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BRANDSTOFNAVORSINGSINSTITUUT

VAN SUID-AFRIKA

FUEL RESEARCH INSTITUTE

OF SOUTH AFRICA

ONDERWERP:
SUBJECT: THE MOBILE GAS ANALYSIS LABORATORY OF THE INSTITUTE

AFDELING:
DIVISION: CHEMISTRY

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NAME OF PROJECT	:	GAS ANALYSIS DURING FIRES IN MINES
AUTHOR	:	F E JOUBERT
TITLE	:	THE MOBILE GAS ANALYSIS LABORATORY OF THE INSTITUTE
INVESTIGATION REQUESTED BY	:	COAL MINING RESEARCH CONTROLLING COUNCIL
DIVISION	:	CHEMISTRY

FUEL RESEARCH INSTITUTE OF SOUTH AFRICA

REPORT NO. 77 OF 1976

THE MOBILE GAS ANALYSIS LABORATORY OF THE INSTITUTE

SUMMARY

A mobile gas analysis laboratory has been acquired by the Fuel Research Institute. The purpose of this facility is to provide to the Inspectors of mines and to colliery managements, an on-site gas analysis service during fire control operations.

1. INTRODUCTION

The necessity for gas analysis during fire control operations in collieries was outlined in Technical Memorandum No. 7 of 1975. In the same Memo the problems encountered with a gas chromatographic approach to gas analysis were mentioned, the gas analysis laboratory inspected in Yorks was described, and mention was made of advanced gas analysis equipment on order. This equipment has now been installed in an industrial caravan, tested and calibrated, and the facility is ready for use. Since this report serves primarily as an introduction of the mobile laboratory to industry, the description of the analytical instruments is given in the appendix.

2. WHO CAN GET THE FACILITY, HOW, AND AT WHAT COST?

In terms of an agreement with the Government Mining Engineer, any Inspector of Mines can summon the services of certain officers of the Institute in the interests of mine safety. For the duration of the incident or investigation, these officers are technically speaking on the staff of the GME and under the control of the Inspector of Mines. All such services by personnel of the Institute, as well as the use of the mobile caravan and any other necessary apparatus, are free of charge.

In cases of emergency, it may not always be possible to get an Inspector of Mines to phone the Institute immediately, and in such cases colliery managers or senior officials of the Dust and Venti-

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lation laboratories or Rescue Stations can get in touch with the Institute. However, such requests should be subsequently sanctioned by an Inspector of Mines, otherwise the principals of the respective parties will be held responsible for the costs involved.

3. THE USES OF THE MOBILE GAS ANALYSIS FACILITY

(i) When

The mobile gas laboratory is to be used in the first place during sealing operations in cases of colliery heatings or fires. However, if it is necessary in the opinion of an Inspector of Mines to have a gas analysis facility on site for any other reason, for instance when bleeding off gases from reopened workings, it will also be available.

In general it can be stated that mine atmospheres are to be monitored whenever it become dangerous for periods long enough to make monitoring practical.

(ii) Why

When colliery fires are sealed to starve them of oxygen, methane is also being desorped from the coal by the heat, and the resulting gas mixture may in rare cases become explosive, so that it is necessary to monitor the gas composition for the safety of fire-fighting personnel.

(iii) What

Gas samples are analysed for 5 components, namely hydrogen, oxygen, methane, carbon monoxide and carbon dioxide. It is assumed that the only other gas present is nitrogen and this is determined by difference. Additional particulars which become available are Graham's ratio, Young's ratio, and the co-ordinates on the explosibility triangle (refer the Appendix).

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(iv) Where

The mobile facility will be towed to the mine and the gas analysis done on site. It will remain at the mine until the Inspector of Mines engaged in the incident declares that its use is no longer required.

(v) What the mine must provide

An ordinary 15 Amp 3-pin socket, 220 Volt, as well as access for the mobile laboratory, preferably to a point within 30 metres of the 3-pin socket. The gas sampling pipe through one of the stoppings (usually fitted with a gate valve or stop cock) must be either a 65 mm, 50 mm or 35 mm (2½", 2" or 1½") water pipe, threaded on the outside.

(vi) Time delay

When the gas analysis facility is required, two hours are allowed for its preparation to leave the Institute, a travelling time at 70 km/h from Pretoria to the mine, and once on site, a warm-up period of two hours for the analytical instruments.

(vii) How

On site the procedure will be as follows: The instruments will be connected to the 220 V source and allowed to warm up for two hours (actually only the oxygen analyser has this requirement). Officers from the ventilation section of the mine or from the proto teams will be shown how to take gas samples, which is a very simple operation.

Eight gas sample cylinders are available so that samples can be taken at intervals as short as 15 minutes if the turn-around time from shafthead to the fire and back can be held below 2 hours. If a gas sample is handed in at the caravan, the analysis will be available and reported to the Inspector of Mines or the responsible officer within 5 minutes.

F E JOUBERT
PRINCIPAL RESEARCH OFFICER

PRETORIA
FEJ/md
17/11/76

APPENDIX

1. CONTENTS OF THE MOBILE LABORATORY

The 5 metre industrial caravan (refer Figure 1) houses the following:

(i) Five analytical instruments mounted on a steel framework (refer Figure 2).

(ii) Test and calibration gases for all instruments.

(iii) Switchable gas valve and flow meters, also mounted on the frame and connected to the instruments and to the gas cylinders with plastic tubing.

(iv) A programmable electronic calculator.

(v) Gas cylinders, pumps and regulators for taking gas samples. (The cylinders are large enough for a gas flow of a few minutes, to offset any adsorption of gases on the plastic tubing).

2. THE INSTRUMENTS

The 5 analytical instruments are the following:

(i) A single-beam infra-red methane instrument (UNOR) with ranges 0 - 2 and 0 - 20%.

(ii) A single-beam infra-red carbon dioxide instrument (UNOR) with ranges 0 - 2 and 0 - 20%.

(iii) A single-beam double cuvette infra-red carbon monoxide instrument (UNOR) with ranges 0 - 100, 0 - 1 000, 0 - 10 000 and 0 - 100 000 parts per million, i e 0,01%, 0,1%, 1% and 10%.

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(iv) A paramagnetic oxygen analyser (TAYLOR SERVOMEX) with various ranges, from 0 - 2,5% up to 0 - 100%.

(v) A hydrogen thermal conductivity instrument (ADOS) with the single range 0 - 5%.

3. THE CALCULATIONS

Since the hydrogen analyser works on the difference in thermal conductivity between hydrogen and a reference gas (nitrogen), its output must be corrected for the thermal conductivities of the other gases, for which purpose values are listed in the following Table:

TABLE OF THERMAL CONDUCTIVITIES OF SOME PERMANENT GASES

Gas	Thermal conductivity
Nitrogen	1,00
Oxygen	1,01
Carbon monoxide	0,95
Carbon dioxide	0,64
Methane	1,27
Hydrogen	6,97

A programmable electronic calculator is used for:

(i) the correction of the display on the hydrogen analyser;

(ii) the determination of Graham's ratio of CO to oxygen deficiency, the latter being: nitrogen content - 3,81 x oxygen content;

(iii) the determination of Young's ratio of CO_2 to oxygen deficiency;

(iv) the calculation of the ratio of methane to total explosible gases;

(v) the calculation of the co-ordinates on the explosibility triangle.

Please refer to Figure 3 for a worked example, showing the complete input and output of the calculator, and Figure 4 which shows the point plotted on the explosibility triangle.

THE MOBILE GAS ANALYSIS LABORATORY

FIGURE 1

THE GAS ANALYSIS INSTRUMENTS

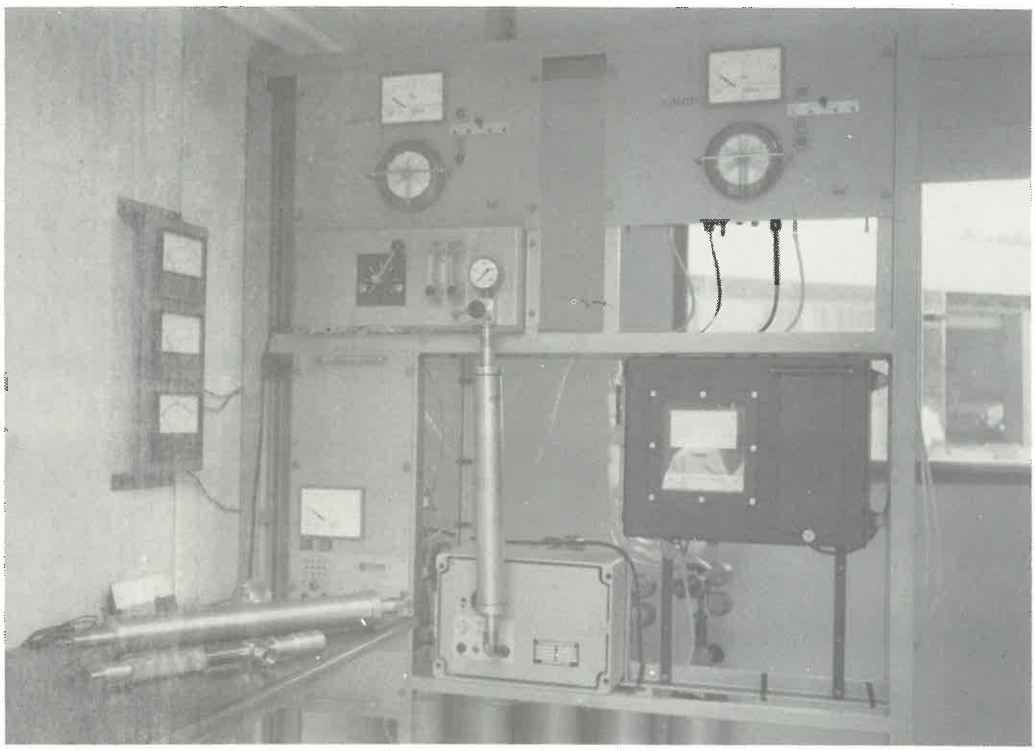


FIGURE 2

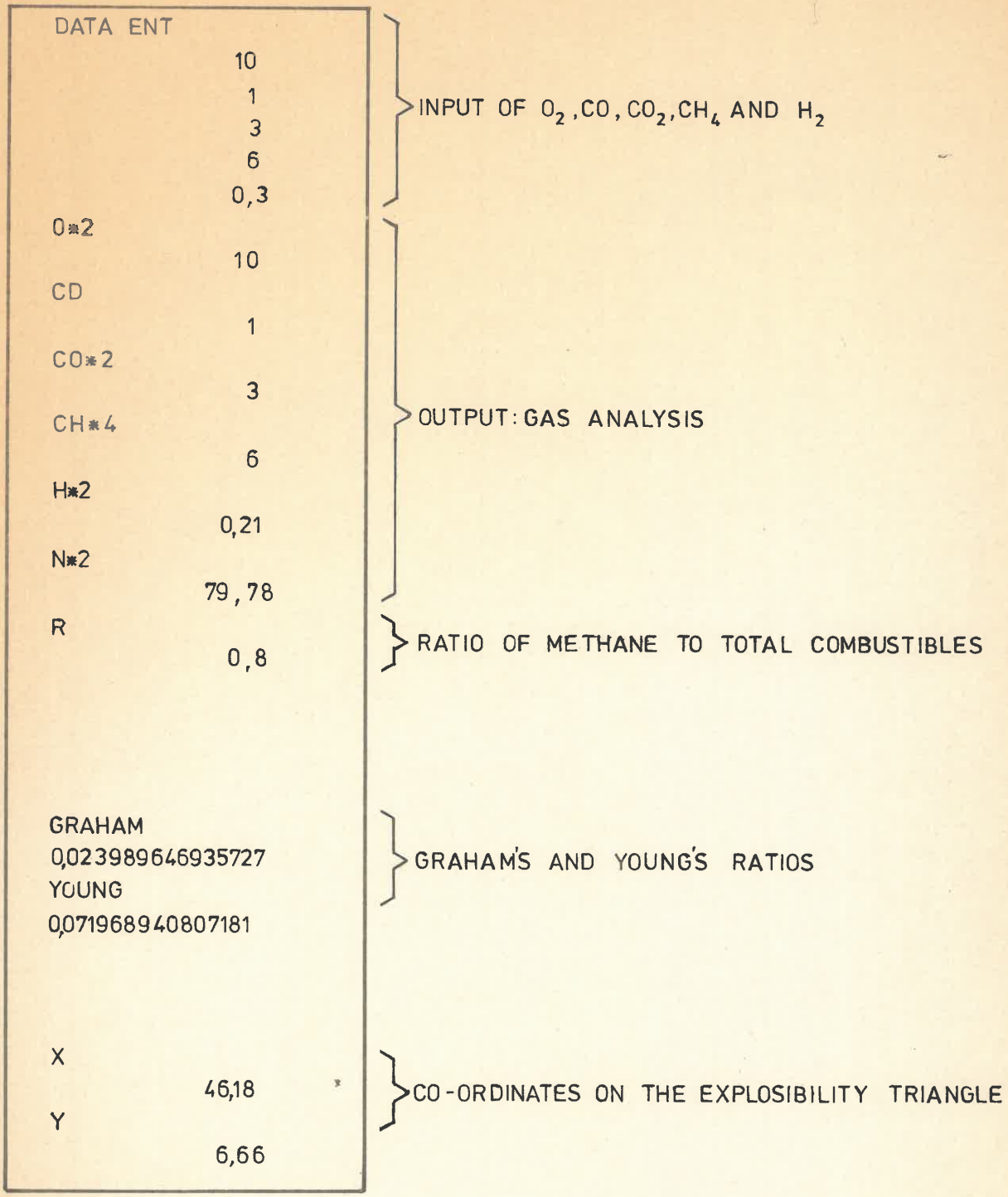
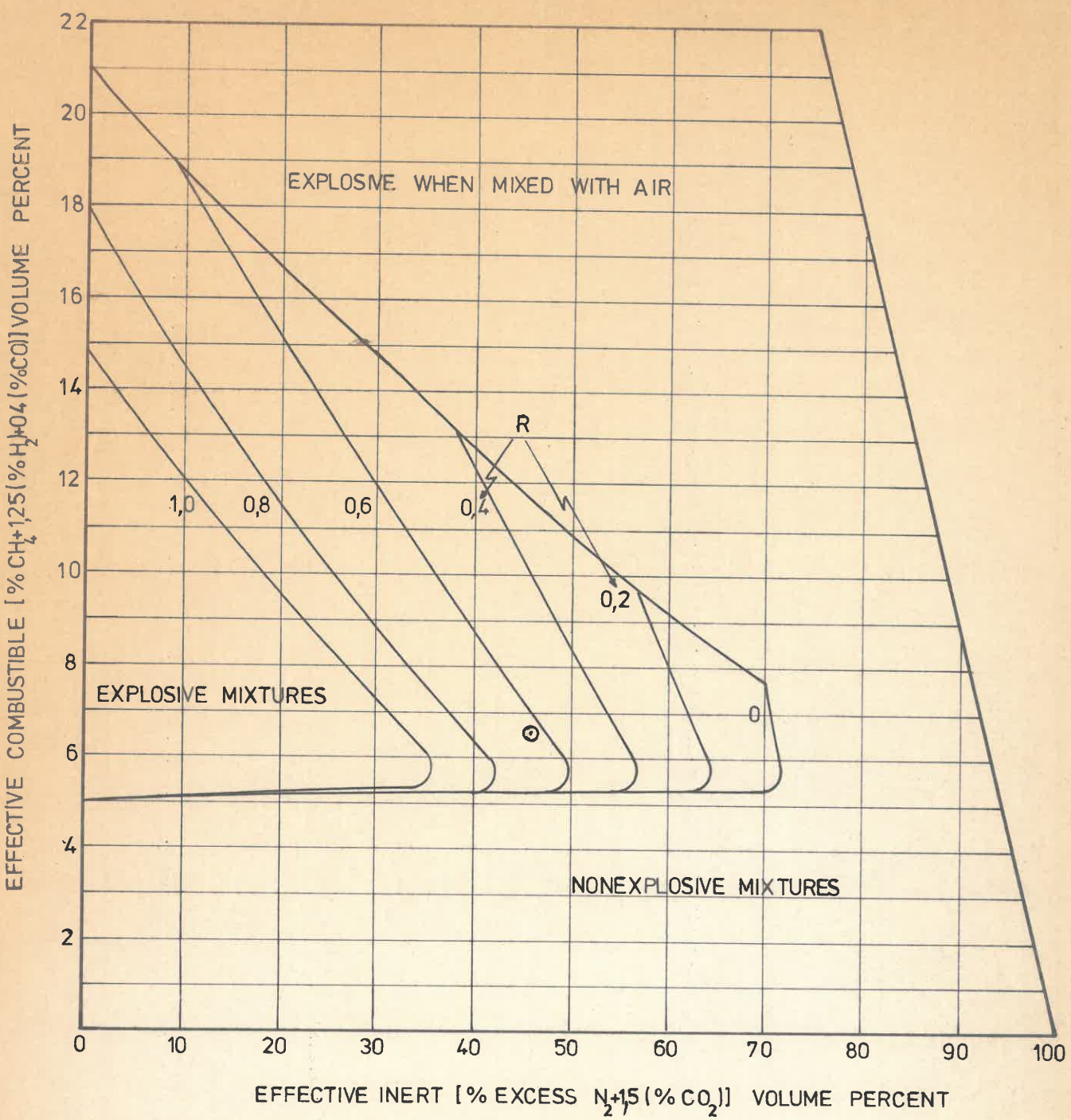

DATA ENT
10
1
3
6
0,3
INPUT OF O_2, CO, CO_2, CH_4 AND H_2
0*2
10
CD
1
CO*2
3
CH*4
6
H*2
0,21
N*2
79,78
OUTPUT: GAS ANALYSIS
R
0,8
RATIO OF METHANE TO TOTAL COMBUSTIBLES
GRAHAM
0,023989646935727
YOUNG
0,071968940807181
GRAHAM'S AND YOUNG'S RATIOS
X
46,18
Y
6,66
CO-ORDINATES ON THE EXPLOSIBILITY TRIANGLE

FIGURE 3



COMPONENT	READING	RANGE	PERCENTAGE
CO_2			
O_2			
CO			
CH_4			
H_2			
N_2			

PERCENT EXCESS N_2 $= N_2 - (3{,}8 \times O_2\%)$

TOTAL COMBUSTIBLE $= CH_4\% + H_2\% + CO\% = D$

$$R = \frac{CH_4\%}{D}$$

FIGURE 4