Kandahar Helmand Power Project (KHPP) ENVIRONMENTAL CLOSE-OUT REPORT

Kandahar Helmand Power Project (KHPP)

Submitted by: Black & Veatch Special Projects Corporation

For the period of:

July, 2011– October, 2013

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ENVIRONMENTAL CLOSE-OUT REPORT FOR KANDAHAR HELMAND POWER PROJECT (KHPP)

COMPONENT 1 (SUBCOMPONENT 1): BRESHNA KOT SITE (BK)
COMPONENT 2: DURAI JUNCTION SUBSTATION (REVISED)
COMPONENT 3: PROJECT MANAGEMENT CAMP (AMTEX VILLAGE)
COMPONENT 4: DIESEL POWER PLANT AT SHORANDAM INDUSTRIAL PARK (SIP)
COMPONENT 6: INSTALLATION AND COMMISSION OF KAJAKI UNIT 2 AND KAJAKI DAM/SUBSTATION

BVSPC PROJECT NO. 042246
COUNTRY/REGION: AFGHANISTAN, KANDAHAR AND HELMAND PROVINCES
PROGRAM: AFGHANISTAN'S SOUTH EAST POWER SYSTEM (SEPS)
ACTIVITY TITLE: KANDAHAR HELMAND POWER PROJECT (KHPP)
QER PREPARED BY: Robert Hooper, Environmental Compliance Manager, Black & Veatch

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PREPARED FOR

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1 Purpose of the Environmental Close-Out Report

As required under contract Section F.4.B, under Management Reports, Black & Veatch has prepared this Environmental Close-Out Report (ECR) to address the "Environmental Report" deliverable. The ECR is designed to indicate whether steps were needed to be taken to amend previous environmental documentation and whether monitoring and evaluation measures presented in the Environmental Mitigation and Management Plan (EMMP) were met.

This ECR is to serve as the close-out report for the period of July, 2011 through October, 2013, the project completion date. This report will serve as the KHPP close-out report required under MOD 10 of the contract.

2 Summary of Mitigation and Management Measures

Compliance with the IEE was coordinated through the use of an Environmental Mitigation and Monitoring Plan (EMMP) approved by USAID on 20 December, 2012. In order to ensure compliance with the EMMP, a monthly monitoring report was created and submitted within each Quarterly Environmental Report (QER). Based upon the Monthly Reports, and the lack of Incident Notifications, it is Black & Veatch's opinion that the mitigation and management measures set forth in the EMMP are effective in suppressing environmental impacts and promoting the socio-economic status of the local region for all components of KHPP.

3 Training

The Training Plan developed by B&V personnel was approved for distribution by USAID on December 26, 2012. B&V commenced providing the training to its personnel and subcontractors on January 16, 2013. As of the end of this reporting period, all personnel (to include local staff) have been trained on Environmental Awareness and sign in sheets for all training has been submitted to USAID for verification. The training plan has also been translated for local written reference for DABS personnel and distributed to DJCN, SIP, KJKI, and BK.

4 Component Summaries

The following chapters provide a summary of mitigation measures' effectiveness for each of the components of KHPP. Spill kits have been placed at each component location and basic training in B&V's corporate environmental policy and the KHPP specific training plan has been delivered to all personnel involved.

4.1 COMPONENT 1: BRESHNA KOT SITE (KDEG AND KDBK)

The Breshna Kot site includes the KDEG and the KDBK portions of the contract and has not experienced any significant impacts to the environment during the project period. The mitigation measures are being followed by the onsite personnel and are effectively managing the potential impacts indicated within the EMMP. The one critical portion of the BK site that required remedial action was the PCB contaminated soils. A containment cell was designed by B&V engineers for disposal of the soil on site, design drawings are attached to the KDEG Environmental Close Out Report as Attachment B. The cell design is based upon the

standards outlined in 40 CFR Part 257 (CRITERIA FOR CLASSIFICATION OF SOLID WASTE DISPOSAL FACILITIES AND PRACTICES), Subparts A and B. The cell is designed to be impervious to all fluids, thus not allowing any migration of contaminates in or out of the cell. Considering the cell is impervious, the depth to the water table (10 – 20 meters), and the persistence of PCB's to attach to soils rather than water, no monitoring wells were installed around the perimeter. The construction of the containment cell was completed on September 8th, 2013. Details of the construction and photos of the progress have been supplied to USAID personnel in the KDEG Close-Out Report approved by USAID on October 22nd, 2014. The KDBK Close-Out Report was accepted by USAID on April 30th, 2014.

The seven (7) generators that have been installed on site are low emission, low noise, and diesel powered MTU's model number 16V4000G63. Originally, the generators were to be within USEPA Tier 4 requirements; however, with the low quality fuel and additional parts required to modify them to meet Tier 4 standards, it was decided to allow them to meet Tier 2 requirements through a contract amendment. These generators will be the main source of power generation when needed and will be supplemented by the existing generators already installed on site. A comparison of the emission calculations for both the new (MTU) and existing generators (KTA and QSK) is provided below as Figures 1 through 5. As evidenced by the data and charts, the approximate reduction of emissions is 37.79%. The calculations for these emissions are from the factory QA/QC testing and the emissions testing that was completed in August 2014. The raw data for each type of generator are attached below for review and comparison as well. The generators' raw data and final emissions report are contained within Attachment A.

4.2 COMPONENT 2: CONSTRUCTION OF DURAI JUNCTION SUBSTATION (DJCN)

DJCN is a new construction substation located in Kandahar Province, Maiwand District, approximately 10 kilometers east of the village of Greshk.

There have been no significant environmental impacts encountered since construction commenced. There were, however, a few potential issues that have been mitigated through engineering controls and construction management.

The first two issues were, and one continues to be, the lack of secondary containment for the generators fuel tanks in both the camp area and the substation. The camp fuel tank containment will be completed through RFMP 015 (Permanent Power to the DJCN Man Camp) to be supervised by our subcontractor VICC (Venco Imtiaz Construction Company) and performed by DABS (Da Afghanistan Bresna Sherkot). The substation fuel tank containment has been completed as of August 26, 2013.

Another issue was the open tower foundation excavations outside of the perimeter of the site. These were all (5) backfilled by VICC and verified by B&V personnel on July 27, 2013.

The final issue was trash disposal of construction debris by VICC. The issue was identified in January of 2013 and remediation of the area commenced in February. Upon receiving the Environmental Management training, VICC senior personnel better understood the situation and why trash could not be strewn about haphazardly. This area has now been completely cleared of all household type trash.

Details of these issues can be found in the DJCN Environmental Close-out Report, which was approved by USAID personnel on September 16, 2013.

4.3 COMPONENT 3: REGIONAL CAMP AND PROJECT MANAGEMENT (AMTEX VILLAGE)

The Amtex Village is a pre-constructed accommodation complex constructed by others with portions leased by Black & Veatch.

One major component of the complex that B&V was responsible for, was the 10.4 acre lay down yard that was constructed by and utilized solely by B&V. B&V and its sub-contractors utilized the yard as a staging area for equipment and supplies prior to being shipped out to the individual sites.

There was one report of a potential environmental impact during the time that B&V occupied the area. One shipping container came in with oil leaking from it; personnel immediately stopped the leak and contained the spill by placing absorbent socks and pillows around the area of the leak. The soils affected by the leak were removed and bagged for disposal and the interior of the container was scrubbed with absorbent granules which were then swept up and bagged for disposal. These bags were then transported to the Breshna Kot site and placed in the containment cell along with the PCB impacted soils.

Based upon the monthly reports, it is Black & Veatch's opinion that no significant impacts to the environment were encountered during the project duration.

4.4 COMPONENT 4: SHORANDAM INDUSTRIAL PARK DIESEL POWER PLANT (SIP)

SIPD is an existing site that has been in operation for decades. The reconstruction of SIPD, including the installation of 10 (ten) generators, 5 (five) transformers, 1 (one) control/admin building, and the refurbishing and reinstallation of 4 (four) underground fuel tanks was completed in late 2011. Beginning in early 2012, the O&M phase was begun. The close out report for SIPD was submitted February 6, 2013 and approved by USAID on February 24, 2013.

4.5 COMPONENT 6: INSTALLATION AND COMMISSION KAJAKI UNIT 2

The Kajaki Dam site is a previously built project site. B&V has had Six (6) minor construction projects at this site: 1) refurbishing of an existing building, 2) the construction of a new septic tank, 3) the upgrade to the warehouse, 4) the upgrade to security related infrastructure and the road, 5) lay down yard upgrade and 6) lastly was the oversight of the installation of the runner cone on Unit 1, which was completed without incident.

There were two (2) reports of potential environmental impacts during the project period. During construction of the security gate mounting poles, 2 UXO (Unexploded Ordinance) devices were found and during the upgrade of the lay down area one further UXO was unearthed; a report was submitted to USAID through our Security Department.

There were no other reports of any environmental impacts during this reporting period, and based upon the monthly reports submitted by field personnel, it is Black & Veatch's opinion that no significant impacts to the environment were encountered during this reporting period. The KJKI Environmental Close-out Report was submitted to USAID on November 13, 2013 and approved on December 10, 2013.

MTU Engine model 16V4000G63	
Continuous Power	**817 kW**
HC	0.44
NO_x	9.6
CO	0.6
PM	0.11
SO_2	0.002
Prime Power	**1226 kW**
HC	0.27
NO_x	10.7
CO	0.4
PM	0.07
SO_2	0.002
Standby Power	**1634 kW**
HC	0.21
NO_x	13.2
CO	0.3
PM	0.05
SO_2	0.002

Cummins Engine model KTA50	
Continuous Power	**1100 kW**
HC	0.201
NO_x	9.5542
CO	1.34
PM	0.098
SO_2	0.1835
Prime Power	**1200 kW**
HC	0.2278
NO_x	10.4922
CO	2.7738
PM	0.12462
SO_2	0.1876
Standby Power	**1429 kW**
HC	0.21842
NO_x	11.7518
CO	3.4438
PM	0.28542
SO_2	0.1876

USEPA Tier 2 Standards for Nonroad Diesel Engines	
HC	N/A
NO_x	N/A
CO	3.5
PM	0.2
SO_2	N/A

Average Emissions

	MTU	KTA50
HC	0.3066667	0.21574
NO_x	11.166667	10.5994
CO	0.4333333	2.5192
PM	0.0766667	0.16934667
SO_2	0.002	0.18623333

MTU Percent Change from KTA50

	MTU	KTA50*	Difference
HC	142.15%	100.00%	42.15%
NO_x	105.35%	100.00%	5.35%
CO	17.20%	100.00%	-82.80%
PM	45.27%	100.00%	-54.73%
SO_2	1.07%	100.00%	-98.93%

Notes:
The KTA50 data has been averaged from three (3) different gensets.
All data is represented as g/kWh.
The average emissions section was calculated by averaging the three (3) power ratings.

*KTA50 data used as the baseline for MTU comparison.

Total Emissions Reduction Percentage of MTU Gensets: 37.79%

FIGURE 1

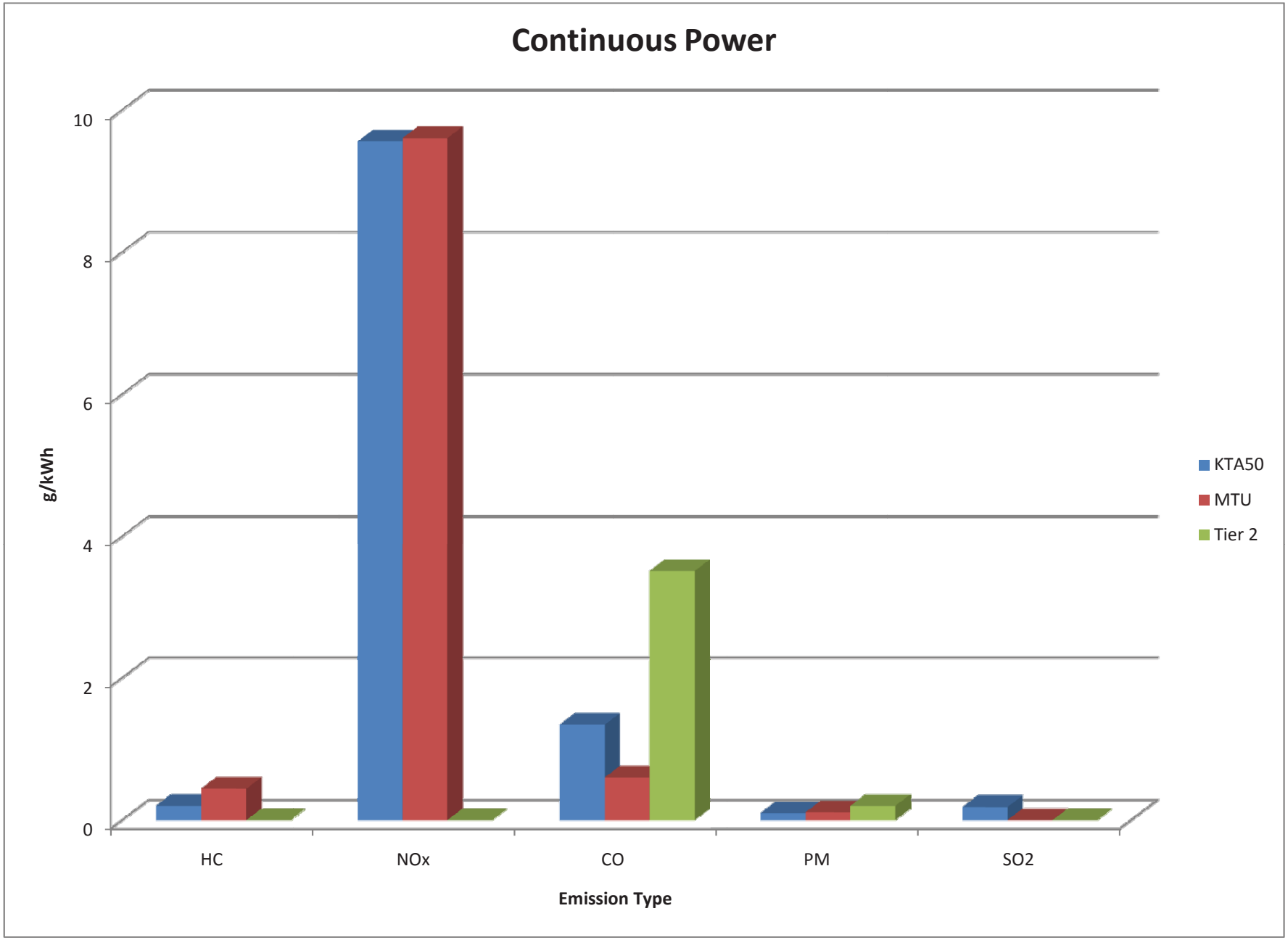
Continuous Power
10
8
6
4
2
0
g/kWh
HC
NOx
CO
PM
SO2
Emission Type
KTA50
MTU
Tier 2

FIGURE 2

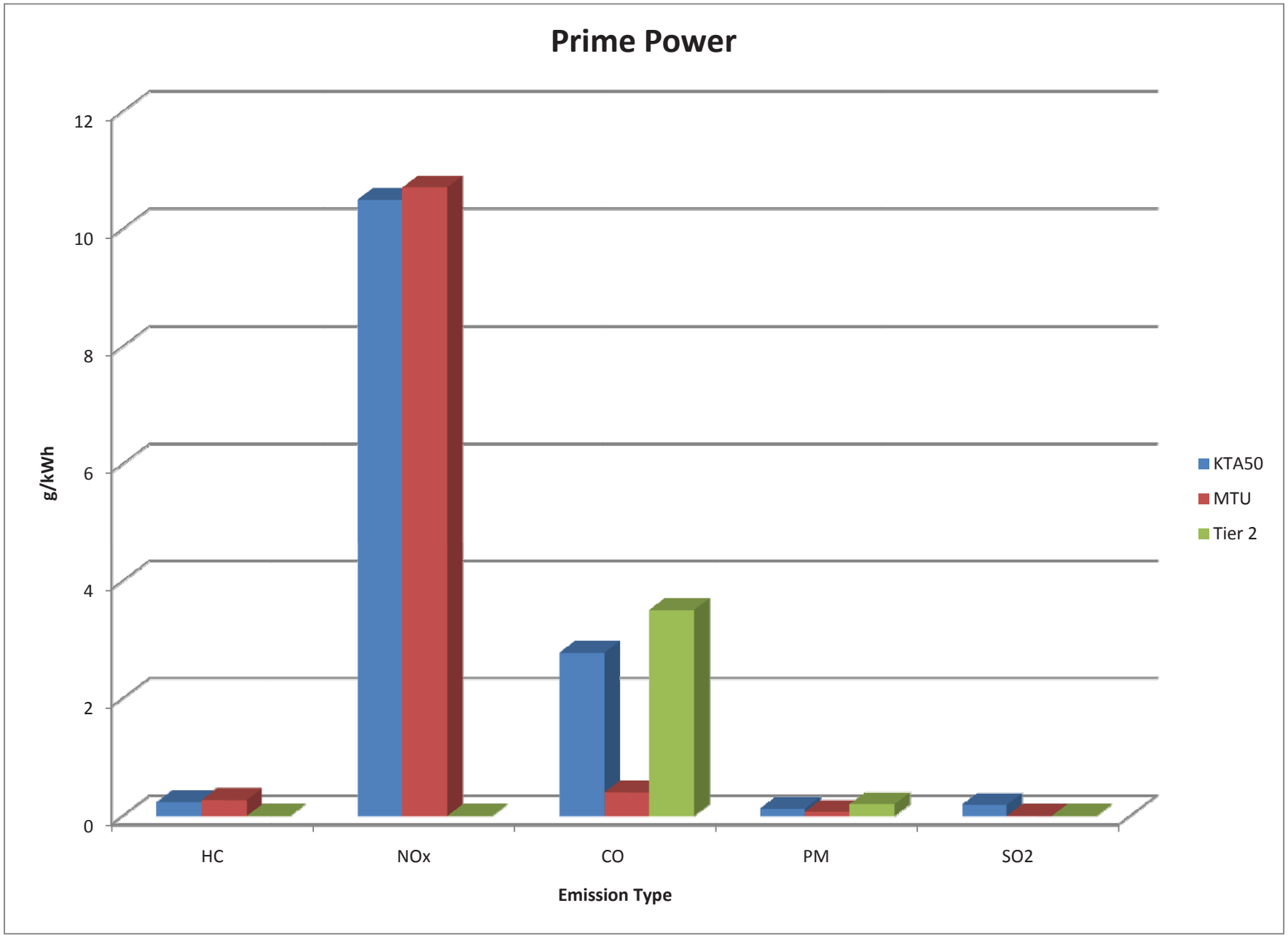
Prime Power
12
10
8
6
4
2
0
g/kWh
HC
NOx
CO
PM
SO2
Emission Type
KTA50
MTU
Tier 2

FIGURE 3

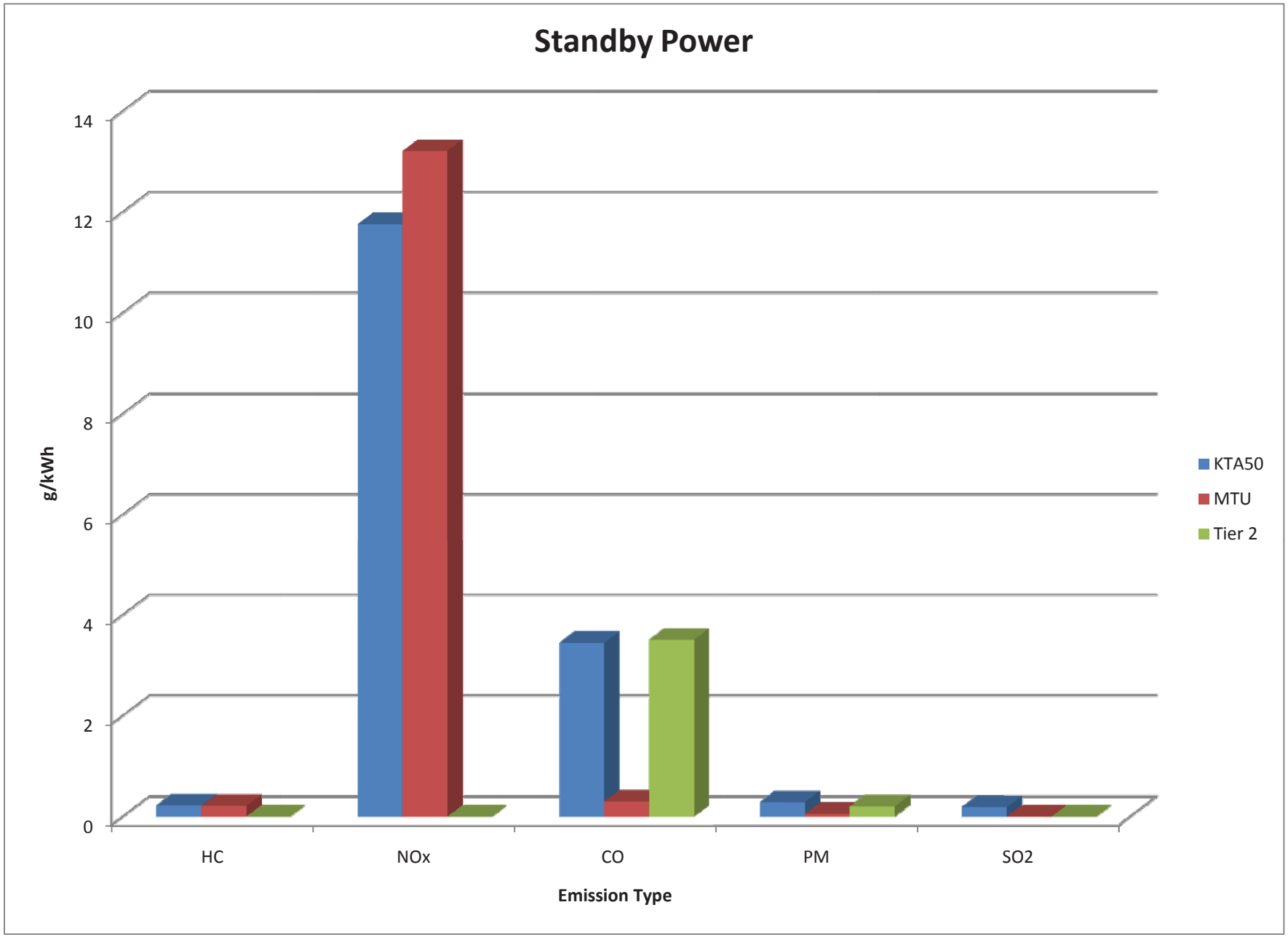
Standby Power
14
12
10
8
6
4
2
0
g/kWh
HC
NOx
CO
PM
SO2
Emission Type
KTA50
MTU
Tier 2

FIGURE 4

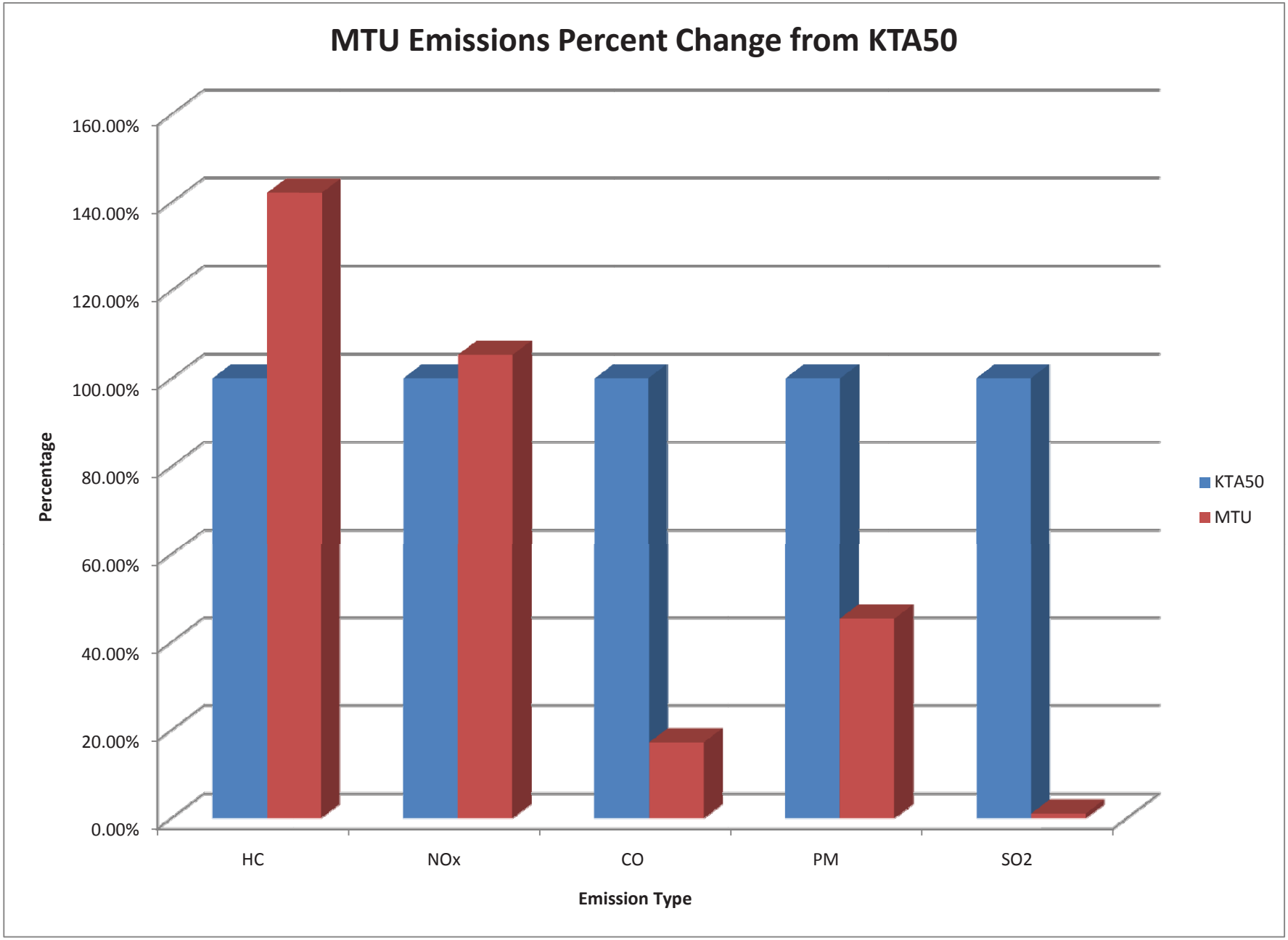
MTU Emissions Percent Change from KTA50
160.00%
140.00%
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Percentage
HC
NOx
CO
PM
SO2
Emission Type
KTA50
MTU

FIGURE 5

ATTACHMENT A

FINAL

EMISSIONS TESTING BRESHNA KOT

KHPP

B&V PROJECT NO. 042246

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PREPARED FOR:

USAID

12 AUGUST 2014

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Executive Summary

RESULTS SUMMARY

BVSPC is pleased to present the report for emissions testing of the MTU diesel generation units at Breshna Kot. A summary of those findings is located in Appendix 1. BVSPC working in consultation with USAID performed emissions testing on the newly installed MTU units and tests on a sampling of the existing KTA and QSK units. The test show that the newly installed MTU units are a substantial improvement in terms of emissions compared to the existing KTA and QSK units. Additionally the new MTU units are meeting Tier 2 emissions standards even when using high sulfur fuel that is provided by DABS.

Overcoming the complexities involved in performing emissions testing in Afghanistan, BVSPC with support of USAID was able to agree on a testing plan that utilized Particulate Matter (PM) testing to provide a baseline for future testing by DABS. In addition BVSPC was able to test for other emissions and compare them favorably to the Tier 2 requirements. The test results are included in this report.

BACKGROUND

As part of KHPP, BVSPC was tasked with installing new diesel generating units at the Breshna Kot Power Generating Station in Kandahar. Our contract stipulates in section C.4.1 in part that "The Contractor must perform all work in accordance with all applicable U.S. and Government of Afghanistan environmental laws, regulations and programs that related to the performance of this contract". The US environmental laws for diesel generators installed in the US called for compliance with Tier 4 emission standards. US environmental law does not require equipment installed outside the US to meet this standard however the contract stipulates that work performed under this contract shall in no case be less stringent than those required by U.S. law regulation. Therefore the contractual requirements are more stringent than the actual EPA requirements for this work.

BVSPC communicated the concern to the Contracting Officer in January 2011. Clarification information was submitted in June 2011 to provide cost impact information for USAID consideration. These communications are found in Appendix 6. BVSPC asked that the equipment to be provided meet Tier 2 standards as the requirement to meet Tier 4 standards was not practical for the installation in Afghanistan. Tier 4 requires low sulfur fuel which is not available in Afghanistan. For Tier 2 equipment to meet Tier 4 standards complex equipment must be installed to clean the exhaust emissions. This equipment requires low sulfur fuel to function properly. As indicated in Appendix 2, BVSPC requested that USAID consider the request to allow BVSPC to provide equipment capable of meeting Tier 2 standards. USAID agreed and asked BVSPC to perform emissions testing on the installed equipment to demonstrate that the use of Tier 2 complaint equipment has a positive affect effect on the environment relative to the existing equipment. After installation and commissioning of the equipment BVSPC did the emissions testing.

TESTING PROGRAM

Emission testing was carried out on three separate occasions at site due to testing company limitations, equipment availability and operation of the diesel generators at site. A local company called Greentech did the testing with BVSPC completing PM testing of the KTA and QSK engines.

1. 24 Nov 2013 – Greentech measured emissions from the MTUs, QSKs and KTAs for O^2, CO, CO^2, NO using their KIGAZ 300 Analyzer. Note that the QSKs and KTAs could not run at full load. PM measurements were not taken as Greentech did not have a device to measure PM.

2. 25 May 2014 – Greentech returned to site this time with their TESTO 350 Gas Analyzer and the PM meter purchased by BVSPC. BVSPC and USAID agreed on a PM testing protocol which is attached for reference. Greentech tested the MTUs again for CO, NOx and SOx and PM. The KTAs and QSKs were not running on this day so they could not be tested. BVSPC collected fuel samples and analyzed them per the PM testing protocol agreed with USAID. See Appendix 4 for the Greentech report.

3. 02 July 2014 – BVSPC returned to site with the PM meter and tested the two QSKs and two KTAs for PM. Test results are included in the summary found in Appendix 1.

CONCLUSION

From the various emissions and fuel testing the following is concluded:

1. The MTUs meet the Tier 2 emissions requirements with PM measured density of 5.8 mg/m3 @ (85% Load for MTU Unit 1) and 4.0 mg/m3 @ (80% Load for MTU Unit 7). DABS were requested to load the units to fully rated load loads shown are the maximum attainable at the time of the test.

2. The PM emissions from the MTUs when converted to g/kWh are .099 g/kWh and 0.070 g/kWh both below the EPA Tier 2 threshold of 0.20 g/kWh.

3. The KTA and QSKs could not be fully loaded as they tripped and their PM density measurements were 43.6 mg/m3 and 34.4 m/m3 respectively.

4. The PM emissions from the KTA and QSK engines are significantly higher than the emissions from the MTU units as expected.

5. Fuel samples taken on 25 May 2014 show high sulfur levels that exceed the requirements for low sulfur fuel needed for Tier 4 emissions requirements. EPA 2010 requirements for fuel state the sulfur should not exceed 15 ppm. Fuel sample taken ranged from a high of 6493 ppm at the main storage tank to 2852 ppm at MTU No. 7 genset. See Appendix 3 for fuel sample results.

6. The decision to use the Tier 2 MTUs is a valid decision considering the emissions of the units are far less than those from the existing units they are to replace and the available fuel in Afghanistan does not support use of Tier 4 capable equipment.

Appendix 1: Summary Test Table

Particulate Meter Testing Form

Project Information

Project Identification	Kandahar Helmand Power Project
Testing Company	Black & Veatch Speccial Projects Corp
Facility Owner	DABS
Facility Address	Breshna Kot Substation, Kandahar Afghanistan

Enivronmental Conditions/Information									**Comments**
	Test Date		25-May-14	25-May-14	2-Jul-14	2-Jul-14	2-Jul-14	2-Jul-14	
	Test Time		12:09:PM	14:45:PM	01:00:PM	12:30:PM	12:00:PM	11:30:AM	
	Ambient Temperature	Degree C	35C	37C	42C	40C	40C	36C	
	Relative Humidity	%	8%	6%	9%	9%	9%	9%	
	Barometric Pressure	hPa	896 hPa	895 hPa	1005 hPa	1005 hPa	1005 hPa	1005 hPa	
Equipment Tested									
	Equipment Number		Unit 1	Unit 7	Unit 5	Unit 12	Unit 1	Unit 2	
	Make		MTU	MTU	Cummins	Cummins	Cummins	Cummins	
	Model		16V4000 G63 -FO	16V4000 G63 - FO	KTA-50 G-3	KTA-50 G-3	QSK-60/G4	QSK-60/G3	
	Cylinders		16 V configuration	16 V configuration					
	Compression Ratio		16.5:1	16.5:1					
	Type		4 Stroke Diesel	4 Stroke Diesel					
	Combustion		Direct Injection	Direct Injection					
	Displacement	liters	76.3	76.3					
	Serial number		5272010646	5272010620	70938-12	70938-19	71237-17	74654-3	
	Generator Nameplate Power Rating	kVA	1806 kVA	1806 kVA	1292 kVA	1292 kVA	2200kVA	2200kVA	
	Engine Nameplate Rating	kW	1965 kW	1965 kW	1074 kW	1074 kW	1800 kW	1800 kW	
Equipment Conditions									
	Power Factor	PF	.80 PF	.80 PF	.84 PF	.85 PF	Not Recorded	Not Recorded	
	Generator Output	kVA	1538 kVA	1440 kVA	407 kVA	416 kVA	Not Recorded	Not Recorded	
	Engine Load	kW	1230 kW	1152 kW	344 kW	354 kW	Not Recorded	680 kW	
	Engine load variation (10 minutes prior to test to 5 minutes after)	kW	1000-1200 kW	1000-1200 kW	330-430 kW	330-430 kW	Not Recorded	630-720 kW	
	Fuel Type and Quality Used		Diesel Fuel No.2	Diesel Fuel No.2	Diesel Fuel No.2	Diesel Fuel No.2	Diesel Fuel No.2	Diesel Fuel No.2	
	Max Percent of Rated Load	%	85%	80%	32%	32%	N/A	38%	KTAs and QSKs tripping
Testing Requirements									
	Genset Stack Particulate Matter Test - Tier 2 EPA (Reference Only)	g/kWh	0.2 g/kWh	0.2 g/kWh	0.2 g/kWh	0.2 g/kWh	0.2 g/kWh	0.2 g/kWh	EPC Std for gensets exceeding 560 kW
	Genset Stack Particulate Matter Test - Tier 4 EPA (Reference Only)	g/kWh	0.1 g/kWh	0.1 g/kWh	0.1 g/kWh	0.1 g/kWh	0.1 g/kWh	0.1 g/kWh	EPC Std for gensets exceeding 560 kW
Test Results									
	Genset Stack Particulate Matter Test	mg/m3	5.8 mg/m3	4.0 mg/m3	43.6 mg/m3	No Reading	34.4 mg/m3	No Reading	Directly Read
	Genset Stack Particulate Matter Test	g/kWh	0.099 g/kWh	0.070 g/kWh	0.183 g/kWh	---------	0.357 g/kWh	---------	Converted
Diesel Fuel									
	EPA Requirement Limit of Sulfur	ppm	15 ppm	15 ppm	---------	---------	---------	---------	Effective 2010
	Test Result of DABS Supplied Fuel	ppm	2811 ppm	2852 ppm	---------	---------	---------	---------	Converted from mg/kg
PM Testing Equipment									
	Manufacturer		Pacific Data Systems	Pacific Data Systems	Pacific Data Systems	Pacific Data Systems	Pacific Data Systems	Pacific Data Systems	
	Model		MAHA MPM-4M	MAHA MPM-4M	MAHA MPM-4M	MAHA MPM-4M	MAHA MPM-4M	MAHA MPM-4M	
	Calibration Certificate Date		16-Jan-14	16-Jan-14	16-Jan-14	16-Jan-14	16-Jan-14	16-Jan-14	

Note: BLUE are measured items

Appendix 2: Agreed PM Testing Plan

PM Testing Protocol

Emissions Testing Breshna Kot Generation - KHPP

BVSPC 05 May 2014

Executive Summary

BVSPC's prime contract requires meeting all current US- EPA standards for the work performed in the contract. Therefore the new MTU units installed at Breshna Kot would need to meet the 2011 Tier 4i emissions standards for 2011 Non-Road Compression-Ignition engines. Tier 4i emission standards require the use of low sulfur fuel not currently available in Afghanistan. Additionally the Tier 4i requirement would necessitate the use of extensive additional exhaust treatment equipment seriously affecting cost, schedule and performance as well as adding additional maintenance requirements. Based on the significant sustainability concerns of meeting Tier 4i standards in Afghanistan, as well as associated cost and schedule impacts to USAID, BVSPC requested in 2011 a waiver to change the contract compliance standard from Tier 4i to Tier 2.

The intent of doing emissions testing at site was to show that the new MTU units met the Tier 2 standards and was a "cleaner" option than the existing KTA and QSK gensets currently at site, which the MTU units are intended to replace. Analytically using the manufacture's factory emissions testing, this can be shown. However, since the fuel at site is assumed to contain about 2,000 ppm of sulfur compared to EPA420-F-04-032standards of 15 ppm, being able to achieve Tier 2 standards is highly unlikely. Additionally, emission testing to Tier 2 standards (NMHC+NOx, DPM and CO) requires specialized equipment that is not available in Afghanistan and would need to be imported. Except in the case of DPM testing, calibration gases as well as the equipment are needed to conduct the tests. Considerable time and expense would be incurred in getting test results that would likely not meet in all cases the Tier 2 emissions requirements due to the relatively low quality fuel provided by DABS for the units.

As an alternative to complete Tier 2 testing, BVSPC is proposing a testing program that measures only Diesel Particulate Matter (DPM). As indicated above, DPM is one of the test criteria for Tier 2. DPM is a good indicator of overall emissions compliance – i.e. improvements in DPM are typically accompanied by improvements in other Tier 2 test components. DPM is made up of unburned fuel and can often be recognized in the exhaust of a diesel engine as sooty black smoke. It is a known carcinogen and is regulated by EPA standards. DPM in the atmosphere does not settle and can affect the health of people outside the power plant as the particles are very small and are easily carried downwind. Additionally, measurement of DPM at the exhaust of an engine is an effective way of evaluating the engine's performance. Since DPM is a known health hazard and a good indicator of both overall emissions and engine performance and maintenance, BVSPC sought a DPM measuring device that could be used routinely by plant operators as part of a regular preventative maintenance program as opposed to a one time test of DPM. Alternatively, USAID could transfer the device to the Afghanistan's National Environmental Protection Agency (NEPA) for their use in monitoring the country's numerous diesel generation plants.

BVSPC was able to source a device to measure DPM that is simple and robust. The equipment is used to measure the Elemental Carbon (EC) in DPM which makes up the predominate component of DPM. The MAHA MPM-4 DP Analyzer is used extensively in the mining industry to measure EC for diesel powered equipment used in the mines. It is used on a regular schedule to track DPM emissions and performance of the engines and gives real time analysis of EC emissions from the engine. Since the relatively poor quality of fuel used by DABS exacerbates diesel emissions, it is particularly important to be able to monitor the component of diesel emissions that poses the greatest health threat to people working and living near the plant. The DPM Analyzer provides a simple and effective means to monitor emissions and identify exhaust emissions changes.

BVSPC is proposing the use of the DPM analyzer to routinely monitor performance of all the generating units at BK in conjunction with a program to correlate DPM emissions to fuel quality. DABS could take fuel samples from the day tanks at the time of DPM testing to establish baseline DPM emissions data and correlate the fuel quality at the time of testing.

Testing Procedure

The generating units should be run at 95-100% load and a one minute sample taken at each engine exhaust. While not mandatory multiple tests can be taken over a period of time to develop an average if the unit loading is not steady. Tests should be taken at normal engine operating temperatures. A fuel sample should be taken as well and analyzed against the MTU standard fuel requirement for the engine, MTU fuel requirement is incorporated for reference. Since the testing is straight forward, testing is recommended every four months to establish a good baseline of information, then twice a year thereafter. The initial test will be performed by a subcontractor hired by BVSPC. Subsequent testing will be by DABS and/or other personnel trained to operate the equipment. Additionally, on the first test the BVSPC contractor will repeat the emissions testing they did in late 2013 to see if there are any differences in the results.

The MAHA MPM-4M DP Analyzer will be used in the continuous test mode for the 60 second test. Results will be in mg/m3 of EC and logged for evaluation and baseline purposes. This can be converted to g/KWh to compare against the EPA Tier 2 requirement of 0.20 g/kWh.

EC emissions for the MTU plant will be compared against EC emissions for the KTA and QSK units. Differences in fuel quality in the units will be noted and correlated to EC emissions. For EC comparative analysis between units, an attempt should be made, if practical, to test operate the KTA and QSK units on the same quality fuel as that used in the MTU units.

Appendix 3: Fuel Sample Test Results

LABORATORY REPORT

Date Reported: 03/07/2014

Report No WAOC-835.1
Sample No WAOC-835.1

Sample received From	AL MASOOD MTU
Sample submited as	Diesel
Description on label	Centrifuge
Serial No	NG

The above sample was analysed as detailed below and the following results obtained

A) Physical &chemical Analysis

Test	Test Method	Unit	Result	MTU Limit
Color	ASTM D1500	_	L 2.5	-
Flash Point	ASTM D 93	°C	53	60
Density@15°C	ASTM D 4052	kg/L	0.8189	0.82-0.86
Viscosity @40 °C	ASTM D 445	mm^2/S	1.935	1.5-4.5
Total Contamination	ASTM D 6217	mg/kg	0.910	24
Chlorous Compond	ASTM D 4929	ppm	<1	-
Water	ASTM D 6304	ppm	21	Max 200
Sulphur Content	ASTM D 2622	mg/kg	3295	Max 5000
Distillation				
IBP		°C	160	160-220
10 %vol recovery		°C	221	
20 %vol recovery		°C	256	
50 %vol recovery	ASTM D 86	°C	279	
85 %vol recovery		°C	336	
90 %vol recovery		°C	349	
FBP		°C	369	
Residue		% vol	1	Max 3
Loss		% vol	0.5	

Normal
Abnormal

Signed for and on behalf of Wimpey Laboratories

P.O.Box: 115086
Tel.: 02-5503324
Fax: 02-5503387
Abu Dhabi
U.A.E.
WIMPEY LABORATORIES L.L.C

for **AJITH KUMAR T. N.**
Laboratory Manager

Test results relate only to the samples tested.

This report shall not be reproduced except in full, without the written approval of the laboratory.

End of Test

LABORATORY REPORT

Date Reported: 03/07/2014

Report No WAOC-835.2
Sample No WAOC-835.2

Sample received From: AL MASOOD MTU
Sample submited as: Diesel
Description on label: Main Storage
Serial No: NG

The above sample was analysed as detailed below and the following results obtained

A) Physical &chemical Analysis

Test	Test Method	Unit	Result	MTU Limit
Color	ASTM D1500	_	L 2.5	-
Flash Point	ASTM D 93	°C	47	60
Density@15°C	ASTM D 4052	kg/L	0.8209	0.82-0.86
Viscosity @40 °C	ASTM D 445	mm^2/S	1.971	1.5-4.5
Total Contamination	ASTM D 6217	mg/kg	0.46	24
Chlorous Compond	ASTM D 4929	ppm	<1	-
Water	ASTM D 6304	ppm	25	Max 200
Sulphur Content	ASTM D2622	mg/kg	6493	Max 5000
Distillation				
IBP		°C	159	160-220
10 %vol recovery		°C	219	
20 %vol recovery		°C	252	
50 %vol recovery	ASTM D 86	°C	276	
85 %vol recovery		°C	339	
90 %vol recovery		°C	347	
FBP		°C	369	
Residue		% vol	1	Max 3
Loss		% vol	0.5	

Normal
Abnormal

Signed for and on behalf of Wimpey Laboratories

For **AJITH KUMAR T. N.**
Laboratory Manager

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End of Test

LABORATORY REPORT

Date Reported: 03/07/2014

Report No WAOC-835.3
Sample No WAOC-835.3

Sample received From: AL MASOOD MTU
Sample submited as: Diesel
Description on label: MTU Genset 1
Serial No: NG

The above sample was analysed as detailed below and the following results obtained

A) Physical &chemical Analysis

Test	Test Method	Unit	Result	MTU Limit
Color	ASTM D1500	_	L 2	-
Flash Point	ASTM D 93	°C	57	60
Density@15°C	ASTM D 4052	kg/L	0.8209	0.82-0.86
Viscosity @40 °C	ASTM D 445	mm^2/S	2.083	1.5-4.5
Total Contamination	ASTM D 6217	mg/kg	0.330	24
Chlorous Compond	ASTM D 4929	ppm	<1	-
Water	ASTM D 6304	ppm	20	Max 200
Sulphur Content	ASTM D2622	mg/kg	2811	Max 5000
Distillation				
IBP		°C	160	160-220
10 %vol recovery		°C	217	
20 %vol recovery		°C	257	
50 %vol recovery	ASTM D 86	°C	279	
85 %vol recovery		°C	341	
90 %vol recovery		°C	351	
FBP		°C	371	
Residue		% vol	1	Max 3
Loss		% vol	0.5	

Normal
Abnormal

Signed for and on behalf of Wimpey Laboratories

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for **AJITH KUMAR T. N**
Laboratory Manager

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End of Test

LABORATORY REPORT

Date Reported: 03/07/2014

Report No WAOC-835.4
Sample No WAOC-835.4

Sample received From: AL MASOOD MTU
Sample submited as: Diesel
Description on label: MTU Genset 7
Serial No: NG

The above sample was analysed as detailed below and the following results obtained

A) Physical &chemical Analysis

Test	Test Method	Unit	Result	MTU Limit
Color	ASTM D1500	_	L 1.5	-
Flash Point	ASTM D 93	°C	59	60
Density@15°C	ASTM D 4052	kg/L	0.8211	0.82-0.86
Viscosity @40 °C	ASTM D 445	mm^2/S	2.099	1.5-4.5
Total Contamination	ASTM D 6217	mg/kg	0.69	24
Chlorous Compond	ASTM D 4929	ppm	<1	-
Water	ASTM D 6304	ppm	22	Max 200
Sulphur Content	ASTM D2622	mg/kg	2852	Max 5000
Distillation				
IBP		°C	157	160-220
10 %vol recovery		°C	222	
20 %vol recovery		°C	251	
50 %vol recovery	ASTM D 86	°C	276	
85 %vol recovery		°C	339	
90 %vol recovery		°C	349	
FBP		°C	367	
Residue		% vol	1	Max 3
Loss		% vol	0.5	

Normal
Abnormal

Signed for and on behalf of Wimpey Laboratories

For **AJITH KUMAR T. N.**
Laboratory Manager

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Test results relate only to the samples tested.
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End of Test

Appendix 4: Greentech Test Results 25 May 2014

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Black & Veatch Special Projects Corp.
AMTEX Village & Business Park
Spin Buldak Road
Across from OP-1, Kandahar Airfield
Kandahar, Afghanistan

Project Name: **Kandahar Helmand Power Project**
Owner's Name: **USAID**
Project Description: **Air Emissions Tests of Diesel Generators at BK Substation, Kandahar**
Project Performed by: Green Tech Construction & Engineering

Introduction

The following report has been prepared in response to a request to finalize air emissions tests for diesel generators at Breshna Kot (BK) substation in Kandahar Helmand Power Project in Kandahar, Afghanistan. The scope of supplemental effort is defined below:

- Two (2) MTU diesels for carbon monoxide (CO), sulphur oxides (SOx) nitrogen oxides (NOx) and particulate matter (PM)
- Two (2) KTA-50 for CO, SOx, NOx and PM - if units are operational during your site visit.
- Two (2) OSK-60 for CO, SOx, NOx and PM
- Provide measurement in both milligrams per cubic meter (mg/m3) and in units of g/kWh.
- Specify fuel designation as heavy or light for purpose of analysis.
- Include evidence of serial numbers of any test equipment used on-site to support evidence of calibration, and acceptance for use.
- Record the engine number of each engine being tested.
- Record engine load concurrently with testing of each engine on the table.
- Record length of time each engine was operating at the time the tests are being taken.
- Record the ambient temperature, barometric pressure and humidity to capture fully "weather" as required in the SOW to conform to the EPA requirements.
- Provide test results for each diesel engine tested.
- Provide test results comparison between each engine type tested on an easy to understand table of comparison.
- Provide test results compared to GIRoA diesel air emission standards or equivalent U.S. standards
- Provide documentation of each instrument to be used and proof of recent calibration. Submit all information in a revised comprehensive report within 7 days of testing.

Based on the agreement made between Green Tech and Black & Veatch, Green Tech needed to retest the operational engines only (running engines). The total number of diesel generators that currently exist at BK is as follow:

- Seven (7) MTU diesel generators
- Seven (7) KTA-50 diesel generators
- Five (5) QSK-60 diesel generators

But unfortunately due to some technical reasons not all the engines mentioned above are running. The below tables indicate the operating status of all the engines that are currently running and were also running on the test date:

MTU Engines Since March 2013 – Tier 4							
Engine	**MTU-1**	**MTU-2**	**MTU-3**	**MTU-4**	**MTU-5**	**MTU-6**	**MTU-7**
Operating Status on Test Date (25 May 2014)	Running	Running	Running	Running	Not Running	Running	Running
Current Operating Status	Running	Running	Running	Running	Not Running	Running	Running

THE KTA-50 ARE CUMMINS 2003 VINTAGE							
Engine	**KTA-50 1**	**KTA-50 2**	**KTA-50 3**	**KTA-50 4**	**KTA-50 5**	**KTA-50 6**	**KTA-50 7**
Operating Status on Test Date (25 May 2014)	Not Running	Not Running	Not Running	Not Running	Not Running	Not Running	Not Running
Current Operating Status	Not Running	Not Running	Not Running	Not Running	Not Running	Not Running	Not Running

QSK-60 ARE CUMMINS 2006 VINTAGE							
Engine	**QSK-60 1**	**QSK-60 2**	**QSK-60 3**	**QSK-60 4**	**QSK-60 5**	**-**	**-**
Operating Status on Test Date (25 May 2014)	Not Running	Not Running	Not Running	Not Running	Not Running		
Current Operating Status	Not Running	Not Running	Not Running	Not Running	Not Running		

Referring to above tables we can see that the KTA-50s and QSK-60s are not running and DABS or USAID are not intending to use them in the future either. Only 6 out of 7 MTU engines are currently working and were under load on the test date (except for MTU number 5 which is out of order/not working). Therefore the following results are only for the MTU engines which were running on the test date.

MTU Generators (photo from first test)

KTA-50 Generators (photo from first test)
Currently not running

QSK-60 Generators (photos from first test)
Currently not running

Test Procedure

The following steps were followed by Green Tech to complete the tests respectively:

1- The first step of air emissions test was to start (switch on) the engines for at least 20 minutes to warm up and put them under load. But Green Tech did not need to switch on the engines as DABS guys had already switched them on in the early morning before Green Tech guys arrive on site.
2- The second step was taking the fuel sample from different points of the fuel network. The fuel used by the MTU engines is diesel which is considered as **light fuel**. Green Tech took the fuel samples from the following locations just before starting the test on 25 May 2014:

   - One diesel fuel sample from the main storage tank
   - One diesel fuel sample from the centrifuge system
   - Six diesel fuel samples after the centrifuge just before it goes into the engine on each of the 6 MTU units.

   These fuel samples were collected in standard plastic bottles and submitted to Mr. Samadi (representative from B&V) on the same day. These will be shipped back to MTU Abu Dhabi for analysis.

3- Third step of the job was to record the ambient temperature, barometric pressure and humidity to capture fully "weather" as required in the SOW to conform to the EPA requirements. Green Tech recorded these parameters for each engine separately just before doing the test for that engine using PHB-318 digital instrument. (below photos)

4- In the fourth step Green Tech recorded the engine load concurrently with testing of first engine (MTU 1). Also the length of time which engine was operating at the time the tests were being taken was recorded. Green Tech recorded the time and also engine load for all the engines afterward in the same method.

5- The fifth step was to measure the PM using the PM meter provided by B&V and SOx, NOx and CO using TESTO 350 Gas Analyzer provided by Green Tech. The documentation and proof of recent calibration is attached at the end of this report.

For PM measurement Green Tech used Pacific Data Systems Model MAHA MPM-4M, Diesel Particle Analyzer. The documentation and proof of recent calibration can be collected from BVSPC at AMTEX.

Test Results

MTU 1	Engine Serial #: 5272010646				
*2nd TEST INFROMATION					
Ambient Temperature (˚C)	RH%	Barometric Pressure (hPa)	Load at the time of testing (KW)	Time	Date
35.1	7.7	896.4	1230	12:09–12:45	2014/5/25
*The information on this table is for the second test only (25 May 2014). This information is not available for the first test.					

		(g/kwh)	(ppm)	Mg/m³	Standard EPA (g/kwh)	GIRoA
CO	1st test	0.257	-	-	3.5	-
	2nd test	0.285	111	139		
NOx	1st test	3.608	-	-	3.5	-
	2nd test	4.508	1072.5	2203		
SOx	1st test	-	-	-	-	-
	2nd test	4.85	95	3979		
PM (mg/m3 EC)	1st test	N/A			0.10	-
	2nd test	5.8				

MTU 2	Engine Serial #: 527108601				
*2nd TEST INFROMATION					
Ambient Temperature (˚C)	RH%	Barometric Pressure (hPa)	Load at the time of testing (KW)	Time	Date
38.2	5.2	896.4	1100	13:28–13:40	2014/5/25
*The information on this table is for the second test only (25 May 2014). This information is not available for the first test.					

		(g/kwh)	(ppm)	Mg/m^3	Standard EPA (g/kwh)	GIRoA
CO	1st test	0.252	-	-	3.5	-
	2nd test	0.273	109	136		
NOx	1st test	3.686	-	-	3.5	-
	2nd test	4.615	1123	2307		
SOx	1st test	-	-	-	-	-
	2nd test	3.62	71	2974		
PM (mg/m3 EC)	1st test	N/A			0.10	-
	2nd test	5.9				

MTU 3	Engine Serial #: 527108608				
*2nd TEST INFROMATION					
Ambient Temperature (˚C)	RH%	Barometric Pressure (hPa)	Load at the time of testing (KW)	Time	Date
37	6.5	895.5	1131	13:40-14:00	2014/5/25
*The information on this table is for the second test only (25 May 2014). This information is not available for the first test.					

		(g/kwh)	(ppm)	Mg/m^3	Standard EPA (g/kwh)	GIRoA
CO	1st test	0.226	-	-	3.5	-
	2nd test	0.293	117	146		
NOx	1st test	3.915	-	-	3.5	-
	2nd test	4.645	1129	2319		
SOx	1st test	-	-	-	-	-
	2nd test	4.7	92	3853		
PM (mg/m3 EC)	1st test	N/A			0.10	-
	2nd test	7.2				

MTU 4	Engine Serial #: 527108605				
*2nd TEST INFROMATION					
Ambient Temperature (˚C)	RH%	Barometric Pressure (hPa)	Load at the time of testing (KW)	Time	Date
35.1	6.8	895.3	1148	14:00-14:25	2014/5/25
*The information on this table is for the second test only (25 May 2014). This information is not available for the first test.					

		(g/kwh)	(ppm)	Mg/m^3	Standard EPA (g/kwh)	GIRoA
CO	1st test	0.399	-	-	3.5	-
	2nd test	0.302	121	151		
NOx	1st test	2.907	-	-	3.5	-
	2nd test	4.664	1138.8	2340		
SOx	1st test	-	-	-	-	-
	2nd test	4.85	95	3979		
PM (mg/m3 EC)	1st test	N/A			0.10	-
	2nd test	6.1				

MTU 6	Engine Serial #: 527108609				
*2nd TEST INFROMATION					
Ambient Temperature (˚C)	RH%	Barometric Pressure (hPa)	Load at the time of testing (KW)	Time	Date
37.4	5.1	895.1	1147	14:25-14:45	2014/5/25
*The information on this table is for the second test only (25 May 2014). This information is not available for the first test.					

		(g/kwh)	(ppm)	Mg/m^3	Standard EPA (g/kwh)	GIRoA
CO	1st test	0.251	-	-	3.5	-
	2nd test	0.283	113	141		
NOx	1st test	4.410	-	-	3.5	-
	2nd test	4.695	1141.5	2345		
SOx	1st test	-	-	-	-	-
	2nd test	4.54	89	3727		
PM (mg/m3 EC)	1st test	N/A			0.10	-
	2nd test	7				

MTU 7	Engine Serial #: 5272010620				
*2nd TEST INFROMATION					
Ambient Temperature (˚C)	RH%	Barometric Pressure (hPa)	Load at the time of testing (KW)	Time	Date
36.9	5.5	894.8	1152	14:45-15:10	2014/5/25

*The information on this table is for the second test only (25 May 2014). This information is not available for the first test.

		(g/kwh)	(ppm)	Mg/m^3	Standard EPA (g/kwh)	GIRoA
CO	1st test	0.207	-	-	3.5	-
	2nd test	0.271	107	134		
NOx	1st test	3.681	-	-	3.5	-
	2nd test	4.752	1143.3	2348		
SOx	1st test	-	-	-	-	-
	2nd test	4.8	94	3937		
PM (mg/m3 EC)	1st test	N/A			0.10	-
	2nd test	4				

Appendix 5: PM Calibration Certificate

testo

Kalibrier-Protokoll

Certificate of conformity • Protocole d'étalonnage
Certificato di taratura • Informe de calibración

Gerät / Module type / Type de modèle / Prodotto / Modelo: **T350**
Seriennummer / Serial No. / No. de série / No. Serie strumento / n° de serie: **02765682**

Temperaturmessung **Temperature measurement** **Measure de température** **Misura della temperatura** **Medición de temperatura**	Sollwert Reference Référence Valore campione Referencia	Istwert Actual value Valeur effective Valore misurato Valor medido	zulässige Abweichung Permissible deviation Différence admissible Scostamento ammesso Desviación permitida
Verbrennungslufttemp./ Ambient air temp. Température d'air de combustion Temperatura aria comburente Temperatura ambiente	100.0 °C	100.2 °C	+- 0.5 °C
Abgastemperatur / Flue gas temperature Température des fumées Temperatura fumi Temperatura gases	100.0 °C	100.0 °C	+- 0.5 °C
Zug-/Druckmessung **Draught/pressure measurement** **Mesure de tirage/de pression** **Misura della pressione/ tiraggio** **Medición de trio/ presión**	8.00 hPa	7.97 hPa	+- 0.12 hPa

Gasmeßwerte / Gas values / Valeurs de gaz measurées / Parametri di misura dei gas / Gases patrón

Reg. Nr. Reg. No. Reg. No. Num. reg. n° certi	Gas Gas Gaz Gas Gas	Sollwert Reference Référence Valore campione Referencia	Istwert Actual value Valeur effective Valore misurato Valor medido	zulässige Abweichung Permissible deviation Différence admissible Scostamento ammesso Desviación permitida
20134811	NO	150 ppm	151 ppm	+- 7.5 ppm
20135030	NO2	100.0 ppm	102.1 ppm	+- 5.0 ppm
20122742	SO2	100 ppm	98 ppm	+- 5 ppm
20140104	O2	5.00 %	5.00 %	+- 0.20 %
20135169	O2	2.50 %	2.50 %	+- 0.20 %
20134811	O2	0.00 %	-0.02 %	+- 0.20 %
20140104	CO	401 ppm	400 ppm	+- 20 ppm
20135169	CO	701 ppm	701 ppm	+- 35 ppm
20134811	CO	100 ppm	102 ppm	+- 10 ppm

Datum/Date/Date/Data/Fecha: **24.03.2014** **Prüfer/Inspector/Vérificateur/Verificatore/Verificador:** **744**

Kalibrier-Protokoll

Certificate of conformity • Protocole d'étalonnage
Certificato di taratura • Informe de calibración

Wir bestätigen, dass dieses Testo-Produkt unter Beachtung eines zertifizierten Qualitätssicherungssystems nach **DIN EN ISO 9001:2008** abgeglichen wurde.

Die dafür verwendeten Messeinrichtungen werden regelmäßig kalibriert und sind rückführbar auf die nationalen Normale der Physikalisch Technischen Bundesanstalt (PTB) Deutschlands oder auf andere nationale Normale. Wo keine nationalen Normale existieren, entspricht das Messverfahren den derzeit gültigen technischen Regeln und Normen.

Dieses Kalibrier-Protokoll belegt die Einhaltung der von uns zugesagten Toleranzen.

Sehr gerne informieren wir Sie über **Kalibrier-Zertifikate**, die die Toleranzen **des gesamten Messsystems** (Messgerät und Fühler) beinhalten.

Dieses Zertifikat benötigen Sie, wenn das Meßsystem in qualitäts-relevanten Prozessen innerhalb eines nach **DIN EN ISO 9001:2008** zertifiziertem Unternehmen eingesetzt wird.

Unsere Kalibrierlabors für Temperatur, Druck, Feuchte, Strömung und elektrische Messgrössen sind vom Deutschen Kalibrierdienst (DKD) akkreditierte Kalibrierlabors.

DKD-Kalibrierscheine werden für Messungen gefordert, bei denen die Genauigkeit eine entscheidende Rolle spielt.

*We confirm that this Testo product was calibrated under the observation of a **DIN EN ISO 9001:2008** certified quality assurance system.*

The measuring installations used for this calibration are calibrated regularly and can be traced back to the national standards of the German Federal Physical and Technical Institution (PTB), or to other national standards. Should no national standards exist, the measuring procedure corresponds with the currently valid technical regulations and standards.

This calibration protocol is proof of adherence to the tolerances as confirmed by us.

*We would be delighted to inform you about **certificates of conformities** which cover the tolerances for the **complete measuring system** (measuring instrument and probes).*

*This certificate is required only if the measuring system is to be used in processes relevant to quality in a company certified to **DIN EN ISO 9001:2008**.*

Our calibration laboratories for temperature, pressure, humidity, velocity and electrical parameters are calibration laboratories accredited by the German Calibration Service (DKD).

DKD calibration certificates are required for measurements where accuracy plays a decisive role.

Nous confirmons par la présente que ce produit testo a été étalonné sous la surveillance d'un système d'assurance qualité selon la norme **DIN EN ISO 9001:2008**.

Les installations de mesure utilisées pour cet étalonnage sont étalonnées de facon régulière et s'appliquent aux normes nationales de l'Institut Fédéral de Techniques Physiques d'Allemagne (PTB) ou aux autres normes nationales. S'il n'existe aucune norme nationale, le processus de mesure est conforme aux règles et normes techniques actuellement valables.

Ce protocole d'étalonnage vous indique que cet appareil respecte bien les tolérances constructeurs annoncées dans nos documentations.

Un **certificat d'étalonnage** est nécessaire pour la vérification de la **chaîne complète** (appareils et sonde). N'hésitez pas à nous contacter pour de plus amples renseignements.

Ce certificat vous sera utile si vous vous trouvez être certifié ou en cours de certification **DIN EN ISO 9001:2008**.

Notre laboratoire d'étalonnage en température, pression, humidité, vitesse d'air et paramètres électriques a été accrédité par le DKD - équivalent BNM/COFRAC -, Bureau de Métrologie Allemand.

Les certificats d'étalonnage DKD/COFRAC sont indispensables lorsque les mesures effectuées doivent être précises.

*Vi confermiamo che questo prodotto è stato collaudato seguendo il sistema di certificazione di qualità **DIN EN ISO 9001:2008**.*

Gli strumenti di misura elettronici utilizzati per la calibrazione sono a loro volta regolarmente verificati e possono essere ricondotti agli standard nazionali del PTB (Physikalisch Technische Bundesanstalt), l'istituto ufficiale tedesco per la determinazione degli standard tecnici.

Questo protocollo di collaudo documenta l'osservanza delle tolleranze da noi indicate.

*Siamo a Vs. disposizione per fornire informazioni sui **Certificati di Taratura** che comprendono le tolleranze del **sistema di misura completo** (strumento e sonda).*

*Questo documento Vi sarà utile se già siete certificati o siete in corso di certificazione **DIN EN ISO 9001:2008**.*

I nostri laboratori di taratura per temperatura, pressione, umidità, velocità dell'aria e parametri elettrici sono stati accreditati dal PTB e sono in grado di rilasciare certificati ufficiali DKD indispensabili quando le misure effettuate devono essere precise o riferibili.

Queste regole, riconosciute in tutta Europa, sono equivalenti a quelle SIT italiane ed alle procedure tecniche standard utilizzate in tutto il mondo.

Confirmamos que este producto Testo se calibró de acuerdo con el sistema de garantía de calidad **DIN EN ISO 9001:2008**.

Las instalaciones de medición utilizadas para esta calibración se calibran con regularidad y pueden tracearse a los estándares nacionales del instituto Federal de Técnicas Físicas Alemán (PTB), o a otros estándares nacionales. Si no existe una norma nacional, el procedimiento de medición corresponde con las regulaciones técnicas y normas válidas en la actualidad.

Este informe de calibración es una prueba de las tolerancias que nosotros confirmamos.

Estaremos encantados en informales sobre **certificados de calibración** que cubran las tolerancias para el **sistema de medición completo** (instrumento de medición y sondas).

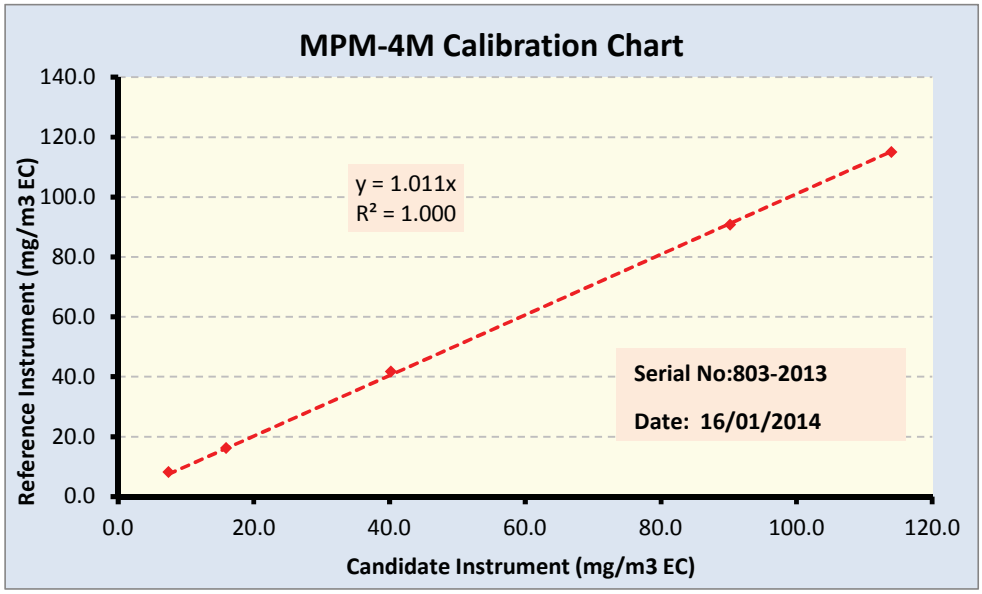
Nuestros laboratorios de calibración para temperatura, presión, humedad, velocidad y parámetros eléctricos son laboratorios de calibración acreditados por el Servicio de calibración alemán (DKD).

Los certificados de calibración DKD son necesarios para las mediciones donde la precisión sea muy importante.

PM Tech

CALIBRATION CERTIFICATE

Certificate Number M4561-140116-2



Test Data	
Reference (mg/m3)	**Candidate** (mg/m3)
114.0	115.0
90.2	90.8
40.2	41.8
15.9	16.2
7.4	8.2

Instrument Desription:
MAHA / PM-Tech MPM-4M laser light-scattering (LLSP) diesel particle measurement system (mining)

Units of measure:
mg/m3 Elemental Carbon (EC)

Reference Instrument:
Independent secondary master LLSP instrument NATA laboratory calibrated, with CSIRO-developed gravimetric TSP - to - EC calibration factors

Sample Source: Diesel generator plant (mechanical fuel injection system)

Signed: .....
Peter Anyon

Date: 16/01/2014

MAHA Australia Pty Ltd
Unit 3, 54 Caswell Street
East Brisbane
QLD 4169, Australia
Tel: (+61) 7 3391 6611
Fax: (+61) 7 3393 1281

Appendix 6: Communications with USAID on Tier 4 Impacts

Boehler, Michael K. (Mike)

From: Whippen Jr., John A.
Sent: Tuesday, June 14, 2011 8:08 PM
To: Bauhan, Thomas L (OIEE/Kabul)
Cc: Marks, John; Miller, Kevin E; Boehler, Michael K. (Mike); Luchtefeld, David; Carpenter, Scott A.
Subject: FW: Tier 4 emission standards impact on capital cost and O&M - 21 MW plant in Kandahar
Attachments: USAID_.pdf

Tom

Please find below response to your questions. Attached also find the original transmittal to USAID requesting a waiver of the Tier 4 standards.

Best Regards

J A Whippen
Chief of Party
Black & Veatch Special Project Corporation Afghanistan
Kandahar Helmand Power Project (KHPP)
Cell: 93 (0) 799 620 012
Alternate email: jwhippen@khp-af.com

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From: Carpenter, Scott A.
Sent: Wednesday, June 15, 2011 12:17 AM
To: Whippen Jr., John A.; Marks, John; Miller, Kevin E
Cc: Boehler, Michael K. (Mike); Luchtefeld, David
Subject: RE: Tier 4 emission standards impact on capital cost and O&M - 21 MW plant in Kandahar

Jack,

I believe these issues were covered in our letter to Ms. Reichert with USAID, dated January 4, 2011, please see the attached.

As we have previously communicated, our understanding is the US EPA Tier 4I emission standard only applies in North America, nowhere else.

See below for additional comments to the two specific questions raised by Mr. Bauhan;

However, in order to support a waiver of the contract requirements, we would like to see the following:

1. B&V's recommendations for mitigating emissions beyond Tier 2 standards without substantially increasing O&M costs (including requiring a higher grade of fuel) Without substantially increasing capital investment or O&M costs, the most feasible way to further mitigate emissions is to specify a low sulphur diesel. However, low sulphur diesel availability in the Afghanistan market is uncertain.
2. B&V's selection criteria for the MTU units. B&V selected the Power Generation Solutions (PGS) proposal, because it most closely met the performance requirements placed in our contract by USAID. "The new generation system shall comprise 14 units each capable of providing 1.5MW on a continuous basis."

Scott A. Carpenter
Black & Veatch
Federal Services Division
Phone/Fax 913 458 8120
Cell 913 523 6131
carpentersa@bv.com

From: Whippen Jr., John A.
Sent: Tuesday, June 14, 2011 5:25 AM
To: Marks, John; Miller, Kevin E
Cc: Carpenter, Scott A.; Boehler, Michael K. (Mike); Luchtefeld, David
Subject: RE: Tier 4 emission standards impact on capital cost and O&M - 21 MW plant in Kandahar

Reminder

Please provide the information requested below.

Best Regards

J A Whippen
Chief of Party
Black & Veatch Special Project Corporation Afghanistan
Kandahar Helmand Power Project (KHPP)
Cell: 93 (0) 799 620 012
Alternate email: jwhippen@khp-af.com

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From: Whippen Jr., John A.
Sent: Sunday, June 12, 2011 11:13 AM
To: Marks, John; Miller, Kevin E

Cc: Carpenter, Scott A.; Boehler, Michael K. (Mike); Luchtefeld, David
Subject: FW: Tier 4 emission standards impact on capital cost and O&M - 21 MW plant in Kandahar

Gentlemen

Please read below RFI from USAID. The first question requires a technical repsonse which PGS may be best to answer, but if not then we need technical Environmental staff to answer.

The second question is a function of the criteria applied by the technical review committee which selected PGS and the proposal they made.

Please gather your views and respond back to me by Tuesdya COB KC June 14, 2011 so I can review and send on to USAID as appropriate.

Best Regards

J A Whippen
Chief of Party
Black & Veatch Special Project Corporation Afghanistan
Kandahar Helmand Power Project (KHPP)
Cell: 93 (0) 799 620 012
Alternate email: jwhippen@khp-af.com

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From: Bauhan, Thomas L (OIEE/Kabul) [TBauhan@usaid.gov]
Sent: Saturday, June 11, 2011 5:52 PM
To: Whippen Jr., John A.; Jack Whippen
Cc: Casey, Roseann; Nims, Matthew; Mir, Mahmood U; Hansen, John F
Subject: RE: Tier 4 emission standards impact on capital cost and O&M - 21 MW plant in Kandahar

Jack,
Thanks for providing the requested input. We had an internal meeting today on the subject standards, which are invoked by Sec C.4.1 of the contract, and on how to move forward with the Kandahar East power plant, for which the contract requires installation of (14) 1.5MW diesel gensets.

USAID recognizes that purchasing and installing gensets of this size complying with current USEPA Tier 4 emissions standards is neither practical nor sustainable in the planned application of these units. We also understand the May 2010 Initial Environmental Examination (IEE) for the project recommends Negative Determination with Conditions per 22 CFR 216, for the "14 new energy efficient, low emission generators" to be installed.

However, in order to support a waiver of the contract requirements, we would like to see the following:

1. B&V's recommendations for mitigating emissions beyond Tier 2 standards without substantially increasing O&M costs (including requiring a higher grade of fuel)
2. B&V's selection criteria for the MTU units

Please let me know if you have any questions

Tom

Tom Bauhan P.E.
COTR - Kandahar Helmand Power Project
Alternate COTR - EQUALS Program
Office of Infrastructure, Engineering & Energy
USAID/Afghanistan
U.S. Phone: (202)216-6288 x 4255
Cell Phone: +93(0)700-234-229
tbauhan@state.gov
tbauhan@usaid.gov

SBU
This email is UNCLASSIFIED.

From: Whippen Jr., John A. [mailto:WhippenJA@bv.com]
Sent: Tuesday, June 07, 2011 1:59 PM
To: Bauhan, Thomas L (OIEE/Kabul)
Cc: Casey, Roseann; Nims, Matthew; Marks, John; Luchtefeld, David; Boehler, Michael K. (Mike)
Subject: Tier 4 emission standards impact on capital cost and O&M - 21 MW plant in Kandahar

Tom

Per your request.

The attached information has been provided by PGS and reviewed by B&V. The impact on cost is not surprising when dealing with SCR.

Best Regards

J A Whippen
Chief of Party
Black & Veatch Special Project Corporation Afghanistan
Kandahar Helmand Power Project (KHPP)
Cell: 93 (0) 799 620 012
Alternate email: jwhippen@khp-af.com

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Attachment to June 7, 2011 email (Whipper to Barnhart, Tom)

COST IMPACT OF APPLICATION OF TIER 4 STANDARDS TO 21 MW PLANT IN KANDAHAR

The units currently on order cannot reach the standards and neither can any generator that we know of currently in production.

MTU has new units currently in design which will be available in 2015 which will meet the Tier 4 standards.

Several makers are producing Tier 4i units with various technologies being applied to the exhausts but none are capable of producing the output of the machines currently on order.

Change can be engineered to the current system to meet Tier 4 standards but there will be cost and operations impacts resulting from this, which are detailed below.

1) Incremental cost to design, engineer and install combined DPF (Diesel Particulate Filters) and SCR (Selective Catalytic Reductions) systems along with storage facilities for aqueous urea solution, $450k per Genset or an additional cost of $6.3M in total.
2) Incremental cost to operate per month in increased spares and use and transport of aqueous urea, $860k per month for the site or $10.3M per year in additional O&M cost.
3) Impact of fuel consumption: with the choking effect of the additional exhaust components and in order to maintain 21MW output the engines would have to be run at higher than optimum levels which will effect fuel efficiency. The 55% operation of 21 days on site storage currently designed for could be reduced to a 9.8 day supply.
4) Due to the non standard set up MTU would not offer full warrantee to the systems and PGS would have to make additional cost provision to close the gap and meet the contractual obligations.

The contract calls for EU stage II and the systems as designed by PGS will meet and exceed these requirements. If the Tier 4 requirements are needed PGS will need a contract extension to allow us to design and introduce the systems.

BLACK & VEATCH
Building a world of difference.

6601 College Boulevard
Overland Park, KS 66211 USA

Black & Veatch Special Projects Corp.

Ms. Alvera Reichert
Contracting Officer
U.S. Agency for International Development
Kabul, Afghanistan
Washington, DC 20523

4 January, 2011
Kandahar Power Initiative

Subject: Request for Information Regarding Diesel Generator Emissions Standards

Dear Ms. Reichert,

The text below describes an area of concern that Black & Veatch has regarding the emission standards associated with the diesel generators that are to be provided and installed under the KHP project. B&V requests your review and comment on the situation and USAID's preferred course of action.

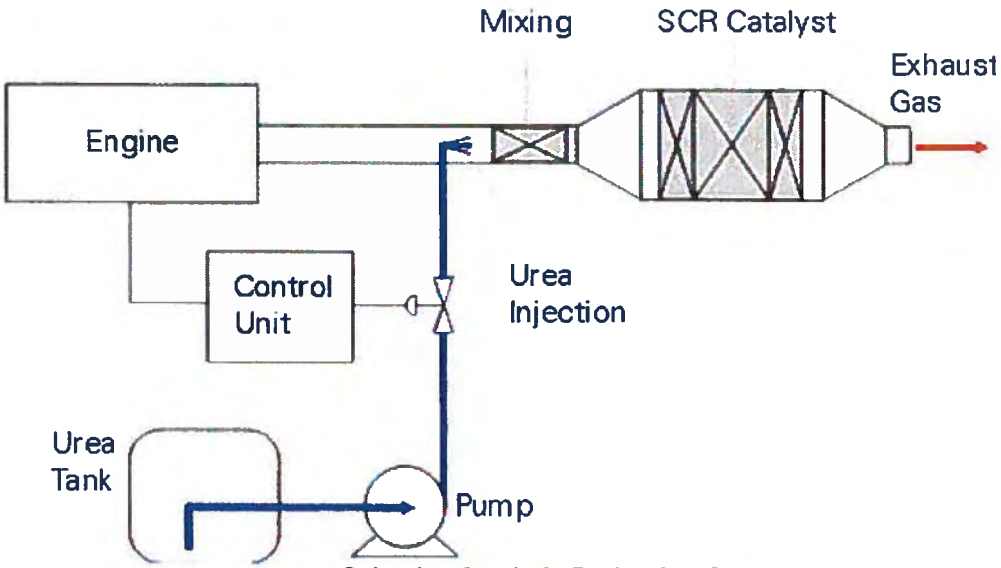
Contract Section C.4.1. Environmental Assessments, second paragraph, top of page 21;

Excerpt from contract;

"The Contractor shall perform all work in such a manner as to minimize the pollution of air, water, or land to control noise and dust and to minimize other environmental damages within reasonable limits and in accordance with all applicable U.S. and the Government of Afghanistan environmental laws, regulations and programs that relate to the performance of this contract. Where there is a conflict between U.S. and Afghan law, the requirements more protective of health and the natural environment shall be used. In no case shall the requirements be less stringent than those required by U.S. law and regulation."

End excerpt from contract.

This contract paragraph requires environmental standards be no less stringent than those required by U.S. law and regulation. In the case of the Kandahar Diesel Generators, applying no less than U.S. law and regulation has significant impacts to the DG equipment. Beginning January 1, 2011, the EPA is requiring all stationary non-emergency diesel generators meet their defined Tier 4 Interim emissions limits. This requires large engine after treatment systems with urea injection for each DG along with running the DGs on Ultra Low Sulfur Diesel (ULSD) that is typically not provided in Afghanistan.



Selective Catalytic Reduction System (SCR)

The EPA Tier 4 standards are for U.S. and U.S. territories only. There is no widespread regulation to Tier 4 outside of North America. There are similar emission requirements in different areas around the world but the EPA Tier 4 Standard to date has not been adopted internationally.

High sulfur content diesel fuel, which is typically supplied to Afghanistan, is incompatible with after treatment devices such as catalyst. DGs using Tier 4 after treatment cannot be sold or operated where Ultra Low Sulfur Diesel (ULSD) is not available.

The DG manufacturers only provide up to EPA Tier 2 units. Aftermarket vendors provide the EPA Tier 4 level engine after treatment system usually comprised of particulate filters and catalyst reduction systems with urea injection. These after treatment units, for the size of DGs needed at the Kandahar Generating Station, are quite large and heavy and would require separate shipping to the site. A urea storage system would be added to the scope of the project with heat tracing and an injection control system (one per DG unit). Design of structural supports for the after treatment system is also required. The after treatment units are typically mounted above the DGs. Adding the after treatment units to the DGs will complicate the installation, operation and maintenance, increase the cost of fuel since ULSD is required, increase spares, and add cost and lead time since these units are manufactured to match the DGs and the site design conditions (not off the shelf equipment). The diesel engine and after treatment system must be matched and certified as a complete system lengthening delivery time of the DGs.

B&V Recommendation:

Allow the use of Tier 2 DG units for the Kandahar Power Project. Tier 2 units are manufacturer's standard production engines for units of the size required for this project and are currently the type sold for Afghanistan. Acceptance of these standard Tier 2 units will significantly reduce equipment cost, simplify installation, simplify operations and maintenance, and help maintain the overall project schedule.

Again, Black & Veatch respectfully requests USAID's concurrence with the aforementioned recommended solution or provide direction on an acceptable remedy to the described situation.

Should you have any questions or require additional information regarding this matter please do not hesitate to contact me.

Sincerely,

David Luchtefeld
Project Manager
Black & Veatch
(913) 458-9815

Appendix 7: MTU Specifications

A TOGNUM GROUP BRAND

DIESEL GENSET - 50 HZ
WATER CHARGE-AIR COOLING

2145 - 2285 kVA
400V

BENEFITS

// Low installment cost
// Best fuel consumption values
// Long maintenance intervals
// High-efficiency components
// Best-in-class reliability and availability

SYSTEM RATINGS

Prime Power

Genset Type	Engine Type	Nominal Rating kVA	Emissions
DP 2145 D5S	16V 4000 G23	2145	Fuel optimized, TA-Luft
DP 2285 D5S	16V 4000 G63	2285	Fuel optimized, TA-Luft

// REFERENCE CONDITIONS

Ambient air temp.:	25°C (77°F)
Charge air coolant temp.:	55°C (131°F)
Ambient air pressure:	1000 mbar
Altitude above sea level:	100 m

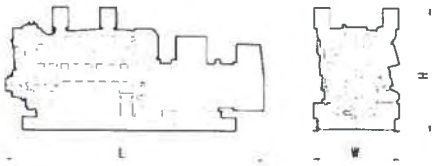
// ENGINE DATA

Bore/Stroke	170/210 mm (6.7/8.3 in)
Cyl. configuration	90°V
Cyl. displacement	4.77 lit. (291 cu in)
Displacement, total	16V: 76.3 lit. (4655 cu in)
Fuel specification	EN 590, Grade No.1-D/2-D (ASTM D975-00)

Application	Definition	
3B	**Prime Power** Continuous operation with variable load	Load factor: < 75 % Operating hours/year: unrestricted Overload: 10 % capability (ICXN)

All Gensets are available with optional voltages 380V and 415V. Ratings can variate please contact your MTU distributor.
Rated Power available up to 40°C/400m and Charge- air coolant temperature for fuel optimized: 70°C or for TA-Luft: 55°C

		Fuel Optimized		TA-Luft	
		Prime Power			
Genset Type		DP2145D5S	DP2285D5S	DP2145D5S	DP2285DS
Engine Type		16V 4000 G23	16V 4000 G63	16V 4000 G23	16V 4000 G63
Generator type		744RSL7056	744RSL7056	744RSL7056	744RSL7056
Fuel Consumption *					
100% load	g/kWh (l/h)	192 (416)	191 (452)	219 (474)	220 (521)
75% load	g/kWh (l/h)	195 (194)	193 (192)	214 (213)	215 (214)
50% load	g/kWh (l/h)	205 (136)	203 (135)	217 (144)	215 (143)
Electrical Radiator**					
Max. air temp. on fan	°C	45	45	45	45
Ambient temperature	°C	40	40	40	40
Fan air flow	m^3/s	29.43	31.14	47.23	45.67
Air flow restriction	Pascal	200	200	200	200
Air Intake					
Intake air depression	mbar	15	15	15	15
Intake air flow	m^3/s	2.1	2.3	3.2	3.3
Exhaust System					
Exhaust gas flow	m^3/s	5.4	5.8	7.4	7.9
Exhaust gas temperature	°C	480	485	480	495
Exhaust back pressure	mbar	30	30	30	30
Generator					
Temperature rise (Insulation Class H)	°C	125	125	125	125
Lube System					
Engine oil capacity	l (gal)	300 (79)	300 (79)	300 (79)	300 (79)
Emissions					
NOx	mg/Nm^3	-	-	1700	1700
CO	mg/Nm^3	-	-	300	300
Dust	mg/Nm^3	-	-	50	50
Air born noise level at 1m	dB(A)	107	109	108	107
Exhaust noise level at 1 m	dB(A)	112	113	113	114
Genset					
Lengths	mm (in)	5090 (200)	5090 (200)	5090 (200)	5090 (200)
Widths	mm (in)	1690 (67)	1690 (67)	1690 (67)	1690 (67)
Height	mm (in)	2150 (85)	2150 (85)	2150 (85)	2150 (85)
Total Weight, wet	kg (lbs)	14169 (31237)	14179 (31259)	14881 (32807)	16807 (37053)
Genset convection heat incl. 10m exhaust pipes	kW (bhp)	180 (241)	197 (264)	180 (241)	197 (264)



* Values referenced are in accordance with ISO 3046-1. Conversion calculated with fuel density of 0.83 g/ml.

** Optional scope: Radiator with electrical fan drive for front or remote installation. Connection parts for front installation available as option.

Note: This drawing is provided for reference only and should not be used for planning installation. Please contact your local distributor for more detailed information. Materials and specifications subject to change without notice.

OE 23 371 (56 3E) 1/09 VMD 2009-12 Subject to alteration due to technological advances.

// **Tognum Group Companies: Europe / Middle East / Africa / Latin America /** MTU Onsite Energy / 88040 Friedrichshafen / Germany / Phone +49 7541 90 7060 / Fax +49 7541 90 7084 / powergenregion1@mtu-online.com // **Asia / Australia / Pacific /** MTU Onsite Energy / 1, Benoi Place / Singapore 629923 / Republic of Singapore / Phone +65 6861 5922 / Fax +65 6861 3615 / powergenregion2@mtu-online.com // **USA / Canada / Mexico /** MTU Onsite Energy Corporation / 100 Power Drive / Mankato, MN 56001 / USA / Phone +1 507 625 7973 / Fax +1 507 625 2968 / powergenregion3@mtu-online.com // **Worldwide for HotModule /** MTU Onsite Energy / 81663 Munich / Germany / Phone +49 89 20 30 42 800 / Fax +49 89 20 30 42 900 / info@mtu-online.com // www.mtu-online.com

Technical Engine Data

16V4000G63
Water charge air cooling (external);
50 Hz - 1.500/min
fuel consumption optimized

Operating method	Four stroke Diesel	**Flywheel housing flange**	SAE 00
Combustion system	Direct Injection	**Flywheel interface**	21
Charging method	Exhaust turbo charger and Water charge air cooling (external);	**Starter ring-gear teeth no.**	182
		Injection system	Common Rail System with electronically controlled high-pressure injection through single injection pumps
Bore / Stroke	170 / 210 mm		
Displacement, total	76.3 Liter		
Number of cylinders	16	**Control / Monitoring**	Electronic engine management system "ADEC"
Cylinder configuration	V - 90°	**Number of turbo chargers**	4
Compression ratio	16.5 : 1	**Number of intercooler**	1
Direction of rotation (viewed from flywheel side)	left		

MTU-Application group				**3D** (ICFN)	**3B** (ICXN)
Power (ISO 3046)		kW	A	2185	1965
Mean piston speed		m/s	A	10.5	10.5
Mean effective pressure		bar	A	22.9	20.6
Engine weight (Engine in basic execution)	dry	kg	R	7700	7700
	wet	kg	R	-	-
Dimensions (Engine only)	length	mm	R	3001	3001
	height	mm	R	1660	1660
	width	mm	R	2154	2154
Consumption					
Specific fuel consumption (be)	100% CP	g/kWh	G	195	191
(Tolerance +5% according to ISO 3046/1)	75% CP	g/kWh	R	193	193
	50% CP	g/kWh	R	198	203
Lube oil consumption (after run-in)			R	-	-
Capacity					
Engine oil capacity, initial filling (standard oil system)	total	Liter	R	300	300
	Oil pan capacity, dipstick mark min.	Liter	L	210	210
	Oil pan capacity, dipstick mark max.	Liter	L	240	240
Engine coolant capacity (without cooling equipment)		Liter	R	175	175
Intercooler coolant capacity		Liter	R	50	50
Heat dissipation					
Engine coolant dissipation	100% load	kW	R	800	730
Charge-air heat dissipation	100% load	kW	R	410	320
Radiation and convection heat, engine		kW	R	90	90
Starter system					
Electrical Starter (make Delco)					
Starter, rated voltage		V	R	24	24
Starter, rated power		kW	R	-	-
Starter, power requirement max.		A	R	-	-
Starter, power requirement at firing speed		A	R	-	-
Recommended battery capacity	Lead-acid	Ah/20h	R	450	450
	NiCd	Ah/5h	R	240	240
Firing speed		1/min	R	80 - 120	80 - 120
Coolant pre-heating					
Preheating temperature (min.)		°C	R	32	32
Heater performance		kW	R	9	9

Technical Engine Data

16V4000G63
Water charge air cooling (external);
50 Hz - 1.500/min
fuel consumption optimized

MTU-Application group			3D (ICFN)	3B (ICXN)
Coolant system, Engine coolant circuit				
Coolant temperature (at engine outlet to cooling equipment)	°C	A	100	100
Coolant temperature after engine, alarm	°C	R	102	102
Coolant temperature after engine, shutdown	°C	L	104	104
Coolant antifreeze content, max. permissible	%	L	50	50
Cooling equipment: coolant flow rate	m^3/h	A	68.5	68.5
Coolant pump: inlet pressure, min.	bar	L	0.2	0.2
Coolant pump: inlet pressure, max.	bar	L	1.5	1.5
Pressure loss in off-engine cooling system, max. permissible	bar	L	0.7	0.7
Cooling equipment: height above engine max. permissible	m	L	15	15
Cooling equipment: design pressure	bar	A	2.5	2.5
Coolant system, Charge-air coolant circuit				
Coolant temperature before intercooler (engine inlet)	°C	A	55	55
Coolant antifreeze content, max. permissible	%	L	50	50
Cooling equipment: coolant flow rate	m^3/h	A	30	30
Pressure loss in off-engine cooling system max. permissible	bar	L	0.7	0.7
Cooling equipment: height above engine max. permissible	m	L	15	15
Cooling equipment: design pressure max. permissible	bar	A	2.5	2.5
Combustion air				
Combustion air volume flow	m^3/s	R	2.6	2.3
Intake air depression new filter	mbar	A	15	15
limit value	mbar	L	50	50
Fuel system				
Fuel supply flow, max.	l/min	R	17	14
Fuel temperature, max.	°C	L	55	55
Fuel pressure at supply connection on engine, max. admissible	bar	L	1.5	1.5
Fuel pressure at supply connection on engine, min. admissible	bar	L	-0.1	-0.1
Exhaust system				
Exhaust volume flow	m^3/s	R	6.6	5.8
Exhaust temperature after turbocharger	°C	R	490	485
Exhaust backpressure limit value	mbar	L	85	85
General operating data				
Recommended minimum continuous load	%	R	20	20
Engine mass moment of inertia, with standard flywheel	kgm^2	R	23.1	23.1
Noise emission				
(Free-field sound pressure level, 1m distance)				
Engine surface noise	dB(A)	R	106	109
Exhaust noise, unsilenced	dB(A)	R	115	113

A = Design value; G = Guarenteed value; R = Guideline value
L = Limit value, up to which the engine can be operated w/o change
- = Data not available; * = Estimated or projected values

Reference conditions

	Standard	Power available up to
Intake air temperature	25°C	40°C
Site altitude above sea level	100 m	400 m

MTU Friedrichshafen GmbH
Maybachplatz 1
88045 Friedrichshafen/Germany
Phone: (07541) 90 70 60
Fax: (07541) 90 70 84

E-Mail: powergen@mtu-online.com
Internet: www.mtu-friedrichshafen.com

Cummins Engine Company, Inc.
Engine Data Sheet

ENGINE MODEL : **KTA50-G3** **CONFIGURATION NUMBER :** D283021DX02

DATA SHEET : DS-6250
DATE : 12Jan01
PERFORMANCE CURVE : FR-6250

INSTALLATION DIAGRAM
• Fan to Flywheel : 3626420

CPL NUMBER
• Engine Critical Parts List : 2227

GENERAL ENGINE DATA

Type		4-Cycle; 60° Vee; 16-Cylinder Diesel
Aspiration		Turbocharged and Aftercooled
Bore x Stroke	— in x in (mm x mm)	6.25 x 6.25 (159 x 159)
Displacement	— in^3 (liter)	3067 (50.3)
Compression Ratio		13.9 : 1
Dry Weight		
Fan to Flywheel Engine	— lb (kg)	11820 (5360)
Heat Exchanger Cooled Engine	— lb (kg)	12260 (5560)
Wet Weight		
Fan to Flywheel Engine	— lb (kg)	12485 (5662)
Heat Exchanger Cooled Engine	— lb (kg)	13085 (5934)
Moment of Inertia of Rotating Components		
• with FW 6009 Flywheel	— $lb_m \cdot ft^2$ ($kg \cdot m^2$)	301 (12.7)
• with FW 6017 Flywheel	— $lb_m \cdot ft^2$ ($kg \cdot m^2$)	515 (21.7)
Center of Gravity from Rear Face of Flywheel Housing (FH 6024)	— in (mm)	47.5 (1206)
Center of Gravity Above Crankshaft Centerline	— in (mm)	11.0 (279)
Maximum Static Loading at Rear Main Bearing	— lb (kg)	2000 (908)

ENGINE MOUNTING

Maximum Bending Moment at Rear Face of Block	— lb • ft (N • m)	4500 (6100)

EXHAUST SYSTEM

Maximum Back Pressure @ Standby Power Rating	— in Hg (mm Hg)	2 (51)

AIR INDUCTION SYSTEM

Maximum Intake Air Restriction		
• with Dirty Filter Element @ Standby Power Rating	— in H_2O (mm H_2O)	25 (635)
• with Clean Filter Element @ Standby Power Rating	— in H_2O (mm H_2O)	15 (381)

COOLING SYSTEM

Coolant Capacity — Engine Only	— US gal (liter)	42.5 (161)
Maximum Coolant Friction Head External to Engine — 1800 rpm	— psi (kPa)	15 (103)
— 1500 rpm	— psi (kPa)	10 (69)
Maximum Static Head of Coolant Above Engine Crank Centerline	— ft (m)	60 (18.3)
Standard Thermostat (Modulating) Range	— °F (°C)	180 - 200 (82 - 93)
Minimum Pressure Cap (For Cooling Systems with less than 2 m [6 ft.] Static Head)	— psi (kPa)	14 (96)
Maximum Top Tank Temperature for Standby / Prime Power	— °F (°C)	220 / 212 (104 / 100)

LUBRICATION SYSTEM

Oil Pressure @ Idle Speed	— psi (kPa)	20 (138)
@ Governed Speed	— psi (kPa)	50 - 70 (345 - 483)
Maximum Oil Temperature	— °F (°C)	250 (121)
Oil Capacity with OP 6024 Oil Pan : High - Low	— US gal (liter)	40 - 32 (151 - 121)
Total System Capacity (Including Bypass Filter)	— US gal (liter)	46.7 (177)
Angularity of OP 6024 Oil Pan — Front Down		30°
— Front Up		30°
— Side to Side		30°

FUEL SYSTEM

Type Injection System		Direct Injection Cummins PT
Maximum Restriction at PT Fuel Injection Pump — with Clean Fuel Filter	— in Hg (mm Hg)	4.0 (102)
— with Dirty Fuel Filter	— in Hg (mm Hg)	8.0 (203)
Maximum Allowable Head on Injector Return Line (Consisting of Friction Head and Static Head)	— in Hg (mm Hg)	6.5 (165)
Maximum Fuel Flow to Injection Pump	— US gph (liter / hr)	165 (625)

ELECTRICAL SYSTEM

Cranking Motor (Heavy Duty, Positive Engagement)	— volt	24	
Battery Charging System, Negative Ground	— ampere	35	
Maximum Allowable Resistance of Cranking Circuit	— ohm	0.002	
Minimum Recommended Battery Capacity			
• Cold Soak @ 50 °F (10 °C) and Above	— 0°F CCA	1280	
• Cold Soak @ 32 °F to 50 °F (0 °C to 10 °C)	— 0°F CCA	1800	
• Cold Soak @ 0 °F to 32 °F (-18 °C to 0 °C)	— 0°F CCA	1800	

COLD START CAPABILITY

Minimum Ambient Temperature for Aided (with Coolant Heater) Cold Start within 10 seconds	— °F (°C)	50	(10)
Minimum Ambient Temperature for Unaided Cold Start	— °F (°C)	45	(7)

PERFORMANCE DATA

All data is based on:
- Engine operating with fuel system, water pump, lubricating oil pump, air cleaner and exhaust silencer; not included are battery charging alternator, fan, and optional driven components.
- Engine operating with fuel corresponding to grade No. 2-D per ASTM D975.
- ISO 3046, Part 1, Standard Reference Conditions of:

Barometric Pressure	: 100 kPa (29.53 in Hg)	Air Temperature	: 25 °C (77 °F)
Altitude	: 110 m (361 ft)	Relative Humidity	: 30%

Steady State Stability Band at any Constant Load	— %	+/- 0.25
Estimated Free Field Sound Pressure Level of a Typical Generator Set:		
Excludes Exhaust Noise; at Rated Load and 7.5 m (24.6 ft); 1800 rpm / 1500 rpm	— dBA	94.6 / 92.4
Exhaust Noise at 1 m Horizontally from Centerline of Exhaust Pipe Outlet Upwards at 45° — 1800 / 1500 rpm	— dBA	126 / 125

		STANDBY POWER		PRIME POWER UNLIMITED TIME	
		60 hz	*50 hz*	*60 hz*	*50 hz*
Governed Engine Speed	— rpm	1800	1500	1800	1500
Engine Idle Speed	— rpm	725 - 775	725 - 775	725 - 775	725 - 775
Gross Engine Power Output	— BHP (kW_m)	1850 (1380)	1645 (1227)	1635 (1220)	1470 (1097)
Brake Mean Effective Pressure	— psi (kPa)	265 (1827)	283 (1951)	235 (1620)	253 (1744)
Piston Speed	— ft / min (m / s)	1875 (9.5)	1562 (7.9)	1875 (9.5)	1562 (7.9)
Friction Horsepower	— HP (kW_m)	225 (168)	155 (116)	225 (168)	155 (116)
Engine Water Flow at Stated Friction Head External to Engine:					
• 4 psi Friction Head	— US gpm (liter / s)	535 (33.7)	440 (27.8)	535 (33.7)	440 (27.8)
• Maximum Friction Head	— US gpm (liter / s)	470 (29.6)	400 (25.2)	470 (29.6)	400 (25.2)
Engine Data with Dry Type Exhaust Manifold					
Intake Air Flow	— cfm (liter / s)	3900 (1840)	3700 (1746)	3700 (1746)	3400 (1605)
Exhaust Gas Temperature	— °F (°C)	887 (475)	977 (525)	860 (460)	968 (520)
Exhaust Gas Flow	— cfm (liter / s)	9100 (4295)	8500 (4011)	8400 (3964)	7900 (3728)
Air to Fuel Ratio	— air : fuel	26.5 : 1	27.0 : 1	27.5 : 1	28.0 : 1
Radiated Heat to Ambient	— BTU / min (kW_m)	10000 (176)	8500 (150)	8500 (150)	7300 (130)
Heat Rejection to Coolant	— BTU / min (kW_m)	51000 (900)	44000 (775)	44000 (775)	38500 (680)
Heat Rejection to Exhaust	— BTU / min (kW_m)	53000 (935)	48000 (845)	47000 (830)	43000 (760)

N.A. - Data is Not Available
N/A - Not Applicable to this Engine
TBD - To Be Determined

ENGINE MODEL : **KTA50-G3**
DATA SHEET : DS-6250
DATE : 12Jan01
CURVE NO. : FR-6250

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: 22Apr03	

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	-	0.09	35	-	0.11	55	-
SO_2 (Sulfur Dioxide)	0.12	56	28	0.12	56	28	0.12	57	27

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	-	0.07	35	-	0.06	30	-
SO_2 (Sulfur Dioxide)	0.12	59	29	0.12	58	28	0.13	56	28

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_2$0/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.

	CUMMINS ENGINE COMPANY, INC Columbus, Indiana 47201 EXHAUST EMISSIONS DATA SHEET	Basic Engine Model: **KTA50-G8** Engine Critical Parts List: **CPL: 2354**	Curve Number: **FR-6243** Date: **15Feb01**	Page No.

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 Low Temperature Aftercooled**
Emissions Control Device : **Turbocharging, Low Temperature Aftercooling (1 Pump/2 Loop) and Step Timing Control (STC)**	

Engine Speed	Standby Power		Prime Power		Continuous Power	
RPM	kWm	BHP	kWm	BHP	kWm	BHP
1500	1429	1915	1200	1608	1100	1475
1800	-----	-----	-----	-----	-----	-----

Exhaust Emissions Data @ 1500 RPM

(at Target Coolant Inlet Temperature to Aftercoolers @ 25 ^oC (77 ^oF) Ambient)

	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)	0.16	60	110	0.13	47	90	0.11	40	80
NOx (Oxides of Nitrogen as NO_2)	6.8	3400	1500	6.0	3000	320	5.6	2800	1250
CO (Carbon Monoxide)	2.0	980	720	1.0	650	480	0.9	560	410
PM (Particulate Matter)	0.26	130		0.09	45		0.06	30	
SO_2 (Sulfur Dioxide)	0.15	68	TBD	0.15	68	TBD	0.14	68	TBD

Exhaust Emissions Data @ 1800 RPM

Not Available at 1800 RPM
For 1800 RPM (see KTA50-G9)

CONVERSIONS: (g/kWm·h = g/BHP·h x 1.34)

Reference Standard: ISO-8178

NOTE: mg/m^3 and PPM numbers are measured dry and corrected to 5% O_2 content.

Data was recorded during steady state rated engine speed (± 25 RPM) with full load (± 2%). Pressures, temperatures, and emission rates were stabilized.

Fuel Specification: ASTM D975 No. 2-D diesel fuel with 0.2% sulfur content (by weight) and 42-50 cetane number.
Fuel Temperature: 99° F ± 9° (at fuel pump inlet)

The HC, NOx, CO and PM emissions data tabulated here were taken from a single engine under the test conditions shown above. Data for SO_2 is calculated. This data is subject to instrumentation, measurement, and engine-to-engine variability. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may result in elevated emission levels. Specifications May Change Without Notice

Cummins Inc. Columbus, Indiana 47201 EXHAUST EMISSIONS DATA SHEET	Basic Engine Model: KTA50-G8	Curve Number: FR-6243	Page No.
	Engine Critical Parts List: CPL: 2354	Date: 6Feb02	

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 Low Temperature Aftercooled**
Emissions Control Device : **Turbocharging, Low Temperature Aftercooling (1 Pump/2 Loop) and Step Timing Control (STC)**	

Engine Speed	Standby Power		Prime Power		Continuous Power	
RPM	kWm	BHP	kWm	BHP	kWm	BHP
1500	1429	1915	1200	1608	1100	1475
1800	-----	-----	-----	-----	-----	-----

Exhaust Emissions Data @ 1500 RPM

(at Target Coolant Inlet Temperature to Aftercoolers @ 25 ^oC (77 ^oF) Ambient)

	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)	0.20	110	210	.25	115	210	.20	105	190
NOx (Oxides of Nitrogen as NO_2)	7.5	3770	1640	6.5	3270	1460	6.1	3070	1370
CO (Carbon Monoxide)	2.9	1460	1080	2.5	1190	720	1.6	910	600
PM (Particulate Matter)	0.3	TBD	TBD	0.1	TBD	TBD	0.1	TBD	TBD
SO_2 (Sulfur Dioxide)	0.15	TBD	TBD	0.15	TBD	TBD	0.14	RBD	TBD

Exhaust Emissions Data @ 1800 RPM

Not Available at 1800 RPM
For 1800 RPM (see KTA50-G9)

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

Engine data

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	16V4000G63				
Emission Stage					
Optimization	fuel optimized				
Application group	3A				
Date	21.11.2012				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	5				

Engine raw emissions*

Cycle point	[-]	n1	n2	n3	n4	n5	n6	n7	n8
Power (P/PN)	[-]	1,00	0,75	0,50	0,25				
Power	[kW]	1634	1226	817	408				
Speed (n/nN)	[-]	1,00	1,00	1,00	1,00				
Speed	[rpm]	1499	1499	1499	1499				
Exhaust temperature after turbine	[°C]	453	423	368	275				
Exhaust massflow	[kg/h]	8293	7009	5632	4499				
Exhaust back pressure	[mbar]	34	23	14	8				
NOx	[g/kWh]	13,2	10,7	9,6	8,3				
	[mg/mN³]	4739	3815	3302	2462				
CO*	[g/kWh]	0,3	0,4	0,6	1,6				
	[mg/mN³]	126	156	221	481				
HC	[g/kWh]	0,21	0,27	0,44	0,99				
	[mg/mN³]	77	99	156	299				
O2	[%]	9,1	10,3	11,8	14,5				
Particulate measured	[g/kWh]	-	-	-	-				
	[mg/mN³]	-	-	-	-				
Particulate calculated	[g/kWh]	0,05	0,07	0,11	0,21				
	[mg/mN³]	18	25	37	64				
Dust (only TA-Luft)	[mg/mN³]	-	-	-	-				
FSN	[-]	0,3	0,4	0,6	0,7				
NO/NO2**	[-]	-	-	-	-				
CO2	[g/kWh]	601	616	640	740				
	[mg/mN³]	224272	224291	224270	223692				
SO2	[g/kWh]	0,002	0,002	0,002	0,002				
	[mg/mN³]	0,7	0,7	0,7	0,7				

* Emission data measurement procedures are consistent with the respective emission evaluation process. Noncertified engines are measured to sales data (TVU/TEN) standard conditions.
These boundary conditions might not be representative for detailed dimensioning of exhaust gas aftertreatment, in this case it is recommended to contact the responsible department for more information.
Measurements are subject to variation. The nominal emission data shown is subject to instrumentation, measurement, facility, and engine-to-engine variations.
All data applies to an engine in new condition. Over extended operating time deterioration may occur which might have an impact on emission.
Exhaust temperature depends on engine ambient conditions.

** No standard test. To be measured on demand.

				MTU Friedrichshafen GmbH			Benennung/Title **Emissionsdatenblatt** **Emission Data Sheet**
					Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
				Bearbeiter/Drawn by	21.11.2012	Rehm	
-	Freigabe	21.11.12	Zwisler	Geprüft/Checked	21.11.2012	Rehm	**EDS 4000 0411**
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKF	Schneemann	

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Engine data

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	16V4000G63				
Emission Stage					
Optimization	fuel optimized				
Application group	3A				
Date	21.11.2012				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	measured				

Engine raw emissions*

Cycle point	[-]	n1	n2	n3	n4	n5	n6	n7	n8
Power (P/PN)	[-]	1,00	0,75	0,50	0,25				
Power	[kW]	1634	1226	817	408				
Speed (n/nN)	[-]	1,00	1,00	1,00	1,00				
Speed	[rpm]	1499	1499	1499	1499				
Exhaust temperature after turbine	[°C]	453	423	368	275				
Exhaust massflow	[kg/h]	8293	7009	5632	4499				
Exhaust back pressure	[mbar]	34	23	14	8				
NOx	[g/kWh]	13,2	10,7	9,6	8,3				
	[mg/mN³]	3531	2559	1894	1006				
CO*	[g/kWh]	0,3	0,4	0,6	1,6				
	[mg/mN³]	94	104	127	196				
HC	[g/kWh]	0,21	0,27	0,44	0,99				
	[mg/mN³]	57	67	89	122				
O2	[%]	9,1	10,3	11,8	14,5				
Particulate measured	[g/kWh]	-	-	-	-				
	[mg/mN³]	-	-	-	-				
Particulate calculated	[g/kWh]	0,05	0,07	0,11	0,21				
	[mg/mN³]	14	17	21	26				
Dust (only TA-Luft)	[mg/mN³]	-	-	-	-				
FSN	[-]	0,3	0,4	0,6	0,7				
NO/NO2**	[-]	-	-	-	-				
CO2	[g/kWh]	601	616	640	740				
	[mg/mN³]	167095	150431	128649	91433				
SO2	[g/kWh]	0,002	0,002	0,002	0,002				
	[mg/mN³]	0,5	0,5	0,4	0,3				

* Emission data measurement procedures are consistent with the respective emission evaluation process. Noncertified engines are measured to sales data (TVU/TEN) standard conditions.
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All data applies to an engine in new condition. Over extended operating time deterioration may occur which might have an impact on emission.
Exhaust temperature depends on engine ambient conditions.

** No standard test. To be measured on demand.

				MTU Friedrichshafen GmbH			Benennung/Title **Emissionsdatenblatt** **Emission Data Sheet**
					Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
				Bearbeiter/Drawn by	21.11.2012	Rehm	
-	Freigabe	21.11.12	Zwisler	Geprüft/Checked	21.11.2012	Rehm	**EDS 4000 0411**
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKF	Schneemann	

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