

Installation Of A Sintered Metal Filter
On A Toyota Land Cruiser
Sudbury, Ontario



Toyota Land Cruisers provide good cost/performance in underground mines. Their versatility provides a wide range of configurations for a variety of applications.



Past efforts to significantly reduce emissions of these vehicles did not yield acceptable results.

Wajax Power Systems and TF Hudgins provided a Sintered Metal Filter system to demonstrate the filter's capability to reduce emissions.

Installation was completed on 10/1/2014 at Wajax Power Systems - Lively Location.

Toyota Land Cruiser - Ontario

The Land Cruiser had a 4.2 liter, 6 cylinder diesel engine that produced 96 kW.

The HZJ79L/1HZ6 engine is a non tiered and as such, has no emission controls. The test vehicle included a muffler and a scrubber for CO reduction.

The engines contribute to high levels of pollutants in the mine environment:

- Diesel Particulate Matter
- Carbon Monoxide
- NOX
- NO2
- Hydrocarbons

Toyota Emissions Project

- The trial period of 60 days was chosen and the test included emissions data as well as the data from the ECU.
- Test equipment included:
 - Drager EM200E (Wajax – calibrated Sept 15/2014)
 - Ecom EN2 (Calibrated Oct 10/2014)
 - Ecom AC-Plus (Calibrated Oct/2014)

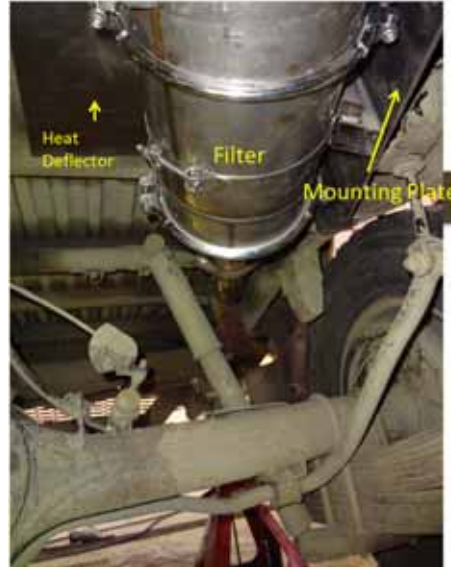
Diesel Particulate Filter Installation

- The CO scrubber was removed prior to the installation of the sintered metal filter system.
- There was a significant reduction in backpressure when CO scrubber was removed.

Date	Exh. Man. Press
Sept 29/2014	4.2 inHg (143 mbar)
Oct 1/2014	1.3 inHg (44 mbar)

(as measured by CVP Mercury Manometer)

- Steel Heat deflector installed for safety consideration.
- Unit enclosed in Ferwin 3A-9Z heat wrap (not shown)
- Additional exhaust noise reduction was achieved with DPF replacing exhaust muffler.



Air Flow Measurement

EFS (exhaust flow sensor) metering system was installed post DPF unit for increased accuracy and system control.



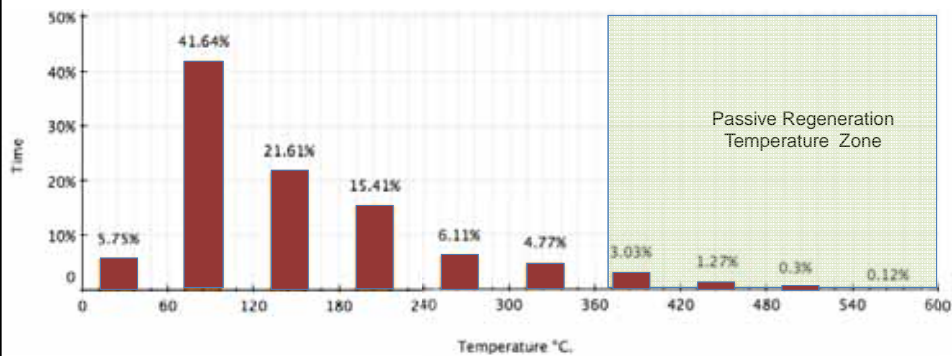
Temperature Profile

- The SMF system is capable of carrying out automatic soot regeneration.
- The ECU computes a soot map and determines when regeneration is required.
- The internal electrical heaters provide thermal energy to initiate soot ignition.
- This vehicle operated at sufficiently high temperatures to regenerate passively.
- This aided in achieving lower average backpressure in the system as the soot did not get a chance to build up on the filter.



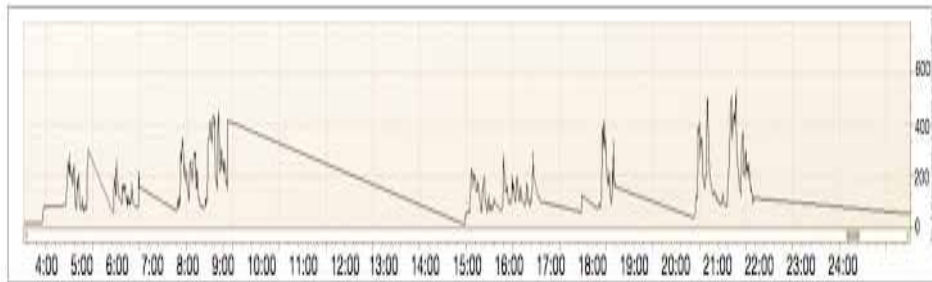
Temperature Profile

Temperature distribution over the 60 day test duration



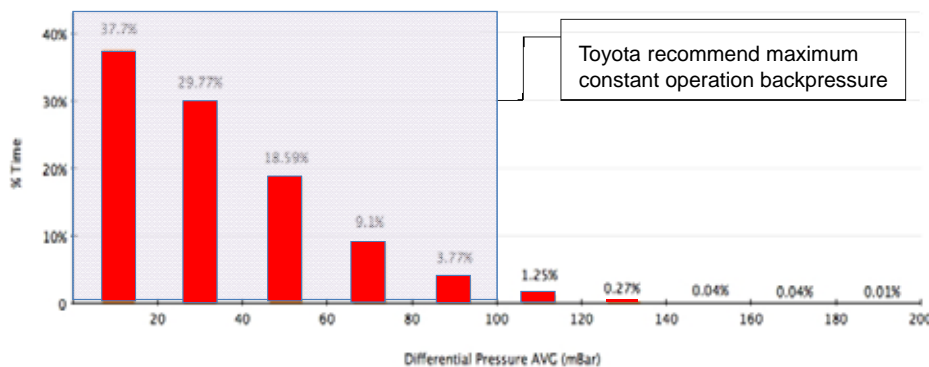
Temperature Profile

The temperature data yielded sufficient temperatures for passive regeneration (400°C or above for 3 minutes)



Additive reduces the ignition temperature of the PM on the filter from normally 600 – 650°C to 380 – 400°C and the system is able to regenerate itself periodically or intermittently by means of the exhaust gas temperature of the engine.

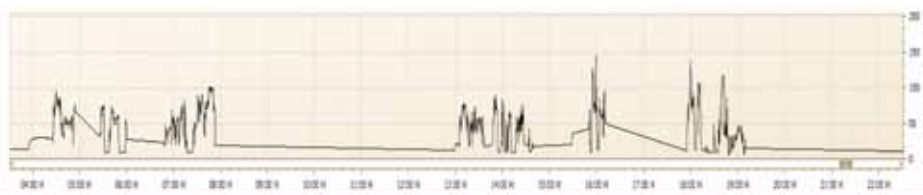
Backpressure Profile



Backpressure Profile

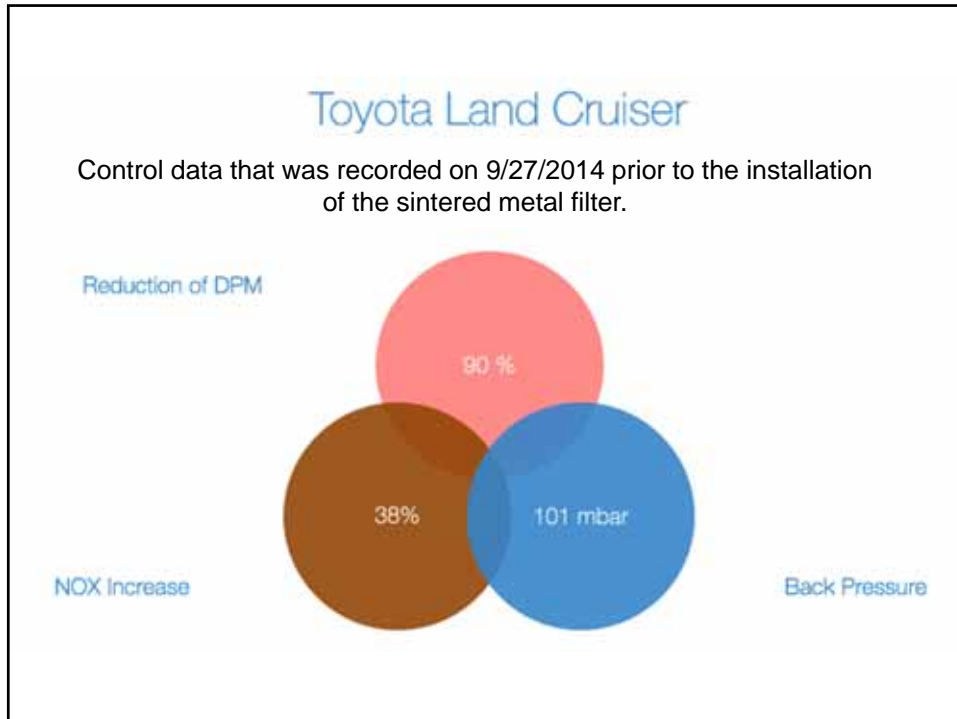
Passive regeneration contributes to maintaining low filter back pressures. The following graph corresponds to the same time period as the previous temperature profile graph.

This illustrates the correlation between temperature, which is caused by the engine burning more fuel and air, and the backpressure.



Emissions Data

Date	Time	Dpf Hrs.	Unit Hrs	T. Air ° F.	T. Gas ° F.	T. Sensor	O2 %	CO ppm	NO ppm	NO2 ppm	Nox ppm	CO2 %	Eff. %	Losses %	Exc. Air	Dew Point °F.	Soot	Gas vel. m/sec
Pre install test																		
9/27/2014	7:19		1548	56	280	66	17.6	166	149	24	173	2.5	74	25.9	6.18	79	9	
10/1/2014	20:30	12	1560	59	306	62	16.5	193	129	37	166	3.3	78	21.6	4.67	84	0	0.6
10/10/2014	11:42	18	1561	16	306	63	17.0	210	122	30	152	2.9					1	
10/16/2014	20:19	46	1592	61	212	68	16.5	360	1	37	38	3.3	87	13.2	4.67	84	0-1	0.2
10/24/2014	8:25	65	1621	63	292	65	17.0	216	150	30	180	2.9	77	22.6	5.25	82	2	
11/3/2014	8:44	97	1653	67	335	75	16.9	208	174	19	193	3.0	74	25.8	5.12	82	0-1	0.1
11/7/2014	7:50	107	1663	65	306	67	16.8	184	189	34	223	3.1	77	22.6	5	83	1	0.1
11/14/2014	8:21	140	1696	65	300	66	16.6	209	190	38	228	3.2	79	21.0	4.77	84	1	0.1
11/21/2014	20:48	168		56	223	58	17.9	201	104	36	140	2.3	79	21.1	6.77	77	0-1	0
12/1/2014	7:56	200	1756	62	308	62	16.6	219	193	36	229	3.2	78	22	4.77	84	2	0.1
12/18/2014		281	1839															



CONCLUSIONS

System performance has achieved the objectives of the test:

- Soot has been reduced by 90%.
- Filter was capable of passive regeneration.
- NOX, CO, NO₂ – All at acceptable levels.

High engine temperatures have allowed this system to passively regenerate and keep the backpressure low.

CONCLUSIONS

- The system has consistently operated with in the performance projections. The Sintered Metal Filter should be considered as a viable technology for reducing diesel particulate matter in a Toyota Land Cruiser.
- As of August 2015 Wajax has installed the SMF filters on 10 additional Toyota Land Cruisers.

Project Partners

Wajax Power Systems



T.F. Hudgins Inc.



Thank You

