

**STATE OF NEW MEXICO  
BEFORE THE ENVIRONMENTAL IMPROVEMENT BOARD**

**IN THE MATTER OF:**

**PROPOSED NEW REGULATION**

**20.2.50**

**No. EIB 21-27 (R)**

***Oil and Gas Sector – Ozone Precursor Pollutants***

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**REBUTTAL TESTIMONY OF JUSTIN LISOWSKI**

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Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS FOR THE RECORD.

A. Justin Lisowski, 3755 Dudley Street, Wheatridge, CO 80022.

Q. ARE YOUR QUALIFICATIONS PROVIDED IN YOUR DIRECT TESTIMONY IN THIS MATTER?

A. Yes.

**I. DEFINITIONS, 20.2.50.7 NMAC**

Q. NMED HAS PROPOSED AT 20.2.50.7.J THAT “CONSTRUCTION” INCLUDE “RELOCATION” OF A STATIONARY SOURCE AND INCLUDE TEMPORARY INSTALLATIONS AND PORTABLE SOURCES. IN ITS TESTIMONY, NMED CITED IS PART 72 PERMIT REGULATIONS (EXHIBIT 32, PAGE 15). WHAT IS THE PROBLEM WITH THIS APPROACH, PARTICULARLY FOR ENGINES AND TURBINES?

A. The challenge with “relocation” being part of the definition of “construction” is that it would trigger an engine or turbine that is being moved or redeployed to be classified as new engine and therefore fall under a different emission guideline. The same challenge is present with like-kind replacement. Engines (and less commonly turbines) are regularly relocated to continuously optimize horsepower utilization needed for each facility and/or well pad. This includes decreasing engine size (and effectively reducing annual criteria pollutant tonnage) as facility throughput decreases or increasing engine HP as a facility is expanding. This allows for engines to remain in compliance with the proposed existing engines emission limits, even if they are relocated to another location. If “relocation” is part of the definition of construction, then it may require engine replacement or costly engine emission retrofit technologies to be required due to this practice of optimization.

Q. DOES THE CONSTRUCTION DEFINITION IN NMOGA EXHIBIT 47, PAGE 3, PROVIDE A BETTER APPROACH TO CONSTRUCTION FOR ENGINES AND TURBINES? WHY?

A. Yes, the NMOGA redline referenced is a more practical definition of construction. It allows for existing engines to be remain subject to table 1 emission limits even if relocated, replaced with in-kind equipment, or if it is a used as a temporary installation.

### III. ENGINES AND TURBINES

Q. IN THEIR TESTIMONY, EXHIBIT 32, PAGES 32-34, MS. KUEHN AND MR. PALMER STATE THAT “READILY AVAILABLE OPTIONS FOR CONTROLLING NO<sub>x</sub> ON TWO-STROKE AND FOUR-STROKE LEAN BURN ENGINES INCLUDE LOW EMISSIONS CONTROLS, SELECTIVE CATALYTIC REDUCTION (SCR) AND NON-SELECTIVE CATALYTIC REDUCTION (NSCR). ARE THESE CONTROLS AVAILABLE FOR ALL SIZES OF LEAN BURN ENGINE?

A. The Low Emission Control (LEC) technologies is greatly simplified and is much more complex than the testimony implies. LEC, in this context for lean burn engines only, is not just a one size or one category of engine component, but rather a generic term for equipment that can reduce engine emissions. This can include, but is not limited to high pressure fuel injection, prechambers, turbo charger upgrades, piston design, micro-pilot ignition, etc. Not every LEC can be applied to every size or engine type, for instance, smaller bore engines, such as the Caterpillar G3500 or Waukesha L7042 GL do not have the physical space for a prechamber (see image below), nor can a prechamber reduce NO<sub>x</sub> because of the inability to have the correct cylinder-to-prechamber volume ratio. For a prechamber to be effective, the cylinder-to-prechamber ratio needs to be approximately 10% of the clearance volume of the engine, making small bore engines have a thimble-sized prechamber, which would not be effective. For example, it is my understanding that a Waukesha 7042GL (lean burn) that has all LEC technology that is applicable and available can only meet 2.0 g/bhp-hr and the same applies to Caterpillar G3500s engines of certain vintages and hp ranges. SCR technology is a post-combustion control technology (i.e. downstream of the engine on the engine exhaust system) and is theoretically viable on all lean burn engines, however, it is not technically practical as many challenges exist in application. SCR can be extremely expensive, large, requires on-site power, and can be complicated to operate reliably. NSCR is not applicable for lean burn engines; it is applied to all sizes of rich burn engines (installed on nearly all engines after 2006) and is likely paired with every rich burn engine currently operating in NM.

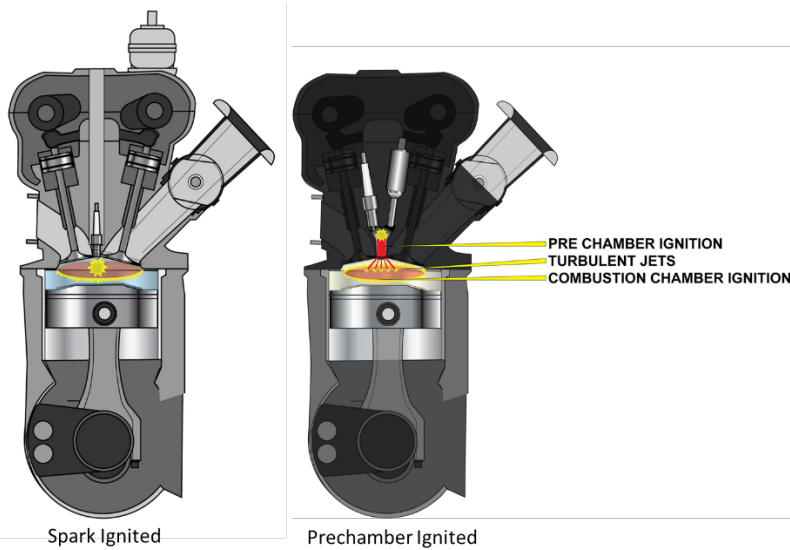


Figure 1: This cartoon graphic illustrates the physical space that may be required for a pre-chamber and that a pre-chamber most often is integrated into the engine architecture and cannot be retrofitted. The exception to this is large bore legacy engines (e.g. Cooper-Bessemer, Clark, AJAX, etc.) often have space to add a "screw-in prechamber" in the location of the spark plug. But on modern engines, that is almost entirely, not an option. Image is for illustration purposes only. Source: [F1: BURNING LEAN – PRE-CHAMBER COMBUSTION TECHNOLOGY \(drivetribes.com\)](#)

Q. IN ADDITION TO THE DIFFICULTY OR COST-INEFFECTIVENESS FOR SMALL LEAN BURN ENGINES, ARE THERE PROBLEM WITH RETROFITTING ANY OF THESE TECHNOLOGIES TO EXISTING ENGINES, AS OPPOSED TO NEW ENGINES?

A. In some cases, yes. Architecture of many engines can provide issues with adapting retrofit technologies. The testimony from NMED implies that any lean burn engine can meet proposed NOx levels for any category, simply by applying LEC which is not accurate for the reasons outlined in my prior answer. Additionally, LEC technology has limitations on its lowest achievable NOx emissions that vary based on engine model, vintage, etc. In many cases, applying every LEC technology that is applicable and/or available to a specific engine will not achieve NMED's proposed NOx levels. For many existing lean burns currently in service, 2.0 g NOx/bhp-hr is the lowest achievable level.

Q. DO YOU AGREE WITH THEIR STATEMENT, IN EXHIBIT 32, PAGE 37, LINES 16-21, THAT THE PENNSYLVANIA GP-5 REGULATION PROVIDES SUPPORT FOR 500 HP?

A. From my recollection and understanding of GP-5, it was intended to be focused on midstream and downstream providers. According to discussions I have had on the topic, it is evidenced that many engines operating in Pennsylvania gathering service (i.e. upstream) are under Exemption 38. This is indicative that GP-5 is not absolute but instead contains options for exemptions, with similar options not currently available in the proposed NMED rule. If NMED references GP-5 as supportive of proposed emission limits, they should also consider some of the off ramps/exemptions for challenged applications.

Q. IN THEIR TESTIMONY, EXHIBIT 32, PAGES 37-38, LINES 22-7, MS. KUEHN AND MR. PALMER STATE THAT COOPER MACHINERY SERVICES OFFERS RETROFIT OPTIONS FOR ALL CLARK, COOPER-BESSEMER, AND INGERSOLL-RAND SLOW SPEED ENGINES. DOES THIS ADDRESS CONCERNS FROM OPERATORS ON LEGACY ENGINES MEETING THE PROPOSED NOX LIMITS?

A. No, it does not address concerns. The "0.5 g/bhp-hr NOx SOLUTION" for Cooper Machinery Services consists of supplying a multitude of LEC technologies that I have previously mentioned. The capital requirement to apply such solutions will vary significantly from engine to engine, determined for example by, condition of engine, existing LEC, load at which the engine operates, and others. I am not familiar with the explicit cost of the Cooper Machinery Services solutions, however, Clark, IR, and Cooper-Bessemer make up a very small subset of the legacy engines in service in NM (less than 3%) and there are still other legacy engines (2-stroke and 4-stroke) that the Cooper solution is not applicable to.

Q. CAN ALL LEAN BURN ENGINES BE RETROFITTED WITH LOW EMISSIONS COMBUSTION COMPONENTS OR IS THIS ONLY APPLICABLE TO LARGE BORE ENGINES?

A. Not all LEC components are applicable or effective on every engine and the choice of components depends on many factors, one being bore size.

Q. IN EXHIBIT 32, PAGE 38-39, MS. KUEHN AND MR. PALMER TESTIFY THAT 97% OF RETROFITTED UNITS COULD ACHIEVE 2.0 G/BHP-HR, BUT LESS THAN 75% COULD ACHIEVE 1.0 G/BHP-HR AND ONLY 25% COULD ACHIEVE 0.5 G/BHP-HR. BASED ON THIS INFORMATION, IS 0.5 G/BHP-HR ACHIEVABLE?

A. For existing engines, this information shows that 0.5 g NOx/bhp-hr is likely only achievable on a minority subset of the engines in service through the use of LEC technology.

Q. IS SCR A REALISTIC ALTERNATIVE FOR THE MAJORITY OF EXISTING ENGINES IN USE IN NEW MEXICO?

A. No it is not. Besides a high cost to install and operate, through field conversation, anecdotally, they are difficult to operate reliability. On top of that, they require site power, which most locations in NM do not have. I believe the technical and economic challenges of SCR implementation is illustrated through the lack of use in the oilfield.

Q. WHAT SHOULD THE NOx LIMIT BE FOR THESE ENGINES GIVEN WHAT CAN BE DONE?

A. I believe a pragmatic approach should be taken on what is achievable within reasonable cost and effort. In my memo submitted with the NMOGA testimony, I have provided recommendations for emission levels for new engines that are more agnostic to type of engine and/or manufacturer. In lieu of an agnostic approach, which is not as appropriate for existing engines, focusing on what is practically achievable (i.e. through the use of currently available LEC and without requiring SCR) is how the limits should be set.

1 Q. DOES NMOGA EXHIBIT 47, REDLINE OF SECTION 20.2.50.113 NMAC, SET  
2 FORTH A MORE APPROPRIATE STANDARD FOR THESE UNITS?

3 A. Yes, the NMOGA redline is more appropriate and achievable. However, as presented in  
4 my testimony submitted by NMOGA, I believe a more agnostic limit should be given for new  
5 engines with no discrepancy between rich burn and lean burn engines. For existing units, 2-  
6 stroke lean burns are legacy, but often in critical pipeline service and a relaxed standard should  
7 be given for practical achievability limits. Not to mention, many are integral units, meaning the  
8 compressor is built into the engine such that engine replacement to meet emission limits requires  
9 replacement of the compressor too.

10 Q. IN MS. KUEHN'S AND MR. PALMER'S TESTIMONY IN EXHIBIT 32, PAGES 32-  
11 34, DID THEY INDICATE THAT FOR RICH-BURN ENGINES THE ONLY CONTROL IS  
12 NSCR?

13 A. Yes, that is accurate, NSCR is the only control for rich burns. Improved AFR controls  
14 can be implemented to ensure proper engine operation (i.e. alternating slightly rich and lean from  
15 stoichiometric), provide mapping across load ranges and variable environmental conditions, and  
16 better manage O2 (and/or NOx) sensor drift, but AFR allows for NSCR to function properly, by  
17 keeping the engine operating at the proper parameters.

18 Q. DOES PENNSYLVANIA REGULATION GP-5 TELL US MUCH ABOUT WHAT  
19 CAN ACTUALLY BE ACHIEVED FOR THE SMALLER RICH-BURN ENGINES? WHY IS  
20 IT NOT A GOOD REFERENCE?

21 A. Referencing a standard doesn't tell us what can be achieved, just what is the regulation.  
22 A better reference would be whether these standards are being achieved in practice or if a shift to  
23 larger engines or electric motors is being made. A check against number of units operating  
24 under Exemption 38 should be explored.

25 Q. WHAT ARE THE PROBLEMS WITH THE PROPOSED LIMITS FOR RICH-BURN  
26 ENGINES?

27 A. Generally speaking, there is not a problem with the proposed rich burn limits. It is often  
28 easier to achieve low NOx on a rich burn equipped with NSCR than a lean burn. Because of  
29 that, it is confusing as to why NMED proposed more stringent limits on rich burns vs. lean burns.

30 Q. DOES NMOGA EXHIBIT 47, REDLINE OF SECTION 20.2.50.113 NMAC, SET  
31 FORTH A MORE APPROPRIATE STANDARD FOR THESE NEW AND EXISTING  
32 UNITS? WHY?

33 A. NMOGA redlines for all engine tables present a more pragmatic approach, focusing on  
34 what is achievable either from available currently from manufacturers and/or with retrofit  
35 technologies, within a reasonable cost and/or effort.

36 Q. ARE THERE LIMITS ON THE USE OF AN OXIDATION CATALYST BASED ON  
37 ENGINE SIZE, EXISTING/NEW STATUS, OR OTHER FACTORS?

A. The limits of an oxidation catalyst, as utilized by a turbine or lean burn engine as a passive post-process control, is that they are generally only limited by the health of the catalyst, size, and operating temperature. An oxidation catalyst needs to be operated in an oxidative environment (i.e. excess air or lean air/fuel ratio) and is very effective at reducing VOCs and CO. However, if the combustion temperatures are reduced via extending the lean limit of operation or LEC retrofits to reduce NO<sub>x</sub>, the catalyst housing temperature gets too low and affects VOC and CO oxidation.

Q. DO YOU AGREE WITH MS. KUEHN AND MR. PALMER'S TESTIMONY IN EXHIBIT 32, PAGES 35-36 THAT WATER/STEAM INJECTION, DRY LOW NO<sub>x</sub> BURNERS OR SCR ARE ALL READILY AVAILABLE OR ARE THERE LIMITS ON THE USE OF THESE TECHNOLOGIES BASED ON TURBINE SIZE, WHETHER IT IS EXISTING OR NEW, OR OTHER FACTORS?

A. No, I do not. Water injection for turbines is outdated technology that is not viable for many reasons. Not all makes, models and ratings have water/steam injection of dry low NO<sub>x</sub> burners available as a product option. More on water injection in later questions.

Q. IN THEIR TESTIMONY AT EXHIBIT 32, PAGES 36-37, MS. KUEHN AND MR. PALMER PROPOSED AN ALTERNATIVE COMPLIANCE APPROACH WHERE "OWNERS AND OPERATORS MAY REDUCE THE NUMBER OF HOURS OF OPERATION IN ORDER TO REDUCE EMISSIONS TO RATES SIMILAR TO THE EMISSIONS REDUCTIONS REQUIREMENTS ACHIEVED BY USING CONTROL DEVICES." DOES THIS APPROACH PROVIDE ADEQUATE FLEXIBILITY?

A. As I interpret this section, it does not, so additional clarification is required. It is interpreted that you have to reduce the number of hours to reduce annual NO<sub>x</sub> and VOC tonnage by 95%. A more reasonable alternative compliance approach would be to reduce the operating hours such that you meet the allowable tonnage per year as proposed in table 1 or table 3. For instance, if you have a limit of 1.0 g NO<sub>x</sub>/bhp-hr and you can only achieve 2.0 g NO<sub>x</sub>/bhp-hr then you can only operate you engine and turbine 50% of the year. However, if you can get to 1.1 g NO<sub>x</sub>/bhp-hr you would be able to operate longer.

Q. DOES NMOGA EXHIBIT 47 AT PROPOSED 20.2.50.113 B.10 NMAC PROVIDE GREATER FLEXIBILITY AT LOWER COST? EXPLAIN.

A. Yes, it allows operators to maintain equipment in critical service and/or avoid high replacement costs or LEC retrofits through fleetwide averaging.

Q. BASED ON THE TESTIMONY OF MS. KUEHN AND MR. PALMER IN EXHIBIT 32, PAGES 36-37, CAN YOU DETERMINE WHETHER IT IS PERMISSIBLE TO TAKE A UNIT OUT OF SERVICE, BACK TO THE SHOP FOR MAINTENANCE, AND THEN RETURN IT? WHY IS SWAPPING LIKE KIND UNITS OR SHOP REPAIR DESIRABLE TO FIELD REPAIR?

A. Units are typically removed from service and taken to a shop for maintenance. This is more common for turbines and for engines when more invasive maintenance is required, such as

top end overhauls, crankshaft replacement, line bores, main bearing replacement, etc. For the larger stationary units, it is less common for this type of unit. It is important to retain the option for operators to have the option to swing in like-kind units when major maintenance is required or allow for units to be taken out and, serviced, and returned to operation. For units that have shop based maintenance, they tend to have more thorough repairs and better operation.

Q. DOES NMOGA EXHIBIT 47, PROPOSED 20.2.50.113 B(11) NMAC, PROVIDE A CLEARER WAY TO ALLOW THIS SUPERIOR MAINTENANCE PRACTICE THAT SHOULD BE INCLUDED IN THE RULE?

A. To my recollection, the intent was to allow for temporary engines and/or turbines to be brought in and utilized to avoid downtime for units that are taken out of service for more invasive maintenance. The NMOGA redline provides more operational flexibility while not triggering more restrictive emission limits for the temporary engine and when the primary engine is brought back online.

Q. MS. KUEHN AND MR. PALMER TESTIFIED, AT EXHIBIT 32, PAGES 38-39, THAT EPA'S *STATIONARY RECIPROCATING INTERNAL COMBUSTION ENGINES UPDATED INFORMATION ON NO<sub>x</sub> EMISSIONS AND CONTROL TECHNIQUES* DOCUMENT SHOWED THAT OUT OF 476 TESTS SHOWED 97% COULD ACHIEVE 2.0 G/BHP-HR OR BETTER, BUT ONLY 75% COULD ACHIEVE 1.0 G/BHP-HR AND 25% 0.5 G/BHP-HR. IN YOUR OPINION, DOES A 75% FAILURE RATE SUPPORT A PROPOSED 0.5 G/BHP-HR STANDARD?

A. In my opinion, a 75% percent failure, shows that a blanket 0.5 g/bhp-hr NO<sub>x</sub> limit is not a technically achievable limit (on average) for existing engines to meet and it highlights the need for more realistic limits and alternative compliance plans.

Q. DOES THE NMOGA REDLINE AT PAGE 14 PROVIDE A REALISTIC AND ACHIEVABLE LEVEL OF NO<sub>x</sub> REDUCTIONS FOR EXISTING TURBINES?

A. Yes, depending on the approach taken.

Q. EXPLAIN WHY.

A. Smaller turbines, nominally below 4,000hp, can not meet the NMED proposed limit of 50 ppm NO<sub>x</sub> and should be subject to KKKK at 150 ppm NO<sub>x</sub>. There is not a technical solution available according to Solar Turbines, the primary manufacturer of this size category, and in NMED Turbine inventory spreadsheet, it accounts for 100% of turbines 1000-4000 hp. Dry low NO<sub>x</sub> is not available in this size category and according to Solar Turbines for the Saturn 10 model, and the combustion chamber is too small for water injection. Water injection hasn't been utilized as the preferred NO<sub>x</sub> reduction technology since the introduction of dry low NO<sub>x</sub> systems.

Q. MS. KUEHN AND MR. PALMER TESTIFIED, AT EXHIBIT 32, PAGE 39, ABOUT CO EMISSION LIMITS. DO THOSE LIMITS HELP OR HINDER ACHIEVING THE NO<sub>x</sub> LIMITS PROPOSED IN TABLE 1?

A. The extremely low limits of 47 ppm CO for lean burns further hinders that class of engine. The argument is that they are not a ozone precursor and since this is introduced specifically to reduce ground level ozone, then CO should not be included or else all CO should be regulated at the NSPS Subpart JJJJ level of 2.0 g CO/BHP-hr.

Q. ARE THE LIMITS IN NMOGA REDLINE, PAGE 14, FOR CO BETTER ESTABLISHED TO ASSIST ACHIEVING THE SPECIFIED NO<sub>x</sub> LIMITS THAN THE NMED LIMITS?

A. Yes, traditional rule of thumb is as NO<sub>x</sub> is reduced on a lean burn engine, combustion temperatures decrease and CO increases. This is partially due to the lower combustion temperatures resulting in incomplete combustion and reduced catalyst operating temperatures, which reduces catalyst efficiency. Raising CO to 2.0g/bhp-hr aligns the rule with NSPS Subpart JJJJ.

Q. IN MS. KUEHN'S AND MR. PALMER'S TESTIMONY ON RICH-BURN ENGINES, DID THEY EVER STATE THAT RICH-BURN ENGINES COULD ACHIEVE THESE LIMITS?

A. To my knowledge they did not state that a rich burn could achieve these limits.

Q. DOES NMOGA'S REDLINE AT PAGE 14 PRESENT A MORE TECHNICALLY APPROPRIATE NO<sub>x</sub> STANDARD FOR EXISTING RICH-BURN ENGINES?

A. To my recollection, the NMOGA redline proposed raising the rich burn horsepower limit from >500 to >1000 which is a more practically achievable horsepower range. The NO<sub>x</sub> limit between NMOGA and the proposed is the same at 0.5g/bhp-hr. It is my opinion, that lean-burn engines and rich-burn engines should be held to the same standard and a higher NO<sub>x</sub> limit for existing engines should be considered as stated in my memo. According to the NMED testimony, an EPA study indicated that less than 25% of engines in their study could actually meet 0.5 g/bhp-hr.

Q. DO YOU AGREE WITH MS. KUEHN'S AND MR. PALMER'S TESTIMONY THAT THE NMNEHC LIMIT SHOULD BE SET AT 0.7 G/BHP-HR RATHER THAN LOWER? DOES THE QUALITY OF NEW MEXICO GAS AFFECT THIS CONCLUSION?

A. 0.7 g/bhp-hr is an acceptable limit for NMNEHC and appears consistent with other regulatory agencies. Higher BTU gas that is common in New Mexico can cause issues for meeting this limit, therefore it is my opinion that NMED should take that into consideration.

Q. DO YOU AGREE WITH THE TESTIMONY OF MS. KUEHN AND MR. PALMER THAT THE GP-5 AND GP-5A RULES FROM PENNSYLVANIA ARE APPROPRIATE FOR NEW SPARK EMISSION ENGINES IN NEW MEXICO? WHY OR WHY NOT?

A. I don't agree that GP-5 and GP-5A are appropriate for NM new spark emission limits as PA only requires 0.3g NO<sub>x</sub>/hp-hr for new lean burn engines >2,370HP. Additionally, there are no lean burn engines that can meet the proposed NM limits of 0.3 g NO<sub>x</sub>/bhp-hr from 1000-1875 bhp. Smaller lean burn engines in the 500-1000 bhp range can be a challenge to meet 0.5g

NOx/bhp-hr as LEC options are either not available and/or applicable or too costly on a dollars/hp range to be utilized. SCR is not a simple catch all as there are significant cost and operational challenges with this technology. Anecdotally, the use of this SCR is very limited within the oil and gas industry, specifically on reciprocating engines in gathering service.

Q. DOES THE NMOGA REDLINE AT PAGE 15 SET FORTH A MORE APPROPRIATE LIMIT FOR NEW SPARK IGNITION ENGINES? WHY?

A. To my recollection, NMOGA proposed limits for new spark ignition engines that were more practically achievable, by identifying the various HP tiers and engine classes that are reasonably available.

Q. IN YOUR TESTIMONY YOU STATED THAT DURING THE PENNSYLVANIA GP-5 RULE DEVELOPMENT THERE WERE NO TURBINES IN THE 1000-5000 HP RANGE INSTALLED ON OR AFTER FEBRUARY 1, 2013 BUT PRIOR TO AUGUST 8, 2018 SO NO EXISTING UNITS WERE AFFECTED SO IT DID NOT COME TO LIGHT THAT NOX EMISSION STANDARDS IN THIS SIZE CATEGORY ARE NOT TECHNICALLY ACHIEVABLE. CAN YOU PROVIDE ADDITIONAL CONTEXT AND THE SOURCE OF THIS INFORMATION?

A. I am not personally familiar with the impact of GP-5 on turbines in Pennsylvania, however, in discussion with Solar Turbines, it was stated that during the development of GP-5, no turbines in the 1000-4000 range were subject to the rule so it wasn't immediately apparent that the limit set forth was unachievable. Upon investigation of sales information with Solar, it was confirmed that 3 turbines (Centaur 40, 4700HP) were sold in this size category during the 2013-2018 timeframe but that were all capable of of SoLoNOx. This is because the 1000-5000HP size category splits a size offering category with Solar. The issue with the GP-5 rules is that no Solar Saturn turbines (1600HP) were sold in this timeframe so no impacted units were in PA to comply. Solar Turbines are the primary supplier of turbines in this HP range and, in NM, account for 100% of turbines in that operating range (based upon NMEDs turbine inventory spreadsheet.)

Q. THE NATIONAL PARK SERVICE IN THEIR TECHNICAL TESTIMONY POWERPOINT IN SLIDE 22 RECOMMENDED LIMITS FOR ALL NEW AND EXISTING RICH BURN ENGINES >500 HP MEET A LIMIT OF 0.2 G NOx/HP-HR. IS THIS ACHIEVABLE?

A. I don't have any experience maintaining NOx limits this low on a rich burn. In theory, the proposed limit is technically possible, but in practice this is a technically infeasible target. There are significant challenges and costs associated with such an extremely low limit. As emission limits on a rich burn become more stringent, the necessary tight operation of AFR control becomes more and more critical, which is challenged with variable fuel, catalyst degradation (especially in sour service) and variable load conditions. For all of NPS's emission recommendations below 1000 HP, this argument has been raised and refuted in other rulemakings (e.g., Colorado) echoing that an extremely low NOx limit may be initially achieved, but cannot be met over time due to many factors including catalyst degradation, AFR drift, and

1 other parameters. NMOGA Exhibit 54, provides an example of this argument that was made  
2 during the Colorado rule making.

3 Q. THE NATIONAL PARK SERVICE IN THEIR TECHNICAL TESTIMONY  
4 POWERPOINT IN SLIDE 22 RECOMMENDED LIMITS FOR ALL NEW AND EXISTING  
5 RICH-BURN ENGINES > 100 HP AND < 500 HP TO MEET 0.25 G NO<sub>x</sub>/HP-HR. IS THIS  
6 ACHIEVABLE AT REASONABLE COST?

7 A. No I don't believe is it achievable at a reasonable cost. The reality is that most small  
8 horsepower rich burns are post-2006 vintage which means they likely already have NSCR  
9 installed and are not considered uncontrolled, i.e. the annual tonnage. It also creates a significant  
10 operational burden of expanding annual compliance testing for a much larger engine inventory,  
11 which is not practically feasible. Reference NMOGA Exhibit 54, provides an example of this  
12 argument that was made during the Colorado rule making.

13  
14 Q. THE NATIONAL PARK SERVICE IN THEIR TECHNICAL TESTIMONY  
15 POWERPOINT IN SLIDE 22 RECOMMENDED THAT RICH-BURN ENGINES <100 HP  
16 MEET A LIMIT OF 1 G NO<sub>x</sub>/HP-HR. IS THIS ACHIEVABLE AT REASONABLE COST?

17 A. In my opinion, this testimony is completely impractical. Nearly every rich burn in  
18 service is operating with NSCR making the criteria pollutants already low such that this  
19 proposed limit will have negligible impact on ground level ozone generation. It is unknown if  
20 this limit is technically achievable. Engines in stop/start service in this low horsepower range are  
21 more likely to be able to meet this limit.

22 Q. THE NATIONAL PARK SERVICE IN THEIR TECHNICAL TESTIMONY  
23 POWERPOINT IN SLIDE 23 RECOMMENDED THAT EXISTING LEAN-BURN ENGINES  
24 <= 100 HP MEET 2.0 G NO<sub>x</sub>/HP-HR. IS THIS ACHIEVABLE AT REASONABLE COST?

25 A. I am not aware of any lean burn engines in this horsepower range. To my knowledge,  
26 small horsepower natural gas engines are entirely (or nearly) rich-burn engines, and post-2006  
27 units already have NSCR installed.

28 Q. THE NATIONAL PARK SERVICE IN THEIR TECHNICAL TESTIMONY  
29 POWERPOINT IN SLIDE 23 RECOMMENDED THAT EXISTING LEAN-BURN ENGINES  
30 >100 HP AND < 500 HP MEET A LIMIT OF 1.0 G NO<sub>x</sub>/HP-HR. IS THIS ACHIEVABLE AT  
31 REASONABLE COST?

32 A. In most cases, it is my opinion that this is not achievable. From my understanding in  
33 discussion with operators and engine providers, in many cases, existing engines already have all  
34 applicable and available LEC technology and cannot achieve less than 2.0 g NO<sub>x</sub>/HP-Hr. and  
35 certainly wouldn't be cost-effective.

36 Q. THE NATIONAL PARK SERVICE IN THEIR TECHNICAL TESTIMONY  
37 POWERPOINT IN SLIDE 23 RECOMMENDED THAT NEW LEAN-BURN ENGINES <=

500 HP MEET A LIMIT OF 1.0 G NO<sub>x</sub>/HP-HR. IS THIS ACHIEVABLE AT REASONABLE COST?

A. No, based on my knowledge of engines in this HP range, this category is designed to meet NSPS 2.0 g NO<sub>x</sub>/BHP-hr and LEC technology is not available for further reduction.

Q. ARE THE PROPOSED NMED EMISSIONS LIMITS FOR THE EXISTING TURBINES ACHIEVABLE. THESE ARE 25 PPMVD @ 25% O<sub>2</sub> (1000-5000 HP), 15 PPMVD @ 25% O<sub>2</sub> (5000-60,000 HP), 9 PPMVD @ 25% O<sub>2</sub> (>60,000 HP)]

A. Based on my discussions with Solar turbines and operators of turbine, these are not generally achievable emission levels. For the small horsepower range, there is not a technical solution available for these turbines to meet 50 PPM NO<sub>x</sub> as proposed by NMED, let alone 25 PPM NO<sub>x</sub>. Solar is the primary manufacturer of turbines in this size class. As for the other size ranges, many are older vintages that do not have low NO<sub>x</sub> retrofit technology available.

Water injection is often discussed as a simple option to achieve these levels NO<sub>x</sub> reductions, but, aside from being an obsolete technology, it is technically infeasible either from combustion size limitations (i.e. you risk turbine damage/blow through) or due to the significant deionized water supply requirements is not practical. Where Solar Turbines does offer water injection, 25 ppm NO<sub>x</sub> is not an available emissions level, but rather 42 ppm NO<sub>x</sub> and higher depending on the model and rating. Estimates of required water volume, using generalized parameters to estimate, nearly 500,000 gallons/1,000 HP/ year. This equates to extremely large volumes of water for large HP turbines. And because deionized water is required, dedicated water plants, in the middle of the desert during a drought would be required.

General Estimate:

Multiple sources provided below by EPA indicate the appropriate water to fuel ratio (by weight) for water injection is around 1:1.

[AP-42, Vol. I, 3.1: Stationary Gas Turbines \(epa.gov\)](#)

[Appendix B.17 Water or Steam Injection Review Draft April 2002 \(epa.gov\)](#)

Converting from volume of natural gas to pounds (lbs) of natural gas in SCF

Volume of gas: 50,000 standard cubic feet (SCF) at 60°F and 14.7psia (or 50 MCF)

Molecular weight (MW) of natural gas: 20 lbs/lb-mole

Ideal gas law conversion factor: 379.3 SCF/lb-mole

$$\text{Weight in lbs of total gas} = (\text{SCF}) * (1 \text{ lb-mole} / 379.3 \text{ SCF}) * (\text{MW of gas in lbs/lb-mole})$$

Weight (mass) of natural gas: 2636.4 lbs

900 BTU/SCF

8.3 lbs/gal of water

Using 1:1 Water to Fuel Ratio = 6.3 gal/MCF

Assume turbine fuel consumption of 800 BTU/BHP-HR

Water required for 1000 HP = 500,000 gal water/year  
 Water required for 1000 HP = 7,800,000 gal water/year

#### IV. COMPRESSOR SEALS

Q. IN THEIR TESTIMONY IN EXHIBIT 32, PAGES 60 AND 63, MS. KUEHN AND MR. PALMER TALK ABOUT PLACING ROD PACKING ON RECIPROCATING COMPRESSORS UNDER NEGATIVE PRESSURE. IS THIS SAFE?

A. As I understand, when negative pressure is used as a control system you have the potential to introduce oxygen which can be a safety issue as well as issue for meeting gas specs to midstream providers (for upstream producers).

Q. DOES A SIMILAR SAFETY ISSUE EXIST WITH PLACING CENTRIFUGAL WET SEALS UNDER NEGATIVE PRESSURE, AS MS. KUEHN AND MR. PALMER RECOMMEND IN EXHIBIT 32, PAGE 62?

A. While I am not specifically familiar with centrifugal wet seals, I understand that when negative pressure is used as a control system you have the potential to introduce oxygen which can be a safety issue as well as issue for meeting gas specs to midstream providers (for upstream producers).

Q. CAN WE INSTALL NON-RESETTABLE HOUR METERS ON ALL COMPRESSORS?

A. To my knowledge, it isn't an issue to install non-resettable meters on compressors and is already used by most operators.

#### IV. HEATERS

Q. IN NMED EXHIBIT 32, MS. BISBEY-KUEHN AND MR. PALMER TESTIFY THAT CO EMISSIONS FROM HEATERS ARE IMPORTANT TO REGULATING HEATER COMBUSTION AND CONTROLLING OZONE. DO YOU AGREE?

A. Similar to engines and turbines, and consistent with my testimony, CO is not a precursor to ground level ozone formation and associated limits for heaters should be removed. As presented by NMED, this rule is specifically targeted to address areas where ozone concentrations exceed 95% of the standard. Removal of CO aligns with the stated intent of these rules.

In addition, CO and NOx are related such that reductions in CO may cause an increase in NOx due to the nature of combustion and pollutant formation. I am not aware of any data NMED has presented to demonstrate that the CO limit will not unduly interfere with achieving the NOx limit or will not otherwise cause increases in NOx emissions, which generally have a more detrimental impact than CO emissions on ozone according to ERG's model.

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By: /s/ Justin Lisowski  
Justin Lisowski