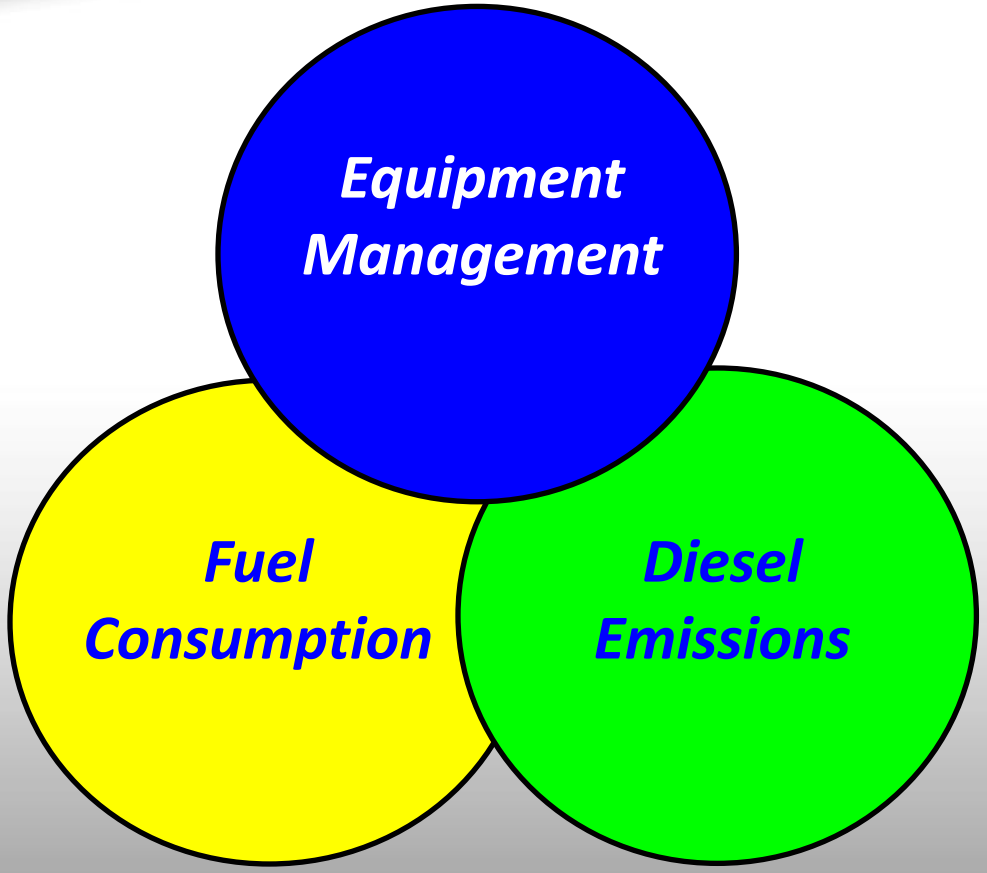
MIRENCO

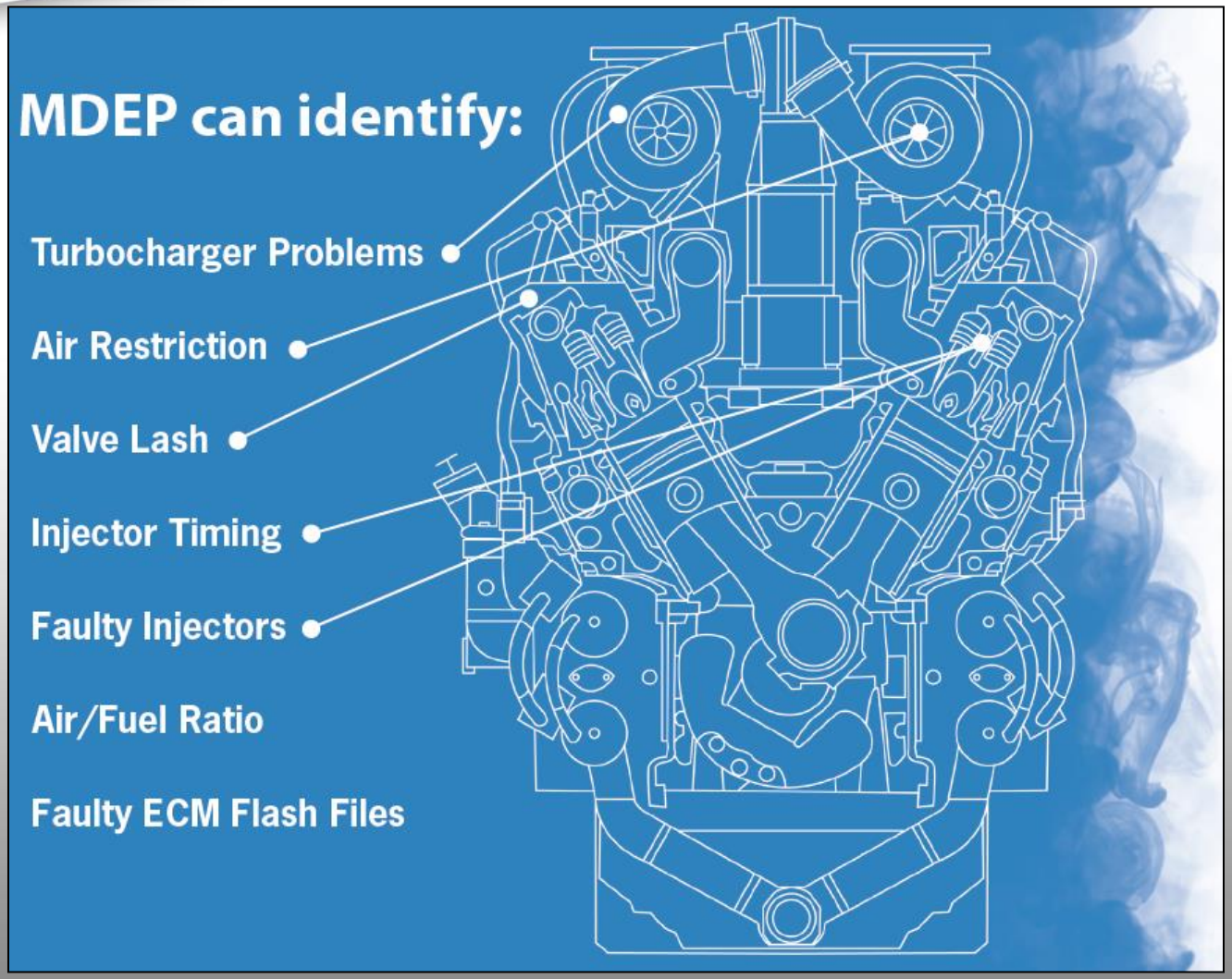
Enhanced Equipment Management through Combustion Analysis

Diagnostic Tool like *Scheduled Oil Sampling*



You Cannot Manage What You Cannot Measure

Common Combustion Issues



Mirenco Diesel Evaluation Procedure (MDEP)

Acceleration Snap Test (DPM)

High DPMs= Over fueling= Black Smoke= High Emissions= Wasted Fuel

0-20%- Acceptable DPMs
20-30%- Combustion Issue may Exist
30%- Combustion Issue causing Fuel Loss

Low "Trail" number indicates room for Improvement
5% DPM=1% Fuel Loss

777B Before Tune Up

Carbon Monoxide is higher than Carbon Dioxide – Indicates Poor Combustion.

Diesel Particulate Matter is Very High – Black Smoke – Wasted Fuel.

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You Cannot Manage What You Cannot Measure

Equipment # 4YC00276

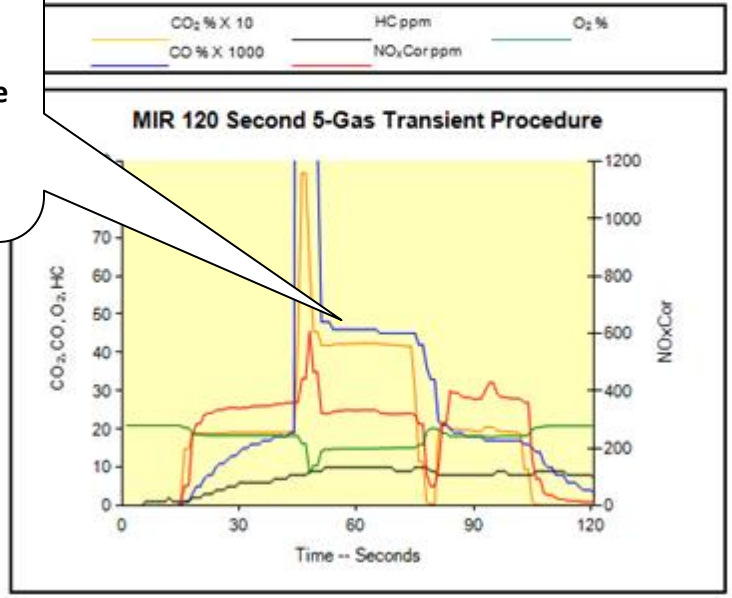
Equipment Reference # 4YC00276

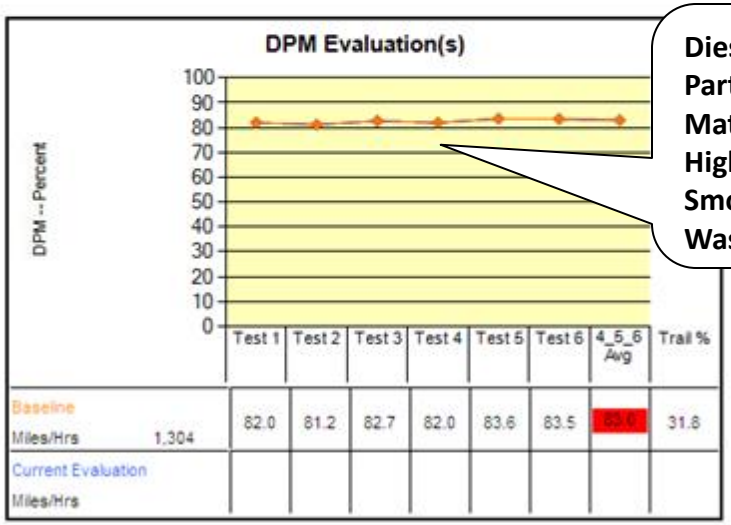
Evaluation Date: 10/13/2010

Evaluation Type: Baseline

Year:	2000	Engine mfr:	Caterpillar
Vehicle type:	Haul truck	Engine model:	3508
Vehicle model:	777B	Injection type:	M
OEM SN:		Fuel type:	No data
Truck position:	Single	Engine position:	Single

Annual fuel consumption (gal):		75,000
Average DPM Density (%):	Baseline 10/13/2010	83.0
Calculated fuel loss (gal):		12,451
Calculated DPM produced (lbs.):		5,043
Average DPM Density (%):	Current Evaluation 10/13/2010	83.0
Calculated fuel loss (gal):		12,451
Calculated DPM produced (lbs.):		5,043





Recommendations:

Evaluation results indicate the engine is injecting more fuel than it can burn during engine acceleration and at full power. Recommend replacing and adjusting the engine's air/fuel control to reduce fuel loss during engine accelerations. Adjust the engine fuel injection to match the engine real-time ability to burn fuel at full power. NOTE -- CO and HC should measure closer to normal after engine over-fueling is reduced.

777B After Tune Up

MIRENCO

You Cannot Manage What You Cannot Measure

Equipment # 4YC00276

Equipment Reference # 4YC00276

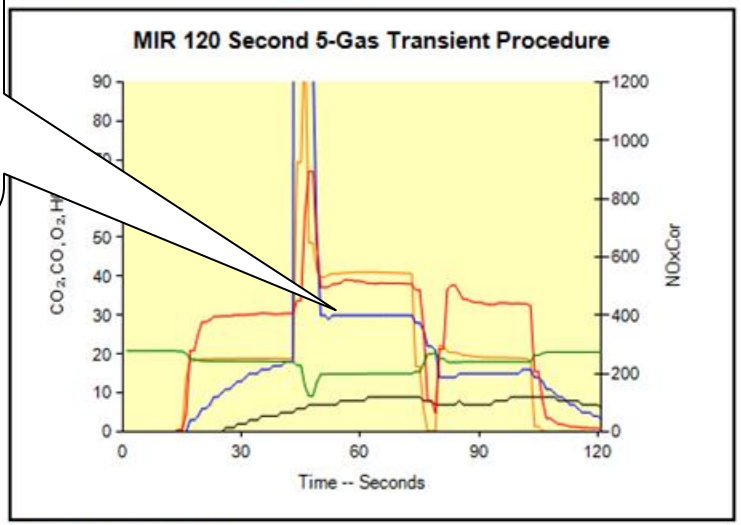
Evaluation Type: A/F Adjusted

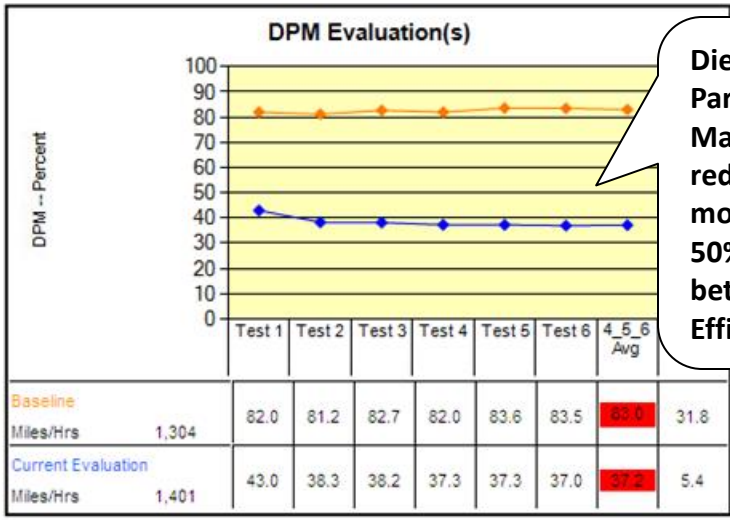
Year:	2000	Engine mfr:	Caterpillar
Vehicle type:	Haul truck	Engine model:	3508
Vehicle model:	777B	Injection type:	M
OEM SN:		Fuel type:	No data
Stack position:	Single	Engine position:	Single

Annual fuel consumption (gal):		75,000
Average DPM Density (%):	Baseline 10/13/2010	83.0
Calculated fuel loss (gal):		12,451
Calculated DPM produced (lbs.):		5,043
Average DPM Density (%):	Current Evaluation 10/21/2010	37.2
Calculated fuel loss (gal):		5,583
Calculated DPM produced (lbs.):		2,261

CO_2 % X 10 — HC ppm — O_2 %

CO % X 1000 — NO_xCor ppm





Baseline Miles/Hrs	1,304	82.0	81.2	82.7	82.0	83.6	83.5	83.0	31.8
Current Evaluation Miles/Hrs	1,401	43.0	38.3	38.2	37.3	37.3	37.0	37.2	5.4

Recommendations:

Evaluation results indicate the engine is injecting more fuel than it can burn during engine acceleration. Recommend adjusting the engine's air/fuel control a bit more during the next MDEP evaluation to reduce fuel loss during engine accelerations If combustion has not improved from this test results. Note - Engine combustion should improve over the next 100 hours from this tune-up

Carbon Monoxide is lower than Carbon Dioxide – Much Better Combustion.

Diesel Particulate Matter reduced by more than 50%. Much better Fuel Efficiency.

777B Oil Sample
Before and after Tune-up

Component	Sample Dte	Oil Hrs	Filter Change	Al	Si	Fe	Soot
ENGINE	1-Jun-10		Yes	1	3	46	209
ENGINE	29-Jun-10	302	Yes	1	2	38	204
ENGINE	5-Aug-10	337	Yes	1	3	42	230
ENGINE	28-Sep-10	313	Yes	1	3	24	124
TUNE -UP							
ENGINE	22-Nov-10	351	Yes	1	3	21	36
ENGINE	3-Jan-11	328	Yes	2	2	19	24

Mining MDEP Analysis

You Cannot Manage What You Cannot Measure

							Baseline					Mirenco Product	Current Evaluation						
Equipment Type	Equipment Model	Engine Position	Eng Year	Eng Mfr	Inj	Stack Position	Date	DPM Density (%)	Trl	Annual DPM (lb)	Annual Fuel Loss (Gal)		Location	Date	DPM Density (%)	Trl	Annual DPM (lb)	Annual Fuel Loss (Gal)	Annual Gallons of Fuel
Excavator	2500	Single	2011	Cum	E	Left	2/25/2011	26.2	5.0	6,356	15,695	RM	Bevins Branc	10/18/2011	15.5	1.0	3,773	9,317	300,000
Excavator	2500	Single	2011	Cum	E	Right	2/25/2011	30.7	5.0	7,454	18,406	RM	Bevins Branc	10/18/2011	14.5	1.0	3,531	8,720	300,000
Loader	992G	Single	2000	Cate	E	Left	5/8/2010	31.8	7.0	1,935	4,777	CM	Bevins Branc	10/18/2011	22.1	1.0	1,345	3,322	75,000
Loader	992G	Single	2000	Cate	E	Right	5/8/2010	25.7	2.0	1,564	3,861	CM	Bevins Branc	10/18/2011	9.1	1.0	554	1,367	75,000
Haul truck	785	Single	2010	Cate	E	Left	3/29/2010	13.5	7.0	546	1,347	CM	Bevins Branc	10/18/2011	22.3	8.0	723	1,786	50,000
Haul truck	785	Single	2010	Cate	E	Right	3/29/2010	23.1	24.0	934	2,306	CM	Bevins Branc	10/18/2011	27.8	3.0	899	2,220	50,000
Haul truck	785	Single	2010	Cate	E	Left	3/2/2010	22.7	10.0	1,837	4,537	CM	Bevins Branc	10/18/2011	17.4	5.0	565	1,396	100,000
Haul truck	785	Single	2010	Cate	E	Right	3/2/2010	21.1	8.0	1,711	4,225	CM	Bevins Branc	10/18/2011	17.2	2.0	556	1,372	100,000
Dozer	D10T	Single	2006	Cate	E	Left	3/30/2010	20.6	4.0	833	2,057	CM	Bevins Branc	10/18/2011	25.9	4.0	1,050	2,593	50,000
Dozer	D10T	Single	2006	Cate	E	Right	3/30/2010	18.7	2.0	758	1,872	CM	Bevins Branc	10/18/2011	26.6	4.0	1,076	2,656	50,000
Dozer	D11R	Single	2002	Cate	E	Left	1/25/2010	39.0	9.0	2,371	5,853	CM	Bevins Branc	10/18/2011	35.7	18.0	2,170	5,357	75,000
Dozer	D11R	Single	2002	Cate	E	Right	1/25/2010	31.1	7.0	1,889	4,665	CM	Bevins Branc	10/18/2011	36.1	8.0	2,195	5,421	75,000
Dozer	D11R	Single	2005	Cate	E	Left	1/18/2010	26.5	7.0	1,607	3,969	CM	Bevins Branc	10/18/2011	26.2	6.0	1,592	3,932	75,000
Dozer	D11R	Single	2005	Cate	E	Right	1/18/2010	19.3	2.0	1,174	2,898	CM	Bevins Branc	10/18/2011	19.9	5.0	1,209	2,984	75,000
Dozer	D10R	Single	2005	Cate	E	Left	3/26/2010	13.4	3.0	541	1,336	CM	Chisholm Sou	10/21/2011	16.2	8.0	658	1,624	50,000
Dozer	D10R	Single	2005	Cate	E	Right	3/26/2010	14.6	1.0	590	1,457	CM	Chisholm Sou	10/21/2011	15.2	6.0	616	1,520	50,000
Loader	992G	Single	2000	Cate	E	Left	6/4/2010	59.8	10.0	3,630	8,964	CM	Colley Fork	10/21/2011	4.7	2.0	286	706	75,000
Loader	992G	Single	2000	Cate	E	Right	6/4/2010	50.9	6.0	3,094	7,639	CM	Colley Fork	10/21/2011	6.7	7.0	407	1,006	75,000
Dozer	D10T	Single	2007	Cate	E	Left	3/25/2010	16.2	5.0	658	1,624	CM	Colley Fork	10/21/2011	19.5	4.0	788	1,946	50,000
Dozer	D10T	Single	2007	Cate	E	Right	3/25/2010	20.5	2.0	829	2,047	CM	Colley Fork	10/21/2011	15.5	2.0	628	1,551	50,000
Dozer	D11R	Single	2002	Cate	E	Left	3/1/2010	49.7	7.0	3,017	7,449	CM	Colley Fork	10/21/2011	26.8	6.0	1,628	4,021	75,000
Dozer	D11R	Single	2002	Cate	E	Right	3/1/2010	44.7	7.0	2,716	6,706	CM	Colley Fork	10/21/2011	18.7	2.0	1,135	2,803	75,000
Loader	992G	Single	2000	Cate	E	Left	8/6/2010	49.5	14.0	3,008	7,427	CM	Daniels Creek	10/13/2011	0.0	0.0	0	0	75,000
Loader	992G	Single	2000	Cate	E	Right	8/6/2010	61.0	17.0	3,704	9,147	CM	Daniels Creek	10/13/2011	0.0	0.0	0	0	75,000
Loader	992D	Single		Cate	M	Left	10/13/2011	87.9	5.0	2,492	6,153		Daniels Creek	10/13/2011	87.9	5.0	2,492	6,153	35,000
Loader	992D	Single		Cate	M	Right	10/13/2011	10.8	3.0	306	755		Daniels Creek	10/13/2011	10.8	3.0	306	755	35,000
Dozer	D10R	Single		Cate	E	Single	10/13/2011	19.7	3.0	1,278	3,155		Daniels Creek	10/13/2011	19.7	3.0	1,278	3,155	80,000
Dozer	D11R	Single	2000	Cate	E	Left	1/27/2010	19.4	9.0	1,180	2,913	CM	First Fork	3/21/2011	18.2	3.0	1,107	2,733	75,000
Dozer	D11R	Single	2000	Cate	E	Right	1/27/2010	25.7	9.0	1,562	3,856	CM	First Fork	3/21/2011	19.1	4.0	1,160	2,865	75,000
Dozer	D11R	Single	2006	Cate	E	Left	1/26/2010	24.1	5.0	1,467	3,622	CM	Kettle Camp	4/25/2011	19.8	6.0	1,202	2,969	75,000
Dozer	D11R	Single	2006	Cate	E	Right	1/26/2010	22.9	5.0	1,389	3,429	CM	Kettle Camp	4/25/2011	22.6	10.0	1,373	3,389	75,000

Mining MDEP Analysis Cont.

							Baseline					Mirenco Product	Current Evaluation						
Equipment Type	Equipment Model	Engine Position	Eng Year	Eng Mfr	Inj	Stack Position	Date	DPM Density (%)	Trl	Annual DPM (lb)	Annual Fuel Loss (Gal)		Location	Date	DPM Density (%)	Trl	Annual DPM (lb)	Annual Fuel Loss (Gal)	Annual Gallons of Fuel
Excavator	EX2500	Single	2000	Cum	E	Left	7/6/2010	36.2	7.0	2,932	7,239		Kettle Camp	7/6/2010	36.2	7.0	2,932	7,239	100,000
Excavator	EX2500	Single	2000	Cum	E	Right	7/6/2010	35.9	7.0	2,906	7,175		Kettle Camp	7/6/2010	35.9	7.0	2,906	7,175	100,000
Dozer	D11R	Single	2002	Cate	E	Left	1/26/2010	34.5	4.0	2,096	5,176	CM	Kettle Camp	10/21/2011	36.3	12.0	2,206	5,446	75,000
Dozer	D11R	Single	2002	Cate	E	Right	1/26/2010	33.8	9.0	2,055	5,075	CM	Kettle Camp	10/21/2011	20.9	5.0	1,272	3,141	75,000
Dozer	D11R	Single	2003	Cate	E	Left	1/25/2010	25.9	9.0	1,575	3,889	CM	Kettle Camp	10/21/2011	28.9	8.0	1,755	4,334	75,000
Dozer	D11R	Single	2003	Cate	E	Right	1/25/2010	28.0	6.0	1,701	4,200	CM	Kettle Camp	10/21/2011	20.8	7.0	1,265	3,123	75,000
OTR Truck	CH 713	Single	1996	Mac	E	Single	9/21/2010	4.6	2.0	149	368		ST&T Leasing	6/6/2011	0.4	0.0	13	33	40,000
OTR Truck	CV 713	Single	2005	Mac	E	Single	9/21/2010	24.3	8.0	786	1,942		ST&T Leasing	6/3/2011	13.5	1.0	438	1,082	40,000
OTR Truck	CV 713	Single	2005	Mac	E	Single	9/20/2010	30.7	2.0	995	2,456		ST&T Leasing	6/3/2011	8.2	1.0	265	655	40,000
OTR Truck	CV 713	Single	2004	Mac	E	Single	9/20/2010	12.3	2.0	399	984		ST&T Leasing	6/3/2011	1.6	0.0	52	129	40,000
OTR Truck	CV 713	Single	2004	Mac	E	Single	9/21/2010	26.9	2.0	872	2,153		ST&T Leasing	9/21/2010	26.9	2.0	872	2,153	40,000
OTR Truck	CV 713	Single	2004	Mac	E	Single	9/21/2010	42.5	1.0	1,377	3,400		ST&T Leasing	6/3/2011	16.5	0.0	535	1,322	40,000
OTR Truck	CV 713	Single	2005	Mac	E	Single	9/21/2010	24.3	1.0	787	1,944		ST&T Leasing	6/6/2011	28.0	1.0	908	2,242	40,000
OTR Truck	CV 713	Single	2005	Mac	E	Single	9/20/2010	8.4	2.0	273	673		ST&T Leasing	6/3/2011	8.5	0.0	276	682	40,000
OTR Truck	CL 713	Single	2005	Mac	E	Single	9/20/2010	23.0	4.0	746	1,842		ST&T Leasing	6/3/2011	11.0	1.0	356	879	40,000
OTR Truck	CV 713	Single	2006	Mac	E	Single	9/20/2010	10.0	8.0	323	796		ST&T Leasing	6/3/2011	10.3	1.0	334	824	40,000
OTR Truck	CV 713	Single	2006	Mac	E	Single	9/20/2010	13.1	2.0	425	1,049		ST&T Leasing	6/3/2011	10.3	1.0	335	827	40,000
OTR Truck	CL 713	Single	2001	Mac	E	Single	9/20/2010	8.1	1.0	264	651		ST&T Leasing	6/3/2011	8.5	4.0	277	683	40,000
OTR Truck	CL 713	Single	2003	Mac	E	Single	9/20/2010	25.3	14.0	818	2,021		ST&T Leasing	9/20/2010	25.3	14.0	818	2,021	40,000
OTR Truck	CL 713	Single	2003	Mac	E	Single	9/20/2010	14.5	1.0	470	1,161		ST&T Leasing	9/20/2010	14.5	1.0	470	1,161	40,000
OTR Truck	379	Single	1993	Cate	M	Single	9/21/2010	88.1	18.0	2,854	7,047		ST&T Leasing	9/21/2010	88.1	18.0	2,854	7,047	40,000
OTR Truck	CV 713	Single	2005	Mac	E	Single	6/6/2011	8.0	3.0	259	639		ST&T Leasing	6/6/2011	8.0	3.0	259	639	40,000
OTR Truck	_Unknown	Single	2002	Cate	E	Single	6/6/2011	5.6	5.0	183	451		ST&T Leasing	6/6/2011	5.6	5.0	183	451	40,000
						Totals/Averages		27.9	6.1	87,675	216,478				20.4	4.4	57,883	142,927	3,730,000

Fuel Reduced

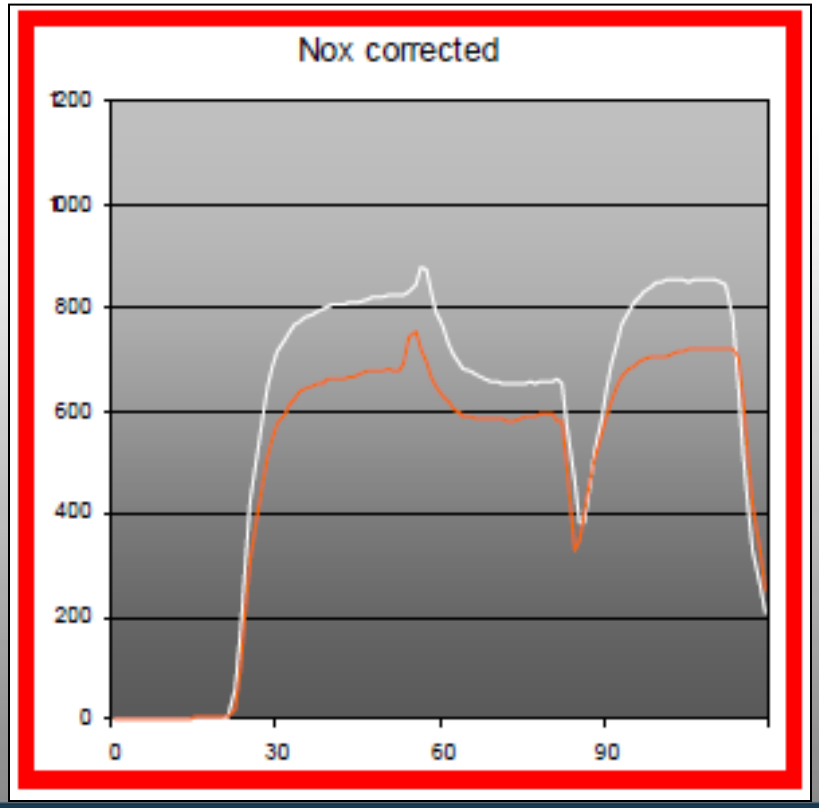
DPMs Reduced

Limestone Quarry Fuel Savings

	Limestone Quarry-Fuel data provided by Customer															
	Mirenco Fuel Burn Study															
	Baseline			Fuel Study #1				Fuel Study #2				#1 & #2 Combined				Year 1 Fuel Savings
	Nov. 2011- Feb. 2012			June 2012-Jan. 2013				Jan 1 2013-May 31 2013				June 2012-May 31 2013				
	Hours	Gallons	GPH	Hours	Gallons	GPH		Hours	Gallons	GPH		Hours	Gallons	GPH		
330M	209	3,056	14.6	1,237	17,497	14.2	(0.47)	501	8540	17.05	2.4	1,738	26,037	15.0	0.4	634
R90	719	4,551	6.3	391	5,880	15.1	8.73	52	1072	20.62	14.3	443	6,952	15.7	9.4	4,151
R90	387	7,076	18.3	460	6,714	14.6	(3.70)	88	1466	16.66	-1.6	548	8,180	14.9	-3.4	(1,844)
777D	818	14,959	18.3	1,731	24,204	14.0	(4.30)	2329	17320	7.437	-10.9	4,060	41,524	10.2	-8.1	(32,712)
777D	677	13,000	19.2	2,232	31,942	14.3	(4.89)	1177	16215	13.78	-5.4	3,409	48,157	14.1	-5.1	(17,304)
777D	708	13,609	19.2	2,341	31,801	13.6	(5.64)	1766	25911	14.67	-4.5	4,107	57,712	14.1	-5.2	(21,229)
EH1700	464	9,791	21.1	743	10,827	14.6	(6.54)	505	8192	16.22	-4.9	1,248	19,019	15.2	-5.9	(7,335)
EH1700	576	10,414	18.1	487	7,386	15.2	(2.91)	164	3018	18.4	0.3	651	10,404	16.0	-2.1	(1,366)
777D	583	12,880	22.1	2,016	29,563	14.7	(7.44)	1243	18317	14.74	-7.4	3,259	47,880	14.7	-7.4	(24,171)
R60	106	1,520	14.4	132	1,554	11.8	(2.59)	269	2647	9.84	-4.6	401	4,201	10.5	-3.9	(1,570)
WA120	46	322	7.0	226	555	2.5	(4.54)	135	647	4.793	-2.2	361	1,202	3.3	-3.7	(1,322)
777F	885	14,080	15.9	1,704	20,988	12.3	(3.59)	1688	26292	15.58	-0.3	3,392	47,280	13.9	-2.0	(6,677)
WA500	527	3,667	7.0	362	4,996	13.8	6.86	1097	4714	4.297	-2.7	1,459	9,710	6.7	-0.3	(440)
980	729	6,583	9.0	1,277	7,757	6.1	(2.96)	712	4613	6.479	-2.6	1,989	12,370	6.2	-2.8	(5,590)
777F	687	11,333	16.5	1,594	19,649	12.3	(4.16)	897	14041	15.65	-0.8	2,491	33,690	13.5	-3.0	(7,393)
992G	894	19,572	21.9	2,264	37,469	16.6	(5.35)	1523	24998	16.41	-5.5	3,787	62,467	16.5	-5.4	(20,474)
992G	977	20,682	21.2	2,807	43,141	15.4	(5.81)	1409	24053	17.07	-4.1	4,216	67,194	15.9	-5.2	(22,088)
TRACKHOE	68	629	9.3	352	1,283	3.6	(5.67)	79	354	4.481	-4.8	431	1,637	3.8	-5.5	(2,376)
D8R	489	7,663	15.7	1,025	9,228	9.0	(6.68)	808	8105	10.03	-5.7	1,833	17,333	9.5	-6.2	(11,414)
D155	717	8,940	12.5	756	7,560	10.0	(2.47)	605	6287	10.39	-2.1	1,361	13,847	10.2	-2.3	(3,129)
D8R	924	8,556	9.3	1,934	15,984	8.3	(0.99)	870	9916	11.4	2.1	2,804	25,900	9.2	0.0	(59)
16G	352	2,116	6.0	592	4,225	7.1	1.12	396	2655	6.705	0.7	988	6,880	7.0	0.9	933
	12,537	194,996	15.6	26,655	340,202	13	(2.79)	18,313	229,373	13	(3.03)	44,968	569,575	12.7	(2.89)	
				Fuel Savings %		18%				19%				19%		182,773

3412 Diagnostics

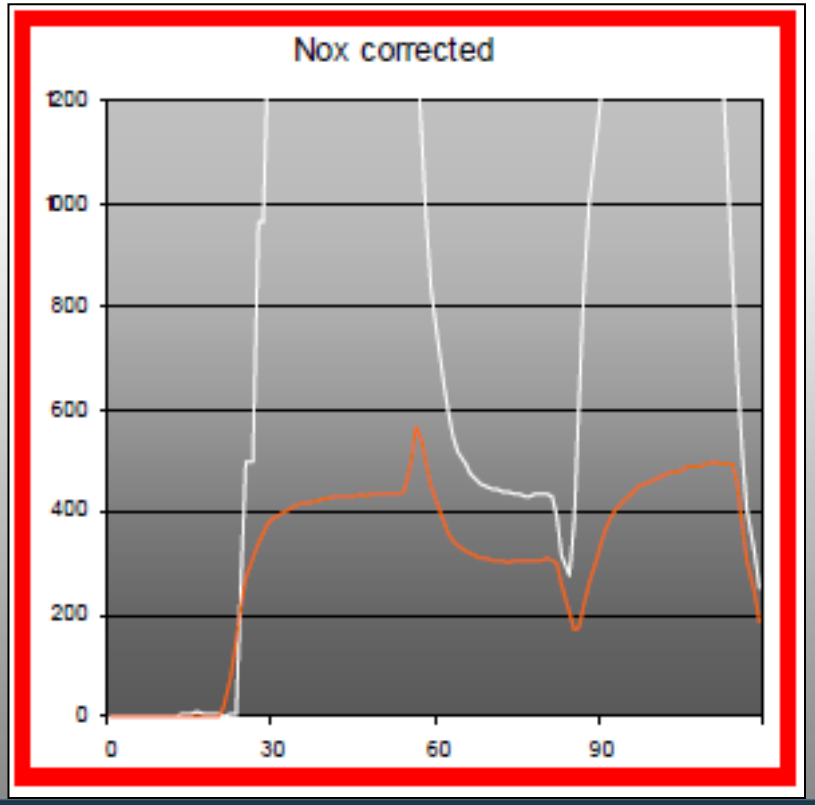
Good 992C



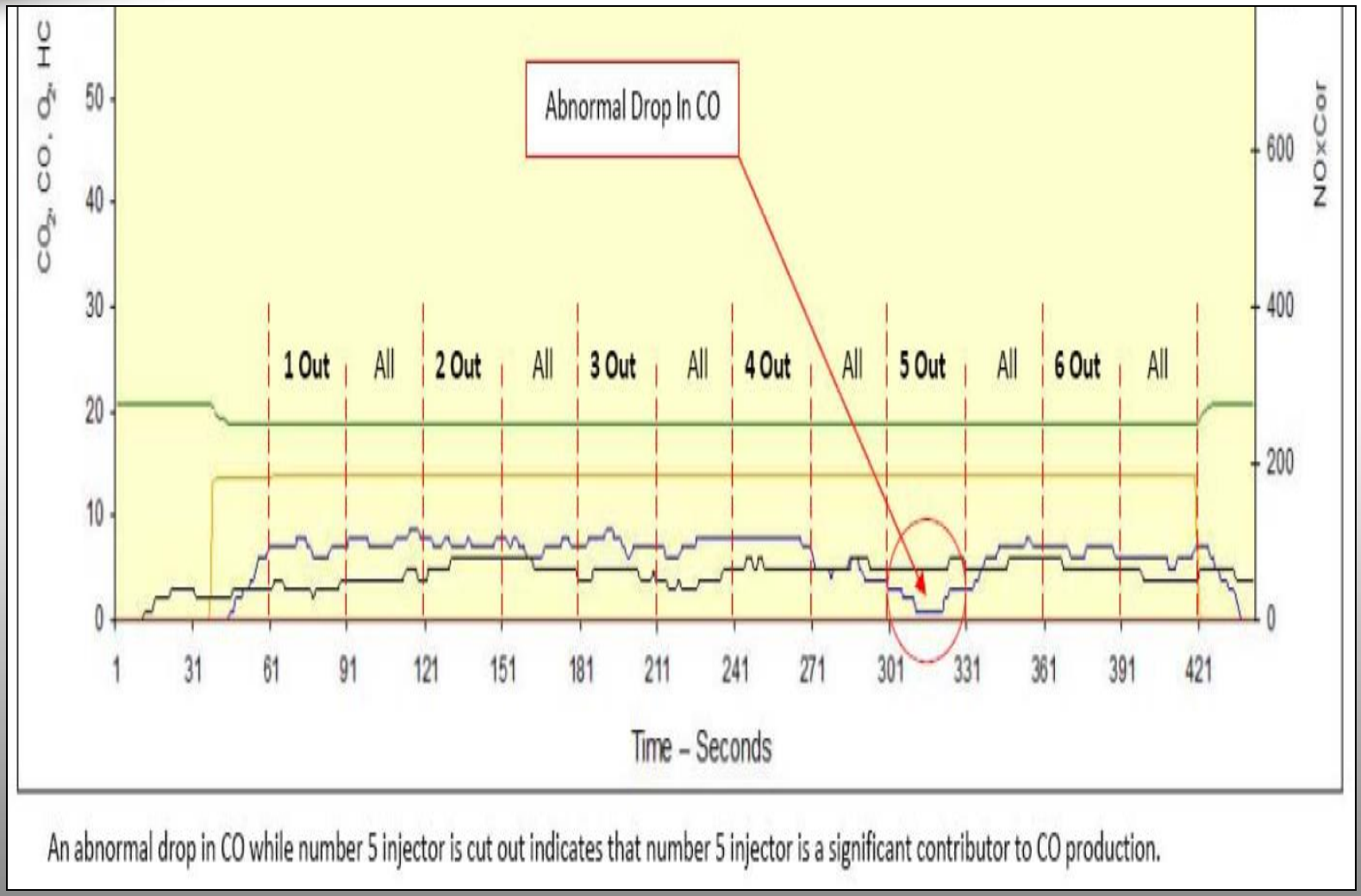
992C

Severe Imbalance

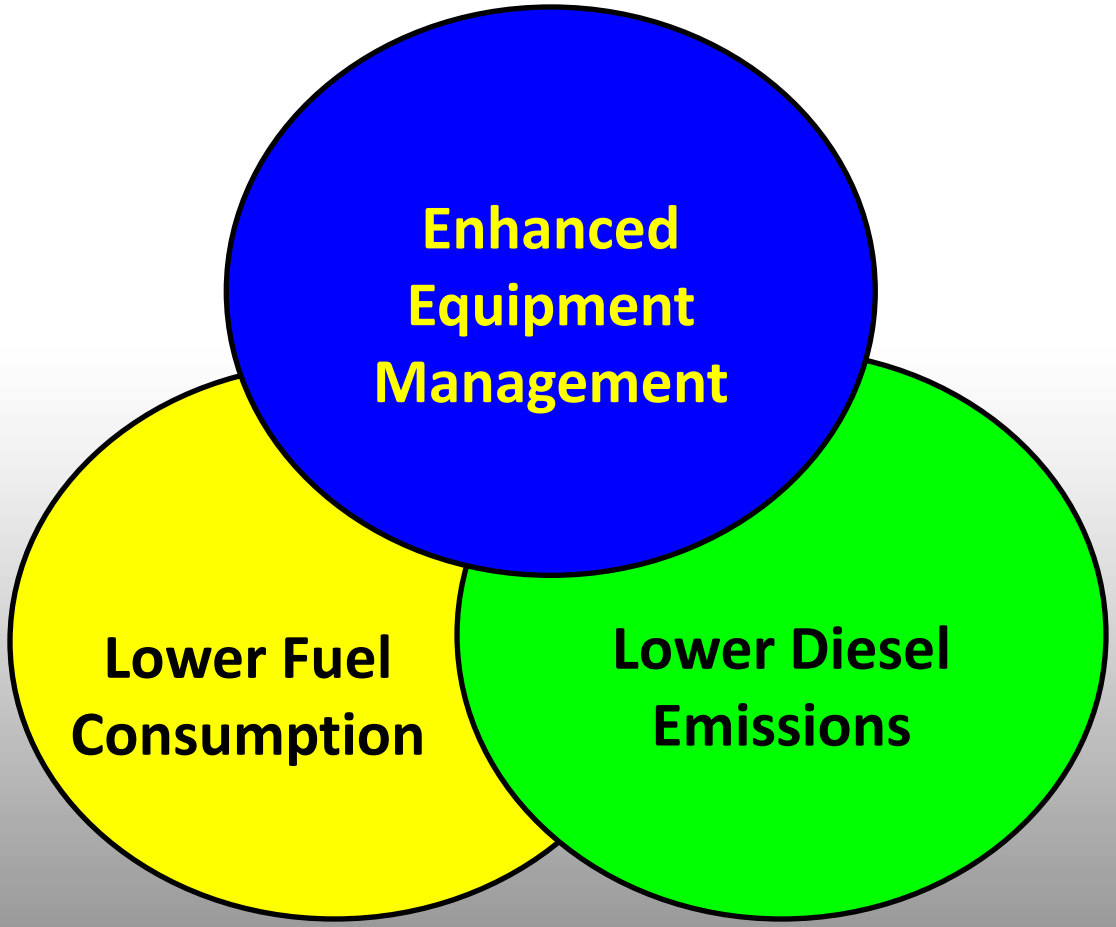
Failure Immediate



Injector Cutout Test



An abnormal drop in CO while number 5 injector is cut out indicates that number 5 injector is a significant contributor to CO production.


Enhanced Equipment Management
Lower Fuel Consumption
Lower Diesel Emissions