SHELL REVISED OUTER CONTINENTAL SHELF LEASE EXPLORATION PLAN, CHUKCHI SEA, ALASKA, REVISION 2: APPENDIX K – AQRP AND NEPA EMISSION INVENTORIES

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LIST OF ABBREVIATIONS

AQRP	Air Quality Regulatory Program
BOEM	Bureau of Ocean Energy Management
CDPF	Catalyzed Diesel Particulate Filter
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DOC	Diesel Oxidation Catalyst
DP	Dynamic Positioning
EDMS	Emissions and Dispersion Modeling System
EIA	Environmental Impact Analysis
EP	Exploration Plan
EPA	Environmental Protection Agency
EWL	Electric Wireline Logging
FAA	Federal Aviation Administration
GHG	Greenhouse Gases
g/kW-hr	Grams Per Kilowatt Hour
HC	Hydrocarbon
hp	Horsepower
HPU	Hydraulic Power Unit
IC	Internal Combustion
IMO	International Maritime Organization
kcal/hr	Kilocalories Per Hour
K/D/R	Kitchen/Dining/Recreation
k-gal	Kilogallon
kg/hr	Kilograms Per Hour
kW	Kilowatt

kWe	Kilowatt-electric
lb/hr	Pounds Per Hour
LTO	Landing/Take-off
MLC	Mudline Cellar
MMBtu/hr	Million British Thermal Units Per Hour
MODU	Mobile Offshore Drilling Unit
MOVES	Motor Vehicle Emission Simulator
MSDS	Material Safety Data Sheet
NARL	Naval Arctic Research Laboratory
NEPA	National Environmental Policy Act
NMTOC	Non-methane Total Organic Compounds
NO_X	Nitrogen Oxide
N_2O	Nitrous Oxide
OCS	Outer Continental Shelf
OSR	Oil Spill Response
OSRV	Oil Spill Response Vessel
OST	Oil Storage Tanker
OSV	Offshore Supply Vessel
OTAQ	Office of Transportation and Air Quality
Pb	Lead
PM	Particulate Matter
ppm	Parts Per Million
ppmv	Parts Per Million by Volume
PSO	Protected Species Observer
ROV	Remotely Operated Vehicle
SAR	Search and Rescue
SCR	Selective Catalytic Reduction
SO_2	Sulfur Dioxide
THC	Total Hydrocarbon

TOC	Total Organic Compounds
UIC	Ukpeaġvik Iñupiat Corporation
ULSD	Ultra Low Sulfur Diesel
USAF	United States Air Force
VOC	Volatile Organic Compounds
ZVSP	Zero-offset Vertical Seismic Profile

EXECUTIVE SUMMARY

This report identifies emission units and emissions to the atmosphere associated with the Shell Gulf of Mexico Inc. (Shell) exploration drilling program at Outer Continental Shelf (OCS) lease blocks at the Burger Prospect in the Chukchi Sea. This document has been prepared to assist the Bureau of Ocean Energy Management (BOEM) in the assessment and authorization of air emissions attributable to Shell's exploration drilling operations. This document presents the following two emission inventories.

1. For purposes of demonstrating applicability under the BOEM Air Quality Regulatory Program (AQRP) (30 CFR Part 550, Subpart C), Shell provides an AQRP emission inventory. As required by 30 CFR 550.218(a)(3), the inventory is estimated based on the projected emissions of the maximum rated capacity of the equipment on the proposed drilling unit under its physical and operational design.

2. For purposes of demonstrating impacts under the National Environmental Policy Act (NEPA), Shell provides a NEPA emission inventory. This inventory provides an estimate of expected emissions in geographic areas of interest.

This document describes the types of activities and locations that would result in onshore and offshore air emissions associated with Shell's exploration drilling program as described in the Shell Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska, Revision 2 (EP Revision 2). The emission inventories described herein adopt a number of conservative assumptions that result in an overestimate of the actual onshore and offshore emissions associated with the EP Revision 2. Actual activities and locations may vary but are expected to contribute to lower increases in air emission impacts. In particular, the following conservative assumptions have been adopted:

- Annual emissions from the drilling units are based on continuous operation of engines, boilers, and incinerators for 24 hours per day (at 80 percent load for the engines; 100 percent load for boilers and incinerators) for the entire 120-day season (2,880 hours per season), even though that is a significant overestimate of their use.

- Annual emissions from certain engines, boilers, and incinerators on a number of support vessels are based on continuous operation 24 hours per day for the entire 120-day season (2,880 hours per season), even though that is a significant overestimate of their use.

- Annual emissions from emergency generator engines, lifeboat engines, rescue crafts, and seldom-used engines on support vessels are based on an assumed 500 hours of operation in the season, even though that is a significant overestimate of their use.

- Annual emissions from the small oil spill response equipment are based on operation of engines 8 hours per day for the entire 120-day season, even though they will only be used for training exercises; this is a significant overestimate of the equipment's use.

- Annual emissions from drilling units do not account for the use of any existing emission control systems (e.g., selective catalytic reduction [SCR], catalyzed diesel particulate filters [CDPF]) when they are currently installed and will be used to reduce emissions (Table 6 identifies the units currently installed with emission control systems).

- Annual emissions from the support vessels do not account for the use of SCR emission control systems when they are currently installed and will be used to reduce emissions (Table 6 identifies the vessels and units currently installed with emission control systems).

- Annual sulfur dioxide (SO_2) emissions are calculated assuming higher, conservative 100 parts per million (ppm) sulfur content, even though Shell will use Ultra Low Sulfur Diesel (ULSD) or a fuel with equal or lower sulfur content (but that will be mixed with fuel blending with any residual non-ULSD fuel that remains in the tanks prior to the drilling season).

1.0 DRILLING UNITS AND SUPPORT VESSELS

This section identifies the drilling units Shell intends to use for exploration drilling and describes the vessels that will support the drilling units. For more detailed information on the drilling units and the support vessels, please refer to section 13.0 of the Chukchi Sea EP Revision 2.

1.1 Drilling Units

Shell plans to use two drilling units, the Motor Vessel (M/V) *Noble Discoverer* (*Discoverer*) and the Mobile Offshore Drilling Unit (MODU) *Transocean Polar Pioneer* (*Polar Pioneer*), to continue its exploration drilling program. Shell presents the known or expected emission units at the time of filing this EP Revision 2, but it is important to note that one or more of the engines on board the drilling units may change as maintenance or equipment needs demands.

1.1.1 *Discoverer*

The *Discoverer* is a drillship equipped with a propulsion engine, electrically powered thrusters, engine-driven electrical generators for the drilling motors, and other self-powered equipment. The self-powered equipment includes hydraulic pumps, cranes, boilers, an incinerator, and other (mostly emergency-related) small sources. There will be no flares and no hydrocarbon-venting sources except for minor amounts associated with the drill cuttings. Table 1 lists the emission units associated with the *Discoverer*.

Table 1. *Discoverer* Emission Units

Emission Unit Group	Candidate Emission Unit(s)	Aggregate Nameplate Rating [a]	
Generator Engines	Caterpillar 3512C (6x)	6,609	kW [b]
Propulsion Engine	STX-MAN 6S42MC7	6,480	kW
Hydraulic Power Unit Engines	John Deere JD6068HF485 (2x)	363	kW
Crane Engines	Liebherr D9508 A7 (2x)	900	kW
Cementing Unit Engines	Detroit 8V-71N (2x)	500	kW
Logging Unit Engine	Caterpillar C7 ACERT	224	kW
Compressor Engine	Detroit 4-71	104	kW
Sidewall Core Tool Engine	John Deere 4024TF270	43	kW
Emergency Generator Engine	Caterpillar 3412	507	kW
Lifeboat Engines	Sabb L3.139LB (4x)	88	kW
Boilers	Clayton 200 (2x)	16	MMBtu/hr [c]
Incinerator	TeamTec GS500C	276	lb/hr [d]

[a] "Aggregate Nameplate Rating" indicates the combined total rating/output for units in the group type.
[b] Kilowatt
[c] Million British thermal units per hour
[d] Pounds per hour

1.1.1.1 Generator Engines

Power generation for drilling exploration wells involves drilling, casing, cementing, and logging. Each activity requires a different level of electrical power consumption. The highest power consumption is expected to occur when the drilling unit is used to excavate and drill the mudline cellar (MLC). (As noted in the EP Revision 2 and discussed in Section 1.2.7 below, some or all of the MLCs may be constructed using a separate MLC Remotely Operated Vehicle [ROV] system.) Casing, cementing, and logging require minimal power, and generator engine demand is reduced during these periods.

Six Caterpillar 3512C generator sets comprise the Generator Engines emission unit group as described in Table 1. This system provides the primary power for the drilling as well as the ship utilities, and the number of operating units and load levels vary throughout the drilling process.

Each of the six generators is fitted with SCR and CDPF control devices that reduce the nitrogen oxide (NO_X), particulate matter (PM), carbon monoxide (CO), and volatile organic compound (VOC) emissions.

Although at least several of the main generators operate continuously while the *Discoverer* is onsite, other diesel engines (described below) are used only occasionally for specialized and intermittent tasks.

1.1.1.2 Propulsion

The *Discoverer* is self-propelled with a single STX-MAN Model 6S42MC7, International Maritime Organization (IMO) Tier II, 6,480 kW engine. This engine will be used to propel the *Discoverer* to the drill site, and to assist in holding position while the mooring is connected and tensioned. In extreme high winds, the engine may be used to assist the anchors in holding the vessel in position.

1.1.1.3 Hydraulic Power Units

The hydraulic power units (HPU) consist of two approximately 200 kW engines and are used primarily for assisting in the rotation of the up to 30-foot-diameter bit for drilling the MLCs. These engines may also be occasionally used for other unspecified tasks.

1.1.1.4 Cranes

The *Discoverer* has two 450 kW engines that power two cranes used intermittently to move materials around the deck and to load/off-load supplies. The operating levels of the crane engines are highly variable depending on the weight and type of material being moved. The duty cycle consists of lifting a load, swinging the load, lowering the load, and idling while the load is disconnected, then swinging back to the position of a new load and idling as it is connected. The only activity that consumes high power is the load lifting; the remainder of the cycle is at low power.

1.1.1.5 Cementing Units

There are two 250 kW cementing pumps on the *Discoverer*. These cementing units are used intermittently to force liquid slurry of cement and additives down the casing and into the annular space between the casing and the wall of the borehole. The cementing units are also used intermittently as high-pressure pumps for hydrostatically testing various types of well equipment and drilling components such as the wellhead connections and the blowout preventer.

1.1.1.6 Logging Unit, Compressor, and Sidewall Core Tool Engines

The logging unit, compressor, and sidewall core tool engines are portable equipment associated with the planned acquisition of a standardized subsurface evaluation program at each drill site. This portable equipment will provide the energy to run the electric wireline logging (EWL) program, the Zero-offset Vertical Seismic Profile (ZVSP) program, and the sidewall coring program at each drill site. The compressor required to conduct the ZVSP program will be used infrequently to collect localized geophysical data at various depths in each well.

1.1.1.7 Emergency Generator

The *Discoverer* has a Caterpillar 3412 engine driving a 507 kW emergency generator to power basic drillship utilities if the primary power system is inoperable. It is capable of powering only domestic and worker safety devices and not the drilling equipment. There are no planned uses of the emergency generator except weekly exercising, which involves operation for approximately 20 minutes.

1.1.1.8 Lifeboats

The *Discoverer* has four lifeboats, each equipped with a Sabb 29.5 horsepower (hp) engine. Vendor data are provided in Attachment F. The only planned use of the lifeboats is monthly exercising to comply with Coast Guard requirements.

1.1.1.9 Boilers

The *Discoverer* has two diesel-fired boilers to provide domestic and workspace heating. Typically, only one boiler is operating at a time.

1.1.1.10 Waste Incinerator

Domestic and other non-hazardous materials are to be incinerated as needed. This man-camp-style incinerator is a two-stage, batch-charged unit capable of burning 276 lb/hr of solid trash.

1.1.2 *Polar Pioneer*

The *Polar Pioneer* is a semi-submersible MODU that is capable of operating in harsh environments and variable water depths. The *Polar Pioneer* can slowly move using the eight onboard electric thrusters; however, it is customary for the *Polar Pioneer* to be towed on location. The *Polar Pioneer* is kept on a drilling location with a conventional mooring system. The *Polar Pioneer* contains main generator engines, boilers, a compressor engine, and an incinerator. Table 2 lists the emission units associated with the *Polar Pioneer*.

Table 2. *Polar Pioneer* Emission Units

Emission Unit Group	Candidate Emission Unit(s)	Aggregate Nameplate Rating [a]	
Generator Engines	Bergen KVG-18 (5x)	13,750	kW
HPU Engines	John Deere 6068HF485 (2x)	373	kW
Logging Unit Engine	Caterpillar C7 ACERT	224	kW
Compressor Engine	Detroit 4-71	104	kW
Sidewall Core Tool Engine	John Deere 4024TF270	43	kW
Emergency Generator Engine	Tejos MTU 12-396	1,120	kW
Small Emergency Engines	Various (8x) [b]	576	kW
Boilers	Aalborg Industries Mission OS (2x)	26	MMBtu/hr
Incinerator	Atlas 600 SL B WS P	220	lb/hr

[a] "Aggregate Nameplate Rating" indicates the combined total rating/output for units in the group type.
[b] See Attachment D for a complete list of the emission units and ratings.

1.1.2.1 Generator Engines

Five Bergen KVG-18 diesel engines, rated at 3,890 hp each, drive five 2,750 kW AC generators, which comprise the Generator Engines emission unit group described in Table 2. Because cementing equipment and cranes are electrified, the *Polar Pioneer* generators provide the primary power for the drilling as well as the ship utilities, and the number of units and load levels vary throughout the drilling process.

Although at least several of the main generators operate continuously while the *Polar Pioneer* is onsite, other diesel engines (described below) are used only occasionally for specialized and intermittent tasks.

1.1.2.2 Hydraulic Power Units

The HPUs consist of two approximately 250 hp engines and are used primarily for assisting in the rotation of the up to 30-foot diameter bit for drilling the MLCs. These engines may also be used occasionally for other unspecified tasks.

1.1.2.3 Logging Unit, Compressor, and Sidewall Core Tool Engines

The logging unit, compressor, and sidewall core tool engines are portable equipment associated with the planned acquisition of a standardized subsurface evaluation program at each drill site.

This portable equipment will provide the energy to run the EWL program, the ZVSP program, and the sidewall coring program at each drill site. The compressor required to conduct the ZVSP program will be used infrequently to collect localized geophysical data at various depths in each well.

1.1.2.4 Emergency Generator Engine

The *Polar Pioneer* has a TEJOS MTU 12-396 1,120 kW emergency generator to power basic drill unit utilities if the primary power system is inoperable. It is capable of powering only domestic and worker safety devices and not the drilling equipment. There are no planned uses of the emergency generator except weekly exercising, which involves operation for approximately 20 minutes at loads up to capacity.

1.1.2.5 Small Emergency Engines

The *Polar Pioneer* has a Rescue Boat equipped with a Harding 212 hp engine, four lifeboats each equipped with a Vetus 52 hp engine, a forward fast rescue craft with a Bukh 144 hp engine, and an Aft fast rescue craft with a Volvo 147 kW engine. The only planned use of the boats is monthly exercising to comply with Coast Guard requirements. In addition, an emergency start compressor engine with a Hatz 11 hp engine is onboard the *Polar Pioneer*.

1.1.2.6 Boilers

The *Polar Pioneer* has two diesel-fired boilers to provide domestic and workspace heating.

1.1.2.7 Waste Incinerator

Domestic and other non-hazardous materials are to be incinerated as needed. This incinerator is a multi-chamber unit capable of burning 100 kilograms per hour (kg/hr) of solid trash. Its incineration capacity is limited to 500 kilocalories per hour (kcal/hr) (580 kW) of heat.

1.2 Support Vessels

The drilling units will be supported by ice management vessels, anchor handlers, science vessels, support tugs, offshore supply vessels (OSVs), oil spill response vessels (OSRVs), tankers, and other vessels as described in the following sections.

1.2.1 Ice Management and Anchor Handling Vessels

The ice management and anchor handling vessels are expected to consist of five contracted ships: two primary ice management vessels and three anchor handling vessels. An anchor handling vessel will provide close support to each drilling unit or work to preset anchors at another drill site, while other primary ice management vessels will normally work several miles upwind of each drilling unit and may monitor the leading edge of any ice floe of possible concern, far upwind up to 30 nautical miles from a drilling unit as described under Appendix G of the EP Revision 2. These activities are necessary for managing ice at distances that provide adequate response time for drilling units to get off a well and anchor in case of encroaching ice that cannot be managed. These response times may vary depending on the drilling stage of the well hole.

Managing ice involves deflecting or, in extreme cases, fragmenting ice floes that could impact the drilling unit when it is drilling. Removal of ice buildup on the upstream side of the drilling unit by "bow washing" may also occur. Bow washing involves backing the anchor handling vessel close to the drilling unit, and pushing the ice to one side or the other with its propeller wash, thereby clearing the ice.

1.2.2 Science Vessels

Two science vessels are responsible for monitoring drill discharges and other science-related tasks. The vessels will sample drilling plume effluent during certain phases of the well drilling. Section 13a of the EP Revision 2 provides a description of drill discharge monitoring conducted by the science vessels. These vessels may also serve to conduct other tasks when not required to conduct discharge monitoring.

1.2.3 Support Tugs

Tug boats will provide support to each of the drilling units. Two tugs will be used to deliver the *Polar Pioneer* to the drilling location and will remain on location in standby mode during drilling operations in case the *Polar Pioneer* must leave location quickly. In addition, another single tug will escort the *Discoverer* to the drill site, assist during mooring, and depart when no longer required. For most of the drilling season, the tugs located onsite will be anchored or will be operated at low speed.

1.2.4 Offshore Supply Vessels

Three OSVs will shuttle equipment and supplies between the drilling units and shore base locations that are out of the Program Area. For example, an OSV will transit to the *Discoverer,* and then position itself in dynamic positioning (DP) mode beside the drilling unit for a day or longer for material or personnel transfer. At any one time, at most only one OSV is expected to be at each drill site location off-loading supplies.

1.2.5 Oil Spill Response Vessels

The OSRVs at the Burger Prospect will include a main OSRV equipped with three 34-foot work boats, and an oil spill response (OSR) tug/barge. These OSRVs will be used in the unplanned and unlikely event of an oil discharge to the water. During the drilling season, these vessels will primarily be used during refueling operations to protect against possible spills and will be located near the refueling Arctic oil storage tanker (OST). These vessels will be available to both the *Discoverer* and the *Polar Pioneer*.

The work boats will remain on the deck of the OSRV and be deployed in the water for training, drills, and response events. Two work boats will be used to tow containment booms, while a third will be used as a backup, for crew changes, and for re-fueling. OSRVs will have on-water drills at a maximum frequency of once per day.

1.2.6 Arctic Oil Storage Tanker

An Arctic OST will reside near the drilling units, and is expected to be staged at the Burger Prospect for the purpose of refueling all the vessels. In the unlikely event of a well-control incident, it will also serve as a receiver of any oil skimmed by the OSRVs. The tanker will be anchored for most of the drilling season, and refueling is expected to involve the other vessel moving to the tanker, with one or more vessels providing booming support during fuel transfers. An onboard incinerator may exist to burn solid waste.

A second OST will be inside the Program Area (i.e., Lease Sale 193 Area) during exploration drilling but not within the 25-mile radius. Therefore, no emission estimates are provided for the second tanker in the AQRP or NEPA emission inventories. The emissions associated with this second OST are comparable to the Arctic OST. In the event of an extended well-control incident, the second OST will transit to the Burger Prospect to provide increased storage capacity for any collected oil.

1.2.7 MLC ROV System Vessel

As described in the EP Revision 2, a vessel capable of operating in DP may be used to provide equipment to excavate MLCs at the Burger Prospect independently of the main drilling units. The MLC ROV system equipment on this vessel includes a dedicated engine to drive specialized underwater gear on or near the seafloor. Section 2d of the EP Revision 2 provides a description of the MLC ROV system and the anticipated use of the MLC ROV system vessel.

1.2.8 Candidate Vessels

Each of the above-listed support vessels may be contracted on a year-to-year basis, and Shell is not certain that the vessels currently described for the project will be available for each drilling season. Table 3 identifies the categories of support vessels and the currently anticipated vessels to be located within 25 miles of one of the drilling units while conducting exploratory drilling.

In addition to the vessels listed in Table 3, other vessels will be located outside of the Chukchi Sea program area and will provide logistical support (see the EP Revision 2, Table 13.a-3). Table 4 lists the emission units associated with each of the support vessels.

Table 3. Support Vessels [a]

Category	Candidate Vessel
***Discoverer* Support Vessels**	
Ice Management	*Fennica*
Anchor Handler	*Aiviq*
Science Vessel	TBD (similar to *Harvey Supporter*)
Support Tug	*Lauren Foss*
***Polar Pioneer* Support Vessels**	
Ice Management	*Nordica*
Anchor Handler	*Tor Viking*
Science Vessel	TBD (similar to *Harvey Explorer*)
Support Tug	*Ocean Wind*
Support Tug	*Ocean Wave*
Common Support Vessels	
Anchor Handler	*Ross Chouest*
Offshore Supply Vessel	*Sisuaq*
Offshore Supply Vessel	*Harvey Supporter*
Oil Spill Response Vessel	*Nanuq*
Oil Spill Response Workboats	(3) 34-foot *Kvichaks* (on *Nanuq*)
Offshore Oil Spill Response Tug/Barge	*Guardsman/Klamath*
Arctic Oil Storage Tanker	TBD (similar to *Affinity*)
MLC ROV System Vessel	TBD (similar to *Harvey Spirit*)

[a] All vessels are assumed to be located within 25 miles of a drilling unit during exploration drilling for the air quality analysis.

Table 4. Support Vessel Emission Units

Vessel and Emission Units	Aggregate Nameplate Rating [a]
***Discoverer* Support Vessels**	
Ice Management (*Fennica*)	
Propulsion and Generator Engines	21,000 kW
Harbour Set Generator Engine	530 kW
Boilers	9 MMBtu/hr
Incinerator	154 lb/hr
Emergency Generator	300 kW
Anchor Handler (*Aiviq*)	
Propulsion Engines	16,251 kW
Generator Engines	6,800 kW
Boilers	5 MMBtu/hr
Incinerator	276 lb/hr
Emergency Engines	1,820 kW
Rescue & Lifeboat Engines	678 kW
OSR Equipment Engines	190 kW
Science Vessel (TBD, similar to *Harvey Supporter*)	
Propulsion and Generator Engines	7,300 kW
Emergency Engines	125 kW
Incinerator	88 lb/hr
Support Tug (*Lauren Foss*)	
Propulsion Engines	6,119 kW
Generator Engines	340 kW
Emergency Engine	70 kW
Thruster Engine	373 kW
***Polar Pioneer* Support Vessels**	
Ice Management (*Nordica*)	
Propulsion and Generator Engines	21,000 kW
Harbour Set Generator Engine	530 kW
Boilers	9 MMBtu/hr
Incinerator	154 lb/hr
Emergency Generator	300 kW
Anchor Handler (*Tor Viking*)	
Propulsion Engines	13,440 kW
Generator Engines	1,000 kW
Boilers	1.37 MMBtu/hr
Emergency Generator	170 kW
Science Vessel (TBD, similar to *Harvey Explorer*)	
Propulsion Engines	3,373 kW
Generator Engines	1,032 kW
Thruster Engines	1,672 kW
Emergency Engines	134 kW
Support Tug (*Ocean Wind*)	
Propulsion Engines	8,119 kW
Generator Engines	465 kW

Table 4. Support Vessel Emission Units (continued)

Vessel and Emission Units	Aggregate Nameplate Rating [a]
Support Tug (*Ocean Wave*)	
Propulsion Engines	8,119 kW
Generator Engines	465 kW
Common Support Vessels	
Anchor Handler (*Ross Chouest*)	
Propulsion and Generator Engines	12,529 kW
Various Engines	1,433 kW
Emergency Engine	320 kW
OSV (*Sisuaq*)	
Propulsion and Generator Engines	7,300 kW
Emergency Engines	125 kW
Various Engines	672 kW
OSR Equipment Engines	355 kW
Incinerator	88 lb/hr
OSV (*Harvey Supporter*)	
Propulsion and Generator Engines	7,300 kW
Emergency Engines	125 kW
OSR Equipment	270 kW
Incinerator	88 lb/hr
OSRV (*Nanuq*)	
Propulsion Engines	5,420 kW
Generator Engines	1,918 kW
Emergency Engines	188 kW
OSR Equipment	365 kW
Incinerator	125 lb/hr
OSR Workboats (Kvichaks)	
Propulsion and Generator Engines	1,370 kW
OSR-T/B (*Guardsman/Klamath*)	
Propulsion Engines	5,373 kW
Generator Engines	299 kW
OSR Equipment Engines	662 kW
Arctic Oil Storage Tanker (TBD, similar to *Affinity*)	
Propulsion and Generator Engines	19,180 kW
Emergency Engines	295 kW
Various Engines	1,431 kW
Boiler	53 MMBtu/hr
Incinerator	188 lb/hr
MLC ROV System Vessel (TBD, similar to *Harvey Spirit*)	
Propulsion Engines	4,582 kW
Generator Engines	1,440 kW
Thruster Engines	2,799 kW
Emergency Engines	99 kW
MLC ROV System Engine	1,000 kW

[a] "Aggregate Nameplate Rating" indicates the combined total rating/output for units in the group type.

2.0 OFFSHORE AIR EMISSIONS

Section 2.1 of this chapter describes the activity of the vessels and the emission units on them. Section 2.2 identifies emission factors for each pollutant and emission unit. Together, the activity level and emission factors enable the calculation of short-term and annual emissions. Section 2.3 of this chapter presents the emissions as appropriate for the AQRP emission inventory that is estimated according to 30 CFR Part 550 Subpart C, while section 2.4 presents emissions to support the NEPA emission inventory.

Air pollutants addressed here are NO_X, CO, particulate matter (PM_{10} and $PM_{2.5}$), VOC, SO_2, lead (Pb), and greenhouse gases (GHG). Short-term emissions are expressed as pounds of pollutant per hour (lb/hr). Long-term emissions are presented as tons of pollutant per year. In effect, the long-term emissions represent annual emissions over a maximum 120-day drill season, and the terms long-term, seasonal, and annual emissions are used interchangeably.

2.1 Vessel and Emission Unit Activity

Calculated short-term emissions are based on engine nameplate ratings, modified by limitations established from a combination of safety policies and good engine care policies. In practice, maximum continuous power ratings of marine engines are typically 10 to 20 percent below nameplate power ratings. Such good engine operating practices extend equipment life.[1] In these calculations, the maximum operating rate for each engine is assumed to be 80 percent of the nameplate rating in both the AQRP and NEPA inventories. In addition, the 80 percent short-term maximum load was used along with the engine or engine group aggregate rating to determine the maximum aggregate rating. All boilers and incinerators are assumed to have a maximum load of 100 percent for both the AQRP and NEPA inventories.

Annual emissions from the drilling units are based on continuous operation of engines (at 80 percent load) for the entire 120-day season. To calculate annual emissions from support vessels, Shell has committed to annual fuel restrictions on the support vessels that are based on 2012 operational data, information supplied by the vessel owners or operators, or anticipated seasonal use. The proposed fuel restrictions apply to main generation and propulsion equipment on the support vessels. The proposed annual fuel restrictions for the support vessels presented in Table 5 are applied to both the AQRP and NEPA emission inventories. Limited fuel combusted by support vessels outside of the 25-mile radius of the drilling units is expected to result in emissions that are well dispersed. These fuel restrictions result in an emission

[1] Documentation of this practice is further explained in the January 11, 2012, letter from Susan Childs to the U.S. Environmental Protection Agency's (EPA's) Natasha Greaves (included under Attachment E). This practice was applied during the actual 2012 source testing required under the EPA air permit and was described under the *Discoverer* Drillship Test Protocol submitted to EPA's Natasha Greaves on February 22, 2012. EPA demonstrated concurrence with the 80 percent assumption by issuing permits and consent orders based on applications that included emission inventories and modeling performed using the 80 percent maximum power limit. The permits included fuel restrictions and emission limits that were calculated based on the 80 percent assumption.

reduction of 44 to 90 percent, depending on the vessel (see Attachment D, Table D-13 for additional details). For similar vessels, a combined fuel restriction is proposed for similar vessels within the group. This applies to the Ice Management group, consisting of the *Fennica* and *Nordica*, and the OSV-type, consisting of the Harvey Gulf Tiger-class vessels, the *Sisuaq* and *Supporter*.

Table 5. Support Vessel Proposed Annual Fuel Restrictions

Category	Candidate Vessel	Proposed Annual Fuel Restriction (gallons/year)
Ice Management	*Fennica* Propulsion and Generator Engines	642,600
Ice Management	*Nordica* Propulsion and Generator Engines	630,000
	Total – Ice Management Group	1,272,600
Anchor Handler	*Aiviq* Propulsion and Generator Engines	1,440,012
Anchor Handler	*Tor Viking* Propulsion and Generator Engines	567,000
Anchor Handler	*Ross Chouest* Propulsion and Generator Engines	420,000
Science Vessel	*Harvey Supporter* Propulsion and Generator Engines	273,000
Science Vessel	*Harvey Explorer* Propulsion and Generator Engines	273,000
OSV	*Sisuaq* Propulsion and Generator Engines	117,852
OSV	*Harvey Supporter* Propulsion and Generator Engines	117,852
	Total – OSV-Type Group	781,704
Support Tug	*Lauren Foss* Propulsion Engines	96,348
Support Tug	*Ocean Wind* Propulsion Engines	399,840
Support Tug	*Ocean Wave* Propulsion Engines	399,840
OSRV	*Nanuq* Propulsion Engines	504,000
OSR-T/B	*Guardsman/Klamath* Propulsion Engines	154,350
Arctic Oil Storage Tanker	*Affinity* Propulsion and Generator Engines	323,400
MLC ROV System Vessel	*Harvey Spirit* Propulsion Engines	111,300

2.2 Emission Factors

NO_X, CO, PM, VOC, and Pb emissions are calculated based on an activity level (discussed in Section 2.1) and an "emission factor" that is expressed as a mass of emissions for a given activity level. The emission factors were selected based on a hierarchy of available data. First, when available, emission tests of a specific engine or group of engines (referred to as a source test) were used to determine emission factors. If source test data were not available, emission factors provided by engine vendors were used. If neither source tests nor vendor data were available, emission factors were selected from the EPA's compilation of emission factors (commonly referred to as AP-42).

There are two exceptions to this hierarchy. First, the NO_X emission factor for the *Discoverer* propulsion engine is based on IMO Annex VI, Tier 2. Second, SO_2 emissions from diesel combustion are calculated based on sulfur content of the fuel, assuming 100 parts per million by volume (ppmv) to account for any fuel blending that may occur when ULSD or lower sulfur content fuels are added during the drilling season to the residual fuels in the tanks that may exist prior to the start of the exploration season.

In the AQRP and NEPA emission inventories, Shell has elected to apply emission factors with pollutant reductions to account for some of the existing control technologies that are currently installed on drilling units and support vessels. Emission factors with emission controls applied are only used where reductions are necessary to demonstrate compliance with these programs. For example, the *Discoverer*, *Fennica*, *Nordica*, *Aiviq*, *Tor Viking*, and *Nanuq* vessels are currently equipped with CDPF and OxyCat emission controls on certain equipment to reduce PM, CO, and VOC emissions. However, these emission reduction technologies are only applied to emission factors in the NEPA emission inventories. CDPF and OxyCat emission reduction technologies are not applied under the AQRP emission inventory because these reductions are not necessary for demonstrating compliance under the AQRP.

The *Discoverer* primary generators have been retrofitted with CleanAIR's E-POD™ system to actively reduce NO_X, using SCR technology. NO_X reacts selectively with ammonia across a catalyst and is reduced to nitrogen and water. The E-POD™ combines SCR technology with oxidation catalysts or particulate filters that reduce PM, CO, and hydrocarbon emissions as well. The *Aiviq's* propulsion and generator engines also contain an E-POD™ system. The *Fennica, Nordica*, and *Tor Viking* main engines have been retrofitted with a different SCR and oxidation catalyst system for the control of NO_X, PM, CO, and VOC emissions. The *Nanuq's* propulsion and generator engines have been retrofitted with CleanAIR's PERMIT™ filter system for the control of PM, CO, and hydrocarbons. Table 6 summarizes the emission units with emission controls.

As shown in Table 6, Shell has installed SCR pollutant control technologies on certain equipment on the drilling units and support vessels. However, no NO_X pollutant reductions for the SCR emission control technologies currently installed are applied to the emission factors used in the AQRP and NEPA emission inventories. The SCR emission reductions are not necessary to demonstrate compliance under the AQRP or NEPA.

Table 6. Units with Emission Controls

Category	Emission Unit	Controls [a]
Drilling Unit	*Discoverer* – Main Generator Engines	SCR and CDPF
Ice Management	*Fennica* – Propulsion and Generator Engines	SCR and OxyCat
Ice Management	*Nordica* – Propulsion and Generator Engines	SCR and OxyCat
Anchor Handler	*Aiviq* – Propulsion Engines	SCR and DOC
Anchor Handler	*Aiviq* – Generator Engines	SCR and CDPF
Anchor Handler	*Tor Viking* – Propulsion and Generator Engines	SCR and OxyCat
Oil Spill Response Vessel	*Nanuq* – Propulsion and Generator Engines	CDPF

[a] DOC = Diesel Oxidation Catalyst

As stated, the AQRP emission inventory assumes that 100 ppmv sulfur content fuel is combusted to account for any fuel blending that may occur when ULSD or another fuel with lower sulfur content is added to any residual fuel that may exist in a tank prior to the start of the exploration season. But, the AQRP emission inventory does not apply any of the existing emission control systems listed in Table 6 because they are not required to demonstrate that the project emissions are below the BOEM exemption thresholds. The NEPA emission inventories account for the use of reduced sulfur fuel on all drilling units and vessels, and also acknowledge the reduction of PM from existing emission control devices on the *Fennica, Nordica, Aiviq, Tor Viking*, and *Nanuq* because these are the only emission controls required to demonstrate compliance under NEPA. Even though emissions are not calculated with all identified emission reductions, Shell will attempt to utilize those controls not applied in the AQRP and NEPA emission inventories during exploration drilling.

2.2.1 Source Test Data

Over several years, Shell had numerous emission units source-tested onboard the *Discoverer* and a number of the candidate support vessels. In 2012, prior to exploration drilling, over 800 various source tests were conducted, as required by the now terminated EPA *Discoverer* Prevention of Significant Deterioration Permit to Construct (R10OCS/PSD-AK-09-01) and the *Kulluk* Title V Permit (R10OCS030000). Shell has elected to use these source test results as applicable for a number of the emission units.

In 2007, NO_X emissions from the *Fennica* were measured. These source tests were completed prior to the installation of the SCR control system on the main propulsion engines. In both the AQRP and NEPA emission inventories, Shell uses the measured uncontrolled NO_X emissions from the 2007 tests for both the *Fennica* and the *Nordica*, a sister ship to the *Fennica*.

Also in 2007, as required by the EPA Kulluk Air Quality Control Minor Permit (R10OCS-AK-07-01), NO_X emissions were measured from two engines on the *Tor Viking*. These source tests were conducted with and without the SCR operating. In both the AQRP and NEPA emission inventories, Shell uses the measured uncontrolled NO_X emissions from the 2007 tests for the *Tor Viking*.

Finally, Transocean had the *Polar Pioneer* main engine #3 source-tested in 2014 to determine emission factors for NO_X and CO.[2] These emission factors are representative of the *Polar Pioneer* Generator Engines group, as described in Table 2, and are used in both the AQRP and NEPA inventories.

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[2] PM filterable was measured during the test, but the condensable particulate portion was not measured during the test. Consequently, the PM source test measurements were not used in these emission calculations.

All the source tests were completed at various loads. To calculate emissions for the drilling units and support vessels, Shell averaged measured emission factors over all the loads over similar engines. For example, the source test results for both *Discoverer* HPU engines, at two different loads, were averaged, and a single factor was determined to represent emissions from the *Discoverer* HPU engines group.[3]

Table 7 lists the emission unit groupings that use source test emission factors in the applicable emission inventory. Copies of the source test summary tables can be found in Attachment F, along with applicable portions of the references provided in section 4.0 of this report.

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[3] Because generators typically convert over 90 percent of the energy coming from the engine into electricity, 2012 source test emission factors for generators provided in pounds per kilowatt electrical hour (lb/kWe-hr) were converted to lb/kW-hr by dividing the average group emission factor by 95 percent. This produced a conservative engine emission factor.

Table 7. Emission Unit Groups with Source Test Emission Factors

Vessel – Emission Unit Group	Pollutants	Emission Inventory	Reference
Discoverer – HPU Engines	Uncontrolled: NO_X	AQRP & NEPA	TRC Test Report, 7/27/2012
Discoverer – Cementing Engines	Uncontrolled: NO_X	AQRP & NEPA	TRC Test Report, 7/27/2012
Discoverer – Boilers	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC	AQRP & NEPA	Avogadro Test Report, 7/27/2012
Discoverer – Incinerator	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC	AQRP & NEPA	Avogadro Test Report, 7/27/2012
Polar Pioneer – Generator Engines	Uncontrolled: NO_X, CO	AQRP & NEPA	Ecoxy AS Test Report, 2/14/2014
Polar Pioneer – HPU Engines	Uncontrolled: NO_X	AQRP & NEPA	TRC Test Report, 7/27/2012
Fennica – Propulsion and Generator Engines	Uncontrolled: NO_X	AQRP & NEPA	Alaska Source Testing, LLC Test Report, 6/28/2007
Fennica – Propulsion and Generator Engines	Controlled: PM_{10}, $PM_{2.5}$	NEPA	TRC Test Report, 8/9/2012
Fennica – Boilers	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Fennica – Incinerator	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Nordica – Propulsion and Generator Engines	Uncontrolled: NO_X	AQRP & NEPA	Alaska Source Testing, LLC Test Report, 6/28/2007
Nordica – Propulsion and Generator Engines	Controlled: PM_{10}, $PM_{2.5}$	NEPA	TRC Test Report, 8/9/2012
Nordica – Boilers	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Nordica – Incinerator	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Aiviq – Propulsion Engines	Controlled: PM_{10}, $PM_{2.5}$	AQRP & NEPA [a]	TRC Test Report, 8/9/2012
Aiviq – Generator Engines	Controlled: PM_{10}, $PM_{2.5}$	NEPA	TRC Test Report, 8/9/2012
Aiviq – Incinerator	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Tor Viking – Propulsion and Generator Engines	Uncontrolled: NO_X	AQRP & NEPA	TRC Test Report, 7/12/2007
Tor Viking – Propulsion and Generator Engines	Controlled: PM_{10}, $PM_{2.5}$	NEPA	TRC Test Report, 8/9/2012
Tor Viking – Boilers	Uncontrolled: NO_X, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Harvey Explorer – Propulsion Engines	Uncontrolled: NO_X, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Harvey Explorer – Generator Engines	Uncontrolled: NO_X, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Harvey Explorer – Thruster Engines	Uncontrolled: NO_X, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012

Table 7. Emission Unit Groups with Source Test Emission Factors (continued)

Vessel – Emission Unit Group	Pollutants	Emission Inventory	Reference
Nanuq – Propulsion Engines	Uncontrolled: NO_X	AQRP & NEPA	TRC Test Report, 7/26/2012
Nanuq – Propulsion Engines	Controlled: PM_{10}, $PM_{2.5}$	NEPA	TRC Test Report, 7/26/2012
Nanuq – Generator Engines	Uncontrolled: NO_X	AQRP & NEPA	TRC Test Report, 7/26/2012
Nanuq – Generator Engines	Controlled: PM_{10}, $PM_{2.5}$	NEPA	TRC Test Report, 7/26/2012
Kvichaks – OSR Workboats Propulsion & Generator Engines	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Sisuaq – Propulsion and Generator Engines	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Harvey Spirit – Propulsion Engines	Uncontrolled: NO_X, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Harvey Spirit – Generator Engines	Uncontrolled: NO_X, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012
Harvey Spirit – Thruster Engines	Uncontrolled: NO_X, PM_{10}, $PM_{2.5}$	AQRP & NEPA	TRC Test Report, 8/9/2012

[a] The controlled emission factor was applied for the AQRP emission inventory because the uncontrolled vendor data PM emission factor was less than the controlled source test emission factor. See Section 2.4 for more information.

2.2.2 Vendor Data

In those cases where source test data were unavailable, vendor emissions data were selected, if available. In other cases, source test data were available for a controlled engine but an uncontrolled emission factor was needed for the emission inventory.

Because the *Discoverer* Caterpillar D399 generator engines were replaced in 2013 with Caterpillar 3512C engines, the 2012 source test data results for these engines are no longer applicable. Vendor data for the Caterpillar 3512C engines were received from Louisiana CAT (Attachment F) with Rated Speed "Nominal Data" for NO_X, CO, hydrocarbon (HC), and particulate matter in lb/hr. These emissions represent uncontrolled engine emissions and were converted to grams per kilowatt hour (g/kW-hr) for use in the emission inventories. Even though controls are present and will be used throughout the season on the generators, the *Discoverer* generation emission factors do not apply any emission reduction.

Because *Discoverer* cranes were replaced in 2013, the 2012 source test data results are no longer applicable. Liebherr Machines Bulle SA, the manufacturer of the cranes, provided an "Exhaust Emission Confirmation" for the installed engine D9508 A7. These emission values are used for the *Discoverer* cranes emission unit group and can be found in Attachment F.

The *Aiviq* propulsion engines are Caterpillar C280-12, and the "Diesel Engine Technical Data" sheet was provided by Caterpillar. Emissions "Nominal Data" are provided on the sheet and the uncontrolled NO_X, CO, and total hydrocarbon (THC) emission rates were used for the *Aiviq* propulsion engines emission unit group. The Caterpillar C280-12 technical data sheet is provided in Attachment F. Two tug boats proposed to be part of the support vessels, the *Ocean Wind* and *Ocean Wave*, have propulsion engines that are Caterpillar C280-12 engines. The vendor uncontrolled NO_X, CO, THC, and particulate emission rates have been used for these engines as well.

Finally, a Cummins KTA50-G3, 1,340 hp engine will be placed onboard the MLC ROV system vessel to excavate MLCs. A Cummins Exhaust Emissions Data Sheet for this engine is provided in Attachment F. The continuous power emissions of HC, NO_X, CO, and PM are used in both emission inventories. Table 8 lists the emission unit groups with vendor emission factors.

Table 8. Emission Unit Groups with Vendor Emission Factors

Vessel – Emission Unit Group	Pollutants	Emission Inventory	Reference
Discoverer – Generator Engines	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC	AQRP & NEPA	Louisiana CAT, 9/17/2013
Discoverer – Propulsion Engine	Uncontrolled: NO_X	AQRP & NEPA	STX-MAN B&W
Discoverer – Cranes	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC	AQRP & NEPA	Liebherr, 11/26/2012
Discoverer and *Polar Pioneer* – Logging Unit Engine	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC	AQRP & NEPA	Caterpillar, 4/16/2012
Discoverer and *Polar Pioneer* – Compressor Engine	Uncontrolled: NO_X, CO, VOC	AQRP & NEPA	Detroit, 6/29/1989
Discoverer and *Polar Pioneer* – Sidewall Core Tool Engine	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC	AQRP & NEPA	John Deere, 2012
Aiviq – Propulsion Engines	Uncontrolled: NO_X, CO, VOC	AQRP & NEPA	Caterpillar, 5/3/2011
Aiviq – Generator Engines	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC	AQRP	CleanAIR Systems, 4/7/2010
Aiviq – Generator Engines	Uncontrolled: NO_X, CO, VOC	NEPA	CleanAIR Systems, 4/7/2010
Ocean Wind/Ocean Wave – Propulsion Engines	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC	AQRP & NEPA	Caterpillar, 5/3/2011
Harvey Spirit – MLC ROV System Engine	Uncontrolled: NO_X, CO, PM_{10}, $PM_{2.5}$, VOC	AQRP & NEPA	Cummins, 4/16/2002

2.2.3 EPA's AP-42 Compilation of Air Pollutant Emission Factors

Where emissions data are not available from source tests or vendors, emission factors from EPA's AP-42 have been applied.

Diesel internal combustion (IC) engine emission factors from AP-42 Chapter 3 are applied for Stationary Internal Combustion Sources, Section 3.3, Gasoline and Diesel Industrial Engines, Table 3.3-1 (<600 hp). In addition, factors are applied from Section 3.4, Large Stationary Diesel and All Stationary Dual-fuel Engines, Table 3.4-1 (>600 hp). Table 9 and Table 10 list these emission factors.

Table 9. EPA AP-42, Table 3.3-1, Emission Factors for Uncontrolled Diesel Industrial Engines

Units	NO_X	CO	PM	TOC [a]
lb/hp-hr	0.031	6.68E-3	2.20E-3	2.47E-3

g/kW-hr	18.8	4.1	1.3	1.5

[a] TOC = Total Organic Compounds.

Table 10. EPA AP-42, Table 3.4-1, Gaseous Emission Factors for Large Stationary Diesel Engines

Units	NO_X	CO	PM	TOC
lb/hp-hr	0.024	5.5E-3	0.0007	0.000705
g/kW-hr	14.59	3.34	0.43	0.43

Boiler emission factors were taken from AP-42's Chapter 1 for external combustion sources, Section 1.3 for fuel oil combustion. NO_X, CO, and filterable PM emission factors for boilers less than 100 MMBtu/hr that fire distillate oil from Table 1.3.1 are applied. The total condensable PM for No. 2 oil-fired emission factor, 2 lb/k-gal, from AP-42 Table 1.3-2 is applied. The filterable PM and total condensable PM were combined to determine the PM_{10} and $PM_{2.5}$ boiler emission factor of 3.3 lb/k-gal. Finally, the non-methane total organic compounds (NMTOC) emission factors for commercial/institutional/residential combustors that fire distillate oil from Table 1.3-3 are applied. A summary of all the boiler emission factors used from AP-42 Section 1.3 are listed in Table 11.

Table 11. Summary of EPA AP-42, Section 1.3 Fuel Oil Combustion Emission Factors

Units	NO_X	CO	PM	NMTOC
lb/k-gal	20	5.0	3.3	0.34

Incinerator emission factors from AP-42's Chapter 2 are applied for solid waste disposal, Section 2.1 for refuse combustors. The uncontrolled NO_X and CO emission factors for modular starved-air combustors from Table 2.1-9 are applied. In an effort to be more conservative, the uncontrolled PM emission factor for mass burn and modular excess air combustors from Table 2.1-2 are applied. Finally, the TOC emission factor for industrial/commercial, multiple chamber refuse combustors other than municipal waste from Table 2.1-12 is applied. A summary of all the incinerator emission factors used from AP-42 Section 2.1 are listed in Table 12.

Table 12. Summary of EPA AP-42, Section 2.1 Refuse Combustors Emission Factors

Units	NO_X	CO	PM	TOC
lb/ton	3.16	0.299	25.1	3.0

2.2.4 Sulfur Dioxide Emissions

Shell has committed to purchase and use ULSD fuel or fuel with lower sulfur content during the drilling season. A material safety data sheet (MSDS) for the fuel type Shell intends to use lists ULSD with a sulfur content of 15 ppm maximum (Attachment F). However, some of the candidate vessels Shell will lease may not utilize ULSD year round when they are not conducting exploratory drilling in the Chukchi Sea. The AQRP and NEPA inventories include SO_2 emissions that are calculated assuming conservative 100 ppm sulfur content. This higher sulfur content accounts for the potential for fuel blending of residual non-ULSD fuel that remains in fuel tanks prior to the drilling season with the ULSD that Shell purchases.

Attachment F also provides a copy of the email from Royal Harris dated April 20, 2011, providing details on the diesel produced by Tesoro Nikiski. The email states the specific gravity of ULSD as 0.8398 using "ASTM D4052 - Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter." This specific gravity was used to calculate the density of diesel as follows:

$$Diesel\ Density = 0.8398 \times 8.34 \frac{lb}{gallon} (density\ of\ water) = 7.0\ lb/gallon \tag{1}$$

In addition, the email supports a net diesel heat content of 131,180 Btu/gallon that was utilized in the AQRP and NEPA emission inventories for the calculation of emissions.

2.2.5 Greenhouse Gas Emissions

Greenhouse gases are not a regulated pollutant by BOEM but are relevant to BOEM's NEPA analysis and are presented in Shell's Environmental Impact Analysis (EIA) addressing the EP Revision 2. 40 CFR Part 98, Subpart C, Table C-1 and Table C-2, provide GHG emission factors for various types of fuel. The carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emission factors for distillate fuel oil No. 2, municipal waste, and petroleum are used from Tables C-1 and C-2 for use in the emission inventories. Table 13 and Table 14 list the emission factors used from Part 98 to calculate GHG emissions. These emission factors, along with the global warming potentials from Part 98 Table A-1 listed in Table 15, are used to determine the CO_2 equivalent (CO_2e) emissions, also referred to as GHG emissions. Equation 2 below shows the CO_2e emission factor used for all diesel combustion sources in the NEPA emission inventory.

Table 13. Table C-1 to Subpart C of Part 98—Default CO_2 Emission Factors

Source	CO_2 kg/MMBtu
Distillate Fuel Oil No. 2	73.96
Municipal Solid Waste	90.7

Table 14. Table C-2 to Subpart C of Part 98—Default CH_4 and N_2O Emission Factors for Various Types of Fuel

Source	CH_4 kg/MMBtu	N_2O kg/MMBtu
Petroleum	3.0E-3	6.0E-4
Municipal Solid Waste	3.2E-2	4.2E-3

Table 15. Table A-1 to Subpart A of Part 98—Global Warming Potentials

Chemical Formula	Global Warming Potential (100 yr)
CO_2	1
CH_4	25
N_2O	298

$$CO_2e = 1 \times 73.96\frac{kg}{MMBtu} + 25 \times 3.0E-3\frac{kg}{MMBtu} + 298 \times 6.0E-4\frac{kg}{MMBtu} = 74.21\frac{kg}{MMBtu} \qquad (2)$$

2.2.6 Lead Emissions

Because lead emission factors for diesel-fired internal combustion engines are not provided in AP-42 Chapter 3, Sections 3.3 and 3.4, EPA's Locating and Estimating (L&E) Air Emissions from Lead Sources and Lead Compounds report was used. Section 5.2.2 of this report provides an emission factor of 2.9E-5 lb/MMBtu for distillate oil-fired gas turbines. These emission factors should be representative of any distillate-fired combustion device.

EPA's AP-42 was used to determine appropriate boiler and incinerator emission factors. A boiler emission factor of 9 lb/10^{12} Btu was used from Chapter 1: External Combustion Sources, Section 1.3: Fuel Oil Combustion, Table 1.3-10: Emission Factors for Trace Elements from Distillate Fuel Oil Combustion Sources. An incinerator emission factor of 2.13E-1 lb/ton was taken from Chapter 2 for solid waste disposal, Section 2.1 for refuse combustors, Table 2.1-2 (Particulate Matter, Metals, and Acid Gas Emission Factors for Mass Burn and Modular Excess Air Combustors).

2.3 AQRP Offshore Emissions Summary

The AQRP emission inventory addresses the emissions from the "facility," which is defined at 30 CFR 550.302 to mean:

> *any installation or device permanently or temporarily attached to the seabed which is used for exploration, development, and production activities for oil, gas, or sulphur and which emits or has the potential to emit any air pollutant from one or more sources. All equipment directly*

associated with the installation or device shall be considered part of a single facility if the equipment is dependent on, or affects the processes of, the installation or device.

In addition to presenting emissions for the drilling units, Shell also presents aggregate emissions for the facility that include the support vessels operating within 25 miles of the drilling units.

The AQRP emission inventory was developed for sources without consideration of emission control technologies, but does include good engine operating practices (i.e., engine power restrictions for ensuring extended equipment life) and proposed seasonal fuel restrictions for the support vessels. Note that the proposed fuel restrictions apply only to main generation and propulsion equipment of some of the support vessels.

The AQRP emissions are based on the conservative assumption that all engines on the *Discoverer* and the *Polar Pioneer* operate every hour of the season at 80 percent load. The boilers and incinerators associated with the drilling units are assumed to operate at rated capacity every hour of the season.

Emissions from the *Discoverer* Support Tug (*Lauren Foss*) generator and thruster engines are based on 21 days per season of operation.

Emissions from all emergency generator engines, lifeboat engines, rescue crafts, and seldom-used engines onboard the support vessels are based on a conservative assumption of 500 hours of operation per season.

Emissions from the small OSR equipment used during training exercises are based on operation of eight hours per day and 120 days of operation per season.

Emissions from propulsion and generator engines onboard the support vessels are based on seasonal fuel restrictions except for the following engines:

- *Fennica* – Harbor Set Generator Engine and Emergency Engine
- *Nordica* – Harbor Set Generator Engine and Emergency Engine
- *Ocean Wind* – Generator Engines
- *Ocean Wave* – Generator Engines
- *Nanuq* – Generator Engines, Emergency Engines, and OSR Equipment Engines
- *Kvichaks* – Propulsion and Generator Engines
- *Guardsman/Klamath* – Generator Engines and OSR Equipment Engines

- MLC ROV System Vessel (*Harvey Spirit*) – Generator Engines, Thruster Engine, Emergency Engine, and MLC ROV System Engine

These engines and the remaining units onboard the drilling units and support vessels are estimated based on 24 hours per day, 120 days per season, for a total of 2,880 hours per season with exception of "Emergency" and "OSR Equipment" engines. Table 16 presents the estimated AQRP projected annual emissions. Attachment A provides the detailed emission calculation summaries.

Table 16. AQRP Projected Annual Emissions [a]

Emission Unit	NO_X ton/year	CO ton/year	PM_{10} ton/year	$PM_{2.5}$ ton/year	VOC ton/year	SO_2 ton/year
Discoverer						
Generator Engines	99.0	21.8	2.7	2.7	7.6	7.6E-1
Propulsion Engine	233.9	55.0	7.0	7.0	7.1	7.5E-1
HPU Engines	2.8	3.8	1.2	1.2	1.4	4.2E-2
Crane Engines	8.3	1.3	0.2	0.2	0.2	1.0E-1
Cementing Unit Engines	16.0	5.2	1.7	1.7	1.9	5.8E-2
Logging Unit Engine	2.3	2.0	0.1	0.1	2.3	2.6E-2
Compressor Engine	3.9	2.6	0.4	0.4	0.2	1.2E-2
Sidewall Core Tool Engine	0.8	0.5	4.3E-2	4.3E-2	0.8	4.9E-3
Emergency Engine	18.8	4.3	0.5	0.5	0.6	5.8E-2
Lifeboat Engines	4.2	0.9	0.3	0.3	0.3	1.0E-2
Boilers	3.6	0.4	5.2E-2	5.2E-2	1.5E-2	2.4E-1
Incinerator	0.6	2.2	1.4	1.4	7.5E-2	6.9E-1
Total – *Discoverer*	**394.3**	**100.1**	**15.7**	**15.7**	**22.3**	**2.8**
Polar Pioneer						
Generator Engines	396.4	49.6	14.9	14.9	15.0	1.6
HPU Engines	2.9	3.9	1.3	1.3	1.4	4.3E-2
Logging Unit Engine	2.3	2.0	0.1	0.1	2.3	2.6E-2
Compressor Engine	3.9	2.6	0.4	0.4	0.2	1.2E-2
Sidewall Core Tool Engine	0.8	0.5	4.3E-2	4.3E-2	0.8	4.9E-3
Emergency Engine	41.5	9.5	1.2	1.2	1.2	1.3E-1
Small Emergency Engines	27.6	6.0	2.0	2.0	2.2	6.6E-2
Boilers	5.6	1.4	0.9	0.9	0.1	3.9E-1
Incinerator	0.5	4.7E-2	4.0	4.0	0.5	5.5E-1
Total - Polar Pioneer	**481.5**	**75.7**	**24.7**	**24.7**	**23.6**	**2.8**
***Discoverer* Support Vessels**						
Ice Management (*Fennica*)						
Propulsion and Generator Engines	93.6	33.1	4.2	4.2	4.2	4.5E-1
Harbour Set Generator Engine	19.6	4.5	0.6	0.6	0.6	6.1E-2
Boilers	1.6	3.8E-2	5.2E-2	5.2E-2	3.3E-2	1.4E-1
Incinerator	0.8	3.3	1.9	1.9	0.3	3.8E-1
Emergency Engine	2.5	0.5	0.2	0.2	0.2	6.0E-3
Anchor Handler (*Aiviq*)						
Propulsion Engines	126.6	8.0	4.0	4.0	11.1	7.1E-1
Generator Engines	49.7	11.3	1.3	1.3	3.4	3.0E-1
Boilers	1.2	0.3	0.2	0.2	2.0E-2	8.1E-2
Incinerator	0.8	2.2	3.6	3.6	0.6	6.9E-1
Emergency Engines	11.7	2.7	0.3	0.3	0.3	3.6E-2
Rescue & Life Boat Engines	5.6	1.2	0.4	0.4	0.4	1.4E-2
OSR Equipment Engines	3.0	0.7	0.2	0.2	0.2	7.3E-3

Table 16. AQRP Projected Annual Emissions [a] (continued)

Emission Unit	NO_X ton/year	CO ton/year	PM_{10} ton/year	$PM_{2.5}$ ton/year	VOC ton/year	SO_2 ton/year
Science Vessel (Similar to *Harvey Supporter*)						
Propulsion and Generator Engines	29.8	5.1	0.7	0.7	1.8	1.9E-1
Emergency Engines	1.0	0.2	0.1	0.1	0.1	2.5E-3
Incinerator	0.2	1.9E-2	1.6	1.6	0.2	2.2E-1
Support Tug (*Lauren Foss*)						
Propulsion Engines	21.7	5.0	0.6	0.6	0.6	6.7E-2
Generator Engines	2.8	0.6	0.2	0.2	0.2	6.9E-3
Emergency Engine	0.6	0.1	4.1E-2	4.1E-2	4.6E-2	1.4E-3
Thruster Engine	3.1	0.7	0.2	0.2	0.2	7.5E-3
Total – *Discoverer* Support Vessels	**376.0**	**79.7**	**20.4**	**20.4**	**24.8**	**3.4**
***Polar Pioneer* Support Vessels**						
Ice Management (*Nordica*)						
Propulsion and Generator Engines	91.8	32.5	4.1	4.1	4.2	4.4E-1
Harbour Set Generator Engine	19.6	4.5	0.6	0.6	0.6	6.1E-2
Boilers	2.0	7.0E-3	3.8E-2	3.8E-2	3.3E-2	1.4E-1
Incinerator	0.2	0.4	0.2	0.2	0.3	3.8E-1
Emergency Engine	2.5	0.5	0.2	0.2	0.2	6.0E-3
Anchor Handler (*Tor Viking*)						
Propulsion Engines	67.0	27.2	3.5	3.5	3.5	3.7E-1
Harbor Generator Engines	5.9	2.0	0.3	0.3	0.3	2.7E-2
Boilers	0.2	7.5E-2	1.8E-2	1.8E-2	5.1E-3	2.1E-2
Emergency Engine	1.4	0.3	0.1	0.1	0.1	3.4E-2
Science Vessel (Similar to *Harvey Explorer*)						
Propulsion Engines	39.9	14.1	0.5	0.5	1.8	1.9E-1
Generator Engines	20.0	10.8	1.0	1.0	3.9	1.2E-1
Thruster Engines	18.7	14.2	1.0	1.0	1.8	1.9E-1
Emergency Engines	1.1	0.2	0.1	0.1	0.1	2.7E-3
Support Tug (*Ocean Wind*)						
Propulsion Engines	49.9	3.1	0.9	0.9	4.4	2.8E-1
Generator Engines	22.3	4.9	1.6	1.6	1.8	5.4E-2
Support Tug (*Ocean Wave*)						
Propulsion Engines	49.9	3.1	0.9	0.9	4.4	2.8E-1
Generator Engines	22.3	4.9	1.6	1.6	1.8	5.4E-2
Total – *Polar Pioneer* Support Vessels	**414.6**	**122.9**	**16.7**	**16.7**	**29.1**	**2.6**
Common Support Vessels						
Anchor Handler (*Ross Chouest*)						
Propulsion and Generator Engines	94.4	21.6	2.8	2.8	2.8	2.9E-1
Various Engines	53.1	12.2	1.5	1.5	1.6	1.7E-1
Emergency Engine	2.7	0.6	0.2	0.2	0.2	6.4E-3

Table 16. AQRP Projected Annual Emissions [a] (continued)

Emission Unit	NO_X ton/year	CO ton/year	PM_{10} ton/year	$PM_{2.5}$ ton/year	VOC ton/year	SO_2 ton/year
OSV (*Sisuaq*)						
Propulsion and Generator Engines	12.9	2.2	0.3	0.3	0.8	8.2E-2
Emergency Engines	1.0	0.2	0.1	0.1	0.1	2.5E-3
Various Engines	32.1	7.1	2.3	2.3	2.6	7.7E-2
OSR Equipment Engines	5.7	1.2	0.4	0.4	0.5	1.4E-2
Incinerator	0.2	1.9E-2	1.6	1.6	0.2	2.2E-1
OSV (*Harvey Supporter*)						
Propulsion and Generator Engines	12.9	2.2	0.3	0.3	0.8	8.2E-2
Emergency Engines	1.0	0.2	0.1	0.1	0.1	2.5E-3
OSR Equipment Engines	4.3	0.9	0.3	0.3	0.3	1.0E-2
Incinerator	0.2	1.9E-2	1.6	1.6	0.2	2.2E-1
OSRV (*Nanuq*)						
Propulsion Engines	56.2	26.0	3.3	3.3	3.3	3.5E-1
Generator Engines	53.2	16.3	2.1	2.1	2.1	2.2E-1
Emergency Engines	1.6	0.3	0.1	0.1	0.1	3.8E-3
OSR Equipment Engines	5.8	1.3	0.4	0.4	0.5	1.4E-2
Incinerator	0.3	2.7E-2	2.3	2.3	0.3	3.1E-1
OSR Workboats (*Kvichaks*)						
Propulsion and Generator Engines	18.2	5.4	0.4	0.4	5.2	1.6E-1
OSR-T/B (*Guardsman/Klamath*)						
Propulsion Engines	34.7	8.0	1.0	1.0	1.0	1.1E-1
Generator Engines	14.3	3.1	1.0	1.0	1.1	3.4E-2
OSR Equipment Engines	10.6	2.3	0.7	0.7	0.8	2.5E-2
Arctic Oil Storage Tanker (Similar to *Affinity*)						
Propulsion and Generator Engines	72.7	16.7	2.1	2.1	2.1	2.3E-1
Emergency Engines	2.5	0.5	0.2	0.2	0.2	5.9E-3
Various Engines	68.5	15.0	4.9	4.9	5.5	1.6E-1
Boiler	11.7	2.9	1.9	1.9	0.2	8.2E-1
Incinerator	0.4	4.0E-2	3.4	3.4	0.4	4.7E-1
MLC ROV System Vessel (Similar to *Harvey Spirit*)						
Propulsion Engines	28.9	5.7	0.3	0.3	0.7	7.8E-2
Generator Engines	44.6	12.2	0.9	0.9	1.6	1.7E-1
Thruster Engines	37.9	23.8	1.2	1.2	3.0	3.2E-1
Emergency Engine	0.8	0.2	0.1	0.1	0.1	2.0E-3
MLC ROV System Engine	33.0	1.7	0.2	0.2	0.4	1.2E-1
Total – Common Support Vessels	**716.5**	**190.0**	**38.0**	**38.0**	**38.8**	**4.8**
Total – Support Vessels	**1,507.1**	**392.6**	**75.1**	**75.1**	**92.7**	**10.8**

[a] All emission factors, operational rates, and calculations can be found in Attachment A.

2.4 NEPA Offshore Emissions Summary

The NEPA emission inventory is similar to the AQRP emission inventory except that PM emission reductions have been applied where PM emission control equipment currently exists on a support vessel. Although the NEPA analysis presented in Attachment B to Appendix C (the EIA) also addresses emissions from the onshore facilities, vehicles, and aircraft trips, the onshore emissions are addressed in Section 3.0 of this report rather than in this section. Both the AQRP and NEPA inventories are limited to a 120-day maximum drilling season.

Although emission controls will be in place (and operational) on many of the largest engines, Shell chooses to demonstrate that exploration operations will not exceed BOEM impact criteria even if the benefits of NO_X or CO emission controls are not taken into consideration. The sole exception to this is the *Aiviq* propulsion engines; because the uncontrolled vendor data PM emission factor was less than the controlled source test emission factor, the controlled emission factor is used in both the AQRP and NEPA emission inventories.

The support vessels that contain PM emission controls are identified in Table 17.

Table 17. Particulate Matter Emission Controls

Category	Emission Units	PM Control Type
Ice Management	*Fennica* – Propulsion and Generator Engines	OxyCat
Anchor Handler	*Aiviq* – Propulsion Engines	DOC
Anchor Handler	*Aiviq* – Generator Engines	CDPF
Ice Management	*Nordica* – Propulsion and Generator Engines	OxyCat
Anchor Handler	*Tor Viking* – Propulsion and Generator Engines	OxyCat
OSRV	*Nanuq* – Propulsion and Generator Engines	CDPF

The *Fennica* and *Nordica* Harbour Generators are assumed not to operate during drilling season because this equipment is not required while away at sea.

Table 18 presents the NEPA emission inventory offshore projected peak hourly emissions by group for the *Discoverer*, the *Polar Pioneer*, and their support vessels. Table 19 presents the offshore projected annual NEPA emission inventory emissions by group.

During exploration activity, the support vessels will virtually always operate within 25 miles of one of the two drilling units. The obvious exception to this is when OSVs are in transit to Dutch Harbor or other resupply ports. It is also possible that on occasion the ice management vessels or other support vessels would travel farther than 25 miles. This activity is accounted for in the proposed annual fuel restrictions and, therefore, the emissions estimates.

Ships traveling farther than 25 miles from the drilling units would disperse the emissions to a greater extent than when they are closer to the drilling units. Because the dispersion modeling conducted in support of the NEPA inventory concentrates all emissions within 25 miles of the drilling units, it results in predictions that are higher than those expected if some vessels venture outside the 25 mile radius. Consequently, additional modeling of that scenario is not warranted.

Table 18. NEPA Offshore Projected Peak Hourly Emissions [a]

Emission Unit	NO_X lb/hr	CO lb/hr	PM_{10} lb/hr	$PM_{2.5}$ lb/hr	VOC lb/hr	SO_2 lb/hr	Pb lb/hr	GHG lb/hr
Discoverer								
Generator Engines	68.8	15.2	1.9	1.9	5.2	5.3E-1	1.4E-3	8,114
Propulsion Engine	162.5	38.2	4.9	4.9	4.9	5.2E-1	1.4E-3	7,956
HPU Engines	1.9	2.6	0.9	0.9	1.0	2.9E-2	7.9E-5	445
Crane Engines	5.7	0.9	0.2	0.2	0.1	7.2E-2	2.0E-4	1,105
Cementing Unit Engines	11.1	3.6	1.2	1.2	1.3	4.0E-2	1.1E-4	614
Logging Unit Engine	1.6	1.4	0.1	0.1	1.6	1.8E-2	4.9E-5	275
Compressor Engine	2.7	1.8	0.2	0.2	0.1	8.4E-3	2.3E-5	128
Sidewall Core Tool Engine	0.6	0.4	3.0E-2	3.0E-2	0.6	3.4E-3	9.3E-6	52
Emergency Engine	13.0	3.0	0.4	0.4	0.4	4.1E-2	1.1E-4	622
Lifeboat Engines	2.9	0.6	0.2	0.2	0.2	7.0E-3	1.9E-5	108
Boilers	2.5	0.3	3.6E-2	3.6E-2	1.0E-2	1.7E-1	1.4E-4	2,608
Incinerator	0.4	1.5	1.0	1.0	0.1	4.8E-1	2.9E-2	281
Polar Pioneer								
Generator Engines	275.2	34.4	10.3	10.3	10.4	1.1	3.0E-3	16,882
HPU Engines	2.0	2.7	0.9	0.9	1.0	3.0E-2	8.1E-5	458
Logging Unit Engine	1.6	1.4	0.1	0.1	1.6	1.8E-2	4.9E-5	275
Compressor Engine	2.7	1.8	0.2	0.2	0.1	8.4E-3	2.3E-5	128
Sidewall Core Tool Engine	0.6	0.4	3.0E-2	3.0E-2	0.6	3.4E-3	9.3E-6	52
Emergency Engine	28.8	6.6	0.8	0.8	0.8	9.0E-2	2.4E-4	1,375
Small Emergency Engines	19.1	4.2	1.4	1.4	1.5	4.6E-2	1.3E-4	707
Boilers	3.9	1.0	0.6	0.6	6.6E-2	2.7E-1	2.3E-4	4,196
Incinerator	0.3	3.3E-2	2.8	2.8	0.3	3.8E-1	2.3E-2	224
***Discoverer* Support Vessels**								
Ice Management (*Fennica*)								
Propulsion and Generator Engines	350.0	123.8	3.4	3.4	15.9	1.7	4.6E-3	25,783
Harbour Set Generator Engine	0	0	0	0	0	0	0	0
Boilers	1.1	2.7E-2	3.6E-2	3.6E-2	2.3E-2	9.5E-2	8.0E-5	1,453
Incinerator	0.5	2.3	1.3	1.3	0.2	2.7E-1	1.6E-2	157
Emergency Engine	10.0	2.2	0.7	0.7	0.8	2.4E-2	6.5E-5	368
Anchor Handler (*Aiviq*)								
Propulsion Engines	231.9	14.6	7.3	7.3	20.3	1.3	3.5E-3	19,952
Generator Engines	91.0	20.7	0.8	0.8	6.3	5.4E-1	1.5E-3	8,349
Boilers	0.8	0.2	0.1	0.1	1.4E-2	5.6E-2	4.7E-5	859
Incinerator	0.6	1.5	2.5	2.5	0.4	4.8E-1	2.9E-2	281
Emergency Engines	46.8	10.7	1.4	1.4	1.4	1.5E-1	4.0E-4	2,235
Rescue & Life Boat Engines	22.5	4.9	1.6	1.6	1.8	5.4E-2	1.5E-4	832
OSR Equipment Engines	6.3	1.4	0.4	0.4	0.5	1.5E-2	4.1E-5	233

Table 18. NEPA Offshore Projected Peak Hourly Emissions [a] (continued)

Emission Unit	NO_X lb/hr	CO lb/hr	PM_{10} lb/hr	$PM_{2.5}$ lb/hr	VOC lb/hr	SO_2 lb/hr	Pb lb/hr	GHG lb/hr
Science Vessel (Similar to *Harvey Supporter*)								
Propulsion and Generator Engines	91.3	15.7	2.3	2.3	5.5	5.8E-1	1.6E-3	8,963
Emergency Engines	4.2	0.9	0.3	0.3	0.3	1.0E-2	2.7E-5	153
Incinerator	0.1	1.3E-2	1.1	1.1	0.1	1.5E-1	9.4E-3	90
Support Tug (*Lauren Foss*)								
Propulsion Engines	157.4	36.1	4.6	4.6	4.6	4.9E-1	1.3E-3	7,513
Generator Engines	11.3	2.5	0.8	0.8	0.9	2.7E-2	7.4E-5	417
Emergency Engine	2.3	0.5	0.2	0.2	0.2	5.6E-3	1.5E-5	86
Thruster Engine	12.4	2.7	0.9	0.9	1.0	3.0E-2	8.1E-5	458
***Polar Pioneer* Support Vessels**								
Ice Management (*Nordica*)								
Propulsion and Generator Engines	350.0	123.8	2.7	2.7	15.9	1.7	4.6E-3	25,783
Harbour Set Generator Engine	0	0	0	0	0	0	0	0
Boilers	1.4	4.8E-3	2.6E-2	2.6E-2	2.3E-2	9.5E-2	8.0E-5	1,453
Incinerator	0.1	0.3	0.2	0.2	0.2	2.7E-1	1.6E-2	157
Emergency Engine	10.0	2.2	0.7	0.7	0.8	2.4E-2	6.5E-5	368
Anchor Handler (*Tor Viking*)								
Propulsion Engines	195.2	79.2	2.2	2.2	10.2	1.1	2.9E-3	16,501
Harbor Generator Engines	17.3	5.9	0.4	0.4	0.8	8.0E-2	2.2E-4	1,228
Boilers	0.2	5.2E-2	1.3E-2	1.3E-2	3.6E-3	1.5E-2	1.2E-5	224
Emergency Generator	5.6	1.2	0.4	0.4	0.5	1.4E-2	3.7E-5	209
Science Vessel (Similar to *Harvey Explorer*)								
Propulsion Engines	56.4	19.9	0.8	0.8	2.5	2.7E-1	7.3E-4	4,141
Generator Engines	13.9	7.5	0.7	0.7	2.7	8.3E-2	2.2E-4	1,267
Thruster Engines	13.0	9.9	0.7	0.7	1.3	1.3E-1	3.6E-4	2,052
Emergency Engines	4.4	1.0	0.3	0.3	0.4	1.1E-2	2.9E-5	164
Support Tug (*Ocean Wind*)								
Propulsion Engines	115.9	7.3	2.1	2.1	10.2	6.5E-1	1.8E-3	9,969
Generator Engines	15.5	3.4	1.1	1.1	1.2	3.7E-2	1.0E-4	571
Support Tug (*Ocean Wave*)								
Propulsion Engines	115.9	7.3	2.1	2.1	10.2	6.5E-1	1.8E-3	9,969
Generator Engines	15.5	3.4	1.1	1.1	1.2	3.7E-2	1.0E-4	571
Common Support Vessels								
Anchor Handler (*Ross Chouest*)								
Propulsion and Generator Engines	322.3	73.9	9.4	9.4	9.5	1.0	2.7E-3	15,383
Various Engines	36.9	8.4	1.1	1.1	1.1	1.1E-1	3.1E-4	1,759
Emergency Engines	10.6	2.3	0.8	0.8	0.8	2.6E-2	7.0E-5	393

Table 18. NEPA Offshore Projected Peak Hourly Emissions [a] (continued)

Emission Unit	NO_X lb/hr	CO lb/hr	PM_{10} lb/hr	$PM_{2.5}$ lb/hr	VOC lb/hr	SO_2 lb/hr	Pb lb/hr	GHG lb/hr
OSV (*Sisuaq*)								
Propulsion and Generator Engines	91.3	15.7	2.3	2.3	5.5	5.8E-1	1.6E-3	8,963
Emergency Engines	4.2	0.9	0.3	0.3	0.3	1.0E-2	2.7E-5	153
Various Engines	22.3	4.9	1.6	1.6	1.8	5.4E-2	1.5E-4	825
OSR Equipment Engines	11.8	2.6	0.8	0.8	0.9	2.8E-2	7.7E-5	436
Incinerator	0.1	1.3E-2	1.1	1.1	0.1	1.5E-1	9.4E-3	90
OSV (*Harvey Supporter*)								
Propulsion and Generator Engines	91.3	15.7	2.3	2.3	5.5	5.8E-1	1.6E-3	8,963
Emergency Engines	4.2	0.9	0.3	0.3	0.3	1.0E-2	2.7E-5	153
OSR Equipment Engines	9.0	2.0	0.6	0.6	0.7	2.2E-2	5.9E-5	331
Incinerator	0.1	1.3E-2	1.1	1.1	0.1	1.5E-1	9.4E-3	90
OSRV (*Nanuq*)								
Propulsion Engines	69.2	32.0	0.2	0.2	4.1	4.3E-1	1.2E-3	6,654
Generator Engines	37.0	11.3	0.1	0.1	1.4	1.5E-1	4.2E-4	2,355
Emergency Engines	6.2	1.4	0.4	0.4	0.5	1.5E-2	4.1E-5	230
OSR Equipment Engines	12.1	2.7	0.9	0.9	1.0	2.9E-2	7.9E-5	448
Incinerator	0.2	1.9E-2	1.6	1.6	0.2	2.2E-1	1.3E-2	127
OSR Workboats (*Kvichaks*)								
Propulsion and Generator Engines	12.6	3.7	0.3	0.3	3.6	1.1E-1	3.0E-4	1,682
OSR-T/B (*Guardsman/Klamath*)								
Propulsion Engines	138.2	31.7	4.0	4.0	4.1	4.3E-1	1.2E-3	6,597
Generator Engines	9.9	2.2	0.7	0.7	0.8	2.4E-2	6.5E-5	366
OSR Equipment Engines	22.0	4.8	1.6	1.6	1.8	5.3E-2	1.4E-4	812
Arctic Oil Storage Tanker (Similar to *Affinity*)								
Propulsion and Generator Engines	493.5	113.1	14.4	14.4	14.5	1.5	4.2E-3	23,548
Emergency Engine	9.8	2.2	0.7	0.7	0.8	2.4E-2	6.4E-5	362
Various Engines	47.6	10.4	3.4	3.4	3.8	1.1E-1	3.1E-4	1,757
Boiler	8.1	2.0	1.3	1.3	0.1	5.7E-1	4.8E-4	8,742
Incinerator	0.3	2.8E-2	2.4	2.4	0.3	3.3E-1	2.0E-2	191
MLC ROV System Vessel (Similar to *Harvey Spirit*)								
Propulsion Engines	136.2	27.0	1.5	1.5	3.5	3.7E-1	1.0E-3	5,626
Generator Engines	31.0	8.5	0.7	0.7	1.1	1.2E-1	3.1E-4	1,768
Thruster Engines	26.3	16.5	0.8	0.8	2.1	2.2E-1	6.1E-4	3,436
Emergency Engine	3.3	0.7	0.2	0.2	0.3	7.9E-3	2.2E-5	122
MLC ROV System Engine	22.9	1.2	0.1	0.1	0.3	8.0E-2	2.2E-4	1,228

[a] All emission factors, operational rates, and calculations can be found in Attachment B.

Table 19. NEPA Offshore Projected Annual Emissions [a]

Emission Unit	NO_X ton/year	CO ton/year	PM_{10} ton/year	$PM_{2.5}$ ton/year	VOC ton/year	SO_2 ton/year	Pb ton/year	GHG tons/year
Discoverer								
Generator Engines	99.0	21.8	2.7	2.7	7.6	7.6E-1	2.1E-3	11,684
Propulsion Engine	233.9	55.0	7.0	7.0	7.1	7.5E-1	2.0E-3	11,456
HPU Engines	2.8	3.8	1.2	1.2	1.4	4.2E-2	1.1E-4	641
Crane Engines	8.3	1.3	0.2	0.2	0.2	1.0E-1	2.8E-4	1,591
Cementing Unit Engines	16.0	5.2	1.7	1.7	1.9	5.8E-2	1.6E-4	884
Logging Unit Engine	2.3	2.0	0.1	0.1	2.3	2.6E-2	7.0E-5	396
Compressor Engine	3.9	2.6	0.4	0.4	0.2	1.2E-2	3.3E-5	185
Sidewall Core Tool Engine	0.8	0.5	4.3E-2	4.3E-2	0.8	4.9E-3	1.3E-5	75
Emergency Engine	18.8	4.3	0.5	0.5	0.6	5.8E-2	1.6E-4	896
Lifeboat Engines	4.2	0.9	0.3	0.3	0.3	1.0E-2	2.8E-5	156
Boilers	3.6	0.4	5.2E-2	5.2E-2	1.5E-2	2.4E-1	2.1E-4	3,756
Incinerator	0.6	2.2	1.4	1.4	0.1	6.9E-1	4.2E-2	404
Total – *Discoverer*	**394.3**	**100.1**	**15.7**	**15.7**	**22.3**	**2.8**	**4.7E-2**	**32,125**
Polar Pioneer								
Generator Engines	396.4	49.6	14.9	14.9	15.0	1.6	4.3E-3	24,310
HPU Engines	2.9	3.9	1.3	1.3	1.4	4.3E-2	1.2E-4	660
Logging Unit Engine	2.3	2.0	0.1	0.1	2.3	2.6E-2	7.0E-5	396
Compressor Engine	3.9	2.6	0.4	0.4	0.2	1.2E-2	3.3E-5	185
Sidewall Core Tool Engine	0.8	0.5	4.3E-2	4.3E-2	0.8	4.9E-3	1.3E-5	75
Emergency Engine	41.5	9.5	1.2	1.2	1.2	1.3E-1	3.5E-4	1,980
Small Emergency Engines	27.6	6.0	2.0	2.0	2.2	6.6E-2	1.8E-4	1,019
Boilers	5.6	1.4	0.9	0.9	0.1	3.9E-1	3.3E-4	6,043
Incinerator	0.5	4.7E-2	4.0	4.0	0.5	5.5E-1	3.4E-2	323
Total – *Polar Pioneer*	**481.5**	**75.7**	**24.7**	**24.7**	**23.6**	**2.8**	**3.9E-2**	**34,989**
***Discoverer* Support Vessels**								
Ice Management (*Fennica*)								
Propulsion and Generator Engines	93.6	33.1	0.9	0.9	4.2	4.5E-1	1.2E-3	6,896
Harbour Set Generator Engine	0	0	0	0	0	0	0	0
Boilers	1.6	3.8E-2	5.2E-2	5.2E-2	3.3E-2	1.4E-1	1.2E-4	2,092
Incinerator	0.8	3.3	1.9	1.9	0.3	3.8E-1	2.4E-2	226
Emergency Engine	2.5	0.5	0.2	0.2	0.2	6.0E-3	1.6E-5	92
Anchor Handler (*Aiviq*)								
Propulsion Engines	126.6	8.0	4.0	4.0	11.1	7.1E-1	1.9E-3	10,895
Generator Engines	49.7	11.3	0.4	0.4	3.4	3.0E-1	8.1E-4	4,559
Boilers	1.2	0.3	0.2	0.2	2.0E-2	8.1E-2	6.8E-5	1,236
Incinerator	0.8	2.2	3.6	3.6	0.6	6.9E-1	4.2E-2	404
Emergency Engines	11.7	2.7	0.3	0.3	0.3	3.6E-2	9.9E-5	559
Rescue & Life Boat Engines	5.6	1.2	0.4	0.4	0.4	1.4E-2	3.7E-5	208
OSR Equipment Engines	3.0	0.7	0.2	0.2	0.2	7.3E-3	2.0E-5	112

Table 19. NEPA Offshore Projected Annual Emissions [a] (continued)

Emission Unit	NO_X ton/year	CO ton/year	PM_{10} ton/year	$PM_{2.5}$ ton/year	VOC ton/year	SO_2 ton/year	Pb ton/year	GHG tons/year
Science Vessel (Similar to *Harvey Supporter*)								
Propulsion and Generator Engines	29.8	5.1	0.7	0.7	1.8	1.9E-1	5.2E-4	2,930
Emergency Engines	1.0	0.2	0.1	0.1	0.1	2.5E-3	6.8E-6	38
Incinerator	0.2	1.9E-2	1.6	1.6	0.2	2.2E-1	1.4E-2	129
Support Tug (*Lauren Foss*)								
Propulsion Engines	21.7	5.0	0.6	0.6	0.6	6.7E-2	1.8E-4	1,034
Generator Engines	2.8	0.6	0.2	0.2	0.2	6.9E-3	1.9E-5	105
Emergency Engine	0.6	0.1	4.1E-2	4.1E-2	4.6E-2	1.4E-3	3.8E-6	21
Thruster Engine	3.1	0.7	0.2	0.2	0.2	7.5E-3	2.0E-5	115
Total – *Discoverer* Support Vessels	**356.4**	**75.2**	**15.7**	**15.7**	**24.2**	**3.3**	**8.5E-2**	**31,652**
***Polar Pioneer* Support Vessels**								
Ice Management (*Nordica*)								
Propulsion and Generator Engines	91.8	32.5	0.7	0.7	4.2	4.4E-1	1.2E-3	6,761
Harbour Set Generator Engine	0	0	0	0	0	0	0	0
Boilers	2.0	7.0E-3	3.8E-2	3.8E-2	3.3E-2	1.4E-1	1.2E-4	2,092
Incinerator	0.2	0.4	0.2	0.2	0.3	3.8E-1	2.4E-2	226
Emergency Engine	2.5	0.5	0.2	0.2	0.2	6.0E-3	1.6E-5	92
Anchor Handler (*Tor Viking*)								
Propulsion Engines	67.0	27.2	0.8	0.8	3.5	3.7E-1	1.0E-3	5,663
Harbor Generator Engines	5.9	2.0	0.1	0.1	0.3	2.7E-2	7.5E-5	421
Boilers	0.2	7.5E-2	1.8E-2	1.8E-2	5.1E-3	2.1E-2	1.8E-5	323
Emergency Engine	1.4	0.3	0.1	0.1	0.1	3.4E-3	9.2E-6	52
Science Vessel (Similar to *Harvey Explorer*)								
Propulsion Engines	39.9	14.1	0.5	0.5	1.8	1.9E-1	5.2E-4	2,930
Generator Engines	20.0	10.8	1.0	1.0	3.9	1.2E-1	3.2E-4	1,825
Emergency Engines	18.7	14.2	1.0	1.0	1.8	1.9E-1	5.2E-4	2,955
Thruster Engines	1.1	0.2	0.1	0.1	0.1	2.7E-3	7.3E-6	41
Support Tug (*Ocean Wind*)								
Propulsion Engines	49.9	3.1	0.9	0.9	4.4	2.8E-1	7.6E-4	4,291
Generator Engines	22.3	4.9	1.6	1.6	1.8	5.4E-2	1.5E-4	822
Support Tug (*Ocean Wave*)								
Propulsion Engines	49.9	3.1	0.9	0.9	4.4	2.8E-1	7.6E-4	4,291
Generator Engines	22.3	4.9	1.6	1.6	1.8	5.4E-2	1.5E-4	822
Total – *Polar Pioneer* Support Vessels	**395.0**	**118.4**	**9.9**	**9.9**	**28.5**	**2.6**	**2.9E-2**	**33,607**
Common Support Vessels								
Anchor Handler (*Ross Chouest*)								
Propulsion and Generator Engines	94.4	21.6	2.8	2.8	2.8	2.9E-1	8.0E-4	4,507
Various Engines	53.1	12.2	1.5	1.5	1.6	1.7E-1	4.5E-4	2,533
Emergency Engine	2.7	0.6	0.2	0.2	0.2	6.4E-3	1.7E-5	98

Table 19. NEPA Offshore Projected Annual Emissions [a] (continued)

Emission Unit	NO_X ton/year	CO ton/year	PM_{10} ton/year	$PM_{2.5}$ ton/year	VOC ton/year	SO_2 ton/year	Pb ton/year	GHG tons/year
OSV (*Sisuaq*)								
Propulsion and Generator Engines	12.9	2.2	0.3	0.3	0.8	8.2E-2	2.2E-4	1,265
Emergency Engines	1.0	0.2	0.1	0.1	0.1	2.5E-3	6.8E-6	38
Various Engines	32.1	7.1	2.3	2.3	2.6	7.7E-2	2.1E-4	1,187
OSR Equipment Engines	5.7	1.2	0.4	0.4	0.5	1.4E-2	3.7E-5	209
Incinerator	0.2	1.9E-2	1.6	1.6	0.2	2.2E-1	1.4E-2	129
OSV (*Harvey Supporter*)								
Propulsion and Generator Engines	12.9	2.2	0.3	0.3	0.8	8.2E-2	2.2E-4	1,265
Emergency Engines	1.0	0.2	0.1	0.1	0.1	2.5E-3	6.8E-6	38
OSR Equipment Engines	4.3	0.9	0.3	0.3	0.3	1.0E-2	2.8E-5	159
Incinerator	0.2	1.9E-2	1.6	1.6	0.2	2.2E-1	1.4E-2	129
OSRV (*Nanuq*)								
Propulsion Engines	56.2	26.0	0.2	0.2	3.3	3.5E-1	9.6E-4	5,409
Generator Engines	53.2	16.3	0.1	0.1	2.1	2.2E-1	6.0E-4	3,391
Emergency Engines	1.6	0.3	0.1	0.1	0.1	3.8E-3	1.0E-5	58
OSR Equipment Engines	5.8	1.3	0.4	0.4	0.5	1.4E-2	3.8E-5	215
Incinerator	0.3	2.7E-2	2.3	2.3	0.3	3.1E-1	1.9E-2	183
OSR Workboats (*Kvichaks*)								
Propulsion and Generator Engines	18.2	5.4	0.4	0.4	5.2	1.6E-1	4.3E-4	2,422
OSR-T/B (*Guardsman/Klamath*)								
Propulsion Engines	34.7	8.0	1.0	1.0	1.0	1.1E-1	2.9E-4	1,656
Generator Engines	14.3	3.1	1.0	1.0	1.1	3.4E-2	9.4E-5	528
OSR Equipment Engines	10.6	2.3	0.7	0.7	0.8	2.5E-2	6.9E-5	390
Arctic Oil Storage Tanker (Similar to *Affinity*)								
Propulsion and Generator Engines	72.7	16.7	2.1	2.1	2.1	2.3E-1	6.2E-4	3,471
Emergency Engine	2.5	0.5	0.2	0.2	0.2	5.9E-3	1.6E-5	91
Various Engines	68.5	15.0	4.9	4.9	5.5	1.6E-1	4.5E-4	2,530
Boiler	11.7	2.9	1.9	1.9	0.2	8.2E-1	6.9E-4	12,589
Incinerator	0.4	4.0E-2	3.4	3.4	0.4	4.7E-1	2.9E-2	275
MLC ROV System Vessel (Similar to *Harvey Spirit*)								
Propulsion Engines	28.9	5.7	0.3	0.3	0.7	7.8E-2	2.1E-4	1,194
Generator Engines	44.6	12.2	0.9	0.9	1.6	1.7E-1	4.5E-4	2,546
Thruster Engines	37.9	23.8	1.2	1.2	3.0	3.2E-1	8.8E-4	4,948
Emergency Engine	0.8	0.2	0.1	0.1	0.1	2.0E-3	5.4E-6	30
MLC ROV System Engine	33.0	1.7	0.2	0.2	0.4	1.2E-1	3.1E-4	1,768
Total – Common Support Vessels	**716.5**	**190.0**	**32.9**	**32.9**	**38.8**	**4.8**	**8.3E-2**	**55,252**
Total – Support Vessels	**1,467.8**	**383.6**	**58.5**	**58.5**	**91.5**	**10.6**	**0.2**	**120,511**

[a] All emission factors, operational rates, and calculations can be found in Attachment B.

3.0 ONSHORE AIR EMISSIONS

Land-based emissions include those from personnel and supply transported to and from the drill site, and any housing emissions dedicated to the project. The on-land activities associated with the exploration activities are likely to include support facilities in Barrow. These facilities in Barrow include a man-camp, storage facilities, and an aircraft hangar, requiring heat and power. Other possible minor support activities may occur in Wainwright at existing leased facilities. Transportation of personnel and materials to and from the airport would be by automobiles, vans, or pickup trucks, fueled with diesel. Transport to and from the vessels to shore will be by up to three helicopters, stationed in Barrow. Additional fixed wing aircraft will be used for crew transport. Communications may be through existing communications center networks or leases from existing facilities.

3.1 Aircraft Activity

Emissions from aircrafts are estimated using the Federal Aviation Administration's (FAA) Emissions and Dispersion Modeling System (EDMS). EDMS is a combined emissions and dispersion model for assessing air quality at civilian airports and military air bases. The model was developed by the FAA in cooperation with the United States Air Force (USAF). The model is used to produce an inventory of emissions generated by sources on and around the airport or air base, and to calculate pollutant concentrations in these environments.

As described in Section 13 of the EP Revision 2, Shell intends to operate the following aircrafts with the exploration drilling program:

- (3) crew change helicopters
- (1) search and rescue (SAR) helicopter
- (1) fixed-wing aircraft for crew transport, with an option for a helicopter
- (1) fixed-wing aircraft for ice reconnaissance
- (1) fixed-wing aircraft for Protected Species Observer (PSO) flights

As described in Table 13.a-3 of the EP Revision 2, Table 20 lists the purpose, proposed aircraft types, and trip frequencies used to determine the air emissions.

Table 20. Support Aircraft Information

Purpose	Aircraft Type	Trip Frequency
Crew Change	(3) S-92, EC225 or similar	40 roundtrips/week (40 roundtrips between Barrow and Burger Prospect)
Search and Rescue	(1) S-92, EC225 or similar	40 hours/month, assumed 7 roundtrips/week
Crew Transport	(1) Saab 340B, Beechcraft 1900, Dash 9 or similar or (1) S-92, EC225 or similar[1]	1 roundtrip every 3 weeks between Wainwright and Barrow or Anchorage
Ice reconnaissance	(1) Gulfstream Aero Commander 690 or similar	1 flight per day
PSO Flights	(1) Gulfstream Aero Commander 690 or similar	1 flight per day

[1] An additional helicopter may be substituted for the fixed-wing aircraft for crew transport. The change in emissions from the alternate aircraft is minimal.

The EDMS estimates emissions for a landing/take-off (LTO) cycle. The aircraft that was closest in size and engine capacity was used to estimate emissions from one LTO cycle. The emissions were then multiplied by the total number of LTOs for the season. Total emissions from these aircraft along with an analysis of the EDMS LTO emission estimates for each scenario can be found in Attachment C2. The EDMS output file can be found in the Appendix K folder of the flash drive.

3.2 Hangar/Storage Building Activity

A hangar/storage building located in Barrow at the airport is expected to be heated by a small 5 MMBtu/hr, natural-gas-fired boiler, and operational 12 hours per day for 168 days per season. The make and model of this boiler is currently unknown; therefore, emission factors from AP-42's Chapter 1 for external combustion sources, Section 1.4 for natural gas combustion were selected. Table 21 lists these emission factors, and total emissions from this source can be found in Attachment C1.

Table 21. Summary of EPA AP-42, Section 1.4 Natural Gas Combustion Emission Factors

Units	NO_X	CO	Total PM [a]	VOC	SO_2	Pb
lb/10^6 scf	100	84	7.6	5.5	0.6	0.0005

[a] PM = Applied for PM_{10} and $PM_{2.5}$.

3.3 Camp Activity

3.3.1 Existing 75-person NARL Camp Activity

The current 75-person camp located near the Naval Arctic Research Laboratory (NARL) is powered by two John Deere PowerTech 13.5L, 448 kW, diesel generators. One generator serves as the primary generator and the other is a backup generator. Similar to the vessel internal combustion engines, it is assumed that "good engine operating practices" will be used to extend the life of the generators. Therefore, the maximum load is assumed to be 80 percent for emission calculations. In addition, it is assumed that the backup generator will only operate 1 hour per week for routine maintenance checks.

The John Deere generators are EPA-certified Tier 3; therefore, 40 CFR 89.112 Nonroad, Tier 3 standards have been selected to calculate emissions. Because there is no Tier 3 VOC emission factor, the Tier 1 standard was (conservatively) selected. Finally, SO_2 emissions were calculated assuming 100 ppm sulfur content (see Section 2.2.4), and lead emissions were calculated using EPA's Locating and Estimating Air Emissions from Lead Sources and Lead Compounds report (see Section 2.2.6). Table 22 lists the emission factors for these engines, and total emissions can be found in Attachment C1.

Table 22. Summary of John Deere PowerTech Emission Factors

Pollutant	EF	Units	Reference
NO_X	4.0	g/kW-hr	40 CFR 89.112 Nonroad, Table 1, Tier 3, 225<kW<450
PM [a]	0.2	g/kW-hr	40 CFR 89.112 Nonroad, Table 1, Tier 3, 225<kW<450
CO	3.5	g/kW-hr	40 CFR 89.112 Nonroad, Table 1, Tier 3, 225<kW<450
VOC	1.3	g/kW-hr	40 CFR 89.112 Nonroad, Table 1, Tier 1, 225<kW<450
SO_2	0.045	g/kW-hr	Calculation
Pb	2.90E-05	lb/MMBtu	EPA's L&E Lead Report, Section 5.2.2, May 1998

[a] PM = Applied for PM_{10} and $PM_{2.5}$.

3.3.2 K/D/R Facility at NARL Camp Activity

The existing camp near NARL is serviced by a kitchen/dining/recreation (K/D/R) facility that is powered by a Caterpillar 3412CDITA, 725 kWe diesel-fired generator engine. The K/D/R generator is located near the existing NARL camp power modules. Vendor data are used to estimate criteria pollutant emissions. Finally, SO_2 emissions were calculated assuming 100 ppm sulfur content (see Section 2.2.4) and lead emissions were calculated using EPA's Locating and Estimating Air Emissions from Lead Sources and Lead Compounds report (see Section 2.2.6). Table 23 lists the emission factors for this engine, and total emissions can be found in Attachment C1.

Table 23. Summary of Emission Factors for the K/D/R Generator

Pollutant	EF	Units	Reference
NO_X	7.95	g/kW-hr	Based on Vendor Data
PM [a]	0.13	g/kW-hr	Based on Vendor Data
CO	0.91	g/kW-hr	Based on Vendor Data
VOC	0.17	g/kW-hr	Based on Vendor Data
SO_2	0.045	g/kW-hr	Calculation
Pb	2.90E-05	lb/MMBtu	EPA's L&E Lead Report, Section 5.2.2, May 1998

[a] PM = Applied for PM_{10} and $PM_{2.5}$.

3.3.3 40-person Camp near NARL Camp Activity

Shell will lease accommodations at the existing 40-person Ukpeaġvik Iñupiat Corporation (UIC) modular construction camp; this camp is now at the UIC storage location in Barrow but would be relocated by UIC to the existing UIC pad near the NARL camp. This is a separate location from the existing UIC camp near NARL described in Section 3.3.1. This 40-person camp will be tied to the grid for power; there are no other emission units onsite.

3.4 Vehicle Activity

Vehicle emissions were estimated using EPA's Office of Transportation and Air Quality (OTAQ) Motor Vehicle Emission Simulator (MOVES). Vehicle emissions are estimated to occur during the transportation of personnel and materials to and from the airport using diesel-fueled automobiles, vans, or pickup trucks. The MOVES model was run to estimate emissions from a passenger truck, model year 2012, in the Alaska North Slope Borough. The MOVES program provides hourly emission estimates for each weekday and weekend day for every month. It was assumed that the emissions for this project will occur during July, August, September, and October. The seasonal emissions were then conservatively estimated to occur 12 hours per day for the total 123 days (July 1^{st} – October 31^{st}). Hourly emissions were estimated by selecting the maximum hourly emissions for each pollutant for the same timeframe. The emission values can be found in Attachment C3, and the MOVES output file can be found in the Appendix K folder of the flash drive.

3.5 NEPA Onshore Emissions Summary

Table 24 presents the projected hourly onshore NEPA emission inventory. Table 25 presents the projected annual onshore NEPA emission inventory.

Table 24. NEPA Onshore Projected Hourly Emissions

Emission Unit	NO_X lb/hr	CO lb/hr	PM_{10} lb/hr	$PM_{2.5}$ lb/hr	VOC lb/hr	SO_2 lb/hr	Pb lb/hr	GHG lb/hr
Aircraft Take-off and Landings								
Crew Change Helicopters								
Take-off	0.5	5.2	0.2	0.2	6.4	0.2	-	431
Landing	0.7	3.6	0.1	0.1	4.2	0.2	-	393
Search and Rescue Helicopter								
Take-off	0.5	5.2	0.2	0.2	6.4	0.2	-	431
Landing	0.7	3.6	0.1	0.1	4.2	0.2	-	393
Crew Transport Fixed-wing Aircraft								
Take-off	0.8	2.4	0.1	0.1	1.4	0.2	-	594
Landing	0.2	1.3	0.3	0.3	0.8	0.1	-	269
Ice Reconnaissance Fixed-wing Aircraft								
Take-off	0.7	3.6	2.5E-2	2.5E-2	0.4	0.1	-	361
Landing	0.2	2.5	1.2E-2	1.2E-2	0.3	0.1	-	192
PSO Fixed-wing Aircraft								
Take-off	0.7	3.6	2.5E-2	2.5E-2	0.4	0.1	-	361
Landing	0.2	2.5	1.2E-2	1.2E-2	0.3	0.1	-	192
Hangar/Storage Building								
Natural Gas Boiler	0.5	0.4	3.7E-2	3.7E-2	2.7E-2	2.9E-3	2.5E-6	585
NARL Camp								
Primary Generator Engine	3.2	2.8	0.2	0.2	1.0	3.6E-2	9.7E-5	550
Backup Generator Engine	3.2	2.8	0.2	0.2	1.0	3.6E-2	9.7E-5	550
K/D/R Generator Engine	11.3	1.3	0.2	0.2	0.2	6.5E-2	1.8E-4	990
Vehicles								
Passenger Truck (Model Year 2012)	1.3E-2	1.1E-2	4.5E-5	4.5E-5	1.7E-3	3.4E-5	-	5

Table 25. NEPA Onshore Projected Annual Emissions

Emission Unit	NO_X ton/year	CO ton/year	PM_{10} ton/year	$PM_{2.5}$ ton/year	VOC ton/year	SO_2 ton/year	Pb ton/year	GHG tons/year
Aircraft Take-off and Landings								
Crew Change Helicopters								
Take-off	0.2	1.8	6.9E-2	6.9E-2	2.2	6.9E-2	-	148
Landing	0.2	1.2	3.4E-2	3.4E-2	1.4	6.9E-2	-	135
Search and Rescue Helicopter								
Take-off	3.0E-2	0.3	1.2E-2	1.2E-2	0.4	1.2E-2	-	26
Landing	4.2E-2	0.2	6.0E-3	6.0E-3	0.3	1.2E-2	-	24
Crew Transport Fixed-wing Aircraft								
Take-off	2.4E-3	7.2E-3	3.0E-4	3.0E-4	4.2E-3	6.0E-4	-	2
Landing	6.0E-4	3.9E-3	9.9E-4	9.9E-4	2.4E-3	3.0E-4	-	1
Ice Reconnaissance Fixed-wing Aircraft								
Take-off	4.2E-2	0.2	1.5E-3	1.5E-3	2.4E-2	6.0E-3	-	22
Landing	1.2E-2	0.2	7.2E-4	7.2E-4	1.8E-2	6.0E-3	-	12
Ice Over/PSO Fixed-wing Aircraft								
Take-off	4.2E-2	0.2	1.5E-3	1.5E-3	2.4E-2	6.0E-3	-	22
Landing	1.2E-2	0.2	7.2E-4	7.2E-4	1.8E-2	6.0E-3	-	12
Total – Air Craft Support	**0.6**	**4.3**	**0.1**	**0.1**	**4.4**	**0.2**	**-**	**401**
Hangar/Storage Building								
Natural Gas Boiler	0.4	0.3	2.7E-2	2.7E-2	1.9E-2	2.1E-3	1.8E-6	422
Total – Hangar/Storage Building	**0.4**	**0.3**	**2.7E-2**	**2.7E-2**	**1.9E-2**	**2.1E-3**	**1.8E-6**	**422**
NARL Camp								
Primary Generator Engine	6.4	5.6	0.3	0.3	2.1	7.2E-2	2.0E-4	1,109
Backup Generator Engine	3.8E-2	3.3E-2	1.9E-3	1.9E-3	1.2E-2	4.3E-4	1.2E-6	7
K/D/R Generator Engine	22.8	2.6	0.4	0.4	0.5	1.3E-1	3.5E-4	1,997
Total – NARL Camp	**29.2**	**8.2**	**0.7**	**0.7**	**2.6**	**0.2**	**5.5E-4**	**3,112**
Vehicles								
Passenger Truck (Model Year 2012)	5.7E-3	4.3E-3	2.6E-5	2.6E-5	6.3E-4	2.0E-5	-	3
Total – Vehicles	**5.7E-3**	**4.3E-3**	**2.6E-5**	**2.6E-5**	**6.3E-4**	**2.0E-5**	**-**	**3**
Total – Onshore	**30.2**	**12.8**	**0.9**	**0.9**	**6.9**	**0.4**	**5.5E-04**	**3,937**

4.0 REFERENCES

Copies of references noted below can be found in Attachment F of this report.

^F1: Discoverer Generator Engines: Louisiana CAT. *Caterpillar 3512C Offshore Electric Engine (LLB) Performance Data*. Obtained from Lance Peltier on September 17, 2013.

^F2: Discoverer Propulsion Engine: STX-MAN B&W. *Extent of Delivery STX-MAN B&W M/E S42MC*. Date Unknown.

^*Discoverer HPU Engines (F3) and Cementing Engines (F4): TRC. *Emissions Test Report Discoverer Shell Gulf of Mexico, Inc.* Report Issued: July 27, 2012. (MLC Compressors, HPU Engines, Cranes, Cementing Engines).

^F5: Discoverer Cranes: Liebherr Machines Bulle SA. *Diesel Engines Exhaust Emission Confirmation, D9508 A7*. November 26, 2012.

^F6: Discoverer and Polar Pioneer Logging Unit Engine: Caterpillar. *C7 ACERT™ Industrial Engine, CAT® Engine Specifications.* April 16, 2012.

^F7: Discoverer and Polar Pioneer Compressor Engine: Detroit Diesel Corporation. *4-71 Marine Engine Specification Data and Engine Performance Curve.* June 29, 1989.

^F8: Discoverer and Polar Pioneer Sidewall Core Tool Engine: John Deere. *PowerTech 4024T Diesel Engine.* ©2012.

^*Discoverer Boilers (F9) and Incinerator (F10): The Avogadro Group, LLC. *Source Test Report 2012 Emission Compliance Tests Noble Discoverer Drillship*. July 27, 2012. (Main Generators, Boilers and Incinerator).

^F11: Discoverer Lifeboats: Sabb Motor A/S Test Department. *Works Test Certificate.* No Date.

^*F12: Polar Pioneer Generation: Ecoxy AS. *Test Report: Source specific NO_X-factors for Polar Pioneer.* Date of Test: January 31, 2014. Date of Report: February 14, 2014.

^*F3: Polar Pioneer HPU Engines: TRC. *Emissions Test Report Discoverer Shell Gulf of Mexico, Inc.* Report Issued: July 27, 2012. (MLC Compressors, HPU Engines, Cranes, Cementing Engines).

^*F14: Fennica: Alaska Source Testing, LLC. *Summary of Test Results Shell Offshore, Inc. Fennica/Nordica Icebreaker May 25, 2007 NO_X Emissions Testing Frontier Discoverer Drilling Unit Permit R10OCS-AK-07-02.* June 28, 2007.

^*F15: Fennica: TRC. *Emissions Test Report Fennica Icebreaker #1 Shell Gulf of Mexico, Inc.* Report Issued: June 1, 2012. Submittal Date of Revised Report: August 9, 2012.

^*F16: Nordica: TRC. *Emissions Test Report Nordica Icebreaker #1 Shell Gulf of Mexico, Inc.* Report Issued: June 11, 2012. Submittal Date of Revised Report: August 9, 2012.

^F17: Aiviq and Support Tug Propulsion Engines: Caterpillar. *C280 Diesel Engine Technical Data*. May 3, 2011.

^*F18: Aiviq: TRC. *Emissions Test Report Aiviq Icebreaker #2/Anchor Handler Shell Gulf of Mexico, Inc.* Report Issued: June 22, 2012. Submittal Date of Revised Report: August 9, 2012.

^F19: Aiviq: CleanAIR Systems. *Proposal for Hull 247(Aiviq), 3512 Engines E-POD with ENDURE SCR & ASSURE DOC or PERMIT Filter units in a 316 Stainless Steel Double Wall Insulated Critical Grade Silencer*. April 7, 2010.

^*F20: Tor Viking: TRC. *Emissions Test Report Shell Offshore, Inc. Nitrogen Oxides (NO_X) Emissions Testing Kulluk Drilling Unit Tor Viking II (Icebreaker) Norway. Dates of Test: May 16-19, 2007.* July 12, 2007.

^*F21: Tor Viking: TRC. *Emissions Test Report Tor Viking Icebreaker #2/Anchor Handler Shell Gulf of Mexico, Inc.* Report Issued: June 12, 2012. Submittal Date of Revised Report: August 9, 2012.

^*F22: Nanuq: TRC. *Emissions Test Report Nanuq Oil Spill Response Vessel Shell Gulf of Mexico, Inc.* Report Issued: July 26, 2012.

^*F23: Kvichak: TRC. *Emissions Test Report Kvichak No. 5 Oil Spill Response Work Boat Shell Gulf of Mexico, Inc.* Report Issued: August 9, 2012.

^*F24: Sisuaq: TRC. *Emissions Test Report Sisuaq Resupply Vessel Shell Gulf of Mexico, Inc.* Report Issued: June 15, 2012. Submittal Date of Revised Report: August 9, 2012.

^*F25: Harvey Spirit: TRC. *Emissions Test Report Harvey Spirit Resupply Ship Shell Gulf of Mexico, Inc.* Report Issued: July 31, 2012. Submittal Data of Revised Report: August 9, 2012.

^F26: MLC ROV System Engine: Cummins. *Exhaust Emissions Data Sheet. Basic Engine Model: KTA50-G3.* April 16, 2002.

^F27: Harris, Royal. *Diesel Question Email.* [Communication with Bruce Harland, Crowley.] April 20, 2011.

^*F28: Camp Generator: John Deere. *Off-Highway Diesel Engine Ratings Tier 3/Stage III A. Page 27: PowerTech Plus 13.5L Engines, 6135H.* No date.

^F29: Camp Generator: Caterpillar. *Gen Set Package Performance Data [BLG02887].* June 10, 2014.

^F30: Harvey Explorer: TRC. *Emissions Test Report Harvey Explorer Resupply Ship Shell Gulf of Mexico, Inc.* Report Issued: July 22, 2012. Submittal Data of Revised Report: August 9, 2012.

United States Environmental Protection Agency (EPA). *AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*.

United States Environmental Protection Agency (EPA). *Locating and Estimating Air Emissions from Sources of Lead and Lead Compounds*. May 1998.

^ Copy provided

* The summary tables are provided; full report available upon request

Attachment A – AQRP Emission Inventory

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Short-Term Maximum Load	Annual Operation	Maximum Aggregate Rating [2]
Discoverer			
Generator Engines	80%	2,880 hrs/yr	5,287 kW
Propulsion Engine	80%	2,880 hrs/yr	5,184 kW
HPU Engines	80%	2,880 hrs/yr	290 kW
Crane Engines	80%	2,880 hrs/yr	720 kW
Cementing Unit Engines	80%	2,880 hrs/yr	400 kW
Logging Unit Engine	80%	2,880 hrs/yr	179 kW
Compressor Engine	80%	2,880 hrs/yr	84 kW
Sidewall Core Tool Engine	80%	2,880 hrs/yr	34 kW
Emergency Engine	80%	2,880 hrs/yr	405 kW
Lifeboat Engines	80%	2,880 hrs/yr	70 kW
Boilers	100%	2,880 hrs/yr	16 MMBtu/hr
Incinerator	100%	2,880 hrs/yr	276 lb/hr
Total - *Discoverer*			
Polar Pioneer			
Generator Engines	80%	2,880 hrs/yr	11,000 kW
HPU Engines	80%	2,880 hrs/yr	299 kW
Logging Unit Engine	80%	2,880 hrs/yr	179 kW
Compressor Engine	80%	2,880 hrs/yr	84 kW
Sidewall Core Tool Engine	80%	2,880 hrs/yr	34 kW
Emergency Engine	80%	2,880 hrs/yr	896 kW
Small Emergency Engines	80%	2,880 hrs/yr	461 kW
Boilers	100%	2,880 hrs/yr	26 MMBtu/hr
Incinerator	100%	2,880 hrs/yr	220 lb/hr
Total - *Polar Pioneer*			
***Discoverer* Support Vessels**			
Ice management (*Fennica*)			
Propulsion and Generator Engines	80%	642,600 gallons/yr	16,800 kW
Harbour Set Generator Engine	80%	2,880 hrs/yr	424 kW
Boilers	100%	2,880 hrs/yr	9 MMBtu/hr
Incinerator	100%	2,880 hrs/yr	154 lb/hr
Emergency Engine	80%	500 hrs/yr	240 kW
Anchor Handler (*Aiviq*)			
Propulsion Engines	80%	1,015,207 gallons/yr	13,001 kW
Generator Engines	80%	424,805 gallons/yr	5,440 kW
Boilers	100%	2,880 hrs/yr	5 MMBtu/hr
Incinerator	100%	2,880 hrs/yr	276 lb/hr
Emergency Engines	80%	500 hrs/yr	1,456 kW
Rescue & Lifeboat Engines	80%	500 hrs/yr	542 kW
OSR Equipment Engines	80%	960 hrs/yr	152 kW
Science Vessel (Similar to *Supporter*)			
Propulsion and Generator Engines	80%	273,000 gallons/yr	5,840 kW
Emergency Engines	80%	500 hours	100 kW
Incinerator	100%	2,880 hours	88 lb/hr
Support Tug (*Lauren Foss*)			
Propulsion Engines	80%	96,348 gallons/yr	4,896 kW
Generator Engines	80%	504 hrs/yr	272 kW
Emergency Engine	80%	500 hrs/yr	56 kW
Thruster Engine	80%	504 hrs/yr	299 kW
Total - *Discoverer* Support Vessels			

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Short-Term Maximum Load	Annual Operation	Maximum Aggregate Rating [2]
***Polar Pioneer* Support Vessels**			
Ice Management (*Nordica*)			
Propulsion and Generator Engines	80%	630,000 gallons/yr	16,800 kW
Harbour Set Generator Engine	80%	2,880 hrs/yr	424 kW
Boilers	100%	2,880 hrs/yr	9 MMBtu/hr
Incinerator	100%	2,880 hrs/yr	154 lb/hr
Emergency Engine	80%	500 hrs/yr	240 kW
Anchor Handler (*Tor Viking*)			
Propulsion Engines	80%	527,734 gallons/yr	10,752 kW
Generator Engines	80%	39,266 gallons/yr	800 kW
Boilers	100%	2,880 hrs/yr	1.37 MMBtu/hr
Emergency Engine	80%	500 hrs/yr	136 kW
Science Vessel (Similar to *Harvey Explorer*)			
Propulsion Engines	80%	273,000 gallons/yr	2,699 kW
Generator Engines	80%	2,880 hrs/yr	826 kW
Thruster Engines	80%	2,880 hrs/yr	1,337 kW
Emergency Engines	80%	500 hrs/yr	107 kW
Support Tug (*Ocean Wind*)			
Propulsion Engines	80%	399,840 gallons/yr	6,496 kW
Generator Engines	80%	2,880 hrs/yr	372 kW
Support Tug (*Ocean Wave*)			
Propulsion Engines	80%	399,840 gallons/yr	6,496 kW
Generator Engines	80%	2,880 hrs/yr	372 kW
Total - *Polar Pioneer* Support Vessels			

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Short-Term Maximum Load	Annual Operation	Maximum Aggregate Rating [2]
Common Support Vessels			
Anchor Handler (*Ross Chouest*)			
Propulsion and Generator Engines	80%	420,000 gallons/yr	10,023 kW
Various Engines	80%	2,880 hrs/yr	1,146 kW
Emergency Engine	80%	500 hrs/yr	256 kW
OSV (*Sisuaq*)			
Propulsion and Generator Engines	80%	117,852 gallons/yr	5,840 kW
Emergency Engines	80%	500 hrs/yr	100 kW
Various Engines	80%	2,880 hrs/yr	537 kW
OSR Equipment Engines	80%	960 hrs/yr	284 kW
Incinerator	100%	2,880 hrs/yr	88 lb/hr
OSV (*Harvey Supporter*)			
Propulsion and Generator Engines	80%	117,852 gallons/yr	5,840 kW
Emergency Engines	80%	500 hrs/yr	100 kW
OSR Equipment Engines	80%	960 hrs/yr	216 kW
Incinerator	100%	2,880 hrs/yr	88 lb/hr
OSRV (*Nanuq*)			
Propulsion Engines	80%	504,000 gallons/yr	4,336 kW
Generator Engines	80%	2,880 hrs/yr	1,534 kW
Emergency Engines	80%	500 hrs/yr	150 kW
OSR Equipment Engines	80%	960 hrs/yr	292 kW
Incinerator	100%	2,880 hrs/yr	125 lb/hr
OSR Workboats (*Kvichaks*)			
Propulsion and Generator Engines	80%	2,880 hrs/yr	1,096 kW
OSR-T/B (*Guardsman* /*Klamath*)			
Propulsion Engines	80%	154,350 gallons/yr	4,299 kW
Generator Engines	80%	2,880 hrs/yr	239 kW
OSR Equipment Engines	80%	960 hrs/yr	529 kW
Arctic Oil Storage Tanker (Similar to *Affinity*)			
Propulsion and Generator Engines	80%	323,400 gallons/yr	15,344 kW
Emergency Engine	80%	500 hrs/yr	236 kW
Various Engines	80%	2,880 hrs/yr	1,145 kW
Boiler	100%	2,880 hrs/yr	53 MMBtu/hr
Incinerator	100%	2,880 hrs/yr	188 lb/hr
MLC ROV System Vessel (Similar to *Harvey Spirit*)			
Propulsion Engines	80%	111,300 gallons/yr	3,666 kW
Generator Engines	80%	2,880 hrs/yr	1,152 kW
Thruster Engines	80%	2,880 hrs/yr	2,239 kW
Emergency Engine	80%	500 hrs/yr	79 kW
MLC ROV System Engine	80%	2,880 hrs/yr	800 kW
Total - Common Support Vessels			
Total - Support Vessels			

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Oxides of Nitrogen (NO_X) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	5.9 g/kW-hr	Vendor Data	68.8 lb/hr	99.0 ton/yr
Propulsion Engine	14.2 g/kW-hr	Vendor Data	162.5 lb/hr	233.9 ton/yr
HPU Engines	3.0 g/kW-hr	Source Test Data	1.9 lb/hr	2.8 ton/yr
Crane Engines	3.6 g/kW-hr	Vendor Data	5.7 lb/hr	8.3 ton/yr
Cementing Unit Engines	12.6 g/kW-hr	Source Test Data	11.1 lb/hr	16.0 ton/yr
Logging Unit Engine	4.0 g/kW-hr	Vendor Data	1.6 lb/hr	2.3 ton/yr
Compressor Engine	14.8 g/kW-hr	Vendor Data	2.7 lb/hr	3.9 ton/yr
Sidewall Core Tool Engine	7.5 g/kW-hr	Vendor Data	0.6 lb/hr	0.8 ton/yr
Emergency Engine	14.6 g/kW-hr	Table 3.4-1, AP-42	13.0 lb/hr	18.8 ton/yr
Lifeboat Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	2.9 lb/hr	4.2 ton/yr
Boilers	20.8 lb/kgal	Source Test Data	2.5 lb/hr	3.6 ton/yr
Incinerator	3.2 lb/ton	Source Test Data	0.4 lb/hr	0.6 ton/yr
Total - *Discoverer*			**273.8 lb/hr**	**394.3 ton/yr**
Polar Pioneer				
Generator Engines	11.4 g/kW-hr	Source Test Data	275.2 lb/hr	396.4 ton/yr
HPU Engines	3.0 g/kW-hr	Source Test Data	2.0 lb/hr	2.9 ton/yr
Logging Unit Engine	4.0 g/kW-hr	Vendor Data	1.6 lb/hr	2.3 ton/yr
Compressor Engine	14.8 g/kW-hr	Vendor Data	2.7 lb/hr	3.9 ton/yr
Sidewall Core Tool Engine	7.5 g/kW-hr	Vendor Data	0.6 lb/hr	0.8 ton/yr
Emergency Engine	14.6 g/kW-hr	Table 3.4-1, AP-42	28.8 lb/hr	41.5 ton/yr
Small Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	19.1 lb/hr	27.6 ton/yr
Boilers	20.0 lb/kgal	Table 1.3-1, AP-42	3.9 lb/hr	5.6 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.3 lb/hr	0.5 ton/yr
Total - *Polar Pioneer*			**334.3 lb/hr**	**481.5 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	9.4 g/kW-hr	Source Test Data	350.0 lb/hr	93.6 ton/yr
Harbour Set Generator Engine	14.6 g/kW-hr	Table 3.4-1, AP-42	13.6 lb/hr	19.6 ton/yr
Boilers	16.0 lb/kgal	Source Test Data	1.1 lb/hr	1.6 ton/yr
Incinerator	7.1 lb/ton	Source Test Data	0.5 lb/hr	0.8 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	10.0 lb/hr	2.5 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	8.1 g/kW-hr	Vendor Data	231.9 lb/hr	126.6 ton/yr
Generator Engines	7.6 g/kW-hr	Vendor Data	91.0 lb/hr	49.7 ton/yr
Boilers	20.0 lb/kgal	Table 1.3-1, AP-42	0.8 lb/hr	1.2 ton/yr
Incinerator	4.1 lb/ton	Source Test Data	0.6 lb/hr	0.8 ton/yr
Emergency Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	46.8 lb/hr	11.7 ton/yr
Rescue & Lifeboat Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	22.5 lb/hr	5.6 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	6.3 lb/hr	3.0 ton/yr
Science Vessel (Similar to *Supporter*)				
Propulsion and Generator Engines	7.1 g/kW-hr	Source Test Data	91.3 lb/hr	29.8 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	4.2 lb/hr	1.0 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.1 lb/hr	0.2 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	157.4 lb/hr	21.7 ton/yr
Generator Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	11.3 lb/hr	2.8 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	2.3 lb/hr	0.6 ton/yr
Thruster Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	12.4 lb/hr	3.1 ton/yr
Total - *Discoverer* Support Vessels			**1,054.1 lb/hr**	**376.0 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Oxides of Nitrogen (NO_X) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
***Polar Pioneer* Support Vessels**				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	9.4 g/kW-hr	Source Test Data	350.0 lb/hr	91.8 ton/yr
Harbour Set Generator Engine	14.6 g/kW-hr	Table 3.4-1, AP-42	13.6 lb/hr	19.6 ton/yr
Boilers	20.4 lb/kgal	Source Test Data	1.4 lb/hr	2.0 ton/yr
Incinerator	1.8 lb/ton	Source Test Data	0.1 lb/hr	0.2 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	10.0 lb/hr	2.5 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	8.2 g/kW-hr	Source Test Data	195.2 lb/hr	67.0 ton/yr
Generator Engines	9.8 g/kW-hr	Source Test Data	17.3 lb/hr	5.9 ton/yr
Boilers	15.1 lb/kgal	Source Test Data	0.2 lb/hr	0.2 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	5.6 lb/hr	1.4 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	9.5 g/kW-hr	Source Test Data	56.4 lb/hr	39.9 ton/yr
Generator Engines	7.6 g/kW-hr	Source Test Data	13.9 lb/hr	20.0 ton/yr
Thruster Engines	4.4 g/kW-hr	Source Test Data	13.0 lb/hr	18.7 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	4.4 lb/hr	1.1 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	8.1 g/kW-hr	Vendor Data	115.9 lb/hr	49.9 ton/yr
Generator Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	15.5 lb/hr	22.3 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	8.1 g/kW-hr	Vendor Data	115.9 lb/hr	49.9 ton/yr
Generator Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	15.5 lb/hr	22.3 ton/yr
Total - *Polar Pioneer* Support Vessels			**943.8 lb/hr**	**414.6 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Oxides of Nitrogen (NO_X) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	322.3 lb/hr	94.4 ton/yr
Various Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	36.9 lb/hr	53.1 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	10.6 lb/hr	2.7 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	7.1 g/kW-hr	Source Test Data	91.3 lb/hr	12.9 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-41	4.2 lb/hr	1.0 ton/yr
Various Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	22.3 lb/hr	32.1 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	11.8 lb/hr	5.7 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.1 lb/hr	0.2 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	7.1 g/kW-hr	Source Test Data	91.3 lb/hr	12.9 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	4.2 lb/hr	1.0 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	9.0 lb/hr	4.3 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.1 lb/hr	0.2 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	7.2 g/kW-hr	Source Test Data	69.2 lb/hr	56.2 ton/yr
Generator Engines	10.9 g/kW-hr	Source Test Data	37.0 lb/hr	53.2 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	6.2 lb/hr	1.6 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	12.1 lb/hr	5.8 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.2 lb/hr	0.3 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	5.2 g/kW-hr	Source Test Data	12.6 lb/hr	18.2 ton/yr
OSR-T/B (*Guardsman* /*Klamath*)				
Propulsion Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	138.2 lb/hr	34.7 ton/yr
Generator Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	9.9 lb/hr	14.3 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	22.0 lb/hr	10.6 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	493.5 lb/hr	72.7 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	9.8 lb/hr	2.5 ton/yr
Various Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	47.6 lb/hr	68.5 ton/yr
Boiler	20.0 lb/kgal	Table 1.3-1, AP-42	8.1 lb/hr	11.7 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.3 lb/hr	0.4 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	16.9 g/kW-hr	Source Test Data	136.2 lb/hr	28.9 ton/yr
Generator Engines	12.2 g/kW-hr	Source Test Data	31.0 lb/hr	44.6 ton/yr
Thruster Engines	5.3 g/kW-hr	Source Test Data	26.3 lb/hr	37.9 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	3.3 lb/hr	0.8 ton/yr
MLC ROV System Engine	13.0 g/kW-hr	Vendor Data	22.9 lb/hr	33.0 ton/yr
Total - Common Support Vessels			**1,690.5 lb/hr**	**716.5 ton/yr**
Total - Support Vessels			**3,688.4 lb/hr**	**1,507.1 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Carbon Monoxide (CO) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	1.3 g/kW-hr	Vendor Data	15.2 lb/hr	21.8 ton/yr
Propulsion Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	38.2 lb/hr	55.0 ton/yr
HPU Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.6 lb/hr	3.8 ton/yr
Crane Engines	0.6 g/kW-hr	Vendor Data	0.9 lb/hr	1.3 ton/yr
Cementing Unit Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	3.6 lb/hr	5.2 ton/yr
Logging Unit Engine	3.5 g/kW-hr	Vendor Data	1.4 lb/hr	2.0 ton/yr
Compressor Engine	9.9 g/kW-hr	Vendor Data	1.8 lb/hr	2.6 ton/yr
Sidewall Core Tool Engine	5.0 g/kW-hr	Vendor Data	0.4 lb/hr	0.5 ton/yr
Emergency Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	3.0 lb/hr	4.3 ton/yr
Lifeboat Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	0.6 lb/hr	0.9 ton/yr
Boilers	2.4 lb/kgal	Source Test Data	0.3 lb/hr	0.4 ton/yr
Incinerator	10.8 lb/ton	Source Test Data	1.5 lb/hr	2.2 ton/yr
Total - *Discoverer*			**69.5 lb/hr**	**100.1 ton/yr**
Polar Pioneer				
Generator Engines	1.4 g/kW-hr	Source Test Data	34.4 lb/hr	49.6 ton/yr
HPU Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.7 lb/hr	3.9 ton/yr
Logging Unit Engine	3.5 g/kW-hr	Vendor Data	1.4 lb/hr	2.0 ton/yr
Compressor Engine	9.9 g/kW-hr	Vendor Data	1.8 lb/hr	2.6 ton/yr
Sidewall Core Tool Engine	5.0 g/kW-hr	Vendor Data	0.4 lb/hr	0.5 ton/yr
Emergency Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	6.6 lb/hr	9.5 ton/yr
Small Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	4.2 lb/hr	6.0 ton/yr
Boilers	5.0 lb/kgal	Table 1.3-1, AP-42	1.0 lb/hr	1.4 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	3.3E-2 lb/hr	4.7E-2 ton/yr
Total - *Polar Pioneer*			**52.5 lb/hr**	**75.7 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	123.8 lb/hr	33.1 ton/yr
Harbour Set Generator Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	3.1 lb/hr	4.5 ton/yr
Boilers	0.4 lb/kgal	Source Test Data	2.7E-2 lb/hr	3.8E-2 ton/yr
Incinerator	29.9 lb/ton	Source Test Data	2.3 lb/hr	3.3 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.2 lb/hr	0.5 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.5 g/kW-hr	Vendor Data	14.6 lb/hr	8.0 ton/yr
Generator Engines	1.7 g/kW-hr	Vendor Data	20.7 lb/hr	11.3 ton/yr
Boilers	5.0 lb/kgal	Table 1.3-1, AP-42	0.2 lb/hr	0.3 ton/yr
Incinerator	11.1 lb/ton	Source Test Data	1.5 lb/hr	2.2 ton/yr
Emergency Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	10.7 lb/hr	2.7 ton/yr
Rescue & Lifeboat Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	4.9 lb/hr	1.2 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	1.4 lb/hr	0.7 ton/yr
Science Vessel (Similar to *Supporter*)				
Propulsion and Generator Engines	1.2 g/kW-hr	Source Test Data	15.7 lb/hr	5.1 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	1.3E-2 lb/hr	1.9E-2 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	36.1 lb/hr	5.0 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.5 lb/hr	0.6 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	0.5 lb/hr	0.1 ton/yr
Thruster Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.7 lb/hr	0.7 ton/yr
Total - *Discoverer* Support Vessels			**244.0 lb/hr**	**79.7 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Carbon Monoxide (CO) Emissions			
	Factor	**Reference**	**Hourly [3,6]**	**Annual [3,4,5]**
***Polar Pioneer* Support Vessels**				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	123.8 lb/hr	32.5 ton/yr
Harbour Set Generator Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	3.1 lb/hr	4.5 ton/yr
Boilers	0.1 lb/kgal	Source Test Data	4.8E-3 lb/hr	7.0E-3 ton/yr
Incinerator	3.7 lb/ton	Source Test Data	0.3 lb/hr	0.4 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.2 lb/hr	0.5 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	79.2 lb/hr	27.2 ton/yr
Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	5.9 lb/hr	2.0 ton/yr
Boilers	5.0 lb/kgal	Table 1.3-1, AP-42	5.2E-2 lb/hr	7.5E-2 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	0.3 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	19.9 lb/hr	14.1 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	7.5 lb/hr	10.8 ton/yr
Thruster Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	9.9 lb/hr	14.2 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	0.2 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.5 g/kW-hr	Vendor Data	7.3 lb/hr	3.1 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	3.4 lb/hr	4.9 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.5 g/kW-hr	Vendor Data	7.3 lb/hr	3.1 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	3.4 lb/hr	4.9 ton/yr
Total - *Polar Pioneer* Support Vessels			**275.5 lb/hr**	**122.9 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Carbon Monoxide (CO) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	73.9 lb/hr	21.6 ton/yr
Various Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	8.4 lb/hr	12.2 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.3 lb/hr	0.6 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	1.2 g/kW-hr	Source Test Data	15.7 lb/hr	2.2 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-41	0.9 lb/hr	0.2 ton/yr
Various Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	4.9 lb/hr	7.1 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.6 lb/hr	1.2 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	1.3E-2 lb/hr	1.9E-2 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	1.2 g/kW-hr	Source Test Data	15.7 lb/hr	2.2 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.0 lb/hr	0.9 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	1.3E-2 lb/hr	1.9E-2 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	32.0 lb/hr	26.0 ton/yr
Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	11.3 lb/hr	16.3 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	1.4 lb/hr	0.3 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.7 lb/hr	1.3 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	1.9E-2 lb/hr	2.7E-2 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	1.5 g/kW-hr	Source Test Data	3.7 lb/hr	5.4 ton/yr
OSR-T/B (*Guardsman* /*Klamath*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	31.7 lb/hr	8.0 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.2 lb/hr	3.1 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	4.8 lb/hr	2.3 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	113.1 lb/hr	16.7 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.2 lb/hr	0.5 ton/yr
Various Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	10.4 lb/hr	15.0 ton/yr
Boiler	5.0 lb/kgal	Table 1.3-1, AP-42	2.0 lb/hr	2.9 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	2.8E-2 lb/hr	4.0E-2 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	27.0 lb/hr	5.7 ton/yr
Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	8.5 lb/hr	12.2 ton/yr
Thruster Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	16.5 lb/hr	23.8 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
MLC ROV System Engine	0.7 g/kW-hr	Vendor Data	1.2 lb/hr	1.7 ton/yr
Total - Common Support Vessels			**398.7 lb/hr**	**190.0 ton/yr**
Total - Support Vessels			**918.2 lb/hr**	**392.6 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Particulate Matter (PM_{10}) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	0.2 g/kW-hr	Vendor Data	1.9 lb/hr	2.7 ton/yr
Propulsion Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	4.9 lb/hr	7.0 ton/yr
HPU Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	1.2 ton/yr
Crane Engines	0.1 g/kW-hr	Vendor Data	0.2 lb/hr	0.2 ton/yr
Cementing Unit Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	1.7 ton/yr
Logging Unit Engine	0.2 g/kW-hr	Vendor Data	0.1 lb/hr	0.1 ton/yr
Compressor Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.4 ton/yr
Sidewall Core Tool Engine	0.4 g/kW-hr	Vendor Data	3.0E-2 lb/hr	4.3E-2 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.5 ton/yr
Lifeboat Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.3 ton/yr
Boilers	0.3 lb/kgal	Source Test Data	3.6E-2 lb/hr	5.2E-2 ton/yr
Incinerator	6.9 lb/ton	Source Test Data	1.0 lb/hr	1.4 ton/yr
Total - *Discoverer*			**10.9 lb/hr**	**15.7 ton/yr**
Polar Pioneer				
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.3 lb/hr	14.9 ton/yr
HPU Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	1.3 ton/yr
Logging Unit Engine	0.2 g/kW-hr	Vendor Data	0.1 lb/hr	0.1 ton/yr
Compressor Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.4 ton/yr
Sidewall Core Tool Engine	0.4 g/kW-hr	Vendor Data	3.0E-2 lb/hr	4.3E-2 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	1.2 ton/yr
Small Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.4 lb/hr	2.0 ton/yr
Boilers	3.3 lb/kgal	Table 1.3-1, AP-42	0.6 lb/hr	0.9 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	2.8 lb/hr	4.0 ton/yr
Total - *Polar Pioneer*			**17.2 lb/hr**	**24.7 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	15.8 lb/hr	4.2 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.6 ton/yr
Boilers	0.5 lb/kgal	Source Test Data	3.6E-2 lb/hr	5.2E-2 ton/yr
Incinerator	17.0 lb/ton	Source Test Data	1.3 lb/hr	1.9 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.3 g/kW-hr	Source Test Data	7.3 lb/hr	4.0 ton/yr
Generator Engines	0.2 g/kW-hr	Vendor Data	2.4 lb/hr	1.3 ton/yr
Boilers	3.3 lb/kgal	Table 1.3-1, AP-42	0.1 lb/hr	0.2 ton/yr
Incinerator	18.0 lb/ton	Source Test Data	2.5 lb/hr	3.6 ton/yr
Emergency Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	0.3 ton/yr
Rescue & Lifeboat Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	0.4 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.2 ton/yr
Science Vessel (Similar to *Supporter*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.7 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.6 lb/hr	0.6 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	4.1E-2 ton/yr
Thruster Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
Total - *Discoverer* Support Vessels			**44.1 lb/hr**	**20.4 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Particulate Matter (PM_{10}) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
***Polar Pioneer* Support Vessels**				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	15.8 lb/hr	4.1 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.6 ton/yr
Boilers	0.4 lb/kgal	Source Test Data	2.6E-2 lb/hr	3.8E-2 ton/yr
Incinerator	2.2 lb/ton	Source Test Data	0.2 lb/hr	0.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.1 lb/hr	3.5 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	0.3 ton/yr
Boilers	1.2 lb/kgal	Source Test Data	1.3E-2 lb/hr	1.8E-2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	0.1 g/kW-hr	Source Test Data	0.8 lb/hr	0.5 ton/yr
Generator Engines	0.4 g/kW-hr	Source Test Data	0.7 lb/hr	1.0 ton/yr
Thruster Engines	0.2 g/kW-hr	Source Test Data	0.7 lb/hr	1.0 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.2 g/kW-hr	Vendor Data	2.1 lb/hr	0.9 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.1 lb/hr	1.6 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.2 g/kW-hr	Vendor Data	2.1 lb/hr	0.9 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.1 lb/hr	1.6 ton/yr
Total - *Polar Pioneer* Support Vessels			**37.3 lb/hr**	**16.7 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Particulate Matter (PM_{10}) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	9.4 lb/hr	2.8 ton/yr
Various Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.1 lb/hr	1.5 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.3 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-41	0.3 lb/hr	0.1 ton/yr
Various Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	2.3 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.4 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.3 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.6 lb/hr	0.3 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.1 lb/hr	3.3 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	2.1 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.4 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.6 lb/hr	2.3 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	0.1 g/kW-hr	Source Test Data	0.3 lb/hr	0.4 ton/yr
OSR-T/B (*Guardsman* /*Klamath*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.0 lb/hr	1.0 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	1.0 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	0.7 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	14.4 lb/hr	2.1 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Various Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	3.4 lb/hr	4.9 ton/yr
Boiler	3.3 lb/kgal	Table 1.3-1, AP-42	1.3 lb/hr	1.9 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	2.4 lb/hr	3.4 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	0.2 g/kW-hr	Source Test Data	1.5 lb/hr	0.3 ton/yr
Generator Engines	0.3 g/kW-hr	Source Test Data	0.7 lb/hr	0.9 ton/yr
Thruster Engines	0.2 g/kW-hr	Source Test Data	0.8 lb/hr	1.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.1 ton/yr
MLC ROV System Engine	0.1 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Total - Common Support Vessels			**62.1 lb/hr**	**38.0 ton/yr**
Total - Support Vessels			**143.4 lb/hr**	**75.1 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Particulate Matter ($PM_{2.5}$) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	0.2 g/kW-hr	Vendor Data	1.9 lb/hr	2.7 ton/yr
Propulsion Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	4.9 lb/hr	7.0 ton/yr
HPU Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	1.2 ton/yr
Crane Engines	0.1 g/kW-hr	Vendor Data	0.2 lb/hr	0.2 ton/yr
Cementing Unit Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	1.7 ton/yr
Logging Unit Engine	0.2 g/kW-hr	Vendor Data	0.1 lb/hr	0.1 ton/yr
Compressor Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.4 ton/yr
Sidewall Core Tool Engine	0.4 g/kW-hr	Vendor Data	3.0E-2 lb/hr	4.3E-2 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.5 ton/yr
Lifeboat Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.3 ton/yr
Boilers	0.3 lb/kgal	Source Test Data	3.6E-2 lb/hr	5.2E-2 ton/yr
Incinerator	6.9 lb/ton	Source Test Data	1.0 lb/hr	1.4 ton/yr
Total - *Discoverer*			**10.9 lb/hr**	**15.7 ton/yr**
Polar Pioneer				
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.3 lb/hr	14.9 ton/yr
HPU Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	1.3 ton/yr
Logging Unit Engine	0.2 g/kW-hr	Vendor Data	0.1 lb/hr	0.1 ton/yr
Compressor Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.4 ton/yr
Sidewall Core Tool Engine	0.4 g/kW-hr	Vendor Data	3.0E-2 lb/hr	4.3E-2 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	1.2 ton/yr
Small Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.4 lb/hr	2.0 ton/yr
Boilers	3.3 lb/kgal	Table 1.3-1, AP-42	0.6 lb/hr	0.9 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	2.8 lb/hr	4.0 ton/yr
Total - *Polar Pioneer*			**17.2 lb/hr**	**24.7 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	15.8 lb/hr	4.2 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.6 ton/yr
Boilers	0.5 lb/kgal	Source Test Data	3.6E-2 lb/hr	5.2E-2 ton/yr
Incinerator	17.0 lb/ton	Source Test Data	1.3 lb/hr	1.9 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.3 g/kW-hr	Source Test Data	7.3 lb/hr	4.0 ton/yr
Generator Engines	0.2 g/kW-hr	Vendor Data	2.4 lb/hr	1.3 ton/yr
Boilers	3.3 lb/kgal	Table 1.3-1, AP-42	0.1 lb/hr	0.2 ton/yr
Incinerator	18.0 lb/ton	Source Test Data	2.5 lb/hr	3.6 ton/yr
Emergency Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	0.3 ton/yr
Rescue & Lifeboat Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	0.4 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.2 ton/yr
Science Vessel (Similar to *Supporter*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.7 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.6 lb/hr	0.6 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	4.1E-2 ton/yr
Thruster Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
Total - *Discoverer* Support Vessels			**44.1 lb/hr**	**20.4 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Particulate Matter ($PM_{2.5}$) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
***Polar Pioneer* Support Vessels**				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	15.8 lb/hr	4.1 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.6 ton/yr
Boilers	0.4 lb/kgal	Source Test Data	2.6E-2 lb/hr	3.8E-2 ton/yr
Incinerator	2.2 lb/ton	Source Test Data	0.2 lb/hr	0.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.1 lb/hr	3.5 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	0.3 ton/yr
Boilers	1.2 lb/kgal	Source Test Data	1.3E-2 lb/hr	1.8E-2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	0.1 g/kW-hr	Source Test Data	0.8 lb/hr	0.5 ton/yr
Generator Engines	0.4 g/kW-hr	Source Test Data	0.7 lb/hr	1.0 ton/yr
Thruster Engines	0.2 g/kW-hr	Source Test Data	0.7 lb/hr	1.0 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.2 g/kW-hr	Vendor Data	2.1 lb/hr	0.9 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.1 lb/hr	1.6 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.2 g/kW-hr	Vendor Data	2.1 lb/hr	0.9 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.1 lb/hr	1.6 ton/yr
Total - *Polar Pioneer* Support Vessels			**37.3 lb/hr**	**16.7 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Particulate Matter ($PM_{2.5}$) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	9.4 lb/hr	2.8 ton/yr
Various Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.1 lb/hr	1.5 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.3 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-41	0.3 lb/hr	0.1 ton/yr
Various Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	2.3 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.4 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.3 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.6 lb/hr	0.3 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.1 lb/hr	3.3 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	2.1 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.4 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.6 lb/hr	2.3 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	0.1 g/kW-hr	Source Test Data	0.3 lb/hr	0.4 ton/yr
OSR-T/B (*Guardsman* /*Klamath*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.0 lb/hr	1.0 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	1.0 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	0.7 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	14.4 lb/hr	2.1 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Various Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	3.4 lb/hr	4.9 ton/yr
Boiler	3.3 lb/kgal	Table 1.3-1, AP-42	1.3 lb/hr	1.9 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	2.4 lb/hr	3.4 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	0.2 g/kW-hr	Source Test Data	1.5 lb/hr	0.3 ton/yr
Generator Engines	0.3 g/kW-hr	Source Test Data	0.7 lb/hr	0.9 ton/yr
Thruster Engines	0.2 g/kW-hr	Source Test Data	0.8 lb/hr	1.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.1 ton/yr
MLC ROV System Engine	0.1 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Total - Common Support Vessels			**62.1 lb/hr**	**38.0 ton/yr**
Total - Support Vessels			**143.4 lb/hr**	**75.1 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Volatile Organic Compounds (VOC) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	0.5 g/kW-hr	Vendor Data	5.2 lb/hr	7.6 ton/yr
Propulsion Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	4.9 lb/hr	7.1 ton/yr
HPU Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	1.4 ton/yr
Crane Engines	0.1 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Cementing Unit Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.3 lb/hr	1.9 ton/yr
Logging Unit Engine	4.0 g/kW-hr	Vendor Data	1.6 lb/hr	2.3 ton/yr
Compressor Engine	0.6 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Sidewall Core Tool Engine	7.5 g/kW-hr	Vendor Data	0.6 lb/hr	0.8 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.6 ton/yr
Lifeboat Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.3 ton/yr
Boilers	0.1 lb/kgal	Source Test Data	1.0E-2 lb/hr	1.5E-2 ton/yr
Incinerator	0.4 lb/ton	Source Test Data	0.1 lb/hr	7.5E-2 ton/yr
Total - *Discoverer*			**15.5 lb/hr**	**22.3 ton/yr**
Polar Pioneer				
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.4 lb/hr	15.0 ton/yr
HPU Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	1.4 ton/yr
Logging Unit Engine	4.0 g/kW-hr	Vendor Data	1.6 lb/hr	2.3 ton/yr
Compressor Engine	0.6 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Sidewall Core Tool Engine	7.5 g/kW-hr	Vendor Data	0.6 lb/hr	0.8 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	1.2 ton/yr
Small Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.5 lb/hr	2.2 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	6.6E-2 lb/hr	0.1 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.3 lb/hr	0.5 ton/yr
Total - *Polar Pioneer*			**16.4 lb/hr**	**23.6 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	15.9 lb/hr	4.2 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.6 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	2.3E-2 lb/hr	3.3E-2 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.2 lb/hr	0.3 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.7 g/kW-hr	Vendor Data	20.3 lb/hr	11.1 ton/yr
Generator Engines	0.5 g/kW-hr	Vendor Data	6.3 lb/hr	3.4 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	1.4E-2 lb/hr	2.0E-2 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.4 lb/hr	0.6 ton/yr
Emergency Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	0.3 ton/yr
Rescue & Lifeboat Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.8 lb/hr	0.4 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.5 lb/hr	0.2 ton/yr
Science Vessel (Similar to *Supporter*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	5.5 lb/hr	1.8 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.1 lb/hr	0.2 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.6 lb/hr	0.6 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	4.6E-2 ton/yr
Thruster Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	0.2 ton/yr
Total - *Discoverer* Support Vessels			**60.7 lb/hr**	**24.8 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Volatile Organic Compounds (VOC) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
***Polar Pioneer* Support Vessels**				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	15.9 lb/hr	4.2 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.6 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	2.3E-2 lb/hr	3.3E-2 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.2 lb/hr	0.3 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.2 lb/hr	3.5 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	0.3 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	3.6E-3 lb/hr	5.1E-3 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.5 lb/hr	0.1 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	2.5 lb/hr	1.8 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	2.7 lb/hr	3.9 ton/yr
Thruster Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.3 lb/hr	1.8 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.7 g/kW-hr	Vendor Data	10.2 lb/hr	4.4 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	1.8 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.7 g/kW-hr	Vendor Data	10.2 lb/hr	4.4 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	1.8 ton/yr
Total - *Polar Pioneer* Support Vessels			**58.4 lb/hr**	**29.1 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Volatile Organic Compounds (VOC) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	9.5 lb/hr	2.8 ton/yr
Various Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.1 lb/hr	1.6 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	5.5 lb/hr	0.8 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-41	0.3 lb/hr	0.1 ton/yr
Various Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.8 lb/hr	2.6 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.5 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.1 lb/hr	0.2 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	5.5 lb/hr	0.8 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.3 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.1 lb/hr	0.2 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.1 lb/hr	3.3 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	2.1 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.5 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	0.5 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.2 lb/hr	0.3 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	3.6 lb/hr	5.2 ton/yr
OSR-T/B (*Guardsman* /*Klamath*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.1 lb/hr	1.0 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	1.1 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.8 lb/hr	0.8 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	14.5 lb/hr	2.1 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Various Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	3.8 lb/hr	5.5 ton/yr
Boiler	0.3 lb/kgal	Table 1.3-3, AP-42	0.1 lb/hr	0.2 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.3 lb/hr	0.4 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	3.5 lb/hr	0.7 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.1 lb/hr	1.6 ton/yr
Thruster Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	2.1 lb/hr	3.0 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
MLC ROV System Engine	0.2 g/kW-hr	Vendor Data	0.3 lb/hr	0.4 ton/yr
Total - Common Support Vessels			**70.9 lb/hr**	**38.8 ton/yr**
Total - Support Vessels			**190.0 lb/hr**	**92.7 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Sulfur Dioxide (SO_2) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	5.3E-1 lb/hr	7.6E-1 ton/yr
Propulsion Engine	0.045 g/kW-hr	Mass Balance Calculation	5.2E-1 lb/hr	7.5E-1 ton/yr
HPU Engines	0.045 g/kW-hr	Mass Balance Calculation	2.9E-2 lb/hr	4.2E-2 ton/yr
Crane Engines	0.045 g/kW-hr	Mass Balance Calculation	7.2E-2 lb/hr	1.0E-1 ton/yr
Cementing Unit Engines	0.045 g/kW-hr	Mass Balance Calculation	4.0E-2 lb/hr	5.8E-2 ton/yr
Logging Unit Engine	0.045 g/kW-hr	Mass Balance Calculation	1.8E-2 lb/hr	2.6E-2 ton/yr
Compressor Engine	0.045 g/kW-hr	Mass Balance Calculation	8.4E-3 lb/hr	1.2E-2 ton/yr
Sidewall Core Tool Engine	0.045 g/kW-hr	Mass Balance Calculation	3.4E-3 lb/hr	4.9E-3 ton/yr
Emergency Engine	0.045 g/kW-hr	Mass Balance Calculation	4.1E-2 lb/hr	5.8E-2 ton/yr
Lifeboat Engines	0.045 g/kW-hr	Mass Balance Calculation	7.0E-3 lb/hr	1.0E-2 ton/yr
Boilers	1.40 lb/kgal	Mass Balance Calculation	1.7E-1 lb/hr	2.4E-1 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	4.8E-1 lb/hr	6.9E-1 ton/yr
Total - *Discoverer*			**1.9 lb/hr**	**2.8 ton/yr**
Polar Pioneer				
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	1.1 lb/hr	1.6 ton/yr
HPU Engines	0.045 g/kW-hr	Mass Balance Calculation	3.0E-2 lb/hr	4.3E-2 ton/yr
Logging Unit Engine	0.045 g/kW-hr	Mass Balance Calculation	1.8E-2 lb/hr	2.6E-2 ton/yr
Compressor Engine	0.045 g/kW-hr	Mass Balance Calculation	8.4E-3 lb/hr	1.2E-2 ton/yr
Sidewall Core Tool Engine	0.045 g/kW-hr	Mass Balance Calculation	3.4E-3 lb/hr	4.9E-3 ton/yr
Emergency Engine	0.045 g/kW-hr	Mass Balance Calculation	9.0E-2 lb/hr	1.3E-1 ton/yr
Small Emergency Engines	0.045 g/kW-hr	Mass Balance Calculation	4.6E-2 lb/hr	6.6E-2 ton/yr
Boilers	1.40 lb/kgal	Mass Balance Calculation	2.7E-1 lb/hr	3.9E-1 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	3.8E-1 lb/hr	5.5E-1 ton/yr
Total - *Polar Pioneer*			**2.0 lb/hr**	**2.8 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	1.7 lb/hr	4.5E-1 ton/yr
Harbour Set Generator Engine	0.045 g/kW-hr	Mass Balance Calculation	4.2E-2 lb/hr	6.1E-2 ton/yr
Boilers	1.40 lb/kgal	Mass Balance Calculation	9.5E-2 lb/hr	1.4E-1 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	2.7E-1 lb/hr	3.8E-1 ton/yr
Emergency Engine	0.045 g/kW-hr	Mass Balance Calculation	2.4E-2 lb/hr	6.0E-3 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.045 g/kW-hr	Mass Balance Calculation	1.3 lb/hr	7.1E-1 ton/yr
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	5.4E-1 lb/hr	3.0E-1 ton/yr
Boilers	1.40 lb/kgal	Mass Balance Calculation	5.6E-2 lb/hr	8.1E-2 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	4.8E-1 lb/hr	6.9E-1 ton/yr
Emergency Engines	0.045 g/kW-hr	Mass Balance Calculation	1.5E-1 lb/hr	3.6E-2 ton/yr
Rescue & Lifeboat Engines	0.045 g/kW-hr	Mass Balance Calculation	5.4E-2 lb/hr	1.4E-2 ton/yr
OSR Equipment Engines	0.045 g/kW-hr	Mass Balance Calculation	1.5E-2 lb/hr	7.3E-3 ton/yr
Science Vessel (Similar to *Supporter*)				
Propulsion and Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	5.8E-1 lb/hr	1.9E-1 ton/yr
Emergency Engines	0.045 g/kW-hr	Mass Balance Calculation	1.0E-2 lb/hr	2.5E-3 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	1.5E-1 lb/hr	2.2E-1 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	0.045 g/kW-hr	Mass Balance Calculation	4.9E-1 lb/hr	6.7E-2 ton/yr
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	2.7E-2 lb/hr	6.9E-3 ton/yr
Emergency Engine	0.045 g/kW-hr	Mass Balance Calculation	5.6E-3 lb/hr	1.4E-3 ton/yr
Thruster Engine	0.045 g/kW-hr	Mass Balance Calculation	3.0E-2 lb/hr	7.5E-3 ton/yr
Total - *Discoverer* Support Vessels			**6.0 lb/hr**	**3.4 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Sulfur Dioxide (SO_2) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
***Polar Pioneer* Support Vessels**				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	1.7 lb/hr	4.4E-1 ton/yr
Harbour Set Generator Engine	0.045 g/kW-hr	Mass Balance Calculation	4.2E-2 lb/hr	6.1E-2 ton/yr
Boilers	1.40 lb/kgal	Mass Balance Calculation	9.5E-2 lb/hr	1.4E-1 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	2.7E-1 lb/hr	3.8E-1 ton/yr
Emergency Engine	0.045 g/kW-hr	Mass Balance Calculation	2.4E-2 lb/hr	6.0E-3 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	0.045 g/kW-hr	Mass Balance Calculation	1.1 lb/hr	3.7E-1 ton/yr
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	8.0E-2 lb/hr	2.7E-2 ton/yr
Boilers	1.40 lb/kgal	Mass Balance Calculation	1.5E-2 lb/hr	2.1E-2 ton/yr
Emergency Engine	0.0 g/kW-hr	Mass Balance Calculation	1.4E-2 lb/hr	3.4E-3 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	0.045 g/kW-hr	Mass Balance Calculation	2.7E-1 lb/hr	1.9E-1 ton/yr
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	8.3E-2 lb/hr	1.2E-1 ton/yr
Thruster Engines	0.045 g/kW-hr	Mass Balance Calculation	1.3E-1 lb/hr	1.9E-1 ton/yr
Emergency Engines	0.045 g/kW-hr	Mass Balance Calculation	1.1E-2 lb/hr	2.7E-3 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.045 g/kW-hr	Mass Balance Calculation	6.5E-1 lb/hr	2.8E-1 ton/yr
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	3.7E-2 lb/hr	5.4E-2 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.045 g/kW-hr	Mass Balance Calculation	6.5E-1 lb/hr	2.8E-1 ton/yr
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	3.7E-2 lb/hr	5.4E-2 ton/yr
Total - *Polar Pioneer* Support Vessels			**5.2 lb/hr**	**2.6 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Sulfur Dioxide (SO_2) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	1.0 lb/hr	2.9E-1 ton/yr
Various Engines	0.045 g/kW-hr	Mass Balance Calculation	1.1E-1 lb/hr	1.7E-1 ton/yr
Emergency Engine	0.0 g/kW-hr	Mass Balance Calculation	2.6E-2 lb/hr	6.4E-3 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	5.8E-1 lb/hr	8.2E-2 ton/yr
Emergency Engines	0.045 g/kW-hr	Mass Balance Calculation	1.0E-2 lb/hr	2.5E-3 ton/yr
Various Engines	0.045 g/kW-hr	Mass Balance Calculation	5.4E-2 lb/hr	7.7E-2 ton/yr
OSR Equipment Engines	0.045 g/kW-hr	Mass Balance Calculation	2.8E-2 lb/hr	1.4E-2 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	1.5E-1 lb/hr	2.2E-1 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	5.8E-1 lb/hr	8.2E-2 ton/yr
Emergency Engines	0.045 g/kW-hr	Mass Balance Calculation	1.0E-2 lb/hr	2.5E-3 ton/yr
OSR Equipment Engines	0.045 g/kW-hr	Mass Balance Calculation	2.2E-2 lb/hr	1.0E-2 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	1.5E-1 lb/hr	2.2E-1 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	0.045 g/kW-hr	Mass Balance Calculation	4.3E-1 lb/hr	3.5E-1 ton/yr
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	1.5E-1 lb/hr	2.2E-1 ton/yr
Emergency Engines	0.045 g/kW-hr	Mass Balance Calculation	1.5E-2 lb/hr	3.8E-3 ton/yr
OSR Equipment Engines	0.045 g/kW-hr	Mass Balance Calculation	2.9E-2 lb/hr	1.4E-2 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	2.2E-1 lb/hr	3.1E-1 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	1.1E-1 lb/hr	1.6E-1 ton/yr
OSR-T/B (*Guardsman /Klamath*)				
Propulsion Engines	0.045 g/kW-hr	Mass Balance Calculation	4.3E-1 lb/hr	1.1E-1 ton/yr
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	2.4E-2 lb/hr	3.4E-2 ton/yr
OSR Equipment Engines	0.045 g/kW-hr	Mass Balance Calculation	5.3E-2 lb/hr	2.5E-2 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	1.5 lb/hr	2.3E-1 ton/yr
Emergency Engine	0.045 g/kW-hr	Mass Balance Calculation	2.4E-2 lb/hr	5.9E-3 ton/yr
Various Engines	0.045 g/kW-hr	Mass Balance Calculation	1.1E-1 lb/hr	1.6E-1 ton/yr
Boiler	1.40 lb/kgal	Mass Balance Calculation	5.7E-1 lb/hr	8.2E-1 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	3.3E-1 lb/hr	4.7E-1 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	0.045 g/kW-hr	Mass Balance Calculation	3.7E-1 lb/hr	7.8E-2 ton/yr
Generator Engines	0.045 g/kW-hr	Mass Balance Calculation	1.2E-1 lb/hr	1.7E-1 ton/yr
Thruster Engines	0.045 g/kW-hr	Mass Balance Calculation	2.2E-1 lb/hr	3.2E-1 ton/yr
Emergency Engine	0.045 g/kW-hr	Mass Balance Calculation	7.9E-3 lb/hr	2.0E-3 ton/yr
MLC ROV System Engine	0.045 g/kW-hr	Mass Balance Calculation	8.0E-2 lb/hr	1.2E-1 ton/yr
Total - Common Support Vessels			**7.6 lb/hr**	**4.8 ton/yr**
Total - Support Vessels			**18.7 lb/hr**	**10.8 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Lead (Pb) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.4E-3 lb/hr	2.1E-3 ton/yr
Propulsion Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.4E-3 lb/hr	2.0E-3 ton/yr
HPU Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.9E-5 lb/hr	1.1E-4 ton/yr
Crane Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.0E-4 lb/hr	2.8E-4 ton/yr
Cementing Unit Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.1E-4 lb/hr	1.6E-4 ton/yr
Logging Unit Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	4.9E-5 lb/hr	7.0E-5 ton/yr
Compressor Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.0	2.3E-5 lb/hr	3.3E-5 ton/yr
Sidewall Core Tool Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	9.3E-6 lb/hr	1.3E-5 ton/yr
Emergency Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.1E-4 lb/hr	1.6E-4 ton/yr
Lifeboat Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.9E-5 lb/hr	2.8E-5 ton/yr
Boilers	0.00118 lb/kgal	Table 1.3-10, AP-42	1.4E-4 lb/hr	2.1E-4 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	2.9E-2 lb/hr	4.2E-2 ton/yr
Total - *Discoverer*			**3.3E-2 lb/hr**	**4.7E-2 ton/yr**
Polar Pioneer				
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.0E-3 lb/hr	4.3E-3 ton/yr
HPU Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	8.1E-5 lb/hr	1.2E-4 ton/yr
Logging Unit Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	4.9E-5 lb/hr	7.0E-5 ton/yr
Compressor Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.0	2.3E-5 lb/hr	3.3E-5 ton/yr
Sidewall Core Tool Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	9.3E-6 lb/hr	1.3E-5 ton/yr
Emergency Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.4E-4 lb/hr	3.5E-4 ton/yr
Small Emergency Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.3E-4 lb/hr	1.8E-4 ton/yr
Boilers	0.00118 lb/kgal	Table 1.3-10, AP-42	2.3E-4 lb/hr	3.3E-4 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	2.3E-2 lb/hr	3.4E-2 ton/yr
Total - *Polar Pioneer*			**2.7E-2 lb/hr**	**3.9E-2 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.6E-3 lb/hr	1.2E-3 ton/yr
Harbour Set Generator Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.2E-4 lb/hr	1.7E-4 ton/yr
Boilers	0.00118 lb/kgal	Table 1.3-10, AP-42	8.0E-5 lb/hr	1.2E-4 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	1.6E-2 lb/hr	2.4E-2 ton/yr
Emergency Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	6.5E-5 lb/hr	1.6E-5 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.5E-3 lb/hr	1.9E-3 ton/yr
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.5E-3 lb/hr	8.1E-4 ton/yr
Boilers	0.00118 lb/kgal	Table 1.3-10, AP-42	4.7E-5 lb/hr	6.8E-5 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	2.9E-2 lb/hr	4.2E-2 ton/yr
Emergency Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.0E-4 lb/hr	9.9E-5 ton/yr
Rescue & Lifeboat Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.5E-4 lb/hr	3.7E-5 ton/yr
OSR Equipment Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.1E-5 lb/hr	2.0E-5 ton/yr
Science Vessel (Similar to *Supporter*)				
Propulsion and Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.6E-3 lb/hr	5.2E-4 ton/yr
Emergency Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.7E-5 lb/hr	6.8E-6 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	9.4E-3 lb/hr	1.4E-2 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.3E-3 lb/hr	1.8E-4 ton/yr
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.4E-5 lb/hr	1.9E-5 ton/yr
Emergency Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.5E-5 lb/hr	3.8E-6 ton/yr
Thruster Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	8.1E-5 lb/hr	2.0E-5 ton/yr
Total - *Discoverer* Support Vessels			**6.9E-2 lb/hr**	**8.5E-2 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Lead (Pb) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
***Polar Pioneer* Support Vessels**				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.6E-3 lb/hr	1.2E-3 ton/yr
Harbour Set Generator Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.2E-4 lb/hr	1.7E-4 ton/yr
Boilers	0.00118 lb/kgal	Table 1.3-10, AP-42	8.0E-5 lb/hr	1.2E-4 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	1.6E-2 lb/hr	2.4E-2 ton/yr
Emergency Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	6.5E-5 lb/hr	1.6E-5 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.9E-3 lb/hr	1.0E-3 ton/yr
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.2E-4 lb/hr	7.5E-5 ton/yr
Boilers	0.00118 lb/kgal	Table 1.3-10, AP-42	1.2E-5 lb/hr	1.8E-5 ton/yr
Emergency Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.7E-5 lb/hr	9.2E-6 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.3E-4 lb/hr	5.2E-4 ton/yr
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.2E-4 lb/hr	3.2E-4 ton/yr
Thruster Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.6E-4 lb/hr	5.2E-4 ton/yr
Emergency Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.9E-5 lb/hr	7.3E-6 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.8E-3 lb/hr	7.6E-4 ton/yr
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.0E-4 lb/hr	1.5E-4 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.8E-3 lb/hr	7.6E-4 ton/yr
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.0E-4 lb/hr	1.5E-4 ton/yr
Total - *Polar Pioneer* Support Vessels			**3.0E-2 lb/hr**	**2.9E-2 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Unit Description	Lead (Pb) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.7E-3 lb/hr	8.0E-4 ton/yr
Various Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.1E-4 lb/hr	4.5E-4 ton/yr
Emergency Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.0E-5 lb/hr	1.7E-5 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.6E-3 lb/hr	2.2E-4 ton/yr
Emergency Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	2.7E-5 lb/hr	6.8E-6 ton/yr
Various Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.5E-4 lb/hr	2.1E-4 ton/yr
OSR Equipment Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.7E-5 lb/hr	3.7E-5 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	9.4E-3 lb/hr	1.4E-2 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.6E-3 lb/hr	2.2E-4 ton/yr
Emergency Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.7E-5 lb/hr	6.8E-6 ton/yr
OSR Equipment Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	5.9E-5 lb/hr	2.8E-5 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	9.4E-3 lb/hr	1.4E-2 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.2E-3 lb/hr	9.6E-4 ton/yr
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.2E-4 lb/hr	6.0E-4 ton/yr
Emergency Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	4.1E-5 lb/hr	1.0E-5 ton/yr
OSR Equipment Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	7.9E-5 lb/hr	3.8E-5 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	1.3E-2 lb/hr	1.9E-2 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.4	3.0E-4 lb/hr	4.3E-4 ton/yr
OSR-T/B (*Guardsman* /*Klamath*)				
Propulsion Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.2E-3 lb/hr	2.9E-4 ton/yr
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	6.5E-5 lb/hr	9.4E-5 ton/yr
OSR Equipment Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	1.4E-4 lb/hr	6.9E-5 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.2E-3 lb/hr	6.2E-4 ton/yr
Emergency Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	6.4E-5 lb/hr	1.6E-5 ton/yr
Various Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	3.1E-4 lb/hr	4.5E-4 ton/yr
Boiler	0.00118 lb/kgal	Table 1.3-10, AP-42	4.8E-4 lb/hr	6.9E-4 ton/yr
Incinerator	0.21 lb/ton	Table 2.1-2, AP-42	2.0E-2 lb/hr	2.9E-2 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.0E-3 lb/hr	2.1E-4 ton/yr
Generator Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	3.1E-4 lb/hr	4.5E-4 ton/yr
Thruster Engines	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	6.1E-4 lb/hr	8.8E-4 ton/yr
Emergency Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	2.2E-5 lb/hr	5.4E-6 ton/yr
MLC ROV System Engine	0.00012 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	2.2E-4 lb/hr	3.1E-4 ton/yr
Total - Common Support Vessels			**6.9E-2 lb/hr**	**8.3E-2 ton/yr**
Total - Support Vessels			**0.2 lb/hr**	**0.2 ton/yr**

Table A-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Air Quality Regulatory Program Emission Inventory [1]

Notes:

[1] All vessels are assumed to be located within 25 miles of a drill rig during exploration drilling.

[2] Maximum Aggregate Rating is adjusted to account for Short-Term Maximum Load.

[3] Conversion factors

453.592 g/lb
2,000 lb/t
1.34 hp/kW

[4] Engine heat rate

7,000 Btu/hp-hr

[5] Diesel fuel energy

131,180 Btu/gal
131.18 MMBtu/1000 gal

[6] The projected peak hourly emissions presented will not occur in every hour and are not cumulative over the year.

Attachment B – NEPA Offshore Emission Inventory

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Short-Term Maximum Load	Annual Operation	Maximum Aggregate Rating [2]
Discoverer			
Generator Engines	80%	2,880 hours	5,287 kW
Propulsion Engine	80%	2,880 hours	5,184 kW
HPU Engines	80%	2,880 hours	290 kW
Crane Engines	80%	2,880 hours	720 kW
Cementing Unit Engines	80%	2,880 hours	400 kW
Logging Unit Engine	80%	2,880 hours	179 kW
Compressor Engine	80%	2,880 hours	84 kW
Sidewall Core Tool Engine	80%	2,880 hours	34 kW
Emergency Engine	80%	2,880 hours	405 kW
Lifeboat Engines	80%	2,880 hours	70 kW
Boilers	100%	2,880 hours	16 MMBtu/hr
Incinerator	100%	2,880 hours	276 lb/hr
Total - *Discoverer*			
Polar Pioneer			
Generator Engines	80%	2,880 hours	11,000 kW
HPU Engines	80%	2,880 hours	299 kW
Logging Unit Engine	80%	2,880 hours	179 kW
Compressor Engine	80%	2,880 hours	84 kW
Sidewall Core Tool Engine	80%	2,880 hours	34 kW
Emergency Engine	80%	2,880 hours	896 kW
Small Emergency Engines	80%	2,880 hours	461 kW
Boilers	100%	2,880 hours	26 MMBtu/hr
Incinerator	100%	2,880 hours	220 lb/hr
Total - *Polar Pioneer*			
***Discoverer* Support Vessels**			
Ice management (*Fennica*)			
Propulsion and Generator Engines	80%	642,600 gallons/yr	16,800 kW
Harbour Set Generator Engine	0%	0 hours	0 kW
Boilers	100%	2,880 hours	9 MMBtu/hr
Incinerator	100%	2,880 hours	154 lb/hr
Emergency Engine	80%	500 hours	240 kW
Anchor Handler (*Aiviq*)			
Propulsion Engines	80%	1,015,207 gallons/yr	13,001 kW
Generator Engines	80%	424,805 gallons/yr	5,440 kW
Boilers	100%	2,880 hours	5 MMBtu/hr
Incinerator	100%	2,880 hours	276 lb/hr
Emergency Engines	80%	500 hours	1,456 kW
Rescue & Lifeboat Engines	80%	500 hours	542 kW
OSR Equipment Engines	80%	960 hours	152 kW
Science Vessel (Similar to *Harvey Supporter*)			
Propulsion and Generator Engines	80%	273,000 gallons/yr	5,840 kW
Emergency Engines	80%	500 hours	100 kW
Incinerator	100%	2,880 hours	88 lb/hr
Support Tug (*Lauren Foss*)			
Propulsion Engines	80%	96,348 gallons/yr	4,896 kW
Generator Engines	80%	504 hours	272 kW
Emergency Engine	80%	500 hours	56 kW
Thruster Engine	80%	504 hours	299 kW
Total - Discoverer Support Vessels			

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Short-Term Maximum Load	Annual Operation	Maximum Aggregate Rating [2]
Polar Pioneer Support Vessels			
Ice Management (*Nordica*)			
Propulsion and Generator Engines	80%	630,000 gallons/yr	16,800 kW
Harbour Set Generator Engine	0%	0 hours	0 kW
Boilers	100%	2,880 hours	9 MMBtu/hr
Incinerator	100%	2,880 hours	154 lb/hr
Emergency Engine	80%	500 hours	240 kW
Anchor Handler (*Tor Viking*)			
Propulsion Engines	80%	527,734 gallons/yr	10,752 kW
Generator Engines	80%	39,266 gallons/yr	800 kW
Boilers	100%	2,880 hours	1.37 MMBtu/hr
Emergency Engine	80%	500 hours	136 kW
Science Vessel (Similar to *Harvey Explorer*)			
Propulsion Engines	80%	273,000 gallons/yr	2,699 kW
Generator Engines	80%	2,880 hours	826 kW
Thruster Engines	80%	2,880 hours	1,337 kW
Emergency Engines	80%	500 hours	107 kW
Support Tug (*Ocean Wind*)			
Propulsion Engines	80%	399,840 gallons/yr	6,496 kW
Generator Engines	80%	2,880 hours	372 kW
Support Tug (*Ocean Wave*)			
Propulsion Engines	80%	399,840 gallons/yr	6,496 kW
Generator Engines	80%	2,880 hours	372 kW
Total - Polar Pioneer Support Vessels			

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Short-Term Maximum Load	Annual Operation	Maximum Aggregate Rating [2]
Common Support Vessels			
Anchor Handler (*Ross Chouest*)			
Propulsion and Generator Engines	80%	420,000 gallons/yr	10,023 kW
Various Engines	80%	2,880 hours	1,146 kW
Emergency Engine	80%	500 hours	256 kW
OSV (*Sisuaq*)			
Propulsion and Generator Engines	80%	117,852 gallons/yr	5,840 kW
Emergency Engines	80%	500 gallons/yr	100 kW
Various Engines	80%	2,880 hours	537 kW
OSR Equipment Engines	80%	960 hours	284 kW
Incinerator	100%	2,880 hours	88 lb/hr
OSV (*Harvey Supporter*)			
Propulsion and Generator Engines	80%	117,852 gallons/yr	5,840 kW
Emergency Engines	80%	500 hours	100 kW
OSR Equipment Engines	80%	960 hours	216 kW
Incinerator	100%	2,880 hours	88 lb/hr
OSRV (*Nanuq*)			
Propulsion Engines	80%	504,000 gallons/yr	4,336 kW
Generator Engines	80%	2,880 hours	1,534 kW
Emergency Engines	80%	500 hours	150 kW
OSR Equipment Engines	80%	960 hours	292 kW
Incinerator	100%	2,880 hours	125 lb/hr
OSR Workboats (*Kvichaks*)			
Propulsion and Generator Engines	80%	2,880 hours	1,096 kW
OSR-T/B (*Guardsman/Klamath*)			
Propulsion Engines	80%	154,350 gallons/yr	4,299 kW
Generator Engines	80%	2,880 hours	239 kW
OSR Equipment Engines	80%	960 hours	529 kW
Arctic Oil Storage Tanker (Similar to *Affinity*)			
Propulsion and Generator Engines	80%	323,400 gallons/yr	15,344 kW
Emergency Engine	80%	500 hours	236 kW
Various Engines	80%	2,880 hours	1,145 kW
Boiler	100%	2,880 hours	53 MMBtu/hr
Incinerator	100%	2,880 hours	188 lb/hr
MLC ROV System Vessel (Similar to *Harvey Spirit*)			
Propulsion Engines	80%	111,300 gallons/yr	3,666 kW
Generator Engines	80%	2,880 hours	1,152 kW
Thruster Engines	80%	2,880 hours	2,239 kW
Emergency Engine	80%	500 hours	79 kW
MLC ROV System Engine	80%	2,880 hours	800 kW
Total - Common Support Vessels			
Total - Support Vessels			

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Oxides of Nitrogen (NO_X) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	5.9 g/kW-hr	Vendor Data	68.8 lb/hr	99.0 ton/yr
Propulsion Engine	14.2 g/kW-hr	Vendor Data	162.5 lb/hr	233.9 ton/yr
HPU Engines	3.0 g/kW-hr	Source Test Data	1.9 lb/hr	2.8 ton/yr
Crane Engines	3.6 g/kW-hr	Vendor Data	5.7 lb/hr	8.3 ton/yr
Cementing Unit Engines	12.6 g/kW-hr	Source Test Data	11.1 lb/hr	16.0 ton/yr
Logging Unit Engine	4.0 g/kW-hr	Vendor Data	1.6 lb/hr	2.3 ton/yr
Compressor Engine	14.8 g/kW-hr	Vendor Data	2.7 lb/hr	3.9 ton/yr
Sidewall Core Tool Engine	7.5 g/kW-hr	Vendor Data	0.6 lb/hr	0.8 ton/yr
Emergency Engine	14.6 g/kW-hr	Table 3.4-1, AP-42	13.0 lb/hr	18.8 ton/yr
Lifeboat Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	2.9 lb/hr	4.2 ton/yr
Boilers	20.8 lb/kgal	Source Test Data	2.5 lb/hr	3.6 ton/yr
Incinerator	3.2 lb/ton	Source Test Data	0.4 lb/hr	0.6 ton/yr
Total - *Discoverer*			**273.8 lb/hr**	**394.3 ton/yr**
Polar Pioneer				
Generator Engines	11.4 g/kW-hr	Source Test Data	275.2 lb/hr	396.4 ton/yr
HPU Engines	3.0 g/kW-hr	Source Test Data	2.0 lb/hr	2.9 ton/yr
Logging Unit Engine	4.0 g/kW-hr	Vendor Data	1.6 lb/hr	2.3 ton/yr
Compressor Engine	14.8 g/kW-hr	Vendor Data	2.7 lb/hr	3.9 ton/yr
Sidewall Core Tool Engine	7.5 g/kW-hr	Vendor Data	0.6 lb/hr	0.8 ton/yr
Emergency Engine	14.6 g/kW-hr	Table 3.4-1, AP-42	28.8 lb/hr	41.5 ton/yr
Small Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	19.1 lb/hr	27.6 ton/yr
Boilers	20.0 lb/kgal	Table 1.3-1, AP-42	3.9 lb/hr	5.6 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.3 lb/hr	0.5 ton/yr
Total - *Polar Pioneer*			**334.3 lb/hr**	**481.5 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	9.4 g/kW-hr	Source Test Data	350.0 lb/hr	93.6 ton/yr
Harbour Set Generator Engine	14.6 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	16.0 lb/kgal	Source Test Data	1.1 lb/hr	1.6 ton/yr
Incinerator	7.1 lb/ton	Source Test Data	0.5 lb/hr	0.8 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	10.0 lb/hr	2.5 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	8.1 g/kW-hr	Vendor Data	231.9 lb/hr	126.6 ton/yr
Generator Engines	7.6 g/kW-hr	Vendor Data	91.0 lb/hr	49.7 ton/yr
Boilers	20.0 lb/kgal	Table 1.3-1, AP-42	0.8 lb/hr	1.2 ton/yr
Incinerator	4.1 lb/ton	Source Test Data	0.6 lb/hr	0.8 ton/yr
Emergency Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	46.8 lb/hr	11.7 ton/yr
Rescue & Lifeboat Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	22.5 lb/hr	5.6 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	6.3 lb/hr	3.0 ton/yr
Science Vessel (Similar to *Harvey Supporter*)				
Propulsion and Generator Engines	7.1 g/kW-hr	Source Test Data	91.3 lb/hr	29.8 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	4.2 lb/hr	1.0 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.1 lb/hr	0.2 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	157.4 lb/hr	21.7 ton/yr
Generator Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	11.3 lb/hr	2.8 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	2.3 lb/hr	0.6 ton/yr
Thruster Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	12.4 lb/hr	3.1 ton/yr
Total - Discoverer Support Vessels			**1,040.5 lb/hr**	**356.4 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan

National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Oxides of Nitrogen (NO_X) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Polar Pioneer Support Vessels				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	9.4 g/kW-hr	Source Test Data	350.0 lb/hr	91.8 ton/yr
Harbour Set Generator Engine	14.6 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	20.4 lb/kgal	Source Test Data	1.4 lb/hr	2.0 ton/yr
Incinerator	1.8 lb/ton	Source Test Data	0.1 lb/hr	0.2 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	10.0 lb/hr	2.5 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	8.2 g/kW-hr	Source Test Data	195.2 lb/hr	67.0 ton/yr
Generator Engines	9.8 g/kW-hr	Source Test Data	17.3 lb/hr	5.9 ton/yr
Boilers	15.1 lb/kgal	Source Test Data	0.2 lb/hr	0.2 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	5.6 lb/hr	1.4 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	9.5 g/kW-hr	Source Test Data	56.4 lb/hr	39.9 ton/yr
Generator Engines	7.6 g/kW-hr	Source Test Data	13.9 lb/hr	20.0 ton/yr
Thruster Engines	4.4 g/kW-hr	Source Test Data	13.0 lb/hr	18.7 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	4.4 lb/hr	1.1 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	8.1 g/kW-hr	Vendor Data	115.9 lb/hr	49.9 ton/yr
Generator Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	15.5 lb/hr	22.3 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	8.1 g/kW-hr	Vendor Data	115.9 lb/hr	49.9 ton/yr
Generator Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	15.5 lb/hr	22.3 ton/yr
Total - Polar Pioneer Support Vessels			**930.1 lb/hr**	**395.0 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Oxides of Nitrogen (NO_X) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	322.3 lb/hr	94.4 ton/yr
Various Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	36.9 lb/hr	53.1 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	10.6 lb/hr	2.7 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	7.1 g/kW-hr	Source Test Data	91.3 lb/hr	12.9 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	4.2 lb/hr	1.0 ton/yr
Various Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	22.3 lb/hr	32.1 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	11.8 lb/hr	5.7 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.1 lb/hr	0.2 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	7.1 g/kW-hr	Source Test Data	91.3 lb/hr	12.9 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	4.2 lb/hr	1.0 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	9.0 lb/hr	4.3 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.1 lb/hr	0.2 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	7.2 g/kW-hr	Source Test Data	69.2 lb/hr	56.2 ton/yr
Generator Engines	10.9 g/kW-hr	Source Test Data	37.0 lb/hr	53.2 ton/yr
Emergency Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	6.2 lb/hr	1.6 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	12.1 lb/hr	5.8 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.2 lb/hr	0.3 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	5.2 g/kW-hr	Source Test Data	12.6 lb/hr	18.2 ton/yr
OSR-T/B (*Guardsman/Klamath*)				
Propulsion Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	138.2 lb/hr	34.7 ton/yr
Generator Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	9.9 lb/hr	14.3 ton/yr
OSR Equipment Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	22.0 lb/hr	10.6 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	14.6 g/kW-hr	Table 3.4-1, AP-42	493.5 lb/hr	72.7 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	9.8 lb/hr	2.5 ton/yr
Various Engines	18.8 g/kW-hr	Table 3.3-1, AP-42	47.6 lb/hr	68.5 ton/yr
Boiler	20.0 lb/kgal	Table 1.3-1, AP-42	8.1 lb/hr	11.7 ton/yr
Incinerator	3.2 lb/ton	Table 2.1-9, AP-42	0.3 lb/hr	0.4 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	16.9 g/kW-hr	Source Test Data	136.2 lb/hr	28.9 ton/yr
Generator Engines	12.2 g/kW-hr	Source Test Data	31.0 lb/hr	44.6 ton/yr
Thruster Engines	5.3 g/kW-hr	Source Test Data	26.3 lb/hr	37.9 ton/yr
Emergency Engine	18.8 g/kW-hr	Table 3.3-1, AP-42	3.3 lb/hr	0.8 ton/yr
MLC ROV System Engine	13.0 g/kW-hr	Vendor Data	22.9 lb/hr	33.0 ton/yr
Total - Common Support Vessels			**1,690.5 lb/hr**	**716.5 ton/yr**
Total - Support Vessels			**3,661.1 lb/hr**	**1,467.8 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Carbon Monoxide (CO) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	1.3 g/kW-hr	Vendor Data	15.2 lb/hr	21.8 ton/yr
Propulsion Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	38.2 lb/hr	55.0 ton/yr
HPU Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.6 lb/hr	3.8 ton/yr
Crane Engines	0.6 g/kW-hr	Vendor Data	0.9 lb/hr	1.3 ton/yr
Cementing Unit Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	3.6 lb/hr	5.2 ton/yr
Logging Unit Engine	3.5 g/kW-hr	Vendor Data	1.4 lb/hr	2.0 ton/yr
Compressor Engine	9.9 g/kW-hr	Vendor Data	1.8 lb/hr	2.6 ton/yr
Sidewall Core Tool Engine	5.0 g/kW-hr	Vendor Data	0.4 lb/hr	0.5 ton/yr
Emergency Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	3.0 lb/hr	4.3 ton/yr
Lifeboat Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	0.6 lb/hr	0.9 ton/yr
Boilers	2.4 lb/kgal	Source Test Data	0.3 lb/hr	0.4 ton/yr
Incinerator	10.8 lb/ton	Source Test Data	1.5 lb/hr	2.2 ton/yr
Total - *Discoverer*			**69.5 lb/hr**	**100.1 ton/yr**
Polar Pioneer				
Generator Engines	1.4 g/kW-hr	Source Test Data	34.4 lb/hr	49.6 ton/yr
HPU Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.7 lb/hr	3.9 ton/yr
Logging Unit Engine	3.5 g/kW-hr	Vendor Data	1.4 lb/hr	2.0 ton/yr
Compressor Engine	9.9 g/kW-hr	Vendor Data	1.8 lb/hr	2.6 ton/yr
Sidewall Core Tool Engine	5.0 g/kW-hr	Vendor Data	0.4 lb/hr	0.5 ton/yr
Emergency Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	6.6 lb/hr	9.5 ton/yr
Small Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	4.2 lb/hr	6.0 ton/yr
Boilers	5.0 lb/kgal	Table 1.3-1, AP-42	1.0 lb/hr	1.4 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	3.3E-2 lb/hr	4.7E-2 ton/yr
Total - *Polar Pioneer*			**52.5 lb/hr**	**75.7 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	123.8 lb/hr	33.1 ton/yr
Harbour Set Generator Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	0.4 lb/kgal	Source Test Data	2.7E-2 lb/hr	3.8E-2 ton/yr
Incinerator	29.9 lb/ton	Source Test Data	2.3 lb/hr	3.3 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.2 lb/hr	0.5 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.5 g/kW-hr	Vendor Data	14.6 lb/hr	8.0 ton/yr
Generator Engines	1.7 g/kW-hr	Vendor Data	20.7 lb/hr	11.3 ton/yr
Boilers	5.0 lb/kgal	Table 1.3-1, AP-42	0.2 lb/hr	0.3 ton/yr
Incinerator	11.1 lb/ton	Source Test Data	1.5 lb/hr	2.2 ton/yr
Emergency Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	10.7 lb/hr	2.7 ton/yr
Rescue & Lifeboat Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	4.9 lb/hr	1.2 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	1.4 lb/hr	0.7 ton/yr
Science Vessel (Similar to *Harvey Supporter*)				
Propulsion and Generator Engines	1.2 g/kW-hr	Source Test Data	15.7 lb/hr	5.1 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	1.3E-2 lb/hr	1.9E-2 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	36.1 lb/hr	5.0 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.5 lb/hr	0.6 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	0.5 lb/hr	0.1 ton/yr
Thruster Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.7 lb/hr	0.7 ton/yr
Total - Discoverer Support Vessels			**240.9 lb/hr**	**75.2 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Carbon Monoxide (CO) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Polar Pioneer Support Vessels				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	123.8 lb/hr	32.5 ton/yr
Harbour Set Generator Engine	3.3 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	0.1 lb/kgal	Source Test Data	4.8E-3 lb/hr	7.0E-3 ton/yr
Incinerator	3.7 lb/ton	Source Test Data	0.3 lb/hr	0.4 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.2 lb/hr	0.5 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	79.2 lb/hr	27.2 ton/yr
Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	5.9 lb/hr	2.0 ton/yr
Boilers	5.0 lb/kgal	Table 1.3-1, AP-42	5.2E-2 lb/hr	7.5E-2 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	0.3 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	19.9 lb/hr	14.1 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	7.5 lb/hr	10.8 ton/yr
Thruster Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	9.9 lb/hr	14.2 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	0.2 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.5 g/kW-hr	Vendor Data	7.3 lb/hr	3.1 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	3.4 lb/hr	4.9 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.5 g/kW-hr	Vendor Data	7.3 lb/hr	3.1 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	3.4 lb/hr	4.9 ton/yr
Total - Polar Pioneer Support Vessels			**272.4 lb/hr**	**118.4 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Carbon Monoxide (CO) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	73.9 lb/hr	21.6 ton/yr
Various Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	8.4 lb/hr	12.2 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.3 lb/hr	0.6 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	1.2 g/kW-hr	Source Test Data	15.7 lb/hr	2.2 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
Various Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	4.9 lb/hr	7.1 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.6 lb/hr	1.2 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	1.3E-2 lb/hr	1.9E-2 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	1.2 g/kW-hr	Source Test Data	15.7 lb/hr	2.2 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.0 lb/hr	0.9 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	1.3E-2 lb/hr	1.9E-2 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	32.0 lb/hr	26.0 ton/yr
Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	11.3 lb/hr	16.3 ton/yr
Emergency Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	1.4 lb/hr	0.3 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.7 lb/hr	1.3 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	1.9E-2 lb/hr	2.7E-2 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	1.5 g/kW-hr	Source Test Data	3.7 lb/hr	5.4 ton/yr
OSR-T/B (*Guardsman/Klamath*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	31.7 lb/hr	8.0 ton/yr
Generator Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	2.2 lb/hr	3.1 ton/yr
OSR Equipment Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	4.8 lb/hr	2.3 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	113.1 lb/hr	16.7 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	2.2 lb/hr	0.5 ton/yr
Various Engines	4.1 g/kW-hr	Table 3.3-1, AP-42	10.4 lb/hr	15.0 ton/yr
Boiler	5.0 lb/kgal	Table 1.3-1, AP-42	2.0 lb/hr	2.9 ton/yr
Incinerator	0.3 lb/ton	Table 2.1-9, AP-42	2.8E-2 lb/hr	4.0E-2 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	27.0 lb/hr	5.7 ton/yr
Generator Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	8.5 lb/hr	12.2 ton/yr
Thruster Engines	3.3 g/kW-hr	Table 3.4-1, AP-42	16.5 lb/hr	23.8 ton/yr
Emergency Engine	4.1 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
MLC ROV System Engine	0.7 g/kW-hr	Vendor Data	1.2 lb/hr	1.7 ton/yr
Total - Common Support Vessels			**398.7 lb/hr**	**190.0 ton/yr**
Total - Support Vessels			**912.0 lb/hr**	**383.6 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Particulate Matter (PM_{10}) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	0.2 g/kW-hr	Vendor Data	1.9 lb/hr	2.7 ton/yr
Propulsion Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	4.9 lb/hr	7.0 ton/yr
HPU Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	1.2 ton/yr
Crane Engines	0.1 g/kW-hr	Vendor Data	0.2 lb/hr	0.2 ton/yr
Cementing Unit Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	1.7 ton/yr
Logging Unit Engine	0.2 g/kW-hr	Vendor Data	0.1 lb/hr	0.1 ton/yr
Compressor Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.4 ton/yr
Sidewall Core Tool Engine	0.4 g/kW-hr	Vendor Data	3.0E-2 lb/hr	4.3E-2 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.5 ton/yr
Lifeboat Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.3 ton/yr
Boilers	0.3 lb/kgal	Source Test Data	3.6E-2 lb/hr	5.2E-2 ton/yr
Incinerator	6.9 lb/ton	Source Test Data	1.0 lb/hr	1.4 ton/yr
Total - *Discoverer*			**10.9 lb/hr**	**15.7 ton/yr**
Polar Pioneer				
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.3 lb/hr	14.9 ton/yr
HPU Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	1.3 ton/yr
Logging Unit Engine	0.2 g/kW-hr	Vendor Data	0.1 lb/hr	0.1 ton/yr
Compressor Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.4 ton/yr
Sidewall Core Tool Engine	0.4 g/kW-hr	Vendor Data	3.0E-2 lb/hr	4.3E-2 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	1.2 ton/yr
Small Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.4 lb/hr	2.0 ton/yr
Boilers	3.3 lb/kgal	Table 1.3-1, AP-42	0.6 lb/hr	0.9 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	2.8 lb/hr	4.0 ton/yr
Total - *Polar Pioneer*			**17.2 lb/hr**	**24.7 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	0.1 g/kW-hr	Source Test Data	3.4 lb/hr	0.9 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	0.5 lb/kgal	Source Test Data	3.6E-2 lb/hr	5.2E-2 ton/yr
Incinerator	17.0 lb/ton	Source Test Data	1.3 lb/hr	1.9 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.3 g/kW-hr	Source Test Data	7.3 lb/hr	4.0 ton/yr
Generator Engines	0.1 g/kW-hr	Source Test Data	0.8 lb/hr	0.4 ton/yr
Boilers	3.3 lb/kgal	Table 1.3-1, AP-42	0.1 lb/hr	0.2 ton/yr
Incinerator	18.0 lb/ton	Source Test Data	2.5 lb/hr	3.6 ton/yr
Emergency Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	0.3 ton/yr
Rescue & Lifeboat Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	0.4 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.2 ton/yr
Science Vessel (Similar to *Harvey Supporter*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.7 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.6 lb/hr	0.6 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	4.1E-2 ton/yr
Thruster Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
Total - Discoverer Support Vessels			**29.6 lb/hr**	**15.7 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Particulate Matter (PM_{10}) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Polar Pioneer Support Vessels				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	0.1 g/kW-hr	Source Test Data	2.7 lb/hr	0.7 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	0.4 lb/kgal	Source Test Data	2.6E-2 lb/hr	3.8E-2 ton/yr
Incinerator	2.2 lb/ton	Source Test Data	0.2 lb/hr	0.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	0.1 g/kW-hr	Source Test Data	2.2 lb/hr	0.8 ton/yr
Generator Engines	0.2 g/kW-hr	Source Test Data	0.4 lb/hr	0.1 ton/yr
Boilers	1.2 lb/kgal	Source Test Data	1.3E-2 lb/hr	1.8E-2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	0.1 g/kW-hr	Source Test Data	0.8 lb/hr	0.5 ton/yr
Generator Engines	0.4 g/kW-hr	Source Test Data	0.7 lb/hr	1.0 ton/yr
Thruster Engines	0.2 g/kW-hr	Source Test Data	0.7 lb/hr	1.0 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.2 g/kW-hr	Vendor Data	2.1 lb/hr	0.9 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.1 lb/hr	1.6 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.2 g/kW-hr	Vendor Data	2.1 lb/hr	0.9 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.1 lb/hr	1.6 ton/yr
Total - Polar Pioneer Support Vessels			**15.7 lb/hr**	**9.9 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Particulate Matter (PM_{10}) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	9.4 lb/hr	2.8 ton/yr
Various Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.1 lb/hr	1.5 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.3 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Various Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	2.3 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.4 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.3 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.6 lb/hr	0.3 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	0.02 g/kW-hr	Source Test Data	0.2 lb/hr	0.2 ton/yr
Generator Engines	0.03 g/kW-hr	Source Test Data	0.1 lb/hr	0.1 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.4 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.6 lb/hr	2.3 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	0.1 g/kW-hr	Source Test Data	0.3 lb/hr	0.4 ton/yr
OSR-T/B (*Guardsman/Klamath*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.0 lb/hr	1.0 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	1.0 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	0.7 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	14.4 lb/hr	2.1 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Various Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	3.4 lb/hr	4.9 ton/yr
Boiler	3.3 lb/kgal	Table 1.3-1, AP-42	1.3 lb/hr	1.9 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	2.4 lb/hr	3.4 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	0.2 g/kW-hr	Source Test Data	1.5 lb/hr	0.3 ton/yr
Generator Engines	0.3 g/kW-hr	Source Test Data	0.7 lb/hr	0.9 ton/yr
Thruster Engines	0.2 g/kW-hr	Source Test Data	0.8 lb/hr	1.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.1 ton/yr
MLC ROV System Engine	0.1 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Total - Common Support Vessels			**56.9 lb/hr**	**32.9 ton/yr**
Total - Support Vessels			**102.2 lb/hr**	**58.5 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Particulate Matter ($PM_{2.5}$) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	0.2 g/kW-hr	Vendor Data	1.9 lb/hr	2.7 ton/yr
Propulsion Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	4.9 lb/hr	7.0 ton/yr
HPU Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	1.2 ton/yr
Crane Engines	0.1 g/kW-hr	Vendor Data	0.2 lb/hr	0.2 ton/yr
Cementing Unit Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	1.7 ton/yr
Logging Unit Engine	0.2 g/kW-hr	Vendor Data	0.1 lb/hr	0.1 ton/yr
Compressor Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.4 ton/yr
Sidewall Core Tool Engine	0.4 g/kW-hr	Vendor Data	3.0E-2 lb/hr	4.3E-2 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.5 ton/yr
Lifeboat Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.3 ton/yr
Boilers	0.3 lb/kgal	Source Test Data	3.6E-2 lb/hr	5.2E-2 ton/yr
Incinerator	6.9 lb/ton	Source Test Data	1.0 lb/hr	1.4 ton/yr
Total - *Discoverer*			**10.9 lb/hr**	**15.7 ton/yr**
Polar Pioneer				
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.3 lb/hr	14.9 ton/yr
HPU Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	1.3 ton/yr
Logging Unit Engine	0.2 g/kW-hr	Vendor Data	0.1 lb/hr	0.1 ton/yr
Compressor Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.4 ton/yr
Sidewall Core Tool Engine	0.4 g/kW-hr	Vendor Data	3.0E-2 lb/hr	4.3E-2 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	1.2 ton/yr
Small Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.4 lb/hr	2.0 ton/yr
Boilers	3.3 lb/kgal	Table 1.3-1, AP-42	0.6 lb/hr	0.9 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	2.8 lb/hr	4.0 ton/yr
Total - *Polar Pioneer*			**17.2 lb/hr**	**24.7 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	0.1 g/kW-hr	Source Test Data	3.4 lb/hr	0.9 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	0.5 lb/kgal	Source Test Data	3.6E-2 lb/hr	5.2E-2 ton/yr
Incinerator	17.0 lb/ton	Source Test Data	1.3 lb/hr	1.9 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.3 g/kW-hr	Source Test Data	7.3 lb/hr	4.0 ton/yr
Generator Engines	0.1 g/kW-hr	Source Test Data	0.8 lb/hr	0.4 ton/yr
Boilers	3.3 lb/kgal	Table 1.3-1, AP-42	0.1 lb/hr	0.2 ton/yr
Incinerator	18.0 lb/ton	Source Test Data	2.5 lb/hr	3.6 ton/yr
Emergency Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	0.3 ton/yr
Rescue & Lifeboat Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	0.4 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.2 ton/yr
Science Vessel (Similar to *Harvey Supporter*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.7 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.6 lb/hr	0.6 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	4.1E-2 ton/yr
Thruster Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
Total - Discoverer Support Vessels			**29.6 lb/hr**	**15.7 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan

National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Particulate Matter ($PM_{2.5}$) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Polar Pioneer Support Vessels				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	0.1 g/kW-hr	Source Test Data	2.7 lb/hr	0.7 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	0.4 lb/kgal	Source Test Data	2.6E-2 lb/hr	3.8E-2 ton/yr
Incinerator	2.2 lb/ton	Source Test Data	0.2 lb/hr	0.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	0.1 g/kW-hr	Source Test Data	2.2 lb/hr	0.8 ton/yr
Generator Engines	0.2 g/kW-hr	Source Test Data	0.4 lb/hr	0.1 ton/yr
Boilers	1.2 lb/kgal	Source Test Data	1.3E-2 lb/hr	1.8E-2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	0.1 g/kW-hr	Source Test Data	0.8 lb/hr	0.5 ton/yr
Generator Engines	0.4 g/kW-hr	Source Test Data	0.7 lb/hr	1.0 ton/yr
Thruster Engines	0.2 g/kW-hr	Source Test Data	0.7 lb/hr	1.0 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.2 g/kW-hr	Vendor Data	2.1 lb/hr	0.9 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.1 lb/hr	1.6 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.2 g/kW-hr	Vendor Data	2.1 lb/hr	0.9 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.1 lb/hr	1.6 ton/yr
Total - Polar Pioneer Support Vessels			**15.7 lb/hr**	**9.9 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Particulate Matter ($PM_{2.5}$) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	9.4 lb/hr	2.8 ton/yr
Various Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.1 lb/hr	1.5 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.3 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Various Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	2.3 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.4 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	0.2 g/kW-hr	Source Test Data	2.3 lb/hr	0.3 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.6 lb/hr	0.3 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.1 lb/hr	1.6 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	0.0 g/kW-hr	Source Test Data	0.2 lb/hr	0.2 ton/yr
Generator Engines	0.0 g/kW-hr	Source Test Data	0.1 lb/hr	0.1 ton/yr
Emergency Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.4 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	1.6 lb/hr	2.3 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	0.1 g/kW-hr	Source Test Data	0.3 lb/hr	0.4 ton/yr
OSR-T/B (*Guardsman/Klamath*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.0 lb/hr	1.0 ton/yr
Generator Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	1.0 ton/yr
OSR Equipment Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	1.6 lb/hr	0.7 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	14.4 lb/hr	2.1 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.2 ton/yr
Various Engines	1.3 g/kW-hr	Table 3.3-1, AP-42	3.4 lb/hr	4.9 ton/yr
Boiler	3.3 lb/kgal	Table 1.3-1, AP-42	1.3 lb/hr	1.9 ton/yr
Incinerator	25.1 lb/ton	Table 2.1-2, AP-42	2.4 lb/hr	3.4 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	0.2 g/kW-hr	Source Test Data	1.5 lb/hr	0.3 ton/yr
Generator Engines	0.3 g/kW-hr	Source Test Data	0.7 lb/hr	0.9 ton/yr
Thruster Engines	0.2 g/kW-hr	Source Test Data	0.8 lb/hr	1.2 ton/yr
Emergency Engine	1.3 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.1 ton/yr
MLC ROV System Engine	0.1 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Total - Common Support Vessels			**56.9 lb/hr**	**32.9 ton/yr**
Total - Support Vessels			**102.2 lb/hr**	**58.5 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Volatile Organic Compounds (VOC) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	0.5 g/kW-hr	Vendor Data	5.2 lb/hr	7.6 ton/yr
Propulsion Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	4.9 lb/hr	7.1 ton/yr
HPU Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	1.4 ton/yr
Crane Engines	0.1 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Cementing Unit Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.3 lb/hr	1.9 ton/yr
Logging Unit Engine	4.0 g/kW-hr	Vendor Data	1.6 lb/hr	2.3 ton/yr
Compressor Engine	0.6 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Sidewall Core Tool Engine	7.5 g/kW-hr	Vendor Data	0.6 lb/hr	0.8 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.4 lb/hr	0.6 ton/yr
Lifeboat Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	0.3 ton/yr
Boilers	0.1 lb/kgal	Source Test Data	1.0E-2 lb/hr	1.5E-2 ton/yr
Incinerator	0.4 lb/ton	Source Test Data	0.1 lb/hr	0.1 ton/yr
Total - *Discoverer*			**15.5 lb/hr**	**22.3 ton/yr**
Polar Pioneer				
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.4 lb/hr	15.0 ton/yr
HPU Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	1.4 ton/yr
Logging Unit Engine	4.0 g/kW-hr	Vendor Data	1.6 lb/hr	2.3 ton/yr
Compressor Engine	0.6 g/kW-hr	Vendor Data	0.1 lb/hr	0.2 ton/yr
Sidewall Core Tool Engine	7.5 g/kW-hr	Vendor Data	0.6 lb/hr	0.8 ton/yr
Emergency Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	1.2 ton/yr
Small Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.5 lb/hr	2.2 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	6.6E-2 lb/hr	0.1 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.3 lb/hr	0.5 ton/yr
Total - *Polar Pioneer*			**16.4 lb/hr**	**23.6 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	15.9 lb/hr	4.2 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	2.3E-2 lb/hr	3.3E-2 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.2 lb/hr	0.3 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.7 g/kW-hr	Vendor Data	20.3 lb/hr	11.1 ton/yr
Generator Engines	0.5 g/kW-hr	Vendor Data	6.3 lb/hr	3.4 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	1.4E-2 lb/hr	2.0E-2 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.4 lb/hr	0.6 ton/yr
Emergency Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	0.3 ton/yr
Rescue & Lifeboat Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.8 lb/hr	0.4 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.5 lb/hr	0.2 ton/yr
Science Vessel (Similar to *Harvey Supporter*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	5.5 lb/hr	1.8 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.1 lb/hr	0.2 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.6 lb/hr	0.6 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.2 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.2 lb/hr	4.6E-2 ton/yr
Thruster Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	0.2 ton/yr
Total - Discoverer Support Vessels			**60.3 lb/hr**	**24.2 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Volatile Organic Compounds (VOC) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Polar Pioneer Support Vessels				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	15.9 lb/hr	4.2 ton/yr
Harbour Set Generator Engine	0.4 g/kW-hr	Table 3.4-1, AP-42	0 lb/hr	0 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	2.3E-2 lb/hr	3.3E-2 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.2 lb/hr	0.3 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	10.2 lb/hr	3.5 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	0.8 lb/hr	0.3 ton/yr
Boilers	0.3 lb/kgal	Table 1.3-3, AP-42	3.6E-3 lb/hr	5.1E-3 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.5 lb/hr	0.1 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	2.5 lb/hr	1.8 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	2.7 lb/hr	3.9 ton/yr
Thruster Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.3 lb/hr	1.8 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.4 lb/hr	0.1 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.7 g/kW-hr	Vendor Data	10.2 lb/hr	4.4 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	1.8 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.7 g/kW-hr	Vendor Data	10.2 lb/hr	4.4 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.2 lb/hr	1.8 ton/yr
Total - Polar Pioneer Support Vessels			**58.0 lb/hr**	**28.5 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan

National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Volatile Organic Compounds (VOC) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	9.5 lb/hr	2.8 ton/yr
Various Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.1 lb/hr	1.6 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	5.5 lb/hr	0.8 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
Various Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.8 lb/hr	2.6 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.9 lb/hr	0.5 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.1 lb/hr	0.2 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	5.5 lb/hr	0.8 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.7 lb/hr	0.3 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.1 lb/hr	0.2 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.1 lb/hr	3.3 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.4 lb/hr	2.1 ton/yr
Emergency Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.5 lb/hr	0.1 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.0 lb/hr	0.5 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.2 lb/hr	0.3 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	1.5 g/kW-hr	Table 3.4-1, AP-42	3.6 lb/hr	5.2 ton/yr
OSR-T/B (*Guardsman/Klamath*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	4.1 lb/hr	1.0 ton/yr
Generator Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	1.1 ton/yr
OSR Equipment Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	1.8 lb/hr	0.8 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	14.5 lb/hr	2.1 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.8 lb/hr	0.2 ton/yr
Various Engines	1.5 g/kW-hr	Table 3.3-1, AP-42	3.8 lb/hr	5.5 ton/yr
Boiler	0.3 lb/kgal	Table 1.3-3, AP-42	0.1 lb/hr	0.2 ton/yr
Incinerator	3.0 lb/ton	Table 2.1-12, AP-42	0.3 lb/hr	0.4 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	3.5 lb/hr	0.7 ton/yr
Generator Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	1.1 lb/hr	1.6 ton/yr
Thruster Engines	0.4 g/kW-hr	Table 3.4-1, AP-42	2.1 lb/hr	3.0 ton/yr
Emergency Engine	1.5 g/kW-hr	Table 3.3-1, AP-42	0.3 lb/hr	0.1 ton/yr
MLC ROV System Engine	0.2 g/kW-hr	Vendor Data	0.3 lb/hr	0.4 ton/yr
Total - Common Support Vessels			**70.9 lb/hr**	**38.8 ton/yr**
Total - Support Vessels			**189.2 lb/hr**	**91.5 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Sulfur Dioxide (SO_2) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	5.3E-1 lb/hr	7.6E-1 ton/yr
Propulsion Engine	0.05 g/kW-hr	Mass Balance Calculation	5.2E-1 lb/hr	7.5E-1 ton/yr
HPU Engines	0.05 g/kW-hr	Mass Balance Calculation	2.9E-2 lb/hr	4.2E-2 ton/yr
Crane Engines	0.05 g/kW-hr	Mass Balance Calculation	7.2E-2 lb/hr	1.0E-1 ton/yr
Cementing Unit Engines	0.05 g/kW-hr	Mass Balance Calculation	4.0E-2 lb/hr	5.8E-2 ton/yr
Logging Unit Engine	0.05 g/kW-hr	Mass Balance Calculation	1.8E-2 lb/hr	2.6E-2 ton/yr
Compressor Engine	0.05 g/kW-hr	Mass Balance Calculation	8.4E-3 lb/hr	1.2E-2 ton/yr
Sidewall Core Tool Engine	0.05 g/kW-hr	Mass Balance Calculation	3.4E-3 lb/hr	4.9E-3 ton/yr
Emergency Engine	0.05 g/kW-hr	Mass Balance Calculation	4.1E-2 lb/hr	5.8E-2 ton/yr
Lifeboat Engines	0.05 g/kW-hr	Mass Balance Calculation	7.0E-3 lb/hr	1.0E-2 ton/yr
Boilers	1.4 lb/kgal	Mass Balance Calculation	1.7E-1 lb/hr	2.4E-1 ton/yr
Incinerator	3.5 lb/ton	Table 2.1-2, AP-42	4.8E-1 lb/hr	6.9E-1 ton/yr
Total - *Discoverer*			**1.9 lb/hr**	**2.8 ton/yr**
Polar Pioneer				
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	1.1 lb/hr	1.6 ton/yr
HPU Engines	0.0 g/kW-hr	Mass Balance Calculation	3.0E-2 lb/hr	4.3E-2 ton/yr
Logging Unit Engine	0.05 g/kW-hr	Mass Balance Calculation	1.8E-2 lb/hr	2.6E-2 ton/yr
Compressor Engine	0.05 g/kW-hr	Mass Balance Calculation	8.4E-3 lb/hr	1.2E-2 ton/yr
Sidewall Core Tool Engine	0.05 g/kW-hr	Mass Balance Calculation	3.4E-3 lb/hr	4.9E-3 ton/yr
Emergency Engine	0.05 g/kW-hr	Mass Balance Calculation	9.0E-2 lb/hr	1.3E-1 ton/yr
Small Emergency Engines	0.05 g/kW-hr	Mass Balance Calculation	4.6E-2 lb/hr	6.6E-2 ton/yr
Boilers	1.4 lb/kgal	Mass Balance Calculation	2.7E-1 lb/hr	3.9E-1 ton/yr
Incinerator	3.5 lb/ton	Table 2.1-2, AP-42	3.8E-1 lb/hr	5.5E-1 ton/yr
Total - *Polar Pioneer*			**2.0 lb/hr**	**2.8 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	1.7 lb/hr	4.5E-1 ton/yr
Harbour Set Generator Engine	0.05 g/kW-hr	Mass Balance Calculation	0 lb/hr	0 ton/yr
Boilers	1.4 lb/kgal	Mass Balance Calculation	9.5E-2 lb/hr	1.4E-1 ton/yr
Incinerator	3.5 lb/ton	Table 2.1-2, AP-42	2.7E-1 lb/hr	3.8E-1 ton/yr
Emergency Engine	0.05 g/kW-hr	Mass Balance Calculation	2.4E-2 lb/hr	6.0E-3 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	0.05 g/kW-hr	Mass Balance Calculation	1.3 lb/hr	7.1E-1 ton/yr
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	5.4E-1 lb/hr	3.0E-1 ton/yr
Boilers	1.4 lb/kgal	Mass Balance Calculation	5.6E-2 lb/hr	8.1E-2 ton/yr
Incinerator	3.5 lb/ton	Table 2.1-2, AP-42	4.8E-1 lb/hr	6.9E-1 ton/yr
Emergency Engines	0.05 g/kW-hr	Mass Balance Calculation	1.5E-1 lb/hr	3.6E-2 ton/yr
Rescue & Lifeboat Engines	0.05 g/kW-hr	Mass Balance Calculation	5.4E-2 lb/hr	1.4E-2 ton/yr
OSR Equipment Engines	0.05 g/kW-hr	Mass Balance Calculation	1.5E-2 lb/hr	7.3E-3 ton/yr
Science Vessel (Similar to *Harvey Supporter*)				
Propulsion and Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	5.8E-1 lb/hr	1.9E-1 ton/yr
Emergency Engines	0.05 g/kW-hr	Mass Balance Calculation	1.0E-2 lb/hr	2.5E-3 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	1.5E-1 lb/hr	2.2E-1 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	0.05 g/kW-hr	Mass Balance Calculation	4.9E-1 lb/hr	6.7E-2 ton/yr
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	2.7E-2 lb/hr	6.9E-3 ton/yr
Emergency Engine	0.05 g/kW-hr	Mass Balance Calculation	5.6E-3 lb/hr	1.4E-3 ton/yr
Thruster Engine	0.05 g/kW-hr	Mass Balance Calculation	3.0E-2 lb/hr	7.5E-3 ton/yr
Total - Discoverer Support Vessels			**6.0 lb/hr**	**3.3 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Sulfur Dioxide (SO_2) Emissions			
	Factor	**Reference**	**Hourly [3,6]**	**Annual [3,4,5]**
Polar Pioneer Support Vessels				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	1.7 lb/hr	4.4E-1 ton/yr
Harbour Set Generator Engine	0.05 g/kW-hr	Mass Balance Calculation	0 lb/hr	0 ton/yr
Boilers	1.4 lb/kgal	Mass Balance Calculation	9.5E-2 lb/hr	1.4E-1 ton/yr
Incinerator	3.5 lb/ton	Table 2.1-2, AP-42	2.7E-1 lb/hr	3.8E-1 ton/yr
Emergency Engine	0.05 g/kW-hr	Mass Balance Calculation	2.4E-2 lb/hr	6.0E-3 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	0.05 g/kW-hr	Mass Balance Calculation	1.1 lb/hr	3.7E-1 ton/yr
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	8.0E-2 lb/hr	2.7E-2 ton/yr
Boilers	1.4 lb/kgal	Mass Balance Calculation	1.5E-2 lb/hr	2.1E-2 ton/yr
Emergency Engine	0.05 g/kW-hr	Mass Balance Calculation	1.4E-2 lb/hr	3.4E-3 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	0.05 g/kW-hr	Mass Balance Calculation	2.7E-1 lb/hr	1.9E-1 ton/yr
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	8.3E-2 lb/hr	1.2E-1 ton/yr
Thruster Engines	0.05 g/kW-hr	Mass Balance Calculation	1.3E-1 lb/hr	1.9E-1 ton/yr
Emergency Engines	0.05 g/kW-hr	Mass Balance Calculation	1.1E-2 lb/hr	2.7E-3 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	0.05 g/kW-hr	Mass Balance Calculation	6.5E-1 lb/hr	2.8E-1 ton/yr
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	3.7E-2 lb/hr	5.4E-2 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	0.05 g/kW-hr	Mass Balance Calculation	6.5E-1 lb/hr	2.8E-1 ton/yr
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	3.7E-2 lb/hr	5.4E-2 ton/yr
Total - Polar Pioneer Support Vessels			**5.1 lb/hr**	**2.6 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Sulfur Dioxide (SO_2) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	1.0 lb/hr	2.9E-1 ton/yr
Various Engines	0.05 g/kW-hr	Mass Balance Calculation	1.1E-1 lb/hr	1.7E-1 ton/yr
Emergency Engine	0.05 g/kW-hr	Mass Balance Calculation	2.6E-2 lb/hr	6.4E-3 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	5.8E-1 lb/hr	8.2E-2 ton/yr
Emergency Engines	0.05 g/kW-hr	Mass Balance Calculation	1.0E-2 lb/hr	2.5E-3 ton/yr
Various Engines	0.05 g/kW-hr	Mass Balance Calculation	5.4E-2 lb/hr	7.7E-2 ton/yr
OSR Equipment Engines	0.05 g/kW-hr	Mass Balance Calculation	2.8E-2 lb/hr	1.4E-2 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	1.5E-1 lb/hr	2.2E-1 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	5.8E-1 lb/hr	8.2E-2 ton/yr
Emergency Engines	0.05 g/kW-hr	Mass Balance Calculation	1.0E-2 lb/hr	2.5E-3 ton/yr
OSR Equipment Engines	0.05 g/kW-hr	Mass Balance Calculation	2.2E-2 lb/hr	1.0E-2 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	1.5E-1 lb/hr	2.2E-1 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	0.05 g/kW-hr	Mass Balance Calculation	4.3E-1 lb/hr	3.5E-1 ton/yr
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	1.5E-1 lb/hr	2.2E-1 ton/yr
Emergency Engines	0.05 g/kW-hr	Mass Balance Calculation	1.5E-2 lb/hr	3.8E-3 ton/yr
OSR Equipment Engines	0.05 g/kW-hr	Mass Balance Calculation	2.9E-2 lb/hr	1.4E-2 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	2.2E-1 lb/hr	3.1E-1 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	1.1E-1 lb/hr	1.6E-1 ton/yr
OSR-T/B (*Guardsman/Klamath*)				
Propulsion Engines	0.05 g/kW-hr	Mass Balance Calculation	4.3E-1 lb/hr	1.1E-1 ton/yr
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	2.4E-2 lb/hr	3.4E-2 ton/yr
OSR Equipment Engines	0.05 g/kW-hr	Mass Balance Calculation	5.3E-2 lb/hr	2.5E-2 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	1.5 lb/hr	2.3E-1 ton/yr
Emergency Engine	0.05 g/kW-hr	Mass Balance Calculation	2.4E-2 lb/hr	5.9E-3 ton/yr
Various Engines	0.05 g/kW-hr	Mass Balance Calculation	1.1E-1 lb/hr	1.6E-1 ton/yr
Boiler	1.40 lb/kgal	Mass Balance Calculation	5.7E-1 lb/hr	8.2E-1 ton/yr
Incinerator	3.46 lb/ton	Table 2.1-2, AP-42	3.3E-1 lb/hr	4.7E-1 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	0.05 g/kW-hr	Mass Balance Calculation	3.7E-1 lb/hr	7.8E-2 ton/yr
Generator Engines	0.05 g/kW-hr	Mass Balance Calculation	1.2E-1 lb/hr	1.7E-1 ton/yr
Thruster Engines	0.05 g/kW-hr	Mass Balance Calculation	2.2E-1 lb/hr	3.2E-1 ton/yr
Emergency Engine	0.05 g/kW-hr	Mass Balance Calculation	7.9E-3 lb/hr	2.0E-3 ton/yr
MLC ROV System Engine	0.05 g/kW-hr	Mass Balance Calculation	8.0E-2 lb/hr	1.2E-1 ton/yr
Total - Common Support Vessels			**7.6 lb/hr**	**4.8 ton/yr**
Total - Support Vessels			**18.6 lb/hr**	**10.6 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan

National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Lead (Pb) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.4E-3 lb/hr	2.1E-3 ton/yr
Propulsion Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.4E-3 lb/hr	2.0E-3 ton/yr
HPU Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.9E-5 lb/hr	1.1E-4 ton/yr
Crane Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.0E-4 lb/hr	2.8E-4 ton/yr
Cementing Unit Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.1E-4 lb/hr	1.6E-4 ton/yr
Logging Unit Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	4.9E-5 lb/hr	7.0E-5 ton/yr
Compressor Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.0	2.3E-5 lb/hr	3.3E-5 ton/yr
Sidewall Core Tool Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	9.3E-6 lb/hr	1.3E-5 ton/yr
Emergency Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.1E-4 lb/hr	1.6E-4 ton/yr
Lifeboat Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.9E-5 lb/hr	2.8E-5 ton/yr
Boilers	1.18E-3 lb/kgal	Table 1.3-10, AP-42	1.4E-4 lb/hr	2.1E-4 ton/yr
Incinerator	0.2 lb/ton	Table 2.1-2, AP-42	2.9E-2 lb/hr	4.2E-2 ton/yr
Total - *Discoverer*			**3.3E-2 lb/hr**	**4.7E-2 ton/yr**
Polar Pioneer				
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.0E-3 lb/hr	4.3E-3 ton/yr
HPU Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	8.1E-5 lb/hr	1.2E-4 ton/yr
Logging Unit Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	4.9E-5 lb/hr	7.0E-5 ton/yr
Compressor Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.0	2.3E-5 lb/hr	3.3E-5 ton/yr
Sidewall Core Tool Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	9.3E-6 lb/hr	1.3E-5 ton/yr
Emergency Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.4E-4 lb/hr	3.5E-4 ton/yr
Small Emergency Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.3E-4 lb/hr	1.8E-4 ton/yr
Boilers	1.18E-3 lb/kgal	Table 1.3-10, AP-42	2.3E-4 lb/hr	3.3E-4 ton/yr
Incinerator	0.2 lb/ton	Table 2.1-2, AP-42	2.3E-2 lb/hr	3.4E-2 ton/yr
Total - *Polar Pioneer*			**2.7E-2 lb/hr**	**3.9E-2 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.6E-3 lb/hr	1.2E-3 ton/yr
Harbour Set Generator Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	0 lb/hr	0 ton/yr
Boilers	1.18E-3 lb/kgal	Table 1.3-10, AP-42	8.0E-5 lb/hr	1.2E-4 ton/yr
Incinerator	0.2 lb/ton	Table 2.1-2, AP-42	1.6E-2 lb/hr	2.4E-2 ton/yr
Emergency Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	6.5E-5 lb/hr	1.6E-5 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.5E-3 lb/hr	1.9E-3 ton/yr
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.5E-3 lb/hr	8.1E-4 ton/yr
Boilers	1.18E-3 lb/kgal	Table 1.3-10, AP-42	4.7E-5 lb/hr	6.8E-5 ton/yr
Incinerator	0.2 lb/ton	Table 2.1-2, AP-42	2.9E-2 lb/hr	4.2E-2 ton/yr
Emergency Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.0E-4 lb/hr	9.9E-5 ton/yr
Rescue & Lifeboat Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.5E-4 lb/hr	3.7E-5 ton/yr
OSR Equipment Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.1E-5 lb/hr	2.0E-5 ton/yr
Science Vessel (Similar to *Harvey Supporter*)				
Propulsion and Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.6E-3 lb/hr	5.2E-4 ton/yr
Emergency Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.7E-5 lb/hr	6.8E-6 ton/yr
Incinerator	2.13E-1 lb/ton	Table 2.1-2, AP-42	9.4E-3 lb/hr	1.4E-2 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.3E-3 lb/hr	1.8E-4 ton/yr
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.4E-5 lb/hr	1.9E-5 ton/yr
Emergency Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.5E-5 lb/hr	3.8E-6 ton/yr
Thruster Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	8.1E-5 lb/hr	2.0E-5 ton/yr
Total - Discoverer Support Vessels			**6.9E-2 lb/hr**	**8.5E-2 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Lead (Pb) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Polar Pioneer Support Vessels				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.6E-3 lb/hr	1.2E-3 ton/yr
Harbour Set Generator Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	0 lb/hr	0 ton/yr
Boilers	1.18E-3 lb/kgal	Table 1.3-10, AP-42	8.0E-5 lb/hr	1.2E-4 ton/yr
Incinerator	0.2 lb/ton	Table 2.1-2, AP-42	1.6E-2 lb/hr	2.4E-2 ton/yr
Emergency Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	6.5E-5 lb/hr	1.6E-5 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.9E-3 lb/hr	1.0E-3 ton/yr
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.2E-4 lb/hr	7.5E-5 ton/yr
Boilers	1.18E-3 lb/kgal	Table 1.3-10, AP-42	1.2E-5 lb/hr	1.8E-5 ton/yr
Emergency Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.7E-5 lb/hr	9.2E-6 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.3E-4 lb/hr	5.2E-4 ton/yr
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.2E-4 lb/hr	3.2E-4 ton/yr
Thruster Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.6E-4 lb/hr	5.2E-4 ton/yr
Emergency Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.9E-5 lb/hr	7.3E-6 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.8E-3 lb/hr	7.6E-4 ton/yr
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.0E-4 lb/hr	1.5E-4 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.8E-3 lb/hr	7.6E-4 ton/yr
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.0E-4 lb/hr	1.5E-4 ton/yr
Total - Polar Pioneer Support Vessels			**2.9E-2 lb/hr**	**2.9E-2 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan

National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	Lead (Pb) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.7E-3 lb/hr	8.0E-4 ton/yr
Various Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.1E-4 lb/hr	4.5E-4 ton/yr
Emergency Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.0E-5 lb/hr	1.7E-5 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.6E-3 lb/hr	2.2E-4 ton/yr
Emergency Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.7E-5 lb/hr	6.8E-6 ton/yr
Various Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.5E-4 lb/hr	2.1E-4 ton/yr
OSR Equipment Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.7E-5 lb/hr	3.7E-5 ton/yr
Incinerator	2.13E-1 lb/ton	Table 2.1-2, AP-42	9.4E-3 lb/hr	1.4E-2 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.6E-3 lb/hr	2.2E-4 ton/yr
Emergency Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	2.7E-5 lb/hr	6.8E-6 ton/yr
OSR Equipment Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	5.9E-5 lb/hr	2.8E-5 ton/yr
Incinerator	2.13E-1 lb/ton	Table 2.1-2, AP-42	9.4E-3 lb/hr	1.4E-2 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.2E-3 lb/hr	9.6E-4 ton/yr
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.2E-4 lb/hr	6.0E-4 ton/yr
Emergency Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.1E-5 lb/hr	1.0E-5 ton/yr
OSR Equipment Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	7.9E-5 lb/hr	3.8E-5 ton/yr
Incinerator	2.13E-1 lb/ton	Table 2.1-2, AP-42	1.3E-2 lb/hr	1.9E-2 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.0E-4 lb/hr	4.3E-4 ton/yr
OSR-T/B (*Guardsman/Klamath*)				
Propulsion Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.2E-3 lb/hr	2.9E-4 ton/yr
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	6.5E-5 lb/hr	9.4E-5 ton/yr
OSR Equipment Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.4E-4 lb/hr	6.9E-5 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	4.2E-3 lb/hr	6.2E-4 ton/yr
Emergency Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.1	6.4E-5 lb/hr	1.6E-5 ton/yr
Various Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	3.1E-4 lb/hr	4.5E-4 ton/yr
Boiler	1.18E-3 lb/kgal	Table 1.3-10, AP-42	4.8E-4 lb/hr	6.9E-4 ton/yr
Incinerator	2.13E-1 lb/ton	Table 2.1-2, AP-42	2.0E-2 lb/hr	2.9E-2 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.2	1.0E-3 lb/hr	2.1E-4 ton/yr
Generator Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	3.1E-4 lb/hr	4.5E-4 ton/yr
Thruster Engines	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	6.1E-4 lb/hr	8.8E-4 ton/yr
Emergency Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	2.2E-5 lb/hr	5.4E-6 ton/yr
MLC ROV System Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	2.2E-4 lb/hr	3.1E-4 ton/yr
Total - Common Support Vessels			**6.9E-2 lb/hr**	**8.3E-2 ton/yr**
Total - Support Vessels			**1.7E-1 lb/hr**	**0.2 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	GHG (CO_2e) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Discoverer				
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	8,114 lb/hr	11,684 ton/yr
Propulsion Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	7,956 lb/hr	11,456 ton/yr
HPU Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	445 lb/hr	641 ton/yr
Crane Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	1,105 lb/hr	1,591 ton/yr
Cementing Unit Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	614 lb/hr	884 ton/yr
Logging Unit Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	275 lb/hr	396 ton/yr
Compressor Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	128 lb/hr	185 ton/yr
Sidewall Core Tool Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	52 lb/hr	75 ton/yr
Emergency Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	622 lb/hr	896 ton/yr
Lifeboat Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	108 lb/hr	156 ton/yr
Boilers	163.6 lb/MMBtu	40 CFR Part 98, Subpart C	2,608 lb/hr	3,756 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	281 lb/hr	404 ton/yr
Total - *Discoverer*			**22,309 lb/hr**	**32,125 ton/yr**
Polar Pioneer				
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	16,882 lb/hr	24,310 ton/yr
HPU Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	458 lb/hr	660 ton/yr
Logging Unit Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	275 lb/hr	396 ton/yr
Compressor Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	128 lb/hr	185 ton/yr
Sidewall Core Tool Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	52 lb/hr	75 ton/yr
Emergency Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	1,375 lb/hr	1,980 ton/yr
Small Emergency Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	707 lb/hr	1,019 ton/yr
Boilers	163.6 lb/MMBtu	40 CFR Part 98, Subpart C	4,196 lb/hr	6,043 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	224 lb/hr	323 ton/yr
Total - *Polar Pioneer*			**24,298 lb/hr**	**34,989 ton/yr**
***Discoverer* Support Vessels**				
Ice management (*Fennica*)				
Propulsion and Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	25,783 lb/hr	6,896 ton/yr
Harbour Set Generator Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	0 lb/hr	0 ton/yr
Boilers	163.6 lb/MMBtu	40 CFR Part 98, Subpart C	1,453 lb/hr	2,092 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	157 lb/hr	226 ton/yr
Emergency Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	368 lb/hr	92 ton/yr
Anchor Handler (*Aiviq*)				
Propulsion Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	19,952 lb/hr	10,895 ton/yr
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	8,349 lb/hr	4,559 ton/yr
Boilers	163.6 lb/MMBtu	40 CFR Part 98, Subpart C	859 lb/hr	1,236 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	281 lb/hr	404 ton/yr
Emergency Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	2,235 lb/hr	559 ton/yr
Rescue & Lifeboat Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	832 lb/hr	208 ton/yr
OSR Equipment Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	233 lb/hr	112 ton/yr
Science Vessel (Similar to *Harvey Supporter*)				
Propulsion and Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	8,963 lb/hr	2,930 ton/yr
Emergency Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	153 lb/hr	38 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	90 lb/hr	129 ton/yr
Support Tug (*Lauren Foss*)				
Propulsion Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	7,513 lb/hr	1,034 ton/yr
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	417 lb/hr	105 ton/yr
Emergency Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	86 lb/hr	21 ton/yr
Thruster Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	458 lb/hr	115 ton/yr
Total - Discoverer Support Vessels			**78,181 lb/hr**	**31,652 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	GHG (CO_2e) Emissions			
	Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Polar Pioneer Support Vessels				
Ice Management (*Nordica*)				
Propulsion and Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	25,783 lb/hr	6,761 ton/yr
Harbour Set Generator Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	0 lb/hr	0 ton/yr
Boilers	163.6 lb/MMBtu	40 CFR Part 98, Subpart C	1,453 lb/hr	2,092 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	157 lb/hr	226 ton/yr
Emergency Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	368 lb/hr	92 ton/yr
Anchor Handler (*Tor Viking*)				
Propulsion Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	16,501 lb/hr	5,663 ton/yr
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	1,228 lb/hr	421 ton/yr
Boilers	163.6 lb/MMBtu	40 CFR Part 98, Subpart C	224 lb/hr	323 ton/yr
Emergency Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	209 lb/hr	52 ton/yr
Science Vessel (Similar to *Harvey Explorer*)				
Propulsion Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	4,141 lb/hr	2,930 ton/yr
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	1,267 lb/hr	1,825 ton/yr
Thruster Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	2,052 lb/hr	2,955 ton/yr
Emergency Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	164 lb/hr	41 ton/yr
Support Tug (*Ocean Wind*)				
Propulsion Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	9,969 lb/hr	4,291 ton/yr
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	571 lb/hr	822 ton/yr
Support Tug (*Ocean Wave*)				
Propulsion Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	9,969 lb/hr	4,291 ton/yr
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	571 lb/hr	822 ton/yr
Total - Polar Pioneer Support Vessels			**74,626 lb/hr**	**33,607 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Unit Description	GHG (CO_2e) Emissions Factor	Reference	Hourly [3,6]	Annual [3,4,5]
Common Support Vessels				
Anchor Handler (*Ross Chouest*)				
Propulsion and Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	15,383 lb/hr	4,507 ton/yr
Various Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	1,759 lb/hr	2,533 ton/yr
Emergency Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	393 lb/hr	98 ton/yr
OSV (*Sisuaq*)				
Propulsion and Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	8,963 lb/hr	1,265 ton/yr
Emergency Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	153 lb/hr	38 ton/yr
Various Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	825 lb/hr	1,187 ton/yr
OSR Equipment Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	436 lb/hr	209 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	90 lb/hr	129 ton/yr
OSV (*Harvey Supporter*)				
Propulsion and Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	8,963 lb/hr	1,265 ton/yr
Emergency Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	153 lb/hr	38 ton/yr
OSR Equipment Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	331 lb/hr	159 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	90 lb/hr	129 ton/yr
OSRV (*Nanuq*)				
Propulsion Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	6,654 lb/hr	5,409 ton/yr
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	2,355 lb/hr	3,391 ton/yr
Emergency Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	230 lb/hr	58 ton/yr
OSR Equipment Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	448 lb/hr	215 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	127 lb/hr	183 ton/yr
OSR Workboats (*Kvichaks*)				
Propulsion and Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	1,682 lb/hr	2,422 ton/yr
OSR-T/B (*Guardsman/Klamath*)				
Propulsion Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	6,597 lb/hr	1,656 ton/yr
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	366 lb/hr	528 ton/yr
OSR Equipment Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	812 lb/hr	390 ton/yr
Arctic Oil Storage Tanker (Similar to *Affinity*)				
Propulsion and Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	23,548 lb/hr	3,471 ton/yr
Emergency Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	362 lb/hr	91 ton/yr
Various Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	1,757 lb/hr	2,530 ton/yr
Boiler	163.6 lb/MMBtu	40 CFR Part 98, Subpart C	8,742 lb/hr	12,589 ton/yr
Incinerator	2,034.6 lb/ton	40 CFR Part 98, Subpart C	191 lb/hr	275 ton/yr
MLC ROV System Vessel (Similar to *Harvey Spirit*)				
Propulsion Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	5,626 lb/hr	1,194 ton/yr
Generator Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	1,768 lb/hr	2,546 ton/yr
Thruster Engines	696.1 g/kW-hr	40 CFR Part 98, Subpart C	3,436 lb/hr	4,948 ton/yr
Emergency Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	122 lb/hr	30 ton/yr
MLC ROV System Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	1,228 lb/hr	1,768 ton/yr
Total - Common Support Vessels			**103,591 lb/hr**	**55,252 ton/yr**
Total - Support Vessels			**256,398 lb/hr**	**120,511 ton/yr**

Table B-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Offshore Emissions [1]

Notes:

[1] All vessels are assumed to be located within 25 miles of a drill rig during exploration drilling.

[2] Maximum Aggregate Rating is adjusted to account for Short-Term Maximum Load.

[3] Conversion factors

453.592	g/lb
2,000	lb/t
1.34	hp/kW

[4] Engine heat rate

7,000	Btu/hp-hr

[5] Diesel fuel energy

131,180	Btu/gal
131.18	MMBtu/1000 gal

[6] The projected peak hourly emissions presented will not occur in every hour and are not cumulative over the year.

Attachment C – NEPA Onshore Emission Inventory

Attachment C1 – NEPA Onshore Emission Inventory Summary

Table C-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Onshore Emissions

Unit Description	Short-Term Maximum Load	Annual Operation	Maximum Aggregate Rating [1]
Aircraft Take-off and Landings			
Crew Change Helicopters			
Take-off		686 TO/yr	
Landing		686 L/year	
SAR Helicopter			
Take-off		120 TO/year	
Landing		120 L/year	
Crew Transport Fixed-wing Aircraft			
Take-off		6 TO/year	
Landing		6 L/year	
Ice Reconnaissance Fixed-wing Aircraft			
Take-off		120 TO/year	
Landing		120 L/year	
PSO Fixed-wing Aircraft			
Take-off		120 TO/year	
Landing		120 L/year	
Total - Air Craft Support			
Hangar/Storage Building			
Natural Gas Boiler [3]	100%	1,440 hours	5 MMBtu/hr
Total - Hangar/Storage Building			
NARL Camp			
Primary Generator Engine	80%	4,032 hours	358 kW
Backup Generator Engine	80%	24 hours	358 kW
KDR Generator Engine	80%	4,032 hours	645 kW
Total - NARL Camp			
Vehicles			
Passenger Truck (Model Year 2012)		1,476 hours	
Total - Vehicles			
Total - Onshore			

Table C-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Onshore Emissions

Unit Description	Oxides of Nitrogen (NO_X) Emissions			
	Factor	Reference	Hourly [2, 4]	Annual [2]
Aircraft Take-off and Landings				
Crew Change Helicopters				
Take-off	0.5 lb/TO	EDMS 5.1.4.1	0.5 lb/hr	0.2 ton/yr
Landing	0.7 lb/L	EDMS 5.1.4.1	0.7 lb/hr	0.2 ton/yr
SAR Helicopter				
Take-off	0.5 lb/TO	EDMS 5.1.4.1	0.5 lb/hr	3.0E-2 ton/yr
Landing	0.7 lb/L	EDMS 5.1.4.1	0.7 lb/hr	4.2E-2 ton/yr
Crew Transport Fixed-wing Aircraft				
Take-off	0.8 lb/TO	EDMS 5.1.4.1	0.8 lb/hr	2.4E-3 ton/yr
Landing	0.2 lb/L	EDMS 5.1.4.1	0.2 lb/hr	6.0E-4 ton/yr
Ice Reconnaissance Fixed-wing Aircraft				
Take-off	0.7 lb/TO	EDMS 5.1.4.1	0.7 lb/hr	4.2E-2 ton/yr
Landing	0.2 lb/L	EDMS 5.1.4.1	0.2 lb/hr	1.2E-2 ton/yr
PSO Fixed-wing Aircraft				
Take-off	0.7 lb/TO	EDMS 5.1.4.1	0.7 lb/hr	4.2E-2 ton/yr
Landing	0.2 lb/L	EDMS 5.1.4.1	0.2 lb/hr	1.2E-2 ton/yr
Total - Air Craft Support			**5.2 lb/hr**	**0.6 ton/yr**
Hangar/Storage Building				
Natural Gas Boiler [3]	100 lb/10^6 scf	Table 1.4-1, AP-42	0.5 lb/hr	0.4 ton/yr
Total - Hangar/Storage Building			**0.5 lb/hr**	**0.4 ton/yr**
NARL Camp				
Primary Generator Engine	4.0 g/kW-hr	89.112 (a), Tier 3	3.2 lb/hr	6.4 ton/yr
Backup Generator Engine	4.0 g/kW-hr	89.112 (a), Tier 3	3.2 lb/hr	3.8E-2 ton/yr
KDR Generator Engine	8.0 g/kW-hr	Vendor Data	11.3 lb/hr	22.8 ton/yr
Total - NARL Camp			**17.6 lb/hr**	**29.2 ton/yr**
Vehicles				
Passenger Truck (Model Year 2012)		MOVES	1.3E-2 lb/hr	5.7E-3 ton/yr
Total - Vehicles			**1.3E-2 lb/hr**	**5.7E-3 ton/yr**
Total - Onshore			**23.3 lb/hr**	**30.2 ton/yr**

Table C-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Onshore Emissions

Unit Description	Carbon Monoxide (CO) Emissions			
	Factor	Reference	Hourly [2, 4]	Annual [2]
Aircraft Take-off and Landings				
Crew Change Helicopters				
Take-off	5.2 lb/TO	EDMS 5.1.4.1	5.2 lb/hr	1.8 ton/yr
Landing	3.6 lb/L	EDMS 5.1.4.1	3.6 lb/hr	1.2 ton/yr
SAR Helicopter				
Take-off	5.2 lb/TO	EDMS 5.1.4.1	5.2 lb/hr	0.3 ton/yr
Landing	3.6 lb/L	EDMS 5.1.4.1	3.6 lb/hr	0.2 ton/yr
Crew Transport Fixed-wing Aircraft				
Take-off	2.4 lb/TO	EDMS 5.1.4.1	2.4 lb/hr	7.2E-3 ton/yr
Landing	1.3 lb/L	EDMS 5.1.4.1	1.3 lb/hr	3.9E-3 ton/yr
Ice Reconnaissance Fixed-wing Aircraft				
Take-off	3.6 lb/TO	EDMS 5.1.4.1	3.6 lb/hr	0.2 ton/yr
Landing	2.5 lb/L	EDMS 5.1.4.1	2.5 lb/hr	0.2 ton/yr
PSO Fixed-wing Aircraft				
Take-off	3.6 lb/TO	EDMS 5.1.4.1	3.6 lb/hr	0.2 ton/yr
Landing	2.5 lb/L	EDMS 5.1.4.1	2.5 lb/hr	0.2 ton/yr
Total - Air Craft Support			**33.5 lb/hr**	**4.3 ton/yr**
Hangar/Storage Building				
Natural Gas Boiler [3]	84 lb/10^6 scf	Table 1.4-1, AP-42	0.4 lb/hr	0.3 ton/yr
Total - Hangar/Storage Building			**0.4 lb/hr**	**0.3 ton/yr**
NARL Camp				
Primary Generator Engine	3.5 g/kW-hr	89.112 (a), Tier 3	2.8 lb/hr	5.6 ton/yr
Backup Generator Engine	3.5 g/kW-hr	89.112 (a), Tier 3	2.8 lb/hr	3.3E-2 ton/yr
KDR Generator Engine	0.9 g/kW-hr	Vendor Data	1.3 lb/hr	2.6 ton/yr
Total - NARL Camp			**6.8 lb/hr**	**8.2 ton/yr**
Vehicles				
Passenger Truck (Model Year 2012)		MOVES	1.1E-2 lb/hr	4.3E-3 ton/yr
Total - Vehicles			**1.1E-2 lb/hr**	**4.3E-3 ton/yr**
Total - Onshore			**40.7 lb/hr**	**12.8 ton/yr**

Table C-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Onshore Emissions

Unit Description	Particulate Matter (PM_{10}) Emissions			
	Factor	Reference	Hourly [2, 4]	Annual [2]
Aircraft Take-off and Landings				
Crew Change Helicopters				
Take-off	0.2 lb/TO	EDMS 5.1.4.1	0.2 lb/hr	6.9E-2 ton/yr
Landing	0.1 lb/L	EDMS 5.1.4.1	0.1 lb/hr	3.4E-2 ton/yr
SAR Helicopter				
Take-off	0.2 lb/TO	EDMS 5.1.4.1	0.2 lb/hr	1.2E-2 ton/yr
Landing	0.1 lb/L	EDMS 5.1.4.1	0.1 lb/hr	6.0E-3 ton/yr
Crew Transport Fixed-wing Aircraft				
Take-off	0.1 lb/TO	EDMS 5.1.4.1	0.1 lb/hr	3.0E-4 ton/yr
Landing	3.3E-1 lb/L	EDMS 5.1.4.1	0.3 lb/hr	9.9E-4 ton/yr
Ice Reconnaissance Fixed-wing Aircraft				
Take-off	2.5E-2 lb/TO	EDMS 5.1.4.1	2.5E-2 lb/hr	1.5E-3 ton/yr
Landing	1.2E-2 lb/L	EDMS 5.1.4.1	1.2E-2 lb/hr	7.2E-4 ton/yr
PSO Fixed-wing Aircraft				
Take-off	2.5E-2 lb/TO	EDMS 5.1.4.1	2.5E-2 lb/hr	1.5E-3 ton/yr
Landing	1.2E-2 lb/L	EDMS 5.1.4.1	1.2E-2 lb/hr	7.2E-4 ton/yr
Total - Air Craft Support			**1.1 lb/hr**	**0.1 ton/yr**
Hangar/Storage Building				
Natural Gas Boiler [3]	7.6 lb/10^6 scf	Table 1.4-1, AP-42	3.7E-2 lb/hr	2.7E-2 ton/yr
Total - Hangar/Storage Building			**3.7E-2 lb/hr**	**2.7E-2 ton/yr**
NARL Camp				
Primary Generator Engine	0.2 g/kW-hr	89.112 (a), Tier 3	0.2 lb/hr	0.3 ton/yr
Backup Generator Engine	0.2 g/kW-hr	89.112 (a), Tier 3	0.2 lb/hr	1.9E-3 ton/yr
KDR Generator Engine	0.1 g/kW-hr	Vendor Data	0.2 lb/hr	0.4 ton/yr
Total - NARL Camp			**0.5 lb/hr**	**0.7 ton/yr**
Vehicles				
Passenger Truck (Model Year 2012)		MOVES	4.5E-5 lb/hr	2.6E-5 ton/yr
Total - Vehicles			**4.5E-5 lb/hr**	**2.6E-5 ton/yr**
Total - Onshore			**1.6 lb/hr**	**0.9 ton/yr**

Table C-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Onshore Emissions

Unit Description	Particulate Matter ($PM_{2.5}$) Emissions			
	Factor	Reference	Hourly [2, 4]	Annual [2]
Aircraft Take-off and Landings				
Crew Change Helicopters				
Take-off	0.2 lb/TO	EDMS 5.1.4.1	0.2 lb/hr	6.9E-2 ton/yr
Landing	0.1 lb/L	EDMS 5.1.4.1	0.1 lb/hr	3.4E-2 ton/yr
SAR Helicopter				
Take-off	0.2 lb/TO	EDMS 5.1.4.1	0.2 lb/hr	1.2E-2 ton/yr
Landing	0.1 lb/L	EDMS 5.1.4.1	0.1 lb/hr	6.0E-3 ton/yr
Crew Transport Fixed-wing Aircraft				
Take-off	0.1 lb/TO	EDMS 5.1.4.1	0.1 lb/hr	3.0E-4 ton/yr
Landing	3.3E-1 lb/L	EDMS 5.1.4.1	0.3 lb/hr	9.9E-4 ton/yr
Ice Reconnaissance Fixed-wing Aircraft				
Take-off	2.5E-2 lb/TO	EDMS 5.1.4.1	2.5E-2 lb/hr	1.5E-3 ton/yr
Landing	1.2E-2 lb/L	EDMS 5.1.4.1	1.2E-2 lb/hr	7.2E-4 ton/yr
PSO Fixed-wing Aircraft				
Take-off	2.5E-2 lb/TO	EDMS 5.1.4.1	2.5E-2 lb/hr	1.5E-3 ton/yr
Landing	1.2E-2 lb/L	EDMS 5.1.4.1	1.2E-2 lb/hr	7.2E-4 ton/yr
Total - Air Craft Support			**1.1 lb/hr**	**0.1 ton/yr**
Hangar/Storage Building				
Natural Gas Boiler [3]	7.6 lb/10^6 scf	Table 1.4-1, AP-42	3.7E-2 lb/hr	2.7E-2 ton/yr
Total - Hangar/Storage Building			**3.7E-2 lb/hr**	**2.7E-2 ton/yr**
NARL Camp				
Primary Generator Engine	0.2 g/kW-hr	89.112 (a), Tier 3	0.2 lb/hr	0.3 ton/yr
Backup Generator Engine	0.2 g/kW-hr	89.112 (a), Tier 3	0.2 lb/hr	1.9E-3 ton/yr
KDR Generator Engine	0.1 g/kW-hr	Vendor Data	0.2 lb/hr	0.4 ton/yr
Total - NARL Camp			**0.5 lb/hr**	**0.7 ton/yr**
Vehicles				
Passenger Truck (Model Year 2012)		MOVES	4.5E-5 lb/hr	2.6E-5 ton/yr
Total - Vehicles			**4.5E-5 lb/hr**	**2.6E-5 ton/yr**
Total - Onshore			**1.6 lb/hr**	**0.9 ton/yr**

Table C-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Onshore Emissions

Unit Description	Volatile Organic Compounds (VOC) Emissions			
	Factor	Reference	Hourly [2, 4]	Annual [2]
Aircraft Take-off and Landings				
Crew Change Helicopters				
Take-off	6.4 lb/TO	EDMS 5.1.4.1	6.4 lb/hr	2.2 ton/yr
Landing	4.2 lb/L	EDMS 5.1.4.1	4.2 lb/hr	1.4 ton/yr
SAR Helicopter				
Take-off	6.4 lb/TO	EDMS 5.1.4.1	6.4 lb/hr	0.4 ton/yr
Landing	4.2 lb/L	EDMS 5.1.4.1	4.2 lb/hr	0.3 ton/yr
Crew Transport Fixed-wing Aircraft				
Take-off	1.4 lb/TO	EDMS 5.1.4.1	1.4 lb/hr	4.2E-3 ton/yr
Landing	0.8 lb/L	EDMS 5.1.4.1	0.8 lb/hr	2.4E-3 ton/yr
Ice Reconnaissance Fixed-wing Aircraft				
Take-off	0.4 lb/TO	EDMS 5.1.4.1	0.4 lb/hr	2.4E-2 ton/yr
Landing	0.3 lb/L	EDMS 5.1.4.1	0.3 lb/hr	1.8E-2 ton/yr
PSO Fixed-wing Aircraft				
Take-off	0.4 lb/TO	EDMS 5.1.4.1	0.4 lb/hr	2.4E-2 ton/yr
Landing	0.3 lb/L	EDMS 5.1.4.1	0.3 lb/hr	1.8E-2 ton/yr
Total - Air Craft Support			**24.8 lb/hr**	**4.4 ton/yr**
Hangar/Storage Building				
Natural Gas Boiler [3]	5.5 lb/10^6 scf	Table 1.4-2, AP-42	2.7E-2 lb/hr	1.9E-2 ton/yr
Total - Hangar/Storage Building			**2.7E-2 lb/hr**	**1.9E-2 ton/yr**
NARL Camp				
Primary Generator Engine	1.3 g/kW-hr	89.112 (a),Tier 1	1.0 lb/hr	2.1 ton/yr
Backup Generator Engine	1.3 g/kW-hr	89.112 (a),Tier 1	1.0 lb/hr	1.2E-2 ton/yr
KDR Generator Engine	0.2 g/kW-hr	Vendor Data	0.2 lb/hr	0.5 ton/yr
Total - NARL Camp			**2.3 lb/hr**	**2.6 ton/yr**
Vehicles				
Passenger Truck (Model Year 2012)		MOVES	1.7E-3 lb/hr	6.3E-4 ton/yr
Total - Vehicles			**1.7E-3 lb/hr**	**6.3E-4 ton/yr**
Total - Onshore			**27.1 lb/hr**	**6.9 ton/yr**

Table C-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Onshore Emissions

Unit Description	Sulfur Dioxide (SO_2) Emissions Factor	Reference	Hourly [2,4]	Annual [2]
Aircraft Take-off and Landings				
Crew Change Helicopters				
Take-off	0.2 lb/TO	EDMS 5.1.4.1	0.2 lb/hr	6.9E-2 ton/yr
Landing	0.2 lb/L	EDMS 5.1.4.1	0.2 lb/hr	6.9E-2 ton/yr
SAR Helicopter				
Take-off	0.2 lb/TO	EDMS 5.1.4.1	0.2 lb/hr	1.2E-2 ton/yr
Landing	0.2 lb/L	EDMS 5.1.4.1	0.2 lb/hr	1.2E-2 ton/yr
Crew Transport Fixed-wing Aircraft				
Take-off	0.2 lb/TO	EDMS 5.1.4.1	0.2 lb/hr	6.0E-4 ton/yr
Landing	0.1 lb/L	EDMS 5.1.4.1	0.1 lb/hr	3.0E-4 ton/yr
Ice Reconnaissance Fixed-wing Aircraft				
Take-off	0.1 lb/TO	EDMS 5.1.4.1	0.1 lb/hr	6.0E-3 ton/yr
Landing	0.1 lb/L	EDMS 5.1.4.1	0.1 lb/hr	6.0E-3 ton/yr
PSO Fixed-wing Aircraft				
Take-off	0.1 lb/TO	EDMS 5.1.4.1	0.1 lb/hr	6.0E-3 ton/yr
Landing	0.1 lb/L	EDMS 5.1.4.1	0.1 lb/hr	6.0E-3 ton/yr
Total - Air Craft Support			**1.5 lb/hr**	**0.2 ton/yr**
Hangar/Storage Building				
Natural Gas Boiler [3]	0.6 lb/10^6 scf	Table 1.4-2, AP-42	2.9E-3 lb/hr	2.1E-3 ton/yr
Total - Hangar/Storage Building			**2.9E-3 lb/hr**	**2.1E-3 ton/yr**
NARL Camp				
Primary Generator Engine	0.05 g/kW-hr	Mass Balance Calculation	3.6E-2 lb/hr	7.2E-2 ton/yr
Backup Generator Engine	0.0 g/kW-hr	Mass Balance Calculation	3.6E-2 lb/hr	4.3E-4 ton/yr
KDR Generator Engine	0.05 g/kW-hr	Mass Balance Calculation	6.5E-2 lb/hr	1.3E-1 ton/yr
Total - NARL Camp			**1.4E-1 lb/hr**	**0.2 ton/yr**
Vehicles				
Passenger Truck (Model Year 2012)		MOVES	3.4E-5 lb/hr	2.0E-5 ton/yr
Total - Vehicles			**3.4E-5 lb/hr**	**2.0E-5 ton/yr**
Total - Onshore			**1.6 lb/hr**	**0.4 ton/yr**

Table C-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Onshore Emissions

Unit Description	Lead (Pb) Emissions			
	Factor	Reference	Hourly [2, 4]	Annual [2]
Aircraft Take-off and Landings				
Crew Change Helicopters				
Take-off				
Landing				
SAR Helicopter				
Take-off				
Landing				
Crew Transport Fixed-wing Aircraft				
Take-off				
Landing				
Ice Reconnaissance Fixed-wing Aircraft				
Take-off				
Landing				
PSO Fixed-wing Aircraft				
Take-off				
Landing				
Total - Air Craft Support				
Hangar/Storage Building				
Natural Gas Boiler [3]	0.0005 lb/10^6 scf	Table 1.4-2, AP-42	2.5E-6 lb/hr	1.8E-6 ton/yr
Total - Hangar/Storage Building			**2.5E-6 lb/hr**	**1.8E-6 ton/yr**
NARL Camp				
Primary Generator Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	9.7E-5 lb/hr	2.0E-4 ton/yr
Backup Generator Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	9.7E-5 lb/hr	1.2E-6 ton/yr
KDR Generator Engine	1.23E-4 g/kW-hr	EPA 454/R-98-006, Section 5.2.3	1.8E-4 lb/hr	3.5E-4 ton/yr
Total - NARL Camp			**3.7E-4 lb/hr**	**5.5E-4 ton/yr**
Vehicles				
Passenger Truck (Model Year 2012)				
Total - Vehicles				
Total - Onshore			**3.7E-4 lb/hr**	**5.5E-4 ton/yr**

Table C-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
National Environmental Policy Act Emission Inventory - Onshore Emissions

Unit Description	GHG (CO_2e) Emissions Factor	Reference	Hourly [2, 4]	Annual [2]
Aircraft Take-off and Landings				
Crew Change Helicopters				
Take-off	430.5 lb/TO	EDMS 5.1.4.1	431 lb/hr	148 ton/yr
Landing	392.8 lb/L	EDMS 5.1.4.1	393 lb/hr	135 ton/yr
SAR Helicopter				
Take-off	430.5 lb/TO	EDMS 5.1.4.1	431 lb/hr	26 ton/yr
Landing	392.8 lb/L	EDMS 5.1.4.1	393 lb/hr	24 ton/yr
Crew Transport Fixed-wing Aircraft				
Take-off	593.6 lb/TO	EDMS 5.1.4.1	594 lb/hr	2 ton/yr
Landing	268.7 lb/L	EDMS 5.1.4.1	269 lb/hr	1 ton/yr
Ice Reconnaissance Fixed-wing Aircraft				
Take-off	361.4 lb/TO	EDMS 5.1.4.1	361 lb/hr	22 ton/yr
Landing	191.8 lb/L	EDMS 5.1.4.1	192 lb/hr	12 ton/yr
PSO Fixed-wing Aircraft				
Take-off	361.4 lb/TO	EDMS 5.1.4.1	361 lb/hr	22 ton/yr
Landing	191.8 lb/L	EDMS 5.1.4.1	192 lb/hr	12 ton/yr
Total - Air Craft Support			**3,615 lb/hr**	**401 ton/yr**
Hangar/Storage Building				
Natural Gas Boiler [3]	53.1 kg/MMBtu	40 CFR Part 98, Subpart C	585 lb/hr	422 ton/yr
Total - Hangar/Storage Building			**585 lb/hr**	**422 ton/yr**
NARL Camp				
Primary Generator Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	550 lb/hr	1,109 ton/yr
Backup Generator Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	550 lb/hr	7 ton/yr
KDR Generator Engine	696.1 g/kW-hr	40 CFR Part 98, Subpart C	990 lb/hr	1,997 ton/yr
Total - NARL Camp			**2,091 lb/hr**	**3,112 ton/yr**
Vehicles				
Passenger Truck (Model Year 2012)		MOVES	5 lb/hr	3 ton/yr
Total - Vehicles			**5 lb/hr**	**3 ton/yr**
Total - Onshore			**6,296 lb/hr**	**3,937 ton/yr**

Notes:

[1] Maximum Aggregate Rating is adjusted to account for Short-Term Maximum Load.

[2] Conversion factors

453.59 g/lb

2,000 lb/t

2.2046 lb/kg

1.34 hp/kW

[3] Natural Gas Heat Value

1,020 MMBtu/10^6 scf

[4] The projected peak hourly emissions presented will not occur in every hour and are not cumulative over the year.

Attachment C2 – Aircraft EDMS LTO Emissions

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska			BY: N. Tipple	
AIR SCIENCES INC. DENVER • PORTLAND	PROJECT NO: 180-23-1	PAGE: 1	OF: 5	SHEET: Aircraft	
ENGINEERING CALCULATIONS	SUBJECT: EDMS Aircraft Emissions	DATE: February 16, 2015			

CREW CHANGE HELICOPTER EMISSIONS
(3) Sikorsky S-92, Euro Copter C225, or similar helicopters for crew rotation & groceries/supply
Crew Change: Approximately 40 round trips/week between shorebase & prospect – approx. 3.0 hr/trip

RUN FOR 1 AIRCRAFT
EDMS 5.1.4.1 Emissions Inventory Report
Aircraft Emissions by Mode
Study: CrewChange
Scenario - Airport: Baseline - Wiley Post-Will Rogers Mem
Year: 2015
Units: Pounds per Year *lb/LTO*
Generated: 05/28/14 10:30:23
CrewChange - LTO.txt

Type	Engine	ID	Euro. Group	Mode	CO2	H2O	CO	THC	NMHC	VOC	TOG	Fuel Consumption
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Startup								
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi Out	427.8	167.7	5.2	5.5	6.4	6.4	6.4	135.6
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Takeoff	2.7	1.1	2.0E-3	0.0	0.0	0.0	0.0	0.9
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Climb Out								
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Approach	212.1	83.2	1.4	1.3	1.5	1.5	1.5	67.2
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi In	180.7	70.8	2.2	2.3	2.7	2.7	2.7	57.3
				Takeoff	430.5	168.8	5.2	5.5	6.4	6.4	6.4	136.4
				Landing	392.8	154.0	3.6	3.7	4.2	4.2	4.2	124.5
				TOTAL	823.3	322.8	8.7	9.2	10.6	10.6	10.6	261.0

Type	Engine	ID	Euro. Group	Mode	NOx	SOx	PM-10	PM-2.5	PM Non-Volatile	PM Volatile Sulfates	PM Volatile Organics
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Startup							
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi Out	0.5	0.2	0.2	0.2	0.0	1.4E-2	0.2
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Takeoff	1.0E-2	1.0E-3	3.0E-3	3.0E-3	0.0	0.0	3.0E-3
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Climb Out							
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Approach	0.5	0.1	1.2E-2	1.2E-2	0.0	7.0E-3	5.0E-3
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi In	0.2	0.1	0.1	0.1	0.0	6.0E-3	0.1
				Takeoff	0.5	0.2	0.2	0.2	0.0	1.4E-2	0.2
				Landing	0.7	0.2	0.1	0.1	0.0	1.3E-2	0.1
				TOTAL	1.2	0.3	0.3	0.3	0.0	2.7E-2	0.2

blue values are input, black values are calculated or linked

SEARCH AND RESCUE HELICOPTER EMISSIONS

(1) Sikorsky S-92, Euro Copter C225, or similar helicopter for search and rescue operations

Approximately 40 hours/week – approx. 4.0 hr/trip - assume 7 round trips/week

RUN FOR 1 AIRCRAFT

EDMS 5.1.4.1 Emissions Inventory Report
Aircraft Emissions by Mode
Study: SearchRescue
Scenario - Airport: Baseline - Wiley Post-Will Rogers Mem
Year: 2015
Units: Pounds per Year *lb/LTO*
Generated: 05/28/14 10:40:35
SearchRescue - LTO.txt

Type	Engine	ID	Euro. Group	Mode	CO2	H2O	CO	THC	NMHC	VOC	TOG	Fuel Consumption
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Startup								
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi Out	427.8	167.7	5.2	5.5	6.4	6.4	6.4	135.6
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Takeoff	2.7	1.1	2.0E-3	0.0	0.0	0.0	0.0	0.9
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Climb Out								
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Approach	212.1	83.2	1.4	1.3	1.5	1.5	1.5	67.2
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi In	180.7	70.8	2.2	2.3	2.7	2.7	2.7	57.3
				Takeoff	430.5	168.8	5.2	5.5	6.4	6.4	6.4	136.4
				Landing	392.8	154.0	3.6	3.7	4.2	4.2	4.2	124.5
				TOTAL	823.3	322.8	8.7	9.2	10.6	10.6	10.6	261.0

Type	Engine	ID	Euro. Group	Mode	NOx	SOx	PM-10	PM-2.5	PM Non-Volatile	PM Volatile Sulfates	PM Volatile Organics
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Startup							
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi Out	0.5	0.2	0.2	0.2	0.0	1.4E-2	0.2
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Takeoff	1.0E-2	1.0E-3	3.0E-3	3.0E-3	0.0	0.0	3.0E-3
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Climb Out							
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Approach	0.5	0.1	1.2E-2	1.2E-2	0.0	7.0E-3	5.0E-3
Sikorsky S-76 Spirit	T700-GE-700	#1	H2	Taxi In	0.2	0.1	0.1	0.1	0.0	6.0E-3	0.1
				Takeoff	0.5	0.2	0.2	0.2	0.0	1.4E-2	0.2
				Landing	0.7	0.2	0.1	0.1	0.0	1.3E-2	0.1
				TOTAL	1.2	0.3	0.3	0.3	0.0	2.7E-2	0.2

blue values are input, black values are calculated or linked

CREW TRANSPORT FIXED-WING AIRCRAFT EMISSIONS

(1) Saab 340 B, Beechcraft 1900, Dash 9 or similar fixed-wing aircraft for crew transport
Approximately 1 round trips every 3 weeks

RUN FOR 1 AIRCRAFT

EDMS 5.1.4.1 Emissions Inventory Report
Aircraft Emissions by Mode
Study: CrewTransport
Scenario - Airport: Baseline - Wiley Post-Will Rogers Mem
Year: 2015
Units: Pounds per Year *lb/LTO*
Generated: 05/28/14 10:32:29
CrewTransportCT7-9B - LTO.txt

Type	Engine	ID	Euro. Group	Mode	CO2	H2O	CO	THC	NMHC	VOC	TOG	Fuel Consumption
Saab 340-B	CT7-9B	#1	TP	Startup								
Saab 340-B	CT7-9B	#1	TP	Taxi Out	480.0	188.2	2.4	1.2	1.4	1.4	1.4	152.1
Saab 340-B	CT7-9B	#1	TP	Takeoff	43.5	17.0	3.4E-2	2.2E-2	2.5E-2	2.5E-2	2.5E-2	13.8
Saab 340-B	CT7-9B	#1	TP	Climb Out	70.2	27.5	3.6E-2	2.6E-2	3.1E-2	3.0E-2	3.1E-2	22.3
Saab 340-B	CT7-9B	#1	TP	Approach	89.1	34.9	0.4	0.2	0.3	0.3	0.3	28.2
Saab 340-B	CT7-9B	#1	TP	Taxi In	179.7	70.4	0.9	0.4	0.5	0.5	0.5	56.9
				Takeoff	593.6	232.8	2.4	1.2	1.4	1.4	1.4	188.2
				Landing	268.7	105.4	1.3	0.7	0.8	0.8	0.8	85.2
				TOTAL	862.4	338.1	3.8	1.9	2.2	2.2	2.2	273.3

Type	Engine	ID	Euro. Group	Mode	NOx	SOx	PM-10	PM-2.5	PM Non-Volatile	PM Volatile Sulfates	PM Volatile Organics
Saab 340-B	CT7-9B	#1	TP	Startup							
Saab 340-B	CT7-9B	#1	TP	Taxi Out	0.4	0.2	4.9E-2	4.9E-2	0.0	1.6E-2	3.3E-2
Saab 340-B	CT7-9B	#1	TP	Takeoff	0.2	1.8E-2	8.0E-3	8.0E-3	0.0	1.0E-3	6.0E-3
Saab 340-B	CT7-9B	#1	TP	Climb Out	0.3	2.9E-2	1.1E-2	1.1E-2	0.0	2.0E-3	9.0E-3
Saab 340-B	CT7-9B	#1	TP	Approach	0.1	3.6E-2	1.5E-2	1.5E-2	0.0	3.0E-3	1.2E-2
Saab 340-B	CT7-9B	#1	TP	Taxi In	0.2	0.1	1.8E-2	1.8E-2	0.0	6.0E-3	1.2E-2
				Takeoff	0.8	0.2	0.1	0.1	0.0	1.9E-2	4.8E-2
				Landing	0.2	0.1	3.3E-2	3.3E-2	0.0	9.0E-3	2.4E-2
				TOTAL	1.1	0.4	0.1	0.1	0.0	2.8E-2	0.1

blue values are input, black values are calculated or linked

ICE RECONNAISSANCE FIXED-WING AIRCRAFT EMISSIONS

(1) Gulfstream AeroCommander 690 fixed-wing aircraft or similar fixed-wing aircraft for Ice Reconnaissance flights
Approximately 7 trips/week

RUN FOR 1 AIRCRAFT

EDMS 5.1.4.1 Emissions Inventory Report
Aircraft Emissions by Mode
Study: IceOver
Scenario - Airport: Baseline - Wiley Post-Will Rogers Mem
Year: 2015
Units: Pounds per Year *lb/LTO*
Generated: 05/28/14 10:34:41
IceOver - LTO.txt

Type	Engine	ID	Euro. Group	Mode	CO2	H2O	CO	THC	NMHC	VOC	TOG	Fuel Consumption
Rockwell Commander	TPE331-10UK	#1	TP	Startup								
Rockwell Commander	TPE331-10UK	#1	TP	Taxi Out	273.5	107.2	3.5	0.3	0.4	0.4	0.4	86.7
Rockwell Commander	TPE331-10UK	#1	TP	Takeoff	34.1	13.4	4.5E-2	3.0E-3	4.0E-3	4.0E-3	4.0E-3	10.8
Rockwell Commander	TPE331-10UK	#1	TP	Climb Out	53.9	21.1	4.7E-2	3.0E-3	4.0E-3	4.0E-3	4.0E-3	17.1
Rockwell Commander	TPE331-10UK	#1	TP	Approach	90.4	35.5	1.2	0.1	0.1	0.1	0.1	28.7
Rockwell Commander	TPE331-10UK	#1	TP	Taxi In	101.4	39.8	1.3	0.1	0.1	0.1	0.1	32.1
				Takeoff	361.4	141.7	3.6	0.3	0.4	0.4	0.4	114.6
				Landing	191.8	75.2	2.5	0.2	0.3	0.3	0.3	60.8
				TOTAL	553.3	216.9	6.0	0.6	0.7	0.7	0.7	175.4

Type	Engine	ID	Euro. Group	Mode	NOx	SOx	PM-10	PM-2.5	PM Non-Volatile	PM Volatile Sulfates	PM Volatile Organics
Rockwell Commander	TPE331-10UK	#1	TP	Startup							
Rockwell Commander	TPE331-10UK	#1	TP	Taxi Out	0.3	0.1	1.8E-2	1.8E-2	0.0	9.0E-3	9.0E-3
Rockwell Commander	TPE331-10UK	#1	TP	Takeoff	0.1	1.4E-2	3.0E-3	3.0E-3	0.0	1.0E-3	2.0E-3
Rockwell Commander	TPE331-10UK	#1	TP	Climb Out	0.2	2.2E-2	4.0E-3	4.0E-3	0.0	2.0E-3	3.0E-3
Rockwell Commander	TPE331-10UK	#1	TP	Approach	0.1	3.7E-2	5.0E-3	5.0E-3	0.0	3.0E-3	2.0E-3
Rockwell Commander	TPE331-10UK	#1	TP	Taxi In	0.1	4.2E-2	7.0E-3	7.0E-3	0.0	3.0E-3	3.0E-3
				Takeoff	0.7	0.1	2.5E-2	2.5E-2	0.0	1.2E-2	1.4E-2
				Landing	0.2	0.1	1.2E-2	1.2E-2	0.0	6.0E-3	5.0E-3
				TOTAL	1.0	0.2	3.7E-2	3.7E-2	0.0	1.8E-2	1.9E-2

blue values are input, black values are calculated or linked

PSO FIXED-WING AIRCRAFT EMISSIONS

(1) Gulfstream AeroCommander 690 fixed-wing aircraft or similar fixed-wing aircraft for PSO flights
Approximately 7 trips/week

RUN FOR 1 AIRCRAFT

EDMS 5.1.4.1 Emissions Inventory Report
Aircraft Emissions by Mode
Study: IceOver
Scenario - Airport: Baseline - Wiley Post-Will Rogers Mem
Year: 2015
Units: Pounds per Year *lb/LTO*
Generated: 05/28/14 10:34:41
IceOver - LTO.txt

Type	Engine	ID	Euro. Group	Mode	CO2	H2O	CO	THC	NMHC	VOC	TOG	Fuel Consumption
Rockwell Commander	TPE331-10UK	#1	TP	Startup								
Rockwell Commander	TPE331-10UK	#1	TP	Taxi Out	273.5	107.2	3.5	0.3	0.4	0.4	0.4	86.7
Rockwell Commander	TPE331-10UK	#1	TP	Takeoff	34.1	13.4	4.5E-2	3.0E-3	4.0E-3	4.0E-3	4.0E-3	10.8
Rockwell Commander	TPE331-10UK	#1	TP	Climb Out	53.9	21.1	4.7E-2	3.0E-3	4.0E-3	4.0E-3	4.0E-3	17.1
Rockwell Commander	TPE331-10UK	#1	TP	Approach	90.4	35.5	1.2	0.1	0.1	0.1	0.1	28.7
Rockwell Commander	TPE331-10UK	#1	TP	Taxi In	101.4	39.8	1.3	0.1	0.1	0.1	0.1	32.1
				Takeoff	361.4	141.7	3.6	0.3	0.4	0.4	0.4	114.6
				Landing	191.8	75.2	2.5	0.2	0.3	0.3	0.3	60.8
				TOTAL	553.3	216.9	6.0	0.6	0.7	0.7	0.7	175.4

Type	Engine	ID	Euro. Group	Mode	NOx	SOx	PM-10	PM-2.5	PM Non-Volatile	PM Volatile Sulfates	PM Volatile Organics
Rockwell Commander	TPE331-10UK	#1	TP	Startup							
Rockwell Commander	TPE331-10UK	#1	TP	Taxi Out	0.3	0.1	1.8E-2	1.8E-2	0.0	9.0E-3	9.0E-3
Rockwell Commander	TPE331-10UK	#1	TP	Takeoff	0.1	1.4E-2	3.0E-3	3.0E-3	0.0	1.0E-3	2.0E-3
Rockwell Commander	TPE331-10UK	#1	TP	Climb Out	0.2	2.2E-2	4.0E-3	4.0E-3	0.0	2.0E-3	3.0E-3
Rockwell Commander	TPE331-10UK	#1	TP	Approach	0.1	3.7E-2	5.0E-3	5.0E-3	0.0	3.0E-3	2.0E-3
Rockwell Commander	TPE331-10UK	#1	TP	Taxi In	0.1	4.2E-2	7.0E-3	7.0E-3	0.0	3.0E-3	3.0E-3
				Takeoff	0.7	0.1	2.5E-2	2.5E-2	0.0	1.2E-2	1.4E-2
				Landing	0.2	0.1	1.2E-2	1.2E-2	0.0	6.0E-3	5.0E-3
				TOTAL	1.0	0.2	3.7E-2	3.7E-2	0.0	1.8E-2	1.9E-2

blue values are input, black values are calculated or linked

Attachment C3 – Vehicle MOVES Emissions

DIESEL TRUCK EMISSIONS
(1) Ford F-250, or similar diesel truck for personnel and equipment transportation
Approximately 12 hours/day, 7 days/week

RUN FOR 1 DIESEL PASSENGER TRUCK
MOVES2010b movesoutput table
Vehicle Emissions Rural Unrestricted Access
Study: AKTruck4
Scenario - Geographic Bounds - ALASKA - North Slope Borough
Year: 2015
Diesel Fuel - Passenger Truck (Model Year 2012)
Units: Pound, Million BTU, Miles *lb/hr*
Generated: 06/02/14 (*MOVES_Output_ShellVehicle_20140602.xlsx*)

EMISSIONS SUMMARY

	Max Hourly *lb/hr*	**Emissions** *ton/season*
Oxides of Nitrogen (NOx)	1.3E-2	5.7E-3
Primary Exhaust PM10 - Total	4.5E-5	2.6E-5
Carbon Monoxide (CO)	1.1E-2	4.3E-3
Volatile Organic Compounds	1.7E-3	6.3E-4
Sulfur Dioxide (SO2)	3.4E-5	2.0E-5
CO2 Equivalent	5.0	2.9

Conversions

2,000
6.74

**Average density. Exxon Mobil. World Jet Fuel Specifications. 2005 Edition.*
http://www.exxonmobil.com/AviationGlobal/Files/WorldJetFuelSpecifications2005.pdf

blue values are input, black values are calculated or linked

Attachment D – Emission Inventory Supporting Details

Table D-1. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Support Vessels

Category	Candidate Vessel	Primary Location [1]
Discoverer Support Vessels		
Ice Management	*Fennica*	Burger Prospect
Anchor Handler	*Aiviq*	Burger Prospect
Science Vessel	TBD (similar to *Harvey Supporter*)	Burger Prospect
Support Tug	*Lauren Foss*	Burger Prospect
Polar Pioneer Support Vessels		
Ice Management	*Nordica*	Burger Prospect
Anchor Handler	*Tor Viking*	Burger Prospect
Science Vessel	TBD (similar to *Harvey Explorer*)	Burger Prospect
Support Tug	*Ocean Wind*	Burger Prospect
Support Tug	*Ocean Wave*	Burger Prospect
Common Support Vessels		
Anchor Handler	*Ross Chouest*	Burger Prospect
Offshore Supply Vessel	*Sisuaq*	Burger Prospect
Offshore Supply Vessel	*Harvey Supporter*	Burger Prospect
Offshore Supply Vessel	*Harvey Champion*	In Transit [2]
Oil Spill Response Vessel	*Nanuq*	Burger Prospect
Oil Spill Response Workboats	3, 34-foot Kvichaks (on *Nanuq*)	Burger Prospect
Offshore Oil Spill Response Tug/Barge	*Guardsman/Klamath*	Burger Prospect
Arctic Oil Storage Tanker	TBD (similar to *Affinity*)	Burger Prospect
MLC ROV System Vessel	TBD (similar to *Harvey Spirit*)	Burger Prospect

Notes:

[1] All vessels located at Burger Prospect are assumed within 25 miles of a drilling unit during exploration drilling except where noted.

[2] One of the Offshore Supply Vessels is assumed to be in transit and not located within 25 miles of a drilling unit while anchored over a drill site.

Table D-2. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
***Noble Discoverer* Drillship Emission Unit Inventory**

ID	Description	Make/Model	Maximum Rating/Capacity[1]	
D-1	Main Generator Engine	Caterpillar/3512C	1,476 hp	1,101 kW
D-2	Main Generator Engine	Caterpillar/3512C	1,476 hp	1,101 kW
D-3	Main Generator Engine	Caterpillar/3512C	1,476 hp	1,101 kW
D-4	Main Generator Engine	Caterpillar/3512C	1,476 hp	1,101 kW
D-5	Main Generator Engine	Caterpillar/3512C	1,476 hp	1,101 kW
D-6	Main Generator Engine	Caterpillar/3512C	1,476 hp	1,101 kW
		Total - Generator Engines		**6,609 kW**
D-7	Propulsion Engine	STX-MAN/6S42MC7	6,480 kW	6,480 kW
D-12	HPU Engine	John Deere/JD6068HF485	243 hp	181 kW
D-13	HPU Engine	John Deere/JD6068HF485	243 hp	181 kW
		Total - HPU Engines		**363 kW**
D-14	Port Deck Crane Engine	Liebherr/D9508 A7	450 kW	450 kW
D-15	Starbd Deck Crane Engine	Liebherr/D9508 A7	450 kW	450 kW
		Total - Crane Engines		**900 kW**
D-16	Cementing Unit Engine	Detroit/8V-71N	335 hp	250 kW
D-17	Cementing Unit Engine	Detroit/8V-71N	335 hp	250 kW
		Total - Cementing Engines		**500 kW**
	Logging Unit Engine	Caterpillar/C7 ACERT	224 kW	224 kW
	Compressor Engine	Detroit/4-71	140 bhp	104 kW
	Sidewall Core Tool Engine	John Deere/4024TF270	57 bhp	43 kW
D-8	Emergency Generator Engine	Caterpillar/3412	679 hp	507 kW
D-LB-1	Lifeboat No. 1 Engine	Sabb/L3.139LB	29.5 hp	22 kW
D-LB-2	Lifeboat No. 2 Engine	Sabb/L3.139LB	29.5 hp	22 kW
D-LB-3	Lifeboat No. 3 Engine	Sabb/L3.139LB	29.5 hp	22 kW
D-LB-4	Lifeboat No. 4 Engine	Sabb/L3.139LB	29.5 hp	22 kW
		Total - Lifeboat Engines		**88 kW**
D-21	Heat Boiler	Clayton/200	7.97 MMBtu/hr	8 MMBtu/hr
D-22	Heat Boiler	Clayton/200	7.97 MMBtu/hr	8 MMBtu/hr
		Total - Boilers		**16 MMBtu/hr**
D-23	Incinerator	TeamTec/GS500C	276 lb/hr	276 lb/hr

Table D-3. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
***Transocean Polar Pioneer* Drilling Unit Emission Unit Inventory**

ID	Description	Make/Model	Maximum Rating/Capacity[1,2]	
PP-1	Main Generator Engine	Bergen/KVG-18	2,750 kW	2,750 kW
PP-2	Main Generator Engine	Bergen/KVG-18	2,750 kW	2,750 kW
PP-3	Main Generator Engine	Bergen/KVG-18	2,750 kW	2,750 kW
PP-4	Main Generator Engine	Bergen/KVG-18	2,750 kW	2,750 kW
PP-5	Main Generator Engine	Bergen/KVG-18	2,750 kW	2,750 kW
		Total - Generator Engines		**13,750 kW**
	HPU Engine	John Deere/6068HF485	250 hp	187 kW
	HPU Engine	John Deere/6068HF485	250 hp	187 kW
		Total - HPU Engines		**373 kW**
	Logging Unit Engine	Caterpillar/C7 ACERT	224 kW	224 kW
	Compressor Engine	Detroit/4-71	140 bhp	104 kW
	Sidewall Core Tool Engine	John Deere/4024TF270	57 bhp	43 kW
PP-6	Emergency Generator Engine	TEJOS/MTU 12-396	1,120 kW	1,120 kW
PP-10	Rescue Boat Engine	HARDING/MOBO 26	212 hp	158 kW
PP-11	Lifeboat No. 1 Engine	Vetus/M4.55	52 hp	39 kW
PP-12	Lifeboat No. 2 Engine	Vetus/M4.55	52 hp	39 kW
PP-13	Lifeboat No. 3 Engine	Vetus/M4.55	52 hp	39 kW
PP-14	Lifeboat No. 4 Engine	Vetus/M4.55	52 hp	39 kW
PP-15	Forward Fast Rescue Craft Engine	Bukh/144 VTI	144 hp	107 kW
PP-16	Aft Fast Rescue Craft Engine	Volvo/TAMD 41 P	147 kW	147 kW
	Emergency Start Compressor Engine	Hatz/E785	11 hp	8 kW
		Total - Small Emergency Engines		**576 kW**
PP-7	Heat Boiler	Aalborg Industries/Mission OS	6,000 kg/hr	13 MMBtu/hr
PP-8	Heat Boiler	Aalborg Industries/Mission OS	6,000 kg/hr	13 MMBtu/hr
		Total - Boilers		**26 MMBtu/hr**
PP-9	Incinerator	Atlas/600 SL B WS P	100 kg/hr	220 lb/hr

Table D-4. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Ice Management Vessels Emission Unit Inventory

ID	Description	Make/Model	Maximum Rating/Capacity [1]	
		Fennica		
F-1	Main Propulsion and Generator Engine	Wärtsilä/12V32	4,500 kW	4,500 kW
F-2	Main Propulsion and Generator Engine	Wärtsilä/12V32	4,500 kW	4,500 kW
F-3	Main Propulsion and Generator Engine	Wärtsilä/16V32	6,000 kW	6,000 kW
F-4	Main Propulsion and Generator Engine	Wärtsilä/16V32	6,000 kW	6,000 kW
		Total - Propulsion and Generator Engines		**21,000 kW**
F-8	Harbour Set Generator Engine	Wärtsilä/VASA 4R22	710 hp	530 kW
F-5	Heat Boiler	Unex/BH-2000	4.44 MMBtu/hr	4.44 MMBtu/hr
F-6	Heat Boiler	Unex/BH-2000	4.44 MMBtu/hr	4.44 MMBtu/hr
		Total - Boilers		**9 MMBtu/hr**
F-7	Incinerator	Unex/F-1	154 lb/hr	154 lb/hr
F-9	Emergency Generator	Caterpillar/3412	300 kW	300 kW
		Nordica		
Nd-1	Main Propulsion and Generator Engine	Wärtsilä/12V32	4,500 kW	4,500 kW
Nd-2	Main Propulsion and Generator Engine	Wärtsilä/12V32	4,500 kW	4,500 kW
Nd-3	Main Propulsion and Generator Engine	Wärtsilä/16V32	6,000 kW	6,000 kW
Nd-4	Main Propulsion and Generator Engine	Wärtsilä/16V32	6,000 kW	6,000 kW
		Total - Propulsion and Generator Engines		**21,000 kW**
Nd-8	Harbour Set Generator Engine	Wärtsilä/VASA 4R22	710 hp	530 kW
Nd-5	Heat Boiler	Aquamaster Rauma Unex/BH-2000	4.44 MMBtu/hr	4.44 MMBtu/hr
Nd-6	Heat Boiler	Aquamaster Rauma Unex/BH-2000	4.44 MMBtu/hr	4.44 MMBtu/hr
		Total - Boilers		**9 MMBtu/hr**
Nd-7	Incinerator	Unex/F-1	154.0 lb/hr	154 lb/hr
Nd-9	Emergency Generator	Caterpillar/3412	300 kW	300 kW

Table D-5. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Anchor Handler Vessels Emission Unit Inventory

ID	Description	Make/Model	Maximum Rating/Capacity [1,2]	
		Aiviq		
Av-1	Propulsion Engine	Caterpillar/C280-12	5,444 hp	4,063 kW
Av-2	Propulsion Engine	Caterpillar/C280-12	5,444 hp	4,063 kW
Av-3	Propulsion Engine	Caterpillar/C280-12	5,444 hp	4,063 kW
Av-4	Propulsion Engine	Caterpillar/C280-12	5,444 hp	4,063 kW
		Total - Propulsion Engines		**16,251 kW**
Av-5	Hybrid Generator Engine	Caterpillar/3512	1,700 kW	1,700 kW
Av-6	Hybrid Generator Engine	Caterpillar/3512	1,700 kW	1,700 kW
Av-7	Hybrid Generator Engine	Caterpillar/3512	1,700 kW	1,700 kW
Av-8	Hybrid Generator Engine	Caterpillar/3512	1,700 kW	1,700 kW
		Total - Generator Engines		**6,800 kW**
Av-9	Heat Boiler	Aalborg/Mission TFO	40 gal/hr	5 MMBtu/hr
Av-10	Incinerator	TeamTec/GS500C	276 lb/hr	276 lb/hr
Av-13	Emergency Generator #1	Caterpillar/3508	910 kW	910 kW
Av-14	Emergency Generator #2	Caterpillar/3508	910 kW	910 kW
		Total - Emergency Engines		**1,820 kW**
Av-11	Fast Rescue Craft FP 800 Thruster	Volvo/D3-200	200 hp	149 kW
Av-12	Daughter Craft Delta Phantom Thruster			
	Main Propulsion	Yanmar/6LP-STZP	315 hp	235 kW
	Main Propulsion	Yanmar/6LP-STZP	315 hp	235 kW
Av-15	Fassemer 64 Mn Enclosed Lifeboat #1	Sabb/L4S.186LB	39 hp	29 kW
Av-16	Fassemer 64 Mn Enclosed Lifeboat #2	Sabb/L4S.186LB	39 hp	29 kW
		Total - Rescue & Lifeboat Engines		**678 kW**
Av-17	TranRec150 Power Pack Engine	Cummins/6CTA 8.3 M	190 kW	190 kW
		Total - OSR Equipment		**190 kW**
		Tor Viking		
TV-1	Main Propulsion Engine	MaK/6M32	2,880 kW	2,880 kW
TV-2	Main Propulsion Engine	MaK/8M32	3,840 kW	3,840 kW
TV-3	Main Propulsion Engine	MaK/8M32	3,840 kW	3,840 kW
TV-4	Main Propulsion Engine	MaK/6M32	2,880 kW	2,880 kW
		Total - Propulsion Engines		**13,440 kW**
TV-5	Harbor Generator Engine	Caterpillar/3412C	500 kW	500 kW
TV-6	Harbor Generator Engine	Caterpillar/3412C	500 kW	500 kW
		Total - Generator Engines		**1,000 kW**
TV-7	Heat Boiler	Pyro/E1130	1.37 MMBtu/hr	1.37 MMBtu/hr
TV-8	Emergency Generator	Caterpillar/3306	170 kW	170 kW
		Total - Emergency Engines		**170 kW**
		Ross Chouest		
PME	Port Main Engine	Caterpillar/3612	5,502 hp	4,106 kW
SME	Starboard Main Engine	Caterpillar/3612	5,502 hp	4,106 kW
FDDT	Forward Dynamic Directional Thruster Engine	Caterpillar/3512	1,281 hp	956 kW
ADDT	Aft Dynamic Directional Thruster Engine	Caterpillar/3512	1,281 hp	956 kW
P Gen	Port Generator Engine	Caterpillar/3412C	791 hp	590 kW
C Gen	Center Generator Engine	Caterpillar/3412C	791 hp	590 kW
S Gen	Starboard Generator Engine	Caterpillar/3412C	791 hp	590 kW
TT	Tunnel Thruster Engine	Caterpillar/3508	850 hp	634 kW
		Total - Propulsion and Generator Engines		**12,529 kW**
P Winch	Port Winch	Caterpillar/3508	960 hp	716 kW
S Winch	Starboard Winch	Caterpillar/3508	960 hp	716 kW
		Total - Various Engines		**1,433 kW**
E Gen	Emergency Generator	Caterpillar/3406C	429 hp	320 kW

Table D-6. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Support Tugs Inventory

ID	Description	Make/Model	Maximum Rating/Capacity [1]	
		Lauren Foss		
LF-1	Port Main Propulsion	ALCO 16-251F	4,100 hp	3,060 kW
LF-2	Starboard Main Propulsion	ALCO 16-251F	4,100 hp	3,060 kW
		Total - Propulsion Engines		**6,119 kW**
LF-3	Generator	Cummins	170 kW	170 kW
LF-4	Generator	Cummins	170 kW	170 kW
		Total - Generator Engines		**340 kW**
LF-5	Emergency Generator	John Deere	70 kW	70 kW
LF-6	Hydraulic Bow Thruster	Cummins/KTA19	500 hp	373 kW
		Ocean Wind/Ocean Wave		
OW-1	Port Main Propulsion Engine	Caterpillar/C280-12	5,440 hp	4,060 kW
OW-2	Starboard Main Propulsion Engine	Caterpillar/C280-12	5,440 hp	4,060 kW
		Total - Propulsion Engines		**8,119 kW**
OW-3	Harbor Generator Engine	Caterpillar/C18	340 kW	340 kW
OW-4	Emergency Generator Engine	Caterpillar/C6.6	125 kW	125 kW
		Total - Generator Engines		**465 kW**

Table D-7. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Science Vessels and Offshore Support Vessels (OSV) Emission Unit Inventory

ID	Description	Make/Model	Maximum Rating/Capacity [1]	
		Sisuaq		
S-1	Port Outboard Main Engine	Cummins/QSK60DM 16	1,825 kW	1,825 kW
S-2	Port Inboard Main Engine	Cummins/QSK60DM 16	1,825 kW	1,825 kW
S-3	Starboard Inboard Main Engine	Cummins/QSK60DM 16	1,825 kW	1,825 kW
S-4	Starboard Outboard Main Engine	Cummins/QSK60DM 16	1,825 kW	1,825 kW
		Total - Propulsion and Generator Engines		**7,300 kW**
S-5	Emergency Generator	Cummins/6CTA 8.3-DM	125 kW	125 kW
		Total - Emergency Engines		**125 kW**
S-10	STBD. Air Comp M&I Cutting Silos	Cummins/94N14	450 hp	336 kW
S-11	PORT Air Comp M&I Cutting Silos	Cummins/94N14	450 hp	336 kW
		Total - Various Engines		**672 kW**
S-6	TranRec150 Power Pack	Cummins/6CTA 8.3 M	190 kW	190 kW
S-7	AFT-DOP 250 Power Pack	Cummins/6AT3.4-P93	98 hp	73 kW
S-8	FWD-DOP 250 Power Pack	Cummins/6AT3.4-P93	98 hp	73 kW
S-9	Ocean Buster Power Pack	Lombardini/Series 25LD 425/2	19 kW	19 kW
		Total - OSR Equipment		**355 kW**
S-12	Incinerator	Atlas/200 SWS	40 kg/hr	88 lb/hr
		Harvey Supporter		
	Port Outboard Main Engine	Cummins/QSK60DM 16	1,825 kW	1,825 kW
	Port Inboard Main Engine	Cummins/QSK60DM 16	1,825 kW	1,825 kW
	Starboard Inboard Main Engine	Cummins/QSK60DM 16	1,825 kW	1,825 kW
	Starboard Outboard Main Engine	Cummins/QSK60DM 16	1,825 kW	1,825 kW
		Total - Propulsion and Generator Engines		**7,300 kW**
	Emergency Generator	John Deere/6081 AFM75	125 kW	125 kW
		Total - Emergency Engines		**125 kW**
	TranRec150 Power Pack	Cummins/6CTA 8.3 M	190 kW	190 kW
	Power Pack	Lamor	80 kW	80 kW
		Total - OSR Equipment Engines		**270 kW**
	Incinerator	Atlas/200 SWS	40 kg/hr	88 lb/hr
		Harvey Explorer		
HE-1	Starboard Main Engine	Caterpillar/3516BDITA	2,260 hp	1,687 kW
HE-2	Port Main Engine	Caterpillar/3516BDITA	2,260 hp	1,687 kW
		Total - Propulsion Engines		**3,373 kW**
HE-3	Starboard Generator Engine	Caterpillar/3406CDITA	344 kW	344 kW
HE-4	Center Generator Engine	Caterpillar/3406CDITA	344 kW	344 kW
HE-5	Port Generator Engine	Caterpillar/3406CDITA	344 kW	344 kW
		Total - Generator Engines		**1,032 kW**
HE-7	Fwd/Port Bow Thruster	Caterpillar/3412	850 hp	634 kW
HE-8	Aft/Starboard Bow Thruster	Caterpillar/3412	850 hp	634 kW
HE-9	Stern Thruster	Caterpillar/3412EDITA	540 hp	403 kW
		Total - Thruster Engines		**1,672 kW**
HE-6	Emergency Generator Engine	Caterpillar/SR4	99 kW	99 kW
HE-10	FRC Outboard Engine	Mercury Mariner/40	40 hp	30 kW
HE-11	Portable Emergy Bilge Pump	Lambardini/15 LD 315	4.8 kW	5 kW
		Total - Emergency Engines		**134 kW**

Table D-8. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Oil Spill Response Vessels (OSRV) Emission Unit Inventory

ID	Description	Make/Model	Maximum Rating/Capacity [1]	
		Nanuq		
N-1	Propulsion Engine	Caterpillar/3608	2,710 kW	2,710 kW
N-2	Propulsion Engine	Caterpillar/3608	2,710 kW	2,710 kW
		Total - Propulsion Engines		**5,420 kW**
N-3	Electrical Generator Engine	Caterpillar/3508	1,285 hp	959 kW
N-4	Electrical Generator Engine	Caterpillar/3508	1,285 hp	959 kW
		Total - Generator Engines		**1,918 kW**
N-5	Emergency Generator	John Deere/6081AFM75	166 kW	166 kW
N-7	Lifeboat Propulsion Engine	Unknown	29 hp	22 kW
		Total - Emergency Engines		**188 kW**
N-8	Backpack Blower	Unknown	1 hp	1 kW
N-9	RubberMax Boom Power Pack	Elastec/Yanmar/3TNV70	16 kW	16 kW
N-10	RubberMax Boom Power Pack	Elastec/Yanmar/3TNV70	16 kW	16 kW
N-11	Power Pack	Lamor	80 kW	80 kW
N-12	Power Pack	Vikoma/GP10-2E	7 hp	5 kW
N-13	Fire Boom Power Pack	Elastec	7 hp	5 kW
N-14	Dispersant Pump		5 hp	4 kW
N-15	Water Pump	Elastec/Kubota/D722E	14 kW	14 kW
N-16	Water Pump	Elastec/Kubota/D722E	14 kW	14 kW
N-17	3" Pump	Diesel America West/Yanmar/L48V6	3.3 kW	3 kW
N-18	3" Pump	Diesel America West/Yanmar/L48V6	3.3 kW	3 kW
N-19	Portable Generator	Diesel America West	6 kW	6 kW
N-20	Pressure Washer	Diesel America West/Model 100	10 hp	7 kW
	TranRec150 Power Pack	Cummins/6CTA 8.3 M	190 kW	190 kW
		Total - OSR Equipment Engines		**365 kW**
N-6	Incinerator	ACS / CP100	125 lb/hr	125 lb/hr
		Kvichaks		
Kvichak No. 1 34-foot Oil Spill Response Work Boat				
OSRK1-1	Propulsion Engine	Cummins/QSB 5.9	300 hp	224 kW
OSRK1-2	Propulsion Engine	Cummins/QSB 5.9	300 hp	224 kW
OSRK1-3	Generator Engine	Northern Lights/M773LW3	12 hp	9 kW
Kvichak No. 2 34-foot Oil Spill Response Work Boat				
OSRK2-1	Propulsion Engine	Cummins/QSB 5.9	300 hp	224 kW
OSRK2-2	Propulsion Engine	Cummins/QSB 5.9	300 hp	224 kW
OSRK2-3	Generator Engine	Northern Lights/M773LW3	12 hp	9 kW
Kvichak No. 3 34-foot Oil Spill Response Work Boat				
OSRK3-1	Propulsion Engine	Cummins/QSB 5.9	300 hp	224 kW
OSRK3-2	Propulsion Engine	Cummins/QSB 5.9	300 hp	224 kW
OSRK3-3	Generator Engine	Northern Lights/M773LW3	12 hp	9 kW
		Total - OSRV Workboats Propulsion and Generator Engines		**1,370 kW**

Table D-9. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Oil Spill Response (OSR) Tug and Barge Emission Unit Inventory

ID	Description	Make/Model	Maximum Rating/Capacity [1]	
		OSR Tug - *Guardsman*		
	Main Engine	EMD/20-645-EG	3,600 hp	2,687 kW
	Main Engine	EMD/20-645-EG	3,600 hp	2,687 kW
		Total - Propulsion Engines		**5,373 kW**
	Generator Engine	Caterpillar/D3304	200 hp	149 kW
	Generator Engine	Caterpillar/D3304	200 hp	149 kW
		Total - Generator Engines		**299 kW**
		OSR Barge - *Klamath*		
	TranRec150 Power Pack	Cummins/6CTA 8.3 M	190 kW	190 kW
	TranRec150 Power Pack	Cummins/6CTA 8.3 M	190 kW	190 kW
	Generator Engine	John Deere/6081TF001C	151 kW	151 kW
	Generator Engine	Detroit Diesel/671	175 hp	131 kW
		Total - OSR Equipment Engines		**662 kW**

Table D-10. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Arctic Oil Storage Tanker Emission Unit Inventory

ID	Description	Make/Model	Maximum Rating/Capacity [1]	
		Affinity		
A-1	Propulsion Engine	STX MAN/B&W 7S60MD-C	15,820 kW	15,820 kW
A-2	Generator P Engine	STX MAN/B&W 7L23	1,120 kW	1,120 kW
A-3	Electrical C Engine	STX MAN/B&W 7L23	1,120 kW	1,120 kW
A-4	Generator S Engine	STX MAN/B&W 7L23	1,120 kW	1,120 kW
		Total - Propulsion and Generator Engines		**19,180 kW**
A-5	Emergency Generator	Cummins NT 855 D(M)	295 kW	295 kW
		Total - Emergency Engines		**295 kW**
A-6	Power Pack Engine	Cummins/KTA 19-M3	477 kW	477 kW
A-7	Power Pack Engine	Cummins/KTA 19-M3	477 kW	477 kW
A-8	Power Pack Engine	Cummins/KTA 19-M3	477 kW	477 kW
		Total - Various Engines		**1,431 kW**
A-9	Auxiliary Boiler	KANGRIM/MB07S01	25 t (steam)/hr	53 MMBtu/hr
A-10	Incinerator	Teamtec/OG 400	188 lb/hr	188 lb/hr

Table D-11. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
MLC ROV System Vessel Emission Unit Inventory

ID	Description	Make/Model	Maximum Rating/Capacity[1]	
		Harvey Spirit		
HS-1	Starboard Main Engine	GE/7FDM12	3,070 hp	2,291 kW
HS-2	Port Main Engine	GE/7FDM12	3,070 hp	2,291 kW
		Total - Propulsion Engines		**4,582 kW**
HS-3	Starboard Generator Engine	Cummins/KTA19-(M1)	480 kW	480 kW
HS-4	Center Generator Engine	Cummins/KTA19-(M1)	480 kW	480 kW
HS-5	Port Generator Engine	Cummins/KTA19-(M1)	480 kW	480 kW
		Total - Generator Engines		**1,440 kW**
HS-7	Starboard Bow Thruster	Cummins/KTA38-(M1)	1,250 hp	933 kW
HS-8	Port Bow Thruster	Cummins/KTA38-(M1)	1,250 hp	933 kW
HS-9	Stern Thruster	Cummins/KTA38-(M1)	1,250 hp	933 kW
		Total - Thruster Engines		**2,799 kW**
HS-6	Emergency Generator Engine	Cummins/6BTAA5.9-G1	99 kW	99 kW
	MLC ROV System Engine	Cummins/KTA50-G3	1,340 hp	1,000 kW

Tables D-2 through D-11 Notes:

[1] Conversion factors

1.34	hp/kW
2.20462	lb/kg
2204.6	lb/tonne
34.5	lb (steam)/Boiler hp-hour
33,446	Btu/Boiler hp-hour

[2] Diesel fuel energy

131,180	Btu/gal
0.13118	MMBtu/gal

Table D-12. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Support Vessels Proposed Annual Fuel Consumption

Category	Vessel	Annual Fuel Consumption [1]	
Ice Management	*Fennica* Propulsion and Generator Engines	15,300 bbl/year	642,600 gal/year
Ice Management	*Nordica* Propulsion and Generator Engines	15,000 bbl/year	630,000 gal/year
	Total - Ice Management Group	**30,300 bbl/year**	**1,272,600 gal/year**
Anchor Handler	*Aiviq*	34,286 bbl/year	1,440,012 gal/year
	Propulsion Engines	24,172 bbl/year	1,015,207 gal/year
	Generator Engines	10,114 bbl/year	424,805 gal/year
Anchor Handler	*Tor Viking*	13,500 bbl/year	567,000 gal/year
	Propulsion Engines	12,565 bbl/year	527,734 gal/year
	Generator Engines	935 bbl/year	39,266 gal/year
Anchor Handler	*Ross Chouest* Propulsion and Generator Engines	10,000 bbl/year	420,000 gal/year
Science Vessel	*Harvey Supporter* Propulsion and Generator Engines	6,500 bbl/year	273,000 gal/year
Science Vessel	*Harvey Explorer* Propulsion and Generator Engines	6,500 bbl/year	273,000 gal/year
Offshore Supply Vessel	*Sisuaq* Propulsion and Generator Engines	2,806 bbl/year	117,852 gal/year
Offshore Supply Vessel	*Harvey Supporter* Propulsion and Generator Engines	2,806 bbl/year	117,852 gal/year
	Total - OSV Group	**18,612 bbl/year**	**781,704 gal/year**
Support Tug	*Lauren Foss* Propulsion Engines	2,294 bbl/year	96,348 gal/year
Support Tug	*Ocean Wind* Propulsion Engines	9,520 bbl/year	399,840 gal/year
Support Tug	*Ocean Wave P* ropulsion Engines	9,520 bbl/year	399,840 gal/year
Oil Spill Response Vessel	*Nanuq* Propulsion Engines	12,000 bbl/year	504,000 gal/year
Offshore Oil Spill Response Tug/Barge	*Guardsman/Klamath* Propulsion Engines	3,675 bbl/year	154,350 gal/year
Arctic Oil Storage Tanker	*Affinity* Propulsion and Generator Engines	7,700 bbl/year	323,400 gal/year
MLC ROV System Vessel	*Harvey Spirit* Propulsion Engines	2,650 bbl/year	111,300 gal/year

Notes:

[1] Conversion factors

42 US gallons/oil barrel

Table D-13. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Summary of Emission Reductions Applied

Category	Vessel	Reductions Applied	Emission Reduction	
		AQRP EI	Fuel [1]	SO_2 [2]
All	All Vessels	ULSD	N/A	97%
Ice Management	*Fennica* Propulsion and Generator Engines	Fuel, ULSD	81%	97%
Ice Management	*Nordica* Propulsion and Generator Engines	Fuel, ULSD	82%	97%
Anchor Handler	*Aiviq* Propulsion Engines	Fuel, ULSD	62%	97%
	Aiviq Generator Engines	Fuel, ULSD	62%	97%
Anchor Handler	*Tor Viking* Propulsion Engines	Fuel, ULSD	76%	97%
	Tor Viking Generator Engines	Fuel, ULSD	76%	97%
Anchor Handler	*Ross Chouest* Propulsion and Generator Engines	Fuel, ULSD	80%	97%
Science Vessel	*Harvey Supporter* Propulsion and Generator Engines	Fuel, ULSD	77%	97%
Science Vessel	*Harvey Explorer* Propulsion and Generator Engines	Fuel, ULSD	51%	97%
Offshore Supply Vessel	*Sisuaq* Propulsion and Generator Engines	Fuel, ULSD	90%	97%
Offshore Supply Vessel	*Harvey Supporter* Propulsion and Generator Engines	Fuel, ULSD	90%	97%
Support Tug	*Lauren Foss* Propulsion Engines	Fuel, ULSD	90%	97%
Support Tug	*Ocean Wind* Propulsion Engines	Fuel, ULSD	70%	97%
Support Tug	*Ocean Wave P* ropulsion Engines	Fuel, ULSD	70%	97%
Oil Spill Response Vessel	*Nanuq* Propulsion Engines	Fuel, ULSD	44%	97%
Offshore Oil Spill Response Tug/Barge	*Guardsman/Klamath* Propulsion Engines	Fuel, ULSD	83%	97%
Arctic Oil Storage Tanker	*Affinity* Propulsion and Generator Engines	Fuel, ULSD	90%	97%
MLC ROV System Vessel	*Harvey Spirit* Propulsion Engines	Fuel, ULSD	85%	97%

Notes:

[1] Fuel reduction is estimated based on the vessel emissions units fuel potential as calculated in Table D-13a (below)

[2] ULSD=Ultra Low Sulfur Diesel   Sulfur content: 15 ppm

LSD=Low Sulfur Diesel   Sulfur content: 500 ppm

Table D-13a. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Summary of Fuel Potential for Support Vessels with a Proposed Annual Fuel Consumption

Category	Vessel	Maximum Aggregate Rating [1]		Proposed Annual Fuel gal/year	Fuel Potential [2, 3, 4] gal/year	Reduction
Ice Management	*Fennica* Propulsion and Generator Engines	16,800	kW	642,600	3,459,688	81%
Ice Management	*Nordica* Propulsion and Generator Engines	16,800	kW	630,000	3,459,688	82%
Anchor Handler	*Aiviq* Propulsion Engines	13,001	kW	1,015,207	2,677,263	62%
	Aiviq Generator Engines	5,440	kW	424,805	1,120,280	62%
Anchor Handler	*Tor Viking* Propulsion Engines	10,752	kW	527,734	2,214,201	76%
	Tor Viking Generator Engines	800	kW	39,266	164,747	76%
Anchor Handler	*Ross Chouest* Propulsion and Generator Engines	10,023	kW	420,000	2,064,133	80%
Science Vessel	*Harvey Supporter* Propulsion and Generator Engines	5,840	kW	273,000	1,202,654	77%
Science Vessel	*Harvey Explorer* Propulsion and Generator Engines	2,699	kW	273,000	555,714	51%
Offshore Supply Vessel	*Sisuaq* Propulsion and Generator Engines	5,840	kW	117,852	1,202,654	90%
Offshore Supply Vessel	*Harvey Supporter* Propulsion and Generator Engines	5,840	kW	117,852	1,202,654	90%
Support Tug	*Lauren Foss* Propulsion Engines	4,896	kW	96,348	1,008,154	90%
Support Tug	*Ocean Wind* Propulsion Engines	6,496	kW	399,840	1,337,648	70%
Support Tug	*Ocean Wave P* ropulsion Engines	6,496	kW	399,840	1,337,648	70%
Oil Spill Response Vessel	*Nanuq* Propulsion Engines	4,336	kW	504,000	892,929	44%
Offshore Oil Spill Response Tug/Barge	*Guardsman/Klamath* Propulsion Engines	4,299	kW	154,350	885,208	83%
Arctic Oil Storage Tanker	*Affinity* Propulsion and Generator Engines	15,344	kW	323,400	3,159,849	90%
MLC ROV System Vessel	*Harvey Spirit* Propulsion Engines	3,666	kW	111,300	754,886	85%

Notes:

[1] Maximum Aggregate Rating is adjusted to account for Short-Term Maximum Load.

Short-term Maximum Load: 80%

[2] Conversion factors

1.34 hp/kW

120 day/year

24 hr/day

[3] Diesel fuel energy   131,180 Btu/gal

[4] Engine heat rate   7,000 Btu/hp-hr

Table D-14. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Aircraft Emission Unit Inventory

Description	Aircraft Type	EDMS Aircraft Used
Crew Change Helicopters	(3) S-92, EC225 or similar	Sikorsky S-76 Spirit
Search and Rescue (SAR) Helicopter	(1) S-92, EC225 or similar	Sikorsky S-76 Spirit
Crew Transport Fixed-wing Aircraft	(1) Saab 340 B, Beechcraft 1900, Dash 9 or similar	Saab 340-B
PSO Fixed-wing Aircraft	(1) Gulfstream AeroCommander 690 or similar	Rockwell Commander 690
Ice Reconnaissance Fixed-wing Aircraft	(1) Gulfstream AeroCommander 690 or similar	Rockwell Commander 690

Table D-15. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Hangar/Storage Building Emission Unit Inventory

Description	Make/Model	Maximum Rating/Capacity
Natural Gas Boiler	Unknown	5 MMBtu/hr

Table D-16. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
NARL Camp Emission Unit Inventory

Description	Make/Model	Maximum Rating/Capacity [1]	
Primary Generator Engine	John Deere/6135HF485	448 kW	448 kW
Backup Generator Engine	John Deere/6135HF485	448 kW	448 kW
K/D/R Generator Engine	Caterpillar/3412CDITA	1,081 hp	807 kW

[1] Conversion factors

1.34 hp/kW

Table D-17. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Vehicle Emission Unit Inventory

Description
Diesel Fuel - Passenger Truck (Model Year 2012)

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)		
Discoverer - Generator Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate is:		
		5.9	g/kW-hr
Discoverer - Propulsion Engine	Based on vendor data from STX, the emission rate used is:		
		14.2	g/kW-hr (IMO Annex VI, Tier 2)
		5.9	
Discoverer - HPU Engines	Based on separate source tests, the average emission rate is:		
	FD-12 at 70% Load	2.79	g/kW-hr (TRC Test Report, 7/27/12)
	FD-12 at 98% Load	3.88	g/kW-hr (TRC Test Report, 7/27/12)
	FD-13 at 70% Load	2.54	g/kW-hr (TRC Test Report, 7/27/12)
	FD-13 at 98% Load	2.95	g/kW-hr (TRC Test Report, 7/27/12)
	Average	3.04	g/kW-hr
Discoverer - Cranes	Based on vendor data from Liebherr, the emission rate used is:		
		3.6	g/kW-hr
Discoverer - Cementing Engines	Based on separate source tests, the average emission rate is:		
	FD-16 at 68% load	13.15	g/kW-hr (TRC Test Report, 7/27/12)
	FD-16 at 87% load	13.26	g/kW-hr (TRC Test Report, 7/27/12)
	FD-17 at 67% load	11.66	g/kW-hr (TRC Test Report, 7/27/12)
	FD-17 at 86% load	12.42	g/kW-hr (TRC Test Report, 7/27/12)
	Average	12.6	g/kW-hr
Discoverer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is:		
		4.0	g/kW-hr (EPA Tier 3)
Discoverer - Compressor Engine	Based on vendor data from Detroit, the emission rate used is:		
		1,550	g/hr
		14.8	g/kW-hr
Discoverer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is:		
		7.5	g/kW-hr (EPA Tier 2)
Discoverer - Emergency Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is:		
		0.024	lb/hp-hr
		14.6	g/kW-hr
Discoverer - Lifeboat Engines	Based on Table 3.3-1, AP-42, the emission rate used is:		
		0.031	lb/hp-hr
		18.8	g/kW-hr
Discoverer - Boilers	Based on separate source tests, the average emission rate used is:		
	FD-21 at 50% load	0.0201	lb/gal (Avogadro Test Report, 7/27/12)
	FD-21 at 100% load	0.0230	lb/gal (Avogadro Test Report, 7/27/12)
	FD-22 at 50% load	0.0186	lb/gal (Avogadro Test Report, 7/27/12)
	FD-22 at 100% load	0.0214	lb/gal (Avogadro Test Report, 7/27/12)
	Average	20.8	lb/kgal
Discoverer - Incinerator	Based on results of source tests for the incinerator, the emission rate used is:		
	FD-23 at 100% load	3.18	lb/ton (Avogadro Test Report, 7/27/12)

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)
Polar Pioneer - Generator Engines	Based on results of source tests, the average emission rate used is: Average 11.35 g/kW-hr (Ecoxy AS Test Report, 2/14/14)
Polar Pioneer - HPU Engines	Based on separate source tests, the average emission rate used is: FD-12 at 70% Load 2.79 g/kW-hr (TRC Test Report, 7/27/12) FD-12 at 98% Load 3.88 g/kW-hr (TRC Test Report, 7/27/12) FD-13 at 70% Load 2.54 g/kW-hr (TRC Test Report, 7/27/12) FD-13 at 98% Load 2.95 g/kW-hr (TRC Test Report, 7/27/12) Average 3.04 g/kW-hr
Polar Pioneer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is: 4.0 g/kW-hr (EPA Tier 3)
Polar Pioneer - Compressor Engine	Based on vendor data from Detroit, the emission rate used is: 1,550 g/hr 14.8 g/kW-hr
Polar Pioneer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is: 7.5 g/kW-hr (EPA Tier 2)
Polar Pioneer - Emergency Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.024 lb/hp-hr 14.6 g/kW-hr
Polar Pioneer - Small Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr
Polar Pioneer - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 20 lb/kgal Distillate oil fired
Polar Pioneer - Incinerator	Based on Table 2.1-9, AP-42, the emission rate used is: Modular Starved Air Combustors 3.16 lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)
Fennica - Propulsion and Generator Engines	Based on separate source tests, the average uncontrolled emission rate used is: F-3/4 at 35% load 0.0233 lb/kW-hr (AST Test Report, 6/28/07) F-3/4 at 57% load 0.0191 lb/kW-hr (AST Test Report, 6/28/07) F-3/4 at 80% load 0.0201 lb/kW-hr (AST Test Report, 6/28/07) Average 0.0208 lb/kW-hr 9.45 g/kW-hr
Fennica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.024 lb/hp-hr 14.6 g/kW-hr
Fennica - Boilers	Based on separate source tests, the average emission rate used is: Fennica F-5 at 100% load 0.01562 lb/gal (TRC Test Report, 8/9/12) Fennica F-6 at 100% load 0.01641 lb/gal (TRC Test Report, 8/9/12) Average 16.0 lb/kgal
Fennica - Incinerator	Based on source tests, the emission rate used is: Fennica F-7 at 100% load 7.133 lb/ton (TRC Test Report, 8/9/12)
Fennica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)
Nordica - Propulsion and Generator Engines	Based on separate source tests, the average uncontrolled emission rate used is: F-3/4 at 35% load 0.0233 lb/kW-hr (AST Test Report, 6/28/07) F-3/4 at 57% load 0.0191 lb/kW-hr (AST Test Report, 6/28/07) F-3/4 at 80% load 0.0201 lb/kW-hr (AST Test Report, 6/28/07) Average 0.0208 lb/kW-hr 9.45 g/kW-hr
Nordica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.024 lb/hp-hr 14.6 g/kW-hr
Nordica - Boilers	Based on separate source tests, the average emission rate used is: Nd-5 at 100% load 0.02016 lb/gal (TRC Test Report, 8/9/12) Nd-6 at 100% load 0.02056 lb/gal (TRC Test Report, 8/9/12) Average 20.4 lb/kgal
Nordica - Incinerator	Based on source tests, the average emission rate used is: Nd-7 at 100% load 1.82 lb/ton (TRC Test Report, 8/9/12)
Nordica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)
Aiviq - Propulsion Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate used is: 8.09 g/kW-hr
Aiviq - Generator Engines	Based on vendor data from CleanAir Systems, the uncontrolled emission rate used is: 5.66 g/bhp-hr 7.6 g/kW-hr
Aiviq - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu, 20 lb/kgal Distillate oil fired
Aiviq - Incinerator	Based on source tests, the emission rate used is: Av-10 at 100% load 4.07 lb/ton (TRC Test Report, 8/9/12)
Aiviq - Emergency Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.024 lb/hp-hr 14.6 g/kW-hr
Aiviq -Rescue & Lifeboat Engines & OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)
Tor Viking - Propulsion Engines	Based on separate source tests, the average uncontrolled emission rate used is: TV-2 at 35% load 1.756 lb/MMBtu (TRC Test Report, 7/12/07) TV-2 at 57% load 2.004 lb/MMBtu (TRC Test Report, 7/12/07) TV-2 at 80% load 2.045 lb/MMBtu (TRC Test Report, 7/12/07) Average 1.935 lb/MMBtu 8.23 g/kW-hr [2]
Tor Viking - Generator Engines	Based on separate source tests, the average uncontrolled emission rate used is: TV-5 at 35% load 0.0266 lb/kW-hr (TRC Test Report, 7/12/07) TV-5 at 57% load 0.0205 lb/kW-hr (TRC Test Report, 7/12/07) TV-5 at 80% load 0.0178 lb/kW-hr (TRC Test Report, 7/12/07) Average 0.0216 lb/kW-hr 9.81 g/kW-hr
Tor Viking - Boilers	Based on source tests, the average emission rate used is: TV-7 at 100% load 0.01505 lb/gal (TRC Test Report, 8/9/12) 15.05 lb/kgal
Tor Viking - Emergency Generator Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr
Ross Chouest - Propulsion and Generator Engines, and Various Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.024 lb/hp-hr 14.6 g/kW-hr
Ross Chouest - Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)		
Sisuaq and *Harvey Supporter* - Propulsion and Generator Engines	Based on separate source tests, the average emission rate used is:		
	S-1 at 40% load	0.01868	lb/kWe-hr (TRC Test Report 8/9/12)
	S-1 at 65% load	0.01406	lb/kWe-hr (TRC Test Report 8/9/12)
	S-1 at 95% load	0.01588	lb/kWe-hr (TRC Test Report 8/9/12)
	S-2 at 40% load	0.01754	lb/kWe-hr (TRC Test Report 8/9/12)
	S-2 at 65% load	0.01484	lb/kWe-hr (TRC Test Report 8/9/12)
	S-2 at 95% load	0.01578	lb/kWe-hr (TRC Test Report 8/9/12)
	S-3 at 40% load	0.01444	lb/kWe-hr (TRC Test Report 8/9/12)
	S-3 at 65% load	0.01332	lb/kWe-hr (TRC Test Report 8/9/12)
	S-3 at 95% load	0.01539	lb/kWe-hr (TRC Test Report 8/9/12)
	S-4 at 40% load	0.01505	lb/kWe-hr (TRC Test Report 8/9/12)
	S-4 at 65% load	0.01207	lb/kWe-hr (TRC Test Report 8/9/12)
	S-4 at 95% load	0.01109	lb/kWe-hr (TRC Test Report 8/9/12)
	Average	0.014845	lb/kWe-hr
	95% conversion [3]	1.56E-02	lb/kW-hr
		7.088	g/kW-hr
Sisuaq, Harvey Supporter and Harvey Explorer - Various Engines, Emergency Engines, and OSR	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is:		
		0.031	lb/hp-hr
		18.8	g/kW-hr
Sisuaq and *Harvey Supporter* - Incinerators	Based on Table 2.1-9, AP-42, the emission rate used is:		
	Modular Starved Air Combustors	3.16	lb/ton
Harvey Explorer - Propulsion Engines	Based on separate source tests, the average emission rate used is:		
	HE-1 at 20% load	0.04838	lb/kW-hr (TRC Test Report 8/9/12)
	HE-1 at 40% load	0.01368	lb/kW-hr (TRC Test Report 8/9/12)
	HE-1 at 60% load	0.01604	lb/kW-hr (TRC Test Report 8/9/12)
	HE-1 at 80% load	0.01521	lb/kW-hr (TRC Test Report 8/9/12)
	HE-2 at 20% load	0.02910	lb/kW-hr (TRC Test Report 8/9/12)
	HE-2 at 40% load	0.01607	lb/kW-hr (TRC Test Report 8/9/12)
	HE-2 at 60% load	0.01450	lb/kW-hr (TRC Test Report 8/9/12)
	HE-2 at 80% load	0.01435	lb/kW-hr (TRC Test Report 8/9/12)
	Average	0.02092	lb/kW-hr
		9.5	g/kW-hr
Harvey Explorer - Generator Engines	Based on separate source tests, the average emission rate used is:		
	HE-3 at 50% load	0.01060	lb/kWe-hr (TRC Test Report 8/9/12)
	HE-3 at 100% load	0.008343	lb/kWe-hr (TRC Test Report 8/9/12)
	HE-4 at 50% load	0.02020	lb/kWe-hr (TRC Test Report 8/9/12)
	HE-4 at 100% load	0.01295	lb/kWe-hr (TRC Test Report 8/9/12)
	HE-5 at 50% load	0.02574	lb/kWe-hr (TRC Test Report 8/9/12)
	HE-5 at 100% load	0.01807	lb/kWe-hr (TRC Test Report 8/9/12)
	Average	0.01598	lb/kWe-hr
	95% conversion [3]	1.68E-02	lb/kW-hr
		7.6	g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)
Harvey Explorer - Thruster Engines	Based on separate source tests, the average emission rate used is: HE-7 at 20% load 0.007453 lb/kW-hr (TRC Test Report 8/9/12) HE-7 at 40% load 0.002579 lb/kW-hr (TRC Test Report 8/9/12) HE-7 at 60% load 0.005185 lb/kW-hr (TRC Test Report 8/9/12) HE-7 at 80% load 0.008900 lb/kW-hr (TRC Test Report 8/9/12) HE-8 at 20% load 0.01075 lb/kW-hr (TRC Test Report 8/9/12) HE-8 at 40% load 0.005236 lb/kW-hr (TRC Test Report 8/9/12) HE-8 at 60% load 0.004482 lb/kW-hr (TRC Test Report 8/9/12) HE-8 at 80% load 0.005818 lb/kW-hr (TRC Test Report 8/9/12) HE-9 at 20% load 0.01607 lb/kW-hr (TRC Test Report 8/9/12) HE-9 at 40% load 0.009093 lb/kW-hr (TRC Test Report 8/9/12) HE-9 at 60% load 0.01775 lb/kW-hr (TRC Test Report 8/9/12) HE-9 at 80% load 0.02335 lb/kW-hr (TRC Test Report 8/9/12) Average 0.00972 lb/kW-hr 4.4 g/kW-hr
Harvey Explorer - Emergency Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr
Nanuq - Propulsion Engines	Based on separate source tests, the average emission rate used is: N-1 at 25% load 0.01712 lb/kW-hr (TRC Test Report, 7/26/12) N-1 at 50% load 0.01534 lb/kW-hr (TRC Test Report, 7/26/12) N-1 at 75% load 0.01525 lb/kW-hr (TRC Test Report, 7/26/12) N-1 at 100% load 0.01503 lb/kW-hr (TRC Test Report, 7/26/12) N-2 at 25% load 0.01707 lb/kW-hr (TRC Test Report, 7/26/12) N-2 at 50% load 0.01534 lb/kW-hr (TRC Test Report, 7/26/12) N-2 at 75% load 0.01659 lb/kW-hr (TRC Test Report, 7/26/12) N-2 at 100% load 0.01586 lb/kW-hr (TRC Test Report, 7/26/12) Average 0.016 lb/kW-hr 7.23 g/kW-hr
Nanuq - Generator Engines	Based on separate source tests, the average emission rate used is: N-3 at 50% load 0.02004 lb/kWe-hr (TRC Test Report, 7/26/12) N-3 at 100% load 0.02837 lb/kWe-hr (TRC Test Report, 7/26/12) N-4 at 50% load 0.01899 lb/kWe-hr (TRC Test Report, 7/26/12) N-4 at 100% load 0.02417 lb/kWe-hr (TRC Test Report, 7/26/12) Average 2.29E-02 lb/kWe-hr 95% conversion [3] 2.41E-02 lb/kW-hr 10.93 g/kW-hr
Nanuq - Various Engines and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr
Nanuq - Incinerators	Based on Table 2.1-9, AP-42, the emission rate used is: Modular Starved Air Combustors 3.16 lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)
Kvickaks - Propulsion and Generator Engines	Based on separate source tests, the average emission rate used is: OSRK1-1 at 30% load 0.00495 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-1 at 60% load 0.00956 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-1 at 90% load 0.02129 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 30% load 0.00555 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 60% load 0.00745 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 90% load 0.02030 lb/kW-hr (TRC Test Report, 8/9/12) Average 0.012 lb/kW-hr 5.22 g/kW-hr
Guardsman/Klamath - Propulsion Engines	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.024 lb/hp-hr 14.6 g/kW-hr
Guardsman/Klamath - Generator Engines, Various Engines, and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr
Affinity - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.024 lb/hp-hr 14.6 g/kW-hr
Affinity - Emergency Engines & Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr
Affinity - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 20 lb/kgal Distillate oil fired
Affinity - Incinerators	Based on Table 2.1-9, AP-42, the emission rate used is: Modular Starved Air Combustors 3.16 lb/ton
Lauren Foss - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.024 lb/hp-hr 14.6 g/kW-hr
Lauren Foss - Generator Engines, Emergency Generator Engine, Thruster Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr
Ocean Wind & Ocean Wave - Propulsion Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate used is: 8.09 g/kW-hr
Ocean Wind & Ocean Wave - Generator Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.031 lb/hp-hr 18.8 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Oxides of Nitrogen (NO_X)			
Harvey Spirit - Propulsion Engines	Based on separate source tests, the average emission rate used is:			
	HS-1 at 20% load		0.02910	lb/kW-hr (TRC Test Report 8/9/12)
	HS-1 at 40% load		0.01363	lb/kW-hr (TRC Test Report 8/9/12)
	HS-1 at 60% load		0.01581	lb/kW-hr (TRC Test Report 8/9/12)
	HS-1 at 80% load		0.01498	lb/kW-hr (TRC Test Report 8/9/12)
	HS-2 at 20% load		0.1004	lb/kW-hr (TRC Test Report 8/9/12)
	HS-2 at 40% load		0.05618	lb/kW-hr (TRC Test Report 8/9/12)
	HS-2 at 60% load		0.03699	lb/kW-hr (TRC Test Report 8/9/12)
	HS-2 at 80% load		0.03024	lb/kW-hr (TRC Test Report 8/9/12)
		Average	0.03717	lb/kW-hr
			16.9	g/kW-hr
Harvey Spirit - Generator Engines	Based on separate source tests, the average emission rate used is:			
	HS-3 at 50% load		0.02472	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-3 at 100% load		0.03172	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-4 at 50% load		0.02263	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-4 at 100% load		0.02797	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-5 at 50% load		0.02161	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-5 at 100% load		0.02466	lb/kWe-hr (TRC Test Report 8/9/12)
		Average	0.02555	lb/kWe-hr
		95% conversion [3]	2.69E-02	lb/kW-hr
			12.200	g/kW-hr
Harvey Spirit - Thruster Engines	Based on separate source tests, the average emission rate used is:			
	HS-7 at 20% load		0.008804	lb/kW-hr (TRC Test Report 8/9/12)
	HS-7 at 40% load		0.008972	lb/kW-hr (TRC Test Report 8/9/12)
	HS-7 at 60% load		0.01041	lb/kW-hr (TRC Test Report 8/9/12)
	HS-7 at 80% load		0.01547	lb/kW-hr (TRC Test Report 8/9/12)
	HS-8 at 20% load		0.009992	lb/kW-hr (TRC Test Report 8/9/12)
	HS-8 at 40% load		0.01024	lb/kW-hr (TRC Test Report 8/9/12)
	HS-8 at 60% load		0.01356	lb/kW-hr (TRC Test Report 8/9/12)
	HS-8 at 80% load		0.01512	lb/kW-hr (TRC Test Report 8/9/12)
	HS-9 at 20% load		0.009633	lb/kW-hr (TRC Test Report 8/9/12)
	HS-9 at 40% load		0.01216	lb/kW-hr (TRC Test Report 8/9/12)
	HS-9 at 60% load		0.01170	lb/kW-hr (TRC Test Report 8/9/12)
	HS-9 at 80% load		0.01498	lb/kW-hr (TRC Test Report 8/9/12)
		Average	0.01175	lb/kW-hr
			5.3	g/kW-hr
Harvey Spirit - Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is:			
			0.031	lb/hp-hr
			18.8	g/kW-hr
Harvey Spirit - MLC ROV System Engine	Based on Cummins vendor data, the emission rate used is:			
			9.7	g/hp-hr
			13.0	g/kW-hr
Camp - KDR Generator Engine	Based on vendor data from Caterpillar, the uncontrolled emission rate is:			
			1,081	hp
			14.14	lb/hr
			7.95	g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)
Discoverer - Generator Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate is: 1.3 g/kW-hr
Discoverer - Propulsion Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Discoverer - HPU Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Discoverer - Cranes	Based on vendor data from Liebherr, the emission rate used is: 0.55 g/kW-hr
Discoverer - Cementing Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Discoverer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is: 3.5 g/kW-hr (EPA Tier 3)
Discoverer - Compressor Engine	Based on vendor data from Detroit, the emission rate used is: 1,030 g/hr 9.9 g/kW-hr
Discoverer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is: 5.0 g/kW-hr (EPA Tier 2)
Discoverer - Emergency Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Discoverer - Lifeboat Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Discoverer - Boilers	Based on separate source tests, the average emission rate used is: FD-21 at 50% load 0.0011 lb/gal (Avogadro Test Report, 7/27/12) FD-21 at 100% load 0.0025 lb/gal (Avogadro Test Report, 7/27/12) FD-22 at 50% load 0.0012 lb/gal (Avogadro Test Report, 7/27/12) FD-22 at 100% load 0.0047 lb/gal (Avogadro Test Report, 7/27/12) Average 2.4 lb/kgal
Discoverer - Incinerator	Based on source tests for the incinerator, the emission rate used is: FD-23 at 100% load 10.8 lb/ton (Avogadro Test Report, 7/27/12)

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)
Polar Pioneer - Generator Engines	Based on results of source tests, the average emission rate used is: Average 1.42 g/kW-hr (Ecoxy AS Test Report, 2/14/14)
Polar Pioneer - HPU Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Polar Pioneer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is: 3.5 g/kW-hr (EPA Tier 3)
Polar Pioneer - Compressor Engine	Based on vendor data from Detroit, the emission rate used is: 1,030 g/hr 9.9 g/kW-hr
Polar Pioneer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is: 5.0 g/kW-hr (EPA Tier 2)
Polar Pioneer - Emergency Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Polar Pioneer - Small Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Polar Pioneer - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 5.0 lb/kgal Distillate oil fired
Polar Pioneer - Incinerator	Based on Table 2.1-9, AP-42, the emission rate used is: Modular Starved Air Combustors 0.299 lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)		
Fennica - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is:		
		0.0055	lb/hp-hr
		3.3	g/kW-hr
Fennica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is:		
		0.0055	lb/hp-hr
		3.3	g/kW-hr
Fennica - Boilers	Based on separate source tests, the average emission rate used is:		
	Fennica F-5 at 100% load	0.000647	lb/gal (TRC Test Report, 8/9/12)
	Fennica F-6 at 100% load	0.000139	lb/gal (TRC Test Report, 8/9/12)
	Average	0.4	lb/kgal
Fennica - Incinerator	Based on source tests, the emission rate used is:		
	Fennica F-7 at 100% load	29.92	lb/ton (TRC Test Report, 8/9/12)
Fennica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is:		
		0.0068	lb/hp-hr
		4.1	g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)
Nordica - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Nordica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Nordica - Boilers	Based on separate source tests, the average emission rate used is: Nordica Nd-5 at 100% load 0.00010 lb/gal (TRC Test Report, 8/9/12) Nordica Nd-6 at 100% load 0.00004 lb/gal (TRC Test Report, 8/9/12) Average 0.072 lb/kgal
Nordica - Incinerator	Based on source tests, the average emission rate used is: Nordica Nd-7 at 100% load 3.74 lb/ton (TRC Test Report, 8/9/12)
Nordica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)
Aiviq - Propulsion Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate used is: 0.51 g/kW-hr
Aiviq - Generator Engines	Based on Vendor Data from CleanAir Systems, the uncontrolled emission rate used is: 1.29 g/bhp-hr 1.7 g/kW-hr
Aiviq - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu, 5.0 lb/kgal Distillate oil fired
Aiviq - Incinerator	Based on source tests, the emission rate used is: Av-10 at 100% load 11.13 lb/ton (TRC Test Report, 8/9/12)
Aiviq - Emergency Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Aiviq -Rescue & Lifeboat Engines & OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)
Tor Viking - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Tor Viking - Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Tor Viking - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu, 5.0 lb/kgal Distillate oil fired
Tor Viking - Emergency Generator Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Ross Chouest - Propulsion and Generator Engines, and Various Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Ross Chouest - Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)
Sisuaq and *Harvey Supporter* - Propulsion and Generator Engines	Based on separate source tests, the average emission rate used is: S-1 at 40% load 0.007348 lb/kWe-hr (TRC Test Report 8/9/12) S-1 at 65% load 0.0005417 lb/kWe-hr (TRC Test Report 8/9/12) S-1 at 95% load 0.0004214 lb/kWe-hr (TRC Test Report 8/9/12) S-2 at 40% load 0.006487 lb/kWe-hr (TRC Test Report 8/9/12) S-2 at 65% load 0.0006352 lb/kWe-hr (TRC Test Report 8/9/12) S-2 at 95% load 0.0004838 lb/kWe-hr (TRC Test Report 8/9/12) S-3 at 40% load 0.006040 lb/kWe-hr (TRC Test Report 8/9/12) S-3 at 65% load 0.0006666 lb/kWe-hr (TRC Test Report 8/9/12) S-3 at 95% load 0.0004039 lb/kWe-hr (TRC Test Report 8/9/12) S-4 at 40% load 0.006563 lb/kWe-hr (TRC Test Report 8/9/12) S-4 at 65% load 0.0007026 lb/kWe-hr (TRC Test Report 8/9/12) S-4 at 95% load 0.0003690 lb/kWe-hr (TRC Test Report 8/9/12) Average 0.0025552 lb/kWe-hr 95% conversion [3] 2.69E-03 lb/kW-hr 1.220 g/kW-hr
Sisuaq, Harvey Supporter and Harvey Explorer - Various Engines, Emergency Engines, and OSR	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Sisuaq and *Harvey Supporter* - Incinerators	Based on Table 2.1-9, AP-42, the emission rate used is: Modular Starved Air Combustors 0.299 lb/ton
Harvey Explorer - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Harvey Explorer - Generator Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)
Harvey Explorer - Thruster Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Harvey Explorer - Emergency Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Nanuq - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Nanuq - Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Nanuq - Various Engines and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Nanuq - Incinerators	Based on Table 2.1-9, AP-42, the emission rate used is: Modular Starved Air Combustors 0.299 lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)
Kvickaks - Propulsion and Generator Engines	Based on separate source tests, the average emission rate used is: OSRK1-1 at 30% load 0.00113 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-1 at 60% load 0.00421 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-1 at 90% load 0.00328 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 30% load 0.00107 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 60% load 0.00386 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 90% load 0.00686 lb/kW-hr (TRC Test Report, 8/9/12) Average 0.003 lb/kW-hr 1.54 g/kW-hr
Guardsman/Klamath - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Guardsman/Klamath - Generator Engines, Various Engines, and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Affinity - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Affinity - Emergency Engines & Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Affinity - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 5.0 lb/kgal Distillate oil fired
Affinity - Incinerators	Based on Table 2.1-9, AP-42, the emission rate used is: Modular Starved Air Combustors 0.299 lb/ton
Lauren Foss - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Lauren Foss - Generator Engines, Emergency Generator Engine, Thruster Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Ocean Wind & Ocean Wave - Propulsion Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate used is: 0.51 g/kW-hr
Ocean Wind & *Ocean Wave* - Generator Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Carbon Monoxide (CO)
Harvey Spirit - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Harvey Spirit - Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Harvey Spirit - Thruster Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0055 lb/hp-hr 3.3 g/kW-hr
Harvey Spirit - Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0068 lb/hp-hr 4.1 g/kW-hr
Harvey Spirit - MLC ROV System Engine	Based on Cummins vendor data, the emission rate used is: 0.5 g/hp-hr 0.67 g/kW-hr
Camp - KDR Generator Engine	Based on vendor data from Caterpillar, the uncontrolled emission rate is: 1,081 hp 1.61 lb/hr 0.91 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter (PM_{10})
Discoverer - Generator Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate is: 0.16 g/kW-hr
Discoverer - Propulsion Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Discoverer - HPU Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Discoverer - Cranes	Based on vendor data from Liebherr, the emission rate used is: 0.106 g/kW-hr
Discoverer - Cementing Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Discoverer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is: 0.2 g/kW-hr (EPA Tier 3)
Discoverer - Compressor Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Discoverer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is: 0.4 g/kW-hr (EPA Tier 2)
Discoverer - Emergency Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Discoverer - Lifeboat Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Discoverer - Boilers	Based on separate source tests, the average emission rate used is: FD-21 at 50% load 0.0002 lb/gal (Avogadro Test Report, 7/27/12) FD-21 at 100% load 0.0004 lb/gal (Avogadro Test Report, 7/27/12) FD-22 at 50% load 0.0002 lb/gal (Avogadro Test Report, 7/27/12) FD-22 at 100% load 0.0004 lb/gal (Avogadro Test Report, 7/27/12) Average 0.30 lb/kgal
Discoverer - Incinerator	Based on source tests for the incinerator, the emission rate used is: FD-23 at 100% load 6.94 lb/ton (Avogadro Test Report, 7/27/12)

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter (PM_{10})
Polar Pioneer - Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Polar Pioneer - HPU Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Polar Pioneer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is: 0.2 g/kW-hr (EPA Tier 3)
Polar Pioneer - Compressor Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Polar Pioneer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is: 0.4 g/kW-hr (EPA Tier 2)
Polar Pioneer - Emergency Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Polar Pioneer - Small Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Polar Pioneer - Boilers	Based on Table 1.3-1 & Table 1.3-2, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 3.3 lb/kgal Distillate oil fired
Polar Pioneer - Incinerator	Based on Table 2.1-2, AP-42, the emission rate used is: Modular Excess Air Combustors 25.1 lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter (PM_{10})		
Fennica - Propulsion and Generator Engines	Based on separate source tests, the average controlled emission rate used is:		
	F-1 at 30% load	0.000225	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-1 at 40% load	0.000182	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-1 at 60% load	0.000176	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-1 at 80% load	0.000174	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-1 at 95% load	0.000187	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 30% load	0.000282	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 40% load	0.000216	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 60% load	0.000183	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 80% load	0.000163	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 95% load	0.000208	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 30% load	0.000231	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 40% load	0.000158	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 60% load	0.000136	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 80% load	0.000135	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 95% load	0.000152	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 30% load	0.000248	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 40% load	0.000249	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 60% load	0.000158	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 80% load	0.000141	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 95% load	0.000204	lb/kWe-hr (TRC Test Report, 8/9/12)
	Average	1.91E-04	lb/kWe-hr
	95% conversion [3]	2.01E-04	lb/kW-hr
		0.09	g/kW-hr
	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Fennica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Fennica - Boilers	Based on separate source tests, the average emission rate used is:		
	Fennica F-5 at 100% load	0.000437	lb/gal (TRC Test Report, 8/9/12)
	Fennica F-6 at 100% load	0.000633	lb/gal (TRC Test Report, 8/9/12)
	Average	0.5	lb/kgal
Fennica - Incinerator	Based on source tests, the emission rate used is:		
	Fennica F-7 at 100% load	16.97	lb/ton (TRC Test Report, 8/9/12)
Fennica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is:		
		0.0022	lb/hp-hr
		1.34	g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter (PM_{10})		
Nordica - Propulsion and Generator Engines	Based on separate source tests, the average controlled emission rate used is:		
	Nd-1 at 30% load	0.000186	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-1 at 40% load	0.000129	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-1 at 60% load	0.000160	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-1 at 80% load	0.000206	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-1 at 95% load	0.000152	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 30% load	0.000130	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 40% load	0.000121	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 60% load	0.000104	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 80% load	0.000111	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 95% load	0.000109	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 30% load	0.000197	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 40% load	0.000141	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 60% load	0.000204	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 80% load	0.000113	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 95% load	0.000104	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 30% load	0.000266	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 40% load	0.000154	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 60% load	0.000194	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 80% load	0.000145	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 95% load	0.000152	lb/kWe-hr (TRC Test Report, 8/9/12)
	Average	1.54E-04	lb/kWe-hr
	95% conversion [3]	1.62E-04	lb/kW-hr
		0.07	g/kW-hr
	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Nordica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Nordica - Boilers	Based on separate source tests, the average emission rate used is:		
	Nordica Nd-5 at 100% load	0.00039	lb/gal (TRC Test Report, 8/9/12)
	Nordica Nd-6 at 100% load	0.00039	lb/gal (TRC Test Report, 8/9/12)
	Average	0.389	lb/kgal
Nordica - Incinerator	Based on separate source tests, the average emission rate used is:		
	Nordica Nd-7 at 100% load	2.16	lb/ton (TRC Test Report, 8/9/12)
Nordica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is:		
		0.0022	lb/hp-hr
		1.3	g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter (PM_{10})
Aiviq - Propulsion Engines	Based on separate source tests, the average controlled emission rate used is: Av-1 at 40% load 0.0007502 lb/kW-hr (TRC Test Report, 8/9/12) Av-1 at 65% load 0.0004349 lb/kW-hr (TRC Test Report, 8/9/12) Av-1 at 95% load 0.0003605 lb/kW-hr (TRC Test Report, 8/9/12) Av-2 at 40% load 0.0010320 lb/kW-hr (TRC Test Report, 8/9/12) Av-2 at 65% load 0.0005366 lb/kW-hr (TRC Test Report, 8/9/12) Av-2 at 95% load 0.0003770 lb/kW-hr (TRC Test Report, 8/9/12) Av-3 at 40% load 0.0007505 lb/kW-hr (TRC Test Report, 8/9/12) Av-3 at 65% load 0.0006625 lb/kW-hr (TRC Test Report, 8/9/12) Av-3 at 95% load 0.0004126 lb/kW-hr (TRC Test Report, 8/9/12) Av-4 at 40% load 0.0006335 lb/kW-hr (TRC Test Report, 8/9/12) Av-4 at 65% load 0.0004711 lb/kW-hr (TRC Test Report, 8/9/12) Av-4 at 95% load 0.0003069 lb/kW-hr (TRC Test Report, 8/9/12) Average 0.000561 lb/kW-hr 0.254 g/kW-hr
Aiviq - Generator Engines	Based on separate source tests, the average controlled emission rate used is: Av-5 at 40% load 0.0000649 lb/kWe-hr (TRC Test Report, 8/9/12) Av-5 at 65% load 0.0000614 lb/kWe-hr (TRC Test Report, 8/9/12) Av-5 at 95% load 0.0001753 lb/kWe-hr (TRC Test Report, 8/9/12) Av-6 at 40% load 0.0001906 lb/kWe-hr (TRC Test Report, 8/9/12) Av-6 at 65% load 0.0005122 lb/kWe-hr (TRC Test Report, 8/9/12) Av-6 at 95% load 0.0001521 lb/kWe-hr (TRC Test Report, 8/9/12) Av-7 at 40% load 0.0000375 lb/kWe-hr (TRC Test Report, 8/9/12) Av-7 at 65% load 0.0000515 lb/kWe-hr (TRC Test Report, 8/9/12) Av-7 at 95% load 0.0002109 lb/kWe-hr (TRC Test Report, 8/9/12) Av-8 at 40% load 0.0000298 lb/kWe-hr (TRC Test Report, 8/9/12) Av-8 at 65% load 0.0000497 lb/kWe-hr (TRC Test Report, 8/9/12) Av-8 at 95% load 0.0001061 lb/kWe-hr (TRC Test Report, 8/9/12) Average 1.37E-04 lb/kWe-hr 95% conversion [3] 1.44E-04 lb/kW-hr 0.065 g/kW-hr Based on Vendor Data from CleanAir Systems, the uncontrolled emission rate used is: 0.15 g/bhp-hr 0.20 g/kW-hr
Aiviq - Boilers	Based on Table 1.3-1 & Table 1.3-2, AP-42, the emission rate used is: Boilers <100 MMBtu, 3.3 lb/kgal Distillate oil fired
Aiviq - Incinerator	Based on source tests, the emission rate used is: Av-10 at 100% load 18.04 lb/ton (TRC Test Report, 8/9/12)
Aiviq - Emergency Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Aiviq -Rescue & Lifeboat Engines & OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter (PM_{10})
Tor Viking - Propulsion Engines	Based on separate source tests, the average controlled emission rate used is: TV-1 at 20% load 0.000224 lb/kW-hr (TRC Test Report, 8/9/12) TV-1 at 40% load 0.000156 lb/kW-hr (TRC Test Report, 8/9/12) TV-1 at 60% load 0.000078 lb/kW-hr (TRC Test Report, 8/9/12) TV-1 at 80% load 0.000110 lb/kW-hr (TRC Test Report, 8/9/12) TV-2 at 20% load 0.000706 lb/kW-hr (TRC Test Report, 8/9/12) TV-2 at 40% load 0.000126 lb/kW-hr (TRC Test Report, 8/9/12) TV-2 at 60% load 0.000136 lb/kW-hr (TRC Test Report, 8/9/12) TV-2 at 80% load 0.000163 lb/kW-hr (TRC Test Report, 8/9/12) TV-3 at 20% load 0.000792 lb/kW-hr (TRC Test Report, 8/9/12) TV-3 at 40% load 0.000098 lb/kW-hr (TRC Test Report, 8/9/12) TV-3 at 60% load 0.000080 lb/kW-hr (TRC Test Report, 8/9/12) TV-3 at 80% load 0.000111 lb/kW-hr (TRC Test Report, 8/9/12) TV-4 at 20% load 0.000204 lb/kW-hr (TRC Test Report, 8/9/12) TV-4 at 40% load 0.000113 lb/kW-hr (TRC Test Report, 8/9/12) TV-4 at 60% load 0.000069 lb/kW-hr (TRC Test Report, 8/9/12) TV-4 at 80% load 0.000147 lb/kW-hr (TRC Test Report, 8/9/12) Average 0.000207 lb/kW-hr 0.094 g/kW-hr Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Tor Viking - Generator Engines	Based on separate source tests, the average controlled emission rate used is: TV-5 at 50-60% load 0.000309 lb/kWe-hr (TRC Test Report, 8/9/12) TV-5 at 90-100% load 0.000585 lb/kWe-hr (TRC Test Report, 8/9/12) TV-6 at 50-60% load 0.000296 lb/kWe-hr (TRC Test Report, 8/9/12) TV-6 at 90-100% load 0.000764 lb/kWe-hr (TRC Test Report, 8/9/12) Average 4.88E-04 lb/kWe-hr 95% conversion [3] 5.14E-04 lb/kW-hr 0.233 g/kW-hr Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Tor Viking - Boilers	Based on source tests, the average emission rate used is: TV-7 at 100% load 0.001199 lb/gal (TRC Test Report, 8/9/12) 1.20 lb/kgal
Tor Viking - Emergency Generator Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr
Ross Chouest - Propulsion and Generator Engines, and Various Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Ross Chouest - Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

<table>
<tr><th>Unit Description</th><th colspan="3">Particulate Matter (PM_{10})</th></tr>
<tr><td rowspan="16">Sisuaq and Harvey Supporter - Propulsion and Generator Engines</td><td colspan="3">Based on separate source tests, the average emission rate used is:</td></tr>
<tr><td>S-1 at 40% load</td><td>0.0007158</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-1 at 65% load</td><td>0.0002721</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-1 at 95% load</td><td>0.0001521</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-2 at 40% load</td><td>0.0005606</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-2 at 65% load</td><td>0.0003206</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-2 at 95% load</td><td>0.0001645</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-3 at 40% load</td><td>0.0005356</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-3 at 65% load</td><td>0.0002724</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-3 at 95% load</td><td>0.0001538</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-4 at 40% load</td><td>0.0006883</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-4 at 65% load</td><td>0.0003699</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>S-4 at 95% load</td><td>0.0002251</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>Average</td><td>0.0003692</td><td>lb/kWe-hr</td></tr>
<tr><td>95% conversion [3]</td><td>3.89E-04</td><td>lb/kW-hr</td></tr>
<tr><td></td><td>0.176</td><td>g/kW-hr</td></tr>
<tr><td rowspan="3">Sisuaq, Harvey Supporter and Harvey Explorer - Various Engines, Emergency Engines, and OSR</td><td colspan="3">Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is:</td></tr>
<tr><td></td><td>0.0022</td><td>lb/hp-hr</td></tr>
<tr><td></td><td>1.34</td><td>g/kW-hr</td></tr>
<tr><td rowspan="2">Sisuaq and Harvey Supporter - Incinerators</td><td colspan="3">Based on Table 2.1-2, AP-42, the emission rate used is:</td></tr>
<tr><td>Modular Excess Air Combustors</td><td>25.1</td><td>lb/ton</td></tr>
<tr><td rowspan="11">Harvey Explorer - Propulsion Engines</td><td colspan="3">Based on separate source tests, the average emission rate used is:</td></tr>
<tr><td>HE-1 at 20% load</td><td>0.0002039</td><td>lb/kW-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-1 at 40% load</td><td>0.0006488</td><td>lb/kW-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-1 at 60% load</td><td>0.0002400</td><td>lb/kW-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-1 at 80% load</td><td>0.0002202</td><td>lb/kW-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-2 at 20% load</td><td>0.0001537</td><td>lb/kW-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-2 at 40% load</td><td>0.0004416</td><td>lb/kW-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-2 at 60% load</td><td>0.0002357</td><td>lb/kW-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-2 at 80% load</td><td>0.0001404</td><td>lb/kW-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>Average</td><td>0.0002855</td><td>lb/kW-hr</td></tr>
<tr><td></td><td>0.13</td><td>g/kW-hr</td></tr>
<tr><td rowspan="10">Harvey Explorer - Generator Engines</td><td colspan="3">Based on separate source tests, the average emission rate used is:</td></tr>
<tr><td>HE-3 at 50% load</td><td>0.0005854</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-3 at 100% load</td><td>0.0005120</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-4 at 50% load</td><td>0.001339</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-4 at 100% load</td><td>0.001510</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-5 at 50% load</td><td>0.0004947</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>HE-5 at 100% load</td><td>0.0005116</td><td>lb/kWe-hr (TRC Test Report 8/9/12)</td></tr>
<tr><td>Average</td><td>0.0008255</td><td>lb/kWe-hr</td></tr>
<tr><td>95% conversion [3]</td><td>8.69E-04</td><td>lb/kW-hr</td></tr>
<tr><td></td><td>0.394</td><td>g/kW-hr</td></tr>
</table>

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter (PM_{10})		
Harvey Explorer - Thruster Engines	Based on separate source tests, the average emission rate used is:		
	HE-7 at 20% load	0.0005687	lb/kW-hr (TRC Test Report 8/9/12)
	HE-7 at 40% load	0.0004086	lb/kW-hr (TRC Test Report 8/9/12)
	HE-7 at 60% load	0.0002925	lb/kW-hr (TRC Test Report 8/9/12)
	HE-7 at 80% load	0.001028	lb/kW-hr (TRC Test Report 8/9/12)
	HE-8 at 20% load	0.001134	lb/kW-hr (TRC Test Report 8/9/12)
	HE-8 at 40% load	0.0005634	lb/kW-hr (TRC Test Report 8/9/12)
	HE-8 at 60% load	0.0001611	lb/kW-hr (TRC Test Report 8/9/12)
	HE-8 at 80% load	0.0008515	lb/kW-hr (TRC Test Report 8/9/12)
	HE-9 at 20% load	0.0002540	lb/kW-hr (TRC Test Report 8/9/12)
	HE-9 at 40% load	0.0002326	lb/kW-hr (TRC Test Report 8/9/12)
	HE-9 at 60% load	0.0003345	lb/kW-hr (TRC Test Report 8/9/12)
	HE-9 at 80% load	0.0004861	lb/kW-hr (TRC Test Report 8/9/12)
	Average	0.00053	lb/kW-hr
		0.2	g/kW-hr
Harvey Explorer - Emergency Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is:		
		0.0022	lb/hp-hr
		1.34	g/kW-hr
Nanuq - Propulsion Engines	Based on separate source tests, the average controlled emission rate used is:		
	N-1 at 25% load	0.0000496	lb/kW-hr (TRC Test Report, 7/26/12)
	N-1 at 50% load	0.0000377	lb/kW-hr (TRC Test Report, 7/26/12)
	N-1 at 75% load	0.0000377	lb/kW-hr (TRC Test Report, 7/26/12)
	N-1 at 100% load	0.0000403	lb/kW-hr (TRC Test Report, 7/26/12)
	N-2 at 25% load	0.0001049	lb/kW-hr (TRC Test Report, 7/26/12)
	N-2 at 50% load	0.0000489	lb/kW-hr (TRC Test Report, 7/26/12)
	N-2 at 75% load	0.0000425	lb/kW-hr (TRC Test Report, 7/26/12)
	N-2 at 100% load	0.0000677	lb/kW-hr (TRC Test Report, 7/26/12)
	Average	0.0000537	lb/kW-hr
		0.02	g/kW-hr
	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Nanuq - Generator Engines	Based on separate source tests, the average emission rate used is:		
	N-3 at 50% load	0.0000621	lb/kWe-hr (TRC Test Report, 7/26/12)
	N-3 at 100% load	0.0000659	lb/kWe-hr (TRC Test Report, 7/26/12)
	N-4 at 50% load	0.0000612	lb/kWe-hr (TRC Test Report, 7/26/12)
	N-4 at 100% load	0.0000532	lb/kWe-hr (TRC Test Report, 7/26/12)
	Average	6.06E-05	lb/kWe-hr
	95% conversion [3]	6.38E-05	lb/kW-hr
		0.029	g/kW-hr
	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Nanuq - Various Engines and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is:		
		0.0022	lb/hp-hr
		1.34	g/kW-hr
Nanuq - Incinerators	Based on Table 2.1-2, AP-42, the emission rate used is:		
	Modular Excess Air Combustors	25.1	lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter (PM_{10})
Kvickaks - Propulsion and Generator Engines	Based on separate source tests, the average emission rate used is: OSRK1-1 at 30% load 0.000325 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-1 at 60% load 0.000249 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-1 at 90% load 0.000242 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 30% load 0.000214 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 60% load 0.000269 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 90% load 0.000259 lb/kW-hr (TRC Test Report, 8/9/12) Average 0.000260 lb/kW-hr 0.12 g/kW-hr
Guardsman/Klamath - Propulsion Engines	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Guardsman/Klamath - Generator Engines, Various Engines, and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr
Affinity - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Affinity - Emergency Engines & Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr
Affinity - Boilers	Based on Table 1.3-1 & Table 1.3-2, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 3.3 lb/kgal Distillate oil fired
Affinity - Incinerators	Based on Table 2.1-2, AP-42, the emission rate used is: Modular Excess Air Combustors 25.1 lb/ton
Lauren Foss - Propulsion Engines	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Lauren Foss - Generator Engines, Emergency Generator Engine, Thruster Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Ocean Wind & Ocean Wave - Propulsion Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate used is: 0.15 g/kW-hr
Ocean Wind & *Ocean Wave* - Generator Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter (PM_{10})
Harvey Spirit - Propulsion Engines	Based on separate source tests, the average emission rate used is: HS-1 at 20% load 0.0003084 lb/kW-hr (TRC Test Report 8/9/12) HS-1 at 40% load 0.0003019 lb/kW-hr (TRC Test Report 8/9/12) HS-1 at 60% load 0.0003627 lb/kW-hr (TRC Test Report 8/9/12) HS-1 at 80% load 0.0004138 lb/kW-hr (TRC Test Report 8/9/12) HS-2 at 20% load 0.0005140 lb/kW-hr (TRC Test Report 8/9/12) HS-2 at 40% load 0.0003902 lb/kW-hr (TRC Test Report 8/9/12) HS-2 at 60% load 0.0004083 lb/kW-hr (TRC Test Report 8/9/12) HS-2 at 80% load 0.0004720 lb/kW-hr (TRC Test Report 8/9/12) Average 0.0003964 lb/kW-hr 0.2 g/kW-hr
Harvey Spirit - Generator Engines	Based on separate source tests, the average emission rate used is: HS-3 at 50% load 0.0002927 lb/kWe-hr (TRC Test Report 8/9/12) HS-3 at 100% load 0.0002451 lb/kWe-hr (TRC Test Report 8/9/12) HS-4 at 50% load 0.0003344 lb/kWe-hr (TRC Test Report 8/9/12) HS-4 at 100% load 0.0003086 lb/kWe-hr (TRC Test Report 8/9/12) HS-5 at 50% load 0.001021 lb/kWe-hr (TRC Test Report 8/9/12) HS-5 at 100% load 0.001041 lb/kWe-hr (TRC Test Report 8/9/12) Average 0.0005405 lb/kWe-hr 95% conversion [3] 5.69E-04 lb/kW-hr 0.258 g/kW-hr
Harvey Spirit - Thruster Engines	Based on separate source tests, the average emission rate used is: HS-7 at 20% load 0.0005967 lb/kW-hr (TRC Test Report 8/9/12) HS-7 at 40% load 0.0003190 lb/kW-hr (TRC Test Report 8/9/12) HS-7 at 60% load 0.0002942 lb/kW-hr (TRC Test Report 8/9/12) HS-7 at 80% load 0.0003537 lb/kW-hr (TRC Test Report 8/9/12) HS-8 at 20% load 0.0005237 lb/kW-hr (TRC Test Report 8/9/12) HS-8 at 40% load 0.0003352 lb/kW-hr (TRC Test Report 8/9/12) HS-8 at 60% load 0.0002947 lb/kW-hr (TRC Test Report 8/9/12) HS-8 at 80% load 0.0003782 lb/kW-hr (TRC Test Report 8/9/12) HS-9 at 20% load 0.0004011 lb/kW-hr (TRC Test Report 8/9/12) HS-9 at 40% load 0.0003432 lb/kW-hr (TRC Test Report 8/9/12) HS-9 at 60% load 0.0002766 lb/kW-hr (TRC Test Report 8/9/12) HS-9 at 80% load 0.0003175 lb/kW-hr (TRC Test Report 8/9/12) Average 0.00037 lb/kW-hr 0.2 g/kW-hr
Harvey Spirit - Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr
Harvey Spirit - MLC ROV System Engine	Based on Cummins vendor data, the emission rate used is: 0.06 g/hp-hr 0.08 g/kW-hr
Camp - KDR Generator Engine	Based on vendor data from Caterpillar, the uncontrolled emission rate is: 1,081 hp 0.24 lb/hr 0.13 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)
Discoverer - Generator Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate is: 0.16 g/kW-hr
Discoverer - Propulsion Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Discoverer - HPU Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Discoverer - Cranes	Based on vendor data from Liebherr, the emission rate used is: 0.106 g/kW-hr
Discoverer - Cementing Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Discoverer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is: 0.2 g/kW-hr (EPA Tier 3)
Discoverer - Compressor Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Discoverer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is: 0.4 g/kW-hr (EPA Tier 2)
Discoverer - Emergency Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Discoverer - Lifeboat Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Discoverer - Boilers	Based on separate source tests, the average emission rate used is: FD-21 at 50% load 0.0002 lb/gal (Avogadro Test Report, 7/27/12) FD-21 at 100% load 0.0004 lb/gal (Avogadro Test Report, 7/27/12) FD-22 at 50% load 0.0002 lb/gal (Avogadro Test Report, 7/27/12) FD-22 at 100% load 0.0004 lb/gal (Avogadro Test Report, 7/27/12) Average 0.30 lb/kgal
Discoverer - Incinerator	Based on source tests for the incinerator, the emission rate used is: FD-23 at 100% load 6.94 lb/ton (Avogadro Test Report, 7/27/12)

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)
Polar Pioneer - Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Polar Pioneer - HPU Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Polar Pioneer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is: 0.2 g/kW-hr (EPA Tier 3)
Polar Pioneer - Compressor Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Polar Pioneer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is: 0.4 g/kW-hr (EPA Tier 2)
Polar Pioneer - Emergency Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Polar Pioneer - Small Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Polar Pioneer - Boilers	Based on Table 1.3-1 & Table 1.3-2, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 3.3 lb/kgal Distillate oil fired
Polar Pioneer - Incinerator	Based on Table 2.1-2, AP-42, the emission rate used is: Modular Excess Air Combustors 25.1 lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)		
Fennica - Propulsion and Generator Engines	Based on separate source tests, the average controlled emission rate used is:		
	F-1 at 30% load	0.000225	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-1 at 40% load	0.000182	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-1 at 60% load	0.000176	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-1 at 80% load	0.000174	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-1 at 95% load	0.000187	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 30% load	0.000282	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 40% load	0.000216	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 60% load	0.000183	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 80% load	0.000163	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-2 at 95% load	0.000208	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 30% load	0.000231	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 40% load	0.000158	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 60% load	0.000136	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 80% load	0.000135	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-3 at 95% load	0.000152	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 30% load	0.000248	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 40% load	0.000249	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 60% load	0.000158	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 80% load	0.000141	lb/kWe-hr (TRC Test Report, 8/9/12)
	F-4 at 95% load	0.000204	lb/kWe-hr (TRC Test Report, 8/9/12)
	Average	1.91E-04	lb/kWe-hr
	95% conversion [3]	2.01E-04	lb/kW-hr
		0.09	g/kW-hr
	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Fennica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Fennica - Boilers	Based on separate source tests, the average emission rate used is:		
	Fennica F-5 at 100% load	0.000437	lb/gal (TRC Test Report, 8/9/12)
	Fennica F-6 at 100% load	0.000633	lb/gal (TRC Test Report, 8/9/12)
	Average	0.5	lb/kgal
Fennica - Incinerator	Based on source tests, the emission rate used is:		
	Fennica F-7 at 100% load	16.97	lb/ton (TRC Test Report, 8/9/12)
Fennica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is:		
		0.0022	lb/hp-hr
		1.34	g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)		
Nordica - Propulsion and Generator Engines	Based on separate source tests, the average controlled emission rate used is:		
	Nd-1 at 30% load	0.000186	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-1 at 40% load	0.000129	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-1 at 60% load	0.000160	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-1 at 80% load	0.000206	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-1 at 95% load	0.000152	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 30% load	0.000130	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 40% load	0.000121	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 60% load	0.000104	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 80% load	0.000111	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-2 at 95% load	0.000109	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 30% load	0.000197	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 40% load	0.000141	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 60% load	0.000204	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 80% load	0.000113	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-3 at 95% load	0.000104	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 30% load	0.000266	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 40% load	0.000154	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 60% load	0.000194	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 80% load	0.000145	lb/kWe-hr (TRC Test Report, 8/9/12)
	Nd-4 at 95% load	0.000152	lb/kWe-hr (TRC Test Report, 8/9/12)
	Average	1.54E-04	lb/kWe-hr
	95% conversion [3]	1.62E-04	lb/kW-hr
		0.07	g/kW-hr
	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Nordica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Nordica - Boilers	Based on separate source tests, the average emission rate used is:		
	Nordica Nd-5 at 100% load	0.00039	lb/gal (TRC Test Report, 8/9/12)
	Nordica Nd-6 at 100% load	0.00039	lb/gal (TRC Test Report, 8/9/12)
	Average	0.389	lb/kgal
Nordica - Incinerator	Based on separate source tests, the average emission rate used is:		
	Nordica Nd-7 at 100% load	2.16	lb/ton (TRC Test Report, 8/9/12)
Nordica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is:		
		0.0022	lb/hp-hr
		1.3	g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)
Aiviq - Propulsion Engines	Based on separate source tests, the average controlled emission rate used is: Av-1 at 40% load 0.000750 lb/kW-hr (TRC Test Report, 8/9/12) Av-1 at 65% load 0.000435 lb/kW-hr (TRC Test Report, 8/9/12) Av-1 at 95% load 0.000361 lb/kW-hr (TRC Test Report, 8/9/12) Av-2 at 40% load 0.001032 lb/kW-hr (TRC Test Report, 8/9/12) Av-2 at 65% load 0.000537 lb/kW-hr (TRC Test Report, 8/9/12) Av-2 at 95% load 0.000377 lb/kW-hr (TRC Test Report, 8/9/12) Av-3 at 40% load 0.000751 lb/kW-hr (TRC Test Report, 8/9/12) Av-3 at 65% load 0.000663 lb/kW-hr (TRC Test Report, 8/9/12) Av-3 at 95% load 0.000413 lb/kW-hr (TRC Test Report, 8/9/12) Av-4 at 40% load 0.000634 lb/kW-hr (TRC Test Report, 8/9/12) Av-4 at 65% load 0.000471 lb/kW-hr (TRC Test Report, 8/9/12) Av-4 at 95% load 0.000307 lb/kW-hr (TRC Test Report, 8/9/12) Average 0.000561 lb/kW-hr 0.254 g/kW-hr
Aiviq - Generator Engines	Based on separate source tests, the average controlled emission rate used is: Av-5 at 40% load 0.0000649 lb/kWe-hr (TRC Test Report, 8/9/12) Av-5 at 65% load 0.0000614 lb/kWe-hr (TRC Test Report, 8/9/12) Av-5 at 95% load 0.0001753 lb/kWe-hr (TRC Test Report, 8/9/12) Av-6 at 40% load 0.0001906 lb/kWe-hr (TRC Test Report, 8/9/12) Av-6 at 65% load 0.0005122 lb/kWe-hr (TRC Test Report, 8/9/12) Av-6 at 95% load 0.0001521 lb/kWe-hr (TRC Test Report, 8/9/12) Av-7 at 40% load 0.0000375 lb/kWe-hr (TRC Test Report, 8/9/12) Av-7 at 65% load 0.0000515 lb/kWe-hr (TRC Test Report, 8/9/12) Av-7 at 95% load 0.0002109 lb/kWe-hr (TRC Test Report, 8/9/12) Av-8 at 40% load 0.0000298 lb/kWe-hr (TRC Test Report, 8/9/12) Av-8 at 65% load 0.0000497 lb/kWe-hr (TRC Test Report, 8/9/12) Av-8 at 95% load 0.0001061 lb/kWe-hr (TRC Test Report, 8/9/12) Average 1.37E-04 lb/kWe-hr 95% conversion [3] 1.44E-04 lb/kW-hr 0.065 g/kW-hr Based on Vendor Data from CleanAir Systems, the uncontrolled emission rate used is: 0.15 g/bhp-hr 0.20 g/kW-hr
Aiviq - Boilers	Based on Table 1.3-1 & Table 1.3-2, AP-42, the emission rate used is: Boilers <100 MMBtu, 3.3 lb/kgal Distillate oil fired
Aiviq - Incinerator	Based on source tests, the emission rate used is: Av-10 at 100% load 18.04 lb/ton (TRC Test Report, 8/9/12)
Aiviq - Emergency Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Aiviq -Rescue & Lifeboat Engines & OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)
Tor Viking - Propulsion Engines	Based on separate source tests, the average controlled emission rate used is: TV-1 at 20% load 0.000224 lb/kW-hr (TRC Test Report, 8/9/12) TV-1 at 40% load 0.000156 lb/kW-hr (TRC Test Report, 8/9/12) TV-1 at 60% load 0.000078 lb/kW-hr (TRC Test Report, 8/9/12) TV-1 at 80% load 0.000110 lb/kW-hr (TRC Test Report, 8/9/12) TV-2 at 20% load 0.000706 lb/kW-hr (TRC Test Report, 8/9/12) TV-2 at 40% load 0.000126 lb/kW-hr (TRC Test Report, 8/9/12) TV-2 at 60% load 0.000136 lb/kW-hr (TRC Test Report, 8/9/12) TV-2 at 80% load 0.000163 lb/kW-hr (TRC Test Report, 8/9/12) TV-3 at 20% load 0.000792 lb/kW-hr (TRC Test Report, 8/9/12) TV-3 at 40% load 0.000098 lb/kW-hr (TRC Test Report, 8/9/12) TV-3 at 60% load 0.000080 lb/kW-hr (TRC Test Report, 8/9/12) TV-3 at 80% load 0.000111 lb/kW-hr (TRC Test Report, 8/9/12) TV-4 at 20% load 0.000204 lb/kW-hr (TRC Test Report, 8/9/12) TV-4 at 40% load 0.000113 lb/kW-hr (TRC Test Report, 8/9/12) TV-4 at 60% load 0.000069 lb/kW-hr (TRC Test Report, 8/9/12) TV-4 at 80% load 0.000147 lb/kW-hr (TRC Test Report, 8/9/12) Average 0.000207 lb/kW-hr 0.094 g/kW-hr Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Tor Viking - Generator Engines	Based on separate source tests, the average controlled emission rate used is: TV-5 at 50-60% load 0.000309 lb/kWe-hr (TRC Test Report, 8/9/12) TV-5 at 90-100% load 0.000585 lb/kWe-hr (TRC Test Report, 8/9/12) TV-6 at 50-60% load 0.000296 lb/kWe-hr (TRC Test Report, 8/9/12) TV-6 at 90-100% load 0.000764 lb/kWe-hr (TRC Test Report, 8/9/12) Average 4.88E-04 lb/kWe-hr 95% conversion [3] 5.14E-04 lb/kW-hr 0.233 g/kW-hr Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Tor Viking - Boilers	Based on source tests, the average emission rate used is: TV-7 at 100% load 0.001199 lb/gal (TRC Test Report, 8/9/12) 1.20 lb/kgal
Tor Viking - Emergency Generator Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr
Ross Chouest - Propulsion and Generator Engines, and Various Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Ross Chouest - Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)
Sisuaq and *Harvey Supporter* - Propulsion and Generator Engines	Based on separate source tests, the average emission rate used is: S-1 at 40% load 0.0007158 lb/kWe-hr (TRC Test Report 8/9/12) S-1 at 65% load 0.0002721 lb/kWe-hr (TRC Test Report 8/9/12) S-1 at 95% load 0.0001521 lb/kWe-hr (TRC Test Report 8/9/12) S-2 at 40% load 0.0005606 lb/kWe-hr (TRC Test Report 8/9/12) S-2 at 65% load 0.0003206 lb/kWe-hr (TRC Test Report 8/9/12) S-2 at 95% load 0.0001645 lb/kWe-hr (TRC Test Report 8/9/12) S-3 at 40% load 0.0005356 lb/kWe-hr (TRC Test Report 8/9/12) S-3 at 65% load 0.0002724 lb/kWe-hr (TRC Test Report 8/9/12) S-3 at 95% load 0.0001538 lb/kWe-hr (TRC Test Report 8/9/12) S-4 at 40% load 0.0006883 lb/kWe-hr (TRC Test Report 8/9/12) S-4 at 65% load 0.0003699 lb/kWe-hr (TRC Test Report 8/9/12) S-4 at 95% load 0.0002251 lb/kWe-hr (TRC Test Report 8/9/12) Average 0.0003692 lb/kWe-hr 95% conversion [3] 3.89E-04 lb/kW-hr 0.176 g/kW-hr
Sisuaq, Harvey Supporter and Harvey Explorer - Various Engines, Emergency Engines, and OSR	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr
Sisuaq and *Harvey Supporter* - Incinerators	Based on Table 2.1-2, AP-42, the emission rate used is: Modular Excess Air Combustors 25.1 lb/ton
Harvey Explorer - Propulsion Engines	Based on separate source tests, the average emission rate used is: HE-1 at 20% load 0.0002039 lb/kW-hr (TRC Test Report 8/9/12) HE-1 at 40% load 0.0006488 lb/kW-hr (TRC Test Report 8/9/12) HE-1 at 60% load 0.0002400 lb/kW-hr (TRC Test Report 8/9/12) HE-1 at 80% load 0.0002202 lb/kW-hr (TRC Test Report 8/9/12) HE-2 at 20% load 0.0001537 lb/kW-hr (TRC Test Report 8/9/12) HE-2 at 40% load 0.0004416 lb/kW-hr (TRC Test Report 8/9/12) HE-2 at 60% load 0.0002357 lb/kW-hr (TRC Test Report 8/9/12) HE-2 at 80% load 0.0001404 lb/kW-hr (TRC Test Report 8/9/12) Average 0.0002855 lb/kW-hr 0.13 g/kW-hr
Harvey Explorer - Generator Engines	Based on separate source tests, the average emission rate used is: HE-3 at 50% load 0.0005854 lb/kWe-hr (TRC Test Report 8/9/12) HE-3 at 100% load 0.0005120 lb/kWe-hr (TRC Test Report 8/9/12) HE-4 at 50% load 0.001339 lb/kWe-hr (TRC Test Report 8/9/12) HE-4 at 100% load 0.001510 lb/kWe-hr (TRC Test Report 8/9/12) HE-5 at 50% load 0.0004947 lb/kWe-hr (TRC Test Report 8/9/12) HE-5 at 100% load 0.0005116 lb/kWe-hr (TRC Test Report 8/9/12) Average 0.0008255 lb/kWe-hr 95% conversion [3] 8.69E-04 lb/kW-hr 0.394 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)		
Harvey Explorer - Thruster Engines	Based on separate source tests, the average emission rate used is:		
	HE-7 at 20% load	0.0005687	lb/kW-hr (TRC Test Report 8/9/12)
	HE-7 at 40% load	0.0004086	lb/kW-hr (TRC Test Report 8/9/12)
	HE-7 at 60% load	0.0002925	lb/kW-hr (TRC Test Report 8/9/12)
	HE-7 at 80% load	0.001028	lb/kW-hr (TRC Test Report 8/9/12)
	HE-8 at 20% load	0.001134	lb/kW-hr (TRC Test Report 8/9/12)
	HE-8 at 40% load	0.0005634	lb/kW-hr (TRC Test Report 8/9/12)
	HE-8 at 60% load	0.0001611	lb/kW-hr (TRC Test Report 8/9/12)
	HE-8 at 80% load	0.0008515	lb/kW-hr (TRC Test Report 8/9/12)
	HE-9 at 20% load	0.0002540	lb/kW-hr (TRC Test Report 8/9/12)
	HE-9 at 40% load	0.0002326	lb/kW-hr (TRC Test Report 8/9/12)
	HE-9 at 60% load	0.0003345	lb/kW-hr (TRC Test Report 8/9/12)
	HE-9 at 80% load	0.0004861	lb/kW-hr (TRC Test Report 8/9/12)
	Average	0.00053	lb/kW-hr
		0.2	g/kW-hr
Harvey Explorer - Emergency Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is:		
		0.0022	lb/hp-hr
		1.34	g/kW-hr
Nanuq - Propulsion Engines	Based on separate source tests, the average controlled emission rate used is:		
	N-1 at 25% load	0.0000496	g/kW-hr (TRC Test Report, 7/26/12)
	N-1 at 50% load	0.0000377	g/kW-hr (TRC Test Report, 7/26/12)
	N-1 at 75% load	0.0000377	g/kW-hr (TRC Test Report, 7/26/12)
	N-1 at 100% load	0.0000403	g/kW-hr (TRC Test Report, 7/26/12)
	N-2 at 25% load	0.0001049	g/kW-hr (TRC Test Report, 7/26/12)
	N-2 at 50% load	0.0000489	g/kW-hr (TRC Test Report, 7/26/12)
	N-2 at 75% load	0.0000425	g/kW-hr (TRC Test Report, 7/26/12)
	N-2 at 100% load	0.0000677	g/kW-hr (TRC Test Report, 7/26/12)
	Average	0.0000537	lb/kW-hr
		0.02	g/kW-hr
	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Nanuq - Generator Engines	Based on separate source tests, the average emission rate used is:		
	N-3 at 50% load	0.0000621	lb/kWe-hr (TRC Test Report, 7/26/12)
	N-3 at 100% load	0.0000659	lb/kWe-hr (TRC Test Report, 7/26/12)
	N-4 at 50% load	0.0000612	lb/kWe-hr (TRC Test Report, 7/26/12)
	N-4 at 100% load	0.0000532	lb/kWe-hr (TRC Test Report, 7/26/12)
	Average	6.06E-05	lb/kWe-hr
	95% conversion [3]	6.38E-05	lb/kW-hr
		0.029	g/kW-hr
	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is:		
		0.0007	lb/hp-hr
		0.43	g/kW-hr
Nanuq - Various Engines and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is:		
		0.0022	lb/hp-hr
		1.34	g/kW-hr
Nanuq - Incinerators	Based on Table 2.1-2, AP-42, the emission rate used is:		
	Modular Excess Air Combustors	25.1	lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)
Kvickaks - Propulsion and Generator Engines	Based on separate source tests, the average emission rate used is: OSRK1-1 at 30% load 0.000325 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-1 at 60% load 0.000249 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-1 at 90% load 0.000242 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 30% load 0.000214 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 60% load 0.000269 lb/kW-hr (TRC Test Report, 8/9/12) OSRK1-2 at 90% load 0.000259 lb/kW-hr (TRC Test Report, 8/9/12) Average 2.597E-04 lb/kW-hr 0.12 g/kW-hr
Guardsman/Klamath - Propulsion Engines	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Guardsman/Klamath - Generator Engines, Various Engines, and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr
Affinity - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Affinity - Emergency Engines & Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr
Affinity - Boilers	Based on Table 1.3-1 & Table 1.3-2, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 3.3 lb/kgal Distillate oil fired
Affinity - Incinerators	Based on Table 2.1-2, AP-42, the emission rate used is: Modular Excess Air Combustors 25.1 lb/ton
Lauren Foss - Propulsion Engines	Based on Table 3.4-1, AP-42, the uncontrolled emission rate used is: 0.0007 lb/hp-hr 0.43 g/kW-hr
Lauren Foss - Generator Engines, Emergency Generator Engine, Thruster Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.0022 lb/hp-hr 1.3 g/kW-hr
Ocean Wind & Ocean Wave - Propulsion Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate used is: 0.15 g/kW-hr
Ocean Wind & *Ocean Wave* - Generator Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.0022 lb/hp-hr 1.34 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Particulate Matter ($PM_{2.5}$)		
Harvey Spirit - Propulsion Engines	Based on separate source tests, the average emission rate used is:		
	HS-1 at 20% load	0.000308	lb/kW-hr (TRC Test Report 8/9/12)
	HS-1 at 40% load	0.000302	lb/kW-hr (TRC Test Report 8/9/12)
	HS-1 at 60% load	0.000363	lb/kW-hr (TRC Test Report 8/9/12)
	HS-1 at 80% load	0.000414	lb/kW-hr (TRC Test Report 8/9/12)
	HS-2 at 20% load	0.000514	lb/kW-hr (TRC Test Report 8/9/12)
	HS-2 at 40% load	0.000390	lb/kW-hr (TRC Test Report 8/9/12)
	HS-2 at 60% load	0.000408	lb/kW-hr (TRC Test Report 8/9/12)
	HS-2 at 80% load	0.000472	lb/kW-hr (TRC Test Report 8/9/12)
	Average	0.0003964	lb/kW-hr
		0.2	g/kW-hr
Harvey Spirit - Generator Engines	Based on separate source tests, the average emission rate used is:		
	HS-3 at 50% load	0.0002927	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-3 at 100% load	0.0002451	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-4 at 50% load	0.0003344	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-4 at 100% load	0.0003086	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-5 at 50% load	0.001021	lb/kWe-hr (TRC Test Report 8/9/12)
	HS-5 at 100% load	0.001041	lb/kWe-hr (TRC Test Report 8/9/12)
	Average	0.0005405	lb/kWe-hr
	95% conversion [3]	5.69E-04	lb/kW-hr
		0.258	g/kW-hr
Harvey Spirit - Thruster Engines	Based on separate source tests, the average emission rate used is:		
	HS-7 at 20% load	0.0005967	lb/kW-hr (TRC Test Report 8/9/12)
	HS-7 at 40% load	0.0003190	lb/kW-hr (TRC Test Report 8/9/12)
	HS-7 at 60% load	0.0002942	lb/kW-hr (TRC Test Report 8/9/12)
	HS-7 at 80% load	0.0003537	lb/kW-hr (TRC Test Report 8/9/12)
	HS-8 at 20% load	0.0005237	lb/kW-hr (TRC Test Report 8/9/12)
	HS-8 at 40% load	0.0003352	lb/kW-hr (TRC Test Report 8/9/12)
	HS-8 at 60% load	0.0002947	lb/kW-hr (TRC Test Report 8/9/12)
	HS-8 at 80% load	0.0003782	lb/kW-hr (TRC Test Report 8/9/12)
	HS-9 at 20% load	0.0004011	lb/kW-hr (TRC Test Report 8/9/12)
	HS-9 at 40% load	0.0003432	lb/kW-hr (TRC Test Report 8/9/12)
	HS-9 at 60% load	0.0002766	lb/kW-hr (TRC Test Report 8/9/12)
	HS-9 at 80% load	0.0003175	lb/kW-hr (TRC Test Report 8/9/12)
	Average	0.00037	lb/kW-hr
		0.2	g/kW-hr
Harvey Spirit - Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is:		
		0.0022	lb/hp-hr
		1.34	g/kW-hr
Harvey Spirit - MLC ROV System Engine	Based on Cummins vendor data, the emission rate used is:		
		0.06	g/hp-hr
		0.08	g/kW-hr
Camp - KDR Generator Engine	Based on vendor data from Caterpillar, the uncontrolled emission rate is:		
		1,081	hp
		0.24	lb/hr
		0.13	g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Discoverer - Generator Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate is: 0.45 g/kW-hr
Discoverer - Propulsion Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Discoverer - HPU Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.00247 lb/hp-hr 1.5 g/kW-hr
Discoverer - Cranes	Based on vendor data from Liebherr, the emission rate used is: 0.08 g/kW-hr
Discoverer - Cementing Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.00247 lb/hp-hr 1.5 g/kW-hr
Discoverer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is: 4.0 g/kW-hr (EPA Tier 3)
Discoverer - Compressor Engine	Based on vendor data from Detroit, the emission rate used is: 60 g/hr 0.6 g/kW-hr
Discoverer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is: 7.5 g/kW-hr (EPA Tier 2)
Discoverer - Emergency Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Discoverer - Lifeboat Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.00247 lb/hp-hr 1.5 g/kW-hr
Discoverer - Boilers	Based on separate source tests, the average emission rate used is: FD-21 at 50% load 0.00004 lb/gal (Avogadro Test Report, 7/27/12) FD-21 at 100% load 0.00010 lb/gal (Avogadro Test Report, 7/27/12) FD-22 at 50% load 0.00009 lb/gal (Avogadro Test Report, 7/27/12) FD-22 at 100% load 0.00011 lb/gal (Avogadro Test Report, 7/27/12) Average 0.085 lb/kgal
Discoverer - Incinerator	Based on source tests for the incinerator, the emission rate used is: FD-23 at 100% load 0.375 lb/ton (Avogadro Test Report, 7/27/12)

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Polar Pioneer - Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Polar Pioneer - HPU Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.00247 lb/hp-hr 1.5 g/kW-hr
Polar Pioneer - Logging Unit Engine	Based on vendor data from Caterpillar, the emission rate used is: 4.0 g/kW-hr (EPA Tier 3)
Polar Pioneer - Compressor Engine	Based on vendor data from Detroit, the emission rate used is: 60 g/hr 0.6 g/kW-hr
Polar Pioneer - Sidewall Core Tool Engine	Based on vendor data from Caterpillar, the emission rate used is: 7.5 g/kW-hr (EPA Tier 2)
Polar Pioneer - Emergency Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Polar Pioneer - Small Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.00247 lb/hp-hr 1.5 g/kW-hr
Polar Pioneer - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 0.34 lb/kgal Distillate oil fired
Polar Pioneer - Incinerator	Based on Table 2.1-12, AP-42, the emission rate used is: Refuse Combustor, Industrial/commercial, multiple chamber 3.0 lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Fennica - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Fennica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Fennica - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu, 0.34 lb/kgal Distillate oil fired
Fennica - Incinerator	Based on Table 2.1-12, AP-42, the emission rate used is: Refuse Combustor, Industrial/commercial, multiple chamber 3.0 lb/ton
Fennica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.00247 lb/hp-hr 1.5 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Nordica - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Nordica - Harbor Generator Engine	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Nordica - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu, 0.34 lb/kgal Distillate oil fired
Nordica - Incinerator	Based on Table 2.1-12, AP-42, the emission rate used is: Refuse Combustor, Industrial/commercial, multiple chamber 3.0 lb/ton
Nordica - Emergency Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.00247 lb/hp-hr 1.5 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Aiviq - Propulsion Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate used is: 0.71 g/kW-hr
Aiviq - Generator Engines	Based on Vendor Data from CleanAir Systems, the uncontrolled emission rate used is: 0.39 g/bhp-hr 0.52 g/kW-hr
Aiviq - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu, 0.34 lb/kgal Distillate oil fired
Aiviq - Incinerator	Based on Table 2.1-12, AP-42, the emission rate used is: Refuse Combustor, Industrial/commercial, multiple chamber 3.0 lb/ton
Aiviq - Emergency Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Aiviq -Rescue & Lifeboat Engines & OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Tor Viking - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Tor Viking - Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Tor Viking - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu, 0.34 lb/kgal Distillate oil fired
Tor Viking - Emergency Generator Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr
Ross Chouest - Propulsion and Generator Engines, and Various Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Ross Chouest - Emergency Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Sisuaq and *Harvey Supporter* - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Sisuaq, Harvey Supporter and Harvey Explorer - Various Engines, Emergency Engines, and OSR	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr
Sisuaq and *Harvey Supporter* - Incinerators	Based on Table 2.1-12, AP-42, the emission rate used is: Refuse Combustor, Industrial/commercial, multiple chamber 3.0 lb/ton
Harvey Explorer - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Harvey Explorer - Generator Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Harvey Explorer - Thruster Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Harvey Explorer - Emergency Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr
Nanuq - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Nanuq - Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Nanuq - Various Engines and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr
Nanuq - Incinerators	Based on Table 2.1-12, AP-42, the emission rate used is: Refuse Combustor, Industrial/commercial, multiple chamber 3.0 lb/ton

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan
Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Kvickaks - Propulsion and Generator Engines	Based on Table 3.3-1, AP-42, the emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr
Guardsman/Klamath - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Guardsman/Klamath - Generator Engines, Various Engines, and OSR Equipment Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr
Affinity - Propulsion and Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Affinity - Emergency Engines & Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr
Affinity - Boilers	Based on Table 1.3-1, AP-42, the emission rate used is: Boilers <100 MMBtu/hr, 0.34 lb/kgal Distillate oil fired
Affinity - Incinerators	Based on Table 2.1-12, AP-42, the emission rate used is: Refuse Combustor, Industrial/commercial, multiple chamber 3.0 lb/ton
Lauren Foss - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Lauren Foss - Generator Engines, Emergency Generator Engine, Thruster Engine	Based on Table 3.3-1, AP-42, the emission rate used is: 0.00247 lb/hp-hr 1.5 g/kW-hr
Ocean Wind & Ocean Wave - Propulsion Engines	Based on vendor data from Caterpillar, the uncontrolled emission rate used is: 0.71 g/kW-hr
Ocean Wind & Ocean Wave - Generator Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Unit Description	Volatile Organic Compounds (VOC)
Harvey Spirit - Propulsion Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Harvey Spirit - Generator Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Harvey Spirit - Thruster Engines	Based on Table 3.4-1, AP-42, the emission rate used is: 0.000705 lb/hp-hr 0.43 g/kW-hr
Harvey Spirit - Various Engines	Based on Table 3.3-1, AP-42, the uncontrolled emission rate used is: 0.002470 lb/hp-hr 1.50 g/kW-hr
Harvey Spirit - MLC ROV System Engine	Based on Cummins vendor data, the emission rate used is: 0.13 g/hp-hr 0.17 g/kW-hr
Camp - KDR Generator Engine	Based on vendor data from Caterpillar, the uncontrolled emission rate is: 1,081 hp 0.3 lb/hr 0.17 g/kW-hr

Table D-18. Shell Gulf of Mexico Inc. - Chukchi Sea Exploration Plan Emission Factors (NO_X, CO, PM_{10}, $PM_{2.5}$, VOC)

Notes:

[1] Conversion factors

	453.592	g/lb
	1.34	hp/kW
[2] Engine heat rate	7,000	Btu/hp-hr

[3] Because generators typically convert over 90 percent of the energy coming from the engine into electricality, 2012 source test emission factors for generators provided in pounds per kilowatt electrical hour (lb/kWe-hr) were converted to lb/kW-hr by dividing the average group emission factor by 95 percent. This produced a conservative engine emission factor

Table D-19. Shell Gulf of Mexico Inc., Chukchi Sea Exploration Plan Emission Factors (SO_2, Lead, GHG)

Description	Sulfur Dioxide (SO_2)
Diesel-Fired Engines	Based on the assumed sulfur content in the fuel, the emission rate used is: 100 ppm 0.045 g/kW-hr [2, 3, 4]
Diesel-Fired Boilers	Based on the assumed sulfur content in the fuel, the emission rate used is: 100 ppm 1.399 lb/kgal [4]
Incinerators	Based on Table 2.1-2, EPA AP-42, the emission rate used is: 3.46 lb/ton

Description	Lead (Pb)
Diesel-Fired Engines	Based on EPA 454/R-98-006, Section 5.2.2, the emission rate used is: 2.90E-05 lb/MMBtu 1.23E-04 g/kW-hr [2]
Diesel-Fired Boilers	Based on Table 1.3-10, EPA AP-42, the emission rate used is: 9 lb/10^{12} Btu 1.18E-03 lb/kgal [4]
Incinerators	Based on Table 2.1-2, EPA AP-42, the emission rate used is: 0.213 lb/ton

Description	GHG
Global warming potential (100 yr.)	40 CFR Part 98, Subpart A, Table A-1, 11/29/2013 CO_2 1 CH_4 25 N_20 298
Diesel Sources	40 CFR Part 98, Subpart C, Table C-1 (Distillate Fuel Oil No. 2) CO_2 73.96 kg/MMBtu 693.74 g/kW-hr [2] 40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Petroleum) CH_4 3.00E-03 kg/MMBtu 2.81E-02 g/kW-hr [2] 40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Petroleum) N_20 6.00E-04 kg/MMBtu 5.63E-03 g/kW-hr [2] Diesel-Fired Engines CO_2e 696.13 g/kW-hr Diesel-Fired Boilers CO_2e 163.61 lb/MMBtu
Incinerators	40 CFR Part 98, Subpart C, Table C-1 (Municipal Solid Waste) CO_2 90.7 kg/MMBtu 1,989.6 lb/ton [5] 40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Municipal Solid Waste) CH_4 3.20E-02 kg/MMBtu 0.7 lb/ton [5] 40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Municipal Solid Waste) N_20 4.20E-03 kg/MMBtu 0.1 lb/ton [5] CO_2e 2,034.6 lb/ton

Table D-19. Shell Gulf of Mexico Inc., Chukchi Sea Exploration Plan Emission Factors (SO_2, Lead, GHG)

Description	GHG		
Natural Gas Sources	40 CFR Part 98, Subpart C, Table C-1 (Natural Gas)		
	CO_2	53.06	kg/MMBtu
	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type:Natural Gas)		
	CH_4	1.00E-03	kg/MMBtu
	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type:Natural Gas)		
	N_20	1.00E-04	kg/MMBtu
	Diesel-Fired Boilers		
	CO_2e	53.11	kg/MMBtu

Notes:

[1] Conversion factors			
	453.592	g/lb	
	1.34	hp/kW	
	32.1	lb S/lb-mole S	
	64.1	lb SO_2/lb-mole SO_2	
	2.20462	lb/kg	
[2] Engine heat rate	7,000	Btu/hp-hr	AP42, Table 3.3, footnote a
[3] Diesel fuel energy	131,180	Btu/gal	
[4] Diesel fuel density	7.00	lb/gal	
[5] Municipal solid waste HHV	9.95	MMBtu/short ton	40 CFR Part 98, Subpart C, Table C-1 (Municipal Solid Waste

Attachment E – Supplemental Information

Attachment E1 – January 11, 2012, Letter from Shell to EPA

Shell Exploration & Production

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January 11, 2012

Re: *Frontier Discoverer* Source Tests
Shell OCS Exploration Program

On September 19, 2011, EPA issued Shell Gulf of Mexico Inc. (Shell) Prevention of Significant Deterioration Permits to Construct for the Noble Discoverer drill ship operations in the Chukchi and Beaufort seas. The PSD permits require measurement of emissions from most of the emission units on the Discoverer and on the Discoverer's associated fleet via source testing.

The purpose of this letter is two-fold. First, we request EPA concurrence with Shell's intent to measure at on-shore facilities emissions from certain engines not now on the Discoverer. Secondly, we request EPA concurrence that physical or contractual limitations imposed on engine operating capacity can be considered when defining 100 percent load (and, correspondingly, fractions of that 100 percent load). As explained below, we believe Shell's approach meets the intent of the permit while ensuring a safer and equally realistic testing process.

<u>On-shore testing</u>

Shell intends to test the main generator engines, the port crane engine, the boilers, and the incinerator on the Discoverer because these emission units are permanently installed. However, none of the other engines that require testing are currently onboard the drill ship; in fact, most of the other engines are portable and routinely removed from the drill rig at the end of each drill season.

The PSD permits require Shell to test certain engines prior to the beginning of the drill season. Because of other construction activities that will be undertaken at the same time on the Discoverer, and the limited deck space available for those activities as well as source test equipment, testing certain engines at an on shore site will simply allow for a higher level of safety for testing, and personnel during testing. Shell would maintain that the physical location of the equipment during testing should not be an issue here, as the operating range necessary to be maintained to confirm accurate testing will need to be maintained whether the engine is physically located on the Discoverer at the time of testing or not.

Shell therefore proposes to test the starboard crane engine, the Mud Line Cellar Hydraulic Power Unit engines, the Mud Line Cellar Air Compressor engines, the cementing engines and the C7 logging winch engine at an on-shore facility. It is likely that testing will take place at NC Machinery, south of Tukwila, Washington. Although engine-specific information will be included in test protocols, dynamometers or hydraulic flow restrictors are likely to be used to load these engines to the operating rates required by the permits.

Definition of engine load

The Discoverer PSD permits require Shell to measure emissions from the engines powering the main generators, mud line cellar compressor engines, hydraulic pressure unit engines, crane engines, and cementing and logging engines at multiple loads. However, a number of these engines power equipment that, for various reasons, preclude operating, and as an extension testing, the engine to its full rated capacity. In some other cases, where the emissions units are owned by others, there are contractual restrictions on the maximum allowable engine operating loads.

In both cases, Shell proposes to redefine the maximum operating rate of the engine (100 percent load) to reflect those restrictions. Partial load testing (e.g., 50% load or 80% load) would also be correspondingly adjusted relative to this redefined maximum load condition. Below please find explanations of why, and examples of how, this would work for the subject engines.

FD 1-6. Main Generators

Noble, the owner of the Discoverer, has established 800 kW as the maximum operating rate for the generators, and has installed an electrical distribution system with controls that limit the engines' operating rate accordingly. This operating rate is nearly 20 percent lower than the 988 kW nameplate rating on the engine. With this contractual and operational restriction in place, Shell submits that an engine operating rate that results in 800 kW output reflects the true 100 percent engine load to be encountered during our OCS drilling operations, and that the "100% load" source tests should take place at this restricted engine operating rate. Similarly, source tests at 75% and 50% load should be conducted at engine operating rates that generate 600 and 400 kW, respectively.

FD 14-15. Deck Cranes

Each of the deck cranes engines are rated at 365 HP. The PSD permit requires testing at 60-80% and 80-100% loads.

Crane engine testing is challenging, as the engine is only one part of the crane hoisting system. The maximum load on the system is defined by the boom capacity, which for the cranes on the Discoverer is much less than the hoisting capacity of the corresponding engine and winch. One hundred percent boom capacity for the cranes to be used on the Discoverer translates to about 310-320 HP of engine/winch capacity, which is below their nameplate capacity. Because the cranes cannot physically exceed the boom capacity, the engines are functionally limited to a lower load than their name plate rating. There is a boom radius-load indicator and alarm in the crane cabs that indicates when the load is approaching 100 percent of boom capacity. In this case, then, it is appropriate to consider the maximum load the engines will operate to be 320 HP. Thus, Shell proposes to define 100 percent load for these engines as 320 HP.

FD 12-13. Mud Line Cellar Hydraulic Power Unit Engines.

The MLC HPU engines are rated at 322 HP. The PSD permit requires testing at 50-70% and 80-100% loads.

These engines power hydraulic pumps that operate hydraulic motors on the MLC bit. The hydraulic motor capacity is limited to 150 gallons per minute at 2500 PSI, which translates to an engine load of about 218 HP. The energy load into the hydraulic motor cannot exceed this value. Given this physical limitation, Shell believes the functional maximum load the engine can operate is at 218 HP, and that we should consider this to be 100% load for testing.

We request EPA's written concurrence that testing the starboard crane engine, the Mud Line Cellar Hydraulic Power Unit engines, the Mud Line Cellar Air Compressor engines, the cementing engines and the C7 logging winch engine at an on-shore facility is consistent with the requirements of the Noble Discoverer PSD permits. We also request EPA's written concurrence that we can redefine 100 percent load for the main generators, the crane engines, and the Mud Line Cellar Hydraulic Power Unit engines as proposed above. Please contact Pauline Ruddy (907.771.7243) if you have questions or require additional information regarding these proposals.

Thank you,

Susan Childs

Susan Childs
AK Venture Support Integrator, Manager

Cc: Pauline Ruddy, Shell
Lance Tolson, Shell
Keith Craik, Shell
Eric Hansen, ENVIRON

Attachment F – References

Attachment F1 – Discoverer Generator Engines: Caterpillar 3512C Emissions Data

Discoverer Main Engines
Caterpillar 3512 Emission Factors

Table 1 - Engine Specific Emissions Data - Provided by Engine Supplier (Vendor Data)

Speed RPM	Percent Load	Engine Power BHP	Engine Power kW	Total NO_X (AS NO2) lb/hr	Total NO_X (AS NO2) g/kW-hr	Total CO lb/hr	Total CO g/kW-hr	Total HC lb/hr	Total HC g/kW-hr	PM lb/hr	PM g/kW-hr
1,200	100	1,476	1,101	16.80	6.92	0.34	0.14	0.24	0.10	0.06	0.02
1,200	75	1,107	825	10.40	5.71	0.48	0.26	0.30	0.16	0.03	0.02
1,200	50	738	550	6.06	4.99	1.43	1.18	0.29	0.24	0.10	0.08
1,200	25	369	275	2.90	4.78	0.85	1.40	0.27	0.45	0.12	0.20
1,200	10	148	110	1.69	6.95	0.81	3.33	0.32	1.32	0.12	0.49
Average				**7.57**	**5.87**	**0.78**	**1.26**	**0.28**	**0.45**	**0.09**	**0.16**

Conversions	
453.592	g/lb
1.34102	hp/kW

3512C Engine Serial Numbers:

Serial #	Arrangement #	LMC ID#	CAT ESO #
LLB00137	2617308	12190	FPMQR
LLB00138	2617308	12189	FPMQQ
LLB00139	2617308	12188	FPMQP
LLB00140	2617308	12187	FPMQN
LLB00141	2617308	12192	FPMRG
LLB00142	2617308	12191	FPMRF

Engine Data - Serial # LLB

Sales Model:	3512CDITA
Engine Power:	1,476 HP
Manifold Type:	DRY
Turbo Quantity:	2
Application Type:	OIL FLD-DIE
Rating Type:	P/DRIL-ELECT
Combustion:	Direct Injected
Speed:	1,200 RPM
Governor Type:	ADEM3
Engine App:	Offshore
Engine Rating:	Offshore
Certification:	EPA TIER-2 2006 -
Aspr:	Turbocharged Aftercooled
After Cooler:	SCAC
After Cooler Temp(F):	122 F
Turbo Arrangement:	Parallel
Performance #:	DM8321
Serial # Prefix:	LLB
Engine Test Spec:	0K7405
Compression Ratio:	14.7:1
Crankcase Blowby Rat (CFH)	1476.2 cfh
Fuel Injector	2461854
Unit Injector Timing	64.3 mm
Piston Speed @ rated engine speed	1496.1 ft/min
Fuel rate (rated RPM) no load (gal/hr)	5.2 gal/hr

EMISSIONS DATA

EPA TIER-2 2006 - *** B5

Gaseous emissions data measurements are consistent with those described in
EPA 40 CFR PART 89 SUBPART D and ISO 8178 for measuring HC, CO, PM, and NOx

Gaseous emissions values are WEIGHTED CYCLE AVERAGES and are in compliance
with the following non-road regulations:

LOCALITY	AGENCY/LEVEL	MAX LIMITS - g/kW-hr
U.S. (incl Calif)	EPA/TIER-2	CO:3.5 NOx + HC:6.4 PM:0.2

REFERENCE EXHAUST STACK DIAMETER	10 IN
WET EXHAUST MASS	14,984.8 LB/HR
WET EXHAUST FLOW (746.60 F STACK TEMP)	7,702.14 CFM
WET EXHAUST FLOW RATE (32 DEG F AND 29.98 IN HG)	3,157.00 STD CFM
DRY EXHAUST FLOW RATE (32 DEG F AND 29.98 IN HG)	2,892.27 STD CFM
FUEL FLOW RATE	69 GAL/HR

RATED SPEED "Potential site variation"

ENGINE SPEED RPM	PERCENT LOAD	ENGINE POWER BHP	TOTAL NOX (AS NO2) LB/HR	TOTAL CO LB/HR	TOTAL HC LB/HR	PART MATTER LB/HR	OXYGEN IN EXHAUST PERCENT	DRY SMOKE OPACITY PERCENT	BOSCH SMOKE NUMBER
1,200	100	1476	20.17	0.61	0.33	0.09	11.1	0.3	1.28
1,200	75	1107	12.48	0.87	0.39	0.05	11.6	0.5	1.28
1,200	50	738	7.27	2.58	0.39	0.13	11.9	2.1	1.28
1,200	25	369	3.48	1.52	0.35	0.17	13.6	3.4	1.28
1,200	10	148	2.02	1.46	0.43	0.17	16.4	2.2	1.28

RATED SPEED "Nominal Data"

ENGINE SPEED RPM	PERCENT LOAD	ENGINE POWER BHP	TOTAL NOX (AS NO2) LB/HR	TOTAL CO LB/HR	TOTAL HC LB/HR	TOTAL CO2 LB/HR	PART MATTER LB/HR	OXYGEN IN EXHAUST PERCENT	DRY SMOKE OPACITY PERCENT	BOSCH SMOKE NUMBER
1,200	100	1476	16.8	0.34	0.24	1,515.40	0.06	11.1	0.3	1.28
1,200	75	1107	10.4	0.48	0.3	1,161.60	0.03	11.6	0.5	1.28
1,200	50	738	6.06	1.43	0.29	811.1	0.1	11.9	2.1	1.28
1,200	25	369	2.9	0.85	0.27	449	0.12	13.6	3.4	1.28
1,200	10	148	1.69	0.81	0.32	222.5	0.12	16.4	2.2	1.28

Attachment F2 – Discoverer Propulsion Engine: STX-MAN B&W Vendor Data

Meeting date :
EOD no. :
STX PJT No. :

EXTENT OF DELIVERY

FOR STX - MAN B&W M/E
S42MC

Shipbuilder	:
Shipowner	:
Hull No.	: Number of ship(s) :
Engineering Company	:
Size & type of ship	:
Flag State	:
Engine model	: 6 S42MC7
Output & Q'ty	: 6,480 X 136 rpm X 1 Set(S) / Ship
Type of propulsion	: ☒ FPP
	☒ Single screw 1 engine(s) + one propeller

Shipbuilding schedule
- Steel cutting :
- Launching :
- Ship delivery :
- Expected engine delivery :

Seller Engineering company Purchaser

*** CONTENTS ***

ABBREVIATION

STD : Standard parts

OPT : Optional parts with extra price

B : Built - on engine

S : Equipments separately delivered
and installed on hull side

To be used for filling in :

☒ : Included in scope of supply

Chapter 1. General Specification

STD	OPT	Q'ty /ship	Description	Remarks
			Rules and Regulations	
☒		____	Classification society	DNV
	☒	____	Unattended engine room	E.O
☒		____	Standards : KS, JIS and maker's standard (DIN or ISO : for connected external piping)	
	☒	____	**To comply with IMO NOx emission limitations Tier II** **Keel laying date of Vessel : After 1st January 2011**	**For worldwide**
	☒	____	To be submitted Nox EIAPP Certificate with class : DNV	
☒		____	Unit - Engine output - Pressure - Temperature	 kW kg/cm2 ℃
☒		____	Final paint color - Diesel engine - Electrical equipment - Loosely supply items	 Munsell No.: 2.5 G 7/2 Munsell No.: 2.5 G 7/2 According to maker's standard
			Calculation of torsional and axial vibrations	
☒		____	Standard calculation of torsional vibration for direct coupled engine	
	☒	____	Calculation of axial vibrations requird by Buyer	
☒		____	Barred speed range accepted by owner	
	☒	____	Approval of the calculation results to classification society to be carried out by engine maker	Exclusive of special calculations
	☒		Measurement of torsional vibration during sea trial	by engine maker (1st vessel only)
			Documentation	
☒		____	Name plates on engine in English	
☒		____	Caution plates on engine in English	
☒		10	Sets of Approval drawings in English	for project
☒		12	Sets of Working drawings in English	for project
☒		6	Sets of Final drawings in English	for vessel
☒		6	Sets of Instruction manuals in English	for vessel
☒		6	Certificate of classification society including original	

Chapter 1. General Specification

STD	OPT	Q'ty /ship	Description	Remarks
☒		6	Copies of shop test record	
			Testing of diesel engine with water brake	refer to the chapter 4 of details
☒		___	Official shop test on Marine Diesel Oil with water brake according to class requirements	
☒		___	Buyer will participate. Notice to be given to buyer 14 days before testing	
☒		___	Inspection after shop trial of components from one cylinder unit only	
			Voltage on board for electrical consumers	
☒		___	Electrical power available - AC 440 V, 3Φ, 60Hz - AC 220 V, 1Φ, 60Hz - DC 24 V - Motor starting method : Y-Δ starting 30 kW above	
			Dismantling, packing and shipping of engine	
			Dismantling and packing of engine Available lifting capacity and number of crane hooks required must be informed	
			Dispatch pattern B : Overseas or long-distance transportation, or long term storage : duration from engine delivery until installation is assumed to be between 8(eight) weeks and maximum 6 months.	
	☒	___	Dispatch pattern A3 or B3 Engine disassembled in three sections Mass of heaviest item : ______ tons	
	☒	___	To be supplied lifting tool for dismantled engine (exclusive of lifting wire/rope/shackles)	all vessel

Chapter 2. Diesel Engine Particulars

1. Engine type : 2-stroke, single acting, direct reversible, cross head diesel engine with exhaust gas turbocharger and air cooler

2. Engine model : 6S42MC7

3. Cylinder bore x Stroke : 420 mm x 1,764 mm

4. Engine rating & revolution
   - Nominal max. continuous rating : 6,480kW on flywheel at 136rpm
   - Specified max. continuous rating : 6,480kW on flywheel at 136rpm
   - Continuous service rating (CSR) : 5,508 kW on flywheel at 128.8 rpm (85% of SMCR)
   - Auxiliary machinery and shaft line for main engine to be dimensioned for on engine output of : 6,480kW on flywheel at 136rpm
   - Overload capacity : 7,128kW on flywheel at 140rpm
     110% one (1) hour in every twelve (12) hours

   At tropical condition of
   - Altitude : Sea level (1000 mbar)
   - Ambient temperature : Max 45℃
   - Relative humidity : 60 %
   - Sea water temperature : 32℃ - Fresh water temperature : 36℃

5. Piston speed at MCR : 8.0 m/s

6. Mean effective pressure at MCR : 19.5 bar

7. Max. combustion pressure (Pmax) : 145 bar

8. Direction of engine rotation (ahead) : Clockwise (viewing from stern side to engine)

9. Firing order (ahead) : 1 - 5 - 3 - 4 - 2 - 6

10. Starting : Compressed air Max. 30 bar(kg/㎠)

11. Cooling system : Cylinder liner, cylinder cover : by F.W
    Scavenging air cooler ☒ L.T F.W for central cooling

12. Using fuel oil : HFO 700 cSt / 50 ℃ (up to 700 cSt / 50 ℃)

13. Specific fuel oil consumption at SMCR : 179g/kW hr + 5 % tolerance **(Under Tier 2 Limitation)**
    This data is given in accordance with ISO 3046/1 conditions and using diesel oil with lower calorific value of 42,700 kJ/kg (10,200 kcal/kg)
   - Ambient air temperature : 25 ℃
   - Ambient air pressure : 1000 mbar
   - Charge air coolant temperature : 25 ℃
   - Exh. Gas back pressure after T/C : Max. 300 mm Aq

14. Lub oil consumption : Approximate 3.5 ~ 4.5 kg/cyl./24 h

15. Cylinder Lub oil consumption : 0.7 ~ 1.5 g/ kWh

Chapter 3. Scope of Supply

STD	OPT	Q'ty /ship	Inst	Description	Remarks
				Engine basic	
☒			B	Basic engine of reversible type	
☒			B	With built-in thrust bearing	For direct coupled with propeller
☒			B	Starboard design engine With exhaust pipes on starboard side	
	☒		B	Camshaft part with indicator cam	
	☒		B	Indicator drive including planimeter	planimeter type : analog type
	☒		B	Exhaust valves with DURA	
☒			B	Electronic governor system	model : EGS2200 maker : STX-Lyngso Marine
☒			B	Turning gear with el. Motor	power source : AC 440V, 3Ph,60Hz motor output : 1.5 kW Starting method : D.O.L
				Axial vibration	
☒			B	Axial vibration damper	
	☒		B	Axial vibration monitor with indication for condition check of axial vibration damper	Required for 5+6S50MC-C
				Torsional vibration	
☒			B	Standard size Turning wheel complete(fly wheel)	J=1,575.1kgm2
	☒		B	Tuning wheel	J=3,810kgm2
				Crankshaft & coupling bolts	
☒			B	Crankshaft of forged or casted semi-built type	Coupling hole : 1mm under size
	☒		S	Coupling bolts/nuts between crankshaft & intermediate shaft	Bolt diameter: 2 mm over size
				Engine seating & gallery	
☒			B	Engine prepared for mounting at epoxy chocks	
☒			B	Engine alignment method : Jacking screw type	
	☒		S	Engine foundation parts ☒ Holding down bolts, washers, nuts, protecting cap and distance pieces ☒ Side chocks, liners, bolts & nuts ☒ End chocks, liners, bolts & nuts ☒ Alignment screw	Exclusive of epoxy chock For jacking screw type only

STD	OPT	Q'ty /ship	Inst	Description	Remarks
☒		____	B	Galleries complete including gratings, stanchions & railings (excluding ladders)	
☒		____	B	Preparation for top bracing on exhaust side	
	☒	____	S	Friction shims & disc spring only for mechanical top bracing	
				Micellaneous	
	☒	____	S	With drilled counter flanges, gaskets & bolts/nuts for all flange connections	
	☒	____	S	Touch up paint	quantity : 18L X 1 CAN
				Fuel Oil System	
☒		____	B	Engone internal F.O piping	
	☒	____	B	Insulated fuel oil pipes and main return pipes	
☒		____	B	Drain box with level alarm for fuel oil leakage	refer to sensor list
☒		____	B	Steam tracing in copper pipes for heating of fuel oil pipes	
☒		____	B	Safety cover for F.O pipe connection	according to the SOLAS rule
				L.O System	
☒		____	B	Oil pan with vertical outlets	L.O drain pipe with 3 sheets rubber plate
☒		____	B	Uni-lubricating system for bearing, chain drive piston cooling and camshaft	
☒		____	B	Safety cover for L.O pipe connection	according to the SOLAS rule
				Cylinder L.O system	
☒		____	B	Engine internal cylinder L.O piping	
	☒	____	B	Mechanical cyl. Lubricators, speed & load change dependent type (Maker : Korean maker)	with heating element
				Jacket cooling fresh water system	
☒		____	B	Jacket cooling water piping on engine for freshwater cooling of cylinders	
	☒	____	S	Fexible joint for J.C.F.W outlet	
				Low temperature cooling water system	
	☒	____	B	Central cooling with freshwater at steel pipes	36℃ F.W temperature
				Starting air system	
☒		____	B	Engine internal starting air piping	
	☒	____	B	With slow turning before starting	

STD	OPT	Q'ty /ship		Description	Remarks
	☒	____	S	Double pressure reducing unit for safety device & control air	press. reducing : 30 → 7 kg/㎠ hull side mounting
				Scavenging air system	
☒		____	B	Engine internal scavenging air piping	
	☒	____		Designed for 4.5 bar working pressure of cooling water system	Recommended for central cooling
☒		____	B	Air cooler with coated cast iron covers	
☒		____	B	Float alarm for excessive drain from water mist catcher	
☒		____	B	Two(2) auxiliary blowers with electric motors per engine	power source : AC 440V, 3Ph, 60Hz motor output : 34.5kW Starting method : D.O.L with space heater
☒		____	B	Steam fire extinguishing for scavenge air spaces	
				Exhaust gas system	
☒		____	B	Turbochargers, type TCA	TCA55
☒		____	B	Dry cleaning of Turbocharger turbine side	
☒		____	B	Common L.O system with main L.O for turbocharger	
☒		____	B	T/C located on aft end of engine	
	☒	____	B	Gas outlet vertical	
☒		____	S	Exhaust gas receiver without by-pass flange	
	☒	____	S	Exhaust gas T/C outlet pipe(Transition piece)	
	☒	____	S	Expansion joint after T/C without counter flange	
☒		____	B	T/C tacho pick-up & converter	
☒		____	S	T/C tachometer for ECR	
				Manoeuvring system	
☒		____	B	Manoeuvring system including various pneumatic & solenoid valves & piping etc., for local & remote control Emergency console on engine	☒ with slow turning
☒		____	B	Tag for pneumatic parts	
☒		____	B	Line filter for control air & safety air inlet	

STD	OPT	Q'ty /ship		Description	Remarks
☒		____	S	Repair kit for pneumatic parts	
				Spare parts & tools	
☒		____	S	Standard spare parts in accordance with class requirement & maker's standard	
☒		____	S	Standard tools for maintenance of main engine for normal lifting procedure	
☒		____	S	Grinding machine for exh. valve(electric type)	power souce : 220V 1PH 60Hz maker : Maker's standard
	☒	____	S	Hydraulic jack for holding down bolts and hydraulic jack for end chock bolts(epoxy mounting)	
	☒	____	S	Work table for exhaust valve housing	
☒		____	S	Panels for tool	
				Pressure switch arrangement	
☒		____	B	Switch board arrangement (refer to sensor lists)	

Group for thermometer (dial type)

☒ ____ B Standard thermometers

	range (℃)	boss size
- F.O inlet	0~200	PF3/4
- Main L.O & P.C.O inlet	0~100	PF3/4
- Piston cooling oil outlet(1/cyl.)	0~100	PF3/4
- J.C.W inlet	0~100	PF3/4
- J.C.W outlet(1/cyl.)	0~100	PF3/4
- T/C L.O outlet	0~100	PF3/4
- L.T C.W inlet to air cooler	0~100	PF3/4
- L.T C.W outlet from air cooler	0~100	PF3/4
- Scavenge air inlet of air cooler	0~250	PF3/4
- Scavenge air outlet of air cooler	0~100	PF3/4
- Scavenge air receiver	0~100	PF3/4
- Exh. gas each cyl. outlet (1/cyl.)	0~650	PF3/4
- Exh. gas T/C inlet	0~650	PF3/4
- Exh. gas T/C outlet	0~650	PF3/4
- Thrust bearing	0~120	PF1/2

(OPT) ☒ ____ B Extra thermometer(s)

1 Cooling F. W outlet-common	0~100	PF3/4

Engine pressure gauge arrangement(Oil filled type)

☒ ____ B Standard Press. Gauges unit : kg/cm2

	Type	Range
- F.O inlet	bourdon type,	0 ~ 15
- Scavenge air receiver	bourdon type,	0 ~ 4

STD	OPT	Q'ty /ship		Description	Remarks
				- MLO & PCO inlet	bourdon type, 0 ~ 6
				- Starting air inlet	bourdon type, 0 ~ 50
				- J.C.W inlet	bourdon type, 0 ~ 6
				- L.T C.W inlet	bourdon type, 0 ~ 4
				- Control air inlet(separate panel)	bourdon type, 0 ~ 10
				- Safety air inlet(separate panel)	bourdon type, 0 ~ 10
				- Exh. Valve spring air inlet(separate panel)	bourdon type, 0 ~ 10
				- T/C L. O inlet(TCA,MET,NA , TPL type)	bourdon type, 0 ~ 6
	☒		B	U-type manometer(water) for suction air silencer(VTR, TCA and TPL type only)	
☒			B	U-type manometer(water) for differential pressure of air cooler inlet/outlet	
☒			B	Pressure gauge for differential pressure between exh. gas & scavenge air	
	☒	9	S	Pressure gauges for ECR	unit : kg/cm2
				☒ MLO & PCO inlet(6k)	Electric type
				☒ Jacket C.F.W inlet(6k)	Electric type
				☒ C.W inlet of Air cooler(6k)	Electric type
				☒ F.O inlet(16k)	Electric type
				☒ Starting air inlet(40k)	Electric type
				☒ Scavenge air inlet(4k)	Electric type
				☒ Control air inlet(10k)	Electric type
				☒ Safety air inlet(10k)	Electric type
				☒ Exh. Valve spring air inlet(10k)	Electric type
				Oil mist detector(refer to sensor list)	
	☒		B	Graviner : Type MK6	With indication panel for ECR
				Bridge manoeuvering system	
	☒		S	Bridge manoeuvering system	maker : STX-Lyngso marine
					model : EMS 2200
				Aux. Blower starter	
	☒		S	Starter for aux. blower	
				- Power supply	AC 440V, 3φ, 60Hz
				- Composition	1Panel / 2 aux. blower
				- Control mode	manual + auto
				- Starting method	Y-Δ
				- Protection grade	IP 23
				- Mounting type	wall mounting
				- Running hour meter	
				- Others	maker's standard
				T/G motor starter	
	☒		S	Starter for turning gear motor	
				- Power supply	AC 440V, 3φ, 60Hz
				- Composition	1 panel / 1 eng
				- Control mode	manual

STD	OPT	Q'ty /ship		Description	Remarks
				- Starting method	Y-Δ
				- Protection grade	IP 44
				- Mounting type	wall mounting
				- Others	maker's standard
	☒	____	S	Remote push button box with 20m cables, 1 plug and 2 receptacles for starter	
				Connection between main engine & shipyard's equipment	
☒		____	B	Main Junction Box	
				Miscellaneous	
	☒	____	S	E.C.R Manoeuvering handle	

Chapter 4. Shop test and overhaul inspection

4-1. Inspection

All inspections of the engine are to be carried out in accordance with the Rules and Regulations of the classification society and engine-maker's inspection standard.
Material tests are to be carried out on items which are required by the Rules and Regulations of the classification society

4-2. Shop test and overhauling

The following tests are to be carried out at engine-maker's test bench, using engine-maker's facility, lub. Oil and diesel oil in the presence of the surveyor(s) from classification society and owner.
Lub. Oil and fuel oil are to be selected by the engine-maker.

	Testing item	Running hours
1.	25 % load	30 Min
2.	50 % load	30 Min
3.	75 % load	30 Min
4.	Service load (85 % load)	60 Min
5.	100 % load	120 Min
6.	110 % load	30 Min
7.	Governor test	
8.	Safety device test (over speed, main lub oil low pressure of engine inlet, thrust bearing temperature high, turning gear interock, emergency stop)	
9.	Starting and reversing(for reversible engine only) test	
10.	Minimum revolution running test	
11.	Fuel oil consumption test	
12.	Astern running(for reversible engine only) test at no load	
13.	Main engine bearing clearance must be carried out and recorded at shop by MAN B&W standard dial gauge.	
14.	Nox measurement at shop test (1st engine only in series engines, if required)	

After shop test, appearance inspections are to be carried out on the following parts in the presence of the surveyor(s) from the classification society and owner.

1. Crankshaft without lifting up form bedplate
   (1 set of main and crankpin bearing to be dismantled.)
2. 1 set of main bearing
   (shells to be dismantled from engine)
3. 1 set of crankpin bearing
   (with dismantling from engine)
4. 1 set of crosshead bearing & guide shoe
   (without dismantling from engine)
5. 1 set of crosshead pin and guide shoe
   (without dismantling from engine)

6. 1 set of cylinder liner
   (liner surface, without dismantling from engine)
7. 1 set of cylinder cover
   (combustion surface, dismantled from engine)
8. 1 set of piston complete
   (dismantled from engine)
9. Camshaft driving chain and chain wheel
   (without dismantling from engine)

Remark
The purchaser has the right to send its representative(s) to the engine-maker's plant for the purpose of witnessing inspections and test.
Such representative(s) is (are) not to disturb the manufacturing and testing of the engine
Failure to send such representative(s) is deemed a waiver of the said right and the purchaser will be obliged to accept the result of the said inspections or tests which are accepted by the classification society.

Attachment F3 – TRC, Emissions Test Report Discoverer Shell Gulf of Mexico, Inc., July 27, 2012 – Discoverer HPU Engines Summary

Table 2.4.2 –Overall Summary for NOx, NO2, CO, VOC, & Sulfur Fuel Content

Discoverer - HPU Engine (FD-12) ***John Deere/JD6068HF485 - Serial # PE6068L116243***			
Test Identification	**Emissions Unit**	**80 to 100% Load**	**50 to 70% Load**
Test Identification			
Power Output	**%**	98	70
Fuel Flow Rate	**gal/hr**	10.5	7.3
Mechanical Power Output	**kW**	178	127
SAMPLING RESULTS			
	Test Date	5/4-5/2012	5/5/2012
EPA Methods 3A, 7E, 10, & 25A			
EPA Method 3A	**% O_2**	9.5	10.2
	% CO_2	8.2	7.8
NO_x (based on EPA Method 19 flow rates)	**ppm_{vd}**	532.6	365.4
	lb/hr	1.524	0.7774
	lb/gal	0.1456	0.1065
	g/kW-hr	3.882	2.787
	lb/kW-hr	0.008558	0.006145
NO_2 (based on EPA Method 19 flow rates)	**ppm_{vd}**	232.3	149.8
	lb/hr	0.6647	0.3186
	lb/gal	0.06348	0.04365
	g/kW-hr	1.693	1.142
	lb/kW-hr	0.003732	0.002519
CO (based on EPA Method 19 flow rates)	**ppm_{vd}**	---	0.0
	lb/hr	---	0.0
	lb/gal	---	0.0
	g/kW-hr	---	0.0
	lb/kW-hr	---	0.0
VOC (based on EPA Method 19 flow rates)	**ppm_{vw}**	---	2.5
	lb/hr	---	0.001994
	lb/gal	---	0.0002732
	g/kW-hr	---	0.007157
	lb/kW-hr	---	0.00001578
Total Sulfur - ASTM 5453-09			
Total Sulfur	**ppm_w**	9.7	

11 ppm S = 0.0011 wt% S

Table 2.5.2 –Overall Summary for NOx, NO2, CO, VOC, & Sulfur Fuel Content

Discoverer - HPU Engine (F-13) *John Deere/JD6068HF485 - Serial # PE6068L085194*			
Test Identification	**Emissions Unit**	**98% Load**	**70% Load**
PROCESS DATA			
Power Output	**%**	98	70
Fuel Flow Rate	**gal/hr**	10.0	7.3
Mechanical Power Output	**kW**	178	127
SAMPLING RESULTS			
	Test Date	5/14/2012	5/14-15/2012
EPA Methods 3A, 7E, 10, & 25A			
EPA Method 3A	**% O_2**	9.5	10.4
	% CO_2	8.4	7.6
NO_x (based on EPA Method 19 flow rates)	**ppm_{vd}**	422.9	329.8
	lb/hr	1.158	0.7113
	lb/gal	0.1157	0.09764
	g/kW-hr	2.947	2.536
	lb/kW-hr	0.006496	0.005590
NO_2 (based on EPA Method 19 flow rates)	**ppm_{vd}**	201.9	187.1
	lb/hr	0.5527	0.4048
	lb/gal	0.05523	0.05546
	g/kW-hr	1.407	1.443
	lb/kW-hr	0.003101	0.003180
CO (based on EPA Method 19 flow rates)	**ppm_{vd}**	---	0.0
	lb/hr	---	0.0
	lb/gal	---	0.0
	g/kW-hr	---	0.0
	lb/kW-hr	---	0.0
VOC (based on EPA Method 19 flow rates)	**ppm_{vw}**	---	3.3
	lb/hr	---	0.002729
	lb/gal	---	0.0003705
	g/kW-hr	---	0.009713
	lb/kW-hr	---	0.00002141
Total Sulfur - ASTM 5453-09			
Total Sulfur	**ppm_w**	8.2	

11 ppm S = 0.0011 wt% S

Attachment F4 – TRC, Emissions Test Report Discoverer Shell Gulf of Mexico, Inc., July 27, 2012 – Discoverer Cementing Engines Summary

Table 2.8.2 –Overall Summary for NOx, NO_2, CO, VOC, & Sulfur Fuel Content

Discoverer - Cementing Unit (FD-16) *Caterpillar D343 - Serial # 8VA-7007*			
Test Identification	**Emissions Unit**	**80 to 100% Load**	**50 to 70% Load**
PROCESS DATA			
Power Output	**%**	87	68
Fuel Flow Rate	**gal/hr**	16.2	13.0
Mechanical Power Output	**kW**	217	169
	Test Date	3/28/2012	3/28/2012
EPA Methods 3A, 7E, 10, & 25A			
EPA Method 3A	**% O_2**	12.4	14.3
	% CO_2	6.5	5.4
NO_x (based on EPA Method 19 flow rates)	**ppm_{vd}**	1068.0	767.9
	lb/hr	6.334	4.895
	lb/gal	0.3902	0.3765
	g/kW-hr	13.26	13.15
	lb/kW-hr	0.02922	0.02900
NO_2 (based on EPA Method 19 flow rates)	**ppm_{vd}**	408.4	332.4
	lb/hr	2.421	2.118
	lb/gal	0.1492	0.1629
	g/kW-hr	5.068	5.691
	lb/kW-hr	0.01117	0.01255
CO (based on EPA Method 19 flow rates)	**ppm_{vd}**	---	4.3
	lb/hr	---	0.01668
	lb/gal	---	0.001283
	g/kW-hr	---	0.04483
	lb/kW-hr	---	0.00009884
VOC (based on EPA Method 19 flow rates)	**ppm_{vw}**	---	8.2
	lb/hr	---	0.01909
	lb/gal	---	0.001468
	g/kW-hr	---	0.05130
	lb/kW-hr	---	0.0001131
Total Sulfur - ASTM 5453-09			
Total Sulfur	**ppm_w**	11	

11 ppm S = 0.0011 wt% S

Table 2.9.2 –Overall Summary for NOx, NO2, CO, VOC, & Sulfur Fuel Content

Discoverer - Cementing Engine (FD-17) *Caterpillar D343 - Serial # 8VA-411871*			
Test Identification	**Emissions Unit**	**80 to 100% Load**	**50 to 70% Load**
PROCESS DATA			
Power Output	**%**	86	67
Fuel Flow Rate	**gal/hr**	16.1	12.7
Mechanical Power Output	**kW**	215	167
SAMPLING RESULTS			
	Test Date	4/7/2012	4/7/2012
EPA Methods 3A, 7E, 10, & 25A			
EPA Method 3A	**% O_2**	12.3	14.2
	% CO_2	6.1	4.9
NO_x (based on EPA Method 19 flow rates)	**ppm_{vd}**	1011.2	727.2
	lb/hr	5.895	4.279
	lb/gal	0.3654	0.3370
	g/kW-hr	12.42	11.66
	lb/kW-hr	0.02738	0.02570
NO_2 (based on EPA Method 19 flow rates)	**ppm_{vd}**	358.3	290.5
	lb/hr	2.089	1.709
	lb/gal	0.1295	0.1346
	g/kW-hr	4.401	4.655
	lb/kW-hr	0.009703	0.01026
CO (based on EPA Method 19 flow rates)	**ppm_{vd}**	---	0.0
	lb/hr	---	0.0
	lb/gal	---	0.0
	g/kW-hr	---	0.0
	lb/kW-hr	---	0.0
VOC (based on EPA Method 19 flow rates)	**ppm_{vw}**	---	0.7
	lb/hr	---	0.001443
	lb/gal	---	0.0001136
	g/kW-hr	---	0.003931
	lb/kW-hr	---	0.000008667
Total Sulfur - ASTM 5453-09			
Total Sulfur	**ppm_w**	11	

11 ppm S = 0.0011 wt% S

Attachment F5 – Discoverer Cranes: Liebherr Machines Bulle SA Emission Data

LIEBHERR

Liebherr Machines Bulle SA – P.O. Box 272

To whom it may concern

Liebherr Machines Bulle SA

Dieselmotoren
Diesel engines

Hydraulikkomponenten
Hydraulic components

enginecertification@liebherr.com
26 November 2012

Exhaust Emission Confirmation

The engine	D9508 A7
Code	V08M71008
Configuration	
Rated power [kW]	450
Rated speed [min^{-1}]	1900

has the following exhaust emission values (measured on an engine of the same type) made with American reference fuel :

	Measured value	USA-Standard
CO [g/kWh]	0,55	3,5
HC [g]/kWh]	0,08	-
NOX [g/kWh]	3,61	-
NOx+HC [g/kWh]	3,69	4,0
PM [g/kWh]	0,106	0,2

measured with the test procedure ISO 8178-4 C1. Therefore it complies with US-EPA/CARB 40 CFR, Tier 3

Liebherr Machines Bulle SA

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Attachment F6 – Caterpillar, C7 ACERT™ Industrial Engine, CAT® Engine Specifications, April 16, 2012

C7 ACERT™
Industrial Engine
Tier 3/Stage IIIA
224 bkW/300 bhp @ 2200 rpm

Image shown may not reflect actual engine

CAT® ENGINE SPECIFICATIONS

I-6, 4-Stroke-Cycle Diesel

Bore	110.0 mm (4.33 in)
Stroke	127.0 mm (5.0 in)
Displacement	7.2 L (442 in³)
Aspiration	Turbocharged ATAAC
Compression Ratio	17:1
Rotation (from flywheel end)	Counterclockwise
Lube Oil System (refill)	28 L (7.4 U.S. gal)
Weight, Net Dry (approximate kg, lb)	588 kg (1296 lbs)

FEATURES

Emissions
Meets U.S. EPA Tier 3, EU Stage IIIA emission requirements.

Worldwide Supplier Capability
Caterpillar
- Casts engine blocks and heads
- Machines critical components
- Assembles complete engine
- Factory-designed systems built at Caterpillar ISO 9001:2000 certified facilities
-Ownership of these manufacturing processes enables Caterpillar to produce high quality, dependable product.

Testing
Prototype testing on every model:
- proves computer design
- verifies system torsional stability
- functionality tests every model

Every Caterpillar engine is dynamometer tested under full load to ensure proper engine performance.

Full Range of Attachments
Wide range of bolt-on system expansion attachments, factory designed and tested.

Unmatched Product Support Offered Through Worldwide Caterpillar Dealer Network
More than 1,500 dealer outlets
Caterpillar factory-trained dealer technicians service every aspect of your industrial engine
99.7% of parts orders filled within 24 hours worldwide
Caterpillar parts and labor warranty
Preventive maintenance agreements available for repair before failure options

Scheduled Oil Sampling program matches your oil sample against Caterpillar set standards to determine:
- internal engine component condition
- presence of unwanted fluids
- presence of combustion by-products

Web Site
For all your industrial power requirements, visit www.cat-industrial.com.

STANDARD ENGINE EQUIPMENT

Air Inlet System

Air to air aftercooled (ATAAC)
Turbocharged

Control System

Electronic governing, PTO speed control
Programmable ratings
Cold mode start strategy
Automatic altitude compensation
Power compensation for fuel temperature
Programmable low and high idle and total engine limit
Electronic diagnostics and fault logging
Engine monitoring system
J1939 Broadcast (diagnostic and engine status)
ADEM™ A4 Electronic Control Unit (ECU)

Cooling System

Thermostats and housing, vertical outlet
Jacket water pump, centrifugal
Water pump, inlet

Exhaust System

Exhaust manifold, dry
Optional exhaust outlet

Flywheels and Flywheel Housing

SAE No. 1 Flywheel housing

Fuel System

HEUI™ injection
Fuel filter, secondary (2 micron high performance)
Fuel transfer pump
Fuel priming pump
ACERT™ Technology

Lube System

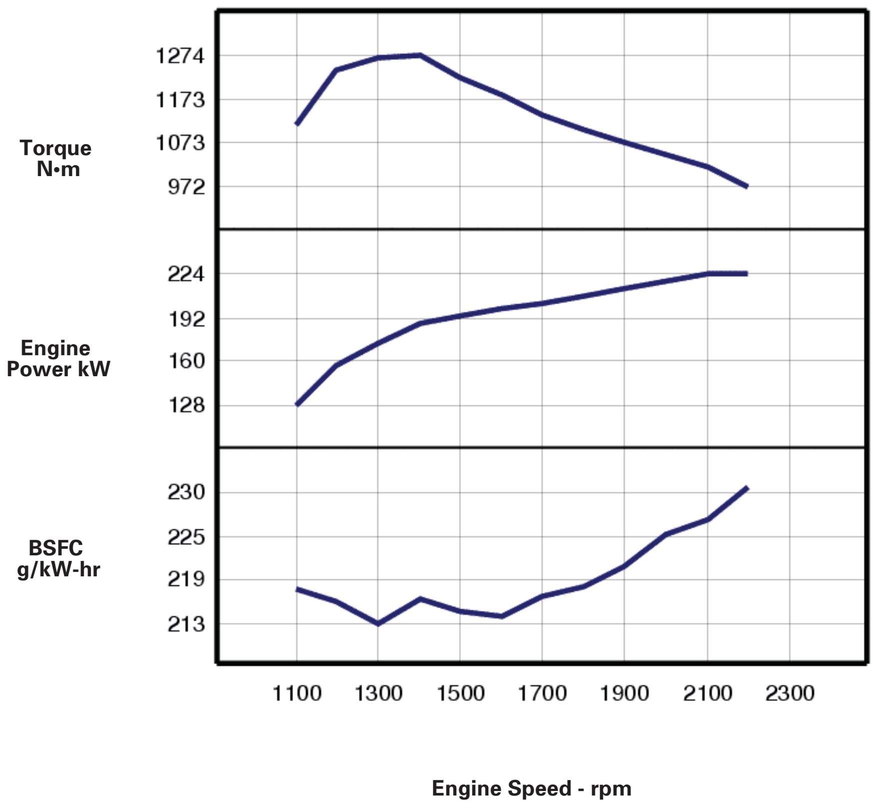
Crankcase breather
Oil cooler
Oil filler
Oil filter
Oil pan front sump
Oil dipstick
Oil pump (gear driven)

General

Paint, Caterpillar Yellow
Vibration damper
Lifting eyes

PERFORMANCE CURVES

IND - D - DM9223-02



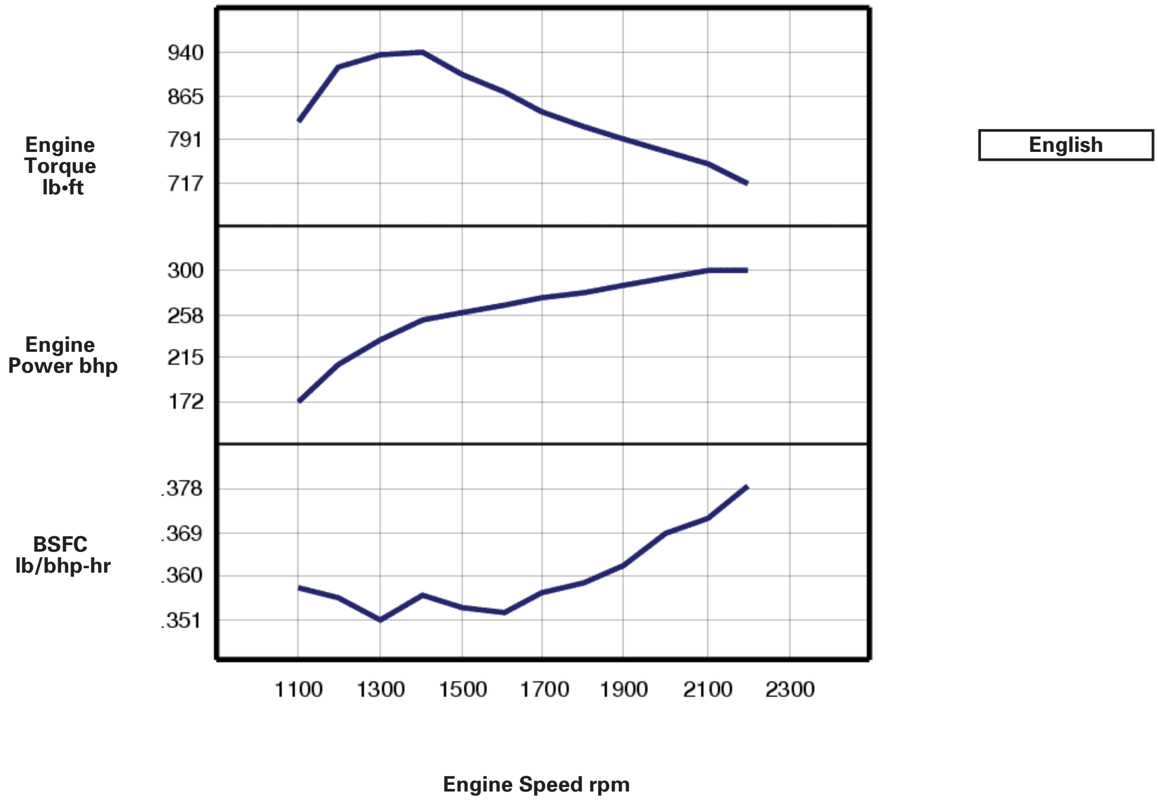
Metric

Engine Speed rpm	Engine Power kW	Torque N•m	BSFC g/kW-hr	Fuel Rate L/hr
2200	224	972	230.1	61.5
2100	224	1019	226.3	60.4
2000	219	1043	224.3	58.4
1900	213	1072	220.3	56.0
1800	208	1104	218	54.1
1700	203	1139	216.7	52.4
1600	198	1184	214.4	50.7
1500	192	1225	214.9	49.3
1400	187	1274	216.4	48.2
1300	173	1271	213.4	44.0
1200	156	1240	216.1	40.1
1100	128	1113	217.6	33.3

C7 ACERT™
Industrial Engine
Tier 3/Stage IIIA
224 bkW/300 bhp @ 2200 rpm

PERFORMANCE CURVES

IND - D - DM9223-02



Engine Speed rpm	Engine Power bhp	Engine Torque lb•ft	BSFC lb/bhp-hr	Fuel Rate gal/hr
2200	300	717	.378	16.2
2100	300	752	.372	16.0
2000	293	769	.369	15.4
1900	286	791	.362	14.8
1800	279	814	.358	14.3
1700	272	840	.356	13.8
1600	266	873	.352	13.4
1500	258	904	.353	13.0
1400	251	940	.356	12.7
1300	232	937	.351	11.6
1200	209	915	.355	10.6
1100	172	821	.358	8.8

C7 ACERT™ Industrial Engine

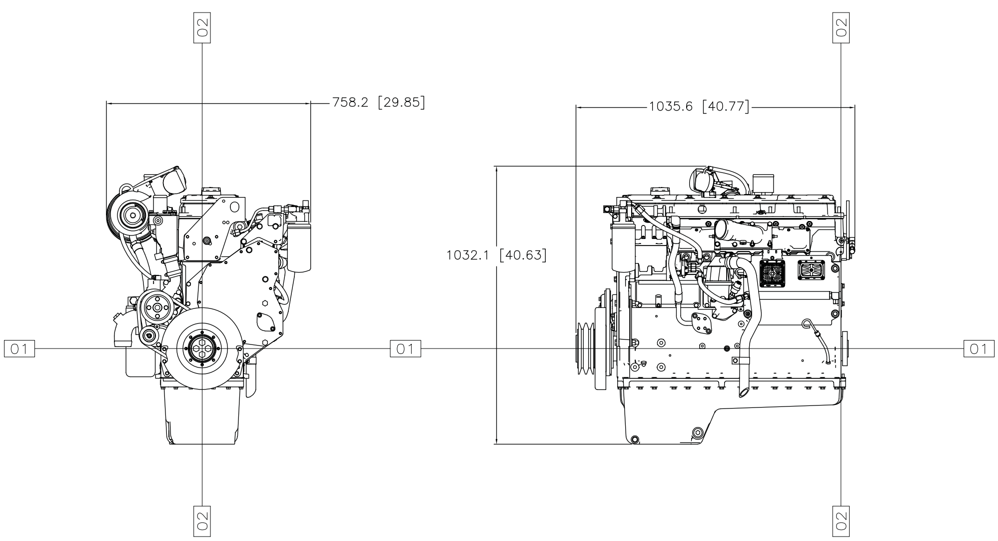
Tier 3/Stage IIIA

224 bkW/300 bhp @ 2200 rpm

RATINGS AND CONDITIONS

IND - D For service where maximum power is required for periodic overloads.

Engine Performance Diesel Engines — 7 liter and higher All rating conditions are based on SAE J1995, inlet air standard conditions of 99 kPa (29.31 in. Hg) dry barometer and 25ºC (77ºF) temperature. Performance measured using a standard fuel with fuel gravity of 35° API having a lower heating value of 42,780 kJ/kg (18,390 btu/lb) when used at 29° C (84.2° F) with a density of 838.9 g/L.



Engine Dimensions	
(1) Length	1052.7 mm (41.44 in)
(2) Width	758.2 mm (29.85 in)
(3) Height	1032.1 mm (40.63 in)

Note: Do not use for installation design. See general dimension drawings for detail (Drawing # 2835788).

Performance Number: DM9223-02

Feature Code: C07DI02 Arr. Number: 2666731

Materials and specifications are subject to change without notice.

16302763

The International System of Units (SI) is used in this publication.

Attachment F7 – Detroit Diesel Corporation, 4-71 Marine Engine Specification Data and Engine Performance Curve, June 29, 1989

Engine Specification Data

General Data

Model	1042-3000,5000
Number of Cylinders	4
Bore and Stroke-in (mm)	4.25x5.00 (108x127)
Displacement-in³ (L)	284 (4.66)
Compression Ratio	18.7:1
Piston Speed-ft/min (m/min)	1750 (533)
Valves Per Cylinder	
Intake	Not Applicable
Exhaust	4
Combustion System	Direct Injection
Engine Type	Inline - 2 Cycle
Aspiration	Natural

Configuration

Turbocharger	Not Applicable
Charge Air Cooling System	None
Blower Type	Standard
Blower Drive Ratio	2.05:1
Low Idle Speed-r/min	550
Max. No Load Speed-r/min	2250
Thrust Bearing Load Limit	
Continuous-lbf(n)	400 (1780)
Intermittent-lbf(n)	1200 (5340)
Engine Crankcase Vent System	Open
Maximum Pressure-in H_2O (kPa)	1.9 (0.47)

Physical Data

Size	
Length-in (mm)	58.0 (1473)
Width-in (mm)	35.0 (889)
Height-in (mm)	41.0 (1041)
Weight, dry-lb (kg)	2275 (1032)
Weight, wet-lb (kg)	2367 (1074)
Center of Gravity Distance	
From R.F.O.B. (x axis)-in (mm)	Not Available
Above Crankshaft (y axis)-in (mm)	Not Available
Right of Output Shaft (z axis)-in (mm)	Not Available
Installation Drawing	5171088

Marine Gear

Type	Allison M20
Reduction Ratios	2.05:1
Lube Oil Capacity approx. (Does not include heat exchanger & connections used externally)-pts (litre)	12 (5.7)
(Marine gear must use straight viscosity oil)	

Fuel System

Fuel Injector/Timing	N60/1.460
Fuel Injection Pump/Timing	Not Applicable
Fuel Consumption-lb/hr (kg/hr)	53.8 (24.4)
Fuel Consumption-gal/hr (L/hr)	7.6 (28.6)
Fuel Spill Rate-lb/hr (kg/hr)	506 (230)
Fuel Spill Rate-gal/hr (L/hr)	71.2 (270)
Total Fuel Flow-lb/hr (kg/hr)	560 (254)
Total Fuel Flow-gal/hr (L/hr)	78.8 (298)
Maximum Allowable Fuel Pump Suction	
Clean System-in Hg (kPa)	6 (20)
Dirty System-in Hg (kPa)	12 (41)
Fuel Filter Micron Size	
Primary-Micron	30
Secondary-Micron	12
Recommended Supply Line Diameter in (mm)	0.5 (12.7)

Lubrication System

Oil Pressure	
Rated Speed-lbf/in² (kPa)	50 (345)
Low Idle-lbf/in² (kPa)	5 (34)
In Pan Oil Temperature-°F (°C)	200-235 (93-113)
Oil Flow-gal/min (L/min)	27 (102)
Oil Pan Capacity	
High-qt (L)	20 (18.9)
Low-qt (L)	15 (14.2)
Total Engine Oil Capacity with filters-qt (L)	22 (20.8)
Bypass Oil Filter Orifice-in (mm)	0.062 (1.57)
Maximum Installation Angle	16°

Emission Data

CO-gm/hr	1030
HC-gm/hr	60
NO_x-gm/hr	1550
SO_2-gm/hr	245
Smoke-Bosch Number	1.5
Noise-dB (A) @ 1m	101

Ref.: E4PR-1041-52-1

All values at rated speed and power with standard engine hardware unless otherwise noted.

Cooling System

Engine Heat Rejection-Btu/min (kW)	4540 (79.8)
Engine Radiated Heat-Btu/min (kW)	790 (13.9)
Fresh Water Flow-gal/min (L/min)	57.5 (218)
Raw Water Flow-gal/min (L/min)	47.0 (254)
Thermostat	
Start to Open-°F (°C)	173 (78)
Fully Open-°F (°C)	186 (86)
Maximum Water Pump Inlet Restriction	
Fresh Water-in Hg (kPa)	3.0 (10.2)
Raw Water-in Hg (kPa)	5.0 (17.0)
Max. Raw Water Pump Pressure lbf/in² (kPa)	10.0 (69.0)
Fresh Water Capacity-qt (L)	24 (22.7)
Minimum Pressure Cap-lbf/in² (kPa)	7.0 (48.3)
Maximum Coolant Pressure (Exclusive of Pressure Cap)-lbf/in² (kPa)	Not Available
Maximum Top Tank Temperature-°F (°C)	200 (93)
Minimum Top Tank Temperature-°F (°C)	160 (71)
Minimum Coolant Fill Rate-gal/min (L/min)	3.0 (11.4)
Suggested Raw Water Pipe Size in (mm)	2.5 (63.5)
Suggested Sea Strainer Size	
Simplex-in (mm)	3.0 (76)
Duplex-in (mm)	4.0 (102)
Maximum Pressure Drop thru Keel Cooler lbf/in² (kPa)	2.5 (17.2)

Air System

Maximum Allowable Temperature Rise (Outside Air to Engine Inlet)-°F (°C)	30 (16.7)
Air Intake Restriction Maximum Limit	
Dirty Air Cleaner-in H_2O (kPa)	25 (6.2)
Clean Air Cleaner-in H_2O (kPa)	16 (4.0)
Engine Air Flow-ft³/min (m³/min)	440 (12.5)
Engine Air Box/Manifold Pressure-in Hg (kPa)	10.0 (33.8)
Recommended Intake Pipe Dia.-in (mm)	5.0 (127)
Suggested Min. Engine Room Vent Area in² (cm²)	
Max. Engine Room Depression 0.2 in H_2O	42 (273)

Exhaust System

Exhaust Flow-ft³/min (m³/min)	1020 (28.9)
Exhaust Temperature-°F (°C)	790 (421)
Maximum Allowable Back Pressure-in Hg (kPa)	4.5 (15.2)
Recommended Exhaust Pipe Dia.	
Single-in (mm)	3.5 (89)
Dual-in (mm)	Not Applicable

Electrical System

Recommended Battery Capacity (CCA @ 0°F)	
12 Volt System	
Above 32°F (0°C)-A	950
Below 32°F (0°C)-A	1250
24 Volt System	
Above 32°F (0°C)-A	475
Below 32°F (0°C)-A	625
Maximum Allowable Resistance of Starting Circuit	
12 volt system-ohm	0.0012
24 volt system-ohm	0.002

Performance Data

Power Output-bhp (kW)	140 (204)
Power Output-shp (kW)	135 (101)
Rated Load Speed-r/min	2100
BMEP-lbf/in² (kPa)	93.1 (642)
Friction Power	
Rated Speed-fhp (kW)	56 (42)

Engine Speed r/min	Power bhp (kW)	Power shp (kW)	Fuel gal/hr (liter/hr)	BSFC lb/bhp hr (g/kW hr)
2100	140 (104)	133 (100)	7.7 (29.1)	.384 (234)
2000	137 (102)	130 (97)	7.5 (28.2)	.382 (232)
1800	128 (95.3)	122 (91)	6.9 (26.2)	.379 (231)
1500	110 (82.1)	105 (78)	6.1 (22.9)	.384 (234)
1200	89 (66.3)	85 (63)	5.1 (19.2)	.399 (242)

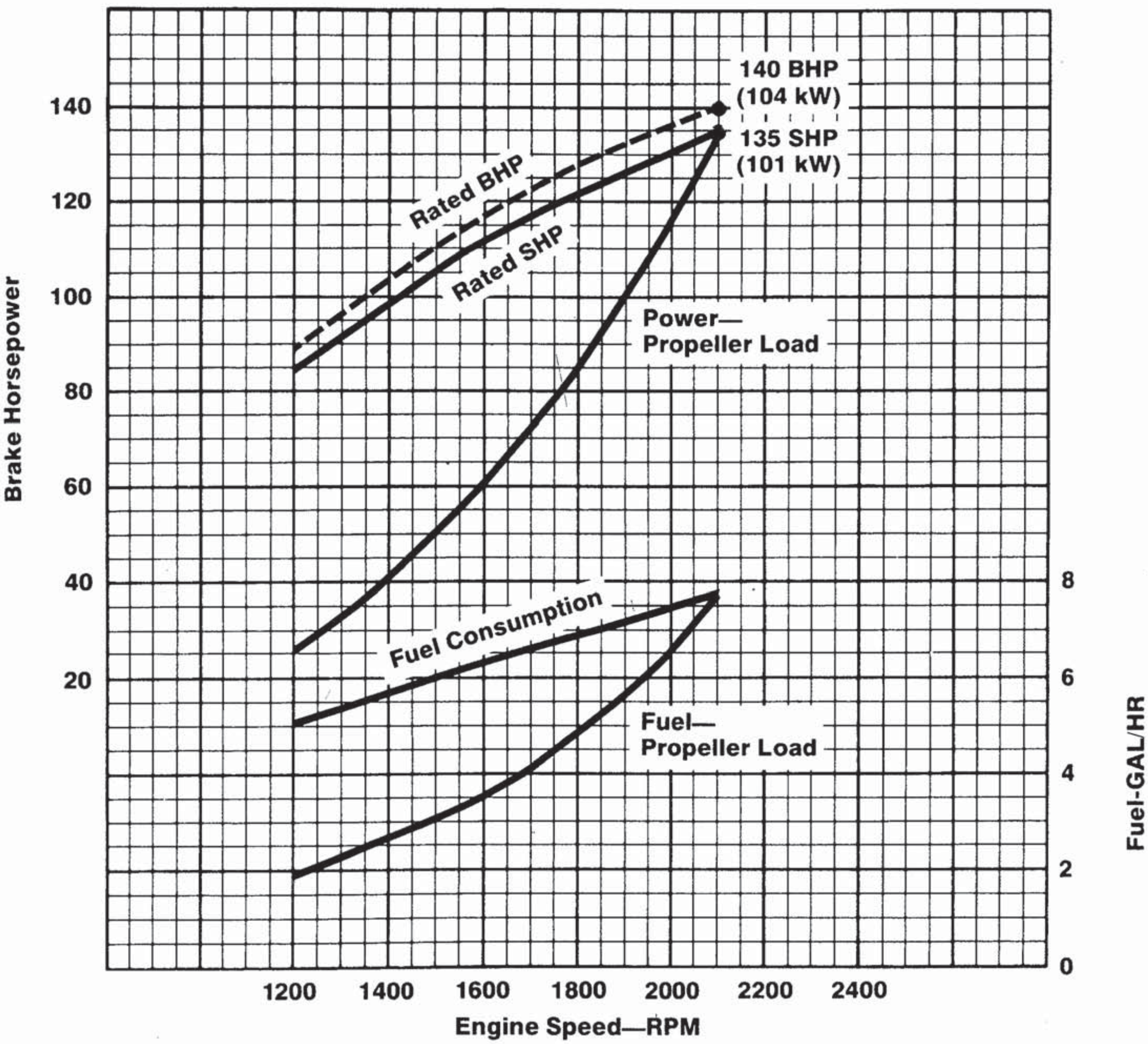
Engine Speed r/min	Prop Load shp (kW)	Prop Fuel gal/hr (liter/hr)	Prop BSFC lb/bhp hr (g/kw hr)
2100	135 (101)	7.7 (29.1)	.384 (234)
2000	117 (87)	6.6 (25.1)	.377 (229)
1800	85 (63)	4.9 (18.5)	.376 (229)
1500	49 (37)	3.0 (11.5)	.394 (239)
1200	25 (19)	1.8 (6.8)	.430 (262)

CURVE NO. E4-1042-52-3
DATE: 7-17-69
REV./DATE: 3/6-29-89
SHT. 2 OF 4

DETROIT DIESEL CORPORATION

4-71
Marine
Rating: Intermittent
140 BHP @ 2100 RPM
135 SHP @ 2100 RPM
Injector: N60

ENGINE PERFORMANCE CURVE



ACCESSORIES: ALLISON M GEAR, RAW WATER PUMP, ALTERNATOR 12V42A

Air Intake Restriction - in. H_2O (kPa) . . 10 (2.5) **Exhaust Back Pressure - in. H_2O (kPa) . . 15 (3.7)**

- Power output guaranteed within 5% at SAE J1228 conditions: 77°F (25°C) air inlet temperature; 29.31 in. Hg (99kPa) dry barometer; 100°F (39°C) fuel inlet temperature (.853 specific gravity at 60°F). Power rated in accordance with NMMA Procedure.
- Conversion factors: Power: kW = bhp × 0.746
  Fuel: L/hr = gal/hr × 3.785
- Values are derived from currently available data and subject to change without notice.

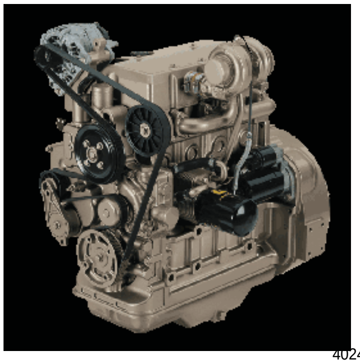
Certified by:

Curve No.
E4-1042-52-3
Date: 7-17-69
Rev./Date: 3/6-29-89
Sht. 1 of 4

Attachment F8 – John Deere, PowerTech 4024T Diesel Engine, 2012

PowerTech
4024T Diesel Engine

Industrial Engine Specifications

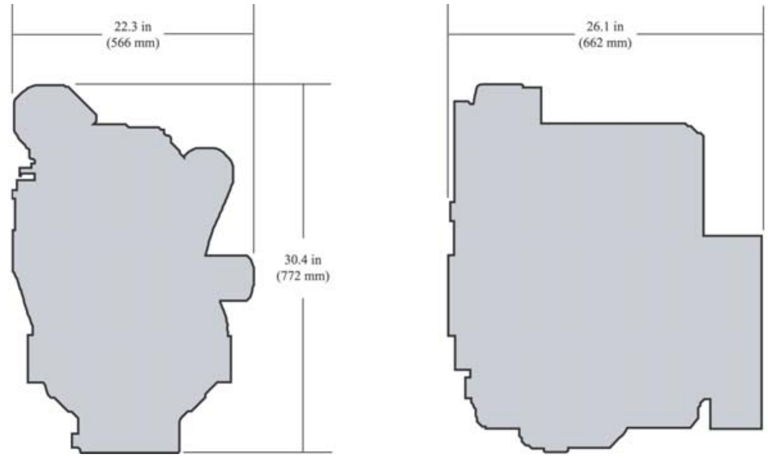


4024T shown

Certifications

CARB
EPA Tier 2
EU Stage II

Dimensions



General data

Model	4024TF270
Number of cylinders	4
Displacement - L (cu in)	2.44 (149)
Bore and Stroke-- mm (in)	86 x 105 (3.39 x 4.13)
Compression Ratio	20.5:1
Engine Type	In-line, 4-Cycle

Aspiration	Turbocharged
Length - mm (in)	662 (26.1)
Width - mm (in)	566 (22.3)
Height-- mm (in)	772 (30.4)
Weight, dry-- kg (lb)	251 (553)

Intermittent BHP is the power rating for variable speed and load applications where full power is required intermittently.

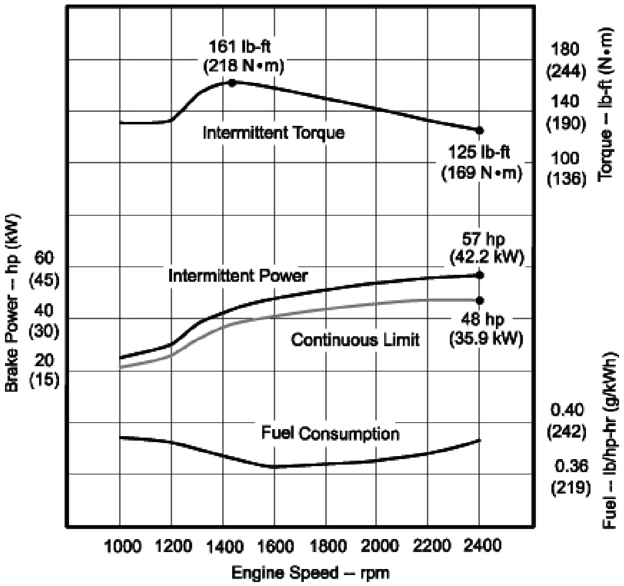
Heavy duty - see application ratings/definitions, engine performance curves.

Continuous BHP is the power rating for applications operating under a constant load and speed for long periods of time.

Power output is within + or - 5% at standard SAE J 1995 and ISO 3046.

Photographs may show non-standard equipment.

Performance curve



Performance data

Intermittent rated speed	42.2 kW (57 hp) @ 2400 rpm
Peak power	42 kW (56 hp) @ 2400 rpm
Peak torque	218 N.m (161 ft-lb) @ 1440 rpm
Torque rise %	30% @ 1440 rpm

Features and benefits

Optimized Gear Train

- Front gear train of two high-contact-ratio gears mounted to the block
- Impressive low noise characteristics

Poly-vee Front Drive

- Automatic belt-tensioner and 6 rib poly-vee drive belt minimizes maintenance and increases belt durability

Independent Fan Drive

- Fan drive operates independently of water pump and is available in two heights to adapt to enclosures
- Fan drive ratios above and below 1:1 are available to match specific application requirements

Hydraulic Valve Lifters

- Automatic adjustment eliminates the need for valve-lash adjustment, contributes to lower noise levels in the valve train
- Lowers operating costs

Multiple-Function Component Integration

- Timing gear cover includes water pump housing, oil pump housing, governor housing and sensors
- Rocker arm cover includes intake manifold
- Integration results in higher quality, easier service, and reliability

Independent Water Pump

- Durable cast-iron water pump resists corrosion and pitting for increased wear life

Smooth Engine Operation

- Optional balancer shafts located inside the engine block with two bearings per shaft
- Decreased vibration reduces operator fatigue and need for instrument and control isolation

Starting Aids

- Quick acting glow plugs are standard equipment and provide exceptional cold weather starting at temperatures as low as -15 degrees Fahrenheit
- Optional block heater is available

Innovative Fuel System

- Contributes to cost effectiveness and clean design
- Mechanically governed unit pumps mounted inside the block eliminate external high-pressure lines, minimize leak paths and reduce noise level

John Deere Power Systems
3801 W. Ridgeway Ave.
PO Box 5100
Waterloo, IA 50704-5100
Phone: 1-800-533-6446
Fax : 319.292.5075

John Deere Power Systems
Usine de Saran
La Foulonnerie - B.P. 11.13
45401 Fleury les Aubrais Cedex
France
Phone: 33.2.38.82.61.19
Fax: 33.2.38.82.60.00

All values at rated speed and power with standard options unless otherwise noted. Specifications and design subject to change without notice.

Attachment F9 – The Avogadro Group, LLC, Source Test Report 2012 Emission Compliance Tests Noble Discoverer Drillship, July 27, 2012 – Discoverer Boilers Summary

TABLE 1-32
FD-21, 22 AT 50% LOAD: CO AND VOC
NOBLE DISCOVERER DRILLSHIP

Parameter	FD-21	FD-22	Permit Limit
Process Data:			
Heat input, MMBtu/hr	4.4	3.9	--
Flue Gas:			
O_2, % volume dry	7.31	9.34	--
CO_2, % volume dry	10.13	8.60	--
Moisture, % by volume	8.93	8.02	--
Stack temperature, °F	346.7	284.8	--
Flow rate, dscfm	1,035	1,112	--
CO Emissions:			
ppm volume dry	7.86	7.08	--
lb/hr	0.035	0.034	--
lb/day	0.852	0.821	--
lb/MMBtu	0.0082	0.0086	0.0770
lb/gallon	0.0011	0.0012	--
VOC Emissions:			
ppm volume dry as C_3H_8	0.24	0.40	--
lb/hr as C	0.001	0.003	--
lb/day as C	0.034	0.060	--
lb/MMBtu as C	0.0003	0.0006	0.00140
lb/gallon as C	0.00004	0.00009	--

Note: VOC results have been reported as actual values instead of the Avogadro-defined detection limit of 2% of the span of the analyzer.

TABLE 1-33
FD-21, 22 AT 50% LOAD: NO_2 AND NO_X
NOBLE DISCOVERER DRILLSHIP

Parameter	FD-21	FD-22	Permit Limit
Process Data:			
Heat input, MMBtu/hr	4.4	3.9	--
Flue Gas:			
O_2, % volume dry	7.31	9.34	--
CO_2, % volume dry	10.13	8.60	--
Moisture, % by volume	8.93	8.02	--
Stack temperature, °F	346.7	284.8	--
Flow rate, dscfm	1,035	1,112	--
NO_2 Emissions:			
ppm volume dry	5.810	2.727	--
lb/hr	0.043	0.022	--
lb/day	1.03	0.52	--
lb/MMBtu	0.0100	0.0055	--
lb/gallon	0.0013	0.0008	--
NO_X Emissions:			
ppm volume dry	87.54	65.85	--
lb/hr	0.649	0.524	--
lb/day	15.58	12.59	--
lb/MMBtu	0.1504	0.1326	0.20*
lb/gallon	0.0201	0.0186	--

Note: *This is the limit for each boiler individually.

TABLE 1-34
FD-21, 22 AT 50% LOAD: PM/PM_{10}/$PM_{2.5}$ FRACTIONS
NOBLE DISCOVERER DRILLSHIP

Parameter	FD-21	FD-22	Permit Limit
Unit Data:			
Heat input, MMBtu/hr	4.4	3.9	--
Flue Gas:			
O_2, % volume dry	7.31	9.34	--
CO_2, % volume dry	10.13	8.60	--
Moisture, % by volume	8.93	8.02	--
Stack temperature, °F	346.7	284.8	--
Flow rate, dscfm	1,035	1,112	--
Filterable PM/PM_{10}/$PM_{2.5}$:			
gr/dscf	0.0002	0.0003	--
lb/hr	0.002	0.002	--
lb/day	0.048	0.059	--
lb/MMBtu	0.0005	0.0006	--
lb/gallon	0.0001	0.0001	--
Condensable PM/PM_{10}/$PM_{2.5}$:			
gr/dscf	0.0004	0.0004	--
lb/hr	0.004	0.004	--
lb/day	0.087	0.095	--
lb/MMBtu	0.0008	0.0010	--
lb/gallon	0.0001	0.0001	--

TABLE 1-35
FD-21, 22 AT 50% LOAD: PM/PM_{10}/$PM_{2.5}$ AND OPACITY
NOBLE DISCOVERER DRILLSHIP

Parameter	FD-21	FD-22	Permit Limit
Unit Data:			
Heat input, MMBtu/hr	4.4	3.9	--
Flue Gas:			
O_2, % volume dry	7.31	9.34	--
CO_2, % volume dry	10.13	8.60	--
Moisture, % by volume	8.93	8.02	--
Stack temperature, °F	346.7	284.8	--
Flow rate, dscfm	1,035	1,112	--
Total PM/PM_{10}/$PM_{2.5}$:			
gr/dscf	0.0006	0.0007	--
lb/hr	0.006	0.006	--
lb/day	0.136	0.154	--
lb/MMBtu	0.0013	0.0016	0.0235*
lb/gallon	0.0002	0.0002	--
Visible Emissions:			
opacity, %	0	0	20

Note: *This is the limit for each boiler individually.

TABLE 1-36
FD-21, 22 AT 100% LOAD: CO AND VOC
NOBLE DISCOVERER DRILLSHIP

Parameter	FD-21	FD-22	Permit Limit
Process Data:			
Heat input, MMBtu/hr	7.1	7.0	--
Flue Gas:			
O_2, % volume dry	6.79	7.91	--
CO_2, % volume dry	10.52	9.49	--
Moisture, % by volume	8.83	8.93	--
Stack temperature, °F	445.9	424.1	--
Flow rate, dscfm	1,732	1,878	--
CO Emissions:			
ppm volume dry	17.15	29.31	--
lb/hr	0.130	0.240	--
lb/day	3.108	5.759	--
lb/MMBtu	0.0173	0.0320	0.0770
lb/gallon	0.0025	0.0047	--
VOC Emissions:			
ppm volume dry as C_3H_8	0.51	0.55	--
lb/hr as C	0.005	0.006	--
lb/day as C	0.120	0.139	--
lb/MMBtu as C	0.0007	0.0008	0.00140
lb/gallon as C	0.00010	0.00011	--

Note: VOC results have been reported as actual values instead of the Avogadro-defined detection limit of 2% of the span of the analyzer.

TABLE 1-37
FD-21, 22 AT 100% LOAD: NO_2 AND NO_X
NOBLE DISCOVERER DRILLSHIP

Parameter	FD-21	FD-22	Permit Limit
Process Data:			
Heat input, MMBtu/hr	7.1	7.0	--
Flue Gas:			
O_2, % volume dry	6.79	7.91	--
CO_2, % volume dry	10.52	9.49	--
Moisture, % by volume	8.83	8.93	--
Stack temperature, °F	445.9	424.1	--
Flow rate, dscfm	1,732	1,878	--
NO_2 Emissions:			
ppm volume dry	6.850	2.780	--
lb/hr	0.085	0.037	--
lb/day	2.04	0.90	--
lb/MMBtu	0.0113	0.0050	--
lb/gallon	0.0016	0.0007	--
NO_X Emissions:			
ppm volume dry	95.87	81.69	--
lb/hr	1.190	1.099	--
lb/day	28.55	26.37	--
lb/MMBtu	0.1586	0.1464	0.20*
lb/gallon	0.0230	0.0214	--

Note: *This is the limit for each boiler individually.

TABLE 1-38
FD-21, 22 AT 100% LOAD: $PM/PM_{10}/PM_{2.5}$ FRACTIONS
NOBLE DISCOVERER DRILLSHIP

Parameter	FD-21	FD-22	Permit Limit
Unit Data:			
Heat input, MMBtu/hr	7.1	7.0	--
Flue Gas:			
O_2, % volume dry	6.79	7.91	--
CO_2, % volume dry	10.52	9.49	--
Moisture, % by volume	8.83	8.93	--
Stack temperature, °F	445.9	424.1	--
Flow rate, dscfm	1,732	1,878	--
Filterable $PM/PM_{10}/PM_{2.5}$:			
gr/dscf	0.0010	0.0009	--
lb/hr	0.015	0.014	--
lb/day	0.351	0.346	--
lb/MMBtu	0.0019	0.002	--
lb/gallon	0.0003	0.0003	--
Condensable $PM/PM_{10}/PM_{2.5}$:			
gr/dscf	0.0003	0.0003	--
lb/hr	0.004	0.005	--
lb/day	0.091	0.120	--
lb/MMBtu	0.0005	0.001	--
lb/gallon	0.0001	0.0001	--

TABLE 1-39
FD-21, 22 AT 100% LOAD: PM/PM_{10}/$PM_{2.5}$ AND OPACITY
NOBLE DISCOVERER DRILLSHIP

Parameter	FD-21	FD-22	Permit Limit
Unit Data:			
Heat input, MMBtu/hr	7.1	7.0	--
Flue Gas:			
O_2, % volume dry	6.79	7.91	--
CO_2, % volume dry	10.52	9.49	--
Moisture, % by volume	8.83	8.93	--
Stack temperature, °F	445.9	424.1	--
Flow rate, dscfm	1,732	1,878	--
Total PM/PM_{10}/$PM_{2.5}$:			
gr/dscf	0.0012	0.0012	--
lb/hr	0.018	0.019	--
lb/day	0.442	0.466	--
lb/MMBtu	0.0024	0.003	0.0235*
lb/gallon	0.0004	0.0004	--
Visible Emissions:			
opacity, %	0	0	20

Note: *This is the limit for each boiler individually.

TABLE 1-40
HEAT BOILERS: AGREGATE LIMITS
NOBLE DISCOVERER DRILLSHIP

Parameter	50% Load*	100% Load*	Permit Limit
NO_X Emissions:			
lb/hr	1.173	2.289	3.19**
lb/day	28.17	54.92	--
lb/MMBtu	0.283	0.305	--
lb/gallon	0.0387	0.0444	--
Total $PM/PM_{10}/PM_{2.5}$:			
lb/hr	0.012	0.037	--
lb/day	0.290	0.908	8.99**
lb/MMBtu	0.0033	0.0054	--
lb/gallon	0.0004	0.0008	--

Note: * These columns are the sum of the average emissions from both Heat Boilers FD-21 and FD-22 at each specified load setting.

**Limit for all Heat Boiler units (FD-21 and FD-22) in aggregate.

6.7 BOILER FD-21 INDIVIDUAL TEST RUN RESULTS

TABLE 6-91
FD-21 AT 50% LOAD: CO AND VOC
NOBLE DISCOVERER DRILLSHIP

Test No.:	Run 1	Run 2	Run 3	Averages
Date:	6/10/12	6/10/12	6/10/12	--
Time:	1250-1357	1417-1520	1544-1646	--
Process Data:				
Heat input, MMBtu/hr	4.3	4.5	4.5	4.4
Flue Gas:				
O_2, % volume dry	7.47	7.26	7.20	7.31
CO_2, % volume dry	10.20	10.00	10.19	10.13
Moisture, % by volume	8.77	9.35	8.67	8.93
Flue gas temperature, °F	342.3	344.6	353.3	346.7
Volumetric flow rate, dscfm	1,027	1,043	1,036	1,035
CO Emissions:				
ppm volume dry	7.60	7.99	7.99	7.86
lb/hr	0.034	0.036	0.036	0.035
lb/day	0.817	0.872	0.866	0.852
lb/MMBtu	0.0080	0.0083	0.0083	0.0082
lb/gallon	0.0011	0.0011	0.0011	0.0011
VOC Emissions:				
ppm volume dry as C_3H_8	0.37	0.13	0.23	0.24
lb/hr as C	0.002	0.001	0.001	0.001
lb/day as C	0.052	0.018	0.032	0.034
lb/MMBtu as C	0.0005	0.0002	0.0003	0.0003
lb/gallon as C	0.00007	0.00002	0.00004	0.00004

Note: VOC results have been reported as actual values instead of the Avogadro-defined detection limit of 2% of the span of the analyzer.

TABLE 6-92
FD-21 AT 50% LOAD: NO_2 AND NO_X
NOBLE DISCOVERER DRILLSHIP

Test No.:	Run 1	Run 2	Run 3	Averages
Date:	6/10/12	6/10/12	6/10/12	--
Time:	1250-1357	1417-1520	1544-1646	--
Process Data:				
Heat input, MMBtu/hr	4.3	4.5	4.5	4.4
Flue Gas:				
O_2, % volume dry	7.47	7.26	7.20	7.31
CO_2, % volume dry	10.20	10.00	10.19	10.13
Moisture, % by volume	8.77	9.35	8.67	8.93
Flue gas temperature, °F	342.3	344.6	353.3	346.7
Volumetric flow rate, dscfm	1,027	1,043	1,036	1,035
NO_2 Emissions:				
ppm volume dry	4.900	6.480	6.050	5.810
lb/hr	0.036	0.048	0.045	0.043
lb/day	0.87	1.16	1.08	1.03
lb/MMBtu	0.0085	0.0111	0.0103	0.0100
lb/gallon	0.0012	0.0015	0.0014	0.0013
NO_X Emissions:				
ppm volume dry	86.98	88.08	87.55	87.54
lb/hr	0.640	0.658	0.650	0.649
lb/day	15.36	15.79	15.60	15.58
lb/MMBtu	0.1512	0.1507	0.1492	0.1504
lb/gallon	0.0207	0.0200	0.0197	0.0201

TABLE 6-93
FD-21 AT 50% LOAD: PM/PM_{10}/$PM_{2.5}$ FRACTIONS
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/10/12	6/10/12	6/10/12	--
Time:	1250-1357	1417-1520	1544-1646	--
Process Data:				
Heat input, MMBtu/hr	4.3	4.5	4.5	4.4
Flue Gas:				
O_2, % volume dry	7.47	7.26	7.20	7.31
CO_2, % volume dry	10.20	10.00	10.19	10.13
Moisture, % by volume	8.77	9.35	8.67	8.93
Flue gas temperature, °F	342.3	344.6	353.3	346.7
Volumetric flow rate, dscfm	1,027	1,043	1,036	1,035
Filterable PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	*0.0002*	*0.0002*	0.0002	0.0002
lb/hr	*0.002*	*0.002*	0.002	0.002
lb/day	*0.047*	*0.046*	0.053	0.048
lb/MMBtu	*0.0005*	*0.0004*	0.0005	0.0005
lb/gallon	*0.0001*	*0.0001*	0.0001	0.0001
Condensable PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	0.0005	0.0005	0.0003	0.0004
lb/hr	0.004	0.004	0.002	0.004
lb/day	0.103	0.106	0.053	0.087
lb/MMBtu	0.0010	0.0010	0.0005	0.0008
lb/gallon	0.0001	0.0001	0.0001	0.0001

Note: Results presented in italics were measured at or below the detection limit and are reported at the detection limit. This approach is not required by the cited test methods, but serves as a conservative reporting method for near-zero results.

TABLE 6-94
FD-21 AT 50% LOAD: $PM/PM_{10}/PM_{2.5}$ AND OPACITY
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/10/12	6/10/12	6/10/12	--
Time:	1250-1357	1417-1520	1544-1646	--
Process Data:				
Heat input, MMBtu/hr	4.3	4.5	4.5	4.4
Flue Gas:				
O_2, % volume dry	7.47	7.26	7.20	7.31
CO_2, % volume dry	10.20	10.00	10.19	10.13
Moisture, % by volume	8.77	9.35	8.67	8.93
Flue gas temperature, °F	342.3	344.6	353.3	346.7
Volumetric flow rate, dscfm	1,027	1,043	1,036	1,035
Total $PM/PM_{10}/PM_{2.5}$:				
gr/dscf	0.0007	0.0007	0.0005	0.0006
lb/hr	0.006	0.006	0.004	0.006
lb/day	0.150	0.152	0.106	0.136
lb/MMBtu	0.0015	0.0015	0.0010	0.0013
lb/gallon	0.0002	0.0002	0.0001	0.0002
Visible Emissions:				
opacity, %	0	0	0	0

TABLE 6-95
FD-21 AT 100% LOAD: CO AND VOC
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/10/12	6/10/12	6/10/12	--
Time:	0806-0908	0930-1032	1059-1202	--
Process Data:				
Heat input, MMBtu/hr	7.1	7.2	7.1	7.1
Flue Gas:				
O_2, % volume dry	6.77	6.80	6.81	6.79
CO_2, % volume dry	10.44	10.47	10.65	10.52
Moisture, % by volume	8.71	8.47	9.30	8.83
Flue gas temperature, °F	429.8	453.5	454.5	445.9
Volumetric flow rate, dscfm	1,749	1,748	1,698	1,732
CO Emissions:				
ppm volume dry	17.26	17.15	17.03	17.15
lb/hr	0.132	0.131	0.126	0.130
lb/day	3.161	3.139	3.026	3.108
lb/MMBtu	0.0174	0.0173	0.0172	0.0173
lb/gallon	0.0026	0.0025	0.0024	0.0025
VOC Emissions:				
ppm volume dry as C_3H_8	1.10	0.15	0.28	0.51
lb/hr as C	0.011	0.002	0.003	0.005
lb/day as C	0.259	0.036	0.065	0.120
lb/MMBtu as C	0.0014	0.0002	0.0004	0.0007
lb/gallon as C	0.00021	0.00003	0.00005	0.00010

Note: VOC results have been reported as actual values instead of the Avogadro-defined detection limit of 2% of the span of the analyzer.

TABLE 6-96
FD-21 AT 100% LOAD: NO_2 AND NO_X
NOBLE DISCOVERER DRILLSHIP

Test No.:	Run 1	Run 2	Run 3	Averages
Date:	6/10/12	6/10/12	6/10/12	--
Time:	0806-0908	0930-1032	1059-1202	--
Process Data:				
Heat input, MMBtu/hr	7.1	7.2	7.1	7.1
Flue Gas:				
O_2, % volume dry	6.77	6.80	6.81	6.79
CO_2, % volume dry	10.44	10.47	10.65	10.52
Moisture, % by volume	8.71	8.47	9.30	8.83
Flue gas temperature, °F	429.8	453.5	454.5	445.9
Volumetric flow rate, dscfm	1,749	1,748	1,698	1,732
NO_2 Emissions:				
ppm volume dry	9.420	5.620	5.510	6.850
lb/hr	0.118	0.070	0.067	0.085
lb/day	2.83	1.69	1.61	2.04
lb/MMBtu	0.0156	0.0093	0.0091	0.0113
lb/gallon	0.0023	0.0013	0.0013	0.0016
NO_X Emissions:				
ppm volume dry	95.87	95.96	95.79	95.87
lb/hr	1.202	1.202	1.165	1.190
lb/day	28.84	28.85	27.96	28.55
lb/MMBtu	0.1584	0.1589	0.1587	0.1586
lb/gallon	0.0234	0.0230	0.0225	0.0230

TABLE 6-97
FD-21 AT 100% LOAD: PM/PM_{10}/$PM_{2.5}$ FRACTIONS
SHELL DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/10/12	6/10/12	6/10/12	--
Time:	0806-0908	0930-1032	1059-1202	--
Process Data:				
Heat input, MMBtu/hr	7.1	7.2	7.1	7.1
Flue Gas:				
O_2, % volume dry	6.77	6.80	6.81	6.79
CO_2, % volume dry	10.44	10.47	10.65	10.52
Moisture, % by volume	8.71	8.47	9.30	8.83
Flue gas temperature, °F	429.8	453.5	454.5	445.9
Volumetric flow rate, dscfm	1,749	1,748	1,698	1,732
Filterable PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	0.0020	0.0004	0.0005	0.0010
lb/hr	0.030	0.006	0.008	0.015
lb/day	0.728	0.133	0.191	0.351
lb/MMBtu	0.0040	0.0007	0.0011	0.0019
lb/gallon	0.0006	0.0001	0.0002	0.0003
Condensable PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	0.0003	0.0002	0.0002	0.0003
lb/hr	0.004	0.003	0.004	0.004
lb/day	0.104	0.082	0.087	0.091
lb/MMBtu	0.0006	0.0005	0.0005	0.0005
lb/gallon	0.0001	0.0001	0.0001	0.0001

TABLE 6-98
FD-21 AT 100% LOAD: PM/PM_{10}/$PM_{2.5}$ AND OPACITY
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/10/12	6/10/12	6/10/12	--
Time:	0806-0908	0930-1032	1059-1202	--
Process Data:				
Heat input, MMBtu/hr	7.1	7.2	7.1	7.1
Flue Gas:				
O_2, % volume dry	6.77	6.80	6.81	6.79
CO_2, % volume dry	10.44	10.47	10.65	10.52
Moisture, % by volume	8.71	8.47	9.30	8.83
Flue gas temperature, °F	429.8	453.5	454.5	445.9
Volumetric flow rate, dscfm	1,749	1,748	1,698	1,732
Total PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	0.0023	0.0006	0.0008	0.0012
lb/hr	0.035	0.009	0.012	0.018
lb/day	0.832	0.215	0.278	0.442
lb/MMBtu	0.0046	0.0012	0.0016	0.0024
lb/gallon	0.0007	0.0002	0.0002	0.0004
Visible Emissions:				
opacity, %	0	0	0	0

6.8 BOILER FD-22 INDIVIDUAL TEST RUN RESULTS

TABLE 6-99
FD-22 AT 50% LOAD: CO AND VOC
NOBLE DISCOVERER DRILLSHIP

Test No.:	Run 1	Run 2	Run 3	Averages
Date:	6/10/12	6/10/12	6/11/12	--
Time:	1722-1824	1913-2015	0731-0833	--
Process Data:				
Heat input, MMBtu/hr	4.0	3.8	3.8	3.9
Flue Gas:				
O_2, % volume dry	8.90	9.54	9.58	9.34
CO_2, % volume dry	9.02	8.32	8.45	8.60
Moisture, % by volume	8.18	7.75	8.14	8.02
Flue gas temperature, °F	273.1	287.1	294.1	284.8
Volumetric flow rate, dscfm	1,082	1,093	1,161	1,112
CO Emissions:				
ppm volume dry	8.89	6.06	6.28	7.08
lb/hr	0.042	0.029	0.032	0.034
lb/day	1.008	0.693	0.763	0.821
lb/MMBtu	0.0105	0.0076	0.0079	0.0086
lb/gallon	0.0014	0.0010	0.0012	0.0012
VOC Emissions:				
ppm volume dry as C_3H_8	0.58	0.15	0.47	0.40
lb/hr as C	0.004	0.001	0.003	0.003
lb/day as C	0.085	0.022	0.073	0.060
lb/MMBtu as C	0.0009	0.0002	0.0008	0.0006
lb/gallon as C	0.00012	0.00003	0.00011	0.00009

Note: VOC results have been reported as actual values instead of the Avogadro-defined detection limit of 2% of the span of the analyzer.

TABLE 6-100
FD-22 AT 50% LOAD: NO_2 AND NO_X
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/10/12	6/10/12	6/11/12	--
Time:	1722-1824	1913-2015	0731-0833	--
Process Data:				
Heat input, MMBtu/hr	4.0	3.8	3.8	3.9
Flue Gas:				
O_2, % volume dry	8.90	9.54	9.58	9.34
CO_2, % volume dry	9.02	8.32	8.45	8.60
Moisture, % by volume	8.18	7.75	8.14	8.02
Flue gas temperature, °F	273.1	287.1	294.1	284.8
Volumetric flow rate, dscfm	1,082	1,093	1,161	1,112
NO_2 Emissions:				
ppm volume dry	3.660	1.070	3.450	2.727
lb/hr	0.028	0.008	0.029	0.022
lb/day	0.68	0.20	0.69	0.52
lb/MMBtu	0.0071	0.0022	0.0071	0.0055
lb/gallon	0.0010	0.0003	0.0010	0.0008
NO_X Emissions:				
ppm volume dry	67.15	65.54	64.86	65.85
lb/hr	0.521	0.513	0.539	0.524
lb/day	12.50	12.32	12.94	12.59
lb/MMBtu	0.1303	0.1343	0.1334	0.1326
lb/gallon	0.0179	0.0184	0.0195	0.0186

TABLE 6-101
FD-22 AT 50% LOAD: $PM/PM_{10}/PM_{2.5}$ FRACTIONS
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/10/12	6/10/12	6/11/12	--
Time:	1722-1824	1913-2015	0731-0833	--
Process Data:				
Heat input, MMBtu/hr	4.0	3.8	3.8	3.9
Flue Gas:				
O_2, % volume dry	8.90	9.54	9.58	9.34
CO_2, % volume dry	9.02	8.32	8.45	8.60
Moisture, % by volume	8.18	7.75	8.14	8.02
Flue gas temperature, °F	273.1	287.1	294.1	284.8
Volumetric flow rate, dscfm	1,082	1,093	1,161	1,112
Filterable $PM/PM_{10}/PM_{2.5}$:				
gr/dscf	0.0003	0.0003	0.0002	0.0003
lb/hr	0.003	0.002	0.002	0.002
lb/day	0.063	0.058	0.057	0.059
lb/MMBtu	0.0007	0.0006	0.0006	0.0006
lb/gallon	0.0001	0.0001	0.0001	0.0001
Condensable $PM/PM_{10}/PM_{2.5}$:				
gr/dscf	0.0003	0.0003	0.0007	0.0004
lb/hr	0.002	0.002	0.007	0.004
lb/day	0.059	0.059	0.167	0.095
lb/MMBtu	0.0006	0.0006	0.0017	0.0010
lb/gallon	0.0001	0.0001	0.0003	0.0001

TABLE 6-102
FD-22 AT 50% LOAD: PM/PM_{10}/$PM_{2.5}$ AND OPACITY
NOBLE DISCOVERER DRILLSHIP

Test No.:	Run 1	Run 2	Run 3	Averages
Date:	6/10/12	6/10/12	6/11/12	--
Time:	1722-1824	1913-2015	0731-0833	--
Process Data:				
Heat input, MMBtu/hr	4.0	3.8	3.8	3.9
Flue Gas:				
O_2, % volume dry	8.90	9.54	9.58	9.34
CO_2, % volume dry	9.02	8.32	8.45	8.60
Moisture, % by volume	8.18	7.75	8.14	8.02
Flue gas temperature, °F	273.1	287.1	294.1	284.8
Volumetric flow rate, dscfm	1,082	1,093	1,161	1,112
Total PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	0.0005	0.0005	0.0009	0.0007
lb/hr	0.005	0.005	0.009	0.006
lb/day	0.122	0.117	0.224	0.154
lb/MMBtu	0.0013	0.0013	0.0023	0.0016
lb/gallon	0.0002	0.0002	0.0003	0.0002
Visible Emissions:				
opacity, %	0	0	0	0

TABLE 6-103
FD-22 AT 100% LOAD: CO AND VOC
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/11/12	6/11/12	6/11/12	--
Time:	0911-1012	1035-1137	1153-1256	--
Process Data:				
Heat input, MMBtu/hr	7.1	6.9	7.1	7.0
Flue Gas:				
O_2, % volume dry	7.92	7.89	7.93	7.91
CO_2, % volume dry	9.54	9.48	9.46	9.49
Moisture, % by volume	8.81	9.02	8.95	8.93
Flue gas temperature, °F	423.8	424.0	424.5	424.1
Volumetric flow rate, dscfm	1,909	1,896	1,827	1,878
CO Emissions:				
ppm volume dry	28.69	29.51	29.73	29.31
lb/hr	0.239	0.244	0.237	0.240
lb/day	5.734	5.857	5.686	5.759
lb/MMBtu	0.0313	0.0321	0.0325	0.0320
lb/gallon	0.0046	0.0048	0.0046	0.0047
VOC Emissions:				
ppm volume dry as C_3H_8	0.58	0.58	0.50	0.55
lb/hr as C	0.006	0.006	0.005	0.006
lb/day as C	0.149	0.148	0.122	0.139
lb/MMBtu as C	0.0008	0.0008	0.0007	0.0008
lb/gallon as C	0.00012	0.00012	0.00010	0.00011

Note: VOC results have been reported as actual values instead of the Avogadro-defined detection limit of 2% of the span of the analyzer.

TABLE 6-104
FD-22 AT 100% LOAD: NO_2 AND NO_X
NOBLE DISCOVERER DRILLSHIP

Test No.:	Run 1	Run 2	Run 3	Averages
Date:	6/11/12	6/11/12	6/11/12	--
Time:	0911-1012	1035-1137	1153-1256	--
Process Data:				
Heat input, MMBtu/hr	7.1	6.9	7.1	7.0
Flue Gas:				
O_2, % volume dry	7.92	7.89	7.93	7.91
CO_2, % volume dry	9.54	9.48	9.46	9.49
Moisture, % by volume	8.81	9.02	8.95	8.93
Flue gas temperature, °F	423.8	424.0	424.5	424.1
Volumetric flow rate, dscfm	1,909	1,896	1,827	1,878
NO_2 Emissions:				
ppm volume dry	2.280	3.010	3.050	2.780
lb/hr	0.031	0.041	0.040	0.037
lb/day	0.75	0.98	0.96	0.90
lb/MMBtu	0.0041	0.0054	0.0055	0.0050
lb/gallon	0.0006	0.0008	0.0008	0.0007
NO_X Emissions:				
ppm volume dry	82.03	81.63	81.42	81.69
lb/hr	1.122	1.109	1.066	1.099
lb/day	26.93	26.61	25.58	26.37
lb/MMBtu	0.1471	0.1460	0.1461	0.1464
lb/gallon	0.0216	0.0220	0.0207	0.0214

TABLE 6-105
FD-22 AT 100% LOAD: $PM/PM_{10}/PM_{2.5}$ FRACTIONS
NOBLE DISCOVERER DRILLSHIP

Test No.:	Run 1	Run 2	Run 3	Averages
Date:	6/11/12	6/11/12	6/11/12	--
Time:	0911-1012	1035-1137	1153-1256	--
Process Data:				
Heat input, MMBtu/hr	7.1	6.9	7.1	7.0
Flue Gas:				
O_2, % volume dry	7.92	7.89	7.93	7.91
CO_2, % volume dry	9.54	9.48	9.46	9.49
Moisture, % by volume	8.81	9.02	8.95	8.93
Flue gas temperature, °F	423.8	424.0	424.5	424.1
Volumetric flow rate, dscfm	1,909	1,896	1,827	1,878
Filterable $PM/PM_{10}/PM_{2.5}$:				
gr/dscf	0.0010	0.0011	0.0006	0.0009
lb/hr	0.016	0.017	0.010	0.014
lb/day	0.393	0.415	0.231	0.346
lb/MMBtu	0.002	0.002	0.001	0.002
lb/gallon	0.0003	0.0003	0.0002	0.0003
Condensable $PM/PM_{10}/PM_{2.5}$:				
gr/dscf	0.0003	0.0003	0.0003	0.0003
lb/hr	0.005	0.005	0.005	0.005
lb/day	0.117	0.122	0.121	0.120
lb/MMBtu	0.001	0.001	0.001	0.001
lb/gallon	0.0001	0.0001	0.0001	0.0001

TABLE 6-106
FD-22 AT 100% LOAD: PM/PM_{10}/$PM_{2.5}$ AND OPACITY
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/11/12	6/11/12	6/11/12	--
Time:	0911-1012	1035-1137	1153-1256	--
Process Data:				
Heat input, MMBtu/hr	7.1	6.9	7.1	7.0
Flue Gas:				
O_2, % volume dry	7.92	7.89	7.93	7.91
CO_2, % volume dry	9.54	9.48	9.46	9.49
Moisture, % by volume	8.81	9.02	8.95	8.93
Flue gas temperature, °F	423.8	424.0	424.5	424.1
Volumetric flow rate, dscfm	1,909	1,896	1,827	1,878
Total PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	0.0013	0.0014	0.0009	0.0012
lb/hr	0.021	0.022	0.015	0.019
lb/day	0.510	0.537	0.351	0.466
lb/MMBtu	0.003	0.003	0.002	0.003
lb/gallon	0.0004	0.0004	0.0003	0.0004
Visible Emissions:				
opacity, %	0	0	0	0

Attachment F10 – The Avogadro Group, LLC, Source Test Report 2012 Emission Compliance Tests Noble Discoverer Drillship, July 27, 2012 – Discoverer Incinerator Summary

TABLE 1-41
INCINERATOR FD-23: CO, NO_2, AND NO_X
NOBLE DISCOVERER DRILLSHIP
JUNE 12, 2012

Parameter	Average Results	Permit Limit
Unit Data:		
Load, ton of waste/hr	0.130	--
Flue Gas:		
O_2, % volume dry	18.03	--
CO_2, % volume dry	2.48	--
Moisture, % by volume	3.98	--
Flue gas temperature, °F	488.8	--
Volumetric flow rate, dscfm	2,159	--
CO Emissions:		
ppm volume dry	151.8	--
lb/hr	1.416	--
lb/ton of waste	10.82	31.0
NO_2 Emissions:		
ppm volume dry	0.073	--
lb/hr	0.001	--
lb/ton of waste	0.0088	--
NO_X Emissions:		
ppm volume dry	26.46	--
lb/hr	0.410	0.65
lb/ton of waste	3.182	5.0

TABLE 1-42
INCINERATOR FD-23: VOC AND SO_2
NOBLE DISCOVERER DRILLSHIP
JUNE 12, 2012

Parameter	Average Results	Permit Limit
Unit Data:		
Load, ton of waste/hr	0.130	--
Flue Gas:		
O_2, % volume dry	18.03	--
CO_2, % volume dry	2.48	--
Moisture, % by volume	3.98	--
Flue gas temperature, °F	488.8	--
Volumetric flow rate, dscfm	2,159	--
VOC Emissions:		
ppm volume dry as C_3H_8	4.10	--
lb/hr as C	0.049	--
lb/ton of waste as C	0.375	3.0
SO_2 Emissions:		
ppm volume dry	4.88	--
lb/hr	0.106	--
lb/ton of waste	0.833	2.50

TABLE 1-43
INCINERATOR FD-23: PM/PM_{10}/$PM_{2.5}$ AND OPACITY
NOBLE DISCOVERER DRILLSHIP

Parameter	Average Results	Permit Limit
Unit Data:		
Load, ton of waste/hr	0.130	--
Flue Gas:		
O_2, % volume dry	18.03	--
CO_2, % volume dry	2.48	--
Moisture, % by volume	3.98	--
Stack temperature, °F	488.8	--
Flow rate, dscfm	2,159	--
Filterable PM/PM_{10}/$PM_{2.5}$:		
gr/dscf	0.0483	--
lb/hr	0.890	--
lb/ton of waste	6.905	--
Condensable PM/PM_{10}/$PM_{2.5}$:		
gr/dscf	0.0003	--
lb/hr	0.005	--
lb/ton of waste	0.038	--
Total PM/PM_{10}/$PM_{2.5}$:		
gr/dscf	0.0486	--
lb/hr	0.895	--
lb/ton of waste	6.943	7.00
Visible Emissions:		
Average of all readings	11.4	--
Highest 6-min average	16.3	20

6.9 INCINERATOR FD-23 INDIVIDUAL TEST RUN RESULTS

TABLE 6-107
INCINERATOR FD-23: CO, NO_2, AND NO_X
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/12/12	6/12/12	6/12/12	--
Time:	0858-1001	1041-1144	1224-1258	--
Process Data:				
Load, ton of waste/hr	0.140	0.120	0.130	0.130
Flue Gas:				
O_2, % volume dry	17.85	18.02	18.23	18.03
CO_2, % volume dry	2.46	2.55	2.43	2.48
Moisture, % by volume	3.32	4.17	4.46	3.98
Flue gas temperature, °F	450.8	503.2	512.3	488.8
Volumetric flow rate, dscfm	2,088	2,153	2,235	2,159
CO Emissions:				
ppm volume dry	216.6	143.2	95.6	151.8
lb/hr	1.972	1.344	0.932	1.416
lb/ton of waste	14.09	11.20	7.17	10.82
NO_2 Emissions:				
ppm volume dry	0.020	0.000	0.270	0.073
lb/hr	0.000	0.000	0.004	0.001
lb/ton of waste	0.0021	0.0000	0.0333	0.0088
NO_X Emissions:				
ppm volume dry	23.45	27.81	28.13	26.46
lb/hr	0.351	0.429	0.450	0.410
lb/ton of waste	2.506	3.574	3.465	3.182

TABLE 6-108
INCINERATOR FD-23: VOC AND SO_2
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/12/12	6/12/12	6/12/12	--
Time:	0858-1001	1041-1144	1224-1258	--
Process Data:				
Load, ton of waste/hr	0.140	0.120	0.130	0.130
Flue Gas:				
O_2, % volume dry	17.85	18.02	18.23	18.03
CO_2, % volume dry	2.46	2.55	2.43	2.48
Moisture, % by volume	3.32	4.17	4.46	3.98
Flue gas temperature, °F	450.8	503.2	512.3	488.8
Volumetric flow rate, dscfm	2,088	2,153	2,235	2,159
VOC Emissions:				
ppm volume dry as C_3H_8	6.15	4.04	2.13	4.10
lb/hr as C	0.072	0.049	0.027	0.049
lb/ton of waste as C	0.515	0.406	0.205	0.375
SO_2 Emissions:				
ppm volume dry	2.27	5.83	6.53	4.88
lb/hr	0.047	0.125	0.146	0.106
lb/ton of waste	0.338	1.042	1.119	0.833

TABLE 6-109
INCINERATOR FD-23: PM/PM_{10}/$PM_{2.5}$ AND OPACITY
NOBLE DISCOVERER DRILLSHIP

Test No.:	**Run 1**	**Run 2**	**Run 3**	**Averages**
Date:	6/12/12	6/12/12	6/12/12	--
Time:	0858-1001	1041-1144	1224-1258	--
Process Data:				
Load, ton of waste/hr	0.140	0.120	0.130	0.130
Flue Gas:				
O_2, % volume dry	17.85	18.02	18.23	18.03
CO_2, % volume dry	2.46	2.55	2.43	2.48
Moisture, % by volume	3.32	4.17	4.46	3.98
Flue gas temperature, °F	450.8	503.2	512.3	488.8
Volumetric flow rate, dscfm	2,088	2,153	2,235	2,159
Filterable PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	0.0518	0.0577	0.0354	0.0483
lb/hr	0.928	1.064	0.679	0.890
lb/ton of waste	6.627	8.868	5.220	6.905
Condensable PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	0.0003	0.0003	0.0002	0.0003
lb/hr	0.005	0.005	0.005	0.005
lb/ton of waste	0.036	0.042	0.037	0.038
Total PM/PM_{10}/$PM_{2.5}$:				
gr/dscf	0.0521	0.0579	0.0357	0.0486
lb/hr	0.933	1.069	0.683	0.895
lb/ton of waste	6.663	8.910	5.256	6.943
Visible Emissions:				
Average of all readings	10.6	12.4	11.2	11.4
Highest 6-min average	13.8	16.3	18.8	16.3

Attachment F11 – Discoverer Lifeboats: Sabb Motor Specification Sheet

SABB MOTOR A/S
TESTDEPARTMENT

WORKS TEST CERTIFICATE SABB

SABB MOTOR ORDER NO.:	0225479
CUSTOMER:	JIANGYIN NORSAFE FRP
CUSTOMER ORDER NO.:	06-IM739
SABB SERIAL NO.:	L3 139LB 257 06
AUTHORITY/CLASS SOCIETY:	MED
CERTIFICATE NO:	MED-B-2294
ENGINE TYPE:	L3 139LB 257 06
ENGINE BLOCK NO.:	06008268
GEARBOX TYPE / RATIO:	ZF 12M / 2,63
GEARBOX SERIAL NO.:	30453

ENGINE OUTPUT (HP):	29,5	FULL LOAD SPEED (RPM):	3000
SPEED UNLOADED MAX (RPM):	356	SPEED UNLOADED MIN (RPM):	1000
DYNAMOMETER SPEED (RPM):	1141	BRAKE LOAD (kg):	15,5
TEST BENCH NO.:	7	BRAKE CONSTANT:	600
AMBIENT TEMP. (°C):	25	HUMIDITY (%):	45
COOLANT TEMP. (°C):	80	AMB.PRESSURE (mmHg):	
ENGINE OIL TEMP. (°C):		LUB.OIL PRESSURE (bar):	2,8
EXHAUST TEMP. (°C):	549	CHARGE AIR PRESSURE (bar):	

THE ENGINE HAS BEEN TESTED IN ACC. WITH APPROVED ENGINE TEST PROCEDURES, AND ISO STANDARD 3046 I / II

DATE OF TESTING:	10,08,06	DATE OF INSPECTION:	10,08,06
SABB TESTDEPT. SIGN.	D.O	SABB INSPECTION DEPT. SIGN.	ES

SABB MOTOR A/S P.O.BOX 7170 - N-5020-BERGEN NORWAY

Attachment F12 – Ecoxy AS, Test Report: Source specific NO_X factors for Polar Pioneer, February 14, 2014

3 RESULTS

Calculated emission values for the main engine are given in Table 2.

Table 1: Calculated source specific emission factors for the measured units (w/o SCR).

Unit	Generator Load		NO_X Emission [g/kWh]		CO Emission [g/kWh]		PM Emission* [g/kWh]
	[%]	kW	Measured	Weighted	Measured	Weighted	Weighted
ME #3	75	2055	10.53	11.35	1.50	1.42	0.15
	50	1400	12.77		0.89		
	25	750	16.21		1.70		

* *Not measured according to ISO8178. Sampling was isokinetic, but not with a dilution tunnel.*

As told in the introduction the PM emission was sampled according to the dust sampling standard EN 13284-1. Then the calculated PM mass flow was divided by the average power (as for the specific NO_X and CO emissions, cf. page 9 Appendix 3).

Polar Pioneer use MGO with 0.05 w-% S as engine fuel. Based on the composition of the fuel (13.6 w-% H and 86.2 w-% C) the mole fraction of hydrogen to carbon (H/C ratio) used in the calculations for MGO is 1.8800 [1]. To check if the fuel values used in the calculations are correct, Ecoxy always compares the calculated excess air ratio based on the O_2 and CO_2 measurements. In Figure 4 the red and blue lines are the theoretical values for the O_2 and CO_2 concentrations, respectively. The points plotted in the figure are measured values. The figure shows that the measured values are in good accordance with the theoretical values.

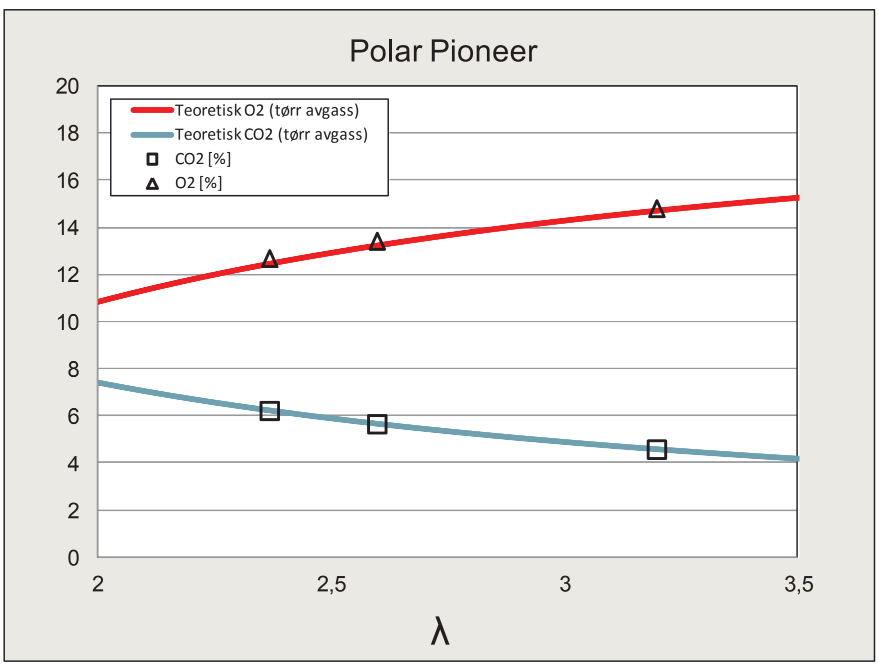


Figure 4: Theoretical and measured O_2 and CO_2 concentrations at varying excess air ratios (λ).

Attachment F13 – Polar Pioneer HPU Engines: See Attachment F3

Attachment F14 – Alaska Source Testing, LLC, Summary of Test Results Shell Offshore, Inc. Fennica/Nordica Icebreaker, June 28, 2007

2. SUMMARY OF RESULTS

A summary of the NO_x test results are presented in Table 2-1.

Table 2-1 **Summary of NO_x Emissions**

Run	Load %	Load kW	NO_x dppmv	NO_x lb/hr	NO_x* Lb/kW-hr
1	35	2100	738.7	51.0	0.0243
2			718.8	48.5	0.0231
3			713.6	47.5	0.0226
Average			**723.7**	**49.0**	**0.0233**
4	57	3480	598.3	61.4	0.0177
5			675.4	69.3	0.0199
6			656.7	69.0	0.0198
Average			**643.5**	**66.6**	**0.0191**
7	80	4800	752.9	97.9	0.0204
8			720.2	92.3	0.0192
9			746.2	99.3	0.0207
Average			**739.8**	**96.5**	**0.0201**

*Based on Methods 2 – 4

A more detailed summary of results is provided in Appendix A. The field data is presented Appendix C.

3. DESCRIPTION OF THE SOURCE

Source Group C1 includes two, identical Wartsila 16V32 main propulsion engines rated at 7884 hp (6000 kW); Unit IDs FN-1 and FN-2.

4. DESCRIPTION OF THE SAMPLE LOCATIONS

The Wartsila 16V32 main propulsion engine exhausts into a vertical, circular stack with an internal diameter of 31.5 inches. The stack is equipped with two ¾ -inch sample ports located approximately 10 feet (3.8 stack diameters) downstream and approximately 3 feet upstream of the nearest flow disturbance.

Mr. Hudson chose a 16 point velocity traverse, 8 points per port. Please refer to Table 4-1 for selected velocity traverse points.

Attachment F15 – TRC, Emissions Test Report Fennica Icebreaker #1 Shell Gulf of Mexico, Inc., August 9, 2012

2.1 Wartsila Propulsion Engine (F-1) 95, 80, 60, 40 & 30% Load Conditions

Table 2.1.1 – Wartsila Propulsion Engine (F-1)
Overall Average Emissions Results for 95, 80, 60, 40, & 30% Load Conditions

FENNICA - Propulsion Engine (F-1) Wartsila 12V32, Serial #5682						
Test Identification	**Emission Unit**	**95% Load**	**80% Load**	**65% Load**	**40% Load**	**30% Load**
PROCESS DATA						
Power Output	**%**	95	80	60	40	30
Fuel Flow Rate	**gal/hr**	237.1	201.9	154.8	108.5	84.3
Electrical Power Output	**kWe**	3,520	2,964	2,227	1,486	1,098
SAMPLING RESULTS						
	Test Date	**4/22/2012**	**4/22/2012**	**4/23/2012**	**4/23-24/2012**	**4/24/2012**
	EPA Method 5/202					
Filterable PM	**gr/dscf**	0.003791	0.003704	0.003322	0.003200	0.003253
	lb/hr	0.4386	0.3789	0.2750	0.1942	0.1719
Condensable PM	**gr/dscf**	0.001907	0.001339	0.001413	0.001262	0.001433
	lb/hr	0.2210	0.1361	0.1170	0.07666	0.07555
Total PM[1]	**gr/dscf**	0.005698	0.005043	0.004735	0.004462	0.004686
	lb/hr	0.6596	0.5151	0.3919	0.2709	0.2475
	lb/gal fuel	0.002782	0.002551	0.002533	0.002496	0.002935
	lb/kWe-hr	0.0001874	0.0001738	0.0001760	0.0001823	0.0002253
	EPA Method 9					
Opacity	**%**	5	5	5	5	5
	EPA Methods 3A, 7E, & 10					
EPA Method 3A	**% O_2**	12.8	13.0	13.4	13.6	14.4
	% CO_2	6.2	6.0	5.7	5.5	4.9
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	65.2	22.8	23.6	32.7	24.5
	lb/hr	6.053	1.845	1.537	1.552	1.013
	lb/gal fuel	0.02553	0.009137	0.009930	0.01430	0.01200
	lb/kWe-hr	0.001719	0.0006223	0.0006901	0.001044	0.0009213
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	26.2	9.6	12.0	14.2	15.6
	lb/hr	2.437	0.7726	0.7803	0.6732	0.6466
	lb/gal fuel	0.01028	0.003826	0.005041	0.006203	0.007660
	lb/kWe-hr	0.0006920	0.0002606	0.0003503	0.0004531	0.0005879
CO (based on EPA Method 19 flow rates)	**Ppmvd**	6.8	5.5	4.5	5.4	5.3
	lb/hr	0.3826	0.2689	0.1774	0.1568	0.1327
	lb/gal fuel	0.001614	0.001332	0.001146	0.001445	0.001574
	lb/kWe-hr	0.0001087	0.00009071	0.00007964	0.0001055	0.0001208
	Total Sulfur – ASTM D 5453					
Total Sulfur	**ppmw**	7.7	7.7	7.9	7.8	7.5

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.2 Wartsila Propulsion Engine (F-2) 95, 80, 60, 40 & 30% Load Conditions

Table 2.2.1 – Wartsila Propulsion Engine (F-2)
Overall Average Emissions Results for 95, 80, 60, 40, & 30% Load Conditions

FENNICA - Propulsion Engine (F-2) Wartsila 12V32, Serial #5683						
Test Identification	**Emission Unit**	**95% Load**	**80% Load**	**60% Load**	**40% Load**	**30% Load**
PROCESS DATA						
Power Output	**%**	95	80	60	40	30
Fuel Flow Rate	**gal/hr**	236.8	200.9	154.2	108.9	86.1
Electrical Power Output	**kWe**	3,506	2,957	2,219	1,476	1,102
SAMPLING RESULTS						
	Test Date	**4/27/2012**	**4/26-27/2012**	**4/26/2012**	**4/25/2012**	**4/24/2012**
	EPA Method 5/202					
Filterable PM	**gr/dscf**	0.003456	0.003664	0.004041	0.004070	0.004861
	lb/hr	0.4129	0.3787	0.3337	0.2617	0.2692
Condensable PM	**gr/dscf**	0.002642	0.001010	0.0008731	0.0008924	0.0007505
	lb/hr	0.3156	0.1044	0.07198	0.05742	0.04155
Total PM[1]	**gr/dscf**	0.006098	0.004675	0.004915	0.004962	0.005612
	lb/hr	0.7286	0.4831	0.4057	0.3191	0.3107
	lb/gal fuel	0.003076	0.002405	0.002631	0.002931	0.003611
	lb/kWe-hr	0.0002078	0.0001634	0.0001829	0.0002163	0.0002819
	EPA Method 9					
Opacity	**%**	5	5	5	5	5
	EPA Methods 3A, 7E, & 10					
EPA Method 3A	**% O_2**	13.0	13.0	13.5	14.0	14.6
	% CO_2	6.0	5.9	5.7	5.2	4.8
NO_x (based on EPA Method 19 flow rates)	**Ppmvd**	47.8	47.2	43.8	37.7	31.5
	lb/hr	4.527	3.830	2.899	1.895	1.364
	lb/gal fuel	0.01912	0.01906	0.01881	0.01741	0.01585
	lb/kWe-hr	0.001291	0.001295	0.001307	0.001284	0.001238
NO_2 (based on EPA Method 19 flow rates)	**Ppmvd**	12.9	16.2	17.2	15.2	10.3
	lb/hr	1.226	1.314	1.140	0.7665	0.4466
	lb/gal fuel	0.005175	0.006538	0.007394	0.007041	0.005188
	lb/kWe-hr	0.0003496	0.0004442	0.0005138	0.0005194	0.0004051
CO (based on EPA Method 19 flow rates)	**Ppmvd**	6.5	5.5	5.2	5.6	6.6
	lb/hr	0.3732	0.2699	0.2108	0.1725	0.1733
	lb/gal fuel	0.001576	0.001343	0.001367	0.001585	0.002014
	lb/kWe-hr	0.0001064	0.00009126	0.00009499	0.0001169	0.0001572
	Total Sulfur – ASTM D 5453					
Total Sulfur	**Ppmw**	7.7	7.8	7.8	7.4	7.7

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.3 Wartsila Propulsion Engine (F-3) 95, 80, 60, 40 & 30% Load Conditions

**Table 2.3.1 – Wartsila Propulsion Engine (F-3)
Overall Average Emissions Results for 95, 80, 60, 40, & 30% Load Conditions**

FENNICA - Propulsion Engine (F-3) Wartsila 16V32, Serial #5680						
Test Identification	Emission Unit	95% Load	80% Load	60% Load	40% Load	30% Load
PROCESS DATA						
Power Output	%	95	80	60	40	30
Fuel Flow Rate	gal/hr	306.5	262.6	202.8	143.3	113.3
Electrical Power Output	kWe	4,614	3,931	2,950	1,968	1,473
SAMPLING RESULTS						
	Test Date	4/18-19/2012	4/19/2012	4/19-20/2012	4/20/2012	4/20-21/2012
	EPA Method 5/202					
Filterable PM	gr/dscf	0.004269	0.003860	0.003633	0.004211	0.004880
	lb/hr	0.5141	0.4100	0.3052	0.2589	0.2685
Condensable PM	gr/dscf	0.001544	0.001142	0.001156	0.0008598	0.001309
	lb/hr	0.1861	0.1216	0.09710	0.05290	0.07205
Total PM[1]	gr/dscf	0.005813	0.005002	0.004789	0.005071	0.006189
	lb/hr	0.7002	0.5317	0.4023	0.3118	0.3405
	lb/gal fuel	0.002289	0.002024	0.001984	0.002176	0.003006
	lb/kWe-hr	0.0001521	0.0001352	0.0001364	0.0001584	0.0002312
	EPA Method 9					
Opacity	%	*5*	*5*	*5*	*5*	*5*
	EPA Methods 3A, 7E, & 10					
EPA Method 3A	% O_2	13.0	13.2	13.3	13.7	14.3
	% CO_2	6.1	5.9	5.9	5.5	4.9
NO_x (based on EPA Method 19 flow rates)	ppmvd	65.1	57.6	58.8	58.3	43.9
	lb/hr	8.051	6.213	4.965	3.669	2.396
	lb/gal fuel	0.02628	0.02366	0.02449	0.02561	0.02115
	lb/kWe-hr	0.001746	0.001581	0.001683	0.001864	0.001627
NO_2 (based on EPA Method 19 flow rates)	ppmvd	19.5	14.6	17.0	20.9	14.2
	lb/hr	2.408	1.575	1.432	1.312	0.7767
	lb/gal fuel	0.007865	0.005999	0.007062	0.009161	0.006856
	lb/kWe-hr	0.0005226	0.0004007	0.0004855	0.0006668	0.0005274
CO (based on EPA Method 19 flow rates)	ppmvd	7.8	7.5	7.6	8.4	12.2
	lb/hr	0.5901	0.4946	0.3922	0.3218	0.4032
	lb/gal fuel	0.001926	0.001884	0.001934	0.002246	0.003560
	lb/kWe-hr	0.0001279	0.0001258	0.0001330	0.0001635	0.0002737
	Total Sulfur – ASTM D 5453					
Total Sulfur	ppmw	7.8	8.0	7.8	7.8	7.7

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.4 Wartsila Propulsion Engine (F-4) 95, 80, 60, 40 & 30% Load Conditions

**Table 2.4.1 – Wartsila Propulsion Engine (F-4)
Overall Average Emissions Results for 95, 80, 60, 40, & 30% Load Conditions**

FENNICA - Propulsion Engine (F-4) Wartsila 16V32, Serial #5681						
Test Identification	**Emission Unit**	**95% Load**	**80% Load**	**60% Load**	**40% Load**	**30% Load**
PROCESS DATA						
Power Output	**%**	95	80	60	40	30
Fuel Flow Rate	**gal/hr**	311.5	264.8	209.5	139.1	113.3
Electrical Power Output	**kWe**	4,681	3,933	3,077	1,921	1,478
SAMPLING RESULTS						
	Test Date	**4/13/2012**	**4/14/2012**	**4/17/2012**	**4/17-18/2012**	**4/18/2012**
	EPA Method 5/202					
Filterable PM	**gr/dscf**	0.004344	0.003232	0.004054	0.004018	0.004529
	lb/hr	0.6176	0.4088	0.4205	0.3032	0.2989
Condensable PM	**gr/dscf**	0.002365	0.001152	0.0006287	0.002318	0.001021
	lb/hr	0.3379	0.1457	0.06521	0.1755	0.06757
Total PM[1]	**gr/dscf**	0.006709	0.004384	0.004683	0.006336	0.005550
	lb/hr	0.9555	0.5545	0.4857	0.4787	0.3665
	lb/gal fuel	0.003071	0.002094	0.002318	0.003442	0.003234
	lb/kWe-hr	0.0002042	0.0001410	0.0001578	0.0002493	0.0002479
	EPA Method 9					
Opacity	**%**	7	6	7	7	5
	EPA Methods 3A, 7E, & 10					
EPA Method 3A	**% O_2**	12.5	12.5	12.9	13.5	14.2
	% CO_2	6.4	6.3	6.1	5.7	5.2
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	49.2	48.3	48.0	42.1	34.6
	lb/hr	5.781	4.823	3.986	2.513	1.857
	lb/gal fuel	0.01857	0.01821	0.01903	0.01806	0.01639
	lb/kWe-hr	0.001235	0.001226	0.001295	0.001308	0.001256
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	6.3	7.1	16.5	18.5	16.6
	lb/hr	0.7479	0.7064	1.372	1.103	0.8928
	lb/gal fuel	0.002407	0.002666	0.006546	0.007931	0.007878
	lb/kWe-hr	0.0001598	0.0001796	0.0004455	0.0005745	0.0006038
CO (based on EPA Method 19 flow rates)	**ppmvd**	33.4	43.9	6.0	6.3	6.4
	lb/hr	2.372	2.673	0.3019	0.2305	0.2102
	lb/gal fuel	0.007601	0.01009	0.001441	0.001657	0.001855
	lb/kWe-hr	0.0005066	0.0006796	0.00009810	0.0001200	0.0001422
	Total Sulfur – ASTM D 5453					
Total Sulfur	**ppmw**	7.8	7.9	7.6	7.2	8.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.5 Heat Boiler #1 (F-5) Maximum Load Condition

Table 2.5 – Heat Boiler #1 (F-5) – 100% Load Condition

FENNICA – Heat Boiler #1 (F-5) Unex BH-2000, Serial #5505 *100% Load*					
Test Identification	**Emission Unit**	**Run 1**	**Run 2**	**Run 3**	***Average***
PROCESS DATA					
Power Output	**%**	100	100	100	***100***
Fuel Flow Rate	**gal/hr**	45.6	45.6	45.6	***45.6***
SAMPLING RESULTS					
	Test Date	**4/15/2012**	**4/15/2012**	**4/15/2012**	---
	EPA Method 5/202 Run Times	1529-1630	1732-1833	1853-1955	
Filterable PM	**gr/dscf**	0.0003237	0.0003212	0.0002412	***0.0002954***
	lb/hr	0.003608	0.003581	0.002768	***0.003319***
Condensable PM	**gr/dscf**	0.001538	0.001566	0.001326	***0.001477***
	lb/hr	0.01714	0.01746	0.01522	***0.01660***
Total PM[1]	**gr/dscf**	0.001861	0.001887	0.001568	***0.001772***
	lb/hr	0.02074	0.02104	0.01799	***0.01992***
	lb/gal fuel	0.0004549	0.0004614	0.0003945	***0.0004369***
	lb/MMBtu	0.002859	0.002899	0.002395	***0.002717***
	EPA Method 9 Run Time			1900-1918	
Opacity	**%**	---	---	0	---
	EPA Methods 3A, 7E & 10 Run Times	1529-1629	1732-1832	1853-1953	
EPA Method 3A	**% O_2**	2.8	2.8	2.7	***2.8***
	% CO_2	13.3	13.3	13.4	***13.3***
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	88.8	89.4	89.4	***89.2***
	lb/hr	0.7104	0.7152	0.7113	***0.7123***
	lb/gal fuel	0.01558	0.01568	0.01560	***0.01562***
	lb/MMBtu	0.1140	0.1148	0.1141	***0.1143***
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	5.4	5.5	5.2	***5.4***
	lb/hr	0.04320	0.04400	0.04137	***0.04286***
	lb/gal fuel	0.0009474	0.0009649	0.0009073	***0.0009399***
	lb/MMBtu	0.006933	0.007061	0.006639	***0.006878***
CO (based on EPA Method 19 flow rates)	**ppmvd**	4.7	5.6	7.9	***6.1***
	lb/hr	0.02289	0.02728	0.03827	***0.02948***
	lb/gal fuel	0.0005020	0.0005982	0.0008392	***0.0006465***
	lb/MMBtu	0.003674	0.004377	0.006141	***0.004731***
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	7.7			

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.6 Heat Boiler #2 (F-6) Maximum Load Condition

Table 2.6 – Heat Boiler #2 (F-6) – 100% Load Condition

FENNICA – Heat Boiler #2 (F-6) Unex BH-2000, Serial #5506 *100% Load*					
Test Identification	**Emission Unit**	**Run 1**	**Run 2**	**Run 3**	***Average***
PROCESS DATA					
Power Output	**%**	100	100	100	***100***
Fuel Flow Rate	**gal/hr**	39.0	40.1	40.1	***39.7***
SAMPLING RESULTS					
	Test Date	**4/14-15/2012**	**4/15/2012**	**4/15/2012**	---
EPA Method 5/202 Run Times		2315-0016	0041-0142	0211-0312	
Filterable PM	**gr/dscf**	0.001048	0.0007508	0.001161	***0.0009865***
	lb/hr	0.009828	0.007137	0.01113	***0.009364***
Condensable PM	**gr/dscf**	0.001537	0.001843	0.001605	***0.001661***
	lb/hr	0.01441	0.01752	0.01538	***0.01577***
Total PM[1]	**gr/dscf**	0.002584	0.002594	0.002766	***0.002648***
	lb/hr	0.02424	0.02465	0.02651	***0.02513***
	lb/gal fuel	0.0006216	0.0006148	0.0006610	***0.0006325***
	lb/MMBtu	0.004039	0.004171	0.004300	***0.004170***
EPA Method 9 Run Time		2332-2350			
Opacity	**%**	0	---	---	---
EPA Methods 3A, 7E & 10 Run Times		2315-0016	0041-0142	0211-0312	
EPA Method 3A	**% O_2**	3.1	3.6	3.0	***3.2***
	% CO_2	13.1	12.7	13.2	***13.0***
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	90.9	90.0	93.0	***91.3***
	lb/hr	0.6325	0.6625	0.6616	***0.6522***
	lb/gal fuel	0.01622	0.01652	0.01650	***0.01641***
	lb/MMBtu	0.1188	0.1210	0.1208	***0.1202***
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	4.9	5.5	5.2	***5.2***
	lb/hr	0.03409	0.04048	0.03699	***0.03719***
	lb/gal fuel	0.0008742	0.001010	0.0009225	***0.0009354***
	lb/MMBtu	0.006402	0.007393	0.006756	***0.006850***
CO (based on EPA Method 19 flow rates)	**ppmvd**	1.2	1.3	1.3	***1.3***
	lb/hr	0.005083	0.005826	0.005631	***0.005513***
	lb/gal fuel	0.0001303	0.0001453	0.0001404	***0.0001387***
	lb/MMBtu	0.0009545	0.001064	0.001028	***0.001016***
Total Sulfur – ASTM D 5453					
Total Sulfur	**ppmw**	7.7			

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.7 Incinerator (F-7) Maximum Load Condition

Table 2.7 – Incinerator (F-7) – 100% Load Condition

FENNICA – Incinerator (F-7) Unex F-1, Serial #1006 *100% Load*					
Test Identification	**Emission Unit**	**Run 1**	**Run 2**	**Run 3**	**Average**
PROCESS DATA					
Power Output	**%**	100	100	100	***100***
Fuel Flow Rate	**gal/hr**	4.86	4.21	4.87	***4.65***
Waste Burned	**lb/hr**	73.64	39.61	25.80	***46.35***
Waste Burned	**tons/hr**	0.037	0.020	0.013	***0.023***
SAMPLING RESULTS					
	Test Date	**4/16/2012**	**4/16/2012**	**4/16/2012**	---
	EPA Method 5/202 Run Times	1216-1317	1341-1442	1500-1602	
Filterable PM	**gr/dscf**	0.04508	0.03624	0.007751	***0.02969***
	lb/hr	0.4643	0.4060	0.08502	***0.3184***
Condensable PM	**gr/dscf**	0.02365	0.004843	0.002179	***0.01022***
	lb/hr	0.2436	0.05425	0.02390	***0.1072***
Total PM[1]	**gr/dscf**	0.06873	0.04108	0.009930	***0.03991***
	lb/hr	0.7078	0.4602	0.1089	***0.4257***
	lb/gal fuel	0.1456	0.1093	0.02237	***0.09244***
	lb/ton waste	19.22	23.24	8.444	***16.97***
	EPA Method 9 Run Time	1245-1303			
Opacity	**%**	24	---	---	---
	EPA Methods 3A, 7E & 10 Run Times	1216-1316	1344-1444	1500-1600	
EPA Method 3A	**% O_2**	19.3	19.7	19.9	***19.6***
	% CO_2	1.7	1.4	1.3	***1.5***
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	25.3	9.1	8.1	***14.2***
	lb/hr	0.2434	0.1011	0.1249	***0.1565***
	lb/gal fuel	0.05007	0.02401	0.02565	***0.03325***
	lb/ton waste	6.609	5.105	9.683	***7.133***
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	10.7	3.3	2.1	***5.4***
	lb/hr	0.1029	0.03666	0.03239	***0.05732***
	lb/gal fuel	0.02118	0.008709	0.006650	***0.01218***
	lb/ton waste	2.795	1.851	2.511	***2.386***
CO (based on EPA Method 19 flow rates)	**ppmvd**	180.7	67.2	52.3	***100.1***
	lb/hr	1.058	0.4546	0.4911	***0.6680***
	lb/gal fuel	0.2177	0.1080	0.1008	***0.1422***
	lb/ton waste	28.74	22.95	38.07	***29.92***
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	7.5			

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

Attachment F16 – TRC, Emissions Test Report Nordica Icebreaker #1 Shell Gulf of Mexico, Inc., August 9, 2012

2.1 Wartsila Propulsion Engine #1 (IB1-1A) 95, 80, 60, 40 & 30% Load Conditions

**Table 2.1.1 – Wartsila Propulsion Engine #1 (IB1-1A)
Overall Average Emissions Results for 95, 80, 60, 40, & 30% Load Conditions**

NORDICA - Propulsion Engine #1 (IB1-1A) Wartsila 12V32, Serial #5908						
Test Identification	**Emission Unit**	**95% Load**	**80% Load**	**60% Load**	**40% Load**	**30% Load**
PROCESS DATA						
Power Output	**%**	95	80	60	40	30
Fuel Flow Rate	**gal/hr**	227.05	195.94	147.39	105.44	81.77
Electrical Power Output	**kWe**	3,463	2,965	2,181	1,468	1,085
SAMPLING RESULTS						
	Test Date	**4/25-26/2012**	**4/26/2012**	**4/24/2012**	**4/26/2012**	**4/26-27/2012**
	EPA Method 5/202					
Filterable PM	**gr/dscf**	0.003358	0.003970	0.002856	0.002527	0.003003
	lb/hr	0.4300	0.4439	0.2489	0.1653	0.1701
Condensable PM	**gr/dscf**	0.0007456	0.001534	0.001120	0.0003651	0.0005639
	lb/hr	0.09547	0.1694	0.09925	0.02391	0.03197
Total PM[1]	**gr/dscf**	0.004103	0.005504	0.003976	0.002892	0.003567
	lb/hr	0.5255	0.6133	0.3482	0.1892	0.2021
	lb/gal fuel	0.002318	0.003124	0.002360	0.001795	0.002469
	lb/kWe-hr	0.0001519	0.0002064	0.0001595	0.0001290	0.0001861
	EPA Method 9					
Opacity	**%**	5	4	0	1	5
	EPA Methods 3A, 7E, & 10					
EPA Method 3A	**% O_2**	13.3	13.4	13.7	14.0	14.9
	% CO_2	5.7	5.6	5.5	5.0	4.7
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	41.9	17.2	16.1	25.4	9.5
	lb/hr	3.965	1.424	1.048	1.234	0.4037
	lb/gal fuel	0.01749	0.007271	0.007106	0.01170	0.004948
	lb/kWe-hr	0.001146	0.0004805	0.0004801	0.0008408	0.0003731
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	8.8	2.5	3.8	8.5	3.1
	lb/hr	0.8297	0.2038	0.2496	0.4147	0.1286
	lb/gal fuel	0.003662	0.001040	0.001692	0.003931	0.001576
	lb/kWe-hr	0.0002399	0.00006870	0.0001143	0.0002824	0.0001189
CO (based on EPA Method 19 flow rates)	**ppmvd**	4.5	3.6	3.1	3.6	4.2
	lb/hr	0.2611	0.1813	0.1227	0.1065	0.1106
	lb/gal fuel	0.001150	0.0009254	0.0008331	0.001010	0.001353
	lb/kWe-hr	0.00007540	0.0006115	0.00005628	0.00007260	0.0001020
	Total Sulfur – ASTM D 5453					
Total Sulfur	**ppmw**	8.8	8.6	9.0	8.9	8.1

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.2 Wartsila Propulsion Engine #2 (IB1-IB) 95, 80, 60, 40 & 30% Load Conditions

**Table 2.2.1 – Wartsila Propulsion Engine #2 (IB1-1B)
Overall Average Emissions Results for 95, 80, 60, 40, & 30% Load Conditions**

NORDICA - Propulsion Engine (IB1-1B) Wartsila 12V32, Serial #5909						
Test Identification	Emission Unit	95% Load	80% Load	60% Load	40% Load	30% Load
PROCESS DATA						
Power Output	%	95	80	60	40	30
Fuel Flow Rate	gal/hr	240.22	200.18	158.17	105.70	88.59
Electrical Power Output	kWe	3,547	2,923	2,277	1,431	1,127
SAMPLING RESULTS						
	Test Date	4/23/2012	4/23/2012	4/24/2012	4/24/2012	4/24/2012
	EPA Method 5/202					
Filterable PM	gr/dscf	0.002663	0.002507	0.002436	0.002268	0.002295
	lb/hr	0.3401	0.2861	0.2288	0.1540	0.1360
Condensable PM	gr/dscf	0.0003612	0.0003486	0.00008751	0.0002885	0.0001730
	lb/hr	0.04605	0.03960	0.008242	0.01950	0.01036
Total PM[1]	gr/dscf	0.003024	0.002855	0.002524	0.002556	0.002468
	lb/hr	0.3862	0.3257	0.2370	0.1735	0.1464
	lb/gal fuel	0.001607	0.001626	0.001499	0.001641	0.001653
	lb/kWe-hr	0.0001089	0.0001114	0.0001041	0.0001213	0.0001299
	EPA Method 9					
Opacity	%	0	0	0	3	5
	EPA Methods 3A, 7E, & 10					
EPA Method 3A	% O_2	13.4	13.6	14.0	14.2	15.0
	% CO_2	5.6	5.4	5.2	4.7	4.5
NO_x (based on EPA Method 19 flow rates)	ppmvd	35.0	35.3	41.5	22.8	13.1
	lb/hr	3.578	3.075	3.028	1.155	0.6273
	lb/gal fuel	0.01490	0.01536	0.01914	0.01094	0.007070
	lb/kWe-hr	0.001009	0.001052	0.001330	0.0008080	0.0005560
NO_2 (based on EPA Method 19 flow rates)	ppmvd	1.3	2.7	9.3	3.6	2.8
	lb/hr	0.1329	0.2326	0.6756	0.1838	0.1350
	lb/gal fuel	0.0005534	0.001164	0.004271	0.001739	0.001515
	lb/kWe-hr	0.00003748	0.00007969	0.0002967	0.0001285	0.0001189
CO (based on EPA Method 19 flow rates)	ppmvd	6.1	5.5	5.9	6.9	7.6
	lb/hr	0.3818	0.2919	0.2604	0.2123	0.2197
	lb/gal fuel	0.001589	0.001458	0.001646	0.002009	0.002485
	lb/kWe-hr	0.0001076	0.00009986	0.0001144	0.0001484	0.0001955
	Total Sulfur – ASTM D 5453					
Total Sulfur	ppmw	7.8	8.1	7.8	8.7	9.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.3 Wartsila Propulsion Engine #3 (IB1-1C) 95, 80, 60, 40 & 30% Load Conditions

Table 2.3.1 – Wartsila Propulsion Engine #3 (IB1-1C)
Overall Average Emissions Results for 95, 80, 60, 40, & 30% Load Conditions

NORDICA - Propulsion Engine (IB1-1C) Wartsila 16V32, Serial #5907						
Test Identification	Emission Unit	95% Load	80% Load	60% Load	40% Load	30% Load
PROCESS DATA						
Power Output	%	95	80	60	40	30
Fuel Flow Rate	gal/hr	300.54	249.62	195.96	136.07	109.12
Electrical Power Output	kWe	4,651	3,839	2,945	1,933	1,474
SAMPLING RESULTS						
	Test Date	4/25/2012	4/27/2012	4/27/2012	4/25/2012	4/25/2012
EPA Method 5/202						
Filterable PM	gr/dscf	0.002054	0.002529	0.004928	0.002602	0.002897
	lb/hr	0.3491	0.3558	0.5577	0.2115	0.2078
Condensable PM	gr/dscf	0.0007904	0.0005581	0.0004028	0.0007540	0.001147
	lb/hr	0.1344	0.07879	0.04549	0.06130	0.08252
Total PM[1]	gr/dscf	0.002845	0.003087	0.005331	0.003356	0.004045
	lb/hr	0.4835	0.4346	0.6032	0.2728	0.2904
	lb/gal fuel	0.001610	0.001742	0.003070	0.002005	0.002662
	lb/kWe-hr	0.0001040	0.0001132	0.0002041	0.0001412	0.0001970
EPA Method 9						
Opacity	%	*5*	*5*	*5*	*5*	*1*
EPA Methods 3A, 7E, & 10						
EPA Method 3A	% O_2	14.5	13.8	13.9	14.1	14.6
	% CO_2	5.5	5.4	5.3	5.1	4.8
NO_x (based on EPA Method 19 flow rates)	ppmvd	30.7	28.1	34.7	48.8	39.8
	lb/hr	4.815	3.154	3.096	3.111	2.177
	lb/gal fuel	0.01601	0.01265	0.01580	0.02286	0.01995
	lb/kWe-hr	0.001035	0.0008223	0.001051	0.001609	0.001477
NO_2 (based on EPA Method 19 flow rates)	ppmvd	2.8	7.9	11.7	15.9	13.4
	lb/hr	0.4455	0.8832	1.046	1.011	0.7356
	lb/gal fuel	0.001481	0.003540	0.005338	0.007428	0.006742
	lb/kWe-hr	0.00009571	0.0002302	0.0003552	0.0005229	0.0004992
CO (based on EPA Method 19 flow rates)	ppmvd	4.2	3.2	3.3	4.7	4.3
	lb/hr	0.4033	0.2211	0.1775	0.1823	0.1444
	lb/gal fuel	0.001341	0.0008856	0.0009056	0.001340	0.001323
	lb/kWe-hr	0.00008666	0.00005758	0.00006027	0.00009431	0.00009798
Total Sulfur – ASTM D 5453						
Total Sulfur	ppmw	8.9	8.3	7.1	8.5	8.1

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.4 Wartsila Propulsion Engine #4 (IB1-1D) 95, 80, 60, 40 & 30% Load Conditions

**Table 2.4.1 – Wartsila Propulsion Engine #4 (IB1-1D)
Overall Average Emissions Results for 95, 80, 60, 40, & 30% Load Conditions**

NORDICA - Propulsion Engine (IB1-1D) Wartsila 16V32, Serial #5906						
Test Identification	**Emission Unit**	**95% Load**	**80% Load**	**60% Load**	**40% Load**	**30% Load**
PROCESS DATA						
Power Output	**%**	95	80	60	40	30
Fuel Flow Rate	**gal/hr**	306.16	258.61	195.84	145.09	111.70
Electrical Power Output	**kWe**	4,670	3,925	2,902	2,051	1,470
SAMPLING RESULTS						
	Test Date	**4/26/2012**	**4/26/2012**	**4/27/2012**	**4/25/2012**	**4/25/2012**
	EPA Method 5/202					
Filterable PM	**gr/dscf**	0.003409	0.003183	0.004262	0.003158	0.004325
	lb/hr	0.5487	0.4400	0.4692	0.2716	0.3124
Condensable PM	**gr/dscf**	0.0009982	0.0009467	0.0008503	0.0005153	0.001100
	lb/hr	0.1603	0.1305	0.09330	0.04403	0.07864
Total PM[1]	**gr/dscf**	0.004407	0.004130	0.005112	0.003673	0.005424
	lb/hr	0.7091	0.5705	0.5625	0.3156	0.3910
	lb/gal fuel	0.002318	0.002206	0.002872	0.002175	0.003502
	lb/kWe-hr	0.0001519	0.0001454	0.0001939	0.0001539	0.0002662
	EPA Method 9					
Opacity	**%**	4	2	5	5	1
	EPA Methods 3A, 7E, & 10					
EPA Method 3A	**% O_2**	13.3	13.4	13.7	14.1	14.8
	% CO_2	5.8	5.6	5.4	5.0	4.6
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	36.2	31.0	35.1	34.7	16.4
	lb/hr	4.634	3.397	3.033	2.373	0.9512
	lb/gal fuel	0.01514	0.01313	0.01549	0.01636	0.008513
	lb/kWe-hr	0.0009923	0.0008654	0.001046	0.001158	0.0006470
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	3.5	3.3	7.5	4.9	1.5
	lb/hr	0.4428	0.3606	0.6476	0.3335	0.08491
	lb/gal fuel	0.001446	0.001395	0.003307	0.002300	0.0007599
	lb/kWe-hr	0.00009479	0.00009193	0.0002232	0.0001627	0.00005775
CO (based on EPA Method 19 flow rates)	**ppmvd**	7.8	7.2	5.7	6.4	7.8
	lb/hr	0.6077	0.4821	0.2997	0.2661	0.2747
	lb/gal fuel	0.001985	0.001864	0.001530	0.001834	0.002460
	lb/kWe-hr	0.0001302	0.0001228	0.0001033	0.0001298	0.0001869
	Total Sulfur – ASTM D 5453					
Total Sulfur	**ppmw**	8.8	8.8	8.3	8.4	8.4

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.5 Heat Boiler #1 (IB1-2A)
100% Load Condition

Table 2.5 – Heat Boiler #1 (IB1-2A) – 100% Load Condition

NORDICA – Heat Boiler #1 (IB1-2A) Aquamaster Rauma, BH-2000, Serial #5527 *100% Load*					
Test Identification	**Emission Unit**	**Run 1**	**Run 2**	**Run 3**	**Average**
PROCESS DATA					
Power Output	**%**	100	100	100	***100***
Fuel Flow Rate	**gal/hr**	39.06	40.13	40.21	***39.80***
Boiler Rating	**MMBtu/hr**	4.44	4.44	4.44	***4.44***
SAMPLING RESULTS					
	Test Date	**4/21/2012**	**4/21/2012**	**4/21/2012**	---
	EPA Method 5/202 Run Times	1540-1641	1659-1801	1817-1919	
Filterable PM	**gr/dscf**	0.0004442	0.001447	0.0008444	***0.0009120***
	lb/hr	0.003812	0.01227	0.007293	***0.007793***
Condensable PM	**gr/dscf**	0.0009180	0.0009452	0.0008444	***0.0009025***
	lb/hr	0.007879	0.008015	0.007293	***0.007729***
Total PM[1]	**gr/dscf**	0.001362	0.002393	0.001689	***0.001815***
	lb/hr	0.01169	0.02029	0.01459	***0.01552***
	lb/gal fuel	0.0002993	0.0005056	0.0003627	***0.0003892***
	lb/MMBtu	0.002214	0.003844	0.002698	***0.002919***
	EPA Method 9 Run Times		1720-1738		
Opacity	**%**	---	---	---	---
	EPA Methods 3A & 7E Run Times	1540-1640	1659-1759	1817-1917	
EPA Method 3A	**% O_2**	3.8	3.6	3.5	***3.6***
	% CO_2	12.4	12.5	12.6	***12.5***
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	108.4	109.6	110.5	***109.5***
	lb/hr	0.7873	0.8083	0.8119	***0.8025***
	lb/gal fuel	0.02016	0.02014	0.02019	***0.02016***
	lb/MMBtu	0.1473	0.1472	0.1475	***0.1473***
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	5.0	5.6	5.8	***5.5***
	lb/hr	0.03631	0.04130	0.04262	**0.04008**
	lb/gal fuel	0.0009297	0.001029	0.001060	**0.001006**
	lb/MMBtu	0.006793	0.007521	0.007744	**0.007353**
CO (based on EPA Method 19 flow rates)	**ppmvd**	0.8	1.0	0.9	**0.9**
	lb/hr	0.003537	0.004490	0.004026	**0.004018**
	lb/gal fuel	0.00009056	0.0001119	0.0001001	**0.0001009**
	lb/MMBtu	0.0006618	0.0008176	0.0007316	**0.0007370**
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	10.0			

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.6 Heat Boiler #2 (IB1-2B)
100% Load Condition

Table 2.6 – Heat Boiler #2 (IB1-2B) – 100% Load Condition

NORDICA – Heat Boiler #2 (IB1-2B) Aquamaster Rauma, BH-2000, Serial #5526 *100% Load*					
Test Identification	**Emission Unit**	**Run 1**	**Run 2**	**Run 3**	**Average**
PROCESS DATA					
Power Output	**%**	100	100	100	***100***
Fuel Flow Rate	**gal/hr**	37.39	37.95	38.13	***37.82***
Boiler Rating	**MMBtu/hr**	4.44	4.44	4.44	***4.44***
SAMPLING RESULTS					
	Test Date	**4/21/2012**	**4/21/2012**	**4/21/2012**	---
	EPA Method 5/202 Run Times	1017-1120	1155-1257	1337-1441	
Filterable PM	**gr/dscf**	0.0007777	0.0003977	0.0008580	***0.0006778***
	lb/hr	0.005963	0.002904	0.007557	***0.005475***
Condensable PM	**gr/dscf**	0.001120	0.001027	0.001329	***0.001159***
	lb/hr	0.008587	0.007503	0.01170	***0.009264***
Total PM[1]	**gr/dscf**	0.001898	0.001425	0.002187	***0.001836***
	lb/hr	0.01455	0.01041	0.01926	***0.01474***
	lb/gal fuel	0.0003892	0.0002742	0.0005051	***0.0003895***
	lb/MMBtu	0.003109	0.002362	0.003625	***0.003032***
	EPA Method 9 Run Times		1210-1228		
Opacity	**%**	---	0	---	---
	EPA Methods 3A & 7E Run Times	1017-1117	1155-1255	1337-1437	
EPA Method 3A	**% O_2**	3.9	4.1	4.1	***4.0***
	% CO_2	11.3	12.2	12.2	***11.9***
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	107.0	109.6	110.5	***109.0***
	lb/hr	0.7483	0.7872	0.7974	***0.7777***
	lb/gal fuel	0.02001	0.02074	0.02091	***0.02056***
	lb/MMBtu	0.1465	0.1519	0.1531	***0.1505***
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	4.4	5.8	6.0	***5.4***
	lb/hr	0.03077	0.04166	0.04330	**0.03858**
	lb/gal fuel	0.0008230	0.001098	0.001136	**0.001019**
	lb/MMBtu	0.006025	0.008036	0.008314	**0.007458**
CO (based on EPA Method 19 flow rates)	**ppmvd**	0.0	0.5	0.6	**0.4**
	lb/hr	0.0	0.002187	0.002636	**0.001608**
	lb/gal fuel	0.0	0.00005762	0.00006914	**0.00004225**
	lb/MMBtu	0.0	0.0004218	0.0005062	**0.0003093**
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	9.6			

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.7 Incinerator (IB1-4)
100% Load Condition

Table 2.7 – Incinerator (IB1-4) – 100% Load Condition

NORDICA – Incinerator (IB1-4) *100% Load*					
Test Identification	**Emission Unit**	**Run 1**	**Run 2**	**Run 3**	**Average**
PROCESS DATA					
Power Output	%	100	100	100	***100***
Fuel Flow Rate	**gal/hr**	2.89	2.89	2.65	***2.81***
Waste Burned	**tons/hr**	0.040	0.040	0.040	***0.040***
SAMPLING RESULTS					
	Test Date	**4/23/2012**	**4/23/2012**	**4/23/2012**	---
	EPA Method 5/202 Run Times	0905-1007	1041-1143	1911-2013	
Filterable PM	**gr/dscf**	0.009853	0.006192	0.01032	***0.008787***
	lb/hr	0.08060	0.04844	0.08158	***0.07021***
Condensable PM	**gr/dscf**	0.002111	0.001586	0.002369	***0.002022***
	lb/hr	0.01727	0.01241	0.01874	***0.01614***
Total PM[1]	**gr/dscf**	0.01196	0.007777	0.01269	***0.01081***
	lb/hr	0.09787	0.06085	0.1003	***0.08634***
	lb/gal fuel	0.03386	0.02105	0.03785	***0.03092***
	lb/ton waste	2.447	1.521	2.508	***2.159***
	EPA Method 9 Run Times			1940-1958	
Opacity	**%**	---	---	0	---
	EPA Methods 3A & 7E Run Times	0950-1005	1041-1141	1911-2011	
EPA Method 3A	**% O_2**	18.9	18.3	17.3	***18.2***
	% CO_2	1.9	2.4	3.4	***2.6***
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	24.0	10.5	30.4	***21.6***
	lb/hr	0.1102	0.03709	0.07111	***0.07280***
	lb/gal fuel	0.03813	0.01283	0.02684	***0.02593***
	lb/ton waste	2.755	0.9272	1.778	***1.820***
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	1.5	1.6	0.8	***1.3***
	lb/hr	0.006888	0.005652	0.001871	**0.004804**
	lb/gal fuel	0.002383	0.001956	0.0007062	**0.001682**
	lb/ton waste	0.1722	0.1413	0.04679	**0.1201**
CO (based on EPA Method 19 flow rates)	**ppmvd**	49.8	132.1	17.6	**66.5**
	lb/hr	0.1392	0.2841	0.02507	**0.1495**
	lb/gal fuel	0.04818	0.09830	0.009459	**0.05198**
	lb/ton waste	3.481	7.102	0.6267	**3.737**
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	14.0			

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

Attachment F17 – Caterpillar C280 Diesel Engine Technical Data, May 3, 2011

C280-12

DIESEL ENGINE TECHNICAL DATA

CATERPILLAR®

Genset	**50 Hz**	RATING:	Marine Aux - Prime
		CERTIFICATION:	IMO II/EPA MARINE TIER II
ENGINE SPEED (rpm):	1000	TURBOCHARGER PART #:	189-4427
COMPRESSION RATIO:	13:1	FUEL TYPE:	Distillate
AFTERCOOLER WATER (°C):	32	RATED ALTITUDE @ 25°C (m):	150
JACKET WATER OUTLET (°C):	90	ASSUMED GENERATOR EFFICIENCY (%):	96
IGNITION SYSTEM:	EUI	ASSUMED GENERATOR POWER FACTOR:	0.8
EXHAUST MANIFOLD:	DRY	MEAN PISTON SPEED (m/s):	10
FIRING PRESSURE, MAXIMUM (kPa)	17300		

RATING		NOTES	LOAD	110%	100%	75%	50%
ENGINE POWER		(2)	bkW	4466	4060	3045	2030
GENERATOR POWER		(2)	ekW	4287	3898	2923	1949
BMEP			kPa	2418	2198	1649	1099
ENGINE EFFICIENCY	**(ISO 3046/1)**	**(1)**	**%**	**42.0%**	**42.1%**	**41.1%**	**38.8%**
ENGINE EFFICIENCY	(NOMINAL)	(1)	%	40.8%	40.9%	39.8%	37.6%

ENGINE DATA							
FUEL CONSUMPTION	**(ISO 3046/1)**	**(1)**	**g/bkw-hr**	**201.5**	**201.0**	**206.3**	**218.9**
FUEL CONSUMPTION	(NOMINAL)	(1)	g/bkw-hr	205.4	204.9	210.3	223.1
FUEL CONSUMPTION	(90% CONFIDENCE)	(1)	g/bkw-hr	207.5	207.1	212.8	225.9
AIR FLOW (@ 25°C, 101.3 kPaa)			Nm3/min	436.1	409.4	335.1	253.5
AIR MASS FLOW			kg/hr	29188	27399	22429	16966
INLET MANIFOLD PRESSURE			kPa (abs)	372.5	348.9	284.6	215.7
INLET MANIFOLD TEMPERATURE			°C	46.0	45.0	40.0	37.0
EXHAUST STACK TEMPERATURE			°C	391.6	376.7	373.0	368.6
EXHAUST GAS FLOW (@ stack temp, 101.3 kPa)			m3/min	939.7	876.2	702.9	529.8
EXHAUST GAS MASS FLOW			kg/hr	30106	28231	23069	17419

EMISSIONS "NOT TO EXCEED DATA"						
NOx (as NO2) + THC (molecular weight of 13.018)		g/bkW-hr	9.88	10.22	11.28	12.00
NOx (as NO2)		g/bkW-hr	9.06	9.30	10.18	10.49
CO		g/bkW-hr	0.98	0.66	0.75	1.13
THC (molecular weight of 13.018)		g/bkW-hr	0.82	0.92	1.10	1.52
Particulates		g/bkW-hr	0.18	0.21	0.34	0.92

EMISSIONS "NOMINAL DATA"						
NOx (as NO2) + THC (molecular weight of 13.018)		g/bkW-hr	8.51	8.80	9.70	10.29
NOx (as NO2)		g/bkW-hr	7.88	8.09	8.85	9.12
CO		g/bkW-hr	0.75	0.51	0.58	0.87
THC (molecular weight of 13.018)		g/bkW-hr	0.63	0.71	0.84	1.17
Particulates		g/bkW-hr	0.13	0.15	0.24	0.66

ENERGY BALANCE DATA							
FUEL INPUT ENERGY (LHV)	(NOMINAL)	(1)	KW	10957	9938	7646	5393
HEAT REJ. TO JACKET WATER	(NOMINAL)	(3)	KW	859	806	676	533
HEAT REJ. TO ATMOSPHERE	(NOMINAL)	(4)	KW	219	199	153	108
HEAT REJ. TO OIL COOLER	(NOMINAL)	(5)	KW	422	398	342	287
HEAT REJ. TO EXH. (LHV to 25°C)	(NOMINAL)	(3)	KW	3475	3142	2523	1910
HEAT REJ. TO EXH. (LHV to 177°C)	(NOMINAL)	(3)	KW	2461	2392	1957	1515
HEAT REJ. TO AFTERCOOLER	(NOMINAL)	(6) (7)	KW	1492	1312	891	520

CONDITIONS AND DEFINITIONS

ENGINE RATING OBTAINED AND PRESENTED IN ACCORDANCE WITH ISO 3046/1 AND SAE J1995 JAN90 STANDARD REFERENCE CONDITIONS OF 25°C, 100 KPA, 30% RELATIVE HUMIDITY AND 150M ALTITUDE AT THE STATED AFTERCOOLER WATER TEMPERATURE
CONSULT ALTITUDE CURVES FOR APPLICATIONS ABOVE MAXIMUM RATED ALTITUDE AND/OR TEMPERATURE
PERFORMANCE AND FUEL CONSUMPTION ARE BASED ON 35 API, 16°C FUEL HAVING A LOWER HEATING VALUE OF 42.780 KJ/KG USED AT 29°C WITH A DENSITY OF 838.9 G/LITER

NOTES

1) FUEL CONSUMPTION TOLERANCE. ISO 3046/1 IS 0, + 5% OF FULL LOAD DATA. NOMINAL IS ± 3 % OF FULL LOAD DATA
2) ENGINE POWER TOLERANCE IS ± 3 % OF FULL LOAD DATA.
3) HEAT REJECTION TO JACKET AND EXHAUST TOLERANCE IS ± 10% OF FULL LOAD DATA. (heat rate based on treated water
4) HEAT REJECTION TO ATMOSPHERE TOLERANCE IS ±50% OF FULL LOAD DATA. (heat rate based on treated water)
5) HEAT REJECTION TO LUBE OIL TOLERANCE IS ± 20% OF FULL LOAD DATA. (heat rate based on treated water)
6) HEAT REJECTION TO AFTERCOOLER TOLERANCE IS ± 5% OF FULL LOAD DATA. (heat rate based on treated water)
7) TOTAL AFTERCOOLER HEAT = AFTERCOOLER HEAT x ACHRF (heat rate based on treated water)
8) FUEL CONSUMPTION DATA IS WITHOUT SEA WATER PUMP.

ALTITUDE DERATION FACTORS IMO II/EPA MARINE TIER II

AIR TO TURBO (°C)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
50	0.94	0.91	0.88	0.86	0.83	0.81	0.78	0.76	0.74	0.71	0.69	0.67	0.65
45	0.95	0.93	0.90	0.87	0.85	0.82	0.80	0.77	0.75	0.73	0.70	0.68	0.66
40	0.97	0.94	0.91	0.89	0.86	0.83	0.81	0.78	0.76	0.74	0.71	0.69	0.67
35	0.98	0.96	0.93	0.90	0.87	0.85	0.82	0.80	0.77	0.75	0.73	0.70	0.68
30	1.00	0.97	0.94	0.92	0.89	0.86	0.84	0.81	0.79	0.76	0.74	0.71	0.69
25	1.00	0.99	0.96	0.93	0.90	0.88	0.85	0.82	0.80	0.77	0.75	0.73	0.70
20	1.00	1.00	0.98	0.95	0.92	0.89	0.86	0.84	0.81	0.79	0.76	0.74	0.72
15	1.00	1.00	0.99	0.96	0.93	0.91	0.88	0.85	0.83	0.80	0.78	0.75	0.73
10	1.00	1.00	1.00	0.98	0.95	0.92	0.89	0.87	0.84	0.82	0.79	0.77	0.74

ALTITUDE (METERS ABOVE SEA LEVEL)

AFTERCOOLER HEAT REJECTION FACTORS

AIR TO TURBO													
50	1.23	1.27	1.30	1.34	1.38	1.42	1.45	1.49	1.53	1.56	1.60	1.64	1.67
45	1.18	1.22	1.25	1.29	1.32	1.36	1.39	1.43	1.46	1.50	1.53	1.57	1.61
40	1.13	1.17	1.20	1.23	1.27	1.30	1.34	1.37	1.40	1.44	1.47	1.50	1.54
35	1.08	1.12	1.15	1.18	1.21	1.24	1.28	1.31	1.34	1.37	1.41	1.44	1.47
30	1.03	1.06	1.10	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.40
25	1.00	1.01	1.04	1.07	1.10	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34
20	1.00	1.00	1.00	1.02	1.05	1.07	1.10	1.13	1.16	1.19	1.21	1.24	1.27
15	1.00	1.00	1.00	1.00	1.00	1.02	1.04	1.07	1.10	1.12	1.15	1.18	1.20
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.04	1.06	1.09	1.11	1.14

ALTITUDE (METERS ABOVE SEA LEVEL)

FREE_FIELD MECHANICAL NOISE

SOUND PRESSURE LEVEL

DISTANCE FROM THE ENGINE (M)	dB(A)	dB								
15M	92	79.2	85.2	84.7	85.3	84.3	82.3	81	78.6	**dB**
7M	98	94.7	90.7	90.2	90.8	89.8	87.8	86.5	84.1	**dB**
1M	109	96.2	102.2	101.7	102.3	101.3	99.3	98	95.6	**dB**
	Overall	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dB(A)**

Octave Band (Hz)

FREE_FIELD EXHAUST NOISE

SOUND PRESSURE LEVEL

DISTANCE FROM THE ENGINE (M)	dB(A)	dB								
15M	98	109.1	106.6	97.4	93.5	88.7	89.2	87.2	82.9	**dB**
7M	105	116.4	113.4	104.2	99.9	95.0	96.4	84.8	90.2	**dB**
1.5M	118	129.4	127.0	116.9	113.4	109.0	110.5	108.1	102.8	**dB**
	Overall	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dB(A)**

Octave Band (Hz)

TOTAL DERATION FACTORS:

This table shows the deration required for various air inlet temperatures and altitudes. Use this information to help determine actual engine power for your site. The total deration factor includes deration due to altitude and ambient temperature, and air inlet manifold temperature deration.

AFTERCOOLER HEAT REJECTION FACTORS:

Aftercooler heat rejection is given for standard conditions of 25°C and 150 m altitude. To maintain a constant air inlet manifold temperature, as the air to turbo temperature goes up, so must the heat rejection. As altitude increases, the turbocharger must work harder to overcome the lower atmospheric pressure. This increases the amount of heat that must be removed from the inlet air by the aftercooler. Use the aftercooler heat rejection factor to adjust for ambient and altitude conditions. Multiply this factor by the standard aftercooler heat rejection.

GENERATOR EFFICIENCY:

Generator power determined with an assumed generator effeciency of 96% [generator power = engine power x 0.96]. If the actual generator efficiency is less than 96% [and greater than 94.5%], the generator power [ekW] listed in the technical data can still be achieved. The BSFC values must be increased by a factor.

The factor is a percentage = 96% - actual generator efficiency.

SOUND DATA:

Data determined by methods according to TM7080.

Attachment F18 – TRC, Emissions Test Report Aiviq Icebreaker #2/Anchor Handler Shell Gulf of Mexico, Inc., August 9, 2012

2.1 Caterpillar C280-12 Propulsion Engine #1 (IB2-1A) 95, 65, & 40% Load Conditions

Table 2.1.1 – Caterpillar C280-12 Propulsion Engine #1 (IB2-1A) Overall Average Emissions Results for 95, 65, & 40% Load Conditions

AIVIQ - Propulsion Engine #1 (IB2-1A) Caterpillar C280-12, Serial #TSJ-00104				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	65	40
Fuel Flow Rate	**gal/hr**	244	179	128
Mechanical Power Output	**kW**	3,471	2,375	1,461
SAMPLING RESULTS				
	Test Date	**5/5/12**	**5/6/12**	**5/8/12**
EPA Method 5/202				
Filterable PM	**gr/dscf**	0.009549	0.01128	0.01483
	lb/hr	1.039	0.9724	1.001
Condensable PM	**gr/dscf**	0.001953	0.0007023	0.001406
	lb/hr	0.2121	0.06053	0.09494
Total PM[1]	**gr/dscf**	0.01150	0.01198	0.01623
	lb/hr	1.251	1.033	1.096
	lb/gal fuel	0.005125	0.005761	0.008550
	lb/kW-hr	0.0003605	0.0004349	0.0007502
EPA Method 9				
Opacity	**%**	6	7	6
EPA Methods 3A, 7E, & 10				
EPA Method 3A	**% O_2**	11.5	12.0	12.5
	% CO_2	6.6	6.1	5.8
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	35.3	70.3	61.0
	lb/hr	2.940	4.525	2.989
	lb/gal fuel	0.01203	0.02523	0.02329
	lb/kW-hr	0.0008472	0.001906	0.002045
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	6.3	9.3	8.1
	lb/hr	0.5219	0.5987	0.3988
	lb/gal fuel	0.002136	0.003338	0.003108
	lb/kW-hr	0.0001504	0.0002521	0.0002729
CO (based on EPA Method 19 flow rates)	**ppmvd**	34.8	31.8	28.8
	lb/hr	1.766	1.245	0.8601
	lb/gal fuel	0.007230	0.006942	0.006701
	lb/kW-hr	0.0005089	0.0005243	0.0005885
Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	10	11	11

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.2 Caterpillar C280-12 Propulsion Engine #2 (IB2-1B) 95, 65, & 40% Load Conditions

Table 2.2.1 – Caterpillar C280-12 Propulsion Engine #2 (IB2-1B) Overall Average Emissions Results for 95, 65, & 40% Load Conditions

AIVIQ - Propulsion Engine #2 (IB2-1B) Caterpillar C280-12, Serial #TSJ-00106				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	65	40
Fuel Flow Rate	**gal/hr**	225	176	127
Mechanical Power Output	**kW**	3,471	2,375	1,461
SAMPLING RESULTS				
	Test Date	**5/2/12**	**5/2/12**	**5/3/12**
	EPA Method 5/202			
Filterable PM	**gr/dscf**	0.01100	0.01572	0.02032
	lb/hr	1.085	1.158	1.388
Condensable PM	**gr/dscf**	0.002269	0.001588	0.001751
	lb/hr	0.2238	0.1167	0.1197
Total PM[1]	**gr/dscf**	0.01327	0.01730	0.02207
	lb/hr	1.309	1.274	1.508
	lb/gal fuel	0.005816	0.007257	0.01184
	lb/kW-hr	0.0003770	0.0005366	0.001032
	EPA Method 9			
Opacity	**%**	11	11	11
	EPA Methods 3A, 7E, & 10			
EPA Method 3A	**% O_2**	10.8	11.7	12.2
	% CO_2	6.9	6.6	6.2
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	70.6	54.6	50.4
	lb/hr	5.047	3.318	2.367
	lb/gal fuel	0.02243	0.01891	0.01859
	lb/kW-hr	0.001454	0.001397	0.001620
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	3.0	2.4	4.7
	lb/hr	0.2145	0.1440	0.2223
	lb/gal fuel	0.0009532	0.0008198	0.001746
	lb/kW-hr	0.00006179	0.00006062	0.0001521
CO (based on EPA Method 19 flow rates)	**ppmvd**	28.6	23.6	24.8
	lb/hr	1.246	0.8736	0.7090
	lb/gal fuel	0.005536	0.004975	0.005568
	lb/kW-hr	0.0003589	0.0003678	0.0004852
	Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	9.9	10.2	10.4

[1]PM2.5 = PM10 = Total PM

15 ppm S = 0.0015 wt% S

2.3 Caterpillar C280-12 Propulsion Engine #3 (IB2-1C) 95, 65, & 40% Load Conditions

Table 2.3.1 – Caterpillar C280-12 Propulsion Engine #3 (IB2-1C) Overall Average Emissions Results for 95, 65, & 40% Load Conditions

AIVIQ - Propulsion Engine #3 (IB2-1C) Caterpillar C280-12, Serial #TSJ-00105				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	65	40
Fuel Flow Rate	**gal/hr**	231	172	124
Mechanical Power Output	**kW**	3,471	2,375	1,461
SAMPLING RESULTS				
	Test Date	**5/4/12**	**5/4/12**	**5/5/12**
	EPA Method 5/202			
Filterable PM	**gr/dscf**	0.01315	0.01918	0.01766
	lb/hr	1.222	1.429	1.036
Condensable PM	**gr/dscf**	0.002276	0.001933	0.001042
	lb/hr	0.2104	0.1440	0.06118
Total PM[1]	**gr/dscf**	0.01543	0.02111	0.01870
	lb/hr	1.432	1.573	1.097
	lb/gal fuel	0.006195	0.009131	0.008844
	lb/kW-hr	0.0004126	0.0006625	0.0007505
	EPA Method 9			
Opacity	**%**	11	11	11
	EPA Methods 3A, 7E, & 10			
EPA Method 3A	**% O_2**	11.4	11.9	12.3
	% CO_2	6.7	6.4	6.1
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	77.1	58.0	54.3
	lb/hr	5.950	3.554	2.487
	lb/gal fuel	0.02584	0.02062	0.02005
	lb/kW-hr	0.001714	0.001496	0.001701
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	9.5	6.5	6.7
	lb/hr	0.7330	0.3963	0.3051
	lb/gal fuel	0.003182	0.002299	0.002461
	lb/kW-hr	0.0002112	0.0001669	0.0002088
CO (based on EPA Method 19 flow rates)	**ppmvd**	21.6	21.2	20.7
	lb/hr	1.027	0.7909	0.5758
	lb/gal fuel	0.004433	0.004589	0.004644
	lb/kW-hr	0.0002959	0.0003330	0.0003940
	Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	11.2	11.2	11.1

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.4 Caterpillar C280-12 Propulsion Engine #4 (IB2-1D) 95, 65, & 40% Load Conditions

**Table 2.4.1 – Caterpillar Propulsion Engine #4 (IB2-1D)
Overall Average Emissions Results for 95, 65, & 40% Load Conditions**

AIVIQ - Propulsion Engine #4 (IB2-1D) Caterpillar C280-12, Serial #TSJ-00107				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	65	40
Fuel Flow Rate	**gal/hr**	241	174	126
Mechanical Power Output	**kW**	3,471	2,375	1,461
SAMPLING RESULTS				
	Test Date	**5/7/12**	**5/7/12**	**5/8/12**
EPA Method 5/202				
Filterable PM	**gr/dscf**	0.008600	0.01233	0.01279
	lb/hr	0.8678	0.9649	0.7570
Condensable PM	**gr/dscf**	0.001963	0.001966	0.002866
	lb/hr	0.1974	0.1539	0.1689
Total PM[1]	**gr/dscf**	0.01056	0.01430	0.01565
	lb/hr	1.065	1.119	0.9259
	lb/gal fuel	0.004438	0.006414	0.007368
	lb/kW-hr	0.0003069	0.0004711	0.0006335
EPA Method 9				
Opacity	**%**	2	8	2
EPA Methods 3A, 7E, & 10				
EPA Method 3A	**% O_2**	11.5	12.0	12.5
	% CO_2	6.6	6.2	6.0
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	60.5	63.2	63.5
	lb/hr	4.924	3.956	3.015
	lb/gal fuel	0.02052	0.02270	0.02399
	lb/kW-hr	0.001419	0.001666	0.002063
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	12.1	11.2	9.9
	lb/hr	0.9869	0.7015	0.4717
	lb/gal fuel	0.004113	0.004025	0.003754
	lb/kW-hr	0.0002843	0.0002954	0.0003228
CO (based on EPA Method 19 flow rates)	**ppmvd**	42.0	40.1	41.7
	lb/hr	2.079	1.531	1.207
	lb/gal fuel	0.008662	0.008783	0.009603
	lb/kW-hr	0.0005989	0.0006445	0.0008259
Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	10.3	9.9	10.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.5 Caterpillar 3512 Hybrid Generator Engine #1 (IB2-1E) 95, 65, & 40% Load Conditions

Table 2.5.1 – Caterpillar 3512 Hybrid Generator Engine #1 (IB2-1E) Overall Average Emissions Results for 95, 65, & 40% Load Conditions

AIVIQ - Hybrid Generator Engine #1 (IB2-1E) Caterpillar 3512, Serial #SLM-00132				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	66	40
Fuel Flow Rate	**gal/hr**	108	82	53
Electrical Power Output	**kWe**	1,381	964	581
SAMPLING RESULTS				
	Test Date	**4/27/12**	**4/27 & 4/30/12**	**4/30/12**
	EPA Method 5/202			
Filterable PM	**gr/dscf**	0.0009549	0.0008476	0.0005737
	lb/hr	0.03489	0.02574	0.01107
Condensable PM	**gr/dscf**	0.005669	0.001097	0.001384
	lb/hr	0.2082	0.03331	0.02610
Total PM[1]	**gr/dscf**	0.006624	0.001944	0.001958
	lb/hr	0.2431	0.05905	0.03717
	lb/gal fuel	0.002248	0.0007196	0.0007040
	lb/kWe-hr	0.0001753	0.00006139	0.00006485
	EPA Method 9			
Opacity	**%**	0	0	0
	EPA Methods 3A, 7E, & 10			
EPA Method 3A	**% O_2**	10.1	11.2	11.7
	% CO_2	7.9	7.2	6.8
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	33.2	20.7	16.5
	lb/hr	1.066	0.5680	0.3034
	lb/gal fuel	0.009846	0.006823	0.005751
	lb/kWe-hr	0.0007707	0.0005859	0.0005242
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	7.2	2.6	3.3
	lb/hr	0.2300	0.07171	0.06014
	lb/gal fuel	0.002125	0.0008642	0.001140
	lb/kWe-hr	0.0001668	0.00007419	0.0001038
CO (based on EPA Method 19 flow rates)	**ppmvd**	0.8	0.9	0.7
	lb/hr	0.01501	0.01542	0.008202
	lb/gal fuel	0.0001385	0.0001875	0.0001557
	lb/kWe-hr	0.00001088	0.00001599	0.00001410
	Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	11	10	10

[1]PM2.5 = PM10 = Total PM

15 ppm S = 0.0015 wt% S

2.6 Caterpillar 3512 Hybrid Generator Engine #2 (IB2-1F) 95, 65, & 40% Load Conditions

Table 2.6.1 – Caterpillar 3512 Hybrid Generator Engine #2 (IB2-1F) Overall Average Emissions Results for 95, 65, & 40% Load Conditions

AIVIQ - Hybrid Generator Engine #2 (IB2-1F) Caterpillar 3512, Serial #SLM-00178				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	65	39
Fuel Flow Rate	**gal/hr**	111	83	55
Electrical Power Output	**kWe**	1,376	950	572
SAMPLING RESULTS				
	Test Date	**4/24-25/12**	**4/23/12, 5/9/12**	**4/24/12**
EPA Method 5/202				
Filterable PM	**gr/dscf**	0.002826	0.002618	0.002315
	lb/hr	0.1101	0.08747	0.05121
Condensable PM	**gr/dscf**	0.002511	0.01148	0.002628
	lb/hr	0.09821	0.3978	0.05812
Total PM[1]	**gr/dscf**	0.005337	0.01410	0.004943
	lb/hr	0.2083	0.4853	0.1093
	lb/gal fuel	0.001892	0.005899	0.001969
	lb/kWe-hr	0.0001521	0.0005122	0.0001906
EPA Method 9				
Opacity	**%**	1	2	1
EPA Methods 3A, 7E, & 10				
EPA Method 3A	**% O_2**	10.2	11.5	11.9
	% CO_2	7.9	6.8	6.5
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	89.4	41.1	36.2
	lb/hr	2.955	1.151	0.7132
	lb/gal fuel	0.02667	0.01393	0.01290
	lb/kWe-hr	0.002147	0.001213	0.001248
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	3.7	5.1	4.9
	lb/hr	0.1214	0.1421	0.09646
	lb/gal fuel	0.001098	0.001721	0.001744
	lb/kWe-hr	0.00008872	0.0001498	0.0001688
CO (based on EPA Method 19 flow rates)	**ppmvd**	0.8	0.5	0.8
	lb/hr	0.01605	0.008166	0.01001
	lb/gal fuel	0.0001452	0.00009959	0.0001805
	lb/kWe-hr	0.00001166	0.000008644	0.00001749
Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	10	11	10

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

Note: Due to a laboratory error, the results for 65% Load condition were calculated with an estimated value for the Run 1 CPM catch.

2.7 Caterpillar 3512 Hybrid Generator Engine #3 (IB2-1G) 95, 65, & 40% Load Conditions

Table 2.7.1 – Caterpillar 3512 Hybrid Generator Engine #3 (IB2-1G) Overall Average Emissions Results for 95, 65, & 40% Load Conditions

AIVIQ - Hybrid Generator Engine #3 (IB2-1G) Caterpillar 3512, Serial #SLM-00125				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	94	67	40
Fuel Flow Rate	**gal/hr**	110	85	55
Electrical Power Output	**kWe**	1,371	969	581
SAMPLING RESULTS				
	Test Date	**4/25/12**	**4/26/12**	**4/26/12**
	EPA Method 5/202			
Filterable PM	**gr/dscf**	0.002023	0.0007520	0.0006302
	lb/hr	0.07857	0.02538	0.01383
Condensable PM	**gr/dscf**	0.005433	0.0007260	0.0003649
	lb/hr	0.2112	0.02444	0.007958
Total PM[1]	**gr/dscf**	0.007456	0.001478	0.0009951
	lb/hr	0.2897	0.04981	0.02179
	lb/gal fuel	0.002639	0.0005879	0.0003946
	lb/kWe-hr	0.0002109	0.00005149	0.00003751
	EPA Method 9			
Opacity	**%**	1	1	0
	EPA Methods 3A, 7E, & 10			
EPA Method 3A	**% O_2**	10.3	11.1	11.8
	% CO_2	7.7	7.1	6.6
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	15.5	18.9	24.8
	lb/hr	1.072	0.5203	0.4803
	lb/gal fuel	0.009778	0.006150	0.008682
	lb/kWe-hr	0.0007816	0.0005366	0.0008262
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	0.3	2.8	0.5
	lb/hr	0.02312	0.07744	0.008966
	lb/gal fuel	0.0002105	0.0009111	0.0001632
	lb/kWe-hr	0.00001692	0.00008061	0.00001542
CO (based on EPA Method 19 flow rates)	**ppmvd**	1.8	1.1	1.1
	lb/hr	0.07418	0.01900	0.01336
	lb/gal fuel	0.0006753	0.0002245	0.0002413
	lb/kWe-hr	0.00005393	0.00001960	0.00002298
	Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	11	10	11

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.8 Caterpillar 3512 Hybrid Generator Engine #4 (IB2-1H) 95, 65, & 40% Load Conditions

Table 2.8.1 – Caterpillar 3512 Hybrid Generator Engine#4 (IB2-1H) Overall Average Emissions Results for 95, 65, & 40% Load Conditions

AIVIQ - Hybrid Generator Engine #4 (IB2-1H) Caterpillar 3512, Serial #SLM-00109				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	65	40
Fuel Flow Rate	**gal/hr**	108	84	52
Electrical Power Output	**kWe**	1,371	950	581
SAMPLING RESULTS				
	Test Date	**4/30/12-5/1/12**	**5/1/12**	**5/1/12**
EPA Method 5/202				
Filterable PM	**gr/dscf**	0.0006234	0.0005492	0.0003679
	lb/hr	0.02706	0.02043	0.008799
Condensable PM	**gr/dscf**	0.002733	0.0007154	0.0003571
	lb/hr	0.1183	0.02670	0.008514
Total PM[1]	**gr/dscf**	0.003357	0.001265	0.0007250
	lb/hr	0.1454	0.04713	0.01731
	lb/gal fuel	0.001346	0.0005602	0.0003323
	lb/kWe-hr	0.0001061	0.00004972	0.00002980
EPA Method 9				
Opacity	**%**	0	0	0
EPA Methods 3A, 7E, & 10				
EPA Method 3A	**% O_2**	10.0	10.9	11.6
	% CO_2	7.9	7.3	6.8
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	24.0	13.6	15.7
	lb/hr	0.7578	0.3674	0.2824
	lb/gal fuel	0.007016	0.004363	0.005398
	lb/kWe-hr	0.0005531	0.0003869	0.0004856
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	0.9	1.3	2.0
	lb/hr	0.02944	0.03593	0.03652
	lb/gal fuel	0.0002726	0.0004268	0.0006976
	lb/kWe-hr	0.00002150	0.00003785	0.00006281
CO (based on EPA Method 19 flow rates)	**ppmvd**	1.1	1.3	1.0
	lb/hr	0.02174	0.02185	0.01131
	lb/gal fuel	0.0002013	0.0002600	0.0002158
	lb/kWe-hr	0.00001586	0.00002301	0.00001945
Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	11	11	11

[1]PM2.5 = PM10 = Total PM

15 ppm S = 0.0015 wt% S

2.9 Incinerator (1B2-4)
100% Load Condition

Table 2.9 – Incinerator (IB2-4) – 100% Load Condition

AIVIQ – Incinerator (IB2-4) *100% Load*					
Test Identification	**Emission Unit**	**Run 1**	**Run 2**	**Run 3**	**Average**
PROCESS DATA					
Power Output	**%**	100	100	100	***100***
Fuel Flow Rate	**gal/hr**	7.36	4.50	6.26	***6.04***
Waste Burned	**tons/hr**	0.094	0.080	0.079	***0.084***
SAMPLING RESULTS					
	Test Date	**5/10/12**	**5/10/12**	**5/11/12**	---
	EPA Method 5/202 Run Times	0820-0927	1005-1114	1542-1650	
Filterable PM	**gr/dscf**	0.06360	0.05644	0.09817	***0.07274***
	lb/hr	1.384	1.036	2.034	***1.485***
Condensable PM	**gr/dscf**	0.001038	0.0001870	0.0007269	***0.0006508***
	lb/hr	0.02259	0.003433	0.01506	***0.01370***
Total PM[1]	**gr/dscf**	0.06464	0.05663	0.09889	***0.07339***
	lb/hr	1.406	1.039	2.049	***1.498***
	lb/gal fuel	0.1911	0.2310	0.3276	***0.2499***
	lb/ton waste	15.03	13.06	26.02	***18.04***
	EPA Method 9 Run Times				
Opacity	**%**	---	---	---	---
	EPA Methods 3A & 7E Run Times	0820-0926	1007-1113	1542-1648	
EPA Method 3A	**% O_2**	18.2	19.0	18.4	***18.5***
	% CO_2	1.8	1.4	1.8	***1.7***
NO_x (based on EPA Method 19 flow rates)	**Ppmvd**	20.8	18.0	21.3	***20.0***
	lb/hr	0.3782	0.2761	0.3688	***0.3410***
	lb/gal fuel	0.05138	0.06135	0.05892	***0.05722***
	lb/ton waste	4.043	3.468	4.683	***4.065***
NO_2 (based on EPA Method 19 flow rates)	**Ppmvd**	1.7	0.0	0.6	***0.8***
	lb/hr	0.03091	0.0	0.01039	**0.01377**
	lb/gal fuel	0.004200	0.0	0.001660	**0.001953**
	lb/ton waste	0.3304	0.0	0.1319	**0.1541**
CO (based on EPA Method 19 flow rates)	**Ppmvd**	120.2	14.6	130.3	**88.4**
	lb/hr	1.331	0.1363	1.374	**0.9469**
	lb/gal fuel	0.1808	0.03030	0.2194	**0.1435**
	lb/ton waste	14.22	1.713	17.44	**11.13**

[1]PM2.5 = PM10 = Total PM

Attachment F19 – CleanAIR Systems, Proposal for Hull 247 (Aiviq), April 7, 2010

CleanAIR SYSTEMS

PROPOSAL

Proposal Date: **Wednesday, April 07, 2010**

Quotation Number: **10020133-MR-E** Revision: **3e**

Customer Contact:	**Richard Allinson**	**Project Description**
Title:		**Hull 247, 3512 Engines**
Email:	richard.allinson@chouest.com	
Phone:	**+44 (0) 1620 670002**	
Cell:	**+44 (0) 7951 319 524**	Address:
Company Name:	**Edison Chouest Offshore**	
Address :	**The Estate Office**	,
	Fenton Barns	
	North Berwick, East Lothian EH39 5BW	
	UK	

Product Quoted: **E-POD with ENDURE SCR & ASSURE DOC or PERMIT Filter units in a 316 Stainless Steel Double Wall Insulated Critical Grade Silencer**

Purchase Order Date: | Requested Installation Date:

Engine Specifications: *CAT*

Engine Model:	**3512C**				Engine S/N:			
EPA Tier Level:	Tier 2				EPA Family #:			
Engine Displacement:	52	liters			Engine Specification #:	DM8430		
Fuel Type:	ULSD (<15 PPM)				Engine Model Year:			
Required Fuel Content:	<50	ppm	Sulfur					
Generator Power Rating:	**1,700**	**ekW**	**Prime**		**Model #:**			
Average Running Load:		Runtime:		hours/year				
Engine Power Output:	**2,400**	**bhp or**	**1788**	**bkW**	**@**	**1,800**	**RPM**	
Exhaust Flow Rate:	13,293	ACFM						
Exhaust Stack Temp:	836	deg F						
Maximum Exhaust Pressure:	27	inches H_2O						

Emissions Specifications:

Engine Emissions:	***5 Mode Average, Do Not Exceed***				
NOx:	5.66	g/bhp-hr			
CO:	1.29	g/bhp-hr			
HC:	0.39	g/bhp-hr			
PM:	0.15	g/bhp-hr			
Emissions Reduction Required:	*Marine Tier 4 (2016)*		**% Reduction**	*Marine Tier 3 (2012)*	
NOx:	1.34	g/bhp-hr	76%	NOx+HC 4.33	g/bhp-hr
CO:		g/bhp-hr			g/bhp-hr
HC:	0.14	g/bhp-hr	64%		g/bhp-hr
PM:	0.03	g/bhp-hr	80%	PM 0.08	g/bhp-hr
Emissions Post After Treatment:	***Estimated***		**% Reduction**		
NOx:	**0.566**	**g/bhp-hr**	**90%**		
CO:	**0.129**	**g/bhp-hr**	**90%**		
HC:	**0.039**	**g/bhp-hr**	**90%**		
PM with ASSURE DOC Units:	**0.119**	**g/bhp-hr**	**20%**	***Note: DOC does not meet Tier 3 PM***	
PM with PERMIT Filter Units:	**0.022**	**g/bhp-hr**	**85%**	***Filters meet Tier 3 and 4 PM***	

CleanAIR SYSTEMS

ENDURE SCR Specifications:				
NOx Reduction:	90%			
Material:	Zeolite based			
Temperature Range:	550 to 1,025 deg. F			
ENDURE SCR Catalyst Part Number:	EAA060612A			
Total Amount of Catalyst:	34	cubic feet		
Number of Catalyst Layers:	3	layers @	49	blocks/layer
SCR Pressure Drop:	**4.1**	inches H_2O as configured at rated load		
Estimated Reductant Consumption:	**5.9**	**gal/hr of**	**32.5% Technical Urea**	**@ rated load**
Ammonia Slip:	<10	ppm		
Catalyst Life Expectancy:	20,000	hours		

E-POD Control System: ***Integrated within the Dosing Cabinet***

*Touch Screen Display & Dual NOx Sensors for a True Closed-Loop System
*Controller, Pressure Sensor, Temperature Sensor
*Power requirement: 240/120 volts AC, 10/20 amps, 50/60 Hertz
*Records NOx levels pre and post, Temperature and Pressure, Time and Date

Dosing Cabinet: ***Included***

*Housed in a NEMA 4 enclosure
*Auto Start, Stop and Purge Cycle
*Dosing Pump
*Pressure Regulator
*Secondary Urea / Aqua Ammonia Filter

Tube Bundle: ***Included***

*1/4" Heat Traced Stainless Steel tubing for Urea Flow
*1/2" Stainless Steel tubing for Compressed Air
*Signal Wires from Dosing Cabinet to E-POD

Injection and Mixing Section: ***Integrated within the E-POD housing***

Type of Injector: Air/Liquid Lance with Urea
Compressed Air Required: Yes, 10 SCFM @ 100 PSIG with dryer
Mixer: Static

Reductant Supply: *Not Included*

Reductant Supply Pump: *Not Provided & May not be necessary if gravity fed*
Urea Heat Tracing: *Not Provided before the Dosing Cabinet*
Storage Tanks: *Customer Supplied*
Reducing Agent: *Customer Supplied*

**The customer will supply the necessary tanks, plumbing safety equipment, monitoring devices, permitting and all parts and expenses to contain the selected reducing agent and supply the required amount to the Reducing Agent Injection System.*

CleanAIR SYSTEMS

ASSURE DOC Specifications:	*Option 1*			
Material:	Catalyzed Cordierite Ceramic substrates			
PM Reduction:	~20%	@ steady state		
CO Reduction:	90%			
HC(VOC) Reduction:	90%			
ASSURE DOC Part Number:	CEH1250B			
Amount of Catalyst:	**3.8**	cubic ft.	**9**	DOC units
Catalyst Pressure Drop:	**5.1**	inches H_2O as configured at rated load		
Regeneration:	Not required			

PERMIT Filter Specifications:	*Option 2*	
Material:	Catalyzed Cordierite Ceramic wall-flow filter substrates	
PM Reduction:	85%	***CARB Level 3+ verified***
CO Reduction:	90%	
HC(VOC) Reduction:	90%	
PERMIT Filter Part Number:	FDA221	
Number of Filters:	**9**	
Filter Pressure Drop:	**9.4**	inches H_2O as configured at rated load
Regeneration using ULSD:	**Independent of Engine Operation - Active Regeneration System Using Integrated Electric Heaters to Control Exhaust Temperature**	
Typical Cleaning Interval:	2,500	hours
Catalyst Life Expectancy:	10,000	hours

Active Regeneration System	
Voltage:	480
Phase:	3
Heater Assembly Watts:	100kW
Number of Heater Assemblies:	1
Element Sheath Material:	Incoloy 800
Controller:	SCR heater / temperature controller
Controller Size:	36" high x 32" wide x 12" deep
Enclosure Rating:	NEMA 12
Interconnecting Wiring:	**Not Included**

Silencer Housing Specifications:	**10020101AE**					
Material:	**316L Stainless Steel**					
Construction:	**Double Wall, Rigid, & Light Weight**					
Insulation:	**2"**	**Between two 304L Stainless Steel Walls**				
Approximate Dimensions (inches):	**276**	**" Length**	**62**	**" Width**	**62**	**" Height**
Estimated Weight:	**10,000**	**pounds**	**4,550**	**kilograms**		
Sound Reduction:	**27-35**	**dBa, Critical Grade Silencing**				
Total System Pressure Drop Silencer+SCR+DOC:	**14.3**	inches H_2O as configured at rated load				
Total System Pressure Drop Silencer+SCR+DPF:	**18.5**	inches H_2O as configured at rated load				
Inlet Size:	**18**	inches				
Outlet Size:	**18**	inches				

The E-POD Silencer Housing is designed to accommodate the ENDURE SCR and either the ASSURE DOC or the PERMIT Filter systems. If not initially purchased, any of these products can be installed at a future date.

CleanAIR SYSTEMS

This System Includes:		
ENDURE SCR Catalyst	**Yes**	
ASSURE DOC	**Option 1**	
PERMIT DPF	**Option 2**	
SILENCER - 316L Stainless Steel	**Yes**	
INTERNAL Mixing and Reductant Injection	**Yes**	
E-POD Controller	**Yes**	***Closed-Loop System***
Operation & Maintenance Manual	**Yes**	
Start-up Commissioning	**Yes**	

This System Excludes:

Delivery/Freight Expenses

Consumables and Utilities (chemicals, water, electricity, etc.)

Reductant tanks, plumbing, supply pumps, etc.

Installation and supply of interconnecting power, control cables, and conduit

Installation of the E-POD System

Exhaust piping insulation *(CleanAIR Systems recommends insulating the exhaust from the engine to the inlet of the filter)*

All necessary permitting

Attachment F20 – TRC, Emissions Test Report Shell Offshore, Inc., NO_X Emissions Testing Tor Viking II, July 12, 2007

Table 2.1.2

Summary of Average NO_x Results

MaK 8M32 Main Propulsion Engine/Generator (Main Engine #2)
Unit TV-2, Source Group C1
May 18, 2007

Shell Offshore, Inc.
Kulluk Drilling Unit (Kulluk)
Norway

SCR OFF						
Method	**Pollutant**	**Emission Unit**	**Run #**			**Average**
LOAD CONDITION – 80%			7	8	9	
Diesel Fuel Useage	---	L/hr	607	612	611	**610**
Method 7E	NO_x	ppm	652.6	649.0	642.5	**648.0**
	NO_x	Lb/hr	45.7	45.6	45.9	**45.7**
	NO_x	lb/MMBtu	2.079	2.039	2.018	**2.045**
	NO_x	lb/gal	0.2847	0.2820	0.2841	**0.2836**
LOAD CONDITION – 57%			4	5	6	
Diesel Fuel Useage	---	L/hr	386	397	397	**393**
Method 7E	NO_x	ppm	596.7	635.4	628.2	**620.1**
	NO_x	lb/hr	36.9	39.2	39.1	**38.4**
	NO_x	lb/MMBtu	1.901	2.052	2.058	**2.004**
	NO_x	lb/gal	0.3620	0.3738	0.3724	**0.3694**
LOAD CONDITION – 35%			1	2	3	
Diesel Fuel Useage	---	L/hr	216	220	221	**219**
Method 7E	NO_x	ppm	573.8	535.8	527.4	**545.7**
	NO_x	lb/hr	18.6	17.3	16.5	**17.5**
	NO_x	lb/MMBtu	1.880	1.731	1.657	**1.756**
	NO_x	lb/gal	0.3264	0.2978	0.2833	**0.3025**

Table 2.1.4

Summary of Average NO_x Results and Permit Limits

Caterpillar 3412 Harbor Generator (Auxiliary Engine #1), TV-5/C2

May 16-17, 2007

Shell Offshore, Inc.
Kulluk Drilling Unit (Kulluk)
Norway

SCR OFF						
Method	**Pollutant**	**Emission Unit**	**Run #**			**Average**
LOAD CONDITION – 80%			1	2	3	
Power Produced	**---**	kW/hr	389	387	381	**386**
Method 7E	**NO_x**	ppm	827.3	823.9	811.9	**821.0**
	NO_x	lb/hr	6.90	6.89	6.79	**6.86**
	NO_x	lb/MMBtu	1.530	1.512	1.490	**1.510**
	NO_x	lb/kW-hr	0.0177	0.0178	0.0178	**0.0178**
LOAD CONDITION – 57%			4	5	6	
Power Produced	**---**	kW/hr	288	287	282	**286**
Method 7E	**NO_x**	ppm	860.0	846.5	771.6	**826.0**
	NO_x	lb/hr	6.21	5.94	5.40	**5.85**
	NO_x	lb/MMBtu	1.809	1.781	1.609	**1.733**
	NO_x	lb/kW-hr	0.0216	0.0207	0.0191	**0.0205**
LOAD CONDITION – 35%			7	8	9	
Power Produced	**---**	kW/hr	177	173	181	**177**
Method 7E	**NO_x**	ppm	838.1	807.6	792.3	**812.7**
	NO_x	lb/hr	4.92	4.68	4.51	**4.70**
	NO_x	lb/MMBtu	2.235	2.154	2.089	**2.159**
	NO_x	lb/kW-hr	0.0278	0.0270	0.0249	**0.0266**

Attachment F21 – TRC, Emissions Test Report Tor Viking Icebreaker #2/Anchor Handler Shell Gulf of Mexico, Inc., August 9, 2012

2.1 MaK Propulsion Engine #1 (TV-1) 80, 60, 40 & 30% Load Conditions

Table 2.1.1 – MaK Propulsion Engine #1 (TV-1)
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

TOR VIKING - Propulsion Engine #1 (TV-1) MaK 6M32, Serial #37351					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	133.4	83.6	45.9	18.8
Mechanical Power Outlet	**kW**	2,313	1,679	1,073	662
SAMPLING RESULTS					
	Test Date	**4/25/12**	**4/24-25/12**	**4/24/12**	**4/25/12**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.001669	0.001729	0.004002	0.007532
	lb/hr	0.1302	0.08852	0.1090	0.1360
Condensable PM	**gr/dscf**	0.001602	0.0008371	0.002137	0.0006736
	lb/hr	0.1247	0.04286	0.05933	0.01215
Total PM[1]	**gr/dscf**	0.003271	0.002566	0.006139	0.008206
	lb/hr	0.2549	0.1314	0.1683	0.1481
	lb/gal fuel	0.001911	0.001579	0.003649	0.007861
	lb/kW-hr	0.0001103	0.00007810	0.0001561	0.0002236
	EPA Method 9				
Opacity	**%**	2	0	0	5
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	13.7	13.8	13.9	16.5
	% CO_2	5.1	5.1	5.0	3.2
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	35.3	65.2	28.0	318.6
	lb/hr	2.022	2.383	0.5665	4.178
	lb/gal fuel	0.01515	0.02851	0.01233	0.2219
	lb/kW-hr	0.0008742	0.001420	0.0005274	0.006308
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	2.8	5.8	2.9	42.1
	lb/hr	0.1584	0.2119	0.05864	0.5524
	lb/gal fuel	0.001188	0.002535	0.001279	0.02932
	lb/kW-hr	0.00006853	0.0001263	0.00005468	0.0008339
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	< 1.0	< 1.0	< 1.0	< 1.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.2 MaK Propulsion Engine #2 (TV-2) 80, 60, 40 & 20% Load Conditions

Table 2.2.1 – MaK Propulsion Engine #2 (TV-2)
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

TOR VIKING - Propulsion Engine #2 (TV-2) MaK 6M32, Serial #37349					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	175.1	112.1	72.7	15.1
Mechanical Power Output	**kW**	3,025	2,241	1,716	801
SAMPLING RESULTS					
	Test Date	**4/26/12**	**4/26/12**	**4/27/12**	**4/27/12**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.001999	0.003216	0.003851	0.01694
	lb/hr	0.2016	0.2161	0.1633	0.3999
Condensable PM	**gr/dscf**	0.002899	0.001334	0.001271	0.007037
	lb/hr	0.2926	0.08900	0.05364	0.1661
Total PM[1]	**gr/dscf**	0.004899	0.004551	0.005122	0.02398
	lb/hr	0.4942	0.3051	0.2169	0.5660
	lb/gal fuel	0.002824	0.002731	0.002985	0.03751
	lb/kW-hr	0.0001634	0.0001363	0.0001264	0.0007062
	EPA Method 9				
Opacity	**%**	1	4	2	2
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	13.5	13.5	12.9	17.8
	% CO_2	5.4	5.3	5.8	2.2
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	112.0	108.1	106.0	246.6
	lb/hr	8.192	5.058	2.976	3.672
	lb/gal fuel	0.04676	0.04512	0.04095	0.2431
	lb/kW-hr	0.002708	0.002257	0.001734	0.004583
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	6.6	6.2	6.2	21.5
	lb/hr	0.4851	0.2899	0.1740	0.3195
	lb/gal fuel	0.002770	0.002587	0.002395	0.02116
	lb/kW-hr	0.0001604	0.0001294	0.0001014	0.0003987
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	< 1.0	< 1.0	< 1.0	< 1.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.3 MaK Propulsion Engine #3 (TV-3) 80, 60, 40 & 20% Load Conditions

Table 2.3.1 – MaK Propulsion Engine #3 (TV-3)
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

TOR VIKING - Propulsion Engine #3 (TV-3) MaK 6M32, Serial #37348					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	163.8	101.8	69.1	15.8
Mechanical Power Output	**kW**	3,063	2,253	1,759	846
SAMPLING RESULTS					
	Test Date	**4/26/12**	**4/26/12**	**4/27/12**	**4/27/12**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.001416	0.001558	0.003282	0.02477
	lb/hr	0.1195	0.08534	0.1147	0.6149
Condensable PM	**gr/dscf**	0.002622	0.001714	0.001574	0.002248
	lb/hr	0.2212	0.09394	0.05555	0.05537
Total PM[1]	**gr/dscf**	0.004038	0.003272	0.004856	0.02702
	lb/hr	0.3407	0.1793	0.1702	0.6703
	lb/gal fuel	0.002080	0.001768	0.002463	0.04219
	lb/kWe-hr	0.0001113	0.00007973	0.00009794	0.0007920
	EPA Method 9				
Opacity	**%**	2	4	4	5
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	13.5	13.3	13.1	17.6
	% CO_2	5.4	5.4	5.7	2.4
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	116.5	90.3	80.8	233.7
	lb/hr	8.000	3.735	2.218	3.428
	lb/gal fuel	0.04885	0.03666	0.03207	0.2169
	lb/kW-hr	0.002612	0.001657	0.001277	0.004052
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	3.5	1.8	1.4	8.1
	lb/hr	0.2427	0.07586	0.03753	0.1192
	lb/gal fuel	0.001482	0.0007442	0.0005424	0.007536
	lb/kW-hr	0.00007921	0.00003365	0.00002161	0.0001409
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	< 1.0	< 1.0	< 1.0	< 1.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.4 MaK Propulsion Engine #4 (TV-4) 80, 60, 40 & 20% Load Conditions

Table 2.4.1 – MaK Propulsion Engine #4 (TV-4)
Overall Average Emissions Results for 80, 60, 40, & 30% Load Conditions

TOR VIKING - Propulsion Engine #4 (TV-4) MaK 6M32, Serial #37350					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	143.2	91.5	50.5	24.3
Mechanical Power Output	**kW**	2,322	1,707	1,117	772
SAMPLING RESULTS					
	Test Date	**4/29/12**	**4/29/12**	**4/29/12**	**4/29/12**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.002903	0.001800	0.004168	0.007542
	lb/hr	0.2185	0.09114	0.1117	0.1384
Condensable PM	**gr/dscf**	0.001624	0.0005175	0.0005196	0.001127
	lb/hr	0.1217	0.02621	0.01393	0.01984
Total PM[1]	**gr/dscf**	0.004527	0.002317	0.004687	0.008669
	lb/hr	0.3402	0.1173	0.1256	0.1582
	lb/gal fuel	0.002377	0.001280	0.002490	0.006488
	lb/kW-hr	0.0001465	0.00006870	0.0001125	0.0002040
	EPA Method 9				
Opacity	**%**	---	1	4	5
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	13.4	13.3	13.4	16.3
	% CO_2	5.5	5.5	5.4	3.5
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	75.3	71.8	43.4	339.9
	lb/hr	4.434	2.680	0.9060	5.588
	lb/gal fuel	0.03098	0.02924	0.01794	0.2300
	lb/kW-hr	0.001910	0.001569	0.0008103	0.007246
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	4.8	4.0	3.3	39.2
	lb/hr	0.2847	0.1481	0.06897	0.6446
	lb/gal fuel	0.001990	0.001615	0.001363	0.02654
	lb/kW-hr	0.0001227	0.00008670	0.00006160	0.0008365
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	< 5.0	< 5.0	< 5.0	< 5.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.5 Harbor Generator - SB 95 and 50% Load Conditions

Table 2.5.1 – Harbor Generator SB
Overall Average Emissions Results for 95 & 50% Load Conditions

TOR VIKING – Harbor Generator SB Caterpillar 3412, Serial #81Z24073			
Test Identification	**Emission Unit**	**95% Load**	**50% Load**
PROCESS DATA			
Power Output	**%**	95	50
Fuel Flow Rate	**gal/hr**	29.7	16.3
Electrical Power Outlet	**kWe**	371	209
SAMPLING RESULTS			
	Test Date	**4/28/12**	**4/28/12**
	EPA Method 5/202		
Filterable PM	**gr/dscf**	0.02325	0.009076
	lb/hr	0.2091	0.06160
Condensable PM	**gr/dscf**	0.0008308	0.0004102
	lb/hr	0.007481	0.002799
Total PM[1]	**gr/dscf**	0.02408	0.009486
	lb/hr	0.2166	0.06440
	lb/gal fuel	0.007294	0.003949
	lb/kWe-hr	0.0005845	0.0003085
	EPA Method 9		
Opacity	**%**	6	6
	EPA Methods 3A & 7E		
EPA Method 3A	**% O_2**	8.8	11.4
	% CO_2	8.3	6.7
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	55.5	71.8
	lb/hr	0.4173	0.3797
	lb/gal fuel	0.01405	0.02328
	lb/kWe-hr	0.001126	0.001819
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	11.4	30.4
	lb/hr	0.08601	0.1607
	lb/gal fuel	0.002896	0.009846
	lb/kWe-hr	0.0002319	0.0007696
	Total Sulfur – ASTM D 5453		
Total Sulfur	**ppmw**	< 1.0	< 1.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.6 Harbor Generator - PS
95 and 50% Load Conditions

Table 2.6.1 – Harbor Generator PS
Overall Average Emissions Results for 95 & 50% Load Conditions

TOR VIKING – Harbor Generator PS Caterpillar 3412, Serial #81Z24079			
Test Identification	**Emission Unit**	**95% Load**	**50% Load**
PROCESS DATA			
Power Output	**%**	95	50
Fuel Flow Rate	**gal/hr**	26.6	14.3
Electrical Power Outlet	**kWe**	366	184
SAMPLING RESULTS			
	Test Date	**4/28/12**	**4/28/12**
EPA Method 5/202			
Filterable PM	**gr/dscf**	0.02834	0.007521
	lb/hr	0.2744	0.05159
Condensable PM	**gr/dscf**	0.0005981	0.0004207
	lb/hr	0.005800	0.002891
Total PM[1]	**gr/dscf**	0.02894	0.007942
	lb/hr	0.2802	0.05448
	lb/gal fuel	0.01051	0.003809
	lb/kWe-hr	0.0007637	0.0002955
EPA Method 9			
Opacity	**%**	4	8
EPA Methods 3A & 7E			
EPA Method 3A	**% O_2**	8.7	12.0
	% CO_2	8.3	6.2
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	65.4	71.8
	lb/hr	0.4399	0.3540
	lb/gal fuel	0.01654	0.02472
	lb/kWe-hr	0.001202	0.001917
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	10.1	19.7
	lb/hr	0.06856	0.09720
	lb/gal fuel	0.002584	0.006781
	lb/kWe-hr	0.0001878	0.0005260
Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	< 1.0	< 1.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.7 Heat Boiler
100% Load Condition

Table 2.7 – Heat Boiler – 100% Load Condition

TOR VIKING – Heat Boiler Pyro E1130, Serial #6948 *100% Load*					
Test Identification	**Emission Unit**	**Run 1**	**Run 2**	**Run 3**	**Average**
PROCESS DATA					
Power Output	**%**	100	100	100	***100***
Fuel Flow Rate	**gal/hr**	3.1	4.0	3.6	***3.6***
Engine Rating	**MMBTU/hr**	1.37	1.37	1.37	***1.37***
SAMPLING RESULTS					
	Test Date	**4/23/12**	**4/23/12**	**4/23/12**	---
EPA Method 5/202 Run Times		1120-1251	1315-1420	1450-1603	
Filterable PM	**gr/dscf**	0.001147	0.001290	0.001194	***0.001210***
	lb/hr	0.001771	0.002168	0.001980	***0.001973***
Condensable PM	**gr/dscf**	0.002242	0.001003	0.0008594	***0.001368***
	lb/hr	0.003461	0.001686	0.001426	***0.002191***
Total PM[1]	**gr/dscf**	0.003390	0.002293	0.002053	***0.002579***
	lb/hr	0.005232	0.003854	0.003406	***0.004164***
	lb/gal fuel	0.001688	0.0009635	0.0009462	***0.001199***
	lb/MMBtu	0.005801	0.003949	0.003558	***0.004436***
EPA Method 9 Run Time			1402-1420		
Opacity	**%**	---	0	---	---
EPA Methods 3A & 7E Run Times		1120-1244	1315-1415	1450-1601	
EPA Method 3A	**% O_2**	4.8	4.9	5.0	***4.9***
	% CO_2	11.5	11.6	11.5	***11.5***
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	77.4	78.1	78.4	***78.0***
	lb/hr	0.04602	0.06029	0.05481	***0.05371***
	lb/gal fuel	0.01485	0.01507	0.01523	***0.01505***
	lb/MMBtu	0.1107	0.1124	0.1136	***0.1122***
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	2.2	2.3	2.4	***2.3***
	lb/hr	0.001308	0.001776	0.001678	***0.001587***
	lb/gal fuel	0.0004220	0.0004439	0.0004661	***0.0004440***
	lb/MMBtu	0.003147	0.003311	0.003476	***0.003311***
Total Sulfur – ASTM D 5453					
Total Sulfur	**ppmw**	< 1.0			

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

Attachment F22 – TRC, Emissions Test Report Nanuq Oil Spill Response Vessel Shell Gulf of Mexico, Inc., July 26, 2012

2.1 Port Main Engine (N-1)
100, 75, 50, & 25% Load Conditions

Table 2.1.1 - Port Main Engine
Overall Average Emissions Results for 100, 75, 50, & 25% Load Conditions

NANUQ – Port Main Engine (N-1) Caterpillar 3608 – Serial #6MC00759					
Test Identification	**Emission Unit**	**100% Load**	**75% Load**	**50% Load**	**25% Load**
PROCESS DATA					
Power Output	**%**	100	75	50	25
Fuel Flow Rate	**gal/hr**	134.8	105.7	76.7	45.7
Mechanical Power Output	**kW**	2710	2033	1355	678
SAMPLING RESULTS					
	Test Date	**6/23/2012**	**6/23/2012**	**6/23-24/2012**	**6/25/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.0006799	0.0009942	0.0006384	0.0007778
	lb/hr	0.03512	0.04177	0.01905	0.01596
Condensable PM	**gr/dscf**	0.001423	0.0008242	0.001072	0.0008646
	lb/hr	0.07421	0.03476	0.03204	0.01767
Total PM[1]	**gr/dscf**	0.002103	0.001818	0.001711	0.001642
	lb/hr	0.1093	0.07653	0.05109	0.03363
	lb/gal fuel	0.0008099	0.0007236	0.0006691	0.0007326
	lb/kW-hr	0.00004034	0.00003765	0.00003770	0.00004964
	EPA Method 9				
Opacity	**%**	5	5	5	5
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	12.9	13.0	13.0	13.8
	% CO_2	6.0	5.8	5.7	5.2
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	757.7	723.1	665.7	565.3
	lb/hr	40.72	30.99	20.79	11.66
	lb/gal fuel	0.3021	0.2931	0.2711	0.2549
	lb/kW-hr	0.01503	0.01525	0.01534	0.01721
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	243.0	235.5	225.9	208.0
	lb/hr	13.06	10.10	7.056	4.289
	lb/gal fuel	0.09688	0.09549	0.09209	0.09378
	lb/kW-hr	0.004819	0.004967	0.005207	0.006331
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	9	9	9	9

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.2 Starboard Main Engine (N-2)
100, 75, 50 & 25% Load Conditions

Table 2.2.1 – Starboard Main Engine
Overall Average Emissions Results for 100, 75, 50, & 25% Load Conditions

NANUQ – Starboard Main Engine (N-2) Caterpillar 3608 – Serial #6MC00760					
Test Identification	**Emission Unit**	**100% Load**	**75% Load**	**50% Load**	**25% Load**
PROCESS DATA					
Power Output	**%**	100	75	50	25
Fuel Flow Rate	**gal/hr**	135	106	74	44
Mechanical Power Output	**kW**	2710	2033	1355	678
SAMPLING RESULTS					
	Test Date	**6/24/2012**	**6/24/2012**	**6/25/2012**	**6/21/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.001206	0.001448	0.001418	0.001196
	lb/hr	0.06110	0.05999	0.04108	0.02252
Condensable PM	**gr/dscf**	0.002359	0.0006412	0.0008680	0.002576
	lb/hr	0.1222	0.02639	0.02520	0.04853
Total PM[1]	**gr/dscf**	0.003566	0.002089	0.002286	0.003772
	lb/hr	0.1833	0.08639	0.06629	0.07106
	lb/gal fuel	0.001352	0.0008129	0.0008978	0.001605
	lb/kW-hr	0.00006765	0.00004250	0.00004892	0.0001049
	EPA Method 9				
Opacity	**%**	5	5	5	0
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	12.9	13.0	12.9	13.7
	% CO_2	6.1	5.9	5.9	4.7
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	800.0	784.2	701.5	589.3
	lb/hr	42.98	33.73	20.79	11.57
	lb/gal fuel	0.3192	0.3172	0.2809	0.2610
	lb/kW-hr	0.01586	0.01659	0.01534	0.01707
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	240.4	252.6	236.1	223.2
	lb/hr	12.90	10.86	6.995	4.382
	lb/gal fuel	0.09581	0.1022	0.09454	0.09884
	lb/kW-hr	0.004762	0.005345	0.005163	0.006467
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	10	6	9	10

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.3 Aft Generator (N-3)
90-100, & 50-60% Load Conditions

Table 2.3.1 – Aft Generator Engine
Overall Average Emissions Results for 90-100 & 50-60% Load Conditions

NANUQ – Aft Generator (N-3) Caterpillar 3508, Serial #S2B00316			
Test Identification	**Emission Unit**	**90-100% Load**	**50-60% Load**
PROCESS DATA			
Power Output	**%**	100	50
Fuel Flow Rate	**gal/hr**	67.4	38.9
Electrical Power Output	**kWe**	856	461
SAMPLING RESULTS			
	Test Date	**6/26/2012**	**6/26/2012**
	EPA Method 5/202		
Filterable PM	**gr/dscf**	0.0005035	0.0005937
	lb/hr	0.01534	0.01094
Condensable PM	**gr/dscf**	0.001359	0.0009498
	lb/hr	0.04105	0.01764
Total PM[1]	**gr/dscf**	0.001863	0.001544
	lb/hr	0.05639	0.02858
	lb/gal fuel	0.0008364	0.0007359
	lb/kWe-hr	0.00006591	0.00006207
	EPA Method 9		
Opacity	**%**	5	0
	EPA Methods 3A & 7E		
EPA Method 3A	**% O_2**	10.5	13.0
	% CO_2	7.5	5.7
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	1170.6	585.9
	lb/hr	24.29	9.232
	lb/gal fuel	0.3603	0.2375
	lb/kWe-hr	0.02837	0.02004
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	393.9	235.7
	lb/hr	8.173	3.714
	lb/gal fuel	0.1213	0.09556
	lb/kWe-hr	0.009547	0.008063
	Total Sulfur – ASTM D 5453		
Total Sulfur	**ppmw**	9	9

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.4 Forward Generator (N-4)
90-100, & 50-60% Load Conditions

Table 2.4.1 – Forward Generator (N-4)
Overall Average Emissions Results for 90-100 & 50-60% Load Conditions

NANUQ – Forward Generator (N-4) Caterpillar 3508, Serial #S2B00315			
Test Identification	**Emission Unit**	**90-100% Load**	**50-60% Load**
PROCESS DATA			
Power Output	**%**	100	50
Fuel Flow Rate	**gal/hr**	67.9	37.5
Electrical Power Output	**kWe**	890	451
SAMPLING RESULTS			
	Test Date	**6/27/2012**	**6/27/2012**
	EPA Method 5/202		
Filterable PM	**gr/dscf**	0.0004638	0.0005135
	lb/hr	0.01198	0.01010
Condensable PM	**gr/dscf**	0.001368	0.0008868
	lb/hr	0.03536	0.01748
Total PM[1]	**gr/dscf**	0.001832	0.001400
	lb/hr	0.04734	0.02759
	lb/gal fuel	0.0006973	0.0007357
	lb/kWe-hr	0.00005319	0.00006115
	EPA Method 9		
Opacity	**%**	5	0
	EPA Methods 3A & 7E		
EPA Method 3A	**% O_2**	10.3	13.0
	% CO_2	7.7	5.8
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	1044.9	563.8
	lb/hr	21.51	8.570
	lb/gal fuel	0.3168	0.2285
	lb/kWe-hr	0.02417	0.01899
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	361.5	248.2
	lb/hr	7.441	3.773
	lb/gal fuel	0.1096	0.1006
	lb/kWe-hr	0.008364	0.008359
	Total Sulfur – ASTM D 5453		
Total Sulfur	**ppmw**	10	10

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

Attachment F23 – TRC, Emissions Test Report Kvichak No. 5 Oil Spill Response Work Boat Shell Gulf of Mexico, Inc., August 9, 2012

2.1 Port Main Engine
90, 60 & 30% Load Conditions

Table 2.1.1 – Port Main Engine
Overall Average Emissions Results for 90, 60, & 30% Load Conditions

KVICHAK - Port Main Engine Cummins QSB 5.9 Diesel Engine - Serial #46715172				
Test Identification	**Emission Unit**	**90% Load**	**60% Load**	**30% Load**
PROCESS DATA				
Power Output	**%**	90	60	30
Fuel Flow Rate	**gal/hr**	12.9	4.4	1.0
Mechanical Power Output	**kW**	181	121	60
SAMPLING RESULTS				
	Test Date	**3/31/2012**	**3/31/2012**	**4/01/2012**
	EPA Method 5/202			
Filterable PM	**gr/dscf**	0.008286	0.01673	0.01747
	lb/hr	0.02953	0.02590	0.01632
Condensable PM	**gr/dscf**	0.003997	0.002725	0.003569
	lb/hr	0.01422	0.004224	0.003334
Total PM[1]	**gr/dscf**	0.01228	0.01946	0.02104
	lb/hr	0.04376	0.03012	0.01966
	lb/gal fuel	0.003404	0.006846	0.01966
	lb/kW-hr	0.0002415	0.0002493	0.0003254
	EPA Method 9			
Opacity	**%**	0	0	0
	EPA Methods 3A, 7E, & 10			
EPA Method 3A	**% O_2**	5.1	8.0	15.9
	% CO_2	11.5	9.5	3.5
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	1,478.1	1,055.3	462.2
	lb/hr	3.858	1.155	0.2989
	lb/gal fuel	0.2998	0.2625	0.2989
	lb/kW-hr	0.02129	0.009561	0.004949
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	46.1	38.0	37.3
	lb/hr	0.1203	0.04159	0.02414
	lb/gal fuel	0.009343	0.009453	0.02414
	lb/kW-hr	0.0006637	0.0003443	0.0003996
CO (based on EPA Method 19 flow rates)	**ppmvd**	374.2	762.8	173.2
	lb/hr	0.5945	0.5083	0.06820
	lb/gal fuel	0.04620	0.1155	0.06820
	lb/kW-hr	0.003281	0.004208	0.001129
	Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	33.0	32.0	33.0

[1]Total PM = PM10 + PM2.5
15 ppm S = 0.0015 wt% S

2.2 Starboard Main Engine
90, 60 & 30% Load Conditions

Table 2.2.1 – Starboard Main Engine
Overall Average Emissions Results for 90, 60, & 30% Load Conditions

KVICHAK – Starboard Main Engine Cummins QSB 5.9 Diesel Engine - Serial #46703341				
Test Identification	**Emission Unit**	**90% Load**	**60% Load**	**30% Load**
PROCESS DATA				
Power Output	**%**	90	60	30
Fuel Flow Rate	**gal/hr**	12.8	3.4	1.1
Mechanical Power Output	**kW**	181	121	60
SAMPLING RESULTS				
	Test Date	**3/29/2012**	**3/30/2012**	**3/30/2012**
	EPA Method 5/202			
Filterable PM	**gr/dscf**	0.01282	0.02020	0.01403
	lb/hr	0.03795	0.02893	0.01037
Condensable PM	**gr/dscf**	0.003019	0.002490	0.003507
	lb/hr	0.008960	0.003559	0.002581
Total PM[1]	**gr/dscf**	0.01584	0.02269	0.01754
	lb/hr	0.04691	0.03249	0.01295
	lb/gal fuel	0.003665	0.009555	0.01178
	lb/kW-hr	0.0002589	0.0002689	0.0002144
	EPA Method 9			
Opacity	**%**	0	0	0
	EPA Methods 3A, 7E, & 10			
EPA Method 3A	**% O_2**	5.4	6.9	15.2
	% CO_2	11.9	10.0	4.0
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	1,404.3	1,126.3	543.6
	lb/hr	3.678	0.8996	0.3354
	lb/gal fuel	0.2874	0.2646	0.3049
	lb/kW-hr	0.02030	0.007447	0.005553
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	30.5	40.6	47.3
	lb/hr	0.07956	0.03244	0.02917
	lb/gal fuel	0.006215	0.009541	0.02652
	lb/kW-h	0.0004390	0.0002685	0.0004830
CO (based on EPA Method 19 flow rates)	**ppmvd**	780.7	958.5	172.3
	lb/hr	1.243	0.4660	0.06475
	lb/gal fuel	0.09709	0.1370	0.05887
	lb/kW-hr	0.006858	0.003857	0.001072
	Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	69.0	65.0	67.0

[1]Total PM = PM10 + PM2.5
15 ppm S = 0.0015 wt% S

Attachment F24 – TRC, Emissions Test Report Sisuaq Resupply Vessel Shell Gulf of Mexico, Inc., August 9, 2012

2.1 Cummins QSK60DM 16 Main Engine #1 (RV/BT-1A) 95, 65 & 40% Load Conditions

Table 2.1.1 –Main Engine #1 (RV/BT-1A)
Overall Average Emissions Results for 95, 65, & 40% Load Conditions

SISUAQ - Main Engine #1 (RV/BT-1A) Cummins QSK60DM 16, Serial #33183925				
Test Identification	Emission Unit	95% Load	65% Load	40% Load
PROCESS DATA				
Power Output	%	95	65	40
Fuel Flow Rate	gal/hr	119.4	91.7	58.4
Electrical Power Output	kWe	1723	1316	761
SAMPLING RESULTS				
	Test Date	4/25-26/2012	4/25/2012	4/24/2012
EPA Method 5/202				
Filterable PM	gr/dscf	0.002559	0.004660	0.007402
	lb/hr	0.1588	0.2501	0.2883
Condensable PM	gr/dscf	0.001669	0.002007	0.006619
	lb/hr	0.1034	0.1080	0.2569
Total PM[1]	gr/dscf	0.004228	0.006667	0.01402
	lb/hr	0.2622	0.3581	0.5452
	lb/gal fuel	0.002196	0.003905	0.009324
	lb/kWe-hr	0.0001521	0.0002721	0.0007158
EPA Method 9				
Opacity	%	0	0	5
EPA Methods 3A, 7E, & 10				
EPA Method 3A	% O_2	11.7	12.6	13.7
	% CO_2	6.6	5.7	4.8
NO_x (based on EPA Method 19 flow rates)	ppmvd	655.0	516.5	542.4
	lb/hr	27.37	18.51	14.21
	lb/gal fuel	0.2294	0.2019	0.2435
	lb/kWe-hr	0.01588	0.01406	0.01868
NO_2 (based on EPA Method 19 flow rates)	ppmvd	11.4	8.2	27.1
	lb/hr	0.4773	0.2951	0.7082
	lb/gal fuel	0.004006	0.003219	0.01214
	lb/kWe-hr	0.0002769	0.0002242	0.0009317
CO (based on EPA Method 19 flow rates)	ppmvd	28.5	32.7	350.4
	lb/hr	0.7261	0.7130	5.589
	lb/gal fuel	0.006083	0.007779	0.09575
	lb/kWe-hr	0.0004214	0.0005417	0.007348
Total Sulfur – ASTM D 5453				
Total Sulfur	ppmw	8.7	9.9	9.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.2 Cummins QSK60DM 16 Main Engine #2 (RV/BT-1B) 95, 65 & 40% Load Conditions

Table 2.2.1 –Main Engine #2 (RV/BT-1B) Overall Average Emissions Results for 95, 65, & 40% Load Conditions

SISUAQ - Main Engine #2 (RV/BT-1B) Cummins QSK60DM 16, Serial #33183926				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	65	***40***
Fuel Flow Rate	**gal/hr**	120.2	93.0	62.5
Electrical Power Output	**kWe**	1730	1,162	779
SAMPLING RESULTS				
	Test Date	**4/27/2012**	**4/26-27/2012**	**4/26/2012**
EPA Method 5/202				
Filterable PM	**gr/dscf**	0.002477	0.005090	0.008090
	lb/hr	0.1529	0.2572	0.3101
Condensable PM	**gr/dscf**	0.002137	0.002275	0.003187
	lb/hr	0.1317	0.1152	0.1221
Total PM[1]	**gr/dscf**	0.004614	0.007365	0.01128
	lb/hr	0.2846	0.3724	0.4322
	lb/gal fuel	0.002362	0.004003	0.006920
	lb/kWe-hr	0.0001645	0.0003206	0.0005606
EPA Method 9				
Opacity	**%**	0	2	5
EPA Methods 3A, 7E, & 10				
EPA Method 3A	**% O_2**	11.5	12.5	13.4
	% CO_2	6.6	5.9	5.0
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	660.3	480.6	502.6
	lb/hr	27.30	17.25	13.55
	lb/gal fuel	0.2270	0.1855	0.2166
	lb/kWe-hr	0.01578	0.01484	0.01754
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	16.0	4.7	6.0
	lb/hr	0.6699	0.1697	0.1626
	lb/gal fuel	0.005561	0.001828	0.002600
	lb/kWe-hr	0.0003872	0.0001459	0.0002094
CO (based on EPA Method 19 flow rates)	**ppmvd**	33.3	33.8	305.1
	lb/hr	0.8370	0.7379	5.011
	lb/gal fuel	0.006966	0.007937	0.08004
	lb/kWe-hr	0.0004838	0.0006352	0.006487
Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	9.5	8.1	9.3

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.3 Cummins QSK60DM 16 Main Engine #3 (RV/BT-1C) 95, 65 & 40% Load Conditions

Table 2.3.1 –Main Engine #3 (RV/BT-1C)
Overall Average Emissions Results for 95, 65, & 40% Load Conditions

SISUAQ - Main Engine #3 (RV/BT-1C) Cummins QSK60DM 16, Serial #33184095				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	65	40
Fuel Flow Rate	**gal/hr**	121.6	88.6	57.8
Electrical Power Output	**kWe**	1,722	1,268	808
SAMPLING RESULTS				
	Test Date	**4/28-29/2012**	**4/28/2012**	**4/27-28/2012**
EPA Method 5/202				
Filterable PM	**gr/dscf**	0.003113	0.005146	0.006987
	lb/hr	0.1657	0.2562	0.2690
Condensable PM	**gr/dscf**	0.001825	0.001799	0.004276
	lb/hr	0.09918	0.08922	0.1638
Total PM[1]	**gr/dscf**	0.004938	0.006944	0.01126
	lb/hr	0.2649	0.3454	0.4328
	lb/gal fuel	0.002177	0.003911	0.007519
	lb/kWe-hr	0.0001538	0.0002724	0.0005356
EPA Method 9				
Opacity	**%**	0	0	5
EPA Methods 3A, 7E, & 10				
EPA Method 3A	**% O_2**	11.3	12.5	13.4
	% CO_2	6.9	5.9	5.0
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	657.2	504.4	477.1
	lb/hr	26.50	16.89	11.66
	lb/gal fuel	0.2179	0.1907	0.2018
	lb/kWe-hr	0.01539	0.01332	0.01444
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	12.3	6.4	22.0
	lb/hr	0.4945	0.2153	0.5383
	lb/gal fuel	0.004067	0.002433	0.009306
	lb/kWe-hr	0.0002872	0.0001698	0.0006662
CO (based on EPA Method 19 flow rates)	**ppmvd**	28.3	41.4	327.9
	lb/hr	0.6956	0.8453	4.880
	lb/gal fuel	0.005720	0.009539	0.08442
	lb/kWe-hr	0.0004039	0.0006666	0.006040
Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	14.4	15.0	16.3

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.4 Cummins QSK60DM 16 Main Engine #4 (RV/BT-1D) 95, 65 & 40% Load Conditions

Table 2.4.1 –Main Engine #4 (RV/BT-1D)
Overall Average Emissions Results for 95, 65, & 40% Load Conditions

SISUAQ - Main Engine #4 (RV/BT-1D) Cummins QSK60DM 16, Serial #33184188				
Test Identification	**Emission Unit**	**95% Load**	**65% Load**	**40% Load**
PROCESS DATA				
Power Output	**%**	95	65	40
Fuel Flow Rate	**gal/hr**	90.9	87.7	60.5
Electrical Power Output	**kWe**	1,728	1,315	810
SAMPLING RESULTS				
	Test Date	**4/30/2012**	**4/29/2012**	**4/29/2012**
EPA Method 5/202				
Filterable PM	**gr/dscf**	0.003433	0.005994	0.008504
	lb/hr	0.2279	0.3226	0.3411
Condensable PM	**gr/dscf**	0.002429	0.003031	0.005475
	lb/hr	0.1611	0.1639	0.2164
Total PM[1]	**gr/dscf**	0.005862	0.009024	0.01398
	lb/hr	0.3890	0.4865	0.5575
	lb/gal fuel	0.004280	0.005549	0.009219
	lb/kWe-hr	0.0002251	0.0003699	0.0006883
EPA Method 9				
Opacity	**%**	0	0	5
EPA Methods 3A, 7E, & 10				
EPA Method 3A	**% O_2**	11.3	12.4	13.3
	% CO_2	7.0	6.2	5.4
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	637.4	482.5	479.2
	lb/hr	19.16	15.87	12.19
	lb/gal fuel	0.2109	0.1810	0.2015
	lb/kWe-hr	0.01109	0.01207	0.01505
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	11.8	8.1	15.4
	lb/hr	0.3558	0.2681	0.3909
	lb/gal fuel	0.003915	0.003057	0.006460
	lb/kWe-hr	0.0002059	0.0002039	0.0004826
CO (based on EPA Method 19 flow rates)	**ppmvd**	34.8	46.2	343.2
	lb/hr	0.6376	0.9239	5.316
	lb/gal fuel	0.007017	0.01054	0.08786
	lb/kWe-hr	0.0003690	0.0007026	0.006563
Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	13.6	14.2	14.6

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

Attachment F25 – TRC, Emissions Test Report Harvey Spirit Resupply Ship Shell Gulf of Mexico, Inc., August 9, 2012

2.1 Starboard Main Engine (HS-1) 80, 60, 40 & 20% Load Conditions

Table 2.1.1 – Starboard Main Engine
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY SPIRIT – Starboard Main Engine (HS-1) GE/7FDM12 – Serial #308996					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	81.5	47.7	22.7	17.5
Mechanical Power Output	**kW**	1831	1374	916	458
SAMPLING RESULTS					
	Test Date	**6/1/2012**	**6/1-2/2012**	**6/2/2012**	**6/2/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.01844	0.01460	0.01048	0.008155
	lb/hr	0.6082	0.3047	0.1651	0.09287
Condensable PM	**gr/dscf**	0.004437	0.009232	0.007071	0.004266
	lb/hr	0.1469	0.1935	0.1113	0.04833
Total PM[1]	**gr/dscf**	0.02296	0.02383	0.01755	0.01242
	lb/hr	0.7578	0.4982	0.2764	0.1412
	lb/gal fuel	0.009328	0.01044	0.01217	0.008274
	lb/kWe-hr	0.0004138	0.0003627	0.0003019	0.0003084
	EPA Method 9				
Opacity	**%**	9	9	1	0
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	12.1	12.3	13.8	15.8
	% CO_2	6.5	6.4	5.3	3.9
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	926.9	1234.8	1253.0	1208.8
	lb/hr	27.42	21.72	12.48	13.32
	lb/gal fuel	0.3366	0.4554	0.5493	0.7613
	lb/kW-hr	0.01498	0.01581	0.01363	0.02910
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	115.3	249.7	299.5	294.7
	lb/hr	3.414	4.400	2.984	3.251
	lb/gal fuel	0.04190	0.09206	0.1312	0.1856
	lb/kW-hr	0.001865	0.003203	0.003259	0.007101
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	9.6	10.0	10.0	10.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.2 Port Main Engine (HS-2)
80, 60, 40, & 20% Load Conditions

Table 2.2.1 - Port Main Engine
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY SPIRIT – Port Main Engine (HS-2) GE/7FDM12 – Serial #308995					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	145.0	118.2	83.8	61.8
Mechanical Power Output	**kW**	1831	1374	916	458
SAMPLING RESULTS					
	Test Date	**6/3/2012**	**6/3/2012**	**6/3/2012**	**6/2-3/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.01016	0.01207	0.007093	0.00923
	lb/hr	0.4233	0.2809	0.1068	0.1111
Condensable PM	**gr/dscf**	0.01060	0.01202	0.01748	0.01031
	lb/hr	0.4411	0.2799	0.2637	0.1243
Total PM[1]	**gr/dscf**	0.02075	0.02409	0.02457	0.01954
	lb/hr	0.8645	0.5608	0.3705	0.2353
	lb/gal fuel	0.005964	0.004740	0.004408	0.003811
	lb/kW-hr	0.0004720	0.0004083	0.0003902	0.0005140
	EPA Method 9				
Opacity	**%**	7	6	5	4
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	12.7	12.0	13.1	14.9
	% CO_2	6.1	6.5	5.8	4.5
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	985.7	1194.0	1505.0	1390.2
	lb/hr	55.39	50.80	51.44	45.99
	lb/gal fuel	0.3819	0.4296	0.6133	0.7444
	lb/kW-hr	0.03024	0.03699	0.05618	0.1004
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	184.1	244.6	263.1	264.9
	lb/hr	10.34	10.39	9.053	8.727
	lb/gal fuel	0.07140	0.08797	0.1069	0.1415
	lb/kW-hr	0.005648	0.007564	0.009886	0.01906
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	10.0	9.9	9.9	10.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.3 Starboard Generator Engine (HS-3) 90-100, & 50-60% Load Conditions

Table 2.3.1 – Starboard Generator Engine
Overall Average Emissions Results for 90-100 & 50-60% Load Conditions

HARVEY SPIRIT – Starboard Generator Engine (HS-3) Cummins/KTA19-(M1), Serial #37220567 Generator Serial #A06C543697			
Test Identification	**Emission Unit**	**90-100% Load**	**50-60% Load**
PROCESS DATA			
Power Output	**%**	90-100	50-60
Fuel Flow Rate	**gal/hr**	38.8	25.9
Electrical Power Output	**kWe**	407	238
SAMPLING RESULTS			
	Test Date	**5/18/2012**	**5/19/2012**
EPA Method 5/202			
Filterable PM	**gr/dscf**	0.01903	0.02677
	lb/hr	0.05536	0.05968
Condensable PM	**gr/dscf**	0.01499	0.004391
	lb/hr	0.04429	0.009840
Total PM[1]	**gr/dscf**	0.03402	0.03116
	lb/hr	0.09965	0.06952
	lb/gal fuel	0.002568	0.002681
	lb/kWe-hr	0.0002451	0.0002927
EPA Method 9			
Opacity	**%**	5	5
EPA Methods 3A & 7E			
EPA Method 3A	**% O_2**	8.3	10.2
	% CO_2	9.2	7.8
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	1327.6	767.2
	lb/hr	12.90	5.870
	lb/gal fuel	0.3324	0.2264
	lb/kWe-hr	0.03172	0.02472
NO_2 (based on EPA Method 19 flow rates)	**Ppmvd**	305.3	138.3
	lb/hr	2.966	1.058
	lb/gal fuel	0.07295	0.04457
	lb/kWe-hr	0.007295	0.004457
Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	12.0	12.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.4 Center Generator Engine (HS-4) 90-100, & 50-60% Load Conditions

**Table 2.4.1 – Center Generator Engine
Overall Average Emissions Results for 90-100 & 50-60% Load Conditions**

HARVEY SPIRIT – Center Generator Engine (HS-4) Cummins/KTA19-(M1), Serial #37220566 Generator Serial #A06C543711			
Test Identification	**Emission Unit**	**90-100% Load**	**50-60% Load**
PROCESS DATA			
Power Output	**%**	90-100	50-60
Fuel Flow Rate	**gal/hr**	36.9	26.4
Electrical Power Output	**kWe**	393	238
SAMPLING RESULTS			
	Test Date	**5/20/2012**	**5/21/2012**
	EPA Method 5/202		
Filterable PM	**gr/dscf**	0.03892	0.02894
	lb/hr	0.1068	0.06808
Condensable PM	**gr/dscf**	0.005306	0.004910
	lb/hr	0.01455	0.01156
Total PM[1]	**gr/dscf**	0.04422	0.03385
	lb/hr	0.1214	0.07964
	lb/gal fuel	0.003293	0.003020
	lb/kWe-hr	0.0003086	0.0003344
	EPA Method 9		
Opacity	**%**		
	EPA Methods 3A & 7E		
EPA Method 3A	**% O_2**	7.8	10.2
	% CO_2	9.5	7.7
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	1242.4	692.7
	lb/hr	11.00	5.389
	lb/gal fuel	0.2981	0.2044
	lb/kWe-hr	0.02797	0.02263
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	213.2	97.8
	lb/hr	1.887	0.7608
	lb/gal fuel	0.05115	0.02886
	lb/kWe-hr	0.004799	0.003194
	Total Sulfur – ASTM D 5453		
Total Sulfur	**ppmw**	13.0	12.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.5 Port Generator Engine (HS-5) 90-100, & 50-60% Load Conditions

Table 2.5.1 – Port Generator Engine
Overall Average Emissions Results for 90-100 & 50-60% Load Conditions

HARVEY SPIRIT – Port Generator Engine (HS-5) Cummins/KTA19-(M1), Serial #37220326 Generator Serial #A06C543698			
Test Identification	**Emission Unit**	**90-100% Load**	**50-60% Load**
PROCESS DATA			
Power Output	**%**	90-100	50-60
Fuel Flow Rate	**gal/hr**	33.7	24.4
Electrical Power Output	**kWe**	385	236
SAMPLING RESULTS			
	Test Date	**6/17/2012**	**6/17/2012**
EPA Method 5/202			
Filterable PM	**gr/dscf**	0.02510	0.02412
	lb/hr	0.2372	0.1889
Condensable PM	**gr/dscf**	0.01720	0.006618
	lb/hr	0.1633	0.05176
Total PM[1]	**gr/dscf**	0.04231	0.03074
	lb/hr	0.4005	0.2407
	lb/gal fuel	0.01188	0.009850
	lb/kWe-hr	0.001041	0.001021
EPA Method 9			
Opacity	**%**	6	5
EPA Methods 3A & 7E			
EPA Method 3A	**% O_2**	8.5	10.5
	% CO_2	9.2	7.7
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	1225.8	689.0
	lb/hr	10.51	5.092
	lb/gal fuel	0.3120	0.2084
	lb/kWe-hr	0.02466	0.02161
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	199.9	49.8
	lb/hr	1.714	0.3678
	lb/gal fuel	0.05082	0.01505
	lb/kWe-hr	0.004454	0.001561
Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	12.0	13.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.6 Aft/Starboard Bow Thruster (HS-7) 80, 60, 40 & 20% Load Conditions

Table 2.6.1 – Aft/Starboard Bow Thruster Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY SPIRIT – Aft/Starboard Bow Thruster (HS-7) Cummins/KTA38-(M1), Serial #33161902					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	33.9	20.8	13.6	5.6
Mechanical Power Output	**kW**	746	559	373	186
SAMPLING RESULTS					
	Test Date	**5/30/2012**	**5/30-31/2012**	**5/31/2012**	**5/31/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.01489	0.01077	0.006460	0.005335
	lb/hr	0.1917	0.01069	0.05365	0.03422
Condensable PM	**gr/dscf**	0.005592	0.005874	0.007862	0.01200
	lb/hr	0.07202	0.05763	0.06529	0.07702
Total PM[1]	**gr/dscf**	0.02048	0.01664	0.01432	0.01734
	lb/hr	0.2638	0.1645	0.1189	0.1112
	lb/gal fuel	0.007781	0.007898	0.008769	0.01993
	lb/kW-hr	0.0003537	0.0002942	0.0003190	0.0005967
	EPA Method 9				
Opacity	**%**	5	5	0	0
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	11.9	13.8	15.2	17.1
	% CO_2	6.6	5.3	4.3	3.1
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	973.3	633.1	445.9	352.4
	lb/hr	11.53	5.822	3.345	1.641
	lb/gal fuel	0.3402	0.2795	0.2466	0.2928
	lb/kW-hr	0.01547	0.01041	0.008972	0.008804
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	438.6	233.9	143.6	125.1
	lb/hr	5.198	2.152	1.077	0.5835
	lb/gal fuel	0.1533	0.1034	0.07944	0.1040
	lb/kW-hr	0.006970	0.003849	0.002889	0.003130
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	11.0	12.0	12.0	11.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.7 Forward/Port Bow Thruster (HS-8) 80, 60, 40 & 20% Load Conditions

Table 2.7.1 –Forward/Port Bow Thruster
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY SPIRIT – Forward/Port Bow Thruster (HS-8) Cummins/KTA38-(M1), Serial #33161907					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	35.1	26.1	15.5	6.9
Mechanical Power Output	**kW**	746	559	373	186
SAMPLING RESULTS					
	Test Date	**5/26/2012**	**5/26/2012**	**5/26/2012**	**5/30/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.01771	0.01071	0.007407	0.004848
	lb/hr	0.2122	0.1068	0.06132	0.03212
Condensable PM	**gr/dscf**	0.005843	0.005814	0.007685	0.009880
	lb/hr	0.06981	0.05799	0.06367	0.06551
Total PM[1]	**gr/dscf**	0.02355	0.01653	0.01509	0.01473
	lb/hr	0.2820	0.1648	0.1250	0.09763
	lb/gal fuel	0.008038	0.006323	0.008052	0.01417
	lb/kW-hr	0.0003782	0.0002947	0.0003352	0.0005237
	EPA Method 9				
Opacity	**%**	5	0	0	0
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	11.1	12.8	14.8	16.7
	% CO_2	7.1	6.0	4.6	3.3
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	995.2	747.6	477.6	359.4
	lb/hr	11.27	7.585	3.816	1.863
	lb/gal fuel	0.3211	0.2910	0.2457	0.2699
	lb/kW-hr	0.01512	0.01356	0.01024	0.009992
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	114.7	78.2	56.9	124.6
	lb/hr	1.299	0.7937	0.4549	0.6460
	lb/gal fuel	0.03703	0.03045	0.02930	0.09355
	lb/kW-hr	0.001742	0.001419	0.001220	0.003465
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	11.0	12.0	13.0	11.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.8 Stern Thruster (HS-9)
80, 60, 40 & 20% Load Conditions

Table 2.8.1 –Stern Thruster
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY SPIRIT – Stern Thruster (HS-9) Cummins/KTA38-(M1), Serial #33162077					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	33.5	21.2	16.6	6.4
Mechanical Power Output	**kW**	746	559	373	186
SAMPLING RESULTS					
	Test Date	**5/21/2012**	**5/22/2012**	**5/25/2012**	**5/25/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.01370	0.009917	0.01193	0.004954
	lb/hr	0.1594	0.09251	0.08248	0.02152
Condensable PM	**gr/dscf**	0.006641	0.006667	0.006576	0.01232
	lb/hr	0.07738	0.06219	0.04548	0.05326
Total PM[1]	**gr/dscf**	0.02034	0.01658	0.01850	0.01728
	lb/hr	0.2368	0.1547	0.1280	0.07478
	lb/gal fuel	0.007069	0.007286	0.007693	0.01175
	lb/kW-hr	0.0003175	0.0002766	0.0003432	0.0004011
	EPA Method 9				
Opacity	**%**	5	0	0	0
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	11.4	13.5	13.9	16.7
	% CO_2	7.0	5.5	5.1	3.3
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	1009.4	723.1	608.1	377.8
	lb/hr	11.17	6.541	4.534	1.796
	lb/gal fuel	0.3334	0.3081	0.2726	0.2821
	lb/kW-hr	0.01498	0.01170	0.01216	0.009633
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	184.0	123.5	99.3	65.6
	lb/hr	2.037	1.117	0.7404	0.3120
	lb/gal fuel	0.06079	0.05260	0.04452	0.04899
	lb/kW-hr	0.002731	0.001997	0.001986	0.001673
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	12.0	12.0	12.0	12.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

Attachment F26 – Cummins, Exhaust Emissions Data Sheet, Basic Engine Model: KTA50-G3, April 16, 2002

Cummins Inc. Columbus, Indiana 47201 EXHAUST EMISSIONS DATA SHEET	Basic Engine Model: **KTA50-G3**	Curve Number: **FR-6250**	*G-DRIVE* **K50 1**
	Engine Critical Parts List: **CPL: 2227**	Date: **16Apr02**	

Displacement : **50.3** litre (**3067** in^3)	Bore : **159** mm (**6.25** in) Stroke : **159** mm (**6.25** in)
No. of Cylinders : **16**	Aspiration : **Turbocharged and Aftercooled**

Engine Speed	Standby Power Rating		Prime Power Rating				Continuous Power Rating	
			Limited Time		Unlimited Time			
RPM	kWm	BHP	kWm	BHP	kWm	BHP	kWm	BHP
1500	1227	1645	1150	1541	1097	1470	900	1206
1800	1380	1850	1300	1742	1220	1635	1000	1340

Exhaust Emissions Data @ 1500 RPM

	Standby Power			Prime Power			Continuous Power		
Component	g/BHP·h	mg/m^3	PPM	g/BHP·h	mg/m^3	PPM	g/BHP·h	mg/m^3	PPM
HC (Total Unburned Hydrocarbons)	0.13	55	110	0.12	50	100	0.10	42	90
NOx (Oxides of Nitrogen as NO_2)	12.00	6100	2880	11.00	5500	2590	9.00	4500	2140
CO (Carbon Monoxide)	2.80	1400	1060	2.70	1400	1020	2.60	1300	930
PM (Particulate Matter)	0.08	40	N.A.	0.09	35	N.A.	0.11	55	N.A.
SO_2 (Sulfur Dioxide)	0.12	N.A.	N.A.	0.12	N.A.	N.A.	0.12	N.A.	N.A.

Exhaust Emissions Data @ 1800 RPM

	Standby Power			Prime Power			Continuous Power		
Component	g/BHP·h	mg/m^3	PPM	g/BHP·h	mg/m^3	PPM	g/BHP·h	mg/m^3	PPM
HC (Total Unburned Hydrocarbons)	0.12	45	90	0.12	45	100	0.13	50	100
NOx (Oxides of Nitrogen as NO_2)	12.70	6300	3040	11.30	5700	2760	9.70	4800	2290
CO (Carbon Monoxide)	1.00	480	400	0.80	360	290	0.50	250	190
PM (Particulate Matter)	0.06	30	N.A.	0.07	35	N.A.	0.06	30	N.A.
SO_2 (Sulfur Dioxide)	0.12	N.A.	N.A.	0.12	N.A.	N.A.	0.13	N.A.	N.A.

Note: mg/m^3 and PPM numbers are measured dry and corrected to 5% O_2 content.

Test Methods and Conditions

Test Methods:
Steady-State emissions recorded per ISO8178-1 during operation at rated engine speed (+/-2%) and stated constant load (+/-2%) with engine temperatures, pressures and emission rates stabilized.

Fuel Specification:
46.5 Cetane Number, 0.035 Wt.% Sulfur; Reference ISO8178-5, 40CFR86.1313-98 Type 2-D and ASTM D975 No. 2-D.

Reference Conditions:
25°C (77°F) Air Inlet Temperature, 40°C (104°F) Fuel Inlet Temperature, 100 kPa (29.53 in Hg) Barometric Pressure; 10.7 g/kg (75 grains H_20/lb) of dry air Humidity (required for NOx correction); Intake Restriction set to maximum allowable limit for clean filter; Exhaust Back Pressure set to maximum allowable limit.

Data was taken from a single engine test according to the test methods, fuel specification and reference conditions stated above and is subject to engine-to-engine variability. Tests conducted with alternate test methods, instrumentation, fuel or reference conditions can yield different results.

Data Subject to Change Without Notice.

Attachment F27 – Ultra Low Sulfur Diesel Supporting Details

Diesel Question Email, April 20, 2011

Ultra Low Sulfur Diesel MSDS

Sabrina Pryor

From: Nicole.StAmand@shell.com
Sent: Wednesday, April 20, 2011 12:32 PM
To: rgsteen@airsci.com
Cc: spryor@airsci.com
Subject: FW: Diesel Question

Importance: High

Follow Up Flag: Follow up
Flag Status: Completed

Rodger

Below is some data from Crowley. Please let me know if you need more.

Nicole

From: Spring, Karen SEPCO-UAX/A/R
Sent: Wednesday, April 20, 2011 10:31 AM
To: St Amand, Nicole M SEPCO-UAX/A/SD
Cc: Yampolsky, Lev M SEPCO-UAX/A/R
Subject: Fw: Diesel Question

Fyi

From: Bruce.Harland@crowley.com <Bruce.Harland@crowley.com>
To: Spring, Karen SEPCO-UAX/A/R
Sent: Wed Apr 20 13:08:09 2011
Subject: FW: Diesel Question

Karen
The values below are for the diesel produced by tesoro in Nikiski. Other sources could differ.
Regards
Bruce

Sent from my GoodLink synchronized handheld (www.good.com)

-----Original Message-----
From: Harris, Royal
Sent: Wednesday, April 20, 2011 01:34 PM Eastern Standard Time
To: Harland, Bruce
Subject: RE: Diesel Question

Oh yes:

The maximum sulfur content of marine diesel is available in Alaska? 15 PPM (D5453)

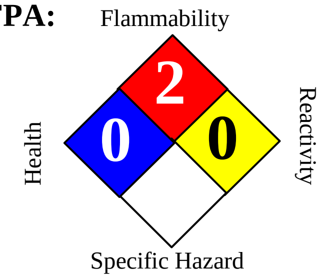
These two questions would be specific to each refiner. Petro Star not back up and running yet. Tesoro, Nikiski, is producing. We also mobilize in products from US West Coast, and also from Korea depending on the relative values.

Based upon Tesoro Nikiski production:
Then what the density: ULS2 Density at 15C is 0.8393 (D4052 Specific Gravity is 0.8398)

heat content (BTU/gal) is? ULS2 D4809 1) gross 139,450 2) net 131,180

Safety Data Sheet
Diesel Low Sulfur (LSD) and Ultra Low Sulfur Diesel (ULSD)

NFPA:



SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name	: Diesel Low Sulfur (LSD) and Ultra Low Sulfur Diesel (ULSD)		
Synonyms	: CARB Diesel, 888100004478		
MSDS Number	888100004478	**Version**	2.31
Product Use Description			
Company	For: Tesoro Refining & Marketing Co. 19100 Ridgewood Parkway, San Antonio, TX 78259		
Tesoro Call Center	(877) 783-7676	**Chemtrec (Emergency Contact)**	(800) 424-9300

SECTION 2. HAZARDS IDENTIFICATION

Classifications

Flammable Liquid – Category 3
Skin Irritation – Category 2
Eye Irritation – Category 2B
Aspiration Hazard – Category 1
Carcinogenicity – Category 2
Acute Toxicity - Inhalation – Category 4
Chronic Aquatic Toxicity – Category 2

Pictograms

Signal Word **Danger**

Hazard Statements

Flammable liquid and vapor.
May be fatal if swallowed and enters airways – do not siphon diesel by mouth.
Causes skin irritation.
Causes eye irritation.
Suspected of causing skin cancer if repeated and prolonged skin contact occurs.
Suspected of causing cancer in the respiratory system if repeated and prolonged over-exposure by inhalation occurs.
May cause damage to liver, kidneys and nervous system by repeated and prolonged inhalation.

Toxic if inhaled.
May cause drowsiness or dizziness by inhalation.
Toxic to aquatic life with long lasting effects.

Precautionary statements

Prevention

Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Keep away from heat, sparks, open flames, welding and hot surfaces.
No smoking.
Keep container tightly closed.
Ground and/or bond container and receiving equipment.
Use explosion-proof electrical equipment.
Use only non-sparking tools if tools are used in flammable atmosphere.
Take precautionary measures against static discharge.
Wear gloves, eye protection and face protection as needed to prevent skin and eye contact with liquid.
Wash hands or liquid-contacted skin thoroughly after handling.
Do not eat, drink or smoke when using this product.
Avoid breathing vapors or mists.
Use only outdoors or in a well-ventilated area.

Response

In case of fire: Use dry chemical, CO2, water spray or fire fighting foam to extinguish.
If swallowed: Immediately call a poison center, doctor, hospital emergency room, medical clinic or 911. Do NOT induce vomiting. Rinse mouth.
If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower.
If in eye: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
If skin or eye irritation persists, get medical attention.
If inhaled: Remove person to fresh air and keep comfortable for breathing.
Immediately call or doctor or emergency medical provider. See Section 4 and Section 11 for medical treatment information.

Storage

Store in a well ventilated place. Keep cool. Store locked up. Keep container tightly closed . Use only approved containers.

Disposal

Dispose of contents/containers to approved disposal site in accordance with local, regional, national, and/or international regulations.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No.	Weight %
Fuels, diesel, No 2; Gasoil - unspecified	68476-34-6	100%
Nonane	111-84-2	0 - 5%
Naphthalene	91-20-3	0 - 1%

1,2,4-Trimethylbenzene	95-63-6	0 - 2%
Xylene	1330-20-7	0 - 2%
Sulfur	7704-34-9	15 ppm maximum

SECTION 4. FIRST AID MEASURES

Inhalation : Move to fresh air. Give oxygen. If breathing is irregular or stopped, administer artificial respiration. Seek medical attention immediately.

Skin contact : Take off all contaminated clothing immediately. Wash off immediately with soap and plenty of water. Wash contaminated clothing before re-use. If skin irritation persists, seek medical attention immediately.

Eye contact : Remove contact lenses. Rinse thoroughly with plenty of water for at least 15 minutes. If symptoms persist, seek medical attention.

Ingestion : Do not induce vomiting without medical advice. If a person vomits when lying on his back, place him in the recovery position. Seek medical attention immediately.

Notes to physician : Symptoms: Dizziness, Discomfort, Headache, Nausea, Disorder, Vomiting, Lung edema, Liver disorders, Kidney disorders. Aspiration may cause pulmonary edema and pneumonitis.

SECTION 5. FIRE-FIGHTING MEASURES

Suitable extinguishing media : SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO2, water spray or fire fighting foam. LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers. Keep containers and surroundings cool with water spray.

Specific hazards during fire fighting : Fire Hazard Do not use a solid water stream as it may scatter and spread fire. Cool closed containers exposed to fire with water spray.

Special protective equipment for fire-fighters : Wear self-contained breathing apparatus and protective suit. Use personal protective equipment.

Further information : Exposure to decomposition products may be a hazard to health. Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions : Evacuate nonessential personnel and remove or secure all ignition sources. Consider wind direction; stay upwind and uphill, if possible. Evaluate the direction of product travel, diking, sewers, etc. to contain spill areas. Spills may infiltrate subsurface soil and groundwater; professional assistance may be necessary to determine the extent of subsurface impact. Ensure adequate ventilation. Use personal protective equipment.

Environmental precautions : Carefully contain and stop the source of the spill, if safe to do so. Protect bodies of water by diking, absorbents, or absorbent boom, if possible. Do not flush down sewer or drainage systems, unless system is designed and permitted to handle such material. The use of fire fighting foam may be useful in certain situations to reduce vapors. The proper use of water spray may effectively disperse product vapors or the liquid itself, preventing contact with ignition sources or areas/equipment that require protection. Discharge into the environment must be avoided. If the product contaminates rivers and lakes or drains inform respective authorities.

Methods for cleaning up : Take up with sand or oil absorbing materials. Carefully shovel, scoop or sweep up into a waste container for reclamation or disposal - caution, flammable vapors may accumulate in closed containers. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).

SECTION 7. HANDLING AND STORAGE

Precautions for safe handling : Keep away from fire, sparks and heated surfaces. No smoking near areas where material is stored or handled. The product should only be stored and handled in areas with intrinsically safe electrical classification.

: Hydrocarbon liquids including this product can act as a non-conductive flammable liquid (or static accumulators), and may form ignitable vapor-air mixtures in storage tanks or other containers. Precautions to prevent static-initated fire or explosion during transfer, storage or handling, include but are not limited to these examples:

(1) Ground and bond containers during product transfers. Grounding and bonding may not be adequate protection to prevent ignition or explosion of hydrocarbon liquids and vapors that are static accumulators.
(2) Special slow load procedures for "switch loading" must be followed to avoid the static ignition hazard that can exist when higher flash point material (such as fuel oil or diesel) is loaded into tanks previously containing low flash point products (such gasoline or naphtha).
(3) Storage tank level floats must be effectively bonded.

For more information on precautions to prevent static-initated fire or explosion, see NFPA 77, Recommended Practice on Static Electricity (2007), and API Recommended Practice 2003, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents (2008).

Conditions for safe storage, including incompatibilities : Keep away from flame, sparks, excessive temperatures and open flame. Use approved containers. Keep containers closed and clearly labeled. Empty or partially full product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose containers to sources of ignition. Store in a well-ventilated area. The storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

: Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure.

Keep away from food, drink and animal feed. Incompatible with oxidizing agents. Incompatible with acids.

SECTION 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Guidelines

List	Components	CAS-No.	Type:	Value
OSHA Z1	Xylene	1330-20-7	PEL	100 ppm 435 mg/m3
	Naphthalene	91-20-3	PEL	10 ppm 50 mg/m3
ACGIH	Diesel Fuel	68476-30-2	TWA	100 mg/m3
	Xylene	1330-20-7	TWA	100 ppm
		1330-20-7	STEL	150 ppm
	Naphthalene	91-20-3	TWA	10 ppm
		91-20-3	STEL	15 ppm
	Nonane	111-84-2	TWA	200 ppm

Engineering measures : Use adequate ventilation to keep gas and vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces. Use only intrinsically safe electrical equipment approved for use in classified areas.

Eye protection : Safety glasses or goggles are recommended where there is a possibility of splashing or spraying.

Hand protection : Gloves constructed of nitrile, neoprene, or PVC are recommended. Consult manufacturer specifications for further information.

Skin and body protection : If needed to prevent skin contact, chemical protective clothing such as of DuPont TyChem®, Saranex or equivalent recommended based on degree of exposure. The resistance of specific material may vary from product to product as well as with degree of exposure.

Respiratory protection : A NIOSH/ MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, ANSI Z88.2-1992, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection. Use a NIOSH/ MSHA-approved positive-pressure supplied-air respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.

Work / Hygiene practices : Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Clear to straw colored liquid
Odor	Characteristic petroleum or kerosene-like odor
Odor threshold	0.1 - 1 ppm typically reported
pH	Not applicable
Melting point/freezing point	Gel point can be about -15°F; freezing requires laboratory conditions
Initial boiling point & range	154 - 372 °C (310° - 702 °F)
Flash point	38°C Minimum for #1 Diesel, 52°C Minimum for #2 Diesel
Evaporation rate	Higher initially and declining as lighter components evaporate
Flammability (solid, gas)	Flammable vapor released by liquid
Upper explosive limit	6.5 %(V)
Lower explosive limit	0.6 %(V)
Vapor pressure	< 2 mm Hg at 20 °C
Vapor density (air = 1)	> 4.5
Relative density (water = 1)	0.86 g/mL
Solubility (in water)	0.0005 g/100 mL
Partition coefficient (n-octanol/water)	> 3.3 as log Pow
Auto-ignition temperature	257 °C (495 °F)
Decomposition temperature	Will evaporate or boil and possibly ignite before decomposition occurs.
Kinematic viscosity	1 to 6 mm²/s range reported for No.1 or No.2 diesel at ambient temperatures
Conductivity (conductivity can be reduced by environmental factors such as a decrease in temperature	Diesel Fuel Oils at terminal load rack: At least 25 pS/m Ultra Low Sulfur Diesel (ULSD) without conductivity additive: 0 pS/m to 5 pS/m ULSD at terminal load rack with conductivity additive: At least 50 pS/m JP-8 at terminal load rack: 150 pS/m to 600 pS/m

SECTION 10. STABILITY AND REACTIVITY

Reactivity	: Vapors may form explosive mixture with air. Hazardous polymerization does not occur.
Chemical stability	Stable under normal conditions.
Possibility of hazardous reactions	Can react with strong oxidizing agents, peroxides, acids and alkalies. Do not use with Viton or Fluorel gaskets or seals.
Conditions to avoid	Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources. Avoid static charge accumulation and discharge (see Section 7).
Hazardous decomposition products	Ignition and burning can release carbon monoxide, carbon dioxide, non-combusted hydrocarbons (smoke) and, depending on formulation, trace amounts

of sulfur dioxide. Diesel exhaust particals may be a lung hazard (see Section 11).

SECTION 11. TOXICOLOGICAL INFORMATION

Inhalation : Vapors or mists from this material can irritate the nose, throat, and lungs, and can cause signs and symptoms of central nervous system depression, depending on the concentration and duration of exposure.

Skin contact Skin irritation leading to dermatitis may occur upon prolonged or repeated contact. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are repeatedly exposed. Long-term, repeated skin contact may cause skin cancer.

Eye contact Eye irritation may result from contact with liquid, mists, and/or vapors.

Ingestion Harmful or fatal if swallowed. Do NOT induce vomiting. This material can irritate the mouth, throat, stomach, and cause nausea, vomiting, diarrhea and restlessness Aspiration hazard if liquid is inhaled into lungs, particularly from vomiting after ingestion. Aspiration may result in chemical pneumonia, severe lung damage, respiratory failure and even death.

Target organs Central nervous system, Eyes, Skin, Kidney, Liver

Further information Studies have shown that similar products produce skin cancer or skin tumors in laboratory animals following repeated applications without washing or removal. The significance of this finding to human exposure has not been determined. Other studies with active skin carcinogens have shown that washing the animal's skin with soap and water between applications reduced tumor formation.
Repeated over-exposure may cause liver and kidney injury
IARC classifies whole diesel fuel exhaust particulates as carcinogenic to humans (Group 1). NIOSH regards whole diesel fuel exhaust particulates as a potential cause of occupational lung cancer based on animal studies and limited evidence in humans.

Component:

Fuels, diesel, No 2; Gasoil - unspecified	68476-34-6	Acute oral toxicity: LD50 rat Dose: 5,001 mg/kg Acute dermal toxicity: LD50 rabbit Dose: 2,001 mg/kg Acute inhalation toxicity: LC50 rat Dose: 7.64 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Severe skin irritation Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation
Nonane	111-84-2	Acute oral toxicity: LD50 mouse Dose: 218 mg/kg Acute inhalation toxicity: LC50 rat Exposure time: 4 h
Naphthalene	91-20-3	Acute oral toxicity: LD50 rat Dose: 2,001 mg/kg Acute dermal toxicity: LD50 rat Dose: 2,501 mg/kg

		Acute inhalation toxicity: LC50 rat Dose: 101 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Mild skin irritation Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation Carcinogenicity: N11.00422130
1,2,4-Trimethylbenzene	95-63-6	Acute inhalation toxicity: LC50 rat Dose: 18 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Skin irritation Eye irritation: Classification: Irritating to eyes. Result: Eye irritation
Xylene	1330-20-7	Acute oral toxicity: LD50 rat Dose: 2,840 mg/kg Acute dermal toxicity: LD50 rabbit Dose: ca. 4,500 mg/kg Acute inhalation toxicity: LC50 rat Dose: 6,350 mg/l Exposure time: 4 h Skin irritation: Classification: Irritating to skin. Result: Mild skin irritation Repeated or prolonged exposure may cause skin irritation and dermatitis, due to degreasing properties of the product. Eye irritation: Classification: Irritating to eyes. Result: Mild eye irritation

Carcinogenicity

NTP	Naphthalene (CAS-No.: 91-20-3)
IARC	Naphthalene (CAS-No.: 91-20-3)
OSHA	No component of this product which is present at levels greater than or equal to 0.1 % is identified as a carcinogen or potential carcinogen by OSHA.
CA Prop 65	WARNING! This product contains a chemical known to the State of California to cause cancer. naphthalene (CAS-No.: 91-20-3)

SECTION 12. ECOLOGICAL INFORMATION

Additional ecological information : Keep out of sewers, drainage areas, and waterways. Report spills and releases, as applicable, under Federal and State regulations.

Component:

Diesel	68476-34-6	Toxicity to fish: LC50 Species: Jordanella floridae Dose: 54 mg/l

Exposure time: 96 h

Toxicity to crustacia:
Species: Palaemonetes pugio
TLm (48 hour) = 3.4 mg/l

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal : Dispose of container and unused contents in accordance with federal, state and local requirements.

SECTION 14. TRANSPORT INFORMATION

CFR

Proper shipping name	: DIESEL FUEL
UN-No.	: UN1202 (NA 1993)
Class	: 3
Packing group	: III

TDG

Proper shipping name	: DIESEL FUEL
UN-No.	: UN1202 (NA 1993)
Class	: 3
Packing group	: III

IATA Cargo Transport

UN UN-No.	: UN1202 (NA 1993)
Description of the goods	: DIESEL FUEL
Class	: 3
Packaging group	: III
ICAO-Labels	: 3
Packing instruction (cargo aircraft)	: 366
Packing instruction (cargo aircraft)	: Y344

IATA Passenger Transport

UN UN-No.	: UN1202 (NA 1993)
Description of the goods	: DIESEL FUEL
Class	: 3
Packaging group	: III
ICAO-Labels	: 3
Packing instruction (passenger aircraft)	: 355
Packing instruction (passenger aircraft)	: Y344

IMDG-Code

UN-No.	: UN 1202 (NA 1993)
Description of the goods	: DIESEL FUEL
Class	: 3
Packaging group	: III
IMDG-Labels	: 3

EmS Number : F-E S-E
Marine pollutant : No

SECTION 15. REGULATORY INFORMATION

: **CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIROMENT)**
The CERCLA definition of hazardous substances contains a "petroleum exclusion" clause which exempts crude oil. Fractions of crude oil, and products (both finished and intermediate) from the crude oil refining process and any indigenous components of such from the CERCLA Section 103 reporting requirements. However, other federal reporting requirements, including SARA Section 304, as well as the Clean Water Act may still apply.

TSCA Status : On TSCA Inventory

DSL Status : All components of this product are on the Canadian DSL list.

SARA 311/312 Hazards : Fire Hazard
Acute Health Hazard
Chronic Health Hazard

SARA III US. EPA Emergency Planning and Community Right-To-Know Act (EPCRA) SARA Title III Section 313 Toxic Chemicals (40 CFR 372.65) - Supplier Notification Required

Components	CAS-No.
Xylene	1330-20-7
1,2,4-Trimethylbenzene	95-63-6
Naphthalene	91-20-3

PENN RTK US. Pennsylvania Worker and Community Right-to-Know Law (34 Pa. Code Chap. 301-323)

Components	CAS-No.
Nonane	111-84-2
Naphthalene	91-20-3
1,2,4-Trimethylbenzene	95-63-6
xylene	1330-20-7
Fuels, diesel, No 2; Gasoil - unspecified	68476-34-6

MASS RTK US. Massachusetts Commonwealth's Right-to-Know Law (Appendix A to 105 Code of Massachusetts Regulations Section 670.000)

Components	CAS-No.
Xylene	1330-20-7
1,2,4-Trimethylbenzene	95-63-6
Naphthalene	91-20-3
Nonane	111-84-2

NJ RTK US. New Jersey Worker and Community Right-to-Know Act (New Jersey Statute Annotated Section 34:5A-5)

Components	CAS-No.
Nonane	111-84-2

Naphthalene	91-20-3
1,2,4-Trimethylbenzene	95-63-6
Xylene	1330-20-7
Fuels, diesel, No 2; Gasoil - unspecified	68476-34-6

California Prop. 65 : WARNING! This product contains a chemical known to the State of California to cause cancer.

Naphthalene 91-20-3

SECTION 16. OTHER INFORMATION

Further information

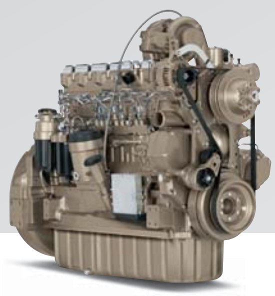
The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

10/29/2012

1153, 1250, 1443, 1454, 1814, 1815, 1866, 1925

Attachment F28 – Off-Highway Diesel Engine Ratings Tier 3/Stage III A. Page 27: PowerTech Plus 13.5L Engines, 6135H

PowerTech Plus 9.0L engines



- Expanded power range:
  6090H: 168 – 298 kW (225 – 400 hp)
- Best-in-class power density
- Higher level of power bulge — up to 11%
- Higher level of peak torque — up to 50%
- More low-speed (1000 rpm) torque — up to 150% of rated speed torque
- Transient response that meets or exceeds Tier 2/Stage II
- Best-in-class fuel economy
- Lower rated speeds to reduce noise and improve fuel economy
- Cold-starting capabilities that meet or exceed Tier 2/Stage II
- New compact size

Tier 3/Stage III A PowerTech Plus 9.0L engines

Engine model	Rated power		Rated speed	Peak power		Peak power	Peak torque		Peak torque
	kW	hp	(rpm)	kW	hp	(rpm)	Nm	lb-ft	(rpm)
6090HF485	168	225	2000	187	251	1800	1095	807	1500
6090HF485	168	225	2200	187	251	2000	1095	807	1500
6090HF485	168	225	2200	168	225	2200	984	726	1500
6090HF485	187	250	2000	205	275	1800	1201	886	1500
6090HF485	187	250	2200	205	275	2000	1201	886	1500
6090HF485	187	250	2200	187	251	2200	1095	807	1500
6090HF485	205	275	2000	224	301	1800	1313	968	1500
6090HF485	205	275	2200	224	301	1800	1313	968	1500
6090HF485	205	275	2200	205	275	2200	1201	886	1500
6090HF485	224	300	2000	243	325	1800	1421	1048	1500
6090HF485	224	300	2200	243	325	2000	1421	1048	1500
6090HF485	224	300	2200	224	300	2200	1313	968	1500
6090HF485	242	325	2000	261	350	1800	1530	1128	1500
6090HF485	242	325	2200	261	350	2000	1530	1128	1500
6090HF485	242	325	2200	242	325	2200	1421	1048	1500
6090HF485	261	350	2000	279	375	1800	1554	1146	1500
6090HF485	261	350	2200	280	375	2000	1543	1138	1500
6090HF485	261	350	2200	261	350	2200	1530	1128	1500
6090HF485	280	375	2200	280	375	2200	1543	1138	1500
6090HF485	298	400	2200	298	400	2200	1550	1143	1500

Bore		Stroke		Length		Width		Height		Weight	
mm	in	mm	in	mm	in	mm	in	mm	in	kg	lb
118	4.7	136	5.4	1208	47.6	630	24.8	1113	43.8	901	1986

Ratings are subject to change.

PowerTech Plus 13.5L engines

- Maintained power range:
  6135H: 261 – 448 kW (350 – 600 hp)
- Best-in-class power density
- Higher level of power bulge — up to 14%
- Higher level of peak torque — up to 43%
- More low-speed (1000 rpm) torque — up to 138% of rated speed torque
- Transient response that meets or exceeds Tier 2/Stage II
- Best-in-class fuel economy
- Lower rated speeds to reduce noise and improve fuel economy
- Cold-starting capabilities that meet or exceed Tier 2/Stage II
- Compact size

Tier 3/Stage III A PowerTech Plus 13.5L engines

Engine model	Rated power		Rated speed	Peak power		Peak power	Peak torque		Peak torque
	kW	hp	(rpm)	kW	hp	(rpm)	Nm	lb-ft	(rpm)
6135HF485	261	350	1900	298	399	1700	1834	1353	1400
6135HF485	261	350	2100	298	400	1900	1602	1182	1400
6135HF485	261	350	2100	261	350	2100	1602	1182	1400
6135HF485	298	400	1900	335	449	1700	2063	1521	1400
6135HF485	298	400	2100	336	450	1900	1834	1353	1400
6135HF485	298	400	2100	298	400	2100	1834	1353	1400
6135HF485	317	425	2100	336	450	1800	2063	1521	1400
6135HF485	336	450	1900	371	498	1700	2290	1689	1400
6135HF485	336	450	2100	373	500	1900	2063	1521	1400
6135HF485	336	450	2100	336	450	2100	2063	1521	1400
6135HF485	373	500	1900	409	548	1700	2430	1792	1400
6135HF485	373	500	2100	373	500	2100	2290	1689	1400
6135HF485	373	500	2100	400	536	1800	2290	1689	1400
6135HF485	392	525	2100	410	550	1800	2430	1792	1400
6135HF485	410	550	2100	423	567	2000	2430	1792	1400
6135HF485	410	550	2100	410	550	2100	2430	1792	1400
6135HF485	448	600	2100	448	600	2100	2550	1881	1600

Bore		Stroke		Length		Width		Height		Weight	
mm	in	mm	in	mm	in	mm	in	mm	in	kg	lb
132	5.2	165	6.5	1334	52.5	855	33.7	1512	59.5	1493	3292

Attachment F29 – Caterpillar, Gen Set Package Performance Data [BLG02887], June 10, 2014

CATERPILLAR®

GEN SET PACKAGE PERFORMANCE DATA [BLG02887]

JUNE 10, 2014

(BLG02887)-ENGINE (AFN01260)-GENERATOR (TFT00461)-GENSET

For Help Desk Phone Numbers Click here

Performance Number: DM9135

Change Level: 01

Sales Model: 3412CDITA **Combustion:** DI

Aspr: TA

Engine Power:
725 W/F EKW 758 W/O F EKW
1,081 HP

Speed: 1,800 RPM

After Cooler: JWAC

Manifold Type: DRY

Governor Type: PEEC

After Cooler Temp(F): --

Turbo Quantity: 4

Engine App: GP

Turbo Arrangement: Series

Hertz: 60

Application Type: PACKAGE-DIE

Engine Rating: PGS

Strategy:

Rating Type: PRIME

Certification: STAT-USE EPA-T1 2006 - 2006

General Performance Data

GEN W/F EKW	PERCENT LOAD	ENGINE POWER BHP	ENGINE BMEP PSI	FUEL BSFC LB/BHP-HR	FUEL RATE GPH	INTAKE MFLD TEMP DEG F	INTAKE MFLD P IN-HG	INTAKE AIR FLOW CFM	EXH MFLD TEMP DEG F	EXH STACK TEMP DEG F	EXH GAS FLOW CFM
725	100	1081	288.34	0.34	53.05	205.16	68.11	2,246.01	1,250.06	954.32	6,250.7
652.5	90	968	258.32	0.34	47.37	198.5	56.95	2,005.88	1,215.5	942.98	5,540.88
580	80	861	229.6	0.34	42.08	193.1	47.29	1,786.92	1,182.56	931.46	4,894.62
543.8	75	809	215.67	0.34	39.55	190.94	42.91	1,691.57	1,165.46	924.44	4,608.57
507.5	70	757	201.9	0.34	37.06	188.96	38.79	1,599.76	1,147.82	916.16	4,333.11
435	60	656	175.06	0.34	32.31	185.18	31.24	1,430.25	1,110.92	896.9	3,817.52
362.5	50	557	148.52	0.35	27.98	181.76	24.58	1,274.86	1,067.36	870.98	3,340.77
290	40	460	122.56	0.36	23.75	178.52	18.66	1,133.6	1,014.62	835.34	2,881.68
217.5	30	360	96.02	0.37	19.21	175.46	13.18	988.81	939.38	780.44	2,408.46
181.3	25	309	82.38	0.38	16.85	174.02	10.66	921.71	890.06	742.64	2,168.32
145	20	257	68.6	0.39	14.48	172.76	8.29	854.62	833.18	698	1,928.18
72.5	10	152	40.61	0.46	9.91	171.86	4.21	752.2	686.48	578.3	1,515

Engine Heat Rejection Data

GEN W/F EKW	PERCENT LOAD	REJ TO JW BTU/MN	REJ TO ATMOS BTU/MN	REJ TO EXHAUST BTU/MN	EXH RCOV TO 350F BTU/MN	FROM OIL CLR BTU/MN	FROM AFT CLR BTU/MN	WORK ENERGY BTU/MN	LHV ENERGY BTU/MN	HHV ENERGY BTU/MN
725	100	26,217.0	6,198.8	43,903.6	25,307.1	3,309.8	7,051.9	45,837.1	114,706.5	122,156.5
652.5	90	23,487.3	5,743.9	38,728.4	22,179.2	3,093.7	5,402.6	41,060.1	102,365.8	109,076.4
580	80	20,928.1	5,402.6	34,121.9	19,335.8	2,883.3	4,037.8	36,510.5	90,991.8	96,963.1
543.8	75	19,733.8	5,118.3	31,960.9	18,084.6	2,780.9	3,469.1	34,292.5	85,532.3	91,105.5
507.5	70	18,482.7	4,890.8	29,913.6	16,833.5	2,684.3	2,900.4	32,131.5	80,186.5	85,418.6
435	60	16,151.0	4,435.9	26,046.4	14,501.8	2,468.1	1,990.4	27,809.4	69,950.0	74,499.5
362.5	50	14,046.9	4,379.0	22,463.6	12,283.9	2,257.7	1,251.1	23,601.0	60,566.4	64,490.4

290	40	11,999.5	4,322.1	18,937.7	10,066.0	2,053.0	625.6	19,506.4	51,410.4	54,765.7
217.5	30	9,724.8	4,037.8	15,241.1	7,734.3	1,814.2	113.7	15,241.1	41,571.9	44,301.6
181.3	25	8,587.3	3,867.1	13,307.5	6,540.0	1,660.6	-56.9	13,080.1	36,510.5	38,842.1
145	20	7,393.1	3,639.7	11,430.8	5,345.8	1,501.4	-284.4	10,919.0	31,335.3	33,382.6
72.5	10	5,061.4	3,355.3	7,904.9	3,014.1	1,182.9	-511.8	6,483.2	21,439.9	22,804.8

EXHAUST Sound Data: 4.92 FEET

GEN W/F EKW	PERCENT LOAD	OVERALL SOUND DB(A)	OBCF 63HZ DB	OBCF 125HZ DB	OBCF 250HZ DB	OBCF 500HZ DB	OBCF 1000HZ DB	OBCF 2000HZ DB	OBCF 4000HZ DB	OBCF 8000HZ DB
725	100	111	100	110	111	110	103	101	100	90
652.5	90	110	99	109	110	109	102	100	99	89
580	80	109	98	108	109	108	101	99	98	88
543.8	75	108	98	108	109	108	101	99	97	88
507.5	70	108	97	107	108	107	100	98	97	87
435	60	107	96	106	107	106	99	97	96	86
362.5	50	106	95	105	106	105	98	96	95	85
290	40	105	94	104	105	104	97	95	94	84
217.5	30	104	93	103	104	103	96	94	93	83
181.3	25	103	93	103	103	103	96	93	92	82
145	20	103	92	102	103	102	95	93	92	82
72.5	10	101	91	101	101	101	94	91	90	80

EXHAUST Sound Data: 22.97 FEET

GEN W/F EKW	PERCENT LOAD	OVERALL SOUND DB(A)	OBCF 63HZ DB	OBCF 125HZ DB	OBCF 250HZ DB	OBCF 500HZ DB	OBCF 1000HZ DB	OBCF 2000HZ DB	OBCF 4000HZ DB	OBCF 8000HZ DB
725	100	97	91	101	96	95	90	89	89	81
652.5	90	96	90	100	95	94	89	88	88	80
580	80	96	89	99	94	93	88	87	87	79
543.8	75	95	89	98	93	93	88	87	87	79
507.5	70	95	88	98	93	92	87	86	86	78
435	60	94	87	97	92	91	86	85	85	77
362.5	50	93	86	96	91	91	85	84	84	76
290	40	92	85	95	90	89	84	83	83	75
217.5	30	91	84	94	89	88	83	82	82	74
181.3	25	90	84	93	88	88	83	82	82	74
145	20	89	83	92	87	87	82	81	81	73
72.5	10	88	82	91	86	86	81	80	80	72

EXHAUST Sound Data: 49.21 FEET

GEN W/F EKW	PERCENT LOAD	OVERALL SOUND DB(A)	OBCF 63HZ DB	OBCF 125HZ DB	OBCF 250HZ DB	OBCF 500HZ DB	OBCF 1000HZ DB	OBCF 2000HZ DB	OBCF 4000HZ DB	OBCF 8000HZ DB
725	100	91	84	94	89	89	83	82	82	74
652.5	90	90	83	93	88	88	82	81	81	73
580	80	89	82	92	87	87	81	80	80	72
543.8	75	88	82	92	87	86	81	80	80	72
507.5	70	88	82	91	86	86	81	80	80	72
435	60	87	81	90	85	85	80	79	79	71
362.5	50	86	80	89	84	84	79	78	78	70
290	40	85	79	88	83	83	78	77	77	69
217.5	30	84	77	87	82	82	76	75	75	68
181.3	25	83	77	86	81	81	76	75	75	67
145	20	83	76	86	81	81	75	74	74	66
72.5	10	81	75	84	79	79	74	73	73	65

MECHANICAL Sound Data: 3.28 FEET

GEN W/F EKW	PERCENT LOAD	OVERALL SOUND DB(A)	OBCF 63HZ DB	OBCF 125HZ DB	OBCF 250HZ DB	OBCF 500HZ DB	OBCF 1000HZ DB	OBCF 2000HZ DB	OBCF 4000HZ DB	OBCF 8000HZ DB
725	100	106	95	102	111	103	99	98	82	77
652.5	90	106	95	102	111	103	99	98	82	77
580	80	106	95	102	111	103	99	98	82	77
543.8	75	106	95	102	111	103	99	98	82	77
507.5	70	106	95	102	111	103	99	98	82	77
435	60	106	95	102	111	103	99	98	82	77
362.5	50	106	95	102	111	103	99	98	82	77
290	40	106	95	102	111	103	99	98	82	77
217.5	30	106	95	102	111	103	99	98	82	77
181.3	25	106	95	102	111	103	99	98	82	77
145	20	106	95	102	111	103	99	98	82	77
72.5	10	106	95	102	111	103	99	98	82	77

MECHANICAL Sound Data: 22.97 FEET

GEN W/F EKW	PERCENT LOAD	OVERALL SOUND DB(A)	OBCF 63HZ DB	OBCF 125HZ DB	OBCF 250HZ DB	OBCF 500HZ DB	OBCF 1000HZ DB	OBCF 2000HZ DB	OBCF 4000HZ DB	OBCJ 8000HZ DB
725	100	94	85	90	98	90	87	86	79	70
652.5	90	94	85	90	98	90	87	86	79	70
580	80	94	85	90	98	90	87	86	79	70
543.8	75	94	85	90	98	90	87	86	79	70
507.5	70	94	85	90	98	90	87	86	79	70
435	60	94	85	90	98	90	87	86	79	70
362.5	50	94	85	90	98	90	87	86	79	70
290	40	94	85	90	98	90	87	86	79	70
217.5	30	94	85	90	98	90	87	86	79	70
181.3	25	94	85	90	98	90	87	86	79	70
145	20	94	85	90	98	90	87	86	79	70
72.5	10	94	85	90	98	90	87	86	79	70

MECHANICAL Sound Data: 49.21 FEET

GEN W/F EKW	PERCENT LOAD	OVERALL SOUND DB(A)	OBCF 63HZ DB	OBCF 125HZ DB	OBCF 250HZ DB	OBCF 500HZ DB	OBCF 1000HZ DB	OBCF 2000HZ DB	OBCF 4000HZ DB	OBCF 8000HZ DB
725	100	88	81	84	92	85	80	79	74	62
652.5	90	88	81	84	92	85	80	79	74	62
580	80	88	81	84	92	85	80	79	74	62
543.8	75	88	81	84	92	85	80	79	74	62
507.5	70	88	81	84	92	85	80	79	74	62
435	60	88	81	84	92	85	80	79	74	62
362.5	50	88	81	84	92	85	80	79	74	62
290	40	88	81	84	92	85	80	79	74	62
217.5	30	88	81	84	92	85	80	79	74	62
181.3	25	88	81	84	92	85	80	79	74	62
145	20	88	81	84	92	85	80	79	74	62
72.5	10	88	81	84	92	85	80	79	74	62

EMISSIONS DATA

STAT-USE EPA-T1 2006 - 2006 ** P2
This engine meets EPA Tier 1 Equivalent Emission Levels for stationary use in 2006.

Gaseous emissions data measurements are consistent with those described in EPA 40 CFR PART 89 SUBPART D and ISO 8178 for measuring HC, CO, PM, and NOx.

Gaseous emissions values are WEIGHTED CYCLE AVERAGES and are capable of meeting the following non-road emission levels:

LOCALITY	AGENCY/LEVEL	MAX LIMITS - g/kW-hr
U. S. (incl Calif)	EPA/TIER-1	CO:11.4 HC:1.3 NOx:9.2 PM:0.5

REFERENCE EXHAUST STACK DIAMETER	8 IN
WET EXHAUST MASS	10,337.5 LB/HR
WET EXHAUST FLOW (953.60 F STACK TEMP)	6,254.23 CFM
WET EXHAUST FLOW RATE (32 DEG F AND 29.98 IN HG)	2,127.00 STD CFM
DRY EXHAUST FLOW RATE (32 DEG F AND 29.98 IN HG)	1,949.02 STD CFM
FUEL FLOW RATE	53 GAL/HR

RATED SPEED "Potential site variation"

GEN PWR EKW	PERCENT LOAD	ENGINE POWER BHP	TOTAL NOX (AS NO2) LB/HR	TOTAL CO LB/HR	TOTAL HC LB/HR	PART MATTER LB/HR	OXYGEN IN EXHAUST PERCENT	DRY SMOKE OPACITY PERCENT	BOSCH SMOKE NUMBER
725	100	1081	17.1100	3.0200	.5700	.4800	9.9000	1.4000	1.2800
543.8	75	809	12.8100	2.0800	.3300	.4000	10.0000	1.4000	1.2800
362.5	50	557	8.1800	1.6200	.2900	.3700	10.7000	2.0000	1.2800
181.3	25	309	4.1700	1.6800	.4100	.2800	12.4000	2.5000	1.2800
72.5	10	152	2.4000	1.8600	.9200	.2000	14.8000	2.0000	1.2800

RATED SPEED "Nominal Data"

GEN PWR EKW	PERCENT LOAD	ENGINE POWER BHP	TOTAL NOX (AS NO2) LB/HR	TOTAL CO LB/HR	TOTAL HC LB/HR	TOTAL CO2 LB/HR	PART MATTER LB/HR	OXYGEN IN EXHAUST PERCENT	DRY SMOKE OPACITY PERCENT	BOSCH SMOKE NUMBER
725	100	1081	14.1400	1.6100	.3000	1,184.1	.2400	9.9000	1.4000	1.2800
543.8	75	809	10.5800	1.1100	.1800	873.9	.2100	10.0000	1.4000	1.2800
362.5	50	557	6.7600	.8700	.1600	618.8	.1900	10.7000	2.0000	1.2800
181.3	25	309	3.4500	.9000	.2200	369.4	.1400	12.4000	2.5000	1.2800
72.5	10	152	1.9800	.9900	.4900	215.2	.1000	14.8000	2.0000	1.2800

Altitude Capability Data(Corrected Power Altitude Capability)

Ambient Operating Temp. / Altitude	50 F	68 F	86 F	104 F	122 F	NORMAL
0 F	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,080.86 l
984.25 F	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,080.86 l
1,640.42 F	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,080.86 l
3,280.84 F	1,080.86 hp	1,080.86 hp	1,080.86 hp	1,078.18 hp	1,044.65 hp	1,080.86 l
4,921.26 F	1,080.86 hp	1,080.86 hp	1,047.34 hp	1,013.81 hp	982.97 hp	1,080.86 l
6,561.68 F	1,055.38 hp	1,019.18 hp	985.65 hp	953.47 hp	923.96 hp	1,028.56 l
8,202.1 F	991.01 hp	957.49 hp	925.3 hp	895.8 hp	868.98 hp	976.26 h
9,842.52 F	930.67 hp	898.48 hp	868.98 hp	840.82 hp	815.34 hp	927.99 h
11,482.94 F	873 hp	843.5 hp	815.34 hp	789.86 hp	764.38 hp	879.71 h
13,123.36 F	818.02 hp	789.86 hp	764.38 hp	740.24 hp	717.45 hp	834.11 h
14,763.78 F	765.72 hp	740.24 hp	716.1 hp	693.31 hp	671.85 hp	791.2 hp

The powers listed above and all the Powers displayed are Corrected Powers

Identification Reference and Notes

Engine Arrangement:	2819205	**Lube Oil Press @ Rated Spd(PSI):**	61.6
Effective Serial No:	BLG02982	**Piston Speed @ Rated Eng SPD (FT/Min):**	1,773.6
Primary Engine Test Spec:	0K2179	**Max Operating Altitude(FT):**	4,921.3
Performance Parm Ref:	TM5739	**PEEC Elect Control Module Ref**	
Performance Data Ref:	DM9135	**PEEC Personality Cont Mod Ref**	
Aux Coolant Pump Perf Ref:			
Cooling System Perf Ref:		**Turbocharger Model**	TV9215-2.00
Certification Ref:	STAT USE EPA T1	**Fuel Injector**	
Certification Year:	2006	**Timing-Static (DEG):**	18.50
Compression Ratio:	13.0	**Timing-Static Advance (DEG):**	3.50
Combustion System:	DI	**Timing-Static (MM):**	0.00
Aftercooler Temperature (F):	--	**Unit Injector Timing (MM):**	--
Crankcase Blowby Rate(CFH):	--	**Torque Rise (percent)**	--
Fuel Rate (Rated RPM) No Load (Gal/HR):	--	**Peak Torque Speed RPM**	--
Lube Oil Press @ Low Idle Spd(PSI):	61.2	**Peak Torque (LB.FT):**	--

Reference Number: DM9135 STAT-USE EPA-T1 20062006P2

Parameters Reference: TM5739

GEN SET - PACKAGED - DIESEL

TOLERANCES:
AMBIENT AIR CONDITIONS AND FUEL USED WILL AFFECT THESE VALUES. EACH OF THE VALUES MAY VARY IN ACCORDANCE WITH THE FOLLOWING TOLERANCES.

Power	+/- 3%
Exhaust Stack Temperature	+/- 8%
Generator Power	+/- 5%
Inlet Airflow	+/- 5%
Intake Manifold Pressure-gage	+/- 10%
Exhaust Flow	+/- 6%
Specific Fuel Consumption	+/- 3%
Fuel Rate	+/- 5%
Heat Rejection	+/- 5%
Heat Rejection - Exhaust Only	+/- 10%

T4i Tolerance Exceptions

C15: Power Tolerance	+4% , -0%
C27: Power Tolerance	+0% , -4%

CONDITIONS:
ENGINE PERFORMANCE IS CORRECTED TO INLET AIR STANDARD CONDITIONS OF 99 KPA (29.31 IN HG) AND 25 DEG C (77 DEG F).

THESE VALUES CORRESPOND TO THE STANDARD ATMOSPHERIC PRESSURE AND TEMPERATURE IN ACCORDANCE WITH SAE J1349. ALSO INCLUDED IS A CORRECTION TO STANDARD FUEL GRAVITY OF 35 DEGREES API HAVING A LOWER HEATING VALUE OF 42,780 KJ/KG (18,390 BTU/LB) WHEN USED AT 29 DEG C (84.2 DEG F) WHERE THE DENSITY IS 838.9 G/L (7.002 LB/GAL).

THE CORRECTED PERFORMANCE VALUES SHOWN FOR CATERPILLAR ENGINES WILL APPROXIMATE THE VALUES OBTAINED WHEN THE OBSERVED PERFORMANCE DATA IS CORRECTED TO SAE J1349, ISO 3046-2 & 8665 & 2288 & 9249 & 1585, EEC 80/1269 AND DIN70020 STANDARD REFERENCE CONDITIONS.

ENGINES ARE EQUIPPED WITH STANDARD ACCESSORIES; LUBE OIL, FUEL PUMP AND JACKET WATER PUMP. THE POWER REQUIRED TO DRIVE AUXILIARIES MUST BE DEDUCTED FROM THE GROSS OUTPUT TO ARRIVE AT THE NET POWER AVAILABLE FOR THE EXTERNAL (FLYWHEEL) LOAD. TYPICAL AUXILIARIES INCLUDE COOLING FANS, AIR COMPRESSORS, AND CHARGING ALTERNATORS.

RATINGS MUST BE REDUCED TO COMPENSATE FOR ALTITUDE AND/OR AMBIENT TEMPERATURE CONDITIONS ACCORDING TO THE APPLICABLE DATA SHOWN ON THE PERFORMANCE DATA SET.

ALTITUDE:

ALTITUDE CAPABILITY - THE RECOMMENDED REDUCED POWER VALUES FOR SUSTAINED ENGINE OPERATION AT SPECIFIC ALTITUDE LEVELS AND AMBIENT TEMPERATURES.

COLUMN "N" DATA - THE FLYWHEEL POWER OUTPUT AT NORMAL AMBIENT TEMPERATURE.

AMBIENT TEMPERATURE - TO BE MEASURED AT THE AIR CLEANER AIR INLET DURING NORMAL ENGINE OPERATION.

NORMAL TEMPERATURE - THE NORMAL TEMPERATURE AT VARIOUS SPECIFIC ALTITUDE LEVELS IS FOUND ON TM2001.

THE GENERATOR POWER CURVE TABULAR DATA REPRESENTS THE NET ELECTRICAL POWER OUTPUT OF THE GENERATOR.

GENERATOR SET RATINGS

EMERGENCY STANDBY POWER (ESP)

OUTPUT AVAILABLE WITH VARYING LOAD FOR THE DURATION OF AN EMERGENCY OUTAGE. AVERAGE POWER OUTPUT IS 70% OF THE ESP RATING. TYPICAL OPERATION IS 50 HOURS PER YEAR, WITH MAXIMUM EXPECTED USAGE OF 200 HOURS PER YEAR.

STANDBY POWER RATING

OUTPUT AVAILABLE WITH VARYING LOAD FOR THE DURATION OF AN EMERGENCY OUTAGE. AVERAGE POWER OUTPUT IS 70% OF THE STANDBY POWER RATING. TYPICAL OPERATION IS 200 HOURS PER YEAR, WITH MAXIMUM EXPECTED USAGE OF 500 HOURS PER YEAR.

PRIME POWER RATING

OUTPUT AVAILABLE WITH VARYING LOAD FOR AN UNLIMITED TIME. AVERAGE POWER OUTPUT IS 70% OF THE PRIME POWER RATING. TYPICAL PEAK DEMAND IS 100% OF PRIME RATED EKW WITH 10% OVERLOAD CAPABILITY FOR EMERGENCY USE FOR A MAXIMUM OF 1 HOUR IN 12. OVERLOAD OPERATION CANNOT EXCEED 25 HOURS PER YEAR.

CONTINUOUS POWER RATING

OUTPUT AVAILABLE WITH NON-VARYING LOAD FOR AN UNLIMITED TIME. AVERAGE POWER OUTPUT IS 70-100% OF THE CONTINUOUS POWER RATING. TYPICAL PEAK DEMAND IS 100% OF CONTINUOUS RATED EKW FOR 100% OF OPERATING HOURS.

SOUND DEFINITIONS:

Sound Power : DM8702
Sound Pressure : TM7080

Date Released

Attachment F30 – TRC, Emissions Test Report Harvey Explorer Resupply Ship Shell Gulf of Mexico, Inc. August 9, 2012.

2.1 Caterpillar Starboard Main Engine (HE-1) 80, 60, 40, & 20% Load Conditions

Table 2.1.1 – Starboard Main Engine
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY EXPLORER – Starboard Main Engine (HE-1) Caterpillar 3516BDITA, Serial #4BW00444					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	95.6	77.7	48.4	39.8
Mechanical Power Output	**kW**	1,348	1,011	674	337
SAMPLING RESULTS					
	Test Date	**5/9/2012**	**5/9/2012**	**5/10/2012**	**5/10/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.005044	0.004655	0.02382	0.003215
	lb/hr	0.1782	0.1461	0.4017	0.03493
Condensable PM	**gr/dscf**	0.003338	0.003050	0.002114	0.003114
	lb/hr	0.1186	0.09652	0.03566	0.03380
Total PM[1]	**gr/dscf**	0.008382	0.007705	0.02593	0.006329
	lb/hr	0.2968	0.2426	0.4373	0.06873
	lb/gal fuel	0.003094	0.003122	0.009046	0.001720
	lb/kW-hr	0.0002202	0.0002400	0.0006488	0.0002039
	EPA Method 9				
Opacity	**%**	7	5	6	2
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	10.7	13.1	10.1	12.9
	% CO_2	7.1	5.3	7.5	5.2
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	685.4	509.1	648.0	1029.8
	lb/hr	20.51	16.22	9.224	16.31
	lb/gal fuel	0.2144	0.2090	0.1913	0.4095
	lb/kW-hr	0.01521	0.01604	0.01368	0.04838
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	36.8	26.7	39.8	95.0
	lb/hr	1.100	0.8515	0.5682	1.511
	lb/gal fuel	0.01150	0.01098	0.01175	0.03780
	lb/kW-hr	0.0008160	0.0008421	0.0008428	0.004483
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	9.0	9.0	9.0	9.1

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.2 Caterpillar Port Main Engine (HE-2) 80, 60, 40 & 20% Load Conditions

Table 2.2.1 – Port Main Engine
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY EXPLORER – Port Main Engine (HE-2) Caterpillar 3516BDITA, Serial #4BW00443					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	84.8	63.5	39.0	24.9
Mechanical Power Output	**kW**	1,348	1,011	674	337
SAMPLING RESULTS					
	Test Date	**5/9/2012**	**5/9/2012**	**5/10/2012**	**5/10/2012**
EPA Method 5/202					
Filterable PM	**gr/dscf**	0.004213	0.006520	0.01929	0.002621
	lb/hr	0.1411	0.1878	0.2680	0.02199
Condensable PM	**gr/dscf**	0.001431	0.001755	0.002133	0.003547
	lb/hr	0.04822	0.05054	0.02966	0.02982
Total PM[1]	**gr/dscf**	0.005644	0.008275	0.02142	0.006168
	lb/hr	0.1893	0.2383	0.2977	0.05181
	lb/gal fuel	0.002248	0.003754	0.007641	0.002073
	lb/kW-hr	0.0001404	0.0002357	0.0004416	0.0001537
EPA Method 9					
Opacity	**%**	5	3	9	5
EPA Methods 3A & 7E					
EPA Method 3A	**% O_2**	10.8	10.3	9.8	12.6
	% CO_2	7.2	7.7	7.9	5.6
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	716.9	763.8	964.3	1,023.5
	lb/hr	19.35	14.66	10.83	9.810
	lb/gal fuel	0.2281	0.2307	0.2772	0.3939
	lb/kW-hr	0.01435	0.01450	0.01607	0.02910
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	93.6	96.0	150.1	235.6
	lb/hr	2.527	1.843	1.685	2.258
	lb/gal fuel	0.02977	0.02901	0.04335	0.09066
	lb/kW-hr	0.001874	0.001823	0.002500	0.006699
Total Sulfur – ASTM D 5453					
Total Sulfur	**ppmw**	9.0	9.0	9.0	9.1

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.3 Starboard Generator Engine #3 (HE-3) 90-100, & 50-60% Load Conditions

Table 2.3.1 – Starboard Generator Engine
Overall Average Emissions Results for 90-100 & 50-60% Load Conditions

HARVEY EXPLORER – Starboard Generator Engine (HE-3) Caterpillar 3406, Serial #9FF03054 1SS00871			
Test Identification	**Emission Unit**	**90-100% Load**	**50-60% Load**
PROCESS DATA			
Power Output	**%**	90-100	50-60
Fuel Flow Rate	**gal/hr**	18.7	14.0
Electrical Power Output	**kWe**	261	166
SAMPLING RESULTS			
	Test Date	**5/3/2012**	**5/3/2012**
	EPA Method 5/202		
Filterable PM	**gr/dscf**	0.01737	0.01487
	lb/hr	0.1118	0.08349
Condensable PM	**gr/dscf**	0.003100	0.002372
	lb/hr	0.01998	0.01337
Total PM[1]	**gr/dscf**	0.02047	0.01724
	lb/hr	0.1318	0.09686
	lb/gal fuel	0.007027	0.006967
	lb/kWe-hr	0.0005120	0.0005854
	EPA Method 9		
Opacity	**%**	1	---
	EPA Methods 3A & 7E		
EPA Method 3A	**% O_2**	9.0	11.9
	% CO_2	8.3	6.1
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	423.1	356.2
	lb/hr	2.147	1.770
	lb/gal fuel	0.1138	0.1261
	lb/kWe-hr	0.008343	0.01060
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	8.5	23.4
	lb/hr	0.04254	0.1164
	lb/gal fuel	0.002327	0.008280
	lb/kWe-hr	0.0001661	0.0006961
	Total Sulfur – ASTM D 5453		
Total Sulfur	**ppmw**	8.9	9.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.4 Center Generator Engine (HE-4) 90-100, & 50-60% Load Conditions

Table 2.4.1 – Center Generator Engine
Overall Average Emissions Results for 90-100 & 50-60% Load Conditions

HARVEY EXPLORER – Center Generator Engine (HE-4) Caterpillar 3406, Serial #9FF03053 1SS00870			
Test Identification	**Emission Unit**	**90-100% Load**	**50-60% Load**
PROCESS DATA			
Power Output	**%**	90-100	50-60
Fuel Flow Rate	**gal/hr**	31.3	23.4
Electrical Power Output	**kWe**	266	155
SAMPLING RESULTS			
	Test Date	**5/4/2012**	**5/4/2012**
	EPA Method 5/202		
Filterable PM	**gr/dscf**	0.05797	0.03575
	lb/hr	0.3863	0.1934
Condensable PM	**gr/dscf**	0.002305	0.002643
	lb/hr	0.01536	0.01428
Total PM[1]	**gr/dscf**	0.06028	0.03840
	lb/hr	0.4016	0.2076
	lb/gal fuel	0.01286	0.008860
	lb/kWe-hr	0.001510	0.001339
	EPA Method 9		
Opacity	**%**	8	---
	EPA Methods 3A & 7E		
EPA Method 3A	**% O_2**	8.8	11.7
	% CO_2	8.5	6.4
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	416.6	380.4
	lb/hr	3.448	3.120
	lb/gal fuel	0.1100	0.1331
	lb/kWe-hr	0.01295	0.02020
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	4.9	9.4
	lb/hr	0.04111	0.08242
	lb/gal fuel	0.001301	0.003499
	lb/kWe-hr	0.0001544	0.0005434
	Total Sulfur – ASTM D 5453		
Total Sulfur	**ppmw**	9.4	9.5

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.5 Port Generator Engine (HE-5) 90-100, & 50-60% Load Conditions

Table 2.5.1 – Port Generator Engine
Overall Average Emissions Results for 90-100 & 50-60% Load Conditions

HARVEY EXPLORER – Port Generator Engine (HE-5) Caterpillar 3406, Serial #9FF03055 1SS00872			
Test Identification	**Emission Unit**	**90-100% Load**	**50-60% Load**
PROCESS DATA			
Power Output	**%**	90-100	50-60
Fuel Flow Rate	**gal/hr**	19.9	16.1
Electrical Power Output	**kWe**	260	166
SAMPLING RESULTS			
	Test Date	**5/3/2012**	**5/3/2012**
EPA Method 5/202			
Filterable PM	**gr/dscf**	0.01566	0.01266
	lb/hr	0.1084	0.06117
Condensable PM	**gr/dscf**	0.003765	0.004389
	lb/hr	0.02609	0.02115
Total PM[1]	**gr/dscf**	0.01942	0.01705
	lb/hr	0.1345	0.08232
	lb/gal fuel	0.006758	0.005101
	lb/kWe-hr	0.0005116	0.0004947
EPA Method 9			
Opacity	**%**	4	---
EPA Methods 3A & 7E			
EPA Method 3A	**% O_2**	9.4	11.7
	% CO_2	7.8	6.0
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	849.9	765.4
	lb/hr	4.685	4.289
	lb/gal fuel	0.2358	0.2657
	lb/kWe-hr	0.01807	0.02574
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	89.8	97.9
	lb/hr	0.4946	0.5492
	lb/gal fuel	0.02490	0.03401
	lb/kWe-hr	0.001912	0.003297
Total Sulfur – ASTM D 5453			
Total Sulfur	**ppmw**	8.9	9.0

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.6 Caterpillar Forward/Port Bow Thruster (HE-7) 80, 60, 40 & 20% Load Conditions

Table 2.6.1 – Forward/Port Bow Thruster Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY EXPLORER – Forward/Port Bow Thruster (HE-7) Caterpillar 3412, Serial #9KS01690					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	25.6	18.5	7.9	4.5
Mechanical Power Output	**kW**	507	380	254	127
SAMPLING RESULTS					
	Test Date	**5/8/2012**	**5/8/2012**	**5/7/2012**	**5/7/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.02245	0.005926	0.01583	0.01579
	lb/hr	0.2998	0.03894	0.09146	0.06279
Condensable PM	**gr/dscf**	0.01662	0.01103	0.002130	0.002346
	lb/hr	0.2218	0.07234	0.01216	0.009325
Total PM[1]	**gr/dscf**	0.03907	0.01696	0.01796	0.01813
	lb/hr	0.5217	0.1113	0.1036	0.07211
	lb/gal fuel	0.02039	0.006004	0.01306	0.01602
	lb/kW-hr	0.001028	0.0002925	0.0004086	0.0005687
	EPA Method 9				
Opacity	**%**	---	6	7	3
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	7.0	10.5	15.7	17.8
	% CO_2	9.9	7.4	2.9	2.1
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	775.4	359.2	133.8	198.5
	lb/hr	4.513	1.972	0.6539	0.9448
	lb/gal fuel	0.1755	0.1077	0.08191	0.2068
	lb/kW-hr	0.008900	0.005185	0.002579	0.007453
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	33.9	13.9	16.0	33.4
	lb/hr	0.1971	0.07680	0.07296	0.1591
	lb/gal fuel	0.007679	0.004187	0.009222	0.03481
	lb/kW-hr	0.0003886	0.0002019	0.0002878	0.001255
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	9.3	9.4	9.2	9.5

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.7 Caterpillar Aft/Starboard Bow Thruster (HE-8) 80, 60, 40 & 20% Load Conditions

Table 2.7.1 – Aft/Starboard Bow Thruster
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY EXPLORER – Aft/Starboard Bow Thruster (HE-8) Caterpillar 3412, Serial #9KS01689					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	15.0	10.6	9.2	5.6
Mechanical Power Output	**kW**	507	380	254	127
SAMPLING RESULTS					
	Test Date	**5/8/2012**	**5/8/2012**	**5/7/2012**	**5/7/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.03840	0.006638	0.02150	0.03071
	lb/hr	0.3561	0.03781	0.1203	0.1233
Condensable PM	**gr/dscf**	0.008176	0.004165	0.004033	0.005111
	lb/hr	0.07580	0.02349	0.02260	0.02052
Total PM[1]	**gr/dscf**	0.04658	0.01080	0.02553	0.03582
	lb/hr	0.4319	0.06130	0.1429	0.1439
	lb/gal fuel	0.02877	0.005788	0.01548	0.02583
	lb/kW-hr	0.0008515	0.0001611	0.0005634	0.001134
	EPA Method 9				
Opacity	**%**	---	3	3	5
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	12.0	15.9	16.0	18.4
	% CO_2	6.1	3.5	3.3	1.6
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	552.3	250.1	220.0	188.9
	lb/hr	2.950	1.705	1.327	1.363
	lb/gal fuel	0.1967	0.1608	0.1438	0.2447
	lb/kW-hr	0.005818	0.004482	0.005236	0.01075
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	36.3	33.2	31.9	32.0
	lb/hr	0.1942	0.2263	0.1934	0.2306
	lb/gal fuel	0.01293	0.02137	0.02095	0.04144
	lb/kW-hr	0.0003830	0.0005950	0.0007630	0.001819
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	9.3	9.4	9.2	9.5

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S

2.8 Caterpillar Stern Thruster (HE-9) 80, 60, 40 & 20% Load Conditions

Table 2.8.1 – Stern Thruster
Overall Average Emissions Results for 80, 60, 40, & 20% Load Conditions

HARVEY EXPLORER – Stern Thruster (HE-9) Caterpillar 3412, Serial #9PW00603					
Test Identification	**Emission Unit**	**80% Load**	**60% Load**	**40% Load**	**20% Load**
PROCESS DATA					
Power Output	**%**	80	60	40	20
Fuel Flow Rate	**gal/hr**	25.5	14.7	4.8	3.9
Mechanical Power Output	**kW**	322	242	161	81
SAMPLING RESULTS					
	Test Date	**5/4/2012**	**5/4/2012**	**5/6/2012**	**5/6/2012**
	EPA Method 5/202				
Filterable PM	**gr/dscf**	0.01897	0.01121	0.007716	0.004455
	lb/hr	0.1451	0.06691	0.02344	0.01178
Condensable PM	**gr/dscf**	0.001521	0.002346	0.004625	0.003293
	lb/hr	0.01162	0.01397	0.01405	0.008688
Total PM[1]	**gr/dscf**	0.02049	0.01356	0.01234	0.007748
	lb/hr	0.1567	0.08089	0.03749	0.02047
	lb/gal fuel	0.006195	0.005502	0.007770	0.005149
	lb/kW-hr	0.0004861	0.0003345	0.0002326	0.0002540
	EPA Method 9				
Opacity	**%**	0	0	0	0
	EPA Methods 3A & 7E				
EPA Method 3A	**% O_2**	9.3	12.9	17.7	18.2
	% CO_2	8.2	5.5	2.4	1.8
NO_x (based on EPA Method 19 flow rates)	**ppmvd**	1,067.8	729.1	307.7	274.6
	lb/hr	7.523	4.288	1.465	1.295
	lb/gal fuel	0.2951	0.2910	0.3033	0.3293
	lb/kW-hr	0.02335	0.01775	0.009093	0.01607
NO_2 (based on EPA Method 19 flow rates)	**ppmvd**	167.0	136.5	64.4	43.4
	lb/hr	1.178	0.8030	0.3027	0.2051
	lb/gal fuel	0.04610	0.05450	0.06312	0.05206
	lb/kW-hr	0.003655	0.003323	0.001880	0.002546
	Total Sulfur – ASTM D 5453				
Total Sulfur	**ppmw**	9.4	9.5	9.5	9.2

[1]PM2.5 = PM10 = Total PM
15 ppm S = 0.0015 wt% S