



***GE Power Systems***

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**Support for Elimination of Oxidation  
Catalyst Requirements  
for  
GE PG7241FA DLN Combustion Turbines**

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# **SUPPORT FOR ELIMINATION OF OXIDATION CATALYST REQUIREMENTS FOR GE PG7241FA DLN COMBUSTION TURBINES**

## ***Applicability***

This position paper applies to GE PG7241FA combustion turbines with DLN combustors firing natural gas and located in all attainment areas and ozone non-attainment areas. For all other GE heavy-duty frame machines, owners are advised to contact their GE Power Systems sales representative for information regarding oxidation catalysts and related requirements.

## ***Abstract***

Emissions regulatory requirements have become more stringent for combustion turbines (CTs), generally requiring installation of post-combustion controls regardless of uncontrolled emission levels, plant location, costs, process feasibility, or resulting environmental impacts. Federal and state regulatory agencies have sought to justify post-combustion controls primarily on the grounds that some existing installations are currently using oxidation catalysts for carbon monoxide (CO) control.

However, a “one-size-fits-all” approach, where all units are required to install a particular technology without consideration of individualized factors, is in direct conflict with the Clean Air Act (CAA) Best Available Control Technology (BACT) analysis procedures and requirements.

The BACT analysis for CO (or any criteria pollutant) must weigh a variety of factors including energy, environmental and economic impacts. Dry Low NO<sub>x</sub> (DLN) combustors for GE PG7241FA combustion turbines are now demonstrating uncontrolled CO emissions in a range so low that the requirement to add an oxidation catalyst on these units will only serve to reduce efficiency and output; produce negative environmental impacts; and, in light of the measured data, will not yield detectable CO

emissions reduction benefits under normal operating conditions.

The comparison with existing installations using CO catalysts appears to be the primary factor influencing regulatory agencies to insist on the installation of oxidation catalysts on all combustion turbine units. However, two additional factors are also considered in this paper; the impetus for expedited permitting, and the anticipated federal regulation for hazardous air pollutant (HAP) emissions from combustion turbines.

The objective of this paper is to demonstrate that the installation of an oxidation catalyst to achieve lower CO levels from GE PG7241FA DLN combustion turbines sited in CO attainment areas and ozone non-attainment areas should not be required by state, local, and/or federal regulatory agencies. The addition of oxidation catalysts to these units results in minimal CO emissions reduction, adds unnecessary costs, and produces negative environmental impacts.

## ***1.0 Introduction***

State and federal regulatory agencies are requiring oxidation catalysts as BACT on combustion turbines in an attempt to achieve lower CO emissions. Such requirements are making it difficult for owners to avoid the installation of oxidation catalysts as add-on controls, regardless of the uncontrolled CO emissions levels. The regulatory-mandated BACT process is being circumvented and U.S. EPA's own BACT guidance is being ignored. The Clean Air Act clearly requires that a BACT determination be conducted on a “case-by-case” basis; however it appears that in many cases the regulatory agencies are influencing applicants' control technol-

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ogy choices and their BACT determination based on the following factors:

- Existing installations of various manufacturers' units that are using CO catalysts (i.e., "presumptive BACT")
- Applicants' demands for an expedited permitting process
- Currently nonexistent, but anticipated, Maximum Achievable Control Technology (MACT) requirements for HAPS

Consequently, the regulatory agencies appear to be excluding other important factors in their BACT determinations, such as:

- Cost effectiveness and feasibility of control
- Evaluation of collateral environmental impacts
- Evaluation of expected CO emissions on public health

GE PG7241FA DLN natural gas-fired combustion turbines have consistently demonstrated uncontrolled CO emissions below 9 parts per million by volume dry (ppmvd) at base load. A requirement to add an oxidation catalyst to a GE PG7241FA DLN combustion turbine with single digit CO emissions will reduce efficiency and output, and produce negative environmental consequences while yielding insignificant (<1 ppm) reduction in CO emissions under normal operating conditions. For areas designated as attainment for carbon monoxide, it becomes critical that the BACT analysis for CO includes environmental, cost effectiveness, and potential health impacts. The following provides justification of why BACT determinations for CO emissions for GE's PG7241FA DLN units should result in a conclusion of "No Add-on Controls."

### 2.0 Existing Installations

A review of existing CT installations located in attainment areas which are using oxidation catalysts indicates that uncontrolled CO emission levels from these units are much higher than the demonstrated emission levels from GE's PG7241FA DLN combustion turbines. The existing installations reviewed have uncontrolled CO emission rates in the range of 15 to 25 ppmvd, while GE's PG7241FA DLNs have demonstrated uncontrolled CO levels of less than 5 ppmvd. When post-combustion control, such as an oxidation catalyst, is added to the higher emitting units, the resulting CO level achieved and permitted is approximately 5 ppmvd. This emission rate is consistently achieved by the GE PG7241FA DLN units, *without any add-on controls*.

In ozone non-attainment areas, an additional consideration is Volatile Organic Compounds (VOC) emissions. Oxidation catalysts can be used to reduce VOC emissions from CTs. However, GE PG7241FA DLN units produce no measurable quantities of VOC emissions, and the guaranteed VOC emission rate of GE 7241FA is consistent with the lowest achievable emission rate (LAER) without any add-on controls.

Given these facts, it seems clear that recent EPA BACT decisions requiring add-on controls for CO emissions on GE PG7241FA DLN units have been made without undertaking a case-by-case BACT analysis as required by the CAA. In addition, it appears that EPA's determination has, in many cases, ignored the results of cost-effectiveness analyses and collateral environmental impacts. These will be discussed in the following sections.

### ***3.0 Expedited Permitting Process***

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The demand to increase electric power supply availability in the U.S. is at an all-time high. In 2001, some states experienced rotating power blackouts (e.g., CA) and others (e.g., NY) were expected to follow suit because of the increased energy demand and the limited number of new power plants permitted and built in the deregulated market. As a result of the need for immediate energy supplies, incomplete or inadequate BACT analyses are conducted in order to expedite the permitting process. The result is that BACT has essentially become an automatic requirement for an oxidation catalyst for CO emissions reduction for future projects.

### ***4.0 Upcoming MACT Requirements for HAPS***

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Some state and local regulatory agencies are using the soon-to-be-proposed U.S. EPA Maximum Achievable Control Technology standard intended for the reduction of hazardous air pollutants (primarily formaldehyde) from combustion turbines as the basis for requiring oxidation catalysts. As of August 2001, when this paper was drafted, the MACT rule for combustion turbines had not yet been proposed. However, EPA has provided some information on what the rule would require through industry meetings and communications. According to the EPA, all new combustion turbines will likely be required to install an oxidation catalyst to reduce hazardous air pollutants (HAPs), unless a formaldehyde emission level of less than 25 parts per billion by volume, dry (ppbvd) corrected to 15% O<sub>2</sub> is achieved. For combustion turbines achieving less than 25 ppbvd @ 15% O<sub>2</sub> of formaldehyde, the MACT requirement is expected to be "No Additional Control."

On August 21, 2001, EPA issued a memorandum indicating, "HAP emissions from lean pre-mix stationary combustion turbines are equivalent or lower than HAP emissions from diffusion flame stationary combustion turbines equipped with oxidation catalyst systems. Thus, lean premix combustion is a comparable technology to oxidation catalyst systems."

Additionally, GE has tested and provided EPA with formaldehyde emissions data using California Air Resources Board (CARB) Method 430 from two GE PG7241FA DLN natural gas-fired turbines. The test results demonstrate that the uncontrolled formaldehyde emissions when blank corrected (corrected for the background levels associated with the sampling train) are typically below 25 ppbvd @ 15% O<sub>2</sub>. Therefore, based on the blank corrected measurements, GE's PG7241FA DLN units may not be subject to the upcoming MACT regulation and an oxidation catalyst would not be required for MACT compliance.

### ***5.0 Cost Effectiveness***

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Inconsistent implementation of BACT across EPA regions will occur if cost of control and the resulting cost-effectiveness levels are not evaluated. As indicated in Table 1, dollars-per-ton cost effectiveness analyses as low as \$2,055 per ton (Newington Energy in New Hampshire) have resulted in a decision that no oxidation catalyst is required for CO from gas combustors with emissions of 15 ppmvd. These figures conflict directly with a recent (2000) decision by EPA Region II that \$6,000 per ton (Heritage Station, 7H project in Oswego, NY) is considered cost effective for CO control in attainment areas. The lack of uniform EPA guidance regarding cost effectiveness determinations is causing inconsistencies in BACT determinations across the country.

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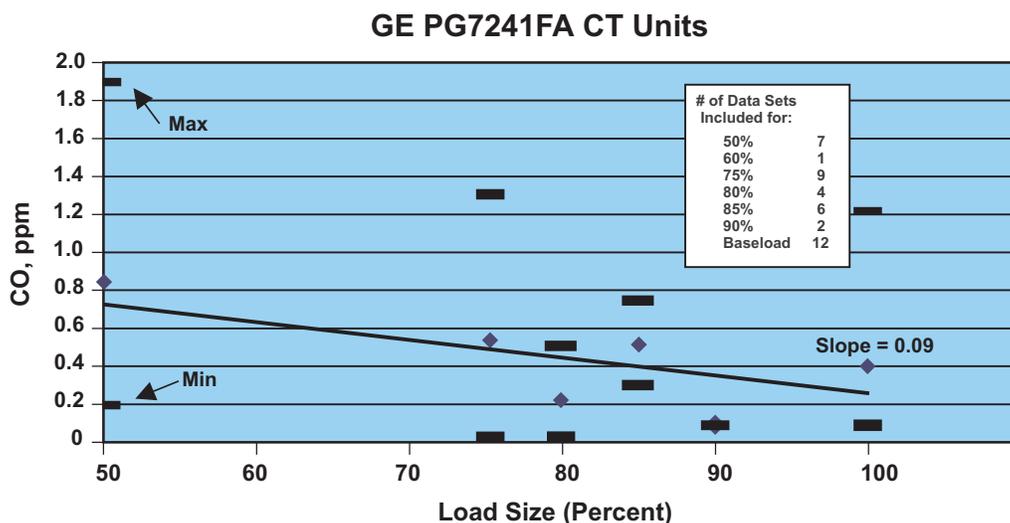
Source/State	Model	Type of Operation	Catalytic Oxidation System Required	Cost Effectiveness (\$/ton)	Final CO BACT Based on Natural Gas	Issuance
Westbrook Pwr/ME	PG7241FA	Combined Cycle	No	>\$3,000	15 ppmv	Draft Findings of Fact and Order (12/98)
Newington Energy/NH	PG7241FA	Combined Cycle	No	\$2,055	15 ppmv	4/99
EMI Tiverton/RI	PG7241FA	Combined Cycle	No	\$7,400	12 ppmv	2/98
RockGen Energy/WI	PG7241FA	Simple Cycle	No	\$15,780	12 ppmv	1/99
SEI/WI	PG7241FA	Simple Cycle	No	\$14,000	12 ppmv	2/99
Tenaska Georgia Ptnrs/GA	PG7241FA	Simple Cycle	No	\$2,300	15 ppmv	12/98
People Gas and Light, McDonnell Energy/IL	PG7241FA	Combined and Simple Cycle	No	\$3,043 \$17,000	0.03 lb/mm Btu	1/99

**Table 1. Cost Effectiveness Levels for Recently Permitted Sites**

GE's data collected to date on GE PG7241FA DLN combustion turbines indicate CO levels below 2 ppmvd at various loads. (See Figure 1). These data suggest that the addition of oxidation catalysts to GE's PG7241FA DLN units will result in less than 1 ppm CO reduction on an average basis. Such reductions will yield unjustifiably high cost per ton of CO controlled.

To demonstrate that GE's PG7241FA DLN units should not require add-on controls for BACT determinations, cost effectiveness calculations are presented in Figure 2.

These cost estimates are based on 1st Quarter, 2001, gathered information from two leading catalyst manufacturers (Englehard & Johnson Matthey). As shown in Figure 2, the requirement for an oxidation catalyst would not be cost effective.



**Figure 1. Average Raw CO Emissions vs. Load Size (Percent)**

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tive for units with (uncontrolled) CO levels slightly less than 7 ppmvd, based on the \$6,000 per ton identified by EPA-Region II.

GE's CO guarantee is meant to accommodate operating conditions at all permitted ambient conditions and has a small margin to account for measurement error and machine and fuel variations. Generally for CO, extremely cold ambient conditions, concurrent with part load combustion turbine operations, will represent the worst-case emissions. GE's PG7241FA DLN turbine is one of the lowest emitting operating combustion turbines in simple cycle and combined cycle systems. Consequently, GE's analysis shows that the CO emission levels from these combustion turbines can be tuned to be below 5 ppmvd. For any emission level below 5 ppmvd, the cost effectiveness will be greater than \$8,000 per ton of CO removed. Based on these consid-

erations, GE is offering CO guarantees of 5 ppmvd for the GE PG7241FA DLN on a case-by-case basis following a detailed evaluation of the situation—thus validating its position that oxidation catalysts are not economically justified for CO emissions reduction for the GE PG7241FA DLN units while firing natural gas.

## 6.0 Other Environmental Impacts

Use of oxidation catalysts to control CO emissions from GE PG7241FA DLN combustion turbines produces collateral impacts that are environmentally detrimental. A BACT analysis, by its definition, must include consideration of collateral environmental impacts. The EPA must consider the severity and resulting expense of these impacts when requiring controls for combustion turbines like GE's PG7241FA DLN machines. In this case, nitric oxide (NO) and sulfur dioxide

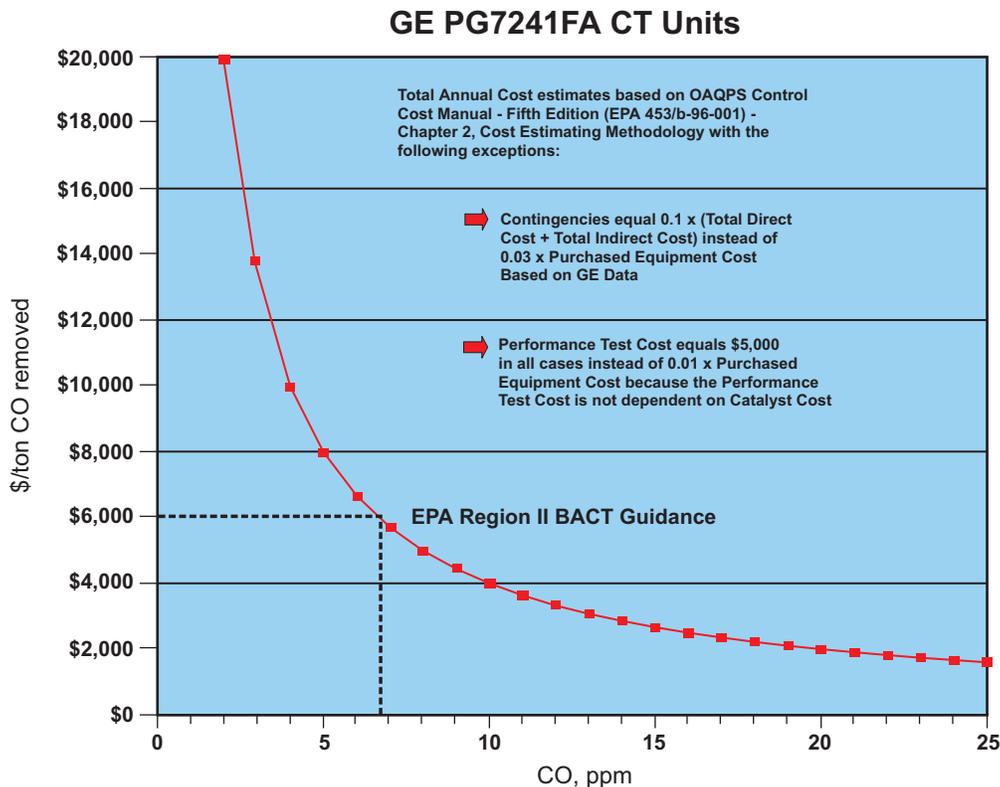


Figure 2. Cost Effectiveness of Oxidation Catalysts

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(SO<sub>2</sub>) present in the exhaust will be oxidized by add-on catalysts to nitrogen dioxide (NO<sub>2</sub>) and sulfur trioxide (SO<sub>3</sub>), both of which promote the formation of acid rain. In addition, if applied in combination with selective catalytic reduction (SCR) for the control of nitrogen oxides (NO<sub>x</sub>), ammonium salts formed as a result of ammonia (NH<sub>3</sub>) slip and SO<sub>3</sub> will result in additional generation of PM10 (particulate matter less than 10 microns in diameter) and accelerated corrosion of the heat recovery steam generator (HRSG). The EPA identified this issue in its August 4, 2000, draft guidance "Consideration of Collateral Environmental Impacts Associated with the Use of SCR on Dry Low NO<sub>x</sub> Combined Cycle Gas Turbines," by John S. Sietz, Director, Office of Air Quality Planning and Standards (OAQPS). Finally, additional carbon dioxide (CO<sub>2</sub>) will be generated due to the output and efficiency losses associated with the pressure drop of the catalyst.

### **7.0 CO as a Public Health Concern**

According to a health risks study conducted by toxicologist R.A. Michaels in a May 2001 report ("*Carbon Monoxide Catalysis: Assessment of Need to Mitigate Public Health Risks Posed by Acute and Chronic Exposure to CO Emitted by Combined Cycle Natural Gas Turbines*"; R.A. Michaels, Ph.D., C.E.P., RAM TRAC Corporation, May 21, 2001), "Ground level CO concentrations arising from combined cycle natural gas turbines were found to be below conservative standards and guidelines limiting human exposure to airborne CO. CO also was found to be below concentrations posing acute or chronic exposure risks to public health." These findings support the conclusion in the report that "*public health concerns do not justify requiring natural gas power generators to be equipped with CO catalysis to reduce ground*

*level CO impacts.*" The health risks study was based on analysis of a CO emission rate of 9 ppmvd, which, as stated previously, is significantly higher than the uncontrolled emissions from GE's PG7241FA DLN combustion turbines firing natural gas.

The following excerpt from page 23 of the RAM TRAC report summarizes the important conclusion that CO catalysts do nothing to improve public health:

"...Risks posed to public health are quantified in this report to be zero, with or without CO catalysts. Indeed, this report reveals that ground level impacts of combined cycle natural gas turbines as modeled by GE are far from impacts which would be required to elicit adverse public health effects. Modeled turbine impacts would have to be increased by over an order of magnitude to elicit adverse effects associated herein with acute or chronic exposure to CO."

In summary, the CO ground level concentrations (GLCs) resultant from the use of the GE PG7241FA DLN are insignificant when compared to the National Ambient Air Quality Standards (NAAQS). The NAAQS are referenced in *Appendix A*.

### **8.0 Other Considerations**

Use of an oxidation catalyst reduces system efficiency and output. System inefficiencies and output losses, in turn, will result in an increase in emissions. Due to the increase in pressure drop associated with the oxidation catalyst in the exhaust gas path, output (MW) will decrease and heat rate (Btu/kWh) will increase. Since combustion turbines are recognized as the least polluting combustion sources to generate electricity, any attempt to make up the energy losses will increase emissions.

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The installation and use of an oxidation catalyst will increase the cost of the electricity (COE) produced. With oxidation catalyst requirements on a new PG7241FA DLN combustion turbine, the added capital and operating costs of the catalyst will be absorbed and paid for by the consumer. Fewer new combined cycle plants will be built due to the high COE resulting from increased capital cost and operation and maintenance costs; and thus less electricity will be generated from new plants. Therefore, total CO emissions will not decrease as rapidly, as a result of the addition of new plants. Emissions of acid rain pollutants and fine particulate matter, NO<sub>x</sub>, SO<sub>2</sub>, CO<sub>2</sub>, and mercury emissions will remain at current levels due to continued operation of existing coal plants.

The use of an oxidation catalyst creates heavy metal wastes. Oxidation catalyst materials contain heavy metal oxides such as platinum and palladium, which are considered hazardous substances by the EPA. Handling, maintenance, cleaning, and disposal of the spent catalyst ele-

ments are potentially harmful to humans and the environment. In addition, spent catalyst elements are considered hazardous waste, thus transferring an air emission issue into a long-term solid waste disposal problem. When applied in combination with SCR, additional salt formation will occur. Ammonia salts cleaned from HRSGs are also wastes, which will need to be disposed of accordingly.

### ***9.0 Summary***

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In summary, the use of an oxidation catalyst to control CO emissions from GE's PG7241FA DLN combustion turbines will result in insignificant (< 1 ppm) reduction of CO and will not substantially reduce ambient CO levels since minimal CO is emitted under normal operating conditions. The application of an oxidation catalyst on GE PG7241FA DLN combustion turbines firing natural gas in simple cycle and combined cycle plants cannot be justified on a cost (per ton of CO removed) basis.

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## Appendix A. Summary of National Ambient Air Quality Standards (NAAQS)<sup>1</sup>

Pollutant	Averaging Time	NAAQS (mg/m <sup>3</sup> )		ppm
		Primary	Secondary	
Carbon monoxide	8-hour	10,000	None	9
	1-hour	40,000	None	35
Lead	Calendar quarter	1.5	Same as primary	—
Nitrogen dioxide	Annual	100	Same as primary	0.053
Ozone <sup>2</sup>	1-hour	235	Same as primary	0.12
PM-10	Annual	50	Same as primary	—
	24-hour	150	Same as primary	—
PM-2.5	Annual	15	Same as primary	—
	24-hour	65	Same as primary	—
Sulfur dioxide	Annual	80	None	0.03
	24-hour	365	None	0.14
	3-hour	None	1300	0.50

<sup>1</sup> National standards, other than those based on annual averages, are not to be exceeded more than once a year (except where noted).

<sup>2</sup> The ozone standard is attained when the expected number of days per calendar year in which the maximum hourly average concentration is above the standard is equal to or less than one.

Source: Code of Federal Regulations, 40 CFR 50.4-50.12.

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