

THE POWER WITHIN

Arch Coal's Emissions Based Maintenance Program

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Arch Coal, Inc.

What are Diesel Emissions?

1. Gaseous
 - A. Carbon Monoxide "CO" 50ppm TLV
 - B. Nitric Oxide "NO" 25ppm TLV
 - C. Nitrogen Dioxide "NO₂" 5ppm TLV

2. Particulate Matter "DPM"
 - A. Elemental Carbon "EC"
 - B. Organic Carbon "OC"
 - C. Total Carbon "EC + OC = TC"
 - D. Whole Diesel Particulate Matter

3. A "tip", CO will usually track with DPM.

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What is Maintenance?

Any ideas?



Arch Coal, Inc.

According to Mr. Webster.

Maintenance is:

1. To keep in an existing state.
2. To preserve from failure or decline.
3. To continue or preserve; keep up.
4. To support or provide for.

Synonyms: preservation, up keep, repairs, and continuance.

A change of paradigm.

- Insanity is: performing the same procedures, expecting different results.

“Albert Einstein “

Maintenance⁺ or “Emissions Based Maintenance Program”.

1. Wherever you are at now is a good starting point. Continue current PM program.
2. Establish a baseline for emissions.
3. Find out where you should be.
4. Get there.
5. Improve.

Baseline for emissions.

1. Analyzer (Enerac, Testo or Ecom).
2. Trained emissions technicians. As small a group as possible.
3. Repeatability on all tests. RPM's, engine temperature, good air, etc.
4. Storage and interpretation of data.
5. Passing on the information.

“Doing an emissions test”.

1. Make sure you are in proper ventilation.
2. Warm up the engine to at least 180°F.
3. Make sure everyone is in a safe place.
4. Put the transmission into high gear with the brakes set.
5. Put the engine to full power.
6. After a few seconds insert the analyzer probe.
7. When the CO stabilizes, record the information.

“Doing an emissions test”.

Getting ready!

1. Safety First!!!
 - a. Proper Ventilation.
 - b. Keep everyone in a safe area.
2. Warm Up the engine and Transmission. The same temperature every time.
3. Keep in mind this test is to determine engine emissions. Not to see if the air filters are plugged, or if there are unexpected parasitic loads on the engine.
4. Repeatability is the Key!!!

“Doing an emissions test”.

Now the Test.

1. It's better to have one person in the cab and one person using the analyzer.
2. The guy in the cab releases the park brakes and hold down on the service brakes and put's the Transmission into high gear and Forward or Reverse.
3. Put the engine into full power.
4. After a few seconds put the analyzer into the exhaust flow.
5. The CO will increase to a point where it will stabilizes. Moving 2-3 points at a time.
6. Verify the O₂ or CO₂ are correct.
7. Record the data.

“Doing an emissions test”.

Now what?

1. Check the data on this test with the Baseline.
2. If the results are in line with the baseline go to the next one. If not refer to bullet 3 on “Getting Ready”.
3. In most cases an increase from the baseline can be repaired on the spot in minimal time. Sometimes it will need to be sent to the shop.

Interpretation of the data.

1. O_2 and CO_2 are designators for engine load and always run inverse.
Example: High O_2 (18%) and low CO_2 (4%) show the engine is at low load.
2. High CO shows too much fuel for the available combustion air.
3. High NO_x usually shows high combustion chamber temperature.

Baseline.

UNIT	BASELINE	% CHANGE	15-Oct-11	8-Oct-11	1-Oct-11	24-Sep-11	17-Sep-11	10-Sep-11
LD001	247.2	23.5%	323	328		200	234	251
LD002	206.5	-19.4%	173	198	219	213	251	185
LD003	247.8	-14.2%	217	210	174	315	322	242
LD005	299.5	0.5%	301	261	319	303	324	289
LD006	341.3	-36.0%	251	375	356	351	256	459
UV026	132.8	21.4%	169	185	101	121	117	104

So what is High CO??

TORQUE CURVE TEST ALL TESTS AT FULL THROTTLE		
MSHA # :	7E-B004-0	
Engine:	Caterpillar 3304 PCNA	
Engine Rating:	100 HP @ 2200 RPM	
Engine Speed, RPM	CO, ppm	CO2, %
2200	392	10.8
2100	394	10.9
2000	352	10.8
1900	348	10.7
1800	330	10.6
1700	332	10.5
1600	315	10.4
1500	313	10.3
1400	314	10.2

TORQUE CURVE TEST - ALL TESTS AT FULL THROTTLE		
MSHA # :	7E-B083	
Engine:	Diamler Chrysler OM 906	
Engine Rating:	201 HP @ 2200 RPM	
Engine Speed, RPM	CO, ppm	CO2, %
2200	71	7.09
2000	130	7.48
1800	134	7.85
1600	145	8.59
1400	446	9.76
1200	1575	10.98

Baseline

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Passing on the information.

<u>DATA</u>	<u>UNIT</u>	<u>DATE</u>	<u>HR'S</u>	<u>O2</u>	<u>CO</u>	<u>CO2</u>	<u>NOX</u>	<u>NO2</u>	<u>NO</u>	<u>CO BASE</u>	<u>OVER LIMIT</u>	<u>CO +20% OF BASE</u>
1	CH524	17-Nov-11	825	6.4	145	10.8	429	23	429	178		214
3	CH527	15-Nov-11	1787	6.5	421	10.7	231	21	253	255	421	307
4	CH531	15-Nov-11	628	6.9	312	10.4	331	15	347	362		434
5	CH532	16-Nov-11	4267	7.3	388	10.1	457	39	496	316	388	379
6	CH533	15-Nov-11	2149	9.7	214	8.3	439	45	485	212		255
8	LD001	14-Nov-11	81	6.4	229	10.7	520	34	554	291		349
9	LD002	16-Nov-11	5762	4.7	317	12.1	221	10	231	207	317	249

Our next steps at AWBG.

1. In 1997 when AWBG started the EBMP our numbers weren't very good.
2. 1597ppm for CO and 997ppm for NO_x. This was with all equipment set to OEM specs.
3. Last week our results for the same fleet were 162ppm for CO and 493ppm for NO_x. This was after some changes from OEM specs.
4. How did we get there?

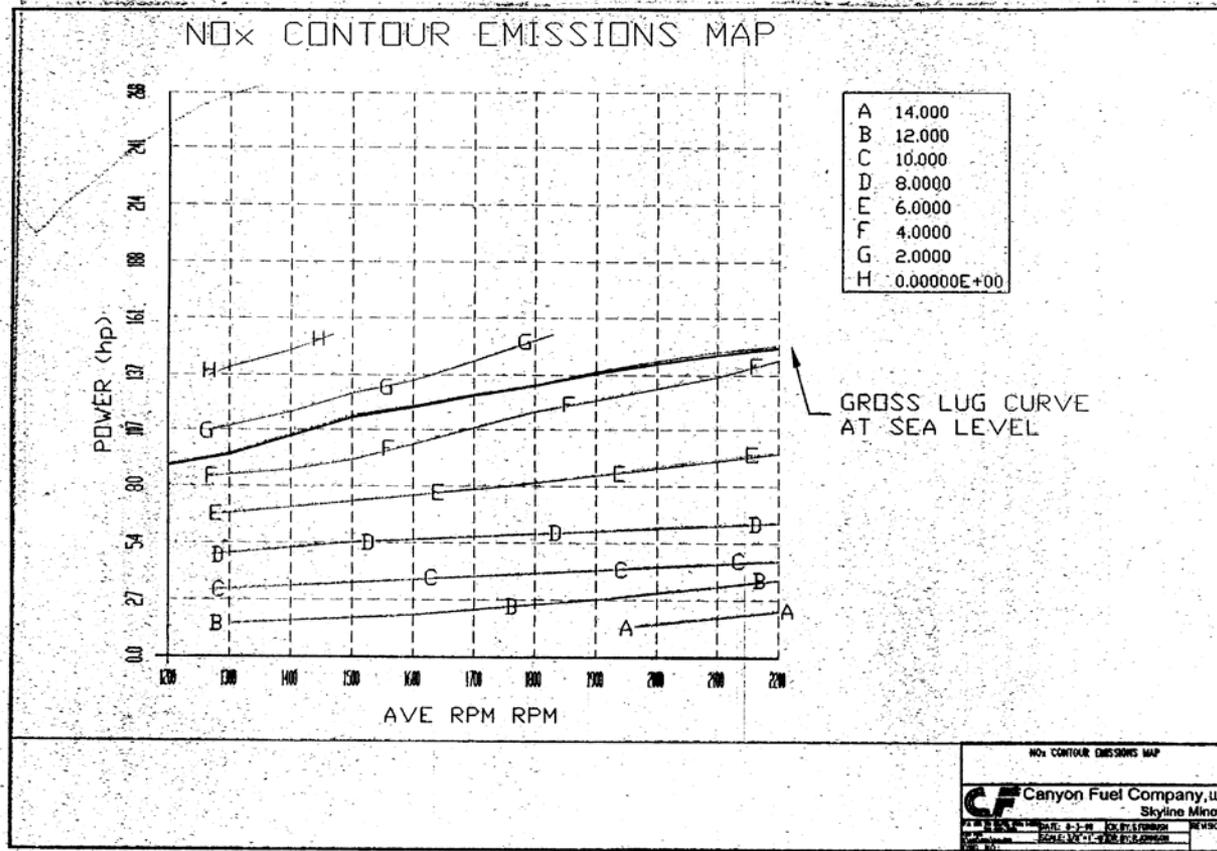
Steps to improvement.

1. Full support from Mine Management. This is critical for success.
2. Full support from the Operations side.
3. Maintenance group support.
4. Understanding the Nuts and Bolts of emissions reduction.
5. Training.

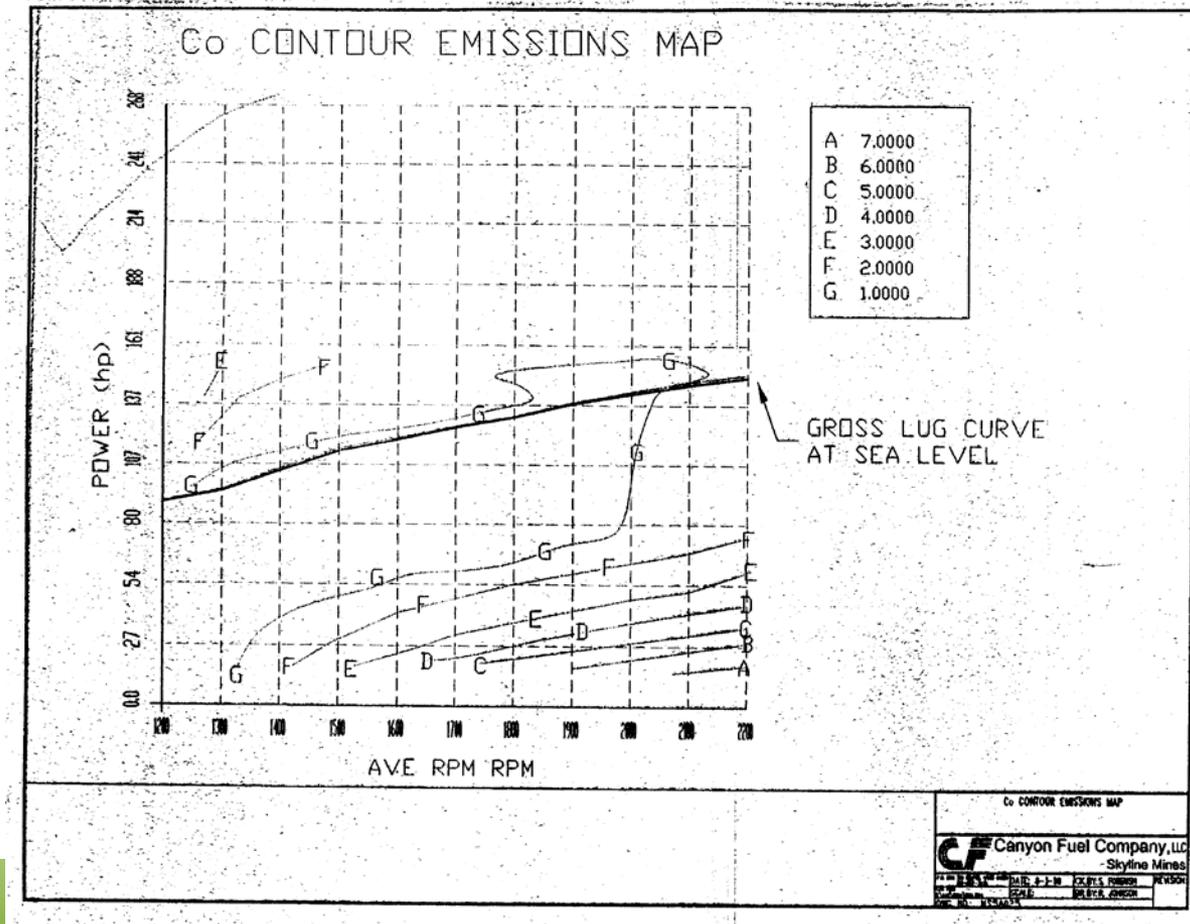
Nuts and Bolts.

1. The effects of elevation. All of our mines are at higher elevation (6,500'-9,000').
2. Most OEM's did not understand the elevation problem at that time.
3. Emissions contour maps.
4. Torque absorption charts.

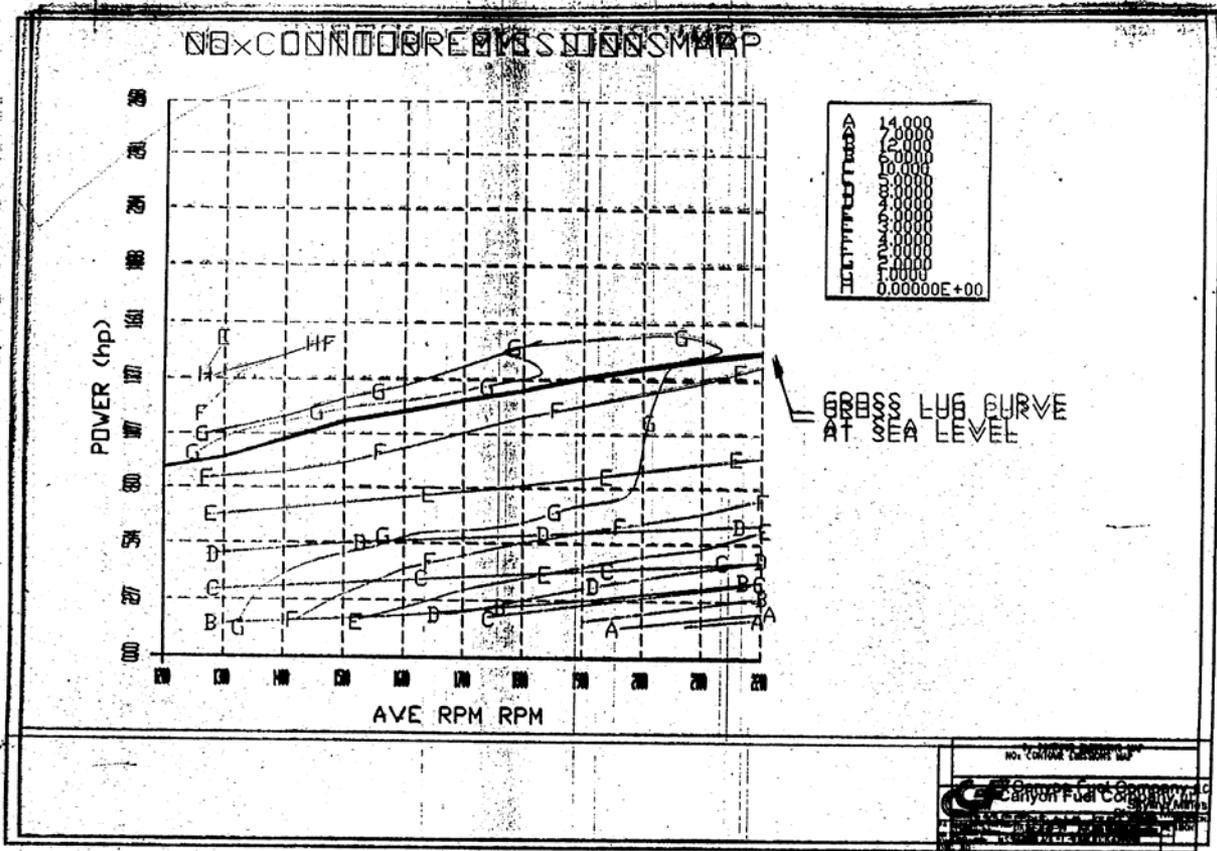
How do we get there? Emissions Contour Maps!!



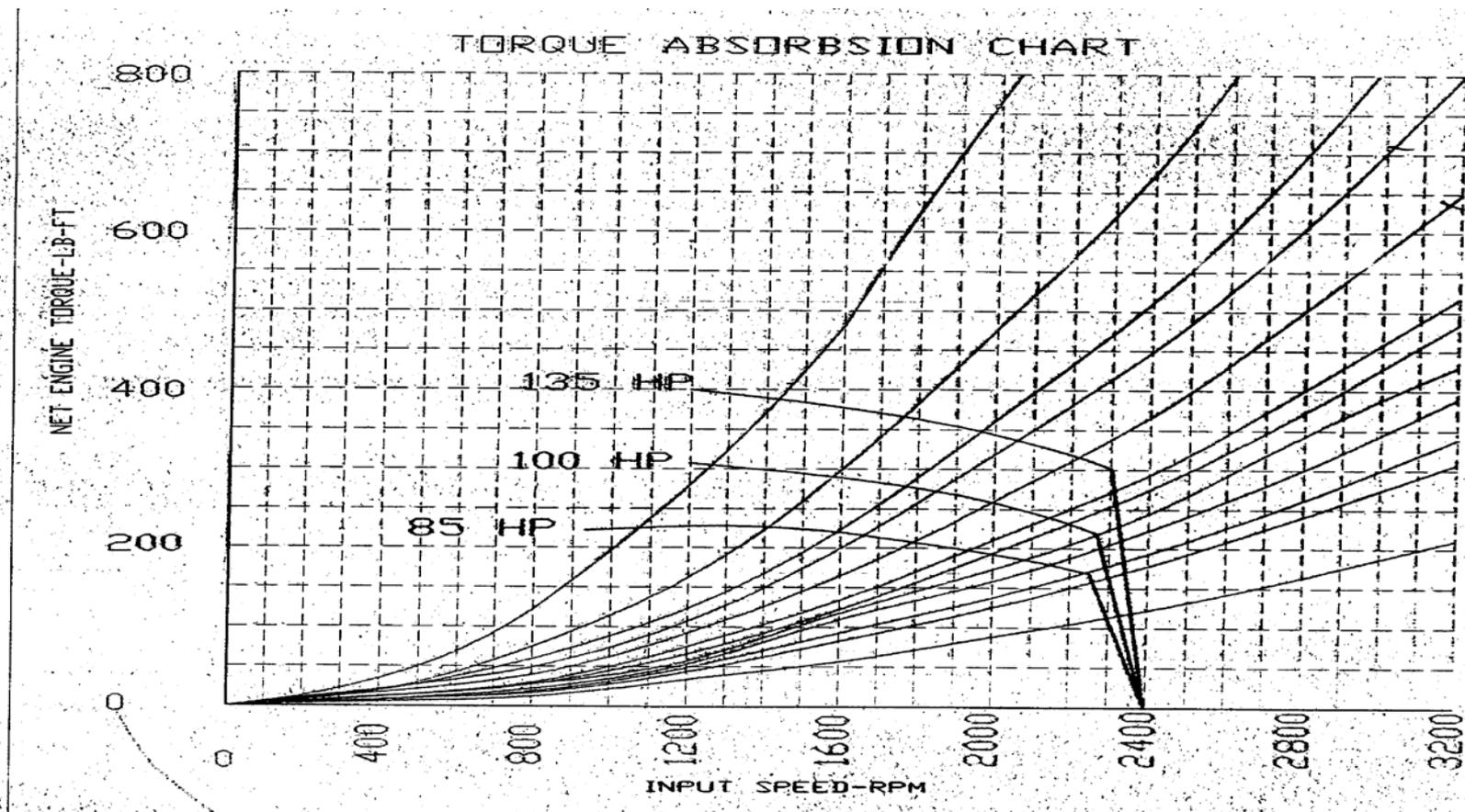
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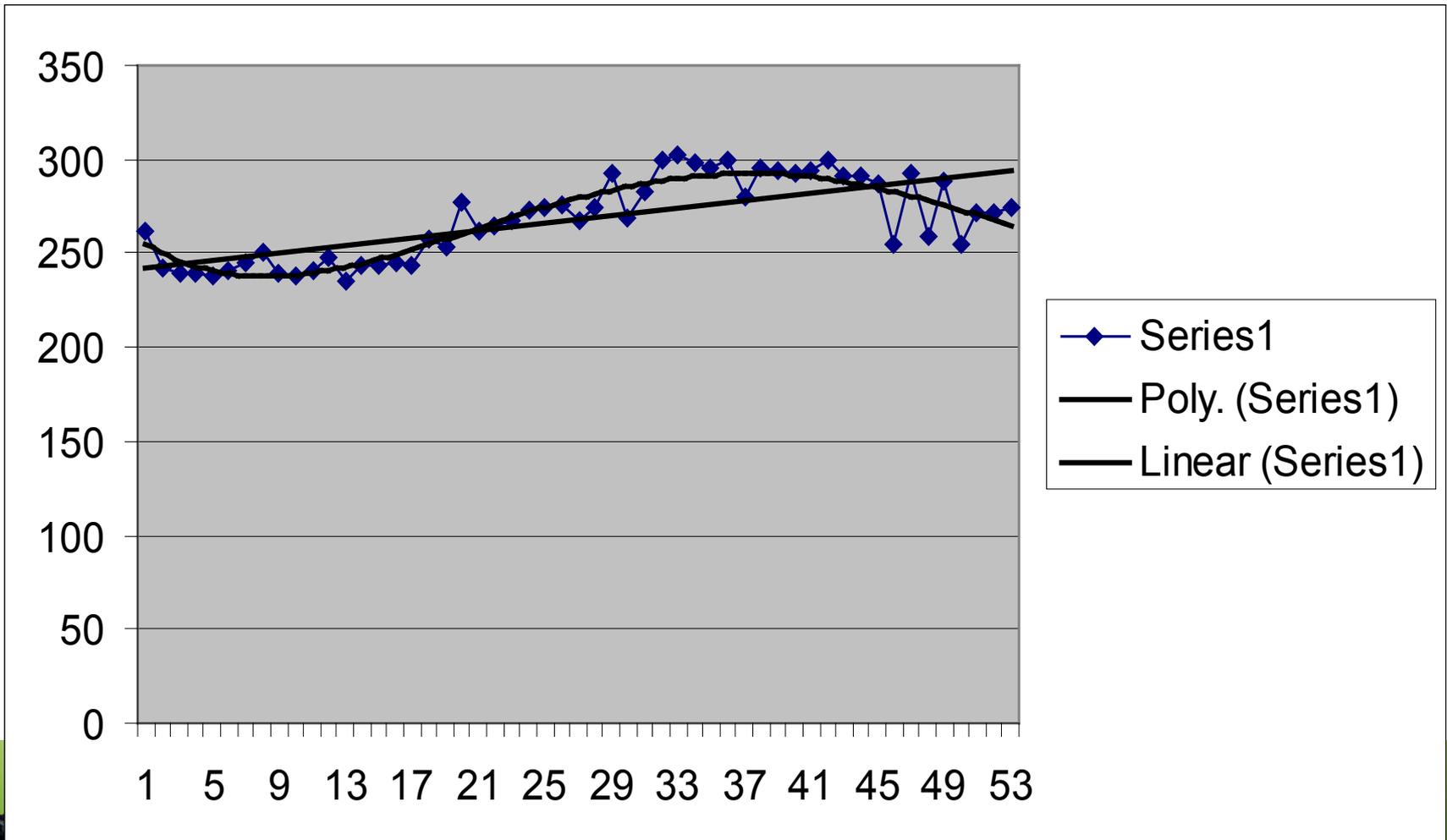
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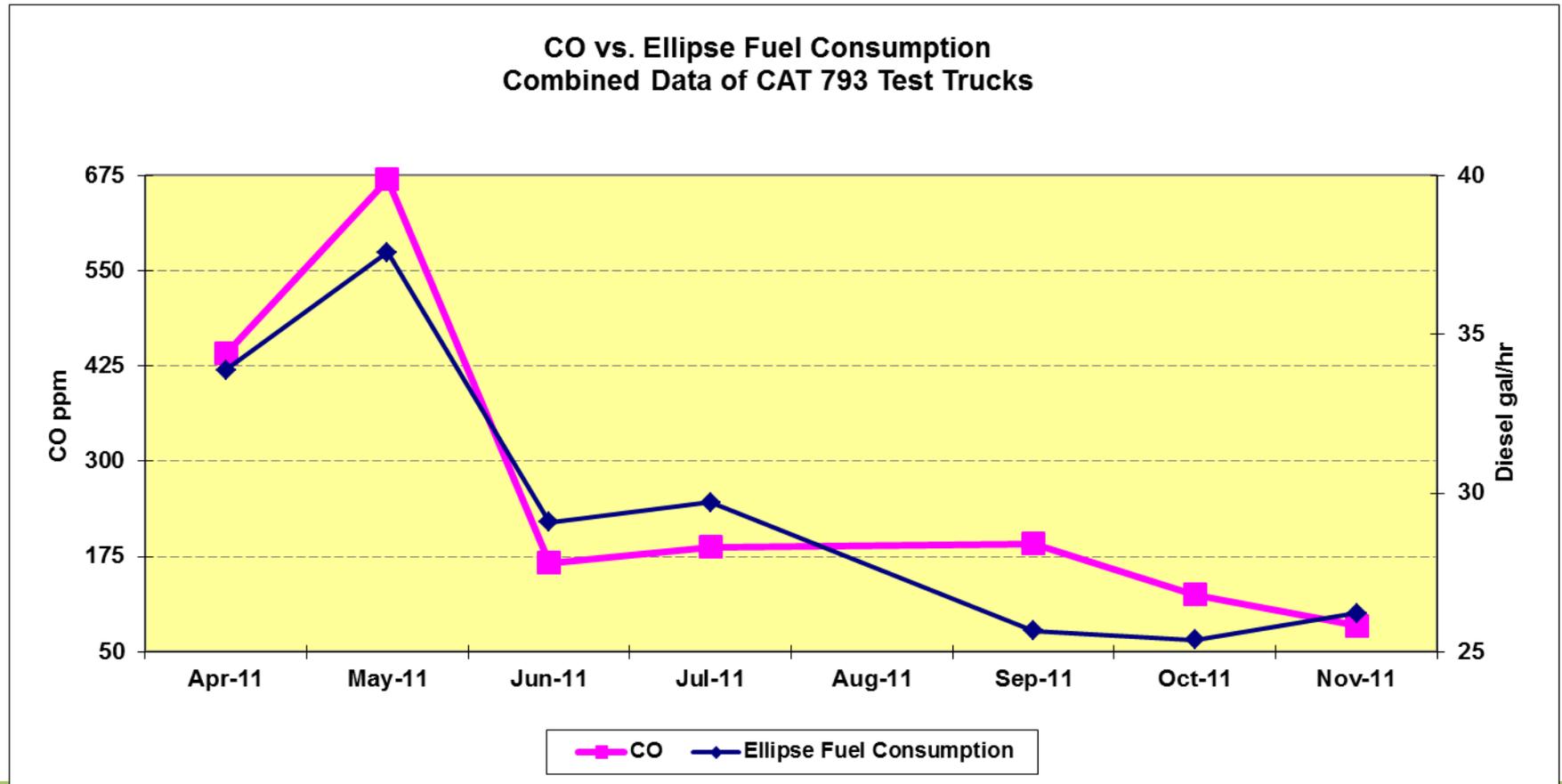
Torque Absorption Chart.



Improvement!



Additional uses. Fuel Consumption.



Questions?