



Independent Witness Report for h2gogo

engine carbonclean

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h2gogo

Independent Witness Report for h2gogo Engine Carbon
Clean Power 1 unit on 9th April 2014 at Long Marston Depot,
supported by The Rail Alliance

Document History and Authorisation

Issue	Date	Changes
1	15 th April 2014	First Formal Issue to h2gogo

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1. Introduction and Executive Summary

Fishbone Solutions was invited by h2gogo Industries Limited (h2gogo) to independently witness a series of tests for the "Engine Carbon Clean Power 1" unit.

The unit creates pure hydrogen from a water supply, and when flushed through an engine's air intake over a period of time, removes much of the built-up soot and carbon within the engine system, in turn reducing emissions.

The test performed at Long Marston depot on 9th April was supported and facilitated by the Rail Alliance, who provided three vehicles to be carbon-cleaned. The role of Fishbone Solutions was to observe that the carbon cleaning tests were conducted in a consistent and meaningful manner and to validate the results created during the tests.

The report below outlines the results and clearly demonstrates that the carbon-cleaning process vastly reduces the emissions from all three differing engine types. This would clearly provide operational benefits to the operators of the vehicles, both to reduce the emissions and to create a cleaner environment around the vehicles.

2. The Test Environment

Test Date: 9th April 2014

Location: The Control Tower, Quinton Rail Technology Centre, Station Road, Long Marston, Stratford-upon-Avon, CV37 8PL

Test Equipment:

1. Boston Emissions Equipment.
 - a. PSI-60USB (Power Supply) serial number 070626000156
 - b. OPA-100 (Smoke Meter)
 - c. AGS-20 (5 Gas Analyser)
2. Test Laptop with Boston Emissions software.

"The test measurement equipment consists of industry standard Gas and Smoke meters and their bespoke measurement software"

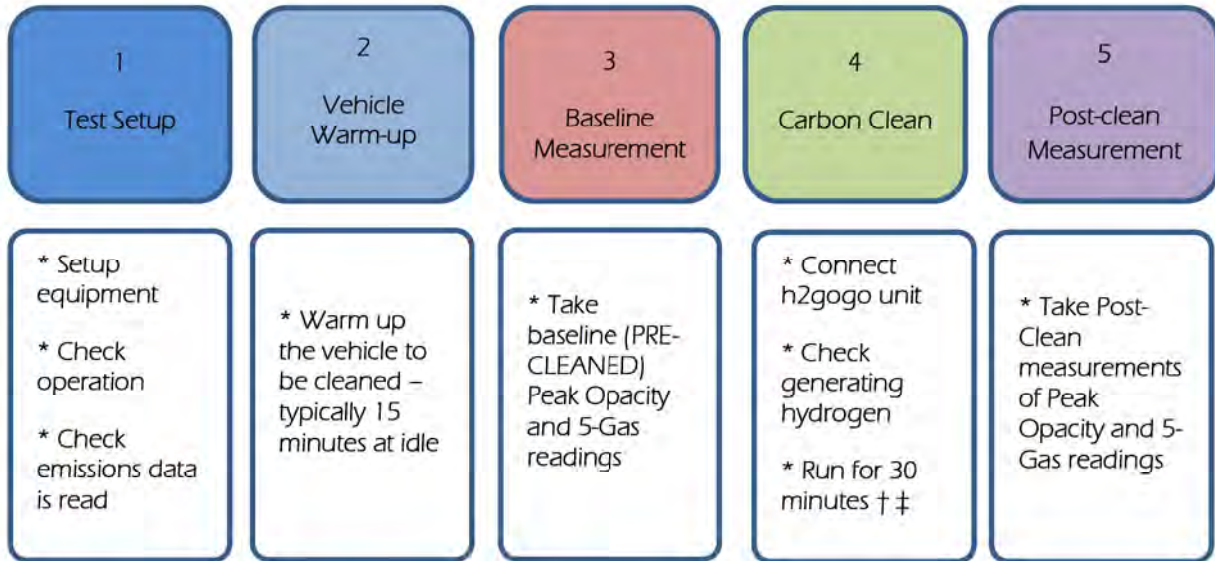
Unit Under Test:

1. h2gogo, Engine Carbon Clean Power 1.



"The Engine Carbon Clean 1 unit is the latest generation carbon-clean system from h2gogo. It is part of a family of units designed to facilitate a number of operations and has been widely proven in a range of internal combustion engine applications"

Test Process:



† Note that the cleaning cycle time may vary depending on the vehicle age and size. During this test the cleaning time for the DMU was lengthened to 45 minutes (see below).

‡ The vehicle is occasionally purged by dabbing the accelerator for 5-10 seconds. This clears the soot and other particles that have been removed during the hydrogen cleaning process.

Vehicles used for Cleaning Process

1. JCB Loadall
2. DMU
3. Henley 10-Ton Forklift

3. Test Results Observed

3.1 Test 1. JCB Loadall

Vehicle Identification

Model: JCB 520
 Vehicle Registration: X141 BWP
 Engine S/N: U1371466
 VIN No. SLP520551E0282821



Process

Setup	Warm-Up	Baseline Measurements	Carbon Clean	Post-Clean Measurements
✓	✓ 15 minutes	✓	✓ 30 minutes	✓

Peak Opacity Readings

	Baseline (Pre-Clean)	Post Clean
K [m ⁻¹]	0.74	0.33
N [%]	27.3	13.3

5-Gas Readings

	Baseline (Pre-Clean)	Post Clean
CO	0.03	0.01
CO ₂	2.8	1.8
HC	6	6
O ₂	16.9	18.2
NO	9	0

Further Observations

- During the cleaning process smoke emitted from the vehicle became noticeably cleaner as the cleaning process progressed, particularly when purged.

“The first carbon-clean test on the JCB demonstrated that, on a well-used vehicle, the cleaning effect reduced the Opacity values as well as the 5-Gas readings by a substantial amount”

3.2 Test 2. DMU

Vehicle Identification

Model: DMU, Pressed Steel Co Ltd 1960
 Vehicle Registration: Lot No. 30546
 Engine S/N: Unknown
 VIN No. N/A



Process

Setup	Warm-Up	Baseline Measurements	Carbon Clean	Post-Clean Measurements
✓	✓ 30 minutes	✓	✓ 45 minutes	✓

Peak Opacity Readings

	Baseline (Pre-Clean)	Post Clean
K [m ⁻¹]	8.6	2.77
N [%]	97.5	69.6

5-Gas Readings

	Baseline (Pre-Clean)	Post Clean
CO	0.10	0.09
CO ₂	3.1	1.2
HC	29	18
O ₂	16.2	19.5
NO	4.535	0

“On a DMU over 50 years old, the engine was clearly dirty and the baseline results showed this. However after the clean the smoke and emissions readings had greatly reduced and the engine was audibly smoother and the exhaust gases visibly cleaner”

Further Observations

- During the cleaning process the engine sound became noticeably quieter and smoother, the diesel ‘knock’ being virtually eliminated towards the end.
- During the cleaning process, when purged, the smoke emitted from the exhausts was much cleaner.

3.3 Test 3. Henley 10-Ton Fork

Vehicle Identification

Model: Henley Hercules 2624
 Vehicle Registration: n/a
 Serial Number: 0970193264
 VIN No. Unknown



Process

Setup	Warm-Up	Baseline Measurements	Carbon Clean	Post-Clean Measurements
✓	✓ 15 minutes	✓	✓ 30 minutes	✓

Peak Opacity Readings

	Baseline (Pre-Clean)	Post Clean
K [m ⁻¹]	7.47	0.75
N [%]	96.0	27.6

5-Gas Readings

	Baseline (Pre-Clean)	Post Clean
CO	0.72	0.09
CO ₂	4.4	2.6
HC	96.0	34
O ₂	15.0	17.7
NO	2.973	0

“Perhaps the dirtiest of the engines on test, the Henley engine was clearly quieter and cleaner after the test; the test results backed up this observation”

Further Observations

- The exhaust emissions were black before the hydrogen clean, becoming much cleaner during and after the cleaning process.
- The engine became much quieter towards the end of the cleaning process, having a much smoother idle with the ‘knock’ effect almost completely eliminated..

4. Summary and Conclusions

The test environment and weather conditions for the test day were entirely suitable to the test event. The three vehicles provided a wide range of engines applications, furthermore their age and hence their relative cleanliness were ideally placed to be able to demonstrate whether the Engine Carbon Clean unit would indeed deliver the anticipated reductions in smoke and emissions.

The JCB unit measurements showed a reduction of over 50% in the Peak Opacity after the carbon clean, this tallied with a reduction on the CO and CO₂ readings, while the NOX readings were reduced to zero after the clean. The vehicle was noticeably quieter at the end of the cleaning process.

The DMU would benefit from a longer cleaning process due to its' engine size (over 6 litres). Nevertheless the measured reading demonstrated a dramatic improvement in a vehicle over 50 years old –Peak Opacity being reduced to 32% of its original value and Smokes being reduced from 97.5% to 69.6%. Again, the gas readings were reduced significantly, most notably CO₂ (3.1 to 1.2ppm) and HC (29 to 18) with NOX again being reduced to a value too low to be picked up by the measurement equipment.

The Henley vehicle was the dirtiest vehicle visibly and audibly. Perhaps the most striking result was the reduction in the noise of the engine and the fact that the exhaust emissions were black at the outset of the cleaning process, and a much cleaner colour at the end. The measurements back up this observation – the CO was reduced to a fraction of its' reading before the clean, whereas the CO₂ and HC were reduced by over 50%. Again, NOX readings were reduced to zero but the most significant result was the Peak Opacity readings being reduced to 10% of its original value after just a 30 minute test.

All three vehicles showed a slight rise in O₂ values – the suggestion here is that the reduction in Carbon inside the engines is facilitating a more efficient internal combustion environment.

4.1 Additional Information

The Boston Test equipment produced certificates for each individual test which have been witnessed and verified by Fishbone Solutions. These certificates are available on request.