STATE OF NEW MEXICO
BEFORE THE ENVIRONMENTAL IMPROVEMENT BOARD

IN THE MATTER OF:

PROPOSED NEW REGULATION
20.2.50 Oil and Gas Sector — Ozone Precursor Pollutants **No. EIB 21-27(R)**

PRE-FILED TECHNICAL TESTIMONY OF MR. JOHN DUTTON, A WITNESS ON BEHALF OF THE GAS COMPRESSOR ASSOCIATION

I. Introduction to My Testimony

My name is John Dutton. I am testifying as a technical witness on behalf of The Gas Compressor Association (The GCA) in this proceeding. My testimony supports The GCA's proposed amendments to the New Mexico Environment Department's (Department) proposed regulation set out as 20.2.50.113.B(2) NMAC and 20.2.50.113.B(3) NMAC in the Department's proposed rule 20.2.50 NMAC (Proposed Rule). The GCA's proposed amendments to the parts of the Proposed Rule that are the subject of my testimony, the emission standards for engines, are set forth in redline in GCA Exhibit 1.

This testimony begins with an overview of my credentials. I will then discuss the Department's proposed engine emissions standards, as set forth in the Proposed Rule at 20.2.50.113.B(2) NMAC and 20.2.50.113.B(3) NMAC and The GCA's proposed amendments thereto. As discussed in this testimony, The GCA's proposed changes to these subsections seek to preserve the Department's central goal of reducing NOx emissions while better accounting for practical realities involving the availability and use of lean-burn engine designs, and avoiding prohibitive cost burdens that would bear little or no relationship to the goal of promoting emission reductions.

I will specifically offer testimony regarding the proposed NOx emissions limits for lean-burn engines over 1000 horsepower in 20.2.50.113.B(2), Table 1 NMAC and the proposed horsepower break in 20.2.50.113.B(3), Table 2 NMAC, and offer testimony to support why four-stroke lean-burn engines in Table 2 that are required to meet 0.3 g/bhp-hr NOx should start at 1875 horsepower rather than 1000 horsepower, as currently proposed in the rule, to accurately reflect the capabilities of lean-burn engines. I will further explain in my testimony engine driver selection as it relates to natural gas compressor packages and the importance of having viable options from more than one manufacturer and that some post combustion controls, *i.e.,* selective catalytic reduction, for lean-burn engines are not economically viable. I will go on to explain why retrofitting existing engines can be cost prohibitive. Finally, I will explain why the NOx requirements for lean-burn engines as set forth in the Proposed Rule at 20.2.50.113.B(2), Table 1 NMAC and 20.2.50.113.B(3), Table 2 NMAC should be revised, and why the Department's proposed inclusion of "Construction" as defined in the rule and "Installation" as a criteria in Table 1 and Table 2 is not appropriate. The applicability of the emission standards should be based on an engine's date of manufacture or reconstruction.

II. Statement of My Qualifications and Relevant Experience.

My resume is attached as GCA Exhibit 13. I received my Bachelor of Science degree in mechanical engineering from the University of Oklahoma in 1991. Since 1991, I have worked in the natural gas compression and midstream pipeline segments. I am a Professional Engineer in the State of Oklahoma.

I began my career as an engineer with a midstream pipeline company in Oklahoma. During that time, I designed pipeline segments and facilities, including the selection of natural gas compressor packages. I also performed reserve estimates and calculated discounted cash flow economics. In 1998, I joined J-W Operating Company (now J-W Energy Company). For the last twenty-three years, I have served in various capacities for the J-W Energy family of companies, working in financial analysis, operations and executive roles in our midstream gathering and compression services businesses. I currently work as President of J-W Power Company, a subsidiary of J-W Energy Company. My current job responsibilities include determining and implementing short and long-term strategic plans to create value for all stakeholders. I am responsible for all aspects of leading and managing the company including safety, daily operations, sales, financial performance, strategic planning, regulatory compliance, economic evaluation and investment of capital.

J-W Power Company is an industry leader in the natural gas compressor business. J-W Power Company has been involved in natural gas compression since 1966, and currently operates one of the largest privately-owned compression leasing fleets in the United States. J-W and other compression services providers rely heavily on the types of engines that are regulated under the Proposed Rule. Through my many years at J-W Power Company, I have become intimately familiar with these engines, their specifications, and how they perform, and how they are regulated. Throughout my career, I have dealt with the engines regulated by the Proposed Rule on a daily basis, both as a consumer who purchases these engines from the manufacturers, and as part of a company that manufactures natural gas compression packages that incorporate those engines and as a compression services provider that must rely on those engines to provide reliable and compliant compression services for our customers.

The GCA is an association whose members include the owners and operators of the engine-driven natural gas compressors that are utilized to provide compression services to oil and gas producers and to midstream companies in the oil and gas industry in New Mexico and throughout the United States. The GCA members serve a vital function in the New Mexico oil and gas industry, and The GCA members' operations in New Mexico are affected by many parts of the Proposed Rule. J-W Power Company is a member of The GCA. In The GCA, I have served as chairman of the environmental committee, as a member of the board of directors, and, in 2017, as chairman of the board.

III. The Proposed Rule's Emission Standards for Existing and New Engines in 20.2.50.113.B(2)&(3) NMAC

(i) The Proposed Emissions Standards for New Engines Set Forth in 20.2.50.113.B(3) NMAC Limit Engine Driver Selection.

There are two major engine manufacturers with established natural gas fired reciprocating engines in the natural gas compression industry for engines with over 1000 horsepower. Those manufacturers are Waukesha, whose primary offerings utilize rich-burn technology, and Caterpillar, whose offerings utilize lean-burn technology.

Lean-burn technology achieves low emissions levels by controlling the actual combustion process, but has limits to the level it can achieve based on physical size constraints which primarily affects the ability to use pre-combustion chamber technology. *See* Pre-filed Technical Testimony of Vic Sheldon, GCA Exhibit 9. The newest larger bore engines have more capability and can achieve the Department's proposed 0.3 g/bhp-hr NOx level as set forth in 20.2.50.113.B(3) NMAC, but these larger bore engines are 1875 horsepower and larger and are 2015 and newer vintage. The Department's proposal in 20.2.50.113.B(3), Table 2 NMAC requiring new four-stroke lean-burn engines over 1000 horsepower to meet 0.3 g/bhp-hr NOx is not consistent with the available technology and would effectively eliminate the use of four-stroke lean-burn engines between 1000 and 1875 horsepower.

Rich-burn technology utilizes precise air-fuel ratio control and must use post combustion treatment via non-selective catalytic reduction (NSCR). The rich-burn technology is scalable down to smaller engines with a reasonable cost per ton of NOx reduction, and with the available NSCR control technology can achieve the emission standards in 20.2.50.113.B(2), Table 1 NMAC or 20.2.50.113.B(3), Table 2 NMAC. As such, the remainder of my testimony applies only to four-stroke lean-burn spark ignited engines.

Both rich-burn and lean-burn technologies have certain advantages, and neither technology should be excluded as part of this rulemaking process. Historically, competition within the space has driven continuous improvement; including technology utilized to reduce emissions and continued support by the manufacturers. The choice of an engine manufacturer and associated combustion technology is a complicated decision and is dependent upon many variables. First, the engine must be matched to the driven equipment by power and speed ratings. Site conditions such as elevation and fuel quality can affect the performance of the engine and result in power being de-rated under some circumstances. Transportation and installation constraints are also part of site conditions, and can limit the ability to use larger engines. Second, other factors such as expertise of operator, supply chain quality, manufacturer support and life cycle costs must be considered. The economic life of a reciprocating natural gas compressor stationary engine this size is 20 to 50 years with scheduled overhauls throughout the life.

The proposed NOx emission standard for new engines would significantly interfere with the market by effectively eliminating the use of an entire class of reliable, efficient, high-performing engines that are important to the compression services providers that operate in New Mexico. The Department should revise the NOx standard in the final rule to avoid forcing a choice on market participants and banning a group of engines that meet and exceed federal standards and operate in compliance with emissions standards across the rest of the country.

(ii) It is Not Economically Viable to Use Post-Combustion Controls to Comply with the Department's Proposed New Engine Emission Standards Set Forth in 20.2.50.113.B(3) NMAC.

The proposed emission standards in Table 2 included in the Proposed Rule at 20.2.50.113.B(3) NMAC would effectively eliminate the lean-burn option from 1000 bhp to 1875 bhp, because the technology to achieve 0.3 g/bhp-hr NOx does not exist without post-combustion controls. The Proposed Rule does provide optional limits for NOx emissions "with control" (i.e., using add-on emission controls). For lean-burn engines, the method for post-combustion control is Selective Catalytic Reduction (SCR). SCR is not operationally or economically viable for the lean-burn engines regulated by the Proposed Rule. The technical spreadsheet supplied by the Department "ICE-Reductions-andCosts-NO2-6-4-21.xls" (NMED Calculations), GCA Exhibit 14, estimates the cost for SCR are approximately $10,206 to $13,555 per ton of NOx on a lean-burn engine of this size range, compared to $101 to $112 per ton of NOx for rich-burn engines with NSCR. The relevant provisions of this table are set forth below in Image 1. These cost estimates are suspect, as very little actual cost data is available because of the impracticable nature of SCR in engines of this size range and the estimates are founded on application of SCR to compression-ignition (diesel) engines. Even if those lean-burn engine cost figures are assumed to be accurate, however, at well over $10,000 per ton of NOx reduction, they represent an unreasonable cost of control.

Image 1

Cost of Control Per Ton Pollutant Reduced for Spark Ignited Internal Combustion Engines. From Bradley Nelson, Alpha-Gamma Technologies, Inc., to Jaime Pagán, EPA/OAQPS/ESD/Combustion Group. May 11, 2006. EPA-HQ-OAR-2005-0030-0060. p. 3.

Horse Power	SCR for Lean Burn Engines ($/ton)	NSCR for Rich Burn Engines ($/ton)
750-1200	$ 10,206	$ 109
1200-2000	$ 13,555	$ 101
>2000	$ 15,813	$ 112

(iii) The Proposed Rule's Emission Standard for Existing Lean-Burn Engines is Based on Faulty Assumptions.

Based on the Department's conclusions as set forth in another excerpt of the NMED Calculation Spreadsheet, Image 2 below, it appears that the Department is assuming that Low Emission Combustion (LEC) technology can be applied to existing four-stroke lean-burn engines that are less than 3,000 horsepower (as a retrofit) to reduce the NOx emissions to the rule limits proposed in 20.2.50.113(B)(2) NMAC.

Image 2

See the "%Reductions" tab for the reduction assigned to each engine based on age, horsepower, controls, and current regulation.

Engine Type	Control Type	Cost Factor Reference
2SLB < 3,000 hp	LEC for NOX	CSAPR TSD and the EPA's Control Strategy Tool (CoST)
4SLB < 3,000 hp	LEC for NOX	CSAPR TSD and the EPA's Control Strategy Tool (CoST)
2SLB > 3,000 hp	LEC for NOX	INGAA
4SLB > 3,000 hp	LEC for NOX	INGAA
Rich Burn	AFR/NSCR for NOX & VOC	2010 NESHAP for RICE
Compression Ignition	SCR for NOX	
	For costs, if engines type is unknown from the SCC, we assumed it was 4SLB for engines >= 1,000 HP.	

The reference for the LEC cost equation in the NMED Calculations is approximately twenty years old (circa 2001). At that time, it was assumed that LEC could be applied and achieve an 80% NOx reduction from a starting point of 9.0 g/bhp-hr. The reference cited by the NMED Calculations, Technical Support Documentation for the Cross-State Air Pollution Rule for the 2008 Ozone NAAQS Docket ID No. EPA-HQ-OAR-2015-0500, GAC Exhibit 11, states "*LEC* *are described as retrofit kits that allow engines to operate on extremely lean fuel mixtures to minimize NOx emissions. The LEC retrofit may include: (1) redesign of cylinder head and pistons to improve mixing (on smaller engines), (2) Precombustion chamber (on larger engines), lower cost, simple versions, (3) Turbocharger, (4) High energy ignition system, (5) Aftercooler, and (6) Air-to-fuel ratio controller. (CSAPR TSD, p. 5-3).*" GAC Exhibit 11 at p. 5-3. Although the cost recovery factor was updated to current assumptions and the capital cost has been escalated to represent current levels, the underlying assumption that the LEC retrofit technology can still be applied to these engines is false. The vast majority of high speed four-stroke lean-burn engines in the natural gas compression space have been utilizing the LEC technology for years and most are capable of 2.0 g/bhp-hr, which approximates the 80% reduction from the original 2001 assumption of 9.0 g/bhp-hr.

The above-referenced EPA document that the Department relies upon for its description of LEC, GCA Exhibit 11, recognizes the limitation of using pre-combustion chambers on smaller engines. The use of pre-combustion chambers is significant, because it enables the engine to use an extremely lean mixture and thus achieve the lowest possible NOx emissions level. The Pre-filed Technical Testimony of Vic Sheldon, CGA Exhibit 9, details the limitation of using pre-combustion chambers on smaller engines as applied to Caterpillar G3500J LE and G3600 A4 engine families. The engine family distinction is important when determining the threshold to achieve 0.3 g/bhp-hr NOx emissions for new four-stroke lean-burn engines for 20.2.50.B(2), Table 2 NMAC.

As shown in Image 3 below, another excerpt from the NMED Calculation Spreadsheet, GCA Exhibit 14, the Department's calculations appear to use AP-42 Emissions factors of 0.98

g/bhp-hr for uncontrolled emissions factors which further shows that LEC has already been applied.

Image 3

AP-42 Emission Factors for NOx Emissions for Natural Gas Fired Reciprocating Engines <90% of Load:			These were the EF's used to e
Engine Type:	lb/MMBtu	g/hp-hr	Reference (from AP-42, July 2000 edition, section 3.2 Natural Gas-fired Reciprocating Engines):
2 Stroke Lean Burn	1.94	2.24	TABLE 3.2-1 UNCONTROLLED EMISSION FACTORS FOR 2-STROKE LEAN-BURN ENGINES (SCC 2-02-002-52)
4 Stroke Lean Burn	0.847	0.98	Table 3.2-2. UNCONTROLLED EMISSION FACTORS FOR 4-STROKE LEAN-BURN ENGINES (SCC 2-02-002-54)
4 Stroke Rich Burn	2.27	2.62	Table 3.2-3. UNCONTROLLED EMISSION FACTORS FOR 4-STROKE RICH-BURN ENGINES (SCC 2-02-002-53)

It appears that the Department is assuming that 0.5 g/bhp-hr NOx on existing engines can be achieved through the further application of LEC ("further" because the starting point for this calculation already assumes that LEC is employed). The assumed reduction of NOx from 0.98 g/bhp-hr to 0.5 g/bhp-hr would thus result in a 49% reduction as provided in the Reduction Matrix from the NMED Calculations as shown in Image 4 below.

Image 4

Reduction matrix			
NG	Controlled by SCR / NSCR /		0%
NG	Uncontrolled	LeanBurn 4-stroke >1000	49%
NG	Uncontrolled	LeanBurn 2-stroke >1000	78%
NG	Uncontrolled	RichBurn >1000	81%
NG	NSPS JJJJ Before 2011	LeanBurn 4-stroke >1000	49%
NG	NSPS JJJJ Before 2011	LeanBurn 2-stroke >1000	75%
NG	NSPS JJJJ Before 2011	RichBurn >1000	75%
NG	NSPS JJJJ 2011 +	LeanBurn 4-stroke >1000	49%
NG	NSPS JJJJ 2011 +	LeanBurn 2-stroke >1000	50%
NG	NSPS JJJJ 2011 +	RichBurn >1000	50%
Diesel	Controlled	>1000 hp	55%

The ability to apply LEC technology again to achieve further reductions in NOx from existing lean-burn engines greater than 1000 bhp varies drastically based on the make and model of the engine. The Department should not base the engine NOx standards on an assumption that LEC can be broadly applied again, or that it would reduce NOx emissions by 49%.

Retrofit control technology on an existing lean-burn engine in a compression package or replacement of an engine with a different engine may not be technically feasible or physically possible. A natural gas compressor package is designed and built around a specific engine. The engine pedestal has a specific size and height to precisely position the engine centerline with the compressor and to accommodate the specific engine mount locations which are unique to each engine model. In addition, the overall package size (width and length) are built to accommodate a specific combination of engine and compressor combination. The cooler for the package is also designed around the heat rejection characteristics of the engine. Converting an engine to a different combustion design usually results in changes to the cooler and associated piping which adds significant cost.

In addition to heat rejection and cooler design factors, installing a different engine type is likely cost prohibitive especially if the replacement engine is physically larger. In some cases, the cost to retrofit exceeds the cost of a new engine. For example, a conversion of a G3606 A3 (1775 horsepower with 0.5 g/bhp-hr NOx) to a G3606 A4 (1875 horsepower with 0.3 g/bhp-hr NOx) along with the necessary package modifications is approximately 120% of the cost of a new engine. The high cost is driven by the significant differences in engine components including the turbocharger, aftercooler, pistons, rods, camshafts, inlet air connections and exhaust outlet.

(iv) Consequences of the Proposed 20.2.50.113.B(2) NMAC NOx Emission Standards for Existing Engines.

Because SCR is not practicable and LEC is already incorporated in the vast majority of the high speed lean-burn engine population, the result of the Department's proposed NOx emission standards for engines at 20.2.50.113.B(2) NMAC would be wide-spread elimination and replacement of *existing* lean-burn engines above 1000 bhp. Table 1 and the timeline set forth in proposed 20.2.50.113.B(2) NMAC effectively mandates replacement of a large number of "existing" lean-burn engines that employ LEC to reduce NOx emissions, but nonetheless are not capable of achieving the NOx limits as-proposed. Table 1 of 20.2.50.113.B(2) NMAC should be amended to reflect NOx standards for existing engines that are consistent with the application of LEC technology as shown below:

Table 1 - EMISSION STANDARDS FOR NATURAL GAS-FIRED SPARK-IGNITION ENGINES MANUFACTURED OR ~~CONSTRUCTED,~~ RECONSTRUCTED~~, OR INSTALLED~~ BEFORE THE EFFECTIVE DATE OF 20.2.50 NMAC.

Engine Type	Rated bhp	NOx	CO	NMNEHC (as propane)
Lean-burn	> 1,000	~~0.50~~2.0 g/bhp-hr	47 ppmvd @ 15% O_2 or 93% reduction	0.70 g/bhp-hr
Rich-burn	> 1,000	0.50 g/bhp-hr	0.60 g/bhp-hr	0.70 g/bhp-hr

(v) Consequences of the Proposed 20.2.50.113.B(3) NMAC NOx Emission Standards for New Engines.

If the Proposed Rule is adopted in its current form, operators who require engines from 1000 to 1875 bhp would not even be able to purchase a *new* lean-burn engine that complies with the applicable NOx emission standard. Instead, they would have to purchase new rich-burn engines or utilize multiple smaller engines on one location to achieve the combined horsepower needs. Alternatively, a larger-than-necessary engine that is capable of achieving the required emissions levels could be used and operated at partial load. However, this would result in unnecessary and wasteful capital investment and increased operating expenses. Operating an engine at partial load also causes challenges with emissions compliance testing and creates permitting issues because potential to emit would still be based on nameplate power. Combining gas streams or nodes to enable the additional horsepower to be utilized for the sole reason of utilizing larger engines would rarely be economical. By eliminating a whole class of engines, the proposed NOx standard would effectively shrink the market for consumers of new engines for use in New Mexico. Moreover, it would create a host of unnecessary operational challenges for compressor service providers seeking a work-around, particularly in the many situations where a lean-burn engine between 1000 and 1875 horsepower is the appropriate size of engine. Therefore, 20.2.50.113.B(3), Table 2 NMAC should be amended as follows:

Table 2 - EMISSION STANDARDS FOR NATURAL GAS-FIRED SPARK-IGNITION ENGINES MANUFACTURED OR ~~CONSTRUCTED,~~ RECONSTRUCTED~~, OR INSTALLED~~ AFTER THE EFFECTIVE DATE OF 20.2.50 NMAC.

Engine Type	Rated bhp	NOx	CO	NMNEHC (as propane)
Lean-burn	>500 - <~~1000~~1,875	0.50 g/bhp-hr	0.60 g/bhp-hr	0.70 g/bhp-hr
Lean-burn	≥ ~~1000~~1,875	0.30 g/bhp-hr uncontrolled or 0.05 g/bhp-hr with control	0.60 g/bhp-hr	0.70 g/bhp-hr
Rich-burn	> 500	0.50 g/bhp-hr	0.60 g/bhp-hr	0.70 g/bhp-hr

(vi) Applicability of the Engine Emission Standards Should Be Based Only on Date of Manufacture or Reconstruction.

As proposed, 20.2.50.113.B(2), Table 1 NMAC and 2.2.50.113.B(3), Table 2 NMAC currently determine applicability based on whether an engine is "constructed, reconstructed, or installed" (emphasis added) either before (Table 1) or after (Table 2) the effective date of the rule. "Construction" is defined in the Proposed Rule at 20.2.50.7.J NMAC as "…fabrication, erection, installation or relocation of a stationary source, including but not limited to temporary installations and portable stationary sources." This definition and how the Proposed Rule determines new or existing standard applicability is not consistent with how the EPA determines applicability for spark-ignition engines. EPA's standards for spark-ignition engines in 40 CFR Part 60, Subpart JJJJ bases applicability on the "date of manufacture" – which is when an engine is originally produced, or when it is reconstructed. See 40 CFR § 60.4230 (basing applicability on manufacture date) and 40 CFR § 60.4248 (defining "date of manufacture").

The language in the Proposed Rule would consider an engine to be "new" (and therefore subject to the new engine emission standards in Table 2 of 20.2.50.113.B(3) NMAC instead of the existing engine emission standards in Table 1 of 20.2.50.113.B(2) NMAC) if it is relocated. As discussed in the Pre-filed Technical Testimony of Vic Sheldon, GCA Exhibit 9, the technology to achieve 0.3 g/bhp-hr NOx level for lean-burn engines is built into the engine (and the remainder of the package as well, as described in my testimony above) and it can be cost prohibitive if not technically infeasible to retrofit older engines with technology that was not part of the original design. An engine should not be considered "new" just because the engine is moved and "installed" at a new location. Relocation of compressor packages is common, and nothing about the relocation should provide a basis for converting the engine in that package from an existing engine into a new engine subject to significantly more-stringent emission standards.

The GCA has proposed to change the applicability triggers for new and existing engine emission standards under the Proposed Rule to make them consistent with the applicable federal standards and to avoid the arbitrary and unreasonable new-source trigger based on "installation" at a new location. "Installed" should not be a criteria for determining if an engine is "new" as opposed to "existing." For these reasons, the amendments to 20.2.50.113.B(2), Table 1 NMAC and 20.2.50.113.B(3), Table 2 NMAC as set forth above, changing “Constructed” to “Manufactured” and removing the word “Installed,” is appropriate.

Determining the applicability of emission standards for engines only makes sense if based on the date of manufacture or reconstruction. The GCA’s recommended horsepower levels and NOx limits in 20.2.50.113.B(2), Table 1 NMAC and 20.2.50.113.B(3), Table 2 NMAC are predicated on and dependent upon these changes to how applicability of the emission standards is determined. If the Department does not change the engine applicability to remove the concepts of “constructed” and “installed” as suggested, then the Department should provide emission limits specific to individual manufacturers, models and vintage, because these factors affect an engine’s ability to achieve a given NOx limit.

IV. Conclusion

The Department’s proposed emissions standards for natural gas-fired spark-ignition four-stroke lean-burn engines as set forth in 20.2.50.113.B(2), Table 1 NMAC and 20.2.50.113.B(3), Table 2 NMAC of the Proposed Rule should be amended as set forth in GCA Exhibit 1 to accurately reflect the capabilities of four-stroke lean-burn engines of this size. The GCA’s proposals are dependent upon also changing “Constructed” to “Manufactured” and removing “Installed” from the description of the tables.

This concludes my direct technical testimony in this matter.