



# Department of Environmental Quality

*To protect, conserve and enhance the quality of Wyoming's environment for the benefit of current and future generations.*



Matthew H. Mead, Governor

John Corra, Director

November 3, 2011

RE: WDEQ/AQD 2011 Engine Emissions Study Summary Report

Dear Wyoming Engine Operator:

The attached report summarizes the results of the 2011 Engine Emissions Study conducted by the Air Quality Division to independently evaluate emissions from engines operating around the State. The study showed that a significant number of engines were not operating within their permitted emission level when independently tested by the Division. Without the facilities conducting more frequent engine monitoring, the resulting excess emissions can continue to occur for substantial periods of time.

The Air Quality Division is currently evaluating a continuation of the engine emission study for the coming year. While we're expecting the study would be similar to what has been done to date, a possible change may be a requirement for facilities to conduct a formal emission test using reference methods for those engines which are shown to be in noncompliance based on the Division's testing. Once plans are finalized, the Division will make every effort to notify potentially affected facilities how we intend to proceed for the next study phase.

I appreciate the cooperation from all the facilities that have participated in the engine emission study to date. Without the assistance from the facility operators, the Air Quality Division certainly would not have been able to accomplish as much testing as was completed. I look forward to continuing to work with the facility/engine operators in the future to develop as effective of an engine emission control program as possible.

Sincerely,

Steven A. Dietrich, P.E.  
Administrator  
Air Quality Division



**WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY  
AIR QUALITY DIVISION  
MEMORANDUM**

**TO:** Steve Dietrich, Administrator *SAD*  
**THROUGH:** Lori Bocchino, Operating Permits Program Manager *LB*  
 Bob Gill, Compliance Program Manager *BG*  
 Chad Schlichtemeier, New Source Review Program Manager *CS*  
 District 1 -5 Engineers (Electronic)  
**FROM:** Jon Walker, Air Quality Engineer *JW*  
**SUBJECT:** 2011 Engine Emissions Study Summary Report  
**DATE:** September 14, 2011

Summary

The Air Quality Division conducted the 2011 Engine Emissions Study to independently evaluate emission data from engines operating around the State. Five week-long studies were conducted in a representative cross section of the State. A test firm was contracted by the Division to evaluate the emissions from the selected engines in an as-found condition. Initially, portable analyzer testing was planned following the Air Quality Division's Portable Analyzer Monitoring Protocol. However, due to reliability issues and high pollutant concentrations, the use of portable analyzer equipment was discontinued midway through the second campaign. Reference method equipment was used for the remainder of the study.

Each of the five 2011 week-long test campaigns began by sending out letters notifying operators in each area of the Division's plans to conduct as-found engine emissions testing. During the week prior to the planned testing, affected operators were contacted to arrange for the Division to have access to facilities in the area. Specific meeting locations were determined shortly before each planned test day. The project goal was to conduct emissions tests on at least 20 engines during each of the five week long test campaigns. During the five weeks of testing, NOx and CO emissions tests were conducted on 130 engines around the State. The engines were permitted to 21 operators and were located at 19 Title V facilities and 42 minor facilities. The following table summarizes emissions testing results by engine type. Additional detail is shown in the attached tables.

**WDEQ/AQD 2011 Engine Emissions Study Results Summary  
Campaigns 1 to 5 Combined Statewide Results by Engine Type**

Note: Preliminary tested levels shown below assume a default BSFC = 9400 Btu/hphr

Engine Type	4SLB 3600 Cats Only	4SLB Excluding 3600 Cats	All 4SLB	4SRB ≥500 HP	4SRB <500 HP	All Rich Burn	2SLB LE, Clean Burn	All Excluding 3600 Cats	All
# Tested	16	65	81	33	13	46	3	114	130
# Failed	1	17	18	15	11	26	0	43	44
% Failed	6%	26%	22%	45%	85%	57%	0%	38%	34%

## Project Goals

The goals of this study were to:

1. Conduct at least 20 emissions tests to quantify the as-found NO<sub>x</sub> and CO emissions during each 5 day long campaign.
2. Verify point source NO<sub>x</sub> and CO emission levels used for air quality modeling and emission inventories.
3. Assess the effectiveness of permitted engine emission levels.

## Discussion

The statistical significance of the acquired data makes it difficult to draw conclusions with a great degree of certainty. However, the following observations are noted:

1. The study showed that a significant number of engines were not operating within their permitted level when independently tested by the Division. Without the facilities conducting more frequent engine monitoring, the resulting excess emissions can continue to occur for substantial periods of time. The Division conducting independent engine testing is an effective method of ensuring the necessary monitoring occurs.
2. Based on the field experience gained during this study, all excess emissions noted are attributed to a lack of maintenance or operational problems. Fuel quality, load changes, ambient conditions and other variables can result in the need for engine adjustments. Internal engine emissions monitoring programs are necessary to ensure ongoing emissions remain within permitted levels. There appears to be great differences in engine emissions monitoring practices between operators and in different areas.
3. Rich burn engines can result in significant excess emissions of NO<sub>x</sub> and/or CO and VOC pollutants. The operators we visited with the best internal monitoring programs would measure emissions as often as weekly and make AFRC or other adjustments as required. Neglect of the rich burn engine or emission control system maintenance can result in a twenty-fold increase in NO<sub>x</sub> and/or CO and VOC emissions.
4. With the exception of some engines in Sublette County, excess NO<sub>x</sub> emissions from lean burn engines are generally less than twice permitted levels. VOC emissions from lean burn engines can be a significant concern, but they were not quantified in this study. Based on conversations with operators, the quality of the oxidation catalysts can vary significantly between catalyst manufacturers.

5. In general, this project has been very well received by the 21 operators that we have visited. As a result of this activity, several operators are establishing internal emissions monitoring programs to ensure ongoing engine emissions remain within permitted levels. To ensure that the operator's internal engine emissions monitoring programs are successful, the AQD's engine test program should be continued.
6. Engines in Sublette County are largely 3600 series Caterpillars used for gas compression and smaller rich and lean burn engines used for electric power generation. Based on discussions with operators, the lean burn Caterpillar generator engines require 80% load for the AFRC to turn on and it will turn off if the load falls below 60%. Some generators have an associated load bank that ensures load conditions that are necessary for the AFRC to function. If the AFRC is not functioning due to low load, engine emissions can be similar to that of an uncontrolled rich burn. Oxygen levels of 0% and 3% and NOx emissions of 6 gm/hphr were measured from lean burn engines in Sublette County when the AFRC was not functioning. Associated load banks can be necessary to ensure lean burn generator engine AFRC's are functional, and rich and lean burn engine loads are stable.
7. The 3600 series Caterpillar engines tested as part of this study appeared to be particularly robust regarding engine emissions, and so the results were shown separate from other engines types in the summary. Other lean burn engines with open chamber designs seemed more readily to produce significant excess emissions depending on operation and maintenance practices.
8. It was the test team's general impression that excess emissions appeared more prevalent with upstream (wellhead and gathering prior to centralized processing) than midstream and downstream facilities. This was generally supported by the observation that these engines are typically the smaller engines and smaller engines had a poorer compliance rate than the larger engines.
9. Monitoring pre-catalyst temperature and pressure drop across the catalyst alone are inadequate to ensure ongoing engine emissions remain within permitted levels. Frequent exhaust sampling and engine adjustments can be necessary. The AQD having an engine emissions monitoring program is the most effective method to ensure necessary internal monitoring activities are occurring.

## WDEQ/AQD 2011 Engine Emissions Study Results Summary Campaigns 1 to 5 Combined Statewide Results by Engine Type

Note: Preliminary tested levels shown below assume a default BSFC = 9400 Btu/hphr

Engine Type	4SLB 3600 Cats Only	4SLB Excluding 3600 Cats	All 4SLB	4SRB ≥500 HP	4SRB <500 HP	All Rich Burn	2SLB LE, Clean Burn	All Excluding 3600 Cats	All
# Tested	16	65	81	33	13	46	3	114	130
# Failed	1	17	18	15	11	26	0	43	44
% Failed	6%	26%	22%	45%	85%	57%	0%	38%	34%

### Campaign 1, District 3, May 16th to 18th, 2011

Test Results from 2 Operators, 4 Major Facilities and 2 Minor Facilities

Engine Type	4SLB 3600 Cats Only	4SLB Excluding 3600 Cats	All 4SLB	4SRB ≥500 HP	4SRB <500 HP	All Rich Burn	2SLB LE, Clean Burn	All Excluding 3600 Cats	All
Average HP	1775	744	1260	1470	N/A	1470	N/A	1228	1365
# Tested	2	5	7	7	0	7	0	12	14
# Failed	0	0	0	1	0	1	0	1	1
% Failed	0%	0%	0%	14%	N/A	14%	N/A	8%	7%

### Campaign 2, Wamsutter, June 20th to 24th, 2011

Test Results from 4 Operators, 2 Major Facilities and 8 Minor Facilities

Engine Type	4SLB 3600 Cats Only	4SLB Excluding 3600 Cats	All 4SLB	4SRB ≥500 HP	4SRB <500 HP	All Rich Burn	2SLB LE, Clean Burn	All Excluding 3600 Cats	All
Average HP	1803	1315	1437	944	85	657	636	951	1062
# Tested	3	9	12	6	3	9	2	20	23
# Failed	0	1	1	4	3	7	0	8	8
% Failed	0%	11%	8%	67%	100%	78%	0%	40%	35%

### Campaign 3, Moxa/LaBarge, July 11th to 15th, 2011

Test Results from 6 Operators, 5 Major Facilities and 9 Minor Facilities

Engine Type	4SLB 3600 Cats Only	4SLB Excluding 3600 Cats	All 4SLB	4SRB ≥500 HP	4SRB <500 HP	All Rich Burn	2SLB LE, Clean Burn	All Excluding 3600 Cats	All
Average HP	2853	1263	1561	1,355	N/A	657	2115	1335	1524
# Tested	3	13	16	7	0	7	1	20	24
# Failed	1	1	2	4	0	4	0	5	6
% Failed	33%	8%	13%	57%	N/A	57%	0%	25%	25%

Note: Data shown includes revisions for (2) 4SLB engines that were subsequently shown to be operating within permitted levels using alternate emissions calculations methods.

## Campaign 4, Sublette, August 1st to 5th, 2011

### Test Results from 11 Operators, 3 Major Facilities and 16 Minor Facilities

Engine Type	4SLB 3600 Cats Only	4SLB Excluding 3600 Cats	All 4SLB	4SRB ≥500 HP	4SRB <500 HP	All Rich Burn	2SLB LE, Clean Burn	All Excluding 3600 Cats	All
Average HP	3681	879	2280	848	445	687	N/A	754	1509
# Tested	8	8	16	9	6	15	0	23	31
# Failed	0	6	6	4	6	10	0	16	16
% Failed	0%	75%	38%	44%	100%	67%	N/A	70%	52%

Note: Data shown includes revisions for (2) 3600 Caterpillar and an additional (1) 4SLB engine that were subsequently shown to be operating within permitted levels using alternate emissions calculations methods.

## Campaign 5, District 3, August 22nd to 26th, 2011

### Test Results from 5 Operators, 6 Major Facilities and 7 Minor Facilities

Engine Type	4SLB 3600 Cats Only	4SLB Excluding 3600 Cats	All 4SLB	4SRB ≥500 HP	4SRB <500 HP	All Rich Burn	2SLB LE, Clean Burn	All Excluding 3600 Cats	All
Average HP	N/A	1175	1175	1630	401	1,015	N/A	1141	1141
# Tested	0	30	30	4	4	8	0	38	38
# Failed	0	9	9	2	2	4	0	13	13
% Failed	N/A	30%	30%	50%	50%	50%	N/A	34%	34%

**WDEQ/AQD 2011 Engine Emissions Study Results Summary  
Campaigns 1 to 5 Results by Facility Type**

Note: Preliminary tested levels shown below assume a default BSFC = 9400 Btu/hphr

Facility Type/Engines Tested		Campaign					Totals
		1	2	3	4	5	
Major Facilities	# Visited	4	2	5	2	6	19
	# Tested	11	10	10	7	23	61
	# Failed	1	4	2	1	11	19
	% Failed	9%	40%	20%	14%	48%	31%
Minor Facilities	# Visited	2	8	9	16	7	42
	# Tested	3	13	14	22	15	67
	# Failed	0	4	5	14	2	25
	% Failed	0%	31%	36%	64%	13%	37%
Total Facilities	# Visited	6	10	14	18	13	61
	# Tested	14	23	24	31	38	130
	# Failed	1	8	7	15	13	44
	% Failed	7%	35%	29%	48%	34%	34%