



FUEL EFFICIENCY COMPARISONS BY EXHAUST EMISSION CARBON BALANCE METHOD

Fuel consumption measurements by reliable and accredited methods have been under constant review and investigation by this company since 1982. The weight of engineering evidence and scientific theory favors the carbon balance method by which carbon measured in engine exhaust gas is related to the carbon content of the fuel consumed. This method has certainly proven to be the most suitable for field testing where minimizing interruptions to operating plant is an essential factor.

The inquiries of accuracy and reliability to which we refer include discussions and advice from the Commonwealth government authority responsible for the test procedure described by the Australian Design Rule 37. This procedure enumerates the data required for fuel consumption measurements by the "carbon balance" or "exhaust gas analysis" method. The advice given is that carbon balance has been found to be a more precise consumption test method than the alternative volumetric-gravimetric methods.

The existing Australian Standard for Fuel Consumption: AS2077-1982 includes carbon balance (exhaust gas analysis) method as one of the standard methods for measuring fuel consumption. The test procedures for mobile equipment as employed by Fuel Technology vary from the Australian Standard protocol in that seldom is a chassis dynamometer available so engines are normally loaded against their torque converter, diesel generators provided that their load can be reproduced make a perfect test bed. Because instrumentation must be portable the measurement of unburned hydrocarbons, being less than 0.2% of normal carbon emission, is made by infra-red rather than flame ionization equipment.

Our experience with this test procedure, where we have been able to compare back to back tests with gravimetric measurements has been a correlation generally within the 1% range.

Fuel Technology calculates the results on the basis of mass, eg. grams carbon per second. Generally it is not necessary to convert these mass flow rates to a volumetric basis.

Included with this bulletin is a report by our scientific consultants, Poseidon Scientific Instruments Pty Ltd, by which our field procedures are evaluated against the paper by E.A. Christie, T.B. Crowle et al from the CSIRO Division of Energy Technology titled The Importance of Fuel Properties in Correlating Carbon Balance and Volumetric Fuel Consumption. It is concluded that the method Fuel Technology employs in its testing procedures is scientifically based, accurate, reliable and simple to perform, requiring no long term running (with attendant variables) or cutting into the engine's fuel system.



Photos 1 and 2 show two views of the exhaust carbon balance test equipment in use measuring fuel consumption of a 1MW diesel alternator set.

The upper photo illustrates the infra-red gas analyzer in use during efficiency tests. The micro-manometer and digital readout thermometer are to the left of the gas analyzer.

The lower photo shows the general arrangement with probe assembly clamped to the engine exhaust stack.



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Ref: JD91-035 JS/ml
(J# 418)

REPORT ON

THE IMPORTANCE OF FUEL PROPERTIES IN
CORRELATING CARBON BALANCE & VOLUMETRIC FUEL CONSUMPTION

SUMMARY:

This paper addresses the reasons for the consistent difference in the estimated fuel consumption as calculated by the Carbon Balance principle as set out in AS-2077 and the measured volumetric fuel consumption.

The findings of the Paper relevant to Fuel Technology's application of the-Carbon Balance Principle are:

- 1) The Carbon Balance principle as set-out in AS-2077 is a repeatable method of estimating the fuel consumption of a vehicle.
- 2) The Carbon Balance method as described underestimates the Volumetric fuel consumption by about 7%.
- 3) When corrections are made to the Volumetric measurement to account for variations in the test fuel specific gravity caused by temperature or variations in supply quality the discrepancy between the Carbon Balance estimate and the Volumetric measurement is reduced to about 3%.

The paper clearly demonstrates the following points:

- 1) That the Carbon Balance method is a highly repeatable method of estimating the fuel consumption of a vehicle.
- 2) Test to Test fluctuations in the Carbon Balance estimation correlate exactly with the Volumetric fluctuations.

The conclusion may be drawn from the report that Fuel Technology's application of the Carbon Balance principle in which grams of carbon used per second is calculated offers a measurement that is independent of fluctuations in the test fuel's quality or temperature.

As the report verifies the repeatability of the Carbon Balance methods, it supports Fuel Technology's method of relative measurements where the effects of symetric errors are further reduced.

In conclusion, the content of this paper supports the use of the Carbon Balance method and warns against the simple us of Volumetric Measurement without adequate consideration for variations in fuel density and quality. The paper demonstrates that Volumetric measurements which neglect these factors may miscalculate the real fuel consumption by as much as 4 percent.

In Fuel Technology's application where the test fuel in not strictly controlled and where there may be significant temperature changes between tests, the application of Carbon Balance method is more likely

to give an accurate measurement of changes in fuel consumption than Volumetric measurements which have not been corrected for variations in fuel specific gravity or temperature.

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Date: 11/9/91

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