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8. SPECIFICATION

Section 1 Introduction
The KM9004 is an electronic combustion analyser, intended for boiler checking and service, which measures the following:

Oxygen O_2 content (%) of flue (stack) gas

Carbon Monoxide CO content (ppm) of flue gas

Nett temperature of flue gas (increase over ambient)

Actual temperature of the flue gas in Celcius or Fahrenheit.

From these readings the instrument calculates the combustion efficiency. It is programmed for different fuels including natural gas, light oil, heavy oil and solid fuel. The parameters can be monitored continuously while the boiler is adjusted to give optimum combustion. rempo

The KM9004 uses either a standard probe (CP4) for gas sampling or a smoke probe for both gas sampling and smoke testing. Either probe is connected by quick release couplings, and the instrument can be used to optimise the combustion efficiency of boilers using the oxygen and carbon monoxide readouts, with the temperature readout as an additional indication of heat transfer efficiency within the boiler. It can also check the smoke emission against standard charts with the smoke probe (see section 3.4).

A printer gives a printout of all parameters on demand. The display unit can be used as a hand-held monitor at distances up to 25 metres away from the main instrument case.

The instrument can be programmed for up to 8 different languages. If it is not set for the correct language on delivery, the local Kane-May dealer should be consulted. The keypad on all instruments is in English.

This manual provides all the information required for normal operation of the instrument. Section 2 describes the instrument and its various functions. Section 3 covers the preparation and Section 4 the starting up and setting up of parameters before operation. Section 5 describes normal operation, with Para. 5.6 summarising the steps. Section 6 covers routine maintenance. Section 7 gives a summary of combustion theory and practice and the determination of combustion efficiency. Section 8 is the specification of the instrument.

In line with its policy of continuous development, Kane-May Limited reserves the right to alter any part of the instrument specification without prior notice. Further information is available from the local Kane-May dealer or from the Service Manager at Kane-May Limited.

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Section 2 DESCRIPTION

This section describes the instrument, and its components and their functions.

2.1 Instrument in Carrying Case

The instrument with its display unit and controls is housed in a convenient carrying case. The probe, water trap and leads are stored in the lid.

At the front left of the top panel is the socket to take the plug for the electricity supply (for recharging the integral battery); the mains fuse (0.16 amp anti-surge); the selector for the appropriate electricity supply voltage (120V or 240V).

At the rear left are the jack socket for the thermocouple jack and the connector for the water trap. (See para. 2.2)

At the rear, under a plastic cover is a compartment for the oxygen (O_2) sensor (see para. 2.5); the particle filter (see para. 2.6) or sulphur dioxide filter (see para. 2.9) and the paper roll for the printer (para. 6.6). All of these components are replaceable.

At the right is the Display Unit, which carries all controls. (see para. 2.3).

2.2 Probe and Water Trap

The probe is constructed of a hollow tube attached to a flexible hose, to draw flue gas from the boiler. Inside the tube near the tip is a thermocouple, whose leads run inside the tube and alongside the flexible hose, and is connected by a jack plug to the socket in the carrying case.

Kane-May supply either a standard probe, solely for combustion analysis, or a smoke probe, which can be used for both combustion analysis and for smoke tests (paras. 2.8 and 5.4).

CAUTION The flexible hose should not be detached from the probe, since the thermocouple leads may be damaged.

The gas drawn from the boiler passes through the water trap, mounted on the carrying case and then into the instrument.

The water trap acts as a filter for large particles, as well as condensing the water which is always present when burning hydrocarbon fuels (especially gas).

2.3 Display Unit

The display unit at the right houses all the controls and the display panel.

On the back of the unit ia a compartment for small batteries. These are not used on this instrument and thus the compartment is empty. However the display viewing angle adjuster is accessible through this compartment.

2.3.1 Keypad

The 4 x 4 keypad provides 16 keys which control all the operations of the instrument. There is an audible bleep when any key is pressed.

Section 2 Description (cont)

Nett Temperature selects for display the nett temperature, which is the difference between the temperature of the flue gas and the reference temperature (either the air at the boiler inlet or at the instrument itself).

Flue Temperature selects actual temperature of the flue gas.

°C/°F selects temperature in Celsius or Fahrenheit.

ON/OFF turns the instrument ON or OFF.

O_2, CO, CO_2 and Efficiency select the appropriate reading for display.

Time/Date is used for setting the correct time and date for the printout, and when selected, displays these parameters.

Fuel selects the relevant fuel from those available.

Smoke is used for runninp the smoke test.

SET/CAL is used for selecting air inlet temperature and for setting parameters (see Section 4).

Print may be pressed at any time to give a printout of all parameters.

I I and ENTER are used for selecting the fuel for adjusting the time and date, and for setting parameters.

The use of the various keys is described in later paragraphs.

2.3.2 Display Panel

The panel above the keypad uses a back-lit dot-matrix LCD giving two lines of display of 16 characters each.

Any 2 parameters can be selected - on start-up O_2 and CO are displayed. A new parameter selected from the keypad is displayed in line 2, and that in line 2 moves up to line 1. Thus all parameters can be scrolled through as desired. The increment (I) and decrement (I) keys may be used to scan all data that is available to the printer. The data is updated continuously while using this facility.

If the viewing angle of the 2 lines of display needs to be rotated up or down, an adjustment screw is provided on the back of the display unit. This is accessible through the empty battery compartment.

2.4 Printer

When the PRINT key is pressed, at any time, the printer gives a printout of all parameters. Note that for convenience in printing, O_2 is shown as O2.

Section 2 Description (cont)
A typical printout is as follows:

. . . .

XXX KANE-MAY XXX
XXX KM9004 XXX

DATE 12/02/87
TIME 13:45

NATURAL GAS

02% 5.0
CO ppm 45
CO2% 9.1

NETT °C 202
TEMP °C 220
TEMP INLT °C 18
EFF % (G) 80.5
STATUS 1

. . . .

The status codes are:

1 Data stable
2 Data not stable
3 O_2 sensor faulty
4 CO sensor faulty
5 O_2 and CO sensors faulty

Codes 1 and 2 are based on the change of readings over the previous 1 minute period. Sensor conditions are determined during self-calibration at start-up.

2.5 O_2 and CO Sensors

2.5.1 O_2 Sensor

The O_2 sensor, fitted in the compartment at the rear of the top panel, is of a fuel-cell type and is disposable. Its lifetime is at least six months and 12 months is typical in normal use. When it becomes impossible to obtain an O_2 reading of 20.9% with air, the display gives a warning. The sensor can be quickly removed and a new one fitted.

2.5.2 CO Sensor

The CO sensor, within the body of the instrument, is of fuel-cell type with a life of 2 to 3 years. If during calibration the CO sensor cannot be calibrated the display unit will give a warning (this will also be shown on a printout if this function is used). A new CO sensor must be fitted if this condition arises and since this requires the use of accurate test gases it is a task that should be undertaken by Kane-May's Service Department or a qualified Kane-May distributor. However other factors may lead to this condition (see para. 6.8).

2.6 Particle Filter

The particle filter (AF9), fitted next to the O_2 sensor, removes the smaller solid contaminates from the flue gas being sampled. If it becomes blocked it should be removed and replaced (see section 6.2).

2.7 Principles of Operation

With the probe tip approximately in the centre of the flue, gas is drawn into the instrument. It flows through the water trap, the filter, the pump, the CO sensor, the O_2 sensor before exhausting to atmosphere.

The gas temperature is measured by the thermocouple and is normally compared with the temperature of the air at inlet to the boiler.

From the readings of O_2 and temperature the instrument determines the combustion efficiency for the fuel being used. The measurement of CO is useful for adjustment of the boiler to give optimum efficiency. The CO_2 reading is derived from the O_2 measurement, and is provided to allow comparison with historic data produced by chemical test kits.

Section 7 discusses theoretical and practical combustion and the estimation of efficiency.

2.8 Smoke Test

The optional smoke probe (CSP4) is available, it allows a standard smoke test to be made. A known volume of flue gas is drawn through smoke test paper, which is then compared with the Standard Discolouration Charts.

2.9 Sulphur Dioxide (SO_2) Filter

When burning certain fuels (e.g. coal and heavy fuel oil) there may be significant concentrations of SO_2. It is then advisable to fit an SO_2 filter (SF9) in place of the normal particle filter (AF9), to obtain accurate CO readings. If the SF9 filter is not used inaccurate readings may result from the cross-sensitivity of the CO sensor to sulphur dioxide.

2.10 Battery

The battery is comprised of maintenance free lead acid cells, which can be recharged by connecting the instrument to the mains electricity supply. After a full day's work it is good practice to put the battery on charge overnight.

If the battery is allowed to become deep discharged the instrument automatically switches off, but retains enough residual power to maintain the date and time.

If the battery is deep discharged, 1 hour charging on the electricity supply will allow the instrument to be used. A full recharge takes between 9 and 15 hours.

CAUTION

Do not store the instrument with the battery discharged. This will cause damage to the lead acid cells. It is strongly recommended that the battery is kept fully charged at all times.

Section 3 Initial Setting-up and Preparation

This section describes the initial setting up of the instrument on delivery; the connection of the probe and thermocouple for normal operation; the checks to be made before starting the day's work with the instrument.

3.1 Initial Setting-Up On Delivery

When the instrument is delivered, the following preparatory work is required. These instructions should be followed carefully.

1. Set the voltage selector switch, at the front left, to the level appropriate to the electricity supply voltage. 120V may be used for supply voltages between 95V and 132V, 50/60Hz. 240V may be used for supply voltages between 185V and 264V, 50/60Hz.
2. Although the instrument is supplied with a fully charged battery, it is good practice to put it on charge overnight before use.
3. The O_2 sensor is supplied packed and unconnected, with caps over its inlet and outlet ports to increase its storage life. It is stored in the compartment at the rear of the top panel. Unpack it and open the ports. With the arrow on the top pointing to the left, plug the lead into the socket at the left hand end. Push the sensor ports into position — yellow to yellow at the right, red to red at the left.
4. Put in a paper roll and feed it through the printer. Turn ON and press PRINT and check the printout is correct, as shown in Para. 2.4.
5. Check the date and time and set them correctly if necessary.

   When the instrument is turned on, there is a self-calibration period up to 5 minutes. Thus the checks in 4 and 5 above cannot be made until this is finished. See para. 4.1

3.2 Connecting Probe and Water Trap

Remove the water trap from the lid and mount it on the gas connector at the rear left. Remove the probe and flexible hose from the lid. Connect the hose to the water trap and insert the thermocouple jack plug in the jack socket at the rear left. Make sure that both are firmly connected.

3.3 Daily Checks

Before starting the day's operation the following checks should be made:

1. Check that the water trap is empty. Empty it if there is water in it.
2. Check that the particle filter is clean outside. Replace the filter if it is very discoloured (para. 6.2).
3. Turn ON and check the date and time. Adjust if necessary.
4. Make sure the carrying case is lying flat and is not on a hot surface.

   If the battery is discharged, a 1 hour charge will allow the instrument to be used on the mains supply. After a full day's work, the battery should be recharged.

3.4 Using the Display Unit for Remote Reading

If desired the display unit can be removed from the case and the extension lead of 8 metres can be fitted. Further extension leads in 8 metre lengths are available as an optional extra. The maximum lead length should be 25 metres.

3.5 Probe Position in Flue

The probe should be inserted through a suitable hole in the boiler flue and positioned so that the tip is at the centre of the flue, normally the position of maximum temperature. Sampling holes for chemical (CO_2) analysers may be suitable. The hole should be at least 10mm (3/8") in diameter. The depth stop should be adjusted so that the probe tip is at the centre of the flue.

The measurement point should be as close as possible to the flue exit from the boiler to avoid ingress of air. It should be at least 2 flue diameters up stream from any draught diverter or other opening to atmosphere. Readings just ahead of an induced draught fan may be impossible because of localised negative pressure. The lowest allowable pressure is −500mm water gauge (−20 inches).

Very large access ports (20mm or more) should be plugged to avoid ingress of air causing reading errors.

Section 4 Starting Up and Setting Parameters

This section covers the starting up procedure and the setting of the various parameters.

4.1 Starting Up

When preparatory work described in Section 3 is completed, press the ON/OFF key to turn the instrument ON, with the probe in free air.

Over a period of up to 5 minutes the instrument makes a series of checks. For 1 second the display panel shows ***KANE-MAY*** to check that the LCD's are working properly. The panel then shows:

CALIBRATING

5 : 00

This remains on the display, with the time counted down at second intervals until the O_2 and CO sensors have settled. The CO sensor is automatically zeroed but the oxygen sensor reading must be set by uing the increment and decrement keys to adjust the reading to 20.90%. Pressing the ENTER key completes the calibration.

If at the end of 5 minutes either one or both sensors cannot be set, the display shows:

OXYGEN SENSOR
FAULT

or CO SENSOR
FAULT

or BOTH CO AND 02
SENSORS FAULTY

This gives warning that the sensors have reached their limit and will need replacing, but the instrument will still try to make them work

The fault message remains on the panel until any key is pressed. The instrument may be used and the printout will show a status code indicating the sensor fault. See Para. 2.4)

If it is required to check either sensor at any time during operation, take the probe out of the flue so that it draws in free air and repeat the calibration procedure.

4.2 Time and Date

Pressing SET/CAL and TIME/DATE allows alteration of the display. The display shows:

DATE/MONTH/YEAR

Pressing the TIME/DATE key reverses the order of DAY/MONTH.
When this is in the format required press the ENTER key.

DATE 21/07/1987

TIME 13:45

A cursor appears under the first digit, which can be altered UP or DOWN with the I and I keys. Pressing ENTER moves the cursor to the next digit. Repeat the process until the correct date and time are entered. Provided the battery is not allowed to become completely discharged, the instrument continues to record the correct time and date.

4.3 Temperature

4.3.1 Reference Temperature

When the instrument is switched ON, the reference temperature (for use in NETT temperature) defaults to the temperature of the instrument.

Since the boiler air inlet may be at a different temperature, it is recommended that the inlet temperature is used as a more accurate reference. To select this, put the probe in the boiler air inlet stream. Press SET/CAL, NETT TEMP then ENTER. The inlet temperature is entered and the display reads zero. The actual air inlet temperature can be displayed by pressing FLUE TEMP.

To revert to start up condition, press SET/CAL, NETT TEMP, NETT TEMP.

4.3.2 Nett Temperature and Flue Temperature

If NETT TEMP is pressed the difference between the temperature of the flue gas and the reference temperature, i.e. the temperature rise through the boiler, is selected for display:

NETT °C . . . 225

If FLUE TEMP is selected the actual temperature of the flue gas is displayed:

TEMP °C . . . 250

4.3.3 °C and °F

Temperature is displayed in either Celsius or Fahrenheit, selected by pressing SET/CAL and °C/°F, followed by ENTER. The selection is retained when the instrument is turned OFF.

4.3.4 Selection of Fuel

The instrument is programmed to give the results for up to 16 different fuels. The fuel is selected by SET/CAL and FUEL and then scrolling through the list using I and I. When the required fuel is displayed, press ENTER. This selection is retained when the instrument is turned OFF.

If the fuel used in the boiler is not included it is recommended that the one which is nearest to it should be selected.

4.5 Efficiency Using Nett or Gross Calorific Value

The combustion efficiency can be calculated using either NETT calorific value or GROSS calorific value of the fuel. See Section 7. Selection is made by pressing SET/CAL and EFF (efficiency) and pressing EFF again to select N or G as required.
The display shows:

EFF (N) % . . . xx.x

or EFF (G) % . . . yy.y

Press ENTER when the required parameter is displayed. This selection is retained when the instrument is turned OFF.

Section 5 Operation

When all the parameters have been set as described in Section 4, everything is ready for operation with the instrument turned ON.

5.1 Normal Operation and Printout

1. Insert the probe into the flue so that its tip is in the middle of the flue duct.
2. After a few moments the readings will settle down to show the characteristics of the flue gas. The required readings can be selected for display on the panel.
3. A printout of all parameters can be obtained whenever required by pressing PRINT. During printing the sensor information is not updated.
4. At the end of measurement it is good practice to remove the probe from the flue and allow air to be drawn through the instrument for 10 minutes to purge any remaining volatile pollutants from the system (gas and condensate).

5.2 Trimming for Maximum Efficiency

Using the O_2 readings and the CO readings, the burner can be trimmed to give optimum combustion efficiency. The optimum occurs with minimum O_2 reading and when the CO is also as near zero as possible. In practice, a small amount of CO (100 to 200 ppm) is acceptable, especially on gas boilers.

5.3 Operating Time

Though the KM 9004 is intended for extended operation over the period of a normal service check, certain precautions are necessary.

The water trap should be inspected and drained if required at frequent intervals, and the disposable particle filter checked and replaced if required, particularly on boilers using heavy oil (soot contamination) or gas (high water content saturing the filter).

If the instrument is to be used for more than one hour for extended testing/monitoring, it is recommended that the probe is removed from the flue to allow air to be aspirated at least once an hour for ten minutes.

After this period, the instrument should be calibrated . This procedure prolongs the life of the sensors and pump avoids internal corrosion and maintains the accuracy of the readings.

5.4 Smoke Test

If a smoke probe is being used for normal testing and a smoke test is required follow the procedure below.

1. Press SMOKE which stops the pumps and displays:
   CONNECT SMOKE
   PROBE & PAPER

Fit the smoke probe with a filter paper. Insert the probe into the flue as normal.

2. Press SMOKE to start pump. This draws 1.69 litres of flue gas through a 6mm hole and displays:

   SMOKE TEST IN
   OPERATION 191

The time remaining for the SMOKE TEST is shown on display in seconds.

When the required flue gas volume has been drawn through, the pump stops and the display changes to:

   REMOVE SMOKE
   SAMPLE

3. Remove the probe and take out the filter paper.
4. Press SMOKE to return to normal operation.
5. Compare the filter paper with the Standard Discolouration Chart supplied.

5.5 Sulphur Dioxide (SO_2) Filter

When using the KM9004 on certain fuels (e.g. coal, and heavy oil), the presence of sulphur in the fuel results in a high concentration of sulphur dioxide (SO_2) relative to carbon monoxide (CO).

This has the effect of increasing the apparent CO reading, owing to the cross-sensitivity of the CO sensor to SO2. If this is suspected, the SF9 filter should be used in place of the particle filter. The SF9 is a chemical filter which removes SO_2. The lifetime of this filter is approximately 12 hours, and its use should be limited to cases where the SO_2 problem exists. On natural gas and light oil fired boilers there is no need to use the SF9 filter as the sulphur content is usually very low.

5.6 Summary of Normal Operation

This paragraph gives a summary of the steps required for normal operation.

		Para.
1.	Connect the water trap, probe hose and thermocouple jack	3.2
2.	Check the water trap, filter, date and time, battery charge, etc	3.3
3.	Turn the instrument ON for self-calibration	4.1
4.	Set the reference temperature, select the fuel and set the parameters required.	4.2 to 4.5
5.	Insert the probe into the flue	5.1
6.	Select the parameters for display as required	5.1
7.	Obtain printout as required	5.1
8.	At the end of the test remove the probe from the flue and allow air to be drawn through the instrument to purge any remaining pollutants.	5.1

SECTION 6. ROUTINE MAINTENANCE.

The KM9004 has been designed to minimise operator maintenance. However, owing to the type of O_2 sensor used and the nature of the measurement, some routine maintenance is necessary.

6.1 Water Trap

The water trap should be cleaned when water collects -the easiest way to do this is to unscrew the polycarbonate bowl, followed by the filter, taking note of the gasket positions. The filter is best cleaned in hot soapy water, rinsing after use in clean water and subsequently blowing dry with an air line. The bowl can be cleaned with a tissue and the whole trap re-assembled.

6.2 Particle Filter

The particle filter is located under the plastic cover at the rear of the case. If it becomes blocked, there is no service possible and it must be replaced. The need for this is shown by:

Discolouration of the filter
Build up of soot, etc.
Slow response to flue gas when probe is inserted in flue
Inability to set the oxygen reading to 20.9% in self-calibration.

This last indication can have several causes. If the problem disappears when the filter is removed, a new filter should be fitted before using the instrument. If not, see para. 6.8 on trouble shooting. A new 0_2 sensor may be needed.

To remove the filter, pull it out of the connector at the left hand end and then disconnect the other end of the hose. To replace the filter, reconnect the tubes, in the reverse order, ensuring the flow is in the correct direction with the arrow from left to right. Replacement filters (AF9) are available from Kane-May dealers.

6.3 Oxygen Sensor

Only OS10 sensors are suitable for KM9004.

The expected lifetime of the O_2ensor (OS10) is between 6 and 12 months. This can be extended by disconnecting the sensor and sealing the inlet and outlet tubes using the plastic caps supplied with the sensor when the instrument is not in use.

OXYGEN SENSOR
FAULTY

It is always worth checking the probe, water trap and particle filter, as flow restrictions may give the same effect.

On replacement, make sure that the correct colours match on the O_2 sensor and the connectors.

NOTE: When a new oxygen sensor is fitted, oxygen readings may take 15 minutes or so to stabilise.

Replacement O_2 sensors (OS10) are available from Kane-May dealers.

6.4 Battery

Although the battery is a sealed type and does not require any maintenance, it is good practice to charge the battery regularly to keep it in good condition. The best method is to charge it overnight with the instrument switched OFF.

CAUTION

Do not store the instrument with the battery discharged. This will cause damage to the lead acid cells. It is strongly recommended that the battery is kept fully charged at all times.

6.5 Probe

The probe does not require any special maintenance except for the occasional wipe over with a damp cloth. However, it does get hot in use and one or two points must be borne in mind when handling and storing the probe. These are:

1. Never immerse the probe in liquid — any liquid drawn into the instrument damages sensors, and can affect the calibration of the thermocouple.
2. Allow the probe to cool in air while the instrument is aspirating air. This allows the probe to cool naturally and helps disperse condensate in the hose of the probe (see Para. 5.3).

6.6 Fitting Paper Roll

To fit a new paper roll, remove the plastic cover at the rear of the case. Put in the new roll, with its free end running forward from the bottom, and feed the end into the printer. Turn on the instrument, press PRINT to draw the paper through the printer. Packs of 10 paper rolls are available from Kane-May dealers. Remember that the self-calibration period must be completed if the instrument has just been turned on.

6.7 Adjusting Viewing Angle of Display

The viewing angle of the display can be rotated up or down by the screw adjustment accessible through the empty battery compartment on the back of the display unit.

6.8 Simple Trouble Shooting

Symptom:	Slow responses to oxygen or carbon monoxide changes.
Cause:	Water trap blocked. Filter blocked. Probe or hose blocked (inspect, clean if necessary, taking care to avoid damage to the thermocouple).
Symptom:	High oxygen readings when aspirating flue gas.
Cause:	Air leakage (check probe, hose fittings, filter and water trap connections). Ensure that O_2 sensor is correctly seated.

Symptom:	Difficulty in setting CO reading to zero in calibration or zero shifting in use.
Cause:	CO sensor may be approaching the end of its life, but background CO level can affect readings (e.g. cigarette smoke, boiler leakage, etc.).
Symptom:	CO reading high and cannot be set to zero.
Cure:	Plug in the mains adaptor and allow the instrument to run for 24 hours. The usual reason for high zero readings is that the instrument has been exposed to very high levels of CO or possibly SO_2 polluting the CO sensor. If this procedure fails, a new CO sensor should be fitted.

If difficulty is experienced in any of the above, the local Kane-May dealer or Service Manager of Kane-May Limited, should be consulted for further advice.

Section 7 Theory and Practice

7.1 Theoretical Combustion

Most fuels in raising steam contain carbon (C) and hydrogen (H). In perfect combustion, the oxygen content (20.9%) of the air supply would be converted by the carbon content of the fuel to carbon dioxide (CO_2), and by the hydrogen content of the fuel to water vapour (H_2O). This type of combustion is known scientifically as stoichiometric combustion, and no oxygen would pass out into the exhaust flue.

7.2 Practical Combustion

In a real situation, the design of combustion chambers makes the perfect combustion, outlined above, impossible. Full combustion is obtained only by having more air available than is required in theory. This is known as "excess air" and its control is the key to optimising combustion efficiency.

7.3 Effects of Increasing/Decreasing Excess Air

If the boiler is to operate on a given fuel type, under a given firing rate, there will be an amount of excess air which gives full combustion and the greatest efficiency of combustion. If the air supply is less than this amount, there is partial combustion of cjrbon (C) to carbon monoxide (CO). This is particularly so in the case of natural gas. With heavier fuels, unburnt or partially burnt fuel results in smoke emission. This partially burnt fuel leads to inefficiency and wastage of fuel. With an air supply over and above the amount required, full combustion takes place, but in this case the extra air cools the combustion chamber and carries heat away into the flue. This is also a cause of inefficiency.

7.4 Determining Optimum Combustion Efficiency

Taking the example of natural gas, stoichiometric combustion would yield 11.9% CO_2 and of course zero O_2.

The KM9004 monitor O_2 and CO continuously. This is of particular use with gas burners, as reducing the air supply until CO begins to form usually gives good combustion conditions.

7.5 Wet and Dry Basis of Analysis

In combustion of hydrocarbon fuels, water vapour is produced in significant amounts owing to the combustion of hydrogen.

At the flue temperatures the volume of water vapour (6% to 12%) is significant and analysis of the flue gases under these conditions (e.g. by an in-line oxygen probe) gives a LOWER (diluted) reading than if the gases are cooled to near ambient temperatures, when the volume of water vapour is reduced by condensation.

In-line analysis is, therefore, said to be WET analysis, but the KM9004 condenses out most of the water before analysing and gives readings on a DRY basis.

The difference is typically 0.5% O_2 between these two situations.

NOTE: The KM9004 instrument is calibrated with perfectly dry gases in production, though calibration uses atmospheric oxygen, whose humidity is around 30-80%, and the instrument in operation analyses virtually saturated gas, 100% RH. Fortunately, the difference in oxygen readings between these methods due to the difference in water vapour concentration is not significant.

Section 7 Theory and Practice

7.6 Nett and Gross Calorific Value

Though readings of O_2 concentration and nett temperature are independent of fuel type, and can be used successfully (with CO concentration) to set up a boiler for MAXIMUM combustion efficiency, the VALUE of this efficiency often needs to be known and reported for comparison purposes.

To arrive at a final efficiency figure from the above factors requires a knowledge of the calorific value of the fuel (heat content), its carbon to hydrogen content, and whether the water produced is lost as steam, or whether this is condensed and the "latent" heat (heat required to turn water into steam) is recovered.

This leads to two conventions for calorific value of fuels.

The GROSS calorific value is the higher figure and assumes that all heat available from the fuel is to be recovered, including latent heat.

In most boilers this is not so and calculations of efficiency based on gross calorific value give maximum obtainable efficiencies much lower than 100% owing to this irrecoverable loss.

Calculations of efficiency based on gross calorific values are used in the U.K., U.S.A., and many other countries.

NETT calorific values do not take account of the latent heat losses, and nett efficiency calculations based on these figures give higher values (by 11% for natural gas) than those obtained from gross efficiency calculations and can approach 100%

Provided that the convention in use is understood, both sytems are equally valid. Clearly, for comparison purposes, a particular convention should be used throughout.

7.7 Radiation Losses

Most boilers lose some available heat by radiation and conduction from the boiler external surfaces to their surroundings. This is "lost" heat and affects the OVERALL efficiency of the boiler in transferring available energy from the fuel into steam energy.

Most calculations of combustion efficiency do NOT include these additional losses, which can account for 1% to 6% of fuel consumption. These losses vary from one boiler to another, and also with load and firing conditions on the same boiler. However, they should be included if a TOTAL efficiency figure is required. The manufacturer of the boiler should be consulted for this data, which cannot be obtained from combustion gas analysis.

7.8 Blowdown Losses

Blowdown losses are incurred if the water system is periodically purged for sediment. The loss of hot water or steam resulting from this can cause a reduction in total efficiency of up to 2%.

Section 7 Theory and Practice
7.9 Combustion Efficiency

KM9004 uses the BS 845-1987 recommendations to determine combustion efficiency.

It is calculated based on a knowledge of the calorific value, carbon and hydrogen content, the percentage of carbon dioxide produced under stoichiometric combustion conditions, and the temperature difference from air inlet to flue on the boiler.

Radiation losses are not taken into account since these are due to the construction of the boiler. Manufacturers data should be consulted if these losses are to be considered.

No allowance is made for losses due to carbon monoxide presence in the flue gases since these are small when the boiler is correctly set with CO levels less than 400 ppm.

Section 8 Specifications
RANGES

Temperature	0 to 600°C 32 to 1000°F

NOTE: The instrument has the ability to operate up to 1200°C with a special high temperature probe.

Oxygen O_2	0 to 25% O_2
Carbon Monoxide CO	0 to 4000 ppm CO
Carbon Dioxide CO_2	0 to 20% CO_2
RESOLUTION	
Temperature	1°C/1°F
O_2	0.1% O_2
CO	1 ppm CO
CO_2	0.1% CO_2
ACCURACY	
Temperature	±3% reading ±2°C/±4°F
O_2	+0.2%/−0.1% O_2
CO	±5% reading ±10 ppm CO
CO_2	±0.3% CO_2
EFFICIENCY	
Nett Efficiency	0 to 100% ±1%
Gross Efficiency	0 to 100% ±1%
O_2 Sensor	Fuel cell type (disposable)
CO Sensor	Fuel cell type (indefinite lifetime)
Battery	Type – lead acid rechargeable 4 hours measurement use from a full charge. Re-charge time – 9 hours (min.)
Mains Supply	120V setting 95 to 132 Vac 50/60Hz 240V setting 185 to 264 Vac 50/60Hz fuse 160mA antisurge only (5 x 20mm)
ENVIRONMENT	
Ambient Temperature	0 to 40°C / 32 to 104°C
Storage Temperature	−20 to 50°C / −23 to 122°F
Operating Humidity	0 to 93% non-condensing

continued..........

Section 8
Specifications cont ....

DIMENSIONS	
Carrying Case	400 x 310 x 150mm (15.8 x 12.2 x 5.9 in)
Probe CP4	combined gas and temperature sampling with detachable thermocouple. 5 metre hose fitted.
WEIGHT	9.0 kg (20lb)
OPTIONAL EXTRA	
Smoke Probe (CSP4)	combined gas, temperature and smoke sampling with detachable thermocouple. 5 metre hose fitted.
Extension Lead (RE9)	8 metre display unit extension lead. Greater lengths (24 metres maximum) may be obtained by connecting RE9 leads together.