Recommendations for Effective Regulation of Emissions for Stationary Engines in Emergency Power Applications

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INTRODUCTION

This paper is intended to inform the actions of regulatory bodies so that regulations are aligned with the intended air quality improvement objectives. This paper provides specific recommendations on how to regulate engines used in emergency power applications to achieve better air quality outcomes than what is realized by simple replication of prime power regulations.

Stationary engines used for emergency power should be regulated differently than stationary engines used for prime power. Emergency engines operate very few hours per year and have distinct operating profiles that result in a much different environmental impact than prime power engines.

RECOMMENDATION AND BASIS

1. Best Available Control Technology (BACT) Standards for emergency diesel engines should remain at Tier 2 (emergency) above 560 bkW and at Tier 3 (emergency) at or below 560 bkW as Tier 4 (non-emergency) emissions levels will not be achieved in practice in significant portions of emergency engine operations; this request for **emergency engine** applications should not be misinterpreted to imply that Tier 4 engines are not effective in **non-emergency** engine applications that operate high hours per year where startup and shutdown are a small fraction of operating time.

2. Emergency gas engine levels should be set at 1.5 g/bhp-hr NOx and 2.0 g/bhp-hr CO for all horsepower ranges; VOC should be set at 1.5 g/bhp-hr for less than 130 hp, and 1.0 g/bhp-hr for greater than or equal to 130 hp. Such levels are achievable with a certified gas engine that is exempt from source test requirements under EPA's NSPS regulations.

3. It is important to note the above approaches would also minimize greenhouse gas (GHG) emissions from emergency applications.

4. Air permitting authorities, as an alternative to cost ineffective solutions, should limit emergency hours of operation (200 hours typical) with force majeure permit provisions for emergency engines in extraordinary grid-power outages to more accurately represent emergency engine impacts on an airshed.

BACKGROUND

U.S. EPA determined1 that the use of aftertreatment devices such as Selective Catalytic Reduction (SCR) and Diesel Particulate Filters (DPF) were not justified based on cost effectiveness ($/ton reduced) for emergency diesel engines in both the NSPS regulations for new engines (40 CFR Part 60 Subpart IIII) and in the regulation of hazardous air pollutants from new and existing engines (NESHAP, 40 CFR 63 Subpart ZZZZ). These regulations require the engines to meet 2007 emissions standards (Tier 3 for 75 HP to 750 HP, and Tier 2 for engines > 750 HP).

In 2011, California Air Resources Board (CARB) Airborne Toxic Control Measure (ATCM) agreed with EPA's reasoning and aligned with EPA regulations to also allow this stationary emergency engine exemption, excepting CARB adopted a 0.15 g/bhp-hr PM for engines < 175 hp.

More stringent particulate matter (PM) emissions levels are required in California, such as the area under jurisdiction of South Coast Air Quality Management District (SCAQMD), to meet area-specific requirements ("sensitive receptor") or for major sources including Federal Title V facilities. None of these regional requirements mandates the use of Tier 4 certified engines.

SCAQMD limits emergency engines to 200 hours total /year which minimizes the modeled and realistic potential emissions in the airshed as an alternative to adding costly controls to engines that run on average < 50 hrs./year. Limiting testing and maintenance to non-ozone forming hours of the day will also mitigate emissions impact notwithstanding facility constraints that may apply..

Appendix A shows the steady state NOx concentration (ppm) for testing and maintenance conditions and full engine power output operation of a diesel engine. The EPA Tier 4 standard is reported in grams/bkW-hr based on a weighted average of 5 operating points and some of the operating conditions may be above the absolute value of the Tier 4 standard.

[1] US EPA June 2006 - Regulatory Impact Analysis of the Standards of Performance for Stationary Compression Ignition Internal Combustion Engines (PDF), page 61

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The test cycle does not include the no load (note: zero bkW drives g/bkW-hr to infinity) high idle operating condition typical of testing and maintenance. Therefore, emissions are not at Tier 4 g/kW-hr levels for the no load testing and maintenance condition, but operation is the lowest mass flow rate possible for engine operation and the mass flow is small when compared to full load exhaust mass flow rates. At zero engine load operation, the required engine temperature for the SCR system to operate will not be achieved. Engines with lower ratings than the example shown would typically have lower engine operating temperatures, especially at less than full load, and thus the time needed to reach the operating temperature of the SCR will be longer. Emergency engines typically run between 0% and 60% load when tested and less than 60% load during emergencies. In other words, even a Tier 4 engine will not achieve Tier 4 in practice in an emergency application.

Several considerations exist when investigating the use of Tier 4 certified technology in stationary emergency diesel engine applications:

1. Certified Tier 4 engines must have safeguards (inducements) to prevent the operation of the engine with certain emissions related faults. For example, certified Tier 4 engines will derate and eventually shut off without diesel exhaust fluid (DEF). The engine can also shut down with high exhaust backpressure. These unexpected shutdowns subordinate the mission of an emergency engine to provide power during an emergency. The EPA does allow the SCR induced engine shutdown to be overridden during an emergency, but only up to 120 hours of operation after which the engine will shut down without a factory override reset. This 120-hour shutdown could occur during an extended emergency and thus could risk human life, public health and safety or critical services. The DPF cannot be bypassed by the operator so DPF backpressure risk cannot be eliminated.

2. SCR systems require high operating temperatures. Achieving optimum operating temperature profiles typically requires at least 20 to 30 minutes at typical emergency engine loads. Emergency standby engines typically have short operation sessions resulting in exhaust temperatures that are too cool for NOx reduction to occur. This limitation of SCR makes them ineffective during typical testing and maintenance operations. The result is Tier 4 emissions levels are not achieved in practice for these short duration events.

3. NOx reductions using SCR are also dependent upon demand load. A lightly loaded engine that is typically operated for short periods of time would not achieve the full NOx reduction potential of the SCR system (see attached). Most operating hours for emergency standby engines occur when performing maintenance and testing checks at low engine loads. Artificially increasing these testing and maintenance loads to elevate temperatures increases GHG emissions at a minimum.

4. SCR requires the use of DEF, a urea-based solution, for the catalytic reaction. This required fluid requires separate storage from the diesel tank. DEF has a limited shelf life and will also degrade over long periods of time. With low hour usage on emergency engines, unused fluids that degrade over time could require additional system maintenance. Additionally, these urea systems could increase the maintenance test frequency.

5. DPFs on emergency engines will also pose their own issues. DPFs typically require engines to operate at higher loads for longer periods or add heat to properly regenerate (burn carbon). This increases fuel consumption resulting in larger required tanks to satisfy minimum run time. This will also increase GHG emissions (CO^2). Some customers may request a bypass to assure the systems never interfere with normal operation. If misused, such bypasses may further reduce control effectiveness and may be considered a defeat device and or tampering if used as part of an EPA certified system.

6. Additional operating and maintenance time under loaded conditions will be required in order to assure proper functioning of the DPFs or to activate SCR dosing. With the already low limits on emergency engine operation (generally less than 200 hours per year total and often less than 50 hours per year including maintenance and repair) added time for maintenance will further limit the possible run time for actual emergencies.

7. Tier 4 engines with aftertreatment systems require more building space and floor loading considerations for engine, urea tank and control systems. Additional structural supports, plumbing, electrical and exhaust ducts may also be required. Load banks or supplemental exhaust heat may also be needed to ensure proper engine loading to prevent DPF plugging. This will increase fuel consumption and GHG emissions (CO^2).

8. Costs for Tier 4 diesel engine generators, installation of necessary additional design requirements, and increased maintenance requirements will run as much as 60% to over 100% more than the standard emergency Tier 2 above 560 bkW and Tier 3 at or below 560 bkW. These costs, for engines that typically operate far below stringent State or Federal hour limits, will far exceed cost-effectiveness ($/ton) basis for engine emission regulation to Tier 4 levels.

ADDITIONAL CONSIDERATIONS FOR SPARK IGNITION ENGINES

This analysis is also applicable to Spark-ignited engines, consistent with EPA NSPS standards. EPA NSPS is clear on source test requirements for a noncertified engine on initial installation and every 3 years thereafter. Certified engines do not require source testing per NSPS. There is no other state or local air district applicable regulation—it is a federally mandated minimum requirement. Manufacturers are only certifying to the emergency and prime gas engine NSPS standards of 2.0 g/bhp-hr NOx and 1.0 g/bhp-hr NOx respectively. Thus, by setting emergency gas engine BACT at 0.5 g/bhp-hr the air district has automatically imposed an expensive source test ($5K - $10K per engine) on initial installation and every 3 years thereafter on the end user.

EPA regulations place the "performance test" requirement on the end user, not on the manufacturer due to this being a site specific NSPS requirement. In most cases, the very low NOx engine will also require the installation of an oxidation catalyst to reduce the CO and VOC to the BACT levels set by authorities. Such regulations should allow manufacturers to voluntarily certify emergency gas engines so that end users are not forced into an expensive, on-going source testing requirement and additional oxidation catalysts for engines that are intended to operate infrequently and for limited hours. Removal of certified OEM engine emissions components/aftertreatment on certified engines to meet a different BACT standard than the US EPA NSPS requirements would be counterproductive for certified products and reintroduce the source test requirement.

CONCLUSION

For all of the foregoing reasons, BACT for emergency diesel engines should be aligned with EPA and CARB regulations which require Tier 2 above 560 bkW and Tier 3 below 560 bkW, as Tier 4 emissions levels will not be achieved in practice, are not cost effective and may compromise safety for stationary emergency diesel applications. Therefore, Tier 4 engine systems would be misapplied for emergency installations, notwithstanding Tier 4 systems are installed in facilities despite the recognition that Tier 4 levels are not achieved in practice in significant portions of emergency engine operations.

Emergency gas engine BACT should be maintained in alignment or revised to allow certified gas engines requirements to align with EPA NSPS' exemption to eliminate costly initial and on-going source testing. Emergency gas engine BACT must allow for certified engines to be used without modification.

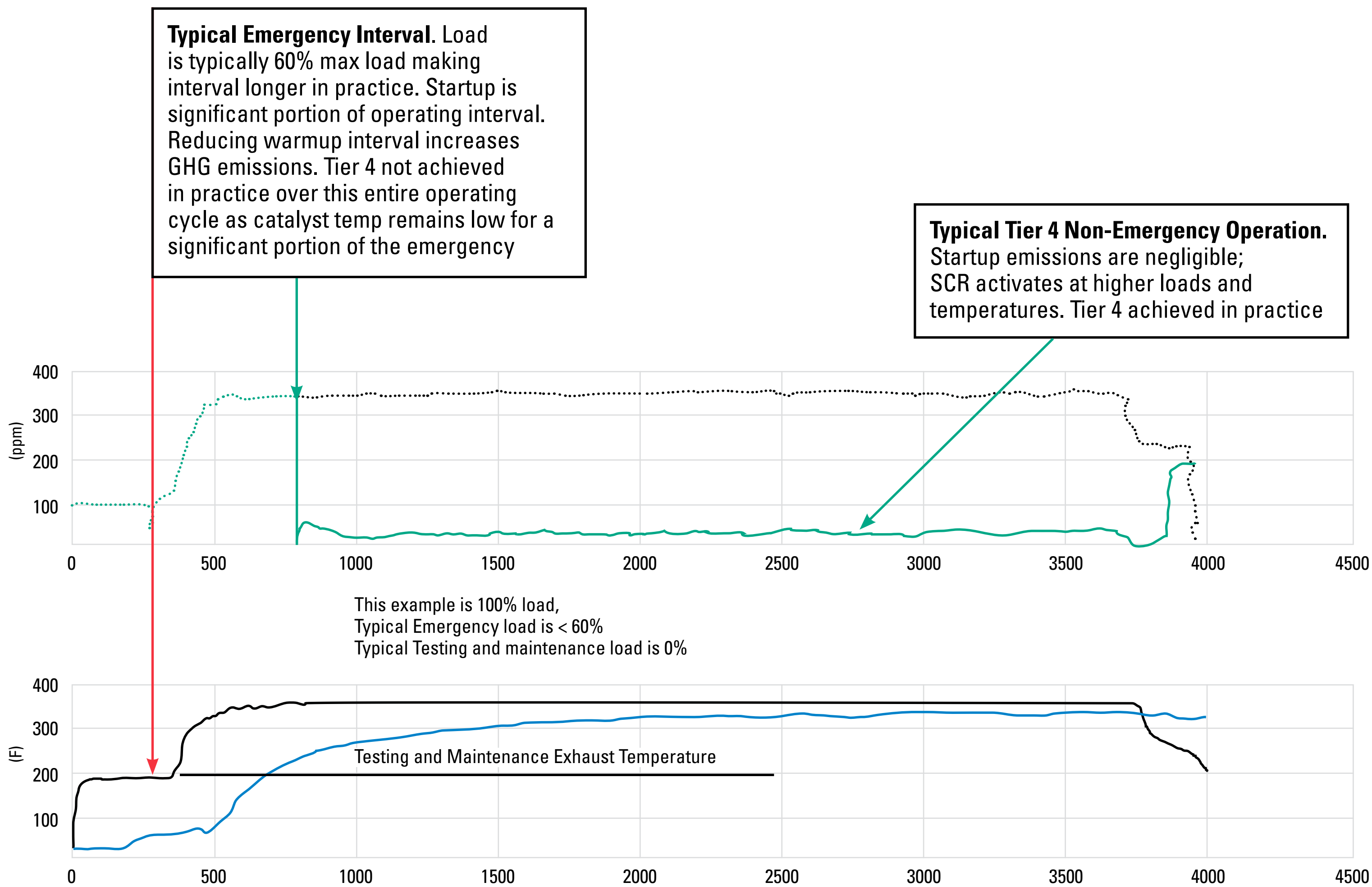
In short, to achieve optimum air quality outcomes beyond what is realized by simple application of prime power regulations to emergency engines, stationary engines used for emergency power should be regulated differently than stationary engines used for prime power and aligned with existing EPA and CARB emergency engine regulations.

APPENDIX A

Emergency Engine Operation of a Cat® C-175 3 MW Non-Emergency Engine (Tier 4)

This example is representative of typical aftertreatment equipped engines above and below 560 kW at 100% load with extended high idle at startup that represents typical testing and maintenance.

Typical Testing and Maintenance interval. NOx sensor is not operating initially, and emissions are represented by the black line for the duration. SCR does not activate during entire test. Mass flow is very low due to no electrical power output. Tier 4 not achieved in practice due to low catalyst inlet temperature over the duration (400 F). Engine operates at high idle (1800 rpm). Test periods range from 5-60 minutes.



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