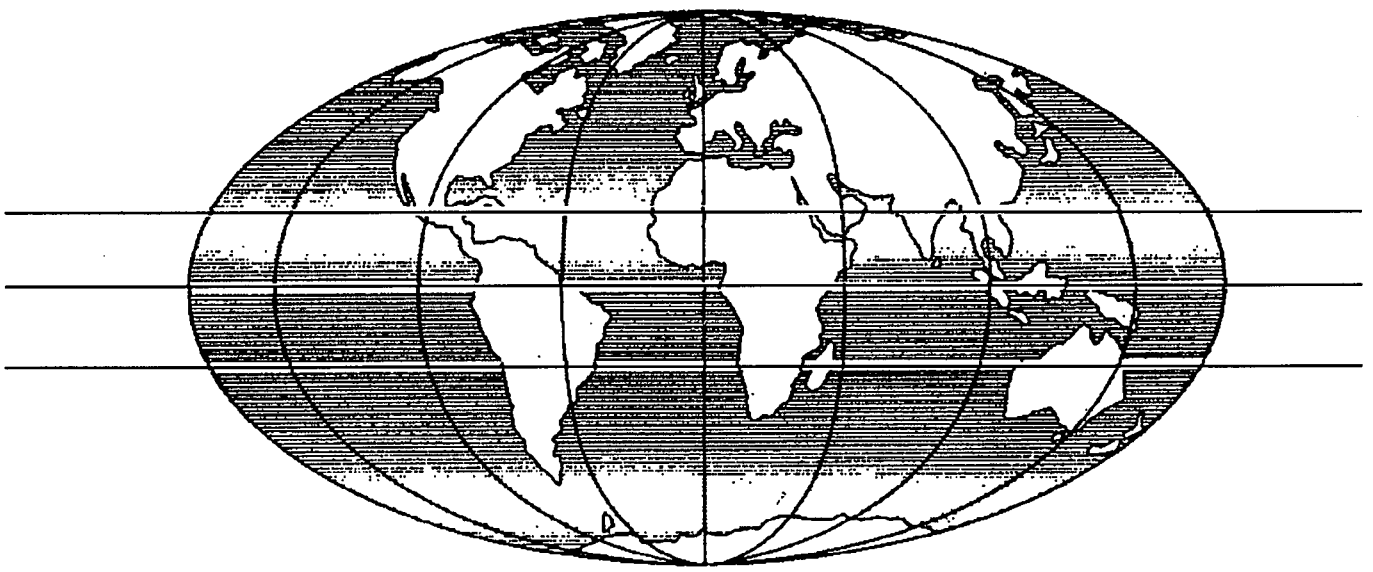
TRL
TRANSPORT RESEARCH LABORATORY

ODA

Reprint

TITLE **Black smoke emissions and fuel consumption: A joint study by the Transport Research Laboratory, UK and CIRT**

by **T Pearce**



Overseas Centre
Transport Research Laboratory
Crowthorne Berkshire United Kingdom

PEARCE, T (1994). Black smoke emissions and fuel consumption: A joint study by the Transport Research Laboratory, UK, and CIRT. In: *Indian Journal of Transport Management, June 1994.*

Black Smoke Emissions and Fuel Consumption: A Joint Study by the Transport Research Laboratory, UK, and CIRT

T.C. PEARCE *

INTRODUCTION

The emission of black smoke by diesel engined trucks and buses is an everyday sight in many countries in the world. At best, it represents an unpleasant smell and more dirt to cover ourselves and surroundings; at worst it can present a health hazard through the inhalation of particles containing hydrocarbons and is also a sign that the vehicle is operating inefficiently and wasting fuel.

Many operators are reluctant to perform extra work on their vehicles during maintenance periods and will not do so unless it can be proved that they will save money. In addition, while there are no routine or random smoke checks in many countries, there are also no outside incentives to improve this particular aspect of a vehicle's performance.

The Overseas Centre of the Transport Research Laboratory in the UK has been carrying out research into the problems of black smoke for some years now and has recently started a joint project with CIRT to measure black smoke emissions from two fleets of vehicles and to correlate the emissions with the fuel consumed by the same vehicles.

This article describes the background to the project and the way in which it will be carried out. It is anticipated that the results will be published later. Any enquiries concerning the project should in the meantime be addressed to Shri P C Rao, Engineering Faculty of CIRT, Pune.

* *Mr. Pearce is a Senior Scientific Officer from the Overseas Centre of the Transport Research Laboratory, U.K.*

THE MEASUREMENT OF BLACK SMOKE

There are two ways of obtaining black smoke emissions from a vehicle under test. The most complex is to mount the vehicle on a dynamometer or rolling rod, and, by altering the resistance to the driving wheels, the vehicle may be driven at a variety of speeds and loads to determine its' emissions of black smoke. The second way, and by far the easiest, is the Free Acceleration Smoke Test. In this test the vehicle's engine is run until normal operating temperature is achieved. Then the accelerator pedal is pressed down to its maximum extent and kept there until the engine reaches its' governed speed. By this action the engine is accelerated at its maximum possible rate against its' own inertia and hence is at full power through its operating speed range. This is repeated several times in order to obtain a mean reading of peak smoke level. The test is defined precisely in ECE Regulation 24 (Ref. 1) and is the method used in this project.

In order to measure the concentration of smoke a device called opacimeter is used. This has supplanted the older filter type devices and measures the density of smoke by shining a beam of light across the exhaust plume. Smoke Meters are available in the U.K. market which sample either the entire plume or part of it and it is the latter type that are commonly used today. A smoke test has recently become compulsory during the annual in-service inspection in the UK and a number of meters have been approved to comply with the requirements of the U.K.'s Vehicle Inspectorate (Ref. 2). These meters operate either from mains electricity supply or from rechargeable batteries and can therefore be used wherever required. For the purposes of this experiment, a Sun ASA 200 Advanced Smoke Analyser was used.

EQUIPMENT DESCRIPTION

The ASA 200 meter is a compact unit that is easily transported in a large briefcase or, when in use, the essential parts can be carried around a depot or workshop reducing the possibility of damage by being left on the workshop floor.

The smoke meter uses a modulated light emitting diode (LED) as a light source and a solid state photodiode light receiver. Within the handset, electronics measure the light level received through that portion of the exhaust smoke passing through the meter, calculate the density of smoke and give the result in the form of the Smoke Absorption Coefficient, (k).

The meter comprises a sensor unit inserted into the vehicle exhaust, linked, via a cable that carries power and data, to a handset (Fig. 1). The handset can also be disconnected from the sensor and plugged into its base station which provides battery charging and a link to the printer for output of results. The printer is also battery powered and equipped with its own charger. Verification filters are also provided to enable calibration of the meter to be carried out at $k = 0$ and a mid point value (normally about $k = 1.7$).

The operation of the meter is controlled by the in-built computer that displays commands and options on the handset LCD display screen. A zero check is performed at the beginning and end of each test to ensure that the optics are not excessively dirty and to enable a correction to be made if not absolutely clean. When the test is started the handset issues commands from the display to start accelerating, to release the throttle and when to start and stop the engine. It also displays the individual peak smoke readings and the final result.

The UK regulations permit the number of accelerations to vary between 4 and 10, a very clean vehicle may therefore pass within 4 accelerations while a dirtier vehicle is given up to 10 attempts to reach the limit. In all cases the result is obtained by taking the mean of the last four values and subtracting the zero check reading. On completion of the test the handset is connected to the printer and the full results are output (Fig. 2). The entire test takes considerably less than five minutes once the vehicle has reached operating temperature.

VEHICLES UNDER TEST

The enthusiastic co-operation of Pune Municipal Transport (PMT) and, from Kolhapur, Ghatge Patil Transport (GPT) is gratefully acknowledged for the selection of vehicles and the collection of data for this project. 25 buses from PMT were selected ranging in age from new to 25 years old and manufactured by both Tata and Ashok Leyland. From GPT, 25 Tata trucks ranging from one to 15 years old were selected and two new luxury Tata coaches. The vehicles will now be tested, approximately once a week for the next three months, immediately on return to their depots for servicing. If work has been carried out on their engines they will be tested again before going back on the road. At the same time, fuel consumption data for the comparable period will be collected, this will be supplemented in the case of GPT by an Index of Performance which takes into account the load factor and route difficulty of their trucks.

DATA ANALYSIS

On completion of the test period, the data will be analysed to investigate the link between black smoke emissions and fuel consumption. It is hoped that it will prove possible to display a direct correlation showing that a reduction in black smoke will enable an operator to save fuel and hence money. It is also anticipated that the use of modern, accurate, computer controlled test equipment will not only remove the subjective influence of the tester but improve the accuracy of testing and persuade operators of the benefits of updating their equipment.

A project report will be prepared on the results of this project and further information on the project or equipment can be obtained from CIRT.

REFERENCES

1. Intereurope, ECE 24, Revision 1, E/ECE/TRANS/505, Intereurope Regulations Ltd., Wokingham, Berkshire, U.K., 1980.

2. Vehicle Inspectorate, Regulations for MOT smoke meters, Vehicle Inspectorate, Bristol, U.K., 1992.

Figure 1 ASA 200 Handset and Sensor

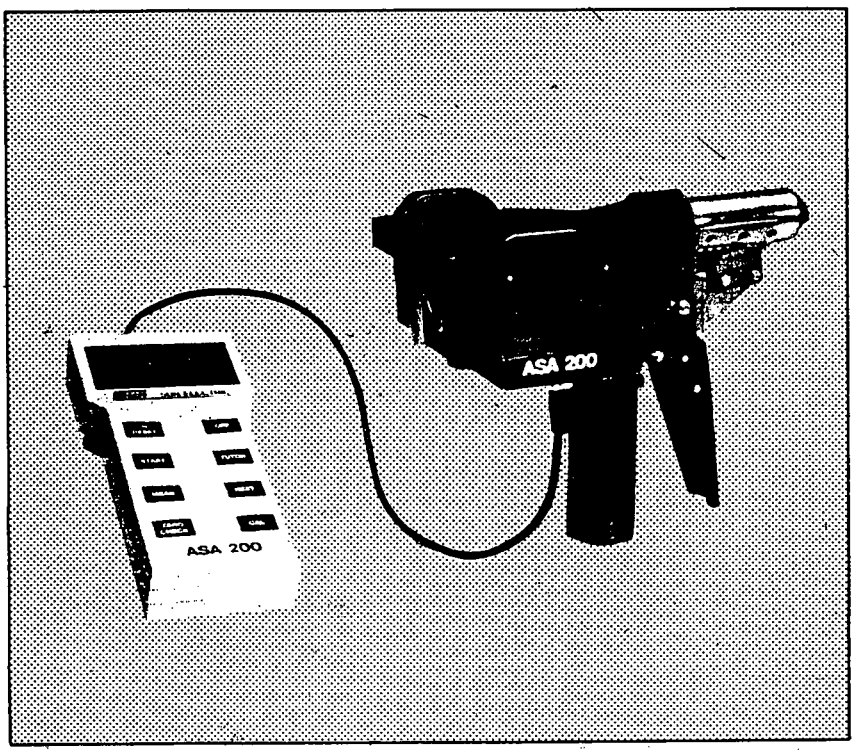


Figure 2 Samples of Printout

SUN ASA 200
Advanced Smoke
Analyser

Test Station : CIRT + TRL
SMOKE EMISSION
PROJECT 1994
PMT - PUNE
FUEL =
DIST =

Diesel Smoke Test
Direct connection (100±C)

Run No.	K	T
1	1.74	98±C
2	2.47	106±C
3	2.58	116±C
4	2.69	122±C
5	0.00	106±C
6	2.00	113±C
7	2.36	124±C
8	2.31	136±C
9	2.24	134±C
10	----	---±C

Zero check K= 0.00

Result K= 2.25

**** PASS ****

Vehicle ID.....

Tester.....

Date 29/04/94 Time 15:46:19

SUN ASA 200
Advanced Smoke
Analyser

Test Station : CIRT + TRL
SMOKE EMISSION
PROJECT 1994
GPT - KOLHAPUR
FUEL =
DIST =

Diesel Smoke Test
Direct connection (100±C)

Run No.	K	T
1	1.58	82±C
2	1.99	92±C
3	2.32	100±C
4	2.81	106±C
5	----	---±C
6	----	---±C
7	----	---±C
8	----	---±C
9	----	---±C
10	----	---±C

Zero check K= 0.07

Result K= 1.95

**** PASS ****

Vehicle ID.....

Tester.....

Date 29/04/94 Time 14:48:02

□□□