EPA Requirements for Diesel Standby Engines In Data Centers

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For 7x24 Fall 2014 Conference

1.0 Introduction

In order to get the Air Emissions Permit for facilities that have diesel standby generators, it is necessary to comply with EPA and local regulatory requirements. Even though diesel standby generators do not operate for many hours per year, EPA requirements can have a significant impact on large data centers.

The EPA regulations are relatively complex and are constantly changing. This article provides an overview of the EPA regulatory framework with a concentration on those requirements for stationary diesel emergency standby generators that are greater than 500HP. This size range is commonly encountered in larger Data Centers. This article also focuses on new installations only – it does not offer insight into the rules that govern existing retrofit installations.

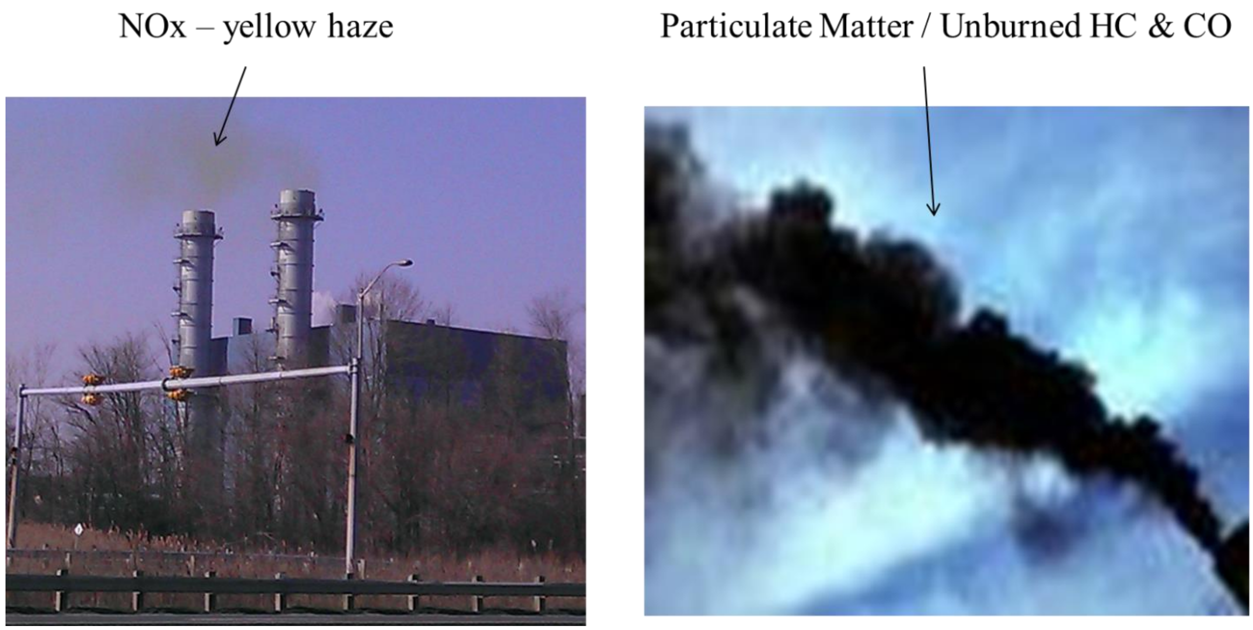
This article attempts to identify some of the key EPA terminology such as National Ambient Air Quality Standards (NAAQS), New Source Performance Standards (NSPS), Reciprocating Internal Combustion Engine (RICE) National Emission Standards for Hazardous Air Pollutants (NESHAP), Tier 2,3,4 and put them in a framework that allows the Critical Power Engineer to understand the current regulations and how those regulations influence the design of new facilities.

2.0 What Emissions are of Concern

A diesel engine generates certain emissions which the EPA considers “criteria” pollutants. “Criteria” pollutants are deemed to be serious health risks and are measured by the EPA throughout the US in geographic entities called “areas”. The key criteria pollutants associated with a diesel engine are: Nitrogen Dioxide (NO_2), Particulate Matter (PM) and Carbon Monoxide (CO). Figure 1 shows examples of these emissions.

Figure 1

Examples of Criteria Pollutants



3.0 Explaining the Regulatory Environment

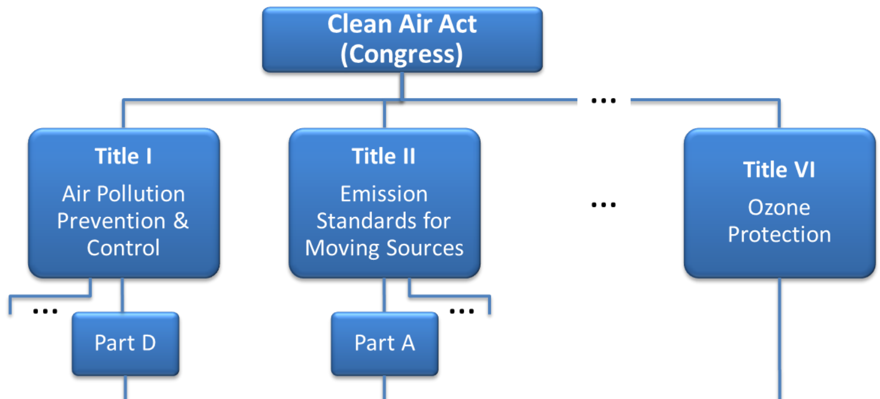
The Clean Air Act forms the regulatory basis for all air compliance activity. It was originally established in the early 1970's. The most important recent major amendments to the Act occurred in 1990. These amendments recognized the need to consider the available technology as a component in determining achievable standards. The EPA terminology for this is Maximum Achievable Control Technology (MACT). Cost effective technology advances in MACT have created the platform for the EPA to look at new emission requirements for diesel engines.

As part of its risk assessment the EPA allows emergency engines to meet somewhat lower standards than non-emergency ones because of the lower annual operating hours. The definition of emergency can be relatively complex. Clearly a utility outage is an emergency condition. There are specific definitions for voltage and frequency variations for electricity reliability that can also constitute an emergency situation. In general a total of 100 hours per year is allocated to emergency generators for maintenance and testing. Of these 100 hours the EPA currently allows up to 50 hours to be used for demand response programs in some jurisdictions – but this aspect is currently under review and may be removed. There are no restrictions on the number of run hours for the engine when it is being used under emergency conditions.

The overall EPA regulatory framework that can impact stationary diesel gensets is shown in Figure 2.

Figure 2

Overall Regulatory Framework



	Plan Requirements For Non-Attainment Areas	Emissions Standards: Diesel Non Road Engines	…	
EPA Regulatory Program	NAAQS/RICE NESHAP/NSPS Office of Air & Radiation	EPA Tier 2,3,4 / Office of Transportation & Air Quality	…	

3.1 EPA Regulatory Framework NAAQS

Maintaining a National Ambient Air Quality Standard (NAAQS) is a fundamental concept of the Clean Air Act. NAAQS are based on limits that are designed to ensure healthy air quality of all citizens regardless of where in the country they live. As part of NAAQS the EPA defines 6 “criteria” pollutants. The modern lean burn diesel engine has improved dramatically in recent years but can still contribute significantly to 3 of the criteria pollutants – NO_2, PM and CO.

NO_2 is one of the constituents of NOx. NOx formation is largely a function of combustion temperature. Typically higher combustion temperature results in a higher level of NOx formation. Particulate Matter (PM) is also a function of combustion temperature. Typically higher combustion temperature results in less PM formation. As a result undesirable NOx and PM formation act in opposing directions when engine designers are looking at combustion temperature. Engine efficiency also typically improves at higher combustion temperatures which is another important consideration for engine designers. Carbon Monoxide (CO) is often a reflection of incomplete oxidation of fuel in the combustion chamber. Most major diesel engine manufacturers have optimized their combustion processes to such an extent that often CO regulatory requirements are not a constraint.

The required targets and the timetable for NAAQS implementation are always changing and apply to each of the criteria pollutants. The EPA goes through a public consultation process to establish the required NAAQS levels for each criteria pollutant. The US is divided into a set of “areas” and the EPA performs measurements of the criteria pollutants in each area. Areas which do not meet the NAAQS targets for criteria pollutants are deemed "non-attainment" areas. For each non-attainment area the affected State is required to prepare a State Implementation Plan (SIP) to resolve the issue and achieve attainment. A special case is the US northeast (Maine to Northern Virginia). Because this air shed is highly populated, it has more stringent air quality standards. The EPA calls this area the Ozone Transport Region (OTR).

When seeking an air permit for a new diesel emergency generator, if there is a NAAQS issue it will most likely relate to NO_2. In 2010 the EPA proposed limits which are based on an hourly worst case of 100 ppb (parts per billion). It is not uncommon, during certain times, for background concentrations in non-attainment areas to be high enough that very little NO_2 needs to be added to make an installation exceed the limit. Prior to 2010 the NO_2 limit was based on a yearly average.

By mid-2013 each State was to have submitted a SIP for its non-attainment areas with respect to NO_2. When a major data center, hospital or other installation installs significant capacity of new diesel standby generators the typical hourly worst case occurs during the full load test of the units. Modeling is done of the site, typically using the EPA's AERMOD (Atmospheric Dispersion Modeling) System. AERMOD is a mathematical simulation of how pollutants will disperse into the atmosphere. The modeling takes into account the topography of the site, its major emissions sources, prevailing wind conditions and other factors which could lead to worst case conditions.

3.2 EPA Regulatory Framework: RICE NESHAP and NSPS

The RICE NESHAP requirements from the EPA have received a lot of attention in the last few years largely because of the impact these requirements have on existing non-emergency diesel and natural gas generators. These requirements have meant that many existing non-emergency diesel generators have had to add oxidation catalysts and other equipment to their engines. In keeping with the overall focus of this article on new emergency diesel generators, we will review RICE NESHAP and NSPS from this standpoint.

A facility is deemed by the EPA to be an "area" source if it has the potential to emit < 10 tons/year of any single hazardous air pollutant or < 25 tons/year of any combination of hazardous air pollutants annually. A "major" source has emissions greater than the "area" source levels. Typically major sources have more stringent requirements.

The EPA has classified over 70 area source categories – examples would be a stationary reciprocating internal combustion engine (RICE), or a boiler. Each of these categories has special NESHAP (National Emissions Standards for Hazardous Air Pollutants) requirements and an associated timeline.

While NESHAP can impact new and existing RICE, NSPS only applies to new installations. Like RICE NESHAP, NSPS typically specifies performance standards that are defined within the EPA "Tier" levels discussed later in this article.

For the Critical Power Engineer, RICE NESHAP and NSPS are typically not a major issue for new emergency diesel gensets > 500HP. Since 2008 all major manufacturers have produced engines which meet RICE NESHAP and NSPS requirements for new emergency diesel engines. To meet RICE NESHAP and NSPS requirements for new diesel emergency engines, the engine must be certified to at least Tier 3 or, if it is greater than 752HP, it must be certified to at least Tier 2. Most of the resulting obligations from RICE NESHAP apply to the facility operators not the Critical Power Engineer designing the facility. For example site operators should use Ultra Low Sulfur Diesel (ULSD) fuel. This is not a big constraint since ULSD has been in wide use since 2007. The facility operator must also record emergency operation with reference to a non-resettable hour meter and make this information available to the EPA if requested. There are other relatively straight forward record keeping and maintenance obligations for facility operators to maintain compliance with RICE NESHAP.

3.3 EPA Regulatory Framework Tier 2,3,4

There has been a lot of press coverage on Tier 4 and its subsets Tier 4i (interim) and Tier 4f (final). The Tier 4 standards have had a huge impact on engine manufacturers because significant emissions reductions have been required to meet these standards. It is not uncommon for a large T4 stationary engine to cost 40% more than a similar power Tier 2 or Tier 3 engine because of the extensive emissions after-treatment equipment that may be required. In addition large stationary T4 gensets often require significantly more space allocation than Tier 2 or Tier 3 units.

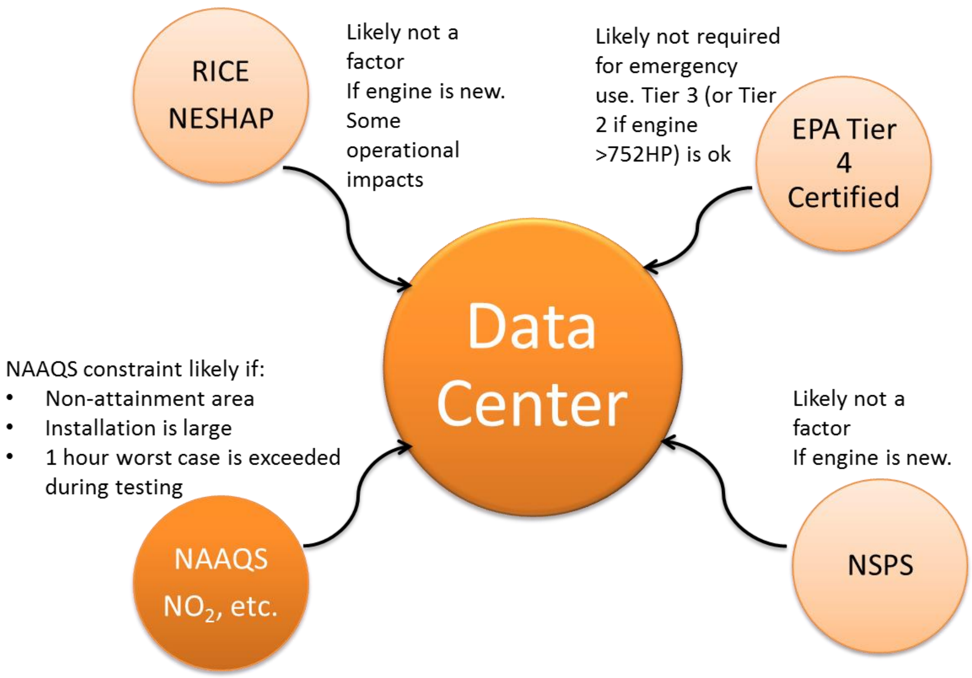
The concept of EPA "Tiers" started in the early 1990's. The current level for new stationary non-emergency diesel engines exceeding 560HP is Tier 4 interim (T4i) and by Jan2015 Tier final (T4f) will be in place for large stationary gensets. Under Tier 4 a large engine is considered to be one which exceeds 752 HP whereas under RICE NESHAP it is 500 HP. In general, EPA T4 standards target on-highway, off-road mobile sources and stationary non-emergency engine driven generators. EPA T4 is not required for emergency gensets, but some engine vendors are advocating use of T4 engines to ensure there are no operating restrictions beyond the current 100 hour maintenance and testing limit currently in place. If a new engine is not T4 it must have a permanent label indicating that it is for emergency use only. It is important to note that, in addition to significant extra cost and space requirements, there can be some significant disadvantages to using T4 certified engines for emergency applications. For example under current EPA rules a certified T4 emergency engine used in a data center must shutdown if the urea (also known as Diesel Exhaust Fluid or DEF) is unavailable. This is not a desirable situation for an emergency generator running during a long utility outage.

3.4 Summary of EPA Regulatory Framework

As mentioned previously this article looks mainly at large diesel engines used in emergency standby application. Figure 3 shows the EPA regulatory impacts for this type of application. If the critical power facility is large (ie has engines that exceed 500 HP), is located in a non-attainment area and does full load testing it may require some form of NOx (NO_2) mitigation.

Figure 3

Possible EPA Impacts for Diesel Engines Used for Emergency Standby



A summary Table of EPA Regulations associated with large stationary Diesel engines used in emergency applications is shown in Table 1.

Table 1

Summary of EPA Regulations for Large Stationary Diesel Engines Used in Emergency Applications

LAW - provides the authority for the EPA to write Regulations	Clean Air Act (Congress)			
REGULATIONS - explain the implementation details	NAAQS	NSPS	RICE NESHAP	TIER 2/3/4
Explanation	National Ambient Air Quality Standards	New Source Performance Standards	Reciprocating Internal Combustion Engine National Emissions Standards for Hazardous Air Pollutants	Emissions Standards for Engines (including Stationary)
Regulatory Reference for Diesel Stationary Engines	40 CFR Part 50	40 CFR Part 60 part IIII (for Diesel Engines)	40 CFR Part 63 subpart ZZZZ	40 CFR part 1039, 1065, 1068 for Tier 4 and 40 CFR part 89 for Tier 3
Overview	Specifies the allowable limits for "criteria" pollutants in EPA defined geographic "areas"	applies to new stationary engines	applies to existing AND new stationary engines.	applies to new engines used in mobile and stationary applications
Latest Amendments	Depends on which criteria pollutant is being considered	Tier 3 has been in effect since 2008 and Tier 2 (applies to larger engines) since 2005	March 2010 with amendments in Jan 2013	Tier 3 has been in effect since 2008 and Tier 2 (applies to larger engines) since 2005
Implication for Diesel <u>Emergency</u> Engines > 500 HP where there is no intent for revenue generation	If large multi-engine installation in a "non-attainment area" and 1 hr test to be conducted at full load may require SCR for NOx reduction to gain air permit	Tier 3 or Tier 2 for HP > 752	No reqmts for major sources but best to comply with diesel engine NSPS. Operator may be reqd to follow certain requirements for fuel use, maintenance and reporting	Tier 3 or Tier 2 for HP > 752. Must be marked "For emergency use".

4.0 Technology to Deal With Air Emissions from Diesel Engines

For large stationary diesel engines up to and including Tier 3, engine manufacturers have adopted many innovative technologies that typically focus on in-cylinder optimizations. Looking beyond Tier 3 much of the focus has been on exhaust after-treatment technologies. For diesel engines the most common after-treatment emission control technologies are:

- **Oxidation catalyst** to deal with CO and unburned Hydrocarbons
- **Diesel particulate filter** to meet Particulate Matter (PM) requirements
- **Selective Catalytic Reduction (SCR)** to meet NOx requirements

As mentioned previously, often NOx (NO_2) becomes the constraining pollutant from a NAAQS standpoint. All diesel engines will also require some level of exhaust silencing. As a result a common configuration for large critical power facilities in non-attainment areas is to use Tier 2 (for engines > 752 HP) and Tier 3 (for engines < 752 HP) with SCR and silencing.

4.1 Oxidation Catalysts and Particulate Filters

For diesel engines, oxidation catalysts are often combined with particulate filters. This can be done by applying the catalysts (which are usually Platinum Group Metals) to a particulate filter. Another common approach is to have separate oxidation catalysts upstream of the particulate filters. The oxidation catalyst creates heat (by oxidizing unburned hydrocarbons) and shifts nitrogen oxide creating a favorable environment for the particulate filters to regenerate.

4.2 Selective Catalytic Reduction (SCR)

SCR works by injecting a reductant (usually 32.5% concentration urea also known as diesel exhaust fluid or DEF) into the exhaust stream. The Urea is converted into ammonia (NH_3) in the hot exhaust stream. The NH_3 combines, in the presence of a catalyst, with the NOx in the exhaust to produce harmless water vapor (H_2O) and Nitrogen (N_2). Many SCR systems can achieve NOx reductions of 95% or higher. Some exhaust after-treatment vendors offer multi-function systems that combine SCR, silencing and slots that can be filled, if required, with oxidation catalysts and particulate filters. This gives the Critical Power Engineer a lot of flexibility – allowing him to add catalysts and filters late in the project cycle without impacting the size of the emissions unit and the surrounding piping should it be required for the air permit. Figure 5 shows an SCR system which combines silencing and other emissions functions in a single cube mounted on an enclosure housing a large standby diesel genset.

Figure 4

Example of Selective Catalytic Reduction System with Integral Silencing

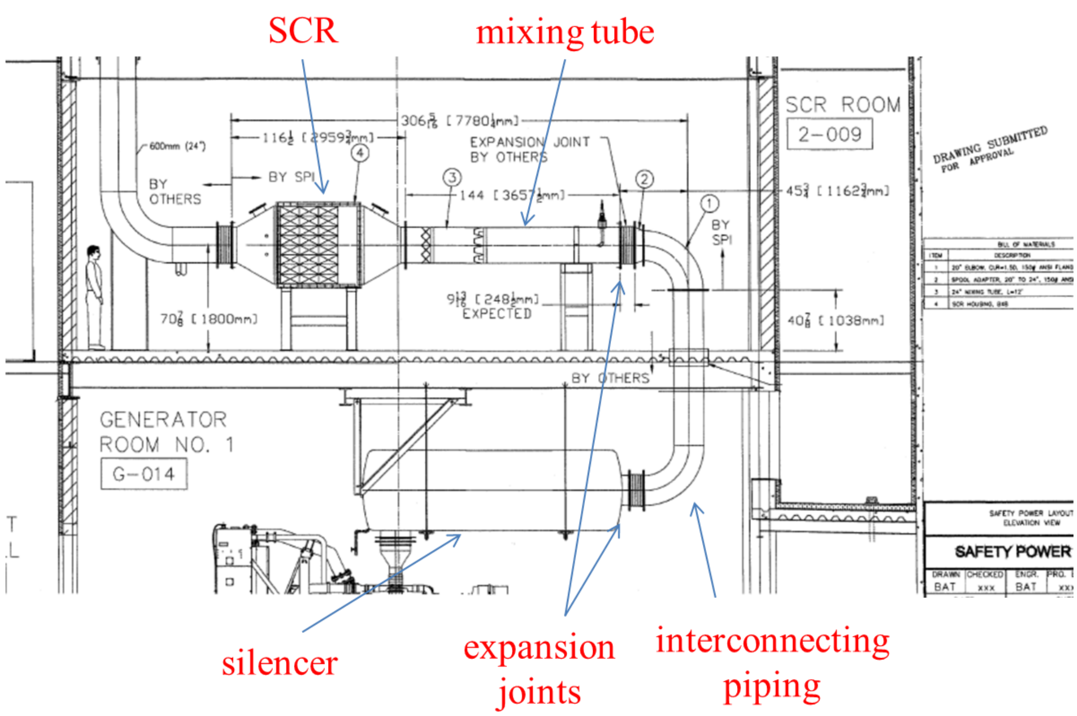
5.0 Challenges faced by the Critical Power Engineer

The Critical Power Engineer is faced with significant air compliance challenges due to the regulatory environment. These challenges are compounded if the site location is not fully finalized when the initial design is done. A change in air shed location could have a significant change in the results of the AERMOD simulation. A change in emissions mitigation requirements could then have a significant impact on the physical space required for the various after-treatment devices.

Until recently after-treatment was done using separate devices for each emissions function. For example Figure 6 shows a separate silencer and SCR system in the exhaust stream of a large generator used in a Data Center. As can be seen in Figure 6, the physical space required for the devices and the complex piping and expansion joints required between them makes for a large and overly complex system.

Figure 5

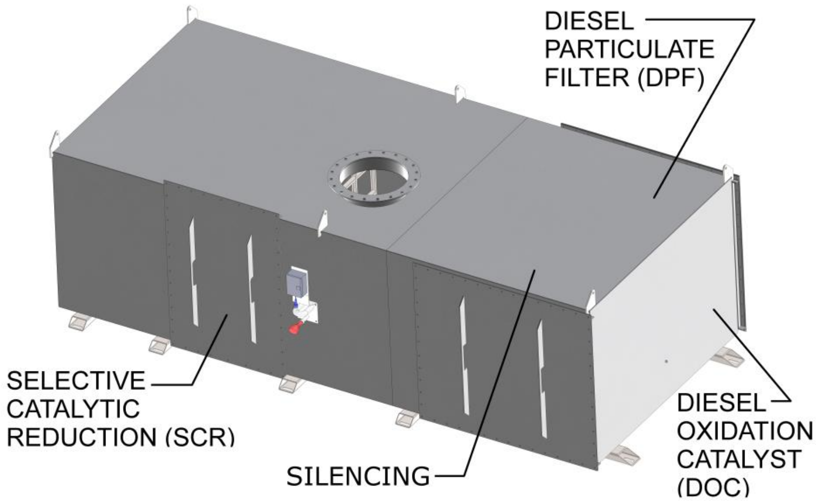
Separate SCR and Silencer in a Data Center: Traditional Approach



Some vendors are offering exhaust after-treatment systems that combine all required functions in a single “cube”. These multi-function systems can contain any combination of SCR, silencing, oxidation catalyst and particulate filters in the same cube. This makes installation much easier and allows the Critical Power Engineer to design a system which meets the regulatory requirements of any air shed in the US. The cube is typically installed above the engine. As a result it does not take up much more space than a conventional silencer. An example of such a system is shown in Figure 6.

Figure 6

Example of a Multi-Function Exhaust System in a Single Cube



6.0 Summary

The regulatory requirements for obtaining an air permit for large scale critical power facilities using stationary diesel engines is continuing to become more complex. It is important for Critical Power Engineers to understand the overall regulatory framework and build enough flexibility into their design to ensure that the requirements for an air permit can be met.

About the Author

Bob Stelzer is the Chief Technical Officer for Safety Power Inc. He is responsible for the engineering team that developed Safety Power's ecoCUBE™ family of products. The ecoCube™ product family has been configured for over 40 different engine types from most of the world's major engine manufacturers. Bob is a mechanical engineer with a Master's degree in engineering. He can be reached at bob.stelzer@safetypower.ca