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GAS COMPRESSOR ASSOCIATION

June 3, 2009

Air and Radiation Docket and Information Center
U.S. Environmental Protection Agency
Attention: Docket ID No. EPA–HQ–OAR–2008–0708
Mailcode-6102T
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

Re: GCA Comments on Proposed Rule for National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines

Dear Docket Clerk:

The Gas Compressor Association (GCA) is a trade organization for the natural gas compression industry. Our member companies manufacture and package natural gas compressor packages and related components. Many members also own and operate rental fleets of natural gas compressors. As of March, 2009, the domestic U.S. fleets of engines owned by the member companies of the GCA totaled approximately 14,700 engines and slightly over 5.3 million horsepower. The engines on these natural gas compressors are spark ignited engines which primarily burn wellhead or field natural gas. In the context of these comments, any references to engines would be limited to spark ignited engines fueled by natural gas driving reciprocating or screw type natural gas compressors. Although many of the comments would apply to other types of engines and driven processes, the comments have not been reviewed for accuracy outside of the natural gas compression industry. The GCA has chosen to provide comments on five main topics:

1. The location of the engines owned by our member companies as it relates to rural versus urban areas and the merits of a subcategory of engines commonly used in the gas compression industry.
2. The cost associated with compliance of the rule
3. Startup, Shutdown and Malfunction (SSM) requirements
4. Proposed Maintenance practices for lean burn engines less than 250 horsepower and rich burn engines less than 50 horsepower
5. Miscellaneous comments on various requirements proposed by the rule

Rural versus Urban areas

The engines in the natural gas compression industry are located in and around areas that produce natural gas. Although there is some natural gas exploration and production in urban areas, the vast majority is located in rural areas. As such, the public health benefit from control of HAP's on these rural engines is diminished. Furthermore, natural gas is one of the cleanest burning fuels and the emission levels from these engines are relatively small. The EPA should consider creating a separate subcategory of engines that are:

- Under 500 horsepower (both rich and lean burn engines)
- Located at area sources of HAP's
- Spark Ignited RICE Fueled by natural gas
- Utilized to drive compressors in the production or intra-state gathering, transportation or processing of natural gas
- Located in rural areas

The requirements for this subcategory of engines should be comprised of REASONABLE work practices and Operator developed maintenance plans that are consistent with engine manufacturer's recommendations and with control of emissions.

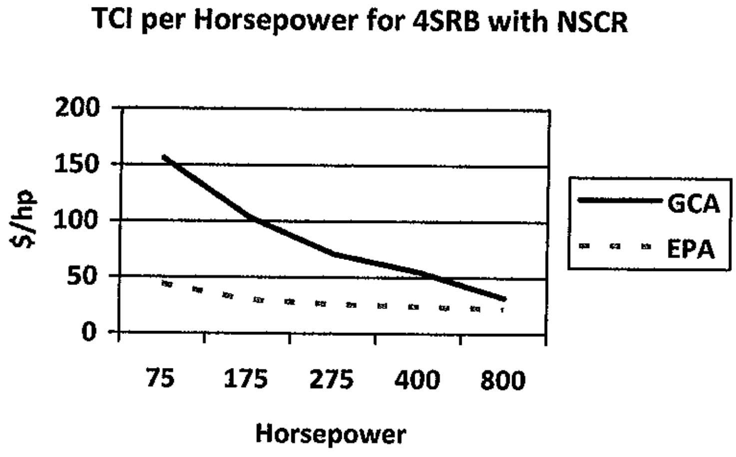
Cost to Comply with Rule

Total Capitalized Investment (TCI) and Capital Recovery Period

The cost assumed by the EPA[i] to install the equipment necessary to achieve compliance with the rule is greatly understated. Several factors contributed to this:

- The EPA used a single data point for all 4SRB engines and assumed the relationship was linear. The purchased equipment cost did not reflect all of the necessary components to perform a complete installation.
- The EPA did not adequately account for the ancillary equipment that must be installed to enable the control device(s) to operate. For example, the vast majority of engines below 500 horsepower do not have an electrical system capable of supporting Air/Fuel Ratio Controls (AFRC's). As a result, batteries and alternators must be installed on the engines to provide power to the AFRC's.
- The assumption that retrofit costs are the same as a new installation is not realistic. It is more expensive to retrofit engines with controls, especially if it is not done in a shop environment. Many engines will have to be retrofitted in the field.

Four member companies of the GCA provided capital cost estimates to install NSCR on 4SRB engines below 1350 horsepower. Of the four companies that provided data, one company did not operate engines over 500 horsepower and therefore, did not provide data for engines in the range of 500 to 1350 horsepower. All of the estimates included purchased equipment cost (PEC) and installation costs which together total direct costs (DC). However, only one company estimated indirect installation and contingency costs. For the rest, a standard factor of 30% of the PEC was assumed to reflect all of the indirect and contingency costs EXCEPT the initial performance test which was estimated directly. For the initial performance test, one estimate was applied for all engines based on commonly accepted costs. The basis for the estimate of the compliance tests is discussed in more detail under annual costs, below. The following chart shows the results of the GCA reported data compared to the EPA's estimates[ii].



In can be seen above that the EPA's assumption of cost per horsepower ($/hp) is significantly "flatter" than GCA curve and shows only a modest increase in cost per horsepower for smaller engines versus engines in the 400 to 800 horsepower range. Because of this, the EPA's assumptions significantly underestimate the cost for the smaller horsepower 4SRB engines, although the correlation is good for 4SRB engines above 800 horsepower.

The TCI to install oxidation catalysts on 4 stroke lean burn engines was also underestimated by the EPA, but to a lesser degree. There are very few 4SLB engines below 400 HP and the greatest disparity is on these smaller engines.

The majority of 2 stroke lean burn engines operated by GCA companies are integral compressor packages manufactured by AJAX. Due to the nature of this engine and the design of the oxidation catalyst, the cost is dramatically higher than the EPA estimated using their standard factor for oxidation catalyst.

The GCA estimates that the average cost required to retrofit engines with the controls necessary to comply with the rule ranges between $50.00 and $70.00 per horsepower. The range of this number is large because the exact makeup (models and horsepower) of each operator's fleet is proprietary. It is further estimated that approximately 85-90% of the total fleet represented by the GCA (5.3 million horsepower) will require retrofit. Using the midpoint of the range ($60.00 per horsepower) and an assumption of 87% of the horsepower being affected, it is estimated that it will cost $346 million dollars for the initial capital investment on just the engines owned by the GCA member companies.

The capital recovery period assumed by the EPA is also too long. The EPA analysis utilizes a capital recovery period of 20 years. The GCA believes that the recovery period should be a MAXIMUM of 10 years due to several factors:

- The economic life of the control equipment is 10 years, during which the element will still need to be replaced every 2-3 years.
- The electronic technology often becomes unsupportable in a time span significantly less than 10 years.
- It is unlikely that the regulatory environment will enable these controls to be used for 20 years. Ever increasing regulations will likely obsolete the technology before the 20 year recovery period has elapsed.

Annual Costs

The comments regarding annual costs are divided into Direct Annual Costs and Indirect Annual Costs.

Direct Annual Costs: For all horsepower classes, the EPA assumed the direct annual costs associated with maintenance to be $260 per year referencing Table 6.2-30 of the non-road diesel Regulatory Impact Analysis. This cost is considerably low compared to the actual cost of compliance for gas compression engines. Below are some of the major issues that were not accounted for or inadequately accounted for by the EPA:

1. Emissions testing on engines over 500 horsepower is required. These tests are estimated to be $3,375 for a test with formaldehyde as the surrogate and $2,200 for test requiring carbon monoxide as the surrogate. If a percent reduction method is used for compliance, these costs will be higher because the amount of equipment required to simultaneously test pre and post controls will double. The above numbers are based on the ability to test an engine in ¾ of a day which represents an average of some individual tests and some tests where multiple engines were tested as a group. By comparison, the EPA assumed $1000 per test using a portable analyzer and made the incorrect assumption that ALL engines will be tested as part of a group. (Two engines at a time if they were under 500 horsepower and three engines at a time if they were over 500 horsepower).
2. Catalyst elements need to be washed every year and replaced on an average of every 3 years. Most engines in the natural gas compression industry cannot be shut down long enough to allow the element to be shipped off for washing and returned. Therefore, a rotation of elements will likely be used. The cost to remove, ship and clean an element should be included in the direct annual costs. Furthermore, if an element is changed, it is assumed that the engine will have to be retested as per 40CFR63.6640(b) which states..."*If you change your catalyst, you must reestablish the values of the operating parameters measured during the initial performance test. When you reestablish the values of your operating parameters, you must also conduct a performance test to demonstrate that you are meeting the required emission limitation applicable to your stationary RICE.*" The EPA should clarify in the final rule, what circumstances do not require a re-test (for example equivalent replacement catalyst element in same housing). As written, the language above strongly implies that each engine must be retested when the catalyst is changed. This will result in engines being tested every year regardless of the horsepower of the engine. Therefore, it must be assumed that all engines requiring catalytic controls will be subject to annual compliance testing.
3. In addition to the labor costs for the maintenance technician to remove and re-install elements for washing or replacement there are often associated direct costs such as cranes on larger engines, and replacement parts such as gaskets and seals.
4. Engines must be shut down and restarted prior to maintenance activities. There are often two personnel involved, an operator and a maintenance technician. It should be noted that in the case of rental compression, these often represent two different companies. Many companies require on-site safety reviews prior to work being started. Equipment has to be secured to isolate energy (lock-out, tag out) and allowed to cool down (especially exhaust) prior to working on the equipment.
5. Down time for maintenance activities has an associated loss in revenue for the operator of the engine that should be accounted for. The GCA did not quantify nor include the downtime in its annual cost estimates but these costs are discussed below under Hidden Costs.
6. All of the other equipment associated with the installation of the control system has some required maintenance and some parts will occasionally fail. Many, such as batteries have a finite life much shorter than the proposed capital recovery period of 10 years and will require routine replacement. This equipment includes:

   a. Thermocouples
   b. AFR control boards
   c. Wiring
   d. Fuel valves
   e. Batteries
   f. Alternators

7. In addition to the maintenance and testing of individual equipment, there will be informal emissions tests performed using portable analyzers. Although these tests do not follow EPA protocol, they give the maintenance technician a good indication as to the overall performance of the engine and the control equipment and are necessary to ensure continuous compliance.

Indirect Annual Costs: Very little cost was assumed by the EPA for record keeping, reporting and monitoring requirements. The reality is that the administrative burden associated with the rule is much larger than assumed by the EPA. Every engine in the gas compression industry will be subject to one of several rules, all with different requirements that must not only be performed, but also documented. The status of the engines will change periodically as the engines are relocated to different sites (Major versus Area Source). See comment on Regulatory Environment. All of these combine to add a significant cost per engine for administrative costs in the range of $300 to $1,800 per engine per year. The capital recovery, which is treated as an indirect annual cost, was previously discussed above.

Total Annual Cost

The table below shows the average total annual cost estimated by the GCA as compared to the estimate by the EPA

Engine Class	Horsepower used in example calculation	EPA Total Annual Cost	GCA Total Annual Cost (excluding lost revenue)
4SRB 50-99 HP	75 horsepower	$856	$6,900
4SRB 100-299 HP	175 horsepower	$1,121	$12,100
4SRB 300-499 HP	275 horsepower	$1,717	$14,400
4SRB 500-1350 HP	800 horsepower	$2,777	$19,100
4SLB 250-499 HP	400 horsepower	$963	$7,700
4SLB 500-1350 HP	800 horsepower	$1,609	$13,700
2SLB 250-800 HP	400 horsepower (AJAX)	$1,001	$26,700

As can be seen from the above table, the EPA numbers underestimate the total annual cost by many orders of magnitude. The above numbers do not include lost revenue or additional fuel use as described below under Hidden Costs.

Emissions reductions

The EPA assumed a total emission of HAP's for all engines of 6.88 E-04 lbs/horsepower-hour which equates to about 0.31 gm/hp-hour. This factor, although close for lean burn engines was also used for rich burn engines. Rich burn engines have significantly lower emissions rates for HAP's and the factor used by the EPA overstates the reduction benefit. This factor is 3-4 times higher than manufacturer's data and the factors in AP-42 for Formaldehyde which accounts for 60-75% of the total HAP's in natural gas fired RICE. The following table shows the estimated cost per ton of HAP reduced using the following assumptions:

1. GCA Total Annual Cost shown above
2. Assumed run time of 98% or 8,585 hours per year
3. 90% reduction of AP-42 emissions factors for all HAP's across catalytic controls.

Estimated Cost per ton of HAP reduced

Engine Class	Horsepower used in example calculation	Cost per Ton all HAP's
4SRB 50-99 HP	75 horsepower	$92,400
4SRB 100-299 HP	175 horsepower	$69,900
4SRB 300-499 HP	275 horsepower	$36,100
4SRB 500-1350 HP	800 horsepower	$24,000
4SLB 250-499 HP	400 horsepower	$9,800
4SLB 500-1350 HP	800 horsepower	$8,200
2SLB 250-800 HP	400 horsepower (AJAX)	$27,900

Additional Hidden Cost associated with the rule

Two additional costs have been identified that are associated with compliance of the rule, both of which have an impact on the cost of energy. The first is the cost associated with lost revenue and the second is the cost associated with increased fuel burn at catalytic set points.

There is a cost associated with lost revenue whenever an engine is shut down. The causes of additional shutdowns associated with this proposed rule include:

- Initial installation of controls. Some engines will be able to be retrofitted while not in use, but many will have to be shut down for the purpose of installing the controls

- Additional downtime associated with the maintenance frequencies proposed by the rule for smaller engines. The frequencies are discussed further in the comments regarding Maintenance Practices.
- Additional downtime associated with catalyst cleaning and replacement
- Additional downtime associated with maintenance, repair and replacement of various devices such as fuel valves, AFR control boards, sensors, thermocouples, etc...

In the case of a single engine installation, the downtime is 100% of the revenue which far exceeds the cost of the actual maintenance. The GCA can provide further discussion of this at the request of the EPA but the range is $30 to $90 per day per horsepower.[iii] If only half of the GCA fleet horsepower required a 24 hour shutdown for the initial retrofit, it would cost the energy industry $159 million for just the horsepower owned by the GCA companies. Additional down time associated with maintenance will add a similar magnitude of cost on an annual basis.

There is also a cost associated with additional fuel burn from operating a 4SRB engine at a catalytic set point which is richer than normal operation. Manufacturer's data for a 145 horsepower Caterpillar G3306 NA estimates this increase in brake specific fuel consumption (BSFC) to be 5%. Assuming 50% of the overall GCA fleet is affected in a similar manner yields an annual cost of $53 million[iv] for just the horsepower owned by the GCA companies.

The EPA should contact trade organizations that represent small, independent operators to determine if compliance with the rule will be overly burdensome on these companies that have limited human and capital resources.

Summary

The EPA has underestimated the costs for the proposed rule and has overestimated the benefit of HAP reductions, especially on 4SRB engines. The hidden costs associated with lost revenue associated with lost natural gas production should be investigated and quantified for the natural gas industry. After the costs and benefits are corrected, the economic justification should be closely reviewed since the EPA has also chosen to go beyond the MACT floor when determining the emissions levels in this proposed rule. This review should be transparent and should define the cost effective threshold relied upon in the analysis. The cost effective threshold should be based on current accepted science and not an arbitrary horsepower threshold intended to regulate a given percentage of engines.

Comments on Startup, Shutdown and Malfunction (SSM)

The following comments are made regarding proposed emissions standards during periods of SSM (startup, shutdown and malfunction). In the context of these comments, any references to engines would be limited to spark ignited engines fueled by natural gas driving reciprocating or screw type natural gas compressors. Although many of the comments would apply to other types of engines, the comments have not been reviewed for accuracy outside of the natural gas compression industry.

The EPA proposal to regulate periods of SSM with a numerical MACT standard is premature. The EPA and industry has not had sufficient time to evaluate what appropriate emissions levels would be (if any) during SSM events. The SSM events do not always have definitive beginning or ending times due to the large number of variables associated that affect them. Each event (Startup, shutdown and malfunction) also has some broadly different characteristics and specifying one emissions level for the wide range of possibilities is not prudent. The assumptions made regarding the MACT standard are based on the best performing 12% of a group of engines (1) that is not representative of the engines operated by the GCA companies and (2) were only tested under normal or "high load" operations, which is completely contradictory to the operation of engines during SSM events.

Shutdown:

The EPA has indicated that Shutdown events should be treated as normal operations based on their statement: *"EPA does not believe that emissions should be different during periods of shutdown compared to normal operations…"* This statement may be predicated on the assumption that the engines are merely turned off as in the case of a mobile source engine. In this case, the actual shutdown event is very short lived and could be considered negligible. Although the uncontrolled emissions levels may temporarily spike, post-combustion controls would be at operating temperature and provide a significant destruction of HAP's. However, stationary engines differ from mobile source engines in the methods used for shutdown. The engine may be shut down in one of two ways, either an unplanned shut down or a planned shutdown. In an *unplanned* shutdown, the engine is shut off rapidly (usually by some sort of safety device or emergency stop) and the emissions profile transitions almost instantaneously from a controlled state to a zero state with a very short lived (a few seconds) spike in emissions. The situation is very different in a *planned* shutdown event. During a planned shutdown, the load is removed from the engine and the engine and/or driven equipment is allowed to cool down prior to stoppage. This has long term mechanical benefits to the engine and driven equipment. During the cool down event, the EPA assumption that the emissions levels are the same as normal operation is incorrect and the same standards should not apply. The nature of the differences varies depending on the type of engine, its application, site conditions and fuel gas makeup (constituents).

Start-up:

The EPA stated the *"EPA does believe that emissions will likely be different during periods of startup and malfunction, particularly for engines relying on catalytic controls."* The basis for this assumption is grounded on the fact that it takes time for the catalyst to reach full temperature. The EPA has made two co-proposals:

1) EPA Proposal 1: *"to have the same standards apply during both normal operation and periods of startup and malfunctions"*. It is unclear what prompted the EPA to propose this standard when by their own admission, they believe it is not possible and there is no data to support that it is possible. This proposal should be dismissed unless evidence can be provided to substantiate the feasibility of compliance of a single standard.
2) EPA Proposal 2: *"emissions limitations that would apply to stationary RICE during periods of startup and malfunction in order to account for the different emissions characteristics of stationary internal combustion engines during startup and malfunction periods, compared to other periods of operation....EPA is co-proposing that the standards during periods of startup and malfunction will be based on emissions expected from the best controlled sources prior to the full warm-up of the catalytic control. The standard is based on the emissions levels from the best controlled engines that do not include catalytic controls."* Again, this proposal appears to be based on the fact that it takes time for the catalyst to reach temperature at which point the emissions reductions begins. This proposal does not take into account that startup event is really made up of two smaller events or phases with different characteristics. The first (Phase I) is the warm-up period of the engine and driven equipment prior to an ability to apply load. The second (Phase II) begins at the application of load and continues until the engine and related equipment reach a steady state. This includes the catalyst, if installed. The EPA has only addressed the second of these two events (Phase II) in their logic and assumptions. During the second phase, the assumptions that the EPA has made are correct. The engine is essentially operating similar to an uncontrolled engine. However, during the first phase, from initial start until the load is applied, the engine is at idle and is not under load. The GCA believes the emissions characteristics of the engine during this period are significantly different than the EPA has assumed, yet no data based on standard protocols exists to support any reasonable assumptions as to the details of those differences.

Malfunction:

As stated above, the EPA does believe that emissions will be different during periods of malfunction than during normal operations. Trying to regulate emissions for a malfunctioning engine is a difficult task due to the many and varied reasons that can cause a malfunction and the unknown effects. Even the same type of malfunction can have different effects depending on the engine due to differences in type, manufacture, control logic, etc... There is no data to support the assumption that a typical engine operating in a malfunction mode would have emissions less than the best performing 12% of engines even without controls. The standard for emissions during malfunction (if promulgated) should be based on science and data, which is not currently available. However, it should be recognized that operators of engines and their associated driven equipment are motivated to keep the engines running properly, independent of regulations, due to the fact the revenue stream is dependent upon and directly proportional to the engine and driven equipment capacity and continuous operation. Any downtime results in loss of revenue and a catastrophic failure can result in days or weeks of downtime. Therefore, operators specify and purchase protection devices on the engine and driven equipment to prevent such operational problems and protect the engine and driven equipment from failure in the event of such malfunctions.

The EPA specifically requested the following comment:
"EPA requests comments on these proposed approaches to addressing emissions during start-up, shutdown and malfunction and the proposed standards that would apply during these periods. See tables 1, 2, and 3 of this preamble." Comments are included below.

Table 1 – Existing <u>Major</u> Sources
Note: sign nomenclature has been corrected from EPA tables

Subcategory	Proposed emissions levels during SSM	Comments
Non-emergency 2SLB 50<HP<249	85 ppmvd CO	1) No engines were in this subcategory when determining emissions limit, therefore no data exists to support the limit is achievable for this subcategory. 2) AJAX units are a very common engine in this subcategory for the natural gas compression industry. Typical AJAX uncontrolled emissions levels are 135 PPM CO to 240 PPM CO (under load) depending on type of combustion chamber and therefore the proposed limit during SSM are unachievable by this type of engine. 3) Proposed limit is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 4) This limit is more stringent than New or Reconstructed sources over 500 HP at major sources which is 259 ppmvd. The smaller existing sources should have a less stringent limit than newer, larger sources. 5) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.
Non-emergency 2SLB 250<HP<500	85 ppmvd CO	1) No engines were in this subcategory when determining emissions limit, therefore no data exists to support the limit is achievable for this subcategory. 2) AJAX units are a very common engine in this subcategory for the natural gas compression industry. Typical AJAX uncontrolled emissions levels are 135 PPM CO to 240 PPM CO (under load) depending on type of combustion chamber and therefore the proposed limit during SSM are unachievable by this engine. 3) Proposed limit is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 4) This limit is more stringent than New or Reconstructed sources over 500 HP at major sources which is 259 ppmvd. The smaller existing sources should have a less stringent limit than newer, larger sources. 5) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.
Non-emergency 4SLB 50>HP<249	95 ppmvd CO	1) No engines were in this subcategory when determining emissions limit, therefore no data exists to support the limit is achievable. 2) This population of engines is small in the natural gas compression industry. Most 4SLB engines are over 400 HP. 3) Proposed limit is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 4) This limit is more stringent than New or Reconstructed sources over 250 HP at major sources which is 420

		ppmvd. The smaller existing sources should have a less stringent limit than newer, larger sources. 5) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.
Non-emergency 4SLB 250<HP<500	95 ppmvd CO	1) Engines in database used to determine limits are not representative of Gas Compression industry. Manufacturer's data for two typical engines are: a. Caterpillar G3408 CLE rated at 425 HP @ 1800 RPM indicates uncontrolled CO of 227 PPM (1027 Btu field gas, under load) b. Waukesha F18GL rated at 400 HP @ 1800 RPM indicates uncontrolled CO of 500 PPM (under load) 2) Proposed limit (and Manufacturer's data) is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 3) Proposed limit is invalid during Phase I (no load) of startup (see discussion for details). 4) This limit is more stringent than New or Reconstructed sources over 250 HP at major sources which is 420 ppmvd. The existing sources should have a less stringent limit than newer sources. 5) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.
Non-emergency 4SRB 50<HP<500	2 ppmvd CH2O	1) The proposed emissions limits are likely not achievable without post combustion controls which are not effective during SSM. Manufacturer's data for uncontrolled emissions for typical engines in this category are listed below in Comment Table A. Typical range is 10-15 times that of proposed limits. 2) Proposed limit is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 3) This limit is the same as all engines over 500 HP at major sources. The smaller existing sources should have a less stringent limit than larger and/or newer sources. 4) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.

Table 2 – Existing Area Sources

Note: sign nomenclature has been corrected from EPA tables

Subcategory	Proposed emissions levels during SSM	Comments
Non-emergency 2SLB 50<HP<249	n/a	See comments on Maintenance Practices
Non-emergency 2SLB HP>250	85 ppmvd CO	1) No engines were in this category when determining emissions limit, therefore no data exists to support the limit is achievable. 2) AJAX units are a very common engine in this subcategory for the natural gas compression industry. Typical AJAX uncontrolled emissions levels are 135 PPM CO to 240 PPM CO (under load) depending on type of combustion chamber and therefore the proposed limit during SSM are unachievable by this engine. 3) Proposed limit is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 4) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.
Non-emergency 4SLB 50>HP<249	95 ppmvd CO	See comments on Maintenance Practices
Non-emergency 4SLB HP<500	95 ppmvd CO	1) Engines in database used to determine limit are not representative of Gas Compression industry. Manufacturer's data for two typical engines are presented below. Note that these values are under load and would not be valid during Phase I of startup or during cool down period. a. Caterpillar G3408 CLE rated at 425 HP @ 1800 RPM indicates uncontrolled CO of 227 PPM (1027 Btu field gas when under load, data is not known for the time the engine is not loaded) b. Waukesha F18GL rated at 400 HP @ 1800 RPM indicates uncontrolled CO of 500 PPM (when under load, data is not known for the time the engine is not under loaded) 2) Proposed limit (and Manufacturer's data) is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 3) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.
Non-emergency 4SRB HP>50	2 ppmvd CH2O	1) The proposed emissions limits are likely not achievable without post combustion controls which are not effective during SSM. Manufacturer's data for uncontrolled emissions for typical engines in this category are listed below in Comment Table A. Typical range is 10-15 times that of proposed limits. 2) Proposed limit is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 3) This limit is the same as all engines over 500 HP at major sources. The smaller existing sources should have a less stringent limit than larger and/or newer sources and the engines at area sources should be less stringent than engines at major sources. 4) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.

Table 3 – Major Sources - New/Reconstructed >500HP & Existing 4SRB during SSM

Subcategory	Proposed emissions levels during SSM	Comments
New/Reconstructed Non-emergency 2SLB HP>500	259 ppmvd CO	1) The proposed emissions limits may not be achievable without post combustion controls which are not effective during SSM. 2) Proposed limit is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 3) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.
New/Reconstructed Non-emergency 4SLB HP>250	420 ppmvd CO	1) The proposed emissions limits may not be achievable without post combustion controls which are not effective during SSM. 2) Proposed limit is invalid during no load phases (warm up and cool down) of startup and shutdown (see discussion for details). 3) Emissions limits during SSM are neither practically measurable nor controllable and there are no established SSM measurement or test protocols.
Existing & New/Reconstructed Non-emergency 4SRB at Major Source HP>500	2 ppmvd CH2O	1) The proposed emissions limits are likely not achievable without post combustion controls which are not effective during SSM. Manufacturer's data for uncontrolled emissions for typical engines in this category are listed below in Comment Table A. Typical range is 10-15 times that of proposed limits. 2) Emissions limits during SSM are neither practically measureable nor controllable and there are no established SSM measurement or testing protocols.

Comment Table A

The following table presents Manufacture's Data for 4SRB engines fueled by Natural Gas from 50 to 500 Horsepower that are commonly used in the gas compression industry. See comments in Tables 1, 2, and 3 regarding engines in this category

Engine Make	Engine Model	Horsepower @RPM	Uncontrolled CH2O, PPMVD @ 15% O2 (Field gas at 1027 Btu/scf used on Caterpillar)
Arrow	VRG 330	68@1800	No PPM data available. Manuf. Data indicates 0.09 gm/HP-hr
Caterpillar	G3304 NAHCR	95@1800	20-29 (depending on AFR set point)
Caterpillar	G3306 NAHCR	145@1800	24-29 (depending on AFR set point)
Caterpillar	G3306 TALCR	203@1800	16-26 (depending on AFR set point)
Caterpillar	G342 NALCR	200@1200	No data available
Caterpillar	G3406 NAHCR	215@1800	29
Caterpillar	G342 TALCR	265@1800	No data available
Caterpillar	G 379 NAHCR	275@1000/330@1200	No data available
Caterpillar	G 3406 TALCR	325@1800	33
Caterpillar	G 3408 TALCR	400@1800	23
Caterpillar	G 398 NAHCR	495@1200	No data available
Cummins	G5.9	84@1800	No data available
Cummins	G8.3	118@1800	No data available
Cummins	KTA 19	265@1200/380@1800	No data available
Cummins	KTA 38	760@1800	No data available
Ford	CSG 649 (56)	58@1800	No data available
Ford	LSG 875 (95)	98@1800	No data available
Waukesha	F817 LCR	118@1400	No PPM data is available. Manuf. Data indicates 0.05 gm/bhp-hr
Waukesha	F817 HCR	125@1400	No PPM data is available. Manuf. Data indicates 0.05 gm/bhp-hr
Waukesha	F1197 LCR	172@1400	No PPM data is available. Manuf. Data indicates 0.05 gm/bhp-hr
Waukesha	F1197 HCR	186@1400	No PPM data is available. Manuf. Data indicates 0.05 gm/bhp-hr

In conclusion, there is a lack of data to support the proposals on limits during periods of SSM. SSM is not considered representative of normal operations and tests conducted during SSM are not valid for compliance purposes for NSPS (see 40 CFR 60.4244(b) and 40 CFR 60.8(c)). Furthermore, it is not technically and economically feasible to monitor or control emissions levels during periods of SSM within a numerical standard. The EPA has not included costs associated with the monitoring and control of emissions during SSM in their analysis. Therefore, both co-proposals are inappropriate and quantitative emissions limits during SSM should be removed from the rule.

Alternative Proposal to quantitative emissions limits during SSM.

The EPA should require work practices in lieu of a quantitative emissions limit as allowed under Section 112 (h) (1) of the Clean Air Act. These work practices should be based on the technology and events that affect the emissions and how to manage those emissions while taking into account the operational limitations of the equipment and personnel that operate it. Each mode (startup, shutdown and malfunction) should be addressed. The following are some characteristics of each mode and how to minimize emissions during each:

Startup:

As mentioned above, there are two phases of a startup mode. The first begins at cranking of the engine, continues after initial start until the engine is brought up to rated speed and placed under load. The second phase begins upon application of load and continues until the engine has reached a steady state of operations. Each of these phases and the effects on emission will be discussed in greater detail.

Phase I (from initial start to applied load): The engine is started at idle speed and without a load applied. Key engine settings such as air/fuel ratio, ignition timing, etc, are different during phase I. The exhaust temperature and the exhaust flow rate is lower. The emissions concentration (PPM) of some constituents maybe higher during phase I than it is at full load but the exhaust flow is lower due to the temporary low load condition. The magnitude of these differences varies significantly depending on engine type. During Phase I, the Operator verifies that key engine parameters such as oil pressure are within safe limits and the engine and driven equipment are allowed to warm up to a pre-determined temperature before the load is applied. This is necessary to ensure oil is circulating at acceptable pressures and temperatures. Some components in the engine and driven equipment expand at different rates based on differing metallurgy and mass. Applying the load to the engine and driven equipment prior to the warm up being completed has detrimental effects on the mechanical integrity of the engine and driven equipment and in rare cases can even result in catastrophic failure. The length of Phase I can vary significantly depending on the temperature of the engine prior to start, the temperature required to safely apply load, and the ambient conditions. If the engine was recently shut down, the first phase of startup can be very short, just long enough to verify the key parameters and begin the loading process. However, if the engine and driven equipment are cold soaked and startup is being done in very cold ambient conditions, phase I of the startup can approach an hour. It should be noted that the engine is not always the limiting factor. In the case of natural gas compressors, the oil temperature of the compressor may necessitate a prolonged warm up period during low ambient temperature conditions.

Several simple emissions tests were conducted in an attempt to gain insight into what the uncontrolled emissions levels are during the first phases of start-up when the engine is not under load. The data is very limited in nature and is not sufficient for the rule making process, but is useful for discussion purposes and what MAY be happening during the initial phase of the startup mode and during a planned shutdown after the load is removed. General observations:

- The CO ppmvd level for the 4SLB was higher than normal operation when the engine was started cold and increased further as the engine was warmed up without load applied. Upon application of rated speed and load the level dropped immediately to normal level (uncontrolled steady state). Most 4SLB engines without pre-combustion chambers operate at a richer fuel mixture at idle than at load. It is thought, but not verified that during this initial warm up period, the absolute value of the CO ppmvd would not necessarily be a good indication of the amount of HAP's in the exhaust stream, although the percent reduction of CO would be a good indication of the reduction of CH2O by the aftertreatment device .
- The AJAX 2SLB engines demonstrated an exhaust flow rate that varies more with RPM than with load. This is due to the scavenging nature of the 2 stroke design. Initial CO concentration levels were consistent with steady state levels when the engine was started cold. Upon warm up, the concentration increased to a factor of 4-5 times that of steady state.
- The vast majority of existing engines below 1350 horsepower employ diaphragm-actuated venturi carburetors which admit gaseous fuel into the inlet air at an approximately correct air/fuel ratio during initial start (cranking, speed increase through crank terminate speed, and into engine idle speed) to overcome installed inertia and connected load from the driven equipment. The carburetor's fuel valve and jet geometry and the related differential area of the diaphragm and spring rate are within the needed range to permit fueling the engine during the start event as well as fine-tuned to properly fuel (at the intended air/fuel ratio) to carry the connected load during the engine's intended operating speed and load range. During start-up, turbocharged and after-cooled engines function similarly to naturally aspirated engines (i.e., within a rich burn combustion air to fuel ratio range) until load may be applied. The air/fuel ratio is enrichened at start and idle to enable the engine to start and accept load. Load should not be applied until after the engine and driven equipment obtain the manufacturer's recommendations for warm-up. Once load is applied, the fuel system establishes the designed air/fuel ratio of combustion (standard rich burn, catalytic rich burn or lean burn). As the load is applied exhaust energy captured by the turbocharger's exhaust turbine (on turbocharged engines) provides additional beneficial (boost) air from the turbocharger's compressor. This enables the engine to accept loads into a range beyond that which the displacement of the naturally aspirated engine can support. Rich burn engines have the properly sized turbocharger (if used), carburetor(s) and supplied gas pressure to provide either the standard air/fuel ratio or the catalytic set point air/fuel ratio. The catalytic set point air/fuel ratio is richer resulting in higher exhaust temperatures which

facilitates the reaction in the catalyst. This also results in a higher fuel usage. Lean burn engines have differently sized turbocharger, carburetor(s) and supplied gas pressure to enable lean combustion air/fuel ratios to fuel the lean burn engine within its load and speed operating range.

- Because lean burn engines operate similar to rich burn engines the increased concentration of CO ppmvd at idle/no load conditions may not indicate increased emissions of HAP's. It is suspected that the correlation between CO and HAP's on lean burn engines during the initial phases of startup and shutdown (the warm up and cool down events) is unreliable whereas the correlation during normal operations is much higher. The percent reduction of CO in exhaust aftertreatment is a good indication of the reduction of HAP's.

Phase II (load applied to steady state): Once the load is applied, the concentration of pollutants changes as more complete combustion becomes possible within the combustion chamber(s) but the exhaust flow rate increases significantly as well. It is during this second phase that the engine (pre-catalyst) will perform more consistent with typical test data for uncontrolled engines since test data is recorded as close to 100% load as possible. During the second phase, the catalyst temperature will increase until it reaches a sufficient temperature to control the emissions to the designed reduction based upon the precious metal loading and catalyst bed space velocities. General temperatures needed for initial light off of 3 way (NSCR) catalysts are 550F with 750 F required for full reduction. Oxidation Catalyst will operate on a slightly lower temperature range with initial light off occurring at 350F and full reduction obtained at 550F. On an engine without catalytic controls, this second phase will be very short in duration since there is no warm up of catalyst. During the second phase, the operator will verify key engine and driven equipment parameters and re-enable safety devices that have been by-passed for the start up process.

Although no established SSM measurement or test protocols exist, some preliminary testing was done on one engine in field site installations during start up events to investigate the time required to complete Phase I and Phase II. It should be noted that these tests were done at relatively warm ambient conditions so the start up events were short. It is understood that the startup events vary by engine and driven equipment manufacturers and conditions, the connected inertia and load, ambient conditions and fuel quality. The preliminary field test data is summarized below:

Engine Type	Ambient Temp.	Type of Start	Phase I duration (idle, no load)	Phase II duration (under load)
1340 HP 4SLB, with O.C.	55 F	Cold soaked	5 minutes	4 minutes
1340 HP 4SLB, with O.C.	77 F	Warm Restart	1 minute	4 minutes

Shutdown

As stated above, there are two phases of shutdown which are opposites of the startup phases. The first phase, which only happens during a *planned* shutdown, is a cool down event which provides mechanical benefits to the engine and driven equipment. The benefit of this cool down event has a finite limit in that the engine will only cool down to a certain point and prolonged idling beyond that point has no additional benefit and results in additional wear on the equipment. That point can be defined by the operator but is specific to a particular class, type or size of engine and its associated driven equipment. It should be noted that this is a major difference between stationary sources and mobile sources. Mobile sources do not typically experience 100% load very often and when they do, they are not immediately shut down in the middle of it. There is an inherent cool down period typically associated with mobile sources in that they must be brought to a stop (parked) before they are turned off. Stationary sources, on the other hand, routinely operate at or near 100% load. The cool down periods for stationary sources vary, but generally last between 1 and 5 minutes. During this phase, engines behave similarly to the discussion above where turbocharged engines do not produce sufficient exhaust to provide boost pressure and lean burn engines run with enrichened air/fuel ratios to provide stability. There will be some emissions reduction from the catalyst during this period, but as exhaust flow rate and temperature decreases, the performance of the catalyst will drop off rapidly. During an *unplanned* shutdown, this cool down event does not occur as the engine is shut down abruptly.

The second phase of shutdown, during which the engine is actually stopped by removal of fuel and/or spark, only lasts a few seconds. The emissions of some constituents may spike during this period, but the length of time and the volume of emissions in negligible. The second phase of shutdown occurs for both planned and unplanned shutdowns. In an *unplanned* shutdown, the engine is shutdown immediately by a safety device, an emergency kill switch or some other abnormal condition such as overload.

Malfunction

A good preventative maintenance plan similar to what is required by the NSPS (40CFR60 Subpart JJJJ) rule will help prevent malfunctions that affect emissions. More serious malfunctions will likely result in an engine shut down. As discussed above, it is impossible to comment on what emission limit is appropriate without a better definition of what the malfunction is. Malfunctions may be associated with either the engine or the control equipment (if installed). The EPA should consider work practices as a solution rather than quantitative limits that are not measurable. The work practices will reduce the number of malfunctions through preventative maintenance, and those that do happen will trigger operator response to correct as soon as possible. A preventative maintenance plan similar to what is required by the NSPS (40CFR60 Subpart JJJJ)rule will help prevent malfunctions. There are already components included in this rule that require processes to identify early a number of malfunctions. For example, monitoring of the pressure drop across a catalyst will give an early indication a fouling condition.

General Comment on length of time spent during periods of startup and shutdown

In the proposed rule, the EPA made a request for comments regarding having a single MACT standard. Specifically…"*EPA requests comment on other approaches to setting MACT standards during periods of start-up, shutdown or malfunction, and notes that an approach that sets a single MACT standard that applies at all times, including SSM periods, may result in a higher overall MACT standard, based on the need to account for variation of operations in setting MACT standards." Reference - holding that the EPA may legitimately account for variability because "each [source] must meet the [specified] standard every day and under all operating conditions."* As can be seen by the discussion below, it is anticipated that most SI engines in the natural gas compression industry will experience periods of Startup and Shutdown less than one quarter of one percent of the time. If the emissions levels during startup and shutdown were quantified (which they currently are not since there are no established SSM measurement or test protocols), then a single MACT standard could be chosen that would represent the average emissions during normal operation, startup and shutdown. For example, an analysis on a unit basis would be:

- Proposed MACT standard during normal operations = 1 (unit)
- If the emissions levels during startup and shutdown were five times greater than during normal operations (this number is not known, 5 is just used as an example), then the emissions during startup and shutdown would be 5x1=5
- Time spent during startup and shutdown = 0.0016 (0.16 percent – see discussion below)
- Single MACT standard to apply at all times = 0.994 or slightly more stringent than the proposed standard

In the above example, the MACT standard to which engines would be tested (during normal operation) would be about 0.6% more stringent to account for the periods of startup and shutdown where the emissions levels were higher. Note that in the above example, there was no time assumed when the engine was not operating. During inoperative periods the emissions would be zero. Since there are no operating hour limits proposed by the rule, the down time should be taken into account if a single MACT standard is chosen. Any measurable amount of down time would likely make the MACT standard less stringent effectively offsetting any increase in the standard to account for periods of startup and shutdown.

Amount of time spent during periods of Startup and Shutdown

Stationary sources are operated differently than mobile sources. The amount of time spent during periods of startup and shutdown is a very small compared to the time spent during normal operations. A large percentage of stationary engines will operate continuously for long periods before they are shutdown for preventative maintenance. The maintenance intervals proposed under this rule will increase the frequency and number of shutdowns and startups for some classes of engines (typically smaller engines at Area sources). Although the time spent during the startup and shutdown process is brief (see discussion below), if the number of startups/shutdowns is increased significantly, it can have a small effect on the overall emissions profile of the engine. The following are typical examples for SI engines driving natural gas compressors as they are *currently* operated:

Startup:

- An average engine may experience 3 startups per month.
- Phase I average time = 10 minutes (warm starts will be less time and cold starts will be longer. 10 minutes is assumed as an average. Warm up of driven equipment can extend this time and Phase I time is very dependent upon site and ambient conditions.
- Phase II average time = 10 minutes (warm starts will be less time and cold starts will be longer time. 10 minutes is assumed as an average).
- If the engine has an overall run time of 98%, which is common in the gas compression industry, the 20 minutes combined for Phase I and Phase II would equate to 0.14% of the time spent during normal operation.

Shutdown:

- An average engine may experience 2 planned shutdowns and 1 unplanned shutdown per month. Every shutdown, whether planned or unplanned will have a startup.
- Phase I average time for planned shutdowns = 4 minutes (Phase I for unplanned shutdowns is non-existent)
- Phase II average time is nearly instantaneous and assumed negligible for both planned and unplanned shutdowns
- If the engine has an overall run time of 98%, which is common in the gas compression industry, the 4 minutes combined for Phase I and Phase II would equate to 0.02% of the time spent during normal operations.

Total Time spent is 0.14%+0.02%=0.16%. It should be noted that in many cases the engines in the natural gas compression industry are at remote unmanned locations. The above numbers are typical, but this data is not routinely recorded because of the burdensome nature and a lack of a suitable on-site, weatherproof place to keep them.

Key components of Work Practices

- Operators should have a written SSM plan
- The details of the plan should be determined by the Operator, not by the EPA. The Operator is more qualified to prepare a SSM than the EPA. The EPA's role should be one of setting minimum standards and guidance, as was provided in NSPS rule (40 CFR 60.4243) and other regulations such as Part 1068 Appendix I and II.
- The plan should be consistent with manufacturer's recommendations for both the engine and driven equipment as well as safe work practices for the remainder of the facility.
- The EPA should also be responsible for determining operators have complied with requirements for a plan which adds enforceability.
- The plan should have sufficient detail for broad classes of engines. Some distinctions which may necessitate different plans, or differentiation within a plan include:
    - 4 stroke versus 2 stroke engines
    - Rich burn versus lean burn engines

    - Other parameters that have a significant impact on emissions or limitations during SSM
- The plan should include strategies to minimize the time spent during SSM events.This is predicated on the assumption that actual ton/year emissions are greater at idle than at full load. There is not sufficient data to support this assumption. If the contrary were proven to be true, then the requirement to minimize time spent at idle should not be included. If this provision is included, then:
    - For startup, Operator should have defined targets of when unit can be safely loaded to prevent excessive idling. Targets should be defined by operator but <u>may</u> include:
        - Oil temperature, pressure, and level within normal range (Engine and Driven Equipment)
        - Water Jacket temperature and levels within normal range (if water cooled).
        - No abnormal conditions
    - For shutdown, Operator should have defined targets of when unit can be safely shut off to prevent excessive idling. Targets should be determined by operator but <u>may</u> include:
        - Turbo temperature (if turbocharged)
        - Water jacket temperature (if water cooled)
        - Defined length of time
- Key parameters should be identified for verification once unit is loaded. These parameters will help identify if there is a problem that will delay the catalyst reaching temperature and <u>may</u> include:
    - O2 percent (or some other measured constituent)within tolerance
    - Exhaust temperature increasing
    - Pressure drop across catalyst not excessive
    - No abnormal conditions

- For Malfunction, the Operator should have defined items which require shut-down and repair such as:
    - O2 percent (or some other measured constituent) outside of a defined range
    - Exhaust leaks upstream of the catalyst
    - Excessive pressure drop across a catalyst
    - Miss-firing or back firing of engine
    - Excessive Surging or control swings

<u>EPA requested comment on defining time frame for periods of SSM:</u>

The EPA has specifically requested comments on the following: "*EPA also asks for comment of the level of specificity needed to define the periods of startup and malfunction to assure clarity regarding when standards for those periods apply, including whether it should be based on the time necessary for an*