT determination for each emission unit subject to BACT. The proposed permit contains emission limitations that represent BACT and the emission inventory reflects these BACT-based emission limitations.

The emission inventory also reflects emission limitations and operating restrictions requested by Shell in its permit application as well as emission limitations and operating restrictions based on

[9] See discussion of SO_2 emissions in Section 2.4.3.

operating conditions assumed in the air quality impact analysis. The PSD regulations require that a source demonstrate that the allowable emissions increase from the new source, in conjunction with all other applicable increases or reductions (including secondary emissions), would not cause or contribute to a violation of the NAAQS or any applicable maximum allowable increase over the baseline concentration in any area. 40 C.F.R. § 52.21(k). The "applicable maximum allowable increase over baseline concentration in any area" are referred to as "increments" and are set forth in 40 C.F.R. § 52.21(c). After application of emission limitations that represent BACT, preliminary modeling indicated that additional restrictions on Shell's emissions and mode of operation would be needed to ensure attainment of the NAAQS and compliance with increment for some pollutants. Therefore, to ensure attainment of NAAQS and compliance with increment, the proposed permit imposes restrictions on emission units and Shell's mode of operation that are in addition to the application of BACT and that further limit operation of and emissions from the project.

The air quality impact analysis is discussed in Section 5. Emission limitations and operational restrictions are needed to demonstrate compliance with the annual increment for NO_x, attainment of the 24-hour $PM_{2.5}$ NAAQS, and compliance with the 24-hour PM-10 increment. Therefore, for most emission units, the permit contains an annual limit on NO_x, and 24-hour limits on PM_{10} and $PM_{2.5}$.

The permit contains monitoring, recordkeeping and reporting to monitor and ensure compliance with the emission limitations. This proposed permit requires stack testing of certain sources prior to commencement of each of the first three drilling seasons. Under this approach, not all emission units in a source category will be tested each year, but by the end of the first three drilling seasons, all of them will have been tested. Monitoring for the daily PM_{10} and $PM_{2.5}$ limits and the annual NO_x limit is based on emission factors derived from source tests, load monitoring or fuel usage, and annual fuel usage limits.

The number and range of stack testing of the newer and the smaller internal combustion engines (FD-9 to FD-20) and boilers (FD-21 to FD-22) in this proposed permit has been reduced from the testing required in EPA's initial August 2009 proposed permit. In comments on the August 2009 proposal, Shell requested that stack testing be eliminated entirely for the newer engines, the smaller engines, and the boilers. (Shell 9/17/09 Comments; Shell 11/23/09 Supp. App; Environ 11/25/09). EPA does not agree with Shell that testing these emission units is unnecessary, but believes that testing at a reduced number of operating loads or operating load ranges will continue to provide a reasonable assurance of compliance and accommodate (in part) Shell's concerns regarding the number of required source tests under the permit generally and the difficulty of stack testing some of these specific units due to their unique operation and function. There are no ambient air standards for VOC and predicted impacts of CO from this project are well below the standards. Therefore, EPA focused the monitoring regime on the BACT emission limits for these pollutants. For VOC and CO, testing at lower loads is expected to provide a higher emission factor than testing at full operating loads (see emissions data for various Caterpillar D343 configurations). The same is true with respect to visible emissions. EPA therefore believes that requiring stack testing for VOC, CO and visible emissions within the expected operating range of each engine will provide a reasonable indication of compliance for the VOC, CO, and visible emission limits for the newer engines, the smaller engines, and the boilers. See Permit Conditions F.6, G.8, H.7, I.7, and J.5. Because the data for NOx and particulate matter is less conclusive, EPA is requiring stack testing at two load ranges – a high-load operating range and a lower-load operating range. Shell requested a reduced testing regime only for certain emission units on board the Discoverer, but EPA believes it is appropriate to extend this approach to the engines on board the icebreakers for the same reasons and has done so in this proposed permit. See Conditions N.10.2 and O.12.2.

Shell has provided EPA with information that Shell asserts shows that testing of the deck cranes (Units FD-14 to FD–15) is not practical because of their location on the ship and because of how the engines are loaded. (Shell 9/17/09 Comments; Shell 11/23/09 Supp. App; Environ 11/25/09). While EPA understands that there may be practical challenges to testing these emission units, EPA has insufficient information at this time to eliminate testing for these units. EPA is therefore proposing that, as with the other newer and smaller engines on the Discoverer, that stack testing be required across a fewer number of load ranges. During the public comment period, EPA invites public comment and additional information from Shell and other commenters that further supports or opposes eliminating the stack testing requirement for the deck cranes.

Except for those conditions addressing notification, reporting and testing, the permit conditions contained in Sections B through Q of the proposed permit apply only during the time that the Discoverer is an OCS source. Permit conditions addressing notification, reporting and testing apply at all times as specified. When the Discoverer is an "OCS Source" for purposes of the proposed permit is discussed in Section 2.4.1.

3.2 Generally Applicable Requirements

This section describes the permit conditions that apply generally to the Discoverer and the Associated Fleet and generally relate to permit administration or enforcement.

Condition A.1 requires the permittee to construct and operate the OCS source and the Associated Fleet in accordance with its application and supporting materials and in accordance with the final permit, as provided in 40 C.F.R. §§ 55.6(a)(4)(i) and 52.21(r)(1).

Condition A.2 specifies the enforcement authority for violation of OCS and PSD regulations and this permit, as provided in 40 C.F.R. §§ 55.9(a)-(b) and 52.21. Operation in violation of a permit term or condition is not authorized under this permit.

Condition A.3 makes clear that the permit does not relieve the permittee of the responsibility to comply fully with all other requirements of federal law as provided in 40 C.F.R. §§ 55.6(a)(4)(iii) and 52.21(r)(3). EPA is aware that Shell is required to obtain approval from other agencies before it is authorized to begin exploratory drilling in the Chukchi Sea and that there is pending litigation regarding the leases under which Shell proposes to conduct its exploratory drilling. EPA believes it is nonetheless appropriate to proceed with issuance of this OCS/PSD permit so that once Shell has all necessary approvals and authorizations to begin its exploratory drilling program on its leases in Lease Area 193, Shell can proceed with its exploratory drilling operations in Lease Area 193 without further delay consistent with a final OCS/PSD permit and all other necessary federal approvals and requirements. Condition A.3 makes clear Shell's obligation to satisfy all other federal requirements prior to commencing operation under this CAA permit.

housing has two large 16-20 inch diameter outlets oriented at 180 degrees to each other to which are attached large pneumatic fast acting valves. The control logic for these valves is such that only one can be closed at any given time. The diverter is a donut-shaped rubber element that is located in the diverter housing above the two outlets. A hydraulically activated piston compresses the element to seal around the drill string (or upon itself if the drill pipe is out of the hole) and direct the flow through the outlet whose valve is in the open position in the event of a shallow fluids (gas, water or air) flow. The opposing outlets permit the rig to divert the flow to the downwind side of the rig. Attached to the valves are large diameter flowlines that direct the flow from the diverter to the edge of the rig. The flowlines are generally horizontal, so that the elevation is approximately 5-15 feet below the rig floor.

Shell anticipates that the likelihood of encountering shallow gas in the planned drill sites is quite low, for the following reasons:

1. Shell has drilled wells nearby that have penetrated the same shallow formations and did not see shallow gas;
2. Shell has conducted shallow hazards seismic surveys to delineate possible shallow gas intervals and have selected locations to avoid any likely potential shallow gas sites;
3. Shell drills with a drilling fluid density that exceeds the anticipated formation fluid pressure;
4. Shell drills a smaller (12 ¼”-17 ½”) pilot hole and uses formation evaluation tools to interpret in real time the possibility of a shallow gas flow environment because drilling the smaller hole limits the amount of gas that can enter the well bore and permits the use of the dynamic kill procedure to shut off the flow; and
5. Shell will have a volume of heavy weight kill mud on hand immediately available to pump in the event of a formation fluid influx so that the appropriate hydrostatic head can be reestablished and influx can be shut off.

Based on the information above, EPA has determined that the very low probability of use of a diverter requires no permit conditions beyond requirements to record and report to EPA if a diversion event occurs. See Condition M.1.

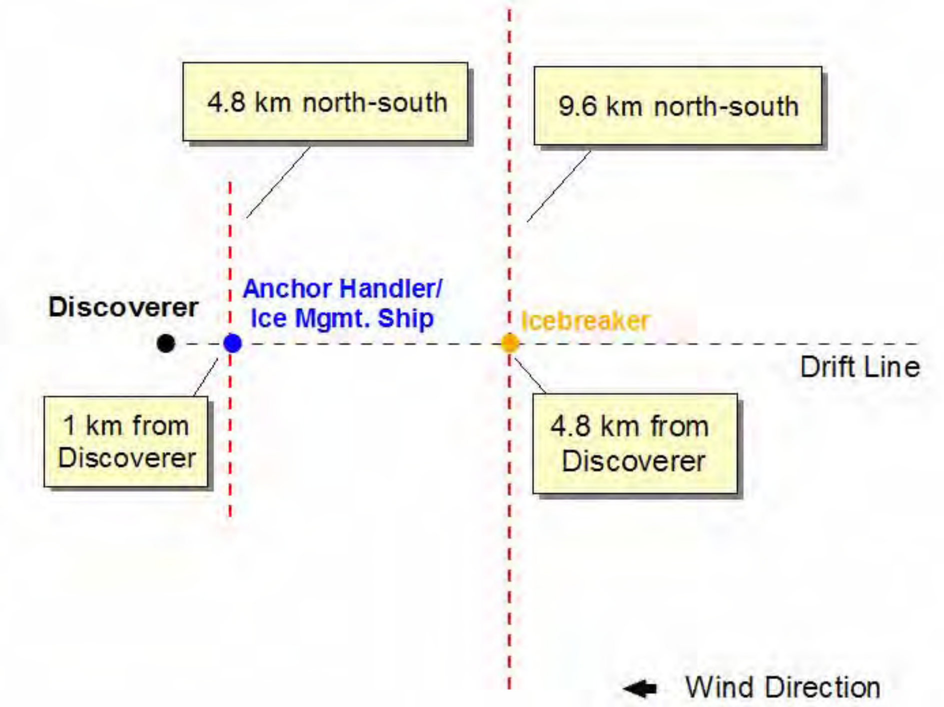
3.5 Ice Management and Anchor Handling Fleet

Since EPA proposed the initial permit for public comment on August 2009, Shell has revised its approach to the use of icebreaking vessels (Shell 9/17/09 Comments). Icebreakers #1 and #2 no longer have linked operational/emissions limits, and they are no longer interchangeable vessels. Shell’s ice management and anchor handling fleet is still expected to consist of two leased ships: an icebreaker (referred to in the permit as Icebreaker #1) and an anchor handler/icebreaker (referred to in the permit as Icebreaker #2). The purpose of this fleet is to manage the ice in the area of the Discoverer, which involves deflecting or in extreme cases breaking up any ice floes that could impact the ship when it is drilling, and to handle the ship’s anchors during connection to and disconnection from the seabed.

The ice floe frequency and intensity is unpredictable and could range from no ice to ice sufficiently dense that the fleet has insufficient capacity and the Discoverer would need to disconnect from its anchors and move off site. Based on statistics on ice at the Sivulliq drill site in the Beaufort Sea, Shell estimates that ice breaking capability in its lease holdings in Lease Area 193 in the Chukchi Sea would only be required 38 percent of the time. For the remainder of the time the ice management and anchor handling fleet would be beyond the 25-mile radius from the Discoverer in a warm stack mode (anchored and occupied).

The primary driver of the ice floe is the wind, so the ice management ships are typically upwind of the Discoverer when managing the ice. Figure 3-1 depicts the approximate locations of the primary icebreaker and the anchor handler/ice management vessel when used to break one-year ice.

Figure 3-1 - Ice management and anchor handling ships locations for breaking of one-year ice



For addressing one-year ice, Icebreaker #1 will typically be positioned from 4,800 meters to 19,000 meters upwind on the drift line and Icebreaker #2 will be located from 1,000 meters to 9,600 meters upwind from the Discoverer. In the case of thick ice, the width of the Icebreaker #1 swath will be about 3 miles (4.8 km) to either side of the drift line and Icebreaker #2 will be moving laterally 1.5 miles (2.4 km) to either side of the drift line. The actual vessel distances will be determined by the ice floe speed, size, thickness, and character, and wind forecast. Although 2-meter-thick first-year ice is not expected, it might occur and the ice management fleet would be moving at near full speed to fragment this ice. Occasionally there may be multi-year ice ridges which are expected to be broken at a much slower speed than used for first-year ice. Multi-year ice may be broken by riding up onto the ice so that the weight of the icebreaker on top of the ice breaks it.

Shell will be leasing Icebreaker #1 from year to year. Consequently, the vessel used as Icebreaker #1 may change from year to year. In order to accommodate this uncertainty, Shell has requested that the permit allow for a generic Icebreaker #1. Furthermore, the fleet could consist of either two vessels or only one vessel, depending on availability of ships and ice conditions. At present, there are only a limited number of eligible ships. Murmansk Shipping of Russia operates two vessels – the Vladimir Ignatjuk and the Kapitan Dranitsyn. Viking leases four vessels – the Odin, the Tor, the Balder and the Vidor. The Talagy is available from Smit, and lastly, the Nordica and Fennica are operated by Finstaship. Shell has dropped the Kapitan Dranitsyn from consideration for this project.

The emission sources from all of these icebreaker class vessels consist of diesel engines for propulsion power, general purpose generators, boilers and incinerators. To accommodate the requested flexibility, Shell has developed a single generic equipment list for Icebreaker #1 that cannot be exceeded for any vessel. Table 3-3 shows the maximum aggregate ratings for each category of equipment for Icebreaker #1.

Table 3-3 – Maximum Aggregate Rating of Emission Sources for Icebreaker #1

Description	Make and Model	Maximum Aggregate Rating
Propulsion Engines	Various	28,400 hp
Generator Engine(s)	Various	2,800 hp
Heat Boiler(s)	Various	10 MMBtu/hr
Incinerator	Various	154 lbs/hr

To execute Icebreaker #2 duties, Shell will use one of two vessels – either the Tor Viking or a new icebreaker being built to their specifications by Edison Chouest. Each of these vessels will be equipped with SCR on the main engines, which will result in a substantial reduction of NOx. (Shell 9/17/09 Comments). The latter vessel has not been named yet but is referred to by the shipbuilder as Hull 247. Throughout this permit documentation, this vessel is also referred to as Hull 247, with the intent that all permit conditions for Icebreaker #2 continue to apply to the vessel, even once it has had its name changed from Hull 247 to its permanent name. Table 3-4 shows the maximum aggregate ratings for each category of equipment for Icebreaker #2.

Table 3-4 – Maximum Aggregate Rating of Emission Sources for Icebreaker #2

Description	Make and Model	Maximum Aggregate Rating
Tor Viking		
Propulsion Engines	Various	17,660 hp
Generator Engine(s)	Various	2,336 hp
Heat Boiler(s)	Various	1.37 MMBtu/hr
Incinerator	Various	151 lbs/hr
Hull 247		
Propulsion Engines	Various	24,000 kW
Heat Boiler(s)	Various	4.00 MMBtu/hr
Incinerator	Various	151 lbs/hr

Marine propulsion engines, such as those used on the icebreakers, have a different emission profile than the more common engines found on board the Discoverer. The most cited reference on emissions from marine engines is a document published by Lloyds Register. However, a more recent publication compares emission factors from Lloyds with more recent emissions data from the Swedish Environmental Research Institute (Corbett 11/23/04). To ensure that the emissions factors used in the emission inventory for this project were adequately conservative, EPA compared these data with emissions data from AP-42 (see Reference Table 3 in Appendix A) and used the highest value for each pollutant.

In addition, Shell has requested limits on $PM_{2.5}$ of 42.2 lbs/hr and on PM_{10} of 48.0 lbs/hr (Air Sciences 2009b) on Icebreaker #1, and 11.4 lbs/hr and 11.7 lbs/hr, respectively, for Icebreaker #2. The permit requires candidate icebreakers to have their emission units tested prior to each drilling season. If a candidate vessel's uncontrolled emissions of $PM_{2.5}$ or PM_{10} are above these values, then the vessel cannot be used as either Icebreaker #1 or Icebreaker #2. Conditions N.1 and O.1 contain these equipment capacity and emission limits for the two icebreakers.

In calculating emissions from the emission sources on board the icebreakers, all sources, except the propulsion engines, were assumed to operate at 100% of rated capacity. The propulsion engines were represented at operating at no more than 80% of rated capacity. Consequently, these restrictions are imposed in Conditions N.2 and O.2.

Based on the emissions calculations and resultant modeling, Shell has determined a maximum usage for the icebreakers. The emissions, fuel and power output limits associated with this scenario are contained in Conditions N.3, N.4, N.5, N.6, O.3, O.4, O.5 and O.6. The fuel and power output limits in Condition N.5, N.6, O.5 and O.6 will also serve to limit emissions of the other pollutants, such as CO. The fuel limits on the icebreakers are based on Shell's estimate of its need for icebreaking capacity and ensure that emissions from the icebreakers will not exceed the modeled emissions scenarios.

Based on Shell's application, there is no scenario where either of the icebreakers is attached to the drillship, thereby becoming part of the OCS source.[11] Consequently, the permit contains Conditions N.8 and O.10 that prohibit such attachment. The permit does allow each icebreaker to approach near the Discoverer for purposes of transferring equipment and crew to and from the Discoverer. Otherwise, Condition N.7 requires Icebreaker #1 to, consistent with the modeling analysis, operate outside of a 4800 meter long cone centered on the centerline of the Discoverer. Similarly, Condition O.7 requires Icebreaker #2 to operate outside of a 1000 meter long cone centered on the centerline of the Discoverer, except during anchor handling operations (Condition O.8) and bow washing (Condition O.9). The air quality impact analysis was based on these operating scenarios and therefore the permit contains emission limits to impose these restrictions. The icebreakers are allowed to transit through their respective cones as these transit events will be of short duration and at low loads as they will not be conducting icebreaking activities within the cones. This is a change from the August 2009 proposed permit. Modeled

[11] As discussed in Section 2.4.1 above, EPA does not consider Icebreaker #2 to be physicially attached to the Discoverer within the meaning of the definition of "OCS source" in 40 C.F.R. § 55.2 during the time it is assisting the Discoverer in the anchor setting and retrieval process.

4. BEST AVAILABLE CONTROL TECHNOLOGY

4.1 BACT Applicability and Introduction

Pursuant to 40 C.F.R. § 52.21(j), a new stationary source shall apply BACT for each pollutant subject to regulation under the Clean Air Act that it would have the potential to emit in significant amounts. Based on the emission inventory for the project presented in Table 2-1, NO_x, PM, $PM_{2.5}$, PM_{10}, SO_2, VOC and CO will be emitted in quantities exceeding their respective significant emission rates. Therefore, BACT must be determined for each emission unit on the Discoverer which emits NO_x, PM, $PM_{2.5,}$ PM_{10}, SO_2, VOC and CO while the drillship is operating as an OCS source.

BACT is defined in 40 C.F.R. §52.21(b)(12) in part as

> an emissions limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under the Act which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 40 C.F.R. parts 60 and 61. If the Administrator determines that technological or economic limitations on the application of measurement technology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of best available control technology.

The Clean Air Act contains a similar BACT definition, although the 1990 Clean Air Act amendments added “clean fuels” after “fuel cleaning or treatment” in the above definition. 42 USC § 7479(c).

On December 1, 1987, EPA issued a memorandum describing the top-down approach for determining BACT. In brief, the top-down approach provides that all available control technologies be ranked in descending order of control effectiveness. Each alternative is then evaluated, starting with the most stringent, until BACT is determined. The top-down approach consists of the following steps, for each pollutant to which BACT applies:

Step 1: Identify all control technologies.

Step 2: Evaluate technical feasibility of options from Step 1 and eliminate options that are technically infeasible based on physical, chemical and engineering principles.

Step 3: Rank the remaining control technologies from Step 2 by control effectiveness, in terms of emission reduction potential.

Step 4: Evaluate the most effective controls from Step 3, considering economic, environmental and energy impacts of each control option. If the top option is not selected, evaluate the next most effective control option.

Step 5: Select BACT (the most effective option from Step 4 not rejected).

In the permit application, Shell applied the EPA top-down BACT methodology to groups of similar emission units on the Discoverer. For example, there are six large diesel generators (FD-1 to FD-6) that are identical and three diesel engine driven compressors that are identical (FD-9 to FD-11), so the BACT analysis was performed for each group of identical engines. Likewise, there are a number of smaller diesel engines [<500 horsepower (hp)] which are similar so that the BACT analysis can be performed for each similar group of emission units. EPA agrees that grouping identical or similar emission units for the BACT analysis is reasonable. EPA's BACT evaluation uses the top-down format and follows a pattern of grouping identical or similar emission units as was done in the Shell permit application.

Throughout the BACT section PM, $PM_{2.5}$ and PM_{10} emissions will be addressed together for all emission units except the incinerator since it is assumed that essentially all of the PM and PM_{10} emissions are also $PM_{2.5}$ emissions, and the control technologies available for $PM_{2.5}$ emissions on the types of equipment aboard the Discoverer will also effectively control PM and PM_{10}. In addition, the BACT analyses for VOC and CO are grouped together because the same control technology is generally used to control both pollutants for the specific types of emission units on the Discoverer.

4.2 SO_2 BACT Analysis for the Diesel IC engines, Boilers and Incinerator

Step 1 – Identify all available control technologies

Most of the SO_2 emissions for this project result from combustion of diesel fuel which contains some amount of sulfur. Sulfur contained in the material burned in the incinerator also contributes to the SO_2 emissions. The available SO_2 control technologies can be grouped into one of two categories: use of low sulfur fuels and post-combustion treatment of the exhaust gases from the emission units. Shell searched the EPA RACT, BACT, LEAR Clearinghouse (RBLC) and the California BACT Clearinghouse (CA-BACT) for determinations made for SO_2 from the type of emission units on the Discoverer (diesel IC engines, small boilers and the incinerator). The search results are shown in Table 4-4 of the permit application (Shell 2/23/09 Rev. App). The most common control technologies found were "no control" or use of "low sulfur fuel." The only post-combustion SO_2 control technology found was a semi-dry scrubber for an incinerator which was much larger than the incinerator on the Discoverer. The RBLC and CA-BACT did not have any post-combustion control technology applications for diesel IC engines, small boilers, or small incinerators. Several other SO_2 flue gas desulfurization control technologies exist and are used on larger SO_2 sources, such as power plants, petroleum refineries, pulp mills and incinerators, but are not found in practice on smaller emission units such as the boilers and incinerator on the Discoverer.

Step 2 – Eliminate technically infeasible control options

For technical reasons, EPA believes that post-combustion SO_2 control technologies are not feasible for any of the emission units on the Discoverer, all of which are relatively small emission units. The fact that no post-combustion controls were found in the RBLC search for diesel IC engines, small boilers, and small incinerators indicates that such controls they have not been found to be technically feasible or cost effective for small emission units in past determinations. Moreover, in this case, the emission units are located on a ship with limited space, and the ship will be located in an Arctic environment (low temperatures and limited fresh water availability). Use of ultra-low sulfur diesel fuel (discussed below) results in very low SO_2 emission rates (the table titled "Summary of Annual Emissions" for the Frontier Discoverer Sources in Appendix A, page A-1 shows less than 0.4 ton per year of SO_2 for the sum of all emission units on the Frontier Discoverer). Even if post-combustion SO_2 controls could be engineered to overcome the factors described above, they could not achieve the same degree of SO_2 emissions reduction as the use of ultra-low sulfur diesel fuel when compared to the use of a higher sulfur baseline fuel. Therefore, the BACT analysis for SO_2 is focused on evaluating diesel fuels with various levels of sulfur content.

Step 3 – Rank the remaining technologies by control effectiveness

Shell identified diesel fuels with three different sulfur contents, including ultra-low sulfur diesel with ≤0.0015 weight percent sulfur (≤15 ppm), low sulfur diesel ≤0.05 weight percent sulfur (≤500 ppm) and higher sulfur diesel fuel (>500 ppm). Since the SO_2 emissions are directly proportional to the sulfur content of the fuel, the fuels are rank ordered in SO_2 reduction effectiveness from the fuel with the lowest amount of sulfur to the fuel with the highest amount of sulfur.

Step 4 – Evaluate the most effective control based on a case-by-case consideration of energy, environmental, and economic impacts

Shell proposed to use the lowest available sulfur content diesel fuel with a sulfur content of ≤15 ppm. Ultra-low sulfur diesel fuel is required by other EPA regulations for both on-road diesel vehicles and for non-road diesel engines. Therefore, ultra-low sulfur diesel fuel is available as a control technology for the emissions units on the Discover. Not only does ultra-low sulfur diesel result in the lowest SO_2 emissions, it is necessary to allow the use of various catalytic control devices for other pollutants such as selective catalytic reduction for NO_x control, oxidation catalysts and catalytic diesel particulate filters for particulate matter, VOC and CO control (discussed in the sections below).

Use of ≤15 ppm ultra-low sulfur diesel for the emission units on the Discoverer provides a greater than 97% reduction in SO_2 emissions compared to low sulfur diesel (≤500 ppm). As mentioned above, using ultra low sulfur diesel fuel, the total annual emissions of SO_2 from all the emission units on the Discoverer are less than one ton per year. Because Shell proposed the most effective control option as BACT and there is no evidence that the most effective control option would have adverse environmental impacts, no additional evaluation is required.

Step 5 – Select SO_2 BACT for the Diesel Engines, Boilers and Incinerator

Since use of ultra-low sulfur diesel fuel is the most effective control option, EPA is proposing that BACT for SO_2 is the use of ultra-low sulfur diesel fuel with ≤0.0015 weight percent sulfur (≤15 ppm) for the emission units located on the Discoverer. The fuel sampling and test methods for determining the sulfur content of the diesel fuel are presented in Section 4.7

4.3 NO_x BACT Analysis

Step 1 – Identify all available control technologies

In general, NO_x emissions are generated in the combustion process as a result of the reaction of oxygen with nitrogen contained in the fuel or with nitrogen present in the combustion air. As described in Section 4.2, we have determined that BACT for SO_2 is the use of ultra low sulfur diesel fuel in all combustion sources on the Discoverer. The processes used by the petroleum refining industry to produce ultra-low sulfur diesel fuel, such as hydrotreating and hydrocracking, remove nitrogen as well as sulfur. Since ultra-low sulfur diesel fuel contains very little nitrogen, most of the NO_x emissions from the emissions units on the Discoverer are attributable to the reaction of oxygen with nitrogen in the combustion air, known as thermal NO_x. The concentration of thermal NO_x formed is a function of the combustion temperature with higher temperatures resulting in higher concentrations of NO_x in the exhaust gas.

Shell searched the EPA RBLC and the CA-BACT for thermal NO_x determinations made for diesel IC engines >500 hp, diesel IC engines <500 hp, small boilers and the incinerator. Their findings are summarized in Table 4-2 of the permit application. For diesel IC engines, the control technologies include combustion modifications designed to lower the combustion temperature and thereby lower the generation rate of NO_x. These combustion modification technologies include injection timing retard (ITR), intake air cooling (AC), high injection pressure for the fuel (HIP) and water injection (WI). Although not listed in the RBLC or CA-BACT, Shell also identified exhaust gas recirculation (EGR) as another diesel IC engine control technology for NO_x that has become commercially available. The RBLC also lists low NO_x design (LND) for several engines, but does not describe the actual NO_x combustion control technology. Presumably the determinations labeled LND are referring to specific combustion chamber designs or other engine modifications that reduce NO_x formation and, thus, these designs are intrinsic to the particular model of engine associated with each RBLC determination for LND.

Shell submitted additional information to supplement the permit application in a document by Environ International Corp. titled “Diesel Engine Best Available control Technology Analysis” as an attachment to an e-mail dated December 11, 2009 (Environ 12/11/09). One of the engine modification control alternatives included in this document was a cam shaft cylinder reengineering kit, which is available for certain engines.

Some of the combustion modification technologies for NOx control have associated negative impacts. For example, ITR results in increased emissions of particulate matter, VOC and CO, decreased fuel efficiency and higher soot contamination of the engine lube oil. The use of combustion modification technologies can result in NO_x emission reductions ranging from 10%

to 50% from baseline emissions depending on the specific technology or combination of technologies (Shell 2/23/09 Rev. App.; EPA 9/28/07 Retrofit Strategies; EPA 1995 AP-42 and updates; MassDEP 6/08).

In 1998 EPA set new emission standards for nonroad diesel engines. The rulemaking was part of a 3-tiered progression to lower emission standards. Each tier involves a phase in by horsepower rating over several years. Tier 1 standards for engines over 50 horsepower were phased in from 1996 to 2000. More stringent Tier 2 standards for all engine sizes were phased in from 2001 to 2006, and yet more stringent Tier 3 standards for engines rated over 50 horsepower were phased in from 2006 to 2008 (EPA 8/98 Nonroad Diesel). Depending on the year of manufacture, new diesel IC engines are available that meet the EPA Tier 2 or Tier 3 emission standards. The resulting lower NO_x emission rates for diesel IC engines designed to meet the Tier 2 or Tier 3 standards are the result of the intrinsic engine design features built into them by the manufacturer.

The only post-combustion exhaust gas treatment for NO_x emissions found by the search of the RBLC and CA-BACT for diesel IC engines was selective catalytic reduction (SCR). SCR involves reaction of a reagent such as urea or ammonia with NO_x in the presence of a catalyst to yield elemental nitrogen. SCR systems have the capability of reducing NO_x emissions by 90% or more. Use of selective non-catalytic reduction (SNCR) has been investigated for controlling NO_x from diesel IC engines. However, because the NO_x reduction reactions are highly dependent on temperature, the NO_x reduction potential of SNCR is much lower than for SCR, and SNCR is not suited for diesel engine applications with low exhaust temperatures (Nam 2/13/02; WRAP 11/28/05).

In the December 11, 2009 supplement to the BACT analysis, Shell included two additional post-combustion control options for NO_x: Lean NO_x Catalyst (LNC) also know as Hydrocarbon SCR (HC SCR) and NO_x Adsorber technology (Environ 12/11/09). LNC or HC SCR utilize a NO_x reduction catalyst and uses unburned hydrocarbons in the exhaust stream or additional diesel fuel that is injected into the LNC device as the reducing agent to react NO_x to elemental nitrogen. LNC is usually integrated with a catalytic diesel particulate filter (discussed further in Section 4.4) to remove excess hydrocarbons by catalytic reaction to carbon dioxide and water. One manufacture of a LNC system is Clēaire whose LONESTAR™ system for off-road applications is designed to achieve at least 40% NO_x reduction (Clēaire 2009). The California Air Resources Board has verified the Clēaire LONESTAR™ system for certain turbo charged diesel engines but excludes 2-stroke engines, engines with original equipment manufacturers diesel particulate filters and engines with external EGR. NO_x Adsorbers adsorb NO_x by catalytically reacting NO to NO_2 and reacting the NO_2 with a chemical coating on the catalyst matrix to form a nitrate salt. Before the chemical coating becomes saturated, it must be regenerated using a chemical such as hydrogen.

The search of the EPA RBLC and the CA-BACT for boilers and incinerators found determinations based on the use of low NO_x burners (LNB), EGR and SNCR.

Good combustion practice of operating and maintaining the emission units according to the manufacturer's recommendations to maximize fuel efficiency and minimize emissions is also an available work practice for all emission units on the Discoverer.

As discussed above, the control option must result in an emission rate no less stringent than an applicable NSPS emission rate, if any NSPS standard for that pollutant is applicable to the source. 40 C.F.R. § 52.21(b)(12)(definition of BACT).

4.3.1 NO_x BACT for the Generator Diesel IC Engines (FD-1 to FD-6)

Step 2 – Eliminate technically infeasible control options

Six Caterpillar D399 generator sets provide the electrical power for drilling and ship utilities on the Discoverer (FD-1 to FD-6). Each of these generator diesel IC engines is rated at 1325 hp, and the normal procedure is to operate the minimum number of engines needed to power the load while keeping each operating engine at 50% capacity or greater. Since the generator diesel IC engines are the largest engines on the Discoverer and will operate for the most hours, thereby resulting in the largest potential uncontrolled emissions, BACT for the generator diesel IC engines was evaluated separately from BACT for the other diesel IC engines.

The available controls for the generator diesel IC engines include ITR, AC, HIP, LND, Tier 2 or 3 controls, WI, EGR, and SCR. EPA's view is that LND, Tier 2 or 3 controls, EGR, and WI are technically infeasible. LND and Tier 2 or 3 level controls are intrinsic to the original engine design and are not part of the Caterpillar D399 design. EGR is not available for older model engines such as the Caterpillar D399. WI is considered technically infeasible for a number of reasons, the most significant being the large amount of extremely pure water required. In general, reduction of NO_x emissions by one percent requires one percent of water in the water-fuel system. In other words, achieving a 50 percent NO_x reduction requires running the engine using a 1:1 mix of water and diesel fuel. A WI system would require water purification equipment and storage capacity on a ship with limited space availability. Another issue with the introduction of water in the combustion chamber is the potential for liquid water droplets to contact the cylinder surface, which would cause an immediate disintegration of the lubrication oil film and damage to the engine. Cold temperature environments (such as the Arctic Ocean) are also problematic for WI systems due to the potential for freezing. For these reasons and because of the potential engine retrofit incompatibility for the Caterpillar D399 engines, EPA believes that WI is technically infeasible for these engines.

ITR, AC, and HIP and good combustion practice are technically feasible for this generator engine model. SCR is technically feasible because the engines are stationary on the vessel deck and there is adequate room to install the SCR devices.

Step 3 – Rank the remaining technologies by control effectiveness

The technically feasible control technologies for the Discoverer's generator diesel IC engines (FD-1 to FD-6) are ranked by control effectiveness as follows:

1. SCR – 90% control (0.5 g/kW-hr NO_x)
2. ITR, AC, and/or HIP – 10% to 50% control
3. Good combustion practices

In the permit application, Shell provided several uncontrolled NO_x emission rates for the Caterpillar D399 generator engines, including actual stack test information for one of the Caterpillar D399 generator engines (FD-1) (TRC 6/3/07). Testing was performed by TRC Environmental Corporation on May 18 and 19, 2007 for three engine load conditions (100%, 75% and 50%). The measured NO_x emission rate ranged from 5.62 g/kW-hr to 6.99 g/kW-hr, with the lowest emission rate at 100% load. Using the lowest measured uncontrolled emission rate of 5.62 g/kW-hr and applying the proposed and guaranteed emission rate of 0.5 g/kW-hr, the percentage reduction in NO_x emissions from applying SCR is >91%. The percentage reduction from the higher uncontrolled emission rates would be even greater.

EPA has promulgated emission standards for non-road diesel IC engines in 40 C.F.R. § 89.112. For engines ≥750 hp, the Tier 2 emission limit for NO_x + non-methane hydrocarbons (NMHC) is 6.4 g/kW-hr. EPA also promulgated emission standards for new and in-use non-road compression-ignition engines in 40 C.F.R. § 1039. Although these standards for engines ≥750 hp do not apply until model year 2011, the NO_x emission standard for generator sets is 0.67 g/kW-hr. By comparison with these standards, the NO_x emission limit of 0.5 g/kW-hr that EPA is proposing in this permit for the generator diesel IC engines is significantly lower.

Recent permitting actions for IC engines by the Alaska Department of Environmental Conservation have not required NO_x emission limits nearly as low as the 0.5 g/kW-hr emission limit proposed for the Discoverer generator IC engines. For example, the permit for the Nixon Fork Mine issued August 13, 2009 included a generator engine operating at 11.1 g/kW-hr; the permit for the Naknek Power Plant issued March 31, 2009 included a generator engine with an emission rate of 26.0 g/kW-hr; and the Liberty Oil Project (BP) permit issued December 12, 2008 included a generator engine with an emission rate of 6.3 g/kW-hr.

Based on achieving the proposed NO_x emissions limit 0.5 g/kW-hr, the maximum NO_x emissions from each Caterpillar D399 generator engine on the Discoverer would be 1.55 tons per year as shown in Appendix A. The maximum total NO_x emissions from all six generator engines would be 9.30 tons per year.

EPA asked Shell to evaluate the use of diesel IC engine modifications such as ITR, AC or HIP in combination with the SCR control system, since theoretically a lower inlet NO_x concentration to the SCR control system would result in a lower outlet value (EPA 4/8/09). In an email to EPA dated April 20, 2009, Shell's environmental consultant provided a response from D.E.C. Marine (Air Sciences 4/20/09). D.E.C. Marine stated that, although the use of engine modifications in addition to the SCR control system would, in theory, result in a lower NO_x emission rate, the engine modifications would have collateral adverse impacts, including increased fuel consumption, lower exhaust gas temperature and increased levels of particulate and hydrocarbon emissions. The surface of the catalyst in the SCR (and the oxidation catalyst) systems would be adversely affected by the higher loading of particulate matter and hydrocarbon emissions and the lower exhaust temperature would reduce the effectiveness of the catalytic reactions in the SCR system. D.E.C. Marine stated that "It is therefore best to optimize the engine for good combustion …….and keeping the temperatures high." D.E.C. Marine also stated that use of the SCR system is a much more effective way to reduce NO_x emissions than using retrofit engine modifications, and that the SCR system is designed with "plenty of margin to make sure we will stay below the guaranteed level of 0.5 g/kW-hr…." EPA agrees that optimizing the engine combustion performance in combination with the SCR control system is a preferred strategy for controlling NO_x from the generator engines.

The use of SCR results in low concentrations of ammonia emissions that are not completely reacted in the SCR system. The unreacted ammonia emissions are also known as ammonia slip. In order to ensure that the ammonia slip is maintained at the minimum level commensurate with achieving the NO_x emission limit of 0.5 g/kW-hr, EPA is proposing an emission limit for ammonia as part of the BACT emission limit for NO_x from the generator engines. D.E.C. Marine stated that the SCR system is designed so that ammonia slip is less than 10 ppm; however, they expect that the ammonia slip will actually be less than 3 ppm because the oxidation catalyst that follows the SCR catalyst will oxidize most of the ammonia that passes through the SCR catalyst (Shell 2/23/09 Rev. App., Appendix F, Footnote 3, page 8). Based on these facts, EPA believes that an ammonia emission limit representative of good performance for the SCR and oxidation catalyst system is 5 ppm at the actual stack gas conditions.

Step 4 – Evaluate the most effective control based on a case-by-case consideration of energy, environmental, and economic impacts

Shell proposed that SCR represents BACT for the generator diesel IC engines because it offers the highest NO_x emissions reduction of ≥90%. Shell requested a technical proposal for an SCR control system from D.E.C. Marine, a Swedish company that has been installing such control systems on marine vessels since 1991. According to a letter from D.E.C. Marine to Shell dated 2008-10-09 (Shell 2/23/09 Rev. App., Application, Appendix F, Footnote 1, page 6), D.E.C. Marine has installed SCR control systems on more than 70 vessels since 1991. The SCR system D.E.C. Marine described in their technical content and offer (Shell 2/23/09 Rev. App., Appendix F, page 195 – 209) is capable of reducing NO_x emissions to as low as 0.1 g/kW-hr under ideal steady state conditions; however, the D.E.C. Marine guarantee is 0.5 g/kW-hr because of the continually varying operating level of the engines and the severe environmental conditions in the Arctic Ocean.

As discussed in more detail in Step 3 above, EPA believes that an emission limit of 0.5 g/kW-hr, in conjunction with good combustion practice and a limit on ammonia slip, represent BACT for the generator diesel IC engines. The D.E.C. Marine SCR system uses a tuned urea injection system where the rate of urea injection is a function of engine operating load. In addition, the system includes a NO_x exhaust analyzer that sequences through the six generator engines to provide a direct measurement of NO_x emissions once per hour for each engine. The information from the NO_x analyzer provides a means for the urea injection algorithm to be optimized over time. Since the NO_x analyzer is not used for instantaneous continuous control of the urea injection system, periodic monitoring of NO_x is appropriate. Use of a continuous NO_x analyzer on each engine would not provide any significant benefit, but would increase the analyzer maintenance requirements and monitoring costs by a factor of six.

Step 5 – Select NO_x BACT for the generator diesel IC engines

Based on the facts presented above, EPA is proposing a NO_x emission limit of 0.50 g/kW-hr, in conjunction with an ammonia emission limit of 5 ppm at actual stack gas conditions, as BACT for the Caterpillar D399 generator diesel IC engines based on the use of SCR technology. The averaging time and compliance test methods for these emission limits (and the emission limits discussed below) are presented in Section 4.8.

4.3.2 NO_x BACT for the Compressor Diesel IC Engines (FD-9 to FD-11)

Step 2 – Eliminate technically infeasible control options

As discussed in Section 4.3, the available control technologies for the Discoverer's three MLC compressor diesel IC engines (FD-9 to FD-11, 540 hp Caterpillar C-15 engines) are ITR, AC, HIP, LND, Tier 2 or Tier 3 controls, WI, EGR, NO_x adsorbers, LNC and SCR. The Caterpillar C-15 diesel engines for the air compressors are new Tier 3 engines which incorporate the technologies of EGR and AC into the intrinsic design of the engines to meet the Tier 3 emission standard of 4.0 g/kW-hr for NO_x + NMHC. Because these engines are designed and tuned to meet Tier 3 standards, they are incompatible with incorporating combustion control technologies such as ITR, AC, HIP, LND, and EGR in addition to the Tier 3 controls. EPA believes that WI is technically infeasible due to the cold climate in which these generators will be operated, the potential engine retrofit incompatibility, the excessive pure water requirements, limited available space on the ship for storing the water, and the potential risk of engine damage associated with this technology.

NO_x adsorbers have been used on light duty vehicles; however, Shell stated that they are not aware of any marine applications of this technology. Shell cites one manufacturer, Johnson Matthey, as stating that they are just starting to look at this technology for stationary applications and the technology is not commercially available for stationary applications (Environ 12/11/09). EPA's Office of Transportation and Air Quality has published a summary of potential retrofit technologies for diesel engines which includes NO_x adsorbers (EPA 12/14/09 Potential Retrofit Technologies). However, NO_x adsorbers are not listed on EPA Verified Retrofit Technologies list nor are they listed on the EPA Verified Nonroad Engine Retrofit Technologies List (EPA 12/14/09 Verified Retrofit Technologies; EPA 12/14/09 Nonroad Retrofit Technologies). Since NO_x adsorber technology is not commercially available, EPA considers this technology to be technically infeasible for this application.

LNC has been used in retrofit applications for both on-road and nonroad diesel engines. Example applications include backhoes, graders, loaders and back-up generators; however, neither Shell nor EPA is aware of any marine applications of LNC. A representative of Clēaire, a vendor of LNC technology, stated that there have been few stationary applications of their LNC systems; and although there are no technical reasons the LNC systems would not work, the Clēaire representative stated that their LNC technology would be more of a demonstration project for this application and technical support during the demonstration of this technology would be needed. Therefore, the Clēaire representative would not recommend their LNC technology as commercial for this application (Environ 12/11/09). EPA considers this technology to be technically infeasible for this application.

The compressor diesel IC engines are portable due to critically limited deck space on the Discoverer. The compressor units are designed to be portable so they can be removed from the drill ship at any time should deck space be required for other equipment or materials. However, for operational reasons the preference is to have the compressor units on board the drill ship to minimize the time required to set up the units for a second MLC operation if so required. The physical location of the compressor units on the Discoverer is shown in the photograph labeled Figure 3-1 of the December 11, 2009 supplement to the BACT analysis (Environ 12/11/09). As can be seen in the photograph, there is very limited space around the compressor units. Shell provided drawings of the SCR and SCR injection control unit sized for the compressor IC engine. The SCR catalyst unit is approximately 30 inches square and 52 inches flange to flange. Additional space would be required for the piping to connect the SCR catalyst unit to the exhaust pipe from the engine. In addition, the SCR injection control unit has a footprint of about 40 inches by 18 inches and a height of approximately 66 inches. The supply of urea for an SCR system for the compressor engines would require a 1000 gallon storage tank with a deck space requirement of approximately 6.5 by 4 feet and would need to be maintained at a temperature above the "salt out temperature" when urea begins to precipitate from solution. Shell contends that there is not adequate space to install the SCR equipment at the location of the compressor units on the Discoverer and that SCR should therefore be considered technically infeasible for this application.

The State of California typically imposes emission controls that are more stringent than the Federal standards. The California Air Resources Board has created a voluntary Portable Engine Registration Program (PERP), which allows owners and operators to register their portable engines/equipment and operate them throughout the state without obtaining permits from local air districts. The current registration requirements for 2009 and 2010 for engines between 75 and 750 bhp are that these engines must meet the Tier 3 standards. Local air districts in California use the PERP when permitting portable engines including skid mounted engines used on offshore platforms and drilling operations. For example, the Santa Barbara County Air Pollution Control District, which has offshore platforms in its jurisdiction, considers engines meeting the PERP requirements to also meet BACT requirements and does not require additional controls for these engines (Environ 12/11/09). Portable engines such as the compressor IC engines which meet the Tier 3 standards would meet BACT requirement without additional controls under the PERP.

For the reasons discussed above, EPA believes that SCR is not technically feasible for portable deck engines and has excluded SCR from further consideration in the BACT analysis for the compressor diesel IC engines.[12]

<u>Step 3 – Rank the remaining technologies by control effectiveness</u>

The technically feasible control technologies for compressor diesel IC engines (FD-9 to FD-11) are ranked by control effectiveness as follows:

1. Tier 3 Emission Standards of 4.0 g/kWh of NO_x + NMHC

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[12] Although we have determinated this technology is not technically feasible, even if it were feasible and remained in the analysis, it would be excluded from consideration in step 4 due to unreasonable control costs. Shell submitted for a cost effectiveness analysis for SCR based on cost quotation data from Johnson Matthey, a SCR vendor, in the December 2009 supplement to the BACT analysis (Environ 12/11/09). The cost effectiveness value calculated for the compressor engines was greater than $34,000/ton of NO_x removed, which is greater than what EPA considers reasonable for a BACT determination.

2. Tier 2 Emission Standards of 6.4 g/kWh of NO_x + NMHC

Step 4 – Evaluate the most effective control based on a case-by-case consideration of energy, environmental, and economic impacts

Since Shell proposed the most effective control option (the Tier 3 emission standards) as BACT and there is no evidence that the most effective control option would have adverse environmental impacts as compared to other control options, no additional evaluation is required.

Step 5 – Select NO_x BACT for the compressor diesel IC engines

Based on the facts presented above, EPA is proposing that BACT for NO_x from the compressor diesel IC engines is 4.0 g/kW-hr NO_x + NMHC, the Tier 3 engine standard.

4.3.3 NO_x BACT for the Smaller Diesel IC Engines (FD-12 to FD-20)

Step 2 – Eliminate technically infeasible control options

The smaller diesel engines on the Discoverer include:

1. FD-12 and FD-13, HPU Engines – 250 hp Detroit 8V-71
2. FD-14 and FD-15, Cranes – 365 hp Caterpillar D343
3. FD-16 and FD-17, Cementing Units – 335 hp Detroit 8V-71N
4. FD-18, Cementing Unit – 147 hp GM 3-71
5. FD-19, Logging Unit Winch – 250 hp Caterpillar C7
6. FD-20, Logging Unit Generator – 35 hp John Deere PE4020TF270D

The available control technologies for engines under 500 hp are ITR, AC, LND, WI, cam shaft reengineering kit, LNC, NO_x adsorbers, SCR and good combustion practices. The Logging Unit Winch engine (FD-19) has been up-graded from the engine proposed in the original permit application to an engine (Caterpillar C7) that meets the Tier 3 engine standards. The logging unit generator engine was also changed to a John Deere engine that meets the Tier 2 engine standards.

As explained in Section 4.3.1, WI is considered technically infeasible due to the cold climate in which these generators will be operated, the potential engine retrofit incompatibility, the excessive pure water requirements, limited available space on the ship for storing the water, and the potential risk of engine damage associated with this technology.

ITR and AC decrease the peak combustion temperature, which lowers the NO_x generation rate but can increase the exhaust gas temperature, which may in turn adversely impact exhaust valve life and turbocharger performance. The Tier 2 and Tier 3 engines are not amenable to ITR or AC because these engines have been optimized as part of the low NO_x design of the engines. ITR is not as effective on engines which lack electronic fuel injection such as the HPU units, the cementing units, and the cranes. ITR and AC result in an increase in emissions of PM, CO and VOC emissions which puts an additional load on the downstream control equipment for those pollutants which is detrimental to the performance of the downstream control equipment. For these reasons EPA considers ITR and AC to be infeasible technology for any of the smaller diesel IC engines on the Discoverer.

EGR is not feasible for retrofit on the HPU units and the cementing units because these engines are older two-stroke engines which are not amenable to EGR. The crane engines are older Caterpillar engines for which EGR is not available. The logging unit engines are newer Tier 2 and Tier 3 engines which incorporate EGR in the low NO_x design of the engines. Therefore, EGR is considered technically infeasible for any of the smaller IC diesel engines on the Discoverer.

Cam shaft cylinder reengineering kits are available from Clean Cam Technology Systems (CCTS) for older Detroit Diesel Corporation two-stroke engines such as the HPU engines and the two larger Cementing unit engines. The CCTS retrofit kits are not available for the older Caterpillar engines or the newer Logging unit engines. The CCTS retrofit kits are considered technically feasible only for the HPU engines (FD-12 and FD-13) and the two larger Cementing unit engines (FD-16 and FD-17).

NO_x adsorbers have been used on light duty vehicles; however, Shell stated that they are not aware of any marine applications of this technology. Shell cites one manufacturer, Johnson Matthey as stating that they are just starting to look at this technology for stationary applications and the technology is not commercially available for stationary applications (Environ 12/11/09). EPA's Office of Transportation and Air Quality has published a summary of potential retrofit technologies for diesel engines which includes NO_x adsorbers (EPA 12/14/09 Potential Retrofit Technologies). However, NO_x adsorbers are not listed on EPA Verified Retrofit Technologies list nor are they listed on the EPA Verified Nonroad Engine Retrofit Technologies List (EPA 12/14/09 Verified Retrofit Technologies; EPA 12/14/09 Nonroad Retrofit Technologies). Since NO_x adsorber technology is not commercially available, EPA considers this technology to be technically infeasible for this application.

LNC has been used in retrofit applications for both on-road and nonroad diesel engines. Example applications include backhoes, graders, loaders and back-up generators; however, neither Shell nor EPA is aware of any marine applications of LNC. A representative of Clēaire, a vendor of LNC technology, stated that there have been few stationary applications of their LNC systems; and although there are no technical reasons the LNC systems would not work, the Clēaire representative stated that their LNC technology would be more of a demonstration project for this application and technical support during the demonstration of this technology would be needed. Therefore, the Clēaire representative would not recommend their LNC technology as commercial for this application (Environ 12/11/09).

There are no determinations for installing SCR on diesel engines under 500 hp in the EPA RBLC or CA-BACT, indicating that SCR has not previously been deemed BACT for this diesel engine category due to technical infeasibility and/or energy, environmental, and/or economic impacts. Although SCR is proposed for the main generator sets, several issues have been identified with applying SCR to the smaller IC engines. Whereas the generator engines will be operated in a manner and in a location where the exhaust temperature going to the SCR can be maintained in the appropriate range and the urea temperature will be above the "salt out temperature," the smaller engines will operate on a more intermittent basis over a wide range of loads in locations more exposed to ambient temperature conditions. The following considerations have an impact on the technical feasibility of SCR for the smaller IC engines.

1. The dynamic loading of the smaller engines with short term load swings up to 50 percent can be expected when these engines are operated. The changing load will result in times when the engine load is not sufficient to achieve the exhaust temperatures necessary for optimal performance of the SCR system. Below about 400ºF the NO_x reduction may be as low as 20%. Excessive ammonia slip can occur when the catalyst temperature is not in the optimum range for the reaction between NO_x and ammonia.

2. The smaller engines are located on the topside deck of the ship and exposed to the ambient climatic conditions in the Arctic which will contribute to the difficulty of maintaining proper temperature in the SCR catalyst. The photos in the December 11, 2009 supplement to the BACT analysis shows several of the smaller engine units in Figures 3-1 through 3-6 (Environ 12/11/09).

3. Urea will "salt out" or precipitate from solution at lower temperatures depending on the concentration of urea in the solution. Whether the urea is stored in local tanks at each engine or transferred from a central storage tank, special precautions would be required to ensure that urea did not precipitate.

4. Space on the ship is limited as shown in Figures 3-1 to 3-3 in the December 11, 2009 supplement to the BACT analysis. Several of the smaller engines are "packaged" into enclosed skids which have little or no additional space to accommodate SCR equipment and urea storage tanks without a total redesign of the units.

5. Shell has expressed concern that taking additional deck space for SCR equipment or for urea storage tanks would compromise the maneuverability of equipment needed during drilling.

For these reasons, EPA believes SCR is technically infeasible for implementation on the smaller diesel IC engines on the Discoverer.

<u>Step 3 – Rank the remaining technologies by control effectiveness</u>

The technically feasible control technologies for the smaller diesel IC engines (FD-12 to FD-20) are ranked by control effectiveness as follows:

1. Cam shaft cylinder reengineering kits
2. Good combustion practice

<u>Step 4 – Evaluate the most effective control based on a case-by-case consideration of energy, environmental, and economic impacts</u>

The cost of the CCTS engine retrofit cam kits varies by size of the engine, but is relatively low. However, the cost of the kits is not the major cost of the engine rebuild. The major costs are associated with providing the technicians and mechanics to the site to extract the engine and shipping the engine to and from the Discoverer and the engine shop where the retrofit kit is installed. The cost of the kit ranges from $4000 to $7500 depending on engine size. The additional cost for logistics and shipping was estimated by Shell to be $50,000 per engine. In the December 11, 2009 supplement to the BACT analysis, Shell estimated the cost effectiveness for the reengineered HPU engines to be $16,202/ton of NO_x reduced and $12, 206/ton of NOx reduced for the reengineered Cementing units (Environ 12/11/09). EPA believes that these cost effectiveness values exceed what is reasonable to be representative of BACT for these engines.

The remaining technically feasible control option is the use of good combustion practice. Good combustion practice for NOx control essentially consists of operating and maintaining the engines according to the manufacturer's recommendations to maximize fuel efficiency and minimize emissions.

Step 5 – Select NO_x BACT for the smaller combustion engines

EPA proposes that BACT for NO_x for all of the smaller diesel IC engines is the good combustion practice of operating and maintaining the engines according to the manufacturer's recommendations to maximize fuel efficiency and minimize emissions. More specifically, EPA proposes the following good combustion practices, in addition to the emission limits set forth below, as BACT for the engines:

- Operating personnel must be trained to identify signs of improper operation and maintenance, including visible plumes, and instructed to report these to the maintenance specialist,

- At least one full-time equipment maintenance specialist must be on board at all times during drilling activities,

- Each emission unit must be inspected by the maintenance specialist at least once a week for proper operation and maintenance consistent with the manufacturer's recommendations,

- The operation and maintenance manual provided by the manufacturer for each emission unit must be maintained on board the Discoverer at all times,

- The manufacturer's recommended operations and scheduled maintenance procedures must be followed for each emission unit.

EPA proposes that the permit include a condition requiring the permittee to follow the good combustion practices listed above.

EPA proposes the following NO_x emission limits as representative of BACT for the smaller diesel IC engines, as shown in Table 4-1. The emission limits shown in Table 4-1 are derived from the emission factors or the emission rates and the engine ratings identified in Appendix A.

Table 4-1 - NO_x Emission Limits for the Smaller Diesel IC Engines

Emission Unit Number and Engine Name	NO_x Emission Limit (g/kW-hr)
FD-12 & 13, HPU Engines	13.155
FD-14 & 15, Deck Crane Engines	10.327
FD-16 & 17 Cementing Unit Engines	13.155
FD-18 Cementing Unit Engine	15.717
FD – 19 Logging Unit Winch Engine	4.0
FD-20, Logging Unit Generator Engine	7.50

4.3.4 NO_x BACT for the Diesel-Fired Boilers (FD-21to FD- 22)

Step 2 – Eliminate technically infeasible control options

The Discoverer has two small diesel fueled boilers (FD-21 and FD-22) to provide heat for domestic and work spaces. According to Shell's application, under typical operations, one boiler will be operating and the second will be on standby, although there may be times when both boilers operate simultaneously. The maximum heat input for each of the existing Clayton Model 200 boilers is approximately 8 million Btu per hour (MMBtu/hr). As shown in Appendix A, the total estimated emissions of NO_x from the two boilers are 6.46 tons per year.

A search of the EPA RBLC and CA-BACT found that previous determinations for NO_x control of small boilers included no controls, low NO_x burners (LNB) and flue gas recirculation (FGR). Literature from Clayton Industries, the manufacturer of the two boilers, states that LNB are available only for natural gas or propane fired boilers (Shell 2/23/09 Rev. App., Appendix F, Footnote 37, page 101), and are not available for the diesel fired boilers on the Discoverer. The Clayton literature also states that FGR is an available option for new boilers, but that they are not aware of any FGR retrofits to any of their existing boilers (Shell 2/23/09 Rev. App., Appendix F, Footnote 38, page 104). There are no determinations for installing SCR on small boilers (<100 MMBtu/hr), nor is EPA aware of any instance where SCR has been installed on small boilers on exploration vessels. The boilers on the Discoverer are located next to the engine room, which is being expanded to accommodate the SCR systems for the generator engines. Shell states that after installation of the SCR for the generator engines, there will be no deck space for additional SCR units. For these reasons, EPA believes that LNB, FGR and SCR are technically infeasible for the small boilers at issue in this specific application.

Step 3 – Rank the remaining technologies by control effectiveness

The only technically feasible NO_x control option for the two boilers (FD-21 and FD-22) is good combustion practices.

Step 4 – Evaluate the most effective control based on a case-by-case consideration of energy, environmental, and economic impacts

Since the top control option from Step 3 (good combustion practices) is the only technically feasible control option, this step is not required.

Step 5 – Select NOx BACT for the diesel-fired boilers

EPA proposes that BACT for NO_x for the diesel-fired boilers be the good combustion practice of operating and maintaining the engines according to the manufacturer's recommendations to maximize fuel efficiency and minimize emissions. More specifically, EPA proposes the following good combustion practices, in addition to the emission limits set forth below, as BACT for the engines:

- Operating personnel must be trained to identify signs of improper operation and maintenance, including visible plumes, and instructed to report these to the maintenance specialist,

- At least one full-time equipment maintenance specialist must be on board at all times during drilling activities,

- Each emission unit must be inspected by the maintenance specialist at least once a week for proper operation and maintenance consistent with the manufacturer's recommendations,

- The operation and maintenance manual provided by the manufacturer for each emission unit must be maintained on board the Discoverer at all times,

- The manufacturer's recommended operation and scheduled maintenance procedures must be followed for each emission unit.

EPA proposes that the permit include a condition requiring the permittee to follow the good combustion practices listed above.

The emission limit representative of NO_x BACT for the boilers is 0.20 pounds per million Btu (lb/MMBtu). This emission limit was derived from the emission rate and boiler size information provided in Appendix A.

4.3.5 NO_x BACT for the Incinerator (FD-23)

Step 2 – Eliminate technically infeasible control options

The Discoverer has a two-stage, batch charged incinerator capable of incinerating 276 pounds per hour of solid trash, or 6624 pounds per day; however, Shell has requested an operating restriction to limit the maximum amount of trash burned to no more than 1300 pounds per day. The maximum incineration capacity is rated at 3 MMBtu/hr. The use rate and batch size will be variable depending on the waste generation rate on board the Discoverer. The only determination for post-combustion controls for NO_x found in the EPA RBLC and CA-BACT searches was for selective non-catalytic reduction (SNCR), although that determination was for a much larger incinerator. Team Tec, the manufacturer of the incinerator on the Discoverer, was not aware of any control technologies that have been installed on this model of incinerator for control of NO_x (Shell 2/23/09 Rev. App., Appendix F, Footnote 39, pages 105 to 112). Since the heat content and the batch size charged to the incinerator will be quite variable, design of an SNCR control system would be infeasible. Therefore, EPA believes that SNCR is technically infeasible for this small incinerator.

Step 3 – Rank the remaining technologies by control effectiveness

The only technically feasible NO_x control option for the incinerator (FD-23) is good combustion practices.

Step 4 – Evaluate the most effective control based on a case-by-case consideration of energy, environmental, and economic impacts

Since the top control option from Step 3 (good combustion practices) is the only technically feasible control option, this step is not required.

Step 5 – Select NOx BACT for the incinerator

EPA proposes that BACT for NO_x for the incinerator be the good combustion practice of operating and maintaining the engines according to the manufacturer's recommendations to maximize fuel efficiency and minimize emissions. More specifically, EPA proposes the following good combustion practices, in addition to the emission limits set forth below, as BACT for the engines:

- Operating personnel must be trained to identify signs of improper operation and maintenance, including visible plumes, and instructed to report these to the maintenance specialist,

- At least one full-time equipment maintenance specialist must be on board at all times during drilling activities,

- Each emission unit must be inspected by the maintenance specialist at least once a week for proper operation and maintenance consistent with the manufacturer's recommendations,

- The operation and maintenance manual provided by the manufacturer for each emission unit must be maintained on board the Discoverer at all times,

- The manufacturer's recommended operation and scheduled maintenance procedures must be followed for each emission unit.

EPA proposes that the permit include a condition requiring the permittee to follow the good combustion practices listed above.

The NO_x emission limit representative of BACT for the incinerator is 5.0 pounds of NO_x per ton of waste burned which is the same as the NO_x emission factor presented in the emission inventory in Appendix A.

4.4 PM/PM_{10}/$PM_{2.5}$ BACT Analysis

Step 1 – Identify all available control technologies

PM/PM_{10}/$PM_{2.5}$ emissions (hereafter referred to as particulate matter or PM[13]) from diesel engines are a complex mixture of compounds which are formed through a number of different mechanisms. Diesel PM emissions are comprised of the soluble organic fraction (SOF), the insoluble fraction, and the sulfate fraction. Fuel and lube oil contribute to the SOF fraction. The insoluble fraction is primarily dry carbonaceous soot from incomplete fuel combustion. The sulfate fraction is produced from the sulfur in diesel fuel. The available PM control technologies for the Discoverer's engines, boilers, and incinerator were determined from searches performed on the RBLC and the CA-BACT. The search conditions and a summary of the resulting control technologies are provided in Table 4-5 of the Shell permit application.

The available PM combustion control technologies for diesel IC engines identified in the RBLC and CA-BACT searches include low sulfur fuel (LSF), oxidation catalyst (OxyCat), diesel particulate filter (DPF), Tier 2 or Tier 3 level controls, and closed crankcase ventilation (CCV), which is sometimes referred to as positive crankcase ventilation (PCV). Although not listed in the RBLC or CA-BACT, the combination of OxyCat and DPF, referred to as a catalytic diesel particulate filter (CDPF), is also an available control technology for PM reduction. This list of available control technology is consistent with the list of diesel retrofit technologies that EPA has approved for use in engine retrofit programs (EPA 12/14/09 Verified Retrofit Technologies), and with the control technologies discussed in the Western Regional Air Partnership "Offroad Diesel Retrofit Guidance Document" (WRAP 11/28/05) and the Massachusetts Department of Environmental Protection "Diesel Engine Retrofits in the Construction Industry: A How To Guide" (MassDEP 6/08).

LSF reduces the sulfate PM fraction by limiting the amount of sulfur in the fuel that is available for sulfate formation. As described in Section 4.2, use of ultra-low sulfur was determined to represent BACT for SO_2 and has the added benefit of reducing the sulfate portion of PM emissions from emission units burning diesel fuel. An OxyCat removes the SOF of PM through catalytic oxidation of the combustible organic matter resulting in an overall PM control efficiency of about 50 percent. A DPF removes the insoluble fraction of PM (soot) by filtration with an overall PM control efficiency of 40 to 50 percent. CDPF technology removes both the SOF and the insoluble fraction of PM with an overall PM control efficiency of about 85 percent. According to information from CleanAIR Systems, a CDPF vendor, the CDPF must be operated at temperatures greater than 300ºC (572ºF) for a certain percentage of the operating time for proper filter regeneration when using low sulfur fuel (Shell 2/23/09 Rev. App., Appendix F,

[13] As discussed above, except with respect to the incinterator, all PM and PM_{10} from all emission units on the Discoverer are assumed to be $PM_{2.5}$,, a conservative assumption.

Footnote 51, page 179). Therefore, the capability to monitor temperature of the engine exhaust gas at the inlet of the CDPF should be required for those emission units for which CDPF technology is determined to represent BACT.

The crankcase of a combustion engine accumulates gases and oil mist called blow-by gases that leak into the crankcase from the combustion chamber and other sources. The blow-by gases must be vented from the crankcase to prevent damage to engine components such as seals. The blow-by gases contains PM, which is primarily SOF, and will contribute to PM emissions if not controlled. CCV systems were developed to remove blow-by gases from the engine and to prevent those vapors from being expelled into the atmosphere. The CCV system does this by directing the blow-by gases back to the intake manifold, so they can be combusted. Shell stated that all of the diesel IC engines on the Discoverer except for the MLC Compressor engines (FD – 9 to FD-11) will be equipped with a CCV system. The MLC Compressor engines have built-in crankcase emission control.

Regardless of the technology applied to achieve BACT, the control option must result in an emission rate no less stringent than an applicable NSPS emission rate, if any NSPS standard for that pollutant is applicable to the source. 40 C.F.R. § 52.21(b)(12)(definition of BACT). EPA has promulgated exhaust emission standards for stationary IC engines under the NSPS Subpart IIII which specifies that engine manufacturers must certify their 2007 and later engines to the applicable emission standard for new nonroad engines in 40 C.F.R. § 89.112 (and several other sections). 40 C.F.R. § 60.4201(a). Engines designed to meet Tier 2 or Tier 3 PM emission standards typically employ a combination of low PM emitting engine designs and DPF or CDPF. For diesel IC engines manufactured to meet the Tier 3 emission standards such as the three 540 hp MLC compressor engines (FD-9 to FD-11) and the 250 hp Logging Unit Winch engine (FD-19), the applicable PM emission standard is 0.2 grams per kilowatt hour (g/kW-hr). 40 C.F.R. § 89.112(a) Table 1.

No PM control technologies were found from the search of the RBLC and CA-BACT for diesel fired boilers less than or equal to 100 MMBtu/hr. Although not found in the previous determinations listed in the RBLC and CA-BACT, PM control technologies such as an electrostatic precipitator (ESP) or a fabric filter could theoretically be designed for the small boilers on the Discoverer.

The only PM control technology for the incinerator found in the RBLC and CA-BACT search was an ESP although it was for a much larger incinerator than the one on the Discoverer. Other control devices such as a ceramic fabric filter, a venturi scrubber or a wet ESP could theoretically be designed for the small incinerator on the Discoverer and were evaluated as control options.

Good combustion practice of operating and maintaining the emission units according to the manufacturer's recommendations to maximize fuel efficiency and minimize emissions is also an available work practice for all emission units on the Discoverer.

4.4.1 PM BACT for the Generator Diesel IC Engines (FD-1 to FD- 6)

Step 2 – Eliminate technically infeasible control options

The available control technologies for the Discoverer's diesel IC engines are LSF, OxyCat, DPF, CDPF, Tier 2 or 3 level controls, and CCV. Tier 2 or Tier 3 level controls are intrinsic to the original engine design; and, therefore, are not considered technically feasible in this case since they are not part of the design of the existing Caterpillar D399 diesel engines.

The primary difference between an OxyCat system and a CDPF is that the OxyCat system is constructed with an open flow catalyst matrix. In contrast, the CDPF is constructed with a catalyst matrix where the inlet channels of the catalyst matrix are plugged at the downstream end, forcing the exhaust gases to flow through the pores of the catalyst matrix and out the adjacent channels, which are plugged at the inlet end of the matrix. Because of this design difference, a CDPF achieves a higher percentage reduction of PM emissions but approximately the same percentage reduction for VOC and CO as compared to an OxyCat system, although at the expense of a higher pressure drop across the catalyst matrix.

The higher pressure drop of the CDPF is of concern because, as described in Section 4.3.1, the generator diesel IC engines will be equipped with the SCR system for NO_x control. The SCR catalyst imposes a backpressure on the engines due to the pressure drop required to move the exhaust gases through the SCR catalyst matrix. Adding the additional pressure drop associated with a CDPF could result in an excessive backpressure on the engines. D.E.C. Marine addressed the possibility of designing a CDPF to be used with the SCR system (Shell 2/23/09 Rev. App., Appendix F, Footnote 41, page 113). Since a CDPF has not been included with the vendor's SCR systems in the past, a feasibility study would have to be conducted before final design. Several considerations would have to be addressed including the additional cross-sectional area needed for the CDPF catalyst matrix (perhaps as much as 50% larger than for an OxyCat matrix), the temperature profiles to determine how well the captured soot would be oxidized in the CDPF, the increased backpressure imposed and the manual cleaning frequency (or filter element exchange) required to keep the backpressure within specifications. D.E.C. Marine stated that they are not aware of any applications of CDPF systems on older heavy duty marine engines without modern electronic controlled fuel injection. Since CDPF systems are not commercially available in combination with SCR systems for diesel engines such as the Discoverer's generator diesel IC engines, EPA believes CDPF systems are technically infeasible for this specific application.[14]

<u>Step 3 – Rank the remaining technologies by control effectiveness</u>

The remaining technically feasible controls for the generator diesel engines include OxyCat, LSF and good combustion practices for control of exhaust gas emissions. CCV or coalescing filters are available for control of crankcase emissions.

<u>Step 4 – Evaluate the most effective control based on a case-by-case consideration of energy, environmental, and economic impacts</u>

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[14] Even if a CDPF was technically feasible in this specific application, Shell estimated the cost effectiveness of a CDPF for the generator engines and found the cost effectiveness values to be in the range of $20,000 to $30,000 per ton of PM removed (see Appendix C of the permit application for the detailed cost calculations). This cost effectivness value exceeds what EPA believes to be representaitve of BAC for these engines.

The most efficient available technology is an OxyCat system with estimated removal efficiency of 50% for PM. As discussed in Section 4.2, EPA's view is that ultra-low sulfur fuel represents BACT for SO_2 control and will have the added benefit of reducing the sulfate fraction of the PM emissions. Therefore, ultra-low sulfur fuel can be considered, in conjunction with OxyCat, as a combination of PM control techniques. The proposed D.E.C. Marine design incorporates oxidation catalyst downstream of the SCR catalyst in the same converter shell, which results in a more compact and economical system than having separate devices. The OxyCat system is expected to reduce PM emissions to <0.127 g/kW-hr.

In addition to the exhaust gases from the engine, the generator diesel IC engines produce emissions from the crankcase, which must be ventilated to prevent pressure buildup from combustion gases that escape around the piston rings during the combustion stroke. Installation of CCV as a retrofit technology will eliminate crankcase PM emissions by recycling them back to the intake manifold of the engine. (Shell 2/23/09 Rev. App., Appendix F, Footnote 47, pages 151 to 166 of the permit application.

Step 5 – Select PM BACT for the Generator Diesel IC Engines

EPA is proposing that BACT for PM from the generator diesel IC engines is 0.127 g/kW-hr based on the use of OxyCat in combination with use of ultra-low sulfur fuel (≤ 15 ppm).

The definition of BACT provides that if EPA determines that technological or economic limitations on the application of measurement technology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of BACT. 40 C.F.R. § 52.21(b)(12). Since quantifying PM emissions from crankcase ventilation is difficult and makes the imposition of an emission standard for the crankcase ventilation infeasible, EPA proposes that BACT for crankcase ventilation be a work practice of installing CCV systems which will eliminate any venting of crankcase emissions to the atmosphere.

In order to detect a major failure of the oxidation catalyst, EPA is also proposing a visible emissions (opacity) limit in addition to the particulate emission limit described above. EPA proposes that visible emissions from the engines, excluding condensed water vapor, shall not reduce visibility through the exhaust effluent more than 20 percent averaged over any six consecutive minutes.

4.4.2 PM BACT for the Compressor Diesel IC Engines (FD-9 to FD-11) and the Logging Unit Winch Engine (FD-19) (all Tier 3 Engines)

Step 2 – Eliminate technically infeasible control options

The compressor diesel IC engines and the Logging Unit Winch engine are newer and meet the EPA Tier 3 emission standards. According to the literature describing the Caterpillar C-15 engines, part of the control technology used on the C-15 engine includes clean gas induction which consists of a DPF and EGR (Shell 2/23/09 Rev. App, Appendix F, footnote 36, pages 94 to 99). Therefore, the C-15 engines include the same type of diesel particulate filtration as achieved with a CDPF. The Tier 3 standard for PM is 0.2 g/kW-hr. Additional add-on PM control devices could be used, such as a CDPF, an OxyCat system or a DPF in series with the integral controls on the Tier 3 engines.

Step 3 – Rank the remaining technologies by control effectiveness

The technically feasible control technologies for the compressor diesel IC engines (FD-9 to FD-11) and the Logging Unit Winch engine (FD-19) are ranked by PM control effectiveness as follows:

1. CDPF – 85 percent control
2. OxyCat – 50 percent control
3. DPF – 40 – 50 percent control
4. Good combustion practices

Step 4 – Evaluate the most effective control based on a case-by-case consideration of energy, environmental, and economic impacts

In the December 11, 2009 supplement to the BACT analysis, Shell included a cost effectiveness calculation for a CDPF for the Compressor engines and the Logging Unit Winch engine (Environ 12/11/09). The calculated cost effectiveness value was $41,883/ton of PM removed for a CDPF on a compressor engine and $90,467/ton of PM removed for a CDPF on the Logging Unit Winch engine. Since the cost effectiveness values estimated for the CDPF on the Tier 3 engines are much greater than $10,000/ton commonly considered high for stationary source BACT determinations, EPA proposes that use of a CDPF does not represent BACT for the Tier 3 engines.

In the December 11, 2009 supplement to the BACT analysis, Shell included a cost effectiveness calculation for an OxyCat system for the compressor engines and the Logging Unit Winch engine (Environ 12/11/09). The calculated cost effectiveness value was $32,139/ton of PM removed for an OxyCat system on a compressor engine and $55,233/ton of PM removed for an OxyCat system on the Logging Unit Winch engine. As in the case of the CDPF discussed above, the cost effectiveness values for an OxyCat system are higher than EPA considers reasonable for a BACT determination.

Since the cost of a DPF is not significantly lower than for an OxyCat and the PM removal efficiency is no greater than an OxyCat system, the cost effectiveness of a DPF on either of the Tier 3 engines is also greater than EPA considers reasonable for a BACT determination.

The remaining technically feasible control option is the use of good combustion practices.

Step 5 – Select PM BACT for the Compressor and Logging Unit Winch IC Engines

The CDPF, OxyCat and the DPF have been eliminated from consideration for use on Tier 3 engines based on unreasonably high cost effectiveness values. EPA proposes that BACT for PM for the compressor diesel IC engines and the Logging Unit Winch engine is that the engines meet the Tier 3 engine PM standard of 0.20 g/kW-hr and the use of good combustion practice for operating and maintaining the engines according to the manufacturer's recommendations to maximize fuel efficiency and minimize emissions. More specifically, EPA proposes the following good combustion practices, in addition to the emission limit set forth above, as BACT for the compressor engines and the Logging Unit Winch engine:

- Operating personnel must be trained to identify signs of improper operation and maintenance, including visible plumes, and instructed to report these to the maintenance specialist,

- At least one full-time equipment maintenance specialist must be on board at all times during drilling activities,

- Each emission unit must be inspected by the maintenance specialist at least once a week for proper operation and maintenance consistent with the manufacturer's recommendations,

- The operation and maintenance manual provided by the manufacturer for each emission unit must be maintained on board the Discoverer at all times,

- The manufacturer's recommended operations and scheduled maintenance procedures must be followed for each emission unit.

EPA proposes that the permit include a condition requiring the permittee to follow the good combustion practices listed above.

In order to detect a significant degradation in the performance of the PM control system inherent to the compressor engines and the Logging Unit Winch engine, EPA is proposing a visible emissions (opacity) limit in addition to the PM emission limit described above. EPA proposes that visible emissions from the engines, excluding condensed water vapor, shall not reduce visibility through the exhaust effluent more than 20 percent averaged over any six consecutive minutes.

4.4.3 PM BACT for the Smaller Diesel IC Engines (FD-12 to FD-18 and FD-20)

<u>Step 2 – Eliminate technically infeasible control options</u>

The available control technologies for the Discoverer's smaller diesel IC engines are LSF, OxyCat, DPF, CDPF, Tier 2 or 3 level controls, and CCV. Tier 2 or Tier 3 level controls are intrinsic to the original engine design. These control technologies are not technically feasible because they are not part of the design of the Discoverer's smaller diesel IC engines. LSF, OxyCat, DPF, and CDPF are all considered technically feasible for the smaller diesel IC engines.

<u>Step 3 – Rank the remaining technologies by control effectiveness</u>

The technically feasible PM control technologies for the exhaust gases from the smaller diesel IC engines are ranked by control effectiveness as follows:

1. CDPF – 85 percent control
2. OxyCat – 50 percent control
3. DPF – 40 to 50 percent control
4. Good combustion practices

Ultra-low sulfur fuel is included in combination with all the above technologies in determining the above control effectiveness.

Step 4 – Evaluate the most effective control based on a case-by-case consideration of energy, environmental, and economic impacts

Since Shell proposed to install CDPF, which EPA agrees is the most effective control option, on each of the smaller diesel IC engines and there is no evidence that the most effective control option would have adverse environmental impacts as compared to other control options, no further analysis is required.

Step 5 – Select PM BACT for the Smaller Diesel Engines

EPA proposes that BACT for PM from the smaller diesel IC engines be an emission rate based on the use of CDPF technology in combination with use of ultra-low sulfur fuel. The BACT emission rate for each of the smaller diesel IC engines is shown in Table 4-2.

Table 4-2 - PM Emission Limits for the Smaller Diesel IC Engines

Emission Unit Number and Engine Name	PM Emission Limit (g/kW-hr)
FD-12 & 13, HPU Engines	0.253
FD-14 & 15, Deck Crane Engines	0.0715
FD-16 & 17, Cementing Unit Engines	0.253
FD-18 Cementing Unit	0.386
FD-20, Logging Winch Engine	0.090

As discussed in Section 4.4.1 above, since quantifying PM emissions from crankcase ventilation is difficult and makes the imposition of an emission standard for the crankcase ventilation infeasible, EPA proposes that BACT for crankcase ventilation be a work practice consisting of installation of CCV for all smaller diesel IC engines except for the MLC Compressor engines (FD 9 to FD-11) and the Logging Unit Winch Engine (FD-19), which have built-in crankcase emission control.

According to the information from CleanAIR Systems, a CDPF vendor, the CDPF must be operated at temperatures greater than 300ºC (572ºF) for a certain percentage of the operating time for proper filter regeneration when using low sulfur fuel. Therefore, EPA proposes that the permit include a condition requiring the permittee to monitor temperature of the engine exhaust gas at the inlet of the CDPF.