MEMO TO	:	Air Quality Staff
FROM	:	James L. Semerad Director Division of Air Quality
RE	:	Testing Requirements for Non-Emergency Engines (RICE) Located at Minor Source Oil and Gas Facilities
DATE	:	June 9, 2021

BACKGROUND:

The Department's *Emission Testing Guideline* is a set of requirements to "*ensure that test results yield data which are representative, consistent and accurate relative to the tested emission unit(s)*". One of these requirements is to test an emission unit within "*at least 90% of the design capacity, or at least 90% of the maximum operating rate/level, whichever is greater.*" This has led to issues while testing non-emergency reciprocating internal combustion engines (engines) within the upstream and midstream oil and gas (O&G) sectors where gas volume and composition has led to limitations in meeting the 90% of design capacity requirement. Previous attempts to derate or otherwise restrict the operating rate of the engines have been challenging due to the flexibility demands of the sectors along with the difficulty in verifying compliance with deratings.

REGULATIONS:

These engines are tested primarily through some combination of the New Source Performance Standards (NSPS) and Maximum Achievable Control Technology (MACT) standards. These standards include NSPS IIII, NSPS JJJJ, and MACT ZZZZ, depending on the engine's horsepower and manufacture date. NSPS IIII and JJJJ require testing "*within 10 percent of 100 percent peak (or the highest achievable) load*". However, MACT ZZZZ requires testing "*at any load condition within plus or minus 10 percent of 100 percent load*" (though it should be noted the Department has not adopted the area source provisions of MACT ZZZZ).

Since MACT ZZZZ does not allow for "highest achievable load" situations, regulated entities can request approval from EPA (or the administrator) for alternative monitoring plans to allow for lower loads. Two recent examples are:

- Kinder Morgan Natural Gas Pipeline's Houston Central Gas Plant in Sheridan, Texas, where 85% to 90% load ±10%, for six engines was accepted as the maximum load due to site-specific operations.
- Five compressor stations of Red Cedar Gathering Company located on the Southern Ute Indian Reservation in Colorado; highest achievable load was accepted for twenty-four engines due to declining field conditions.

Similar situations exist in North Dakota, as engines operating in the O&G sectors commonly drive natural gas compressors or other equipment such as electrical generators. These engines are dependent on oil well production (few wells in North Dakota produce only natural gas), which have fluctuating production due to a variety of conditions. Increases in gas volume can come from new wells being drilled or refractured, infrastructure connecting to already existing wells, or as upsets from other parts of the pipeline system redirect gas into different pipelines. This also leads to decreases in gas volume as oil fields decline in production, wells are disconnected due to operational or contractual demands, as well as operational and contractual demands within the pipeline systems themselves. Based on these factors, "Highest achievable load", as referenced in NSPS IIII and JJJJ, appears to be the most practical load target for these types of engine tests.

<u>HIGHEST ACHIEVABLE LOAD:</u>

What justifies as "highest achievable load" is unclear, however. In general, engines are designed to be operated at 100% load for proper combustion and because sufficient exhaust heat is required to warm up the catalyst. The catalyst is used to control pollutant emissions from the engine and requires high temperatures (e.g. 650° F) for the catalytic reactions involved. Engines operating at low loads may then produce more pollutants than engines operating at higher loads (i.e. better combustion and warmer catalysts), thereby reducing any potential advantage of operating at lower loads to pass an emission test. Thus, "highest achievable load" should not necessarily be associated with "highest emission rate". In conversations with EPA personnel, this rationale has been one of the primary reasons for approving tests conducted at lower loads.

Manufacturer examples (pre-catalyst):

Pollutant	100% load	75% load	50% load
NOx (as NO2)	2.00 g/bhp-hr	2.00 g/bhp-hr	2.00 g/bhp-hr
CO	1.86 g/bhp-hr	1.94 g/bhp-hr	2.09 g/bhp-hr
NMNEHC (VOCs)	0.26 g/bhp-hr	0.28 g/bhp-hr	0.30 g/bhp-hr

2021 data sheet for a gas compression 1400 rpm/1340 bhp Caterpillar G3516 LE (Lean Burn)

Pollutant	100% load	75% load	51% load
NOx (NO + NO2)	11.8 g/bhp-hr	13.1 g/bhp-hr	13.7 g/bhp-hr
CO	9.7 g/bhp-hr	9.6 g/bhp-hr	9.8 g/bhp-hr
NMNEHC (VOCs)	0.05 g/bhp-hr	0.08 g/bhp-hr	0.12 g/bhp-hr

2018 data sheet for a gas compression 1200 rpm/1881 bhp Waukesha L7044GSI S5 (Rich Burn)

Additionally, fluctuating gas volumes complicate operator predications of what engine loads will be "achievable" during testing. Sites with multiple engines may have the ability to shift loads onto the engine being tested, however if there are only a few engines or those engines are on separate process streams (e.g. inlet engines compressing incoming gas vs residue engines compressing outgoing gas) they may not be able to accommodate such load shifts.

Lastly, gas composition can skew the automated load calculations displayed for both operators trying to monitor loads and Department inspectors verifying loads during operation and testing. In conversations with an engine manufacturer, one example given was that calculations of horsepower are setup based on a heating value or BTU for pipeline quality natural gas, consisting of primarily methane-only dry gas. This averages to around 1020–1050 Btu/scf. However, in the O&G sectors, raw natural gas has values much higher, such as 1250 Btu/scf to 1,400 Btu/scf or above. The increase is due to the heavier compounds such as propanes, butanes, pentanes and other NGLs which have not yet been removed through processing. This can lead to automated calculations underestimating the horsepower as the fuel has a much higher heating content than what the calculations assume. The resulting effect is an increased chance of "knocking" or "detonation" within the engine as the timing for combustion will be off. In conversations with operators, while the higher heating value is an initial concern, the danger of knocking/detonation causing damage to the engine is great enough that proper timing is essential for continued operation. Accurate load calculations can reasonably be assumed for properly tuned engines, however for untuned engines what was calculated to be "highest achievable load" may be undercalculated. In addition, onsite Department inspectors cannot easily verify the accuracy or if the engine has even been tuned.

CONCLUSION:

It is recommended that for engines in the upstream and midstream oil and gas sectors, the Department's emission testing guideline may be interpreted to include "highest achievable load" within the testing requirements. Regulated entities should establish this in their test protocol, listing the reason why 90% of design capacity/maximum rate may not be achievable. The test protocol should include statements that:

- Detail that testing will be conducted at the highest achievable load,
- Testing will be representative of normal operating conditions,
- Should site conditions change so that the highest achievable load is no longer representative of the testing conditions, the engine will be retested.

Additionally, "highest achievable load" should be confirmed in the test report if the load was below 90% of design capacity during the emission testing.

For verifying horsepower during site inspections, it is recommended to read the rating from the automated display, if available. However, Department inspectors must keep in mind that if the engine is not used often, or has not been tuned recently, the horsepower reading may be undercalculated. For engines without an automated horsepower display, a possible verification may be to check the suction pressure gauges and see if they match what was reported during testing, as an analog for horsepower.

JLS/RSM: