NOx Control for Cogeneration Facilities

Abstract

The price of natural gas makes it an attractive fuel source for electricity production. While natural gas turbines have often been used as the prime mover, natural gas reciprocating engines are becoming increasingly popular because of their relatively rapid startup times and their relatively high simple cycle efficiencies. This article looks at EPA requirements for natural gas engines which are commonly used in Cogeneration Facilities. It then looks at 2 specific Cogen installations with natural gas engines from the standpoint of emission control. Comments from the owner and the engine dealer are provided to give proponents an idea of what factors they must consider for emission control associated with a natural gas engine installation.

EPA Requirements for Emissions Control

The EPA divides the US into a set of “areas”, each of which is typically a county or major urban area. Through its National Ambient Air Quality Standards (NAAQS), the EPA looks at six “criteria” pollutants to ensure they are in compliance with emissions levels that have been determined through a balanced stakeholder process. These criteria pollutants are found throughout the country and are distinguished from HAP’s (Hazardous Air Pollutants) which are typically associated with a unique type of processing plant. The criteria pollutants that are associated with a natural gas engine are typically ozone, carbon monoxide, nitrogen dioxide (NO_2). Nitrogen dioxide is a component of NOx and NOx is an important precursor for ozone, so NOx is often a key parameter that needs to be measured.

Each criteria pollutant has a Major Source Threshold (MST) which is the number of tons per year that can be emitted by a facility if it wishes to avoid the potentially complex Title V process. Title V requires a public consultation process for the project and has a number of procedural and reporting obligations that many projects wish to avoid. It is important to note that many areas have local requirements that may be more severe than the national EPA standards.

The MST for a project is site dependent. If the project site is in an “attainment” area (ie the area currently meets the EPA required emissions levels for a given criteria pollutant), the MST is higher than if a site is in an extreme non-attainment area. Some examples for NOx MST are shown in the table below.

Type of EPA Area	NOx MST (tons per yr)
Attainment area	100
Non-attainment area – marginal	100
Non-attainment area – moderate	100
Non-attainment area – serious	50
Non-attainment area – severe	25
Non-attainment area – extreme	10

Constraints Faced by Cogen Facilities Applying Emissions Control

For many sites the constraining pollutants will be the MST's for NOx and CO. Typically natural gas engines have relatively low allowable pressure drops in their exhaust systems. This coupled with the installation of heat recovery devices in the exhaust stream and the need to silence the exhaust noise does not leave much available pressure drop for the emission control system. There is an increasing trend to combine the silencer with the emission control device. This combination allows the benefits of exhaust silencing by the catalysts to be taken into account when doing the overall system design from an acoustics standpoint. Another important constraint for many sites is the physical space required for the emission control system. Space allocation for any piece of equipment is expensive.

The ideal emission control system but has the following attributes:

(1) achieves the regulatory requirements – which, for most sites, means meeting the NOx and/or CO requirements
(2) has low pressure drop allowing the placement of heat recovery devices in the exhaust stream
(3) has low temperature drop so that downstream heat recovery devices still have high levels of heat extraction potential
(4) requires relatively little space by integrating silencing and providing flexible installation options
(5) is highly cost effective

Project Profile

Markham District Energy Inc (MDE) is a thermal energy utility owned by the City of Markham. The City of Markham is a rapidly growing community with a population of approximately 300,000 on the northeast border of Toronto. MDE supplies thermal and electrical energy to a broad range of customers with global operations – including Honeywell, Motorola & IBM, a regional hospital and a number of significant residential and commercial properties. MDE is a recognized innovator and received the International District Energy Association's highest honor, the 2013 System of the Year Award.

This article focuses on 2 natural gas cogeneration projects commissioned in 2013 and early 2014. Both projects were implemented under the overall project management of Peter Ronson, VP at MDE. The natural gas engines

for both facilities were Caterpillar engines supplied by Toromont CAT Power Systems. Safety Power Inc supplied the Selective Catalytic Reduction (SCR) systems as a sub-contractor to Toromont for the project.

The larger of the 2 facilities is the Bur Oak Energy Centre. The Bur Oak Energy Centre, produces hot water, chilled water, steam, and electricity for a major hospital, community center, library and other buildings located in close proximity. As part of its energy portfolio the site includes a CAT CG260-16 4MW natural gas engine. The site had to meet stringent NOx limits through a Selective Catalytic Reduction (SCR) emission control system. Space was a major constraint – requiring the SCR to be mounted vertically. As a result the SCR for this 4MW engine took up less than 50 ft^2 of floor space. Because of extensive downstream heat recovery equipment in the exhaust, the SCR had to have a low pressure drop and low heat loss.

According to Peter Ronson, VP of MDE, “we had a complex set of constraints that needed to be met by our emission control system, particularly at the Bur Oak site. We are pleased with the overall performance of the system.”

The second project is the Birchmount Energy Centre. This site includes a CAT CG260-12 3MW gas natural gas engine. The site also had to meet stringent NOx limits through a Selective Catalytic Reduction (SCR) emission control system.While there is downstream heat recovery, unlike Bur Oak, there is no downstream steam generation making the pressure drop requirements somewhat less onerous. However, like Bur Oak, space was at a premium and again the SCR system was mounted vertically.

Toromont, the local Cat® Dealer, supplied a CG260-12 generator set for the Birchmount Energy Centre, a CG260-16 generator set for the Bur Oak Energy Centre, and ancillary electrical and mechanical equipment for both sites including the Selective Catalytic Reduction Systems from Safety Power. The CG260 generator sets provide a combined 7 MW of electricity and 7 MW of thermal energy to the Markham District Energy systems. These projects represented the first in North America that employ Caterpillar’s recently introduced CG260 Series of high-efficiency gas generator sets. The CG260 utilizes particle-free combustion with chamber plugs for extended maintenance intervals and improved heat utilization. According to Lou Colangelo, General Manager for the prime power business in Toromont’s Power Systems Group, “We selected Safety Power to supply the emissions after-treatment for these 2 projects because we had a high level of confidence that they would meet our customer’s requirements. We were pleased with their equipment and support on these 2 projects.”

As previously mentioned, the SCR reactors for both projects were mounted vertically to save space inside the facility. The Bur Oak project uses a series 8 ecoCUBE® SCR system and the smaller Birchmount project uses a series 5 ecoCUBE® SCR. The vertical orientation required some structural modifications and Computational Fluid Dynamics (CFD) modeling to ensure the emissions reductions could be realized within the relatively small available footprint. The Birchmount system was commissioned in December 2013 and the Bur Oak system was commissioned in January 2014. A picture of the Bur Oak reactor and associated control panel is shown. All of the urea injection equipment and associated controls are housed in the single, relatively small control panel. Safety Power uses a model based control algorithm that measures engine out NOx and has an exhaust mass flow sensor to measure total moles of NOx that must be destroyed. This is combined with a downstream NOx sensor which corrects for any model inaccuracies. The combination of CFD analysis to make reactor size as small as possible and advanced control technology ensures customer requirements are met.

According to President and CEO of Safety Power, Robert Desnoyers, “from our perspective this project went extremely smoothly. Our customer, Toromont, did a great job of communicating expectations to us and involving us as an integral part of the project.”

The End

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 50 different engine types from many 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