

# Pennsylvania Technical Advisory Committee

## Diesel Powered Equipment

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5-16-05

Joseph Sbaffoni, Director  
Bureau of Deep Mine Safety  
Fayette County Health Center  
100 New Salem Road, Room 167  
Uniontown, Pa 15402

Dear Mr. Sbaffoni:

Article II-A of the Pennsylvania Bituminous Coal Mine Act of 1961 provides for the use of diesel-powered equipment in underground bituminous coal mines. Section 224-A created a Technical Advisory Committee for the purpose of advising the Secretary regarding implementation of Article II A.

On March 28<sup>th</sup> 2005 the TAC received a request from Hager Equipment of Alabama for the use of:

- BF4M2012 (100hp) Deutz diesel engine (MSHA approval No. 07-ENA040002)
- CleanAir lightly catalyzed Silicon Carbide Diesel Particulate Filter with Platinum Plus Fuel Borne Catalyst (FBC)
- Nett Technologies Diluter (Model 20) ( for exhaust gas temperature control)

After talking with representatives of Hager Equipment, it was stated that the engine and after-treatment was not in its final configuration. Never the less Hager Equipment requested the TAC evaluate the engine and after-treatment for compliance with the Pennsylvania Diesel Law. We stated to Hager Equipment that the TAC may not be able to recommend the use of the complete engine and after-treatment package until it was set in its final configuration, however the TAC could perform a *Technology Evaluation* of the package in its current configuration. This would allow an opportunity for Hager Equipment to address any deficiencies of the current package prior to final equipment approval. Hager Equipment agreed with this approach and set April 28<sup>th</sup> 2005, as the date for the Evaluation.

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## Engine and Filter Evaluation

Duetz BF4M2012 (07-ENA040002)

- 100HP @ 2500 RPM
- Vent Plate (6000 CFM)
- DPM (4.51 g/hr)

CleanAir (Lightly Catalyzed) Diesel Particulate Filter with Platinum Plus (FBC)

- Although the original request was for a Silicon Carbide substrate, the test filter was of a cordierite substrate. The change has little to do with the final recommendation since both filter types are similar in their DPM reduction capabilities.
- Extrapolations of the engine and filter package shows a DPM level of .066mg/m<sup>3</sup> which does meet the .12 mg/m<sup>3</sup> Pennsylvania requirement.
- The Filter and the FBC is currently being used in Pennsylvania at the Emerald Mine

Emissions test of the engine and filter were performed at the Hager facility on April 28<sup>th</sup> with the following results:

Chart 1

#2005-04-28 09:24:56#								
Time(h:m:s)	O2(%)	CO(ppm)	NO(ppm)	NO2(ppm)	NOx(ppm)	SO2(ppm)	CxHy(%)	CO2(%)
0:04:34	14.4	395	535	59	594	0	0	4.8
0:04:44	11.6	271	756	48	804	0	0	6.9
0:04:54	11.1	159	812	40	852	0	0	7.3
0:05:04	10.9	103	848	34	882	0	0	7.4
0:05:14	10.7	79	867	30	897	0	0	7.6
0:05:24	10.6	67	883	28	911	0	0	7.6
0:05:34	10.7	63	903	26	929	0	0	7.6
0:05:44	10.6	61	905	25	930	0	0	7.6
0:05:54	10.6	61	908	24	932	0	0	7.6
0:06:04	10.7	60	911	23	934	0	0	7.6

Chart 1 shows a 90 second stall test that was performed on the untreated exhaust of the engine. The average CO for this test would be 61.3 ppm., which does compare favorable with the MSHA Lug Curve listings (83 ppm). You must keep in consideration that the FBC was present in the shock dose which will lower the raw CO emissions somewhat. Final testing of the untreated emissions will need to be performed with a normal dose of the FBC prior to any TAC recommendation. The chart also shows the turbo lag time for this engine is about 45 seconds, which will allow accurate readings of the CO during the 90 second stall test.

We next performed a treated emissions test which can be seen in chart 2.

Chart 2								
#2005-04-28 09:24:56#								
Time(h:m:s)	O2(%)	CO(ppm)	NO(ppm)	NO2(ppm)	NOx(ppm)	SO2(ppm)	CxHy(%)	CO2(%)
0:10:14	17	337	285	27	312	0	0	2.9
0:10:24	17	336	287	27	314	0	0	2.9
0:10:34	12.3	287	726	25	751	0	0	6.4
0:10:44	11.4	162	776	21	797	0	0	7
0:10:54	11.2	74	816	21	837	0	0	7.2
0:11:04	11.2	36	830	22	852	0	0	7.2
0:11:14	11.2	16	828	26	854	0	0	7.2
0:11:24	10.9	8	868	31	899	0	0	7.4
0:11:34	10.8	5	882	36	918	0	0	7.5
0:11:44	10.9	3	874	41	915	0	0	7.4

The treated CO emissions listed in chart 2 show that the catalyzed exhaust will meet Pennsylvania's requirement of less than 100ppm CO in the treated exhaust. This test shows an average CO reading of 8 ppm.

In summary, the engine and DPM filter will meet all Pennsylvania requirements.

### Evaluation of the Nett technologies Diluter

Tests were then performed on the Nett Technologies Exhaust Gas Diluter (model 20). This item is new to Pennsylvania and as such will need to undergo testing in its final configuration.

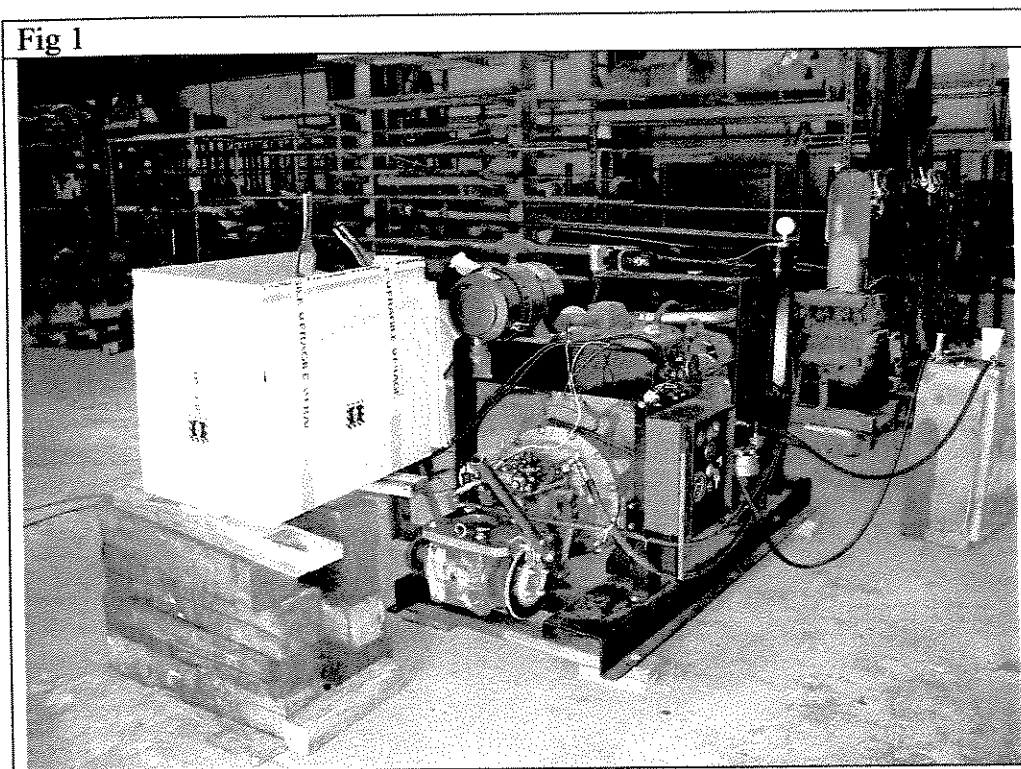
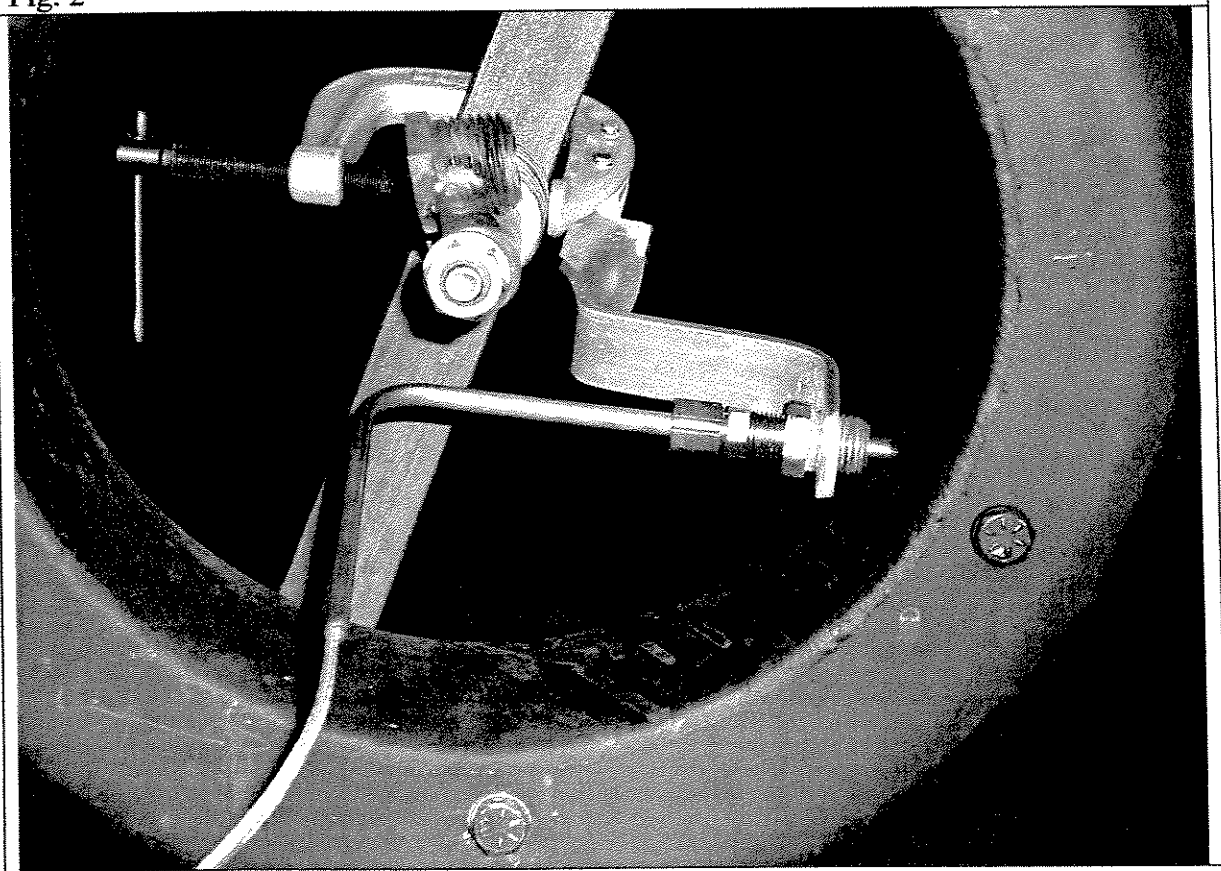


Fig 1

The purpose of the diluter is to mix ambient air with the exhaust to lower the temperature of the exhaust gas below the required 302<sup>0</sup> F. The diluter was encased in a box to simulate the final configuration of this device (Fig. 1) The ambient air entering the box was measured with an anemometer during high idle condition. The amount of ambient air entering the box was found to be approximately 690 CFM. I believe this to be about a 1 to 1 ratio of exhaust and ambient air. We then attached a thermocouple probe (J configuration) to the diluter approximately ¾ of an inch into the exhaust stream (Fig.2). The test protocol used for this evaluation was as follows:

- induce torque converter stall for 90 seconds
- then put the engine in high idle for 90 seconds.
- The procedure was to be completed for three series.

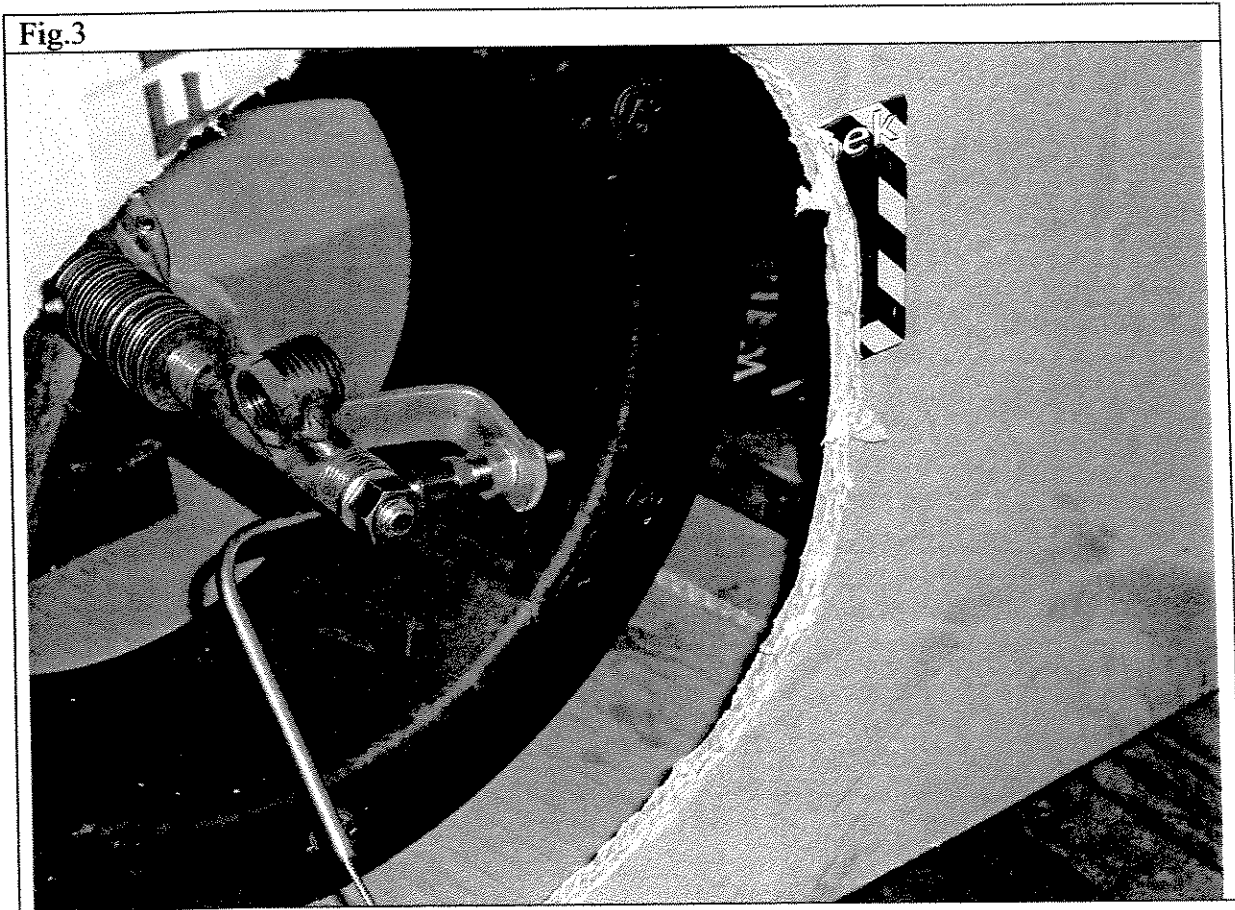
Fig. 2



After the second series, the exhaust gas temperature increased above the 302<sup>0</sup> F requirement (Chart 3). The test was stopped at this time. After studying the setup of the diluter we found that even though the thermocouple probe was located ¾ of an inch in by the outside edge of the diluter the position of the box caused the probe to be positioned 2 ½ inches in by the outer edge of the box. At this time we adjusted the thermocouple probe to be even with the outside edge of the diluter and approximately 1 1/2 inches into the exhaust stream. (Fig.3) We felt this would be acceptable since Pennsylvania law requires the exhaust gas to be under the 302<sup>0</sup> F just prior to entering the mine

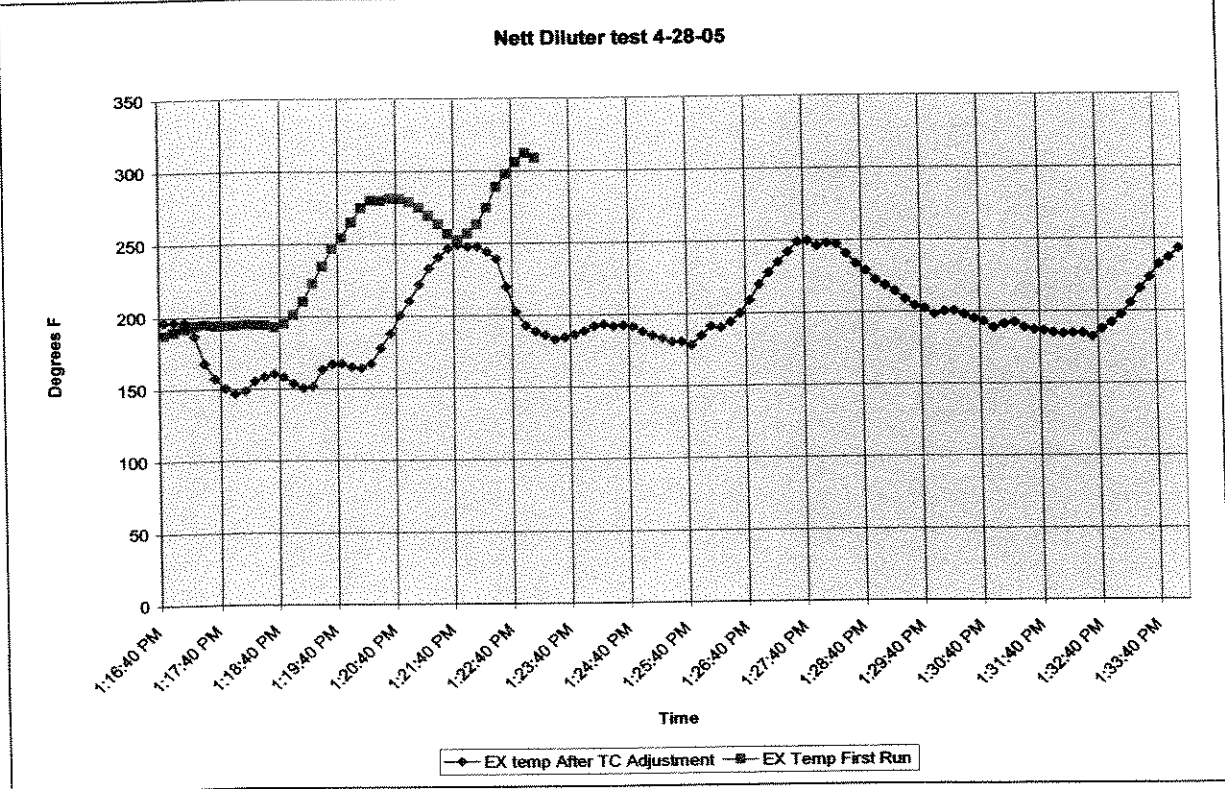
environment. We also noticed the engine and transmission were heating during the test protocol. To rectify this we adjusted the protocol as follows,

- 90 second torque stall
- followed by 4-minutes of high idle. We believed this would allow for some cooling of the transmission during the test cycle.



After adjusting the test protocol and the thermocouple, the test was restarted. The adjustment to the protocol did allow the transmission to undergo three successive stalls without critical over heating. The results of all testing can be seen in Chart 3.

Chart 3



Unlike the first test, the diluter did maintain the exhaust gas below the Pennsylvania requirement during the entire test. (approx 17-minutes) The diluter seemed to set a trend during the testing with the high idle periods ranging from 167 to 192<sup>o</sup> and stall condition ranging from 243 to 252<sup>o</sup> F.

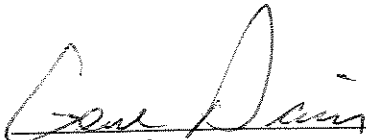
The following findings were discussed with representatives of Hager Equipment.

- It is clear that the position of the exhaust gas temperature shutdown will be critical to the use of this technology.
- If the probe is set too far in by the outer edge of the diluter it will not give an accurate reading of what the temperature of the exhaust gas is prior to entering the mine atmosphere.
- On the other hand if the probe is mounted beyond the outer edge of the diluter we would not be able to tell if the exhaust gas temperature requirement is being met.
- At this time I suggested that a small fan be installed that would increase the flow of ambient air into the diluter during periods of heavy duty cycle. I stated that it would not be necessary to have the fan run constantly but rather have the fan wired to turn on at about 250 degrees F. If this is done properly the Nett Technologies Diluter should meet all Pennsylvania requirements.

## Technology Evaluation Summary

In summation, the TAC believes the Deutz BF4M2012 (100hp) engine and CleanAir Lightly catalyzed DPM filter with FBC will meet all Pennsylvania diesel law requirements. The TAC would recommend the use of the engine and DPM filter after final testing of the engine with the FBC in its normal dose.

Although the TAC does believe the Nett Technologies Exhaust Gas Diluter (model 20) would meet the Pennsylvania requirement for exhaust gas temperature in the test configuration we can not, at this time, recommend the use of the diluter. The diluter will need to be set in its final configuration and further testing will need be performed. The TAC informed Hager Equipment that testing of the diluter in its final configuration would be needed before a final recommendation for its use in Pennsylvania could be made.

  
Gene Davis  
TAC Member

  
Stanley Geary  
TAC Member