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BRANDSTOFNAVORSINGSINSTITUUT
VAN SUID-AFRIKA

FUEL RESEARCH INSTITUTE
OF SOUTH AFRICA

ONDERWERP:
SUBJECT: RAPID MOISTURE DETERMINATION OF COAL.

AFDELING:
DIVISION: ENGINEERING

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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA

REPORT NO. 4 OF 1965

RAPID MOISTURE DETERMINATION OF COAL.

Due to the amount of time involved by the standard method of moisture determinations of coal by heating in a vacuum oven at 105°C for two hours, this method is not suitable for certain industrial applications. A method is required by which moisture can be determined with reasonable accuracy within a few minutes.

Commercial instruments capable of performing this operation almost instantaneously are available. Here the moisture content is actually derived at indirectly from the electrical resistance, dielectic constant or dielectic loss factor. It appeared, as reported hereunder, that none of these methods were suitable for the Institute's purpose. The nuclear resonance method may be suitable but the apparatus is expensive. Scharfetter's method could be considered but has some disadvantages. Finally an adaptation of a method used on the Continent was investigated, where the wet sample is put on the balance pan and dried by radiant heat.

The various methods are briefly reviewed.

THE SHAW MOISTURE METER.

A test was conducted on the Shaw moisture meter to determine the accuracy of the instrument.

Samples were prepared by mixing known quantities of sand and water in closed containers to provide the required range of moisture content. The actual moisture content of these samples were determined by standard procedures.

The instrument operation was conducted according to the attached factory instructions. After the initial adjustment and calibration of the instrument the moisture content of the various samples was determined.

Readings obtained are given in table 1.

From the observations it is apparent that successive readings of the same sample do not correspond. Furthermore drift in meter readings was encountered. As a further test a container with pure water was placed in the instrument

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and even these readings proved to be erratic.

THE MICROWAVE MOISTURE METER. (X Band 10.688 KMc/S).

A microwave moisture meter was supplied by Associated Electrical Industries Ltd., for test purposes. The possibility of adapting this instrument to coal moisture content determinations was investigated.

This instrument comprises a transmitter for generating microwave radiation and a receiver for detecting and measuring the attenuation of the energy passing through the material being measured.

The principle of operation is based on the fact that at centimetre wavelength the loss tangent and dielectric constant of water is very high compared with that of the material by which the water is absorbed. There is a relationship between the water content of a material and its radio frequency attenuation. When the relationship for a given material has been determined by calibration, the attenuation can be used as a measure of its water content. Most materials show a variation of attenuation with temperature.

For the calibration of the instrument coal and anthracite samples of particle size - 1/16" + 30# and - $\frac{1}{8}$" +1/16" were prepared. Equal portions of coal of a particular size grading were placed in several containers and different quantities of water were added. The closed containers with the moistened samples were thoroughly mixed by rotation, in a mixing apparatus. From each container thus prepared a sample was taken and the moisture content determined by conventional methods.

At the same time a definite weight of the sample was placed in a container of the microwave moisture meter, placed in the apparatus and the corresponding reading noted.

The calibration curves obtained are attached (Fig. 1.)

From the calibration curves it can be concluded that:

1. Samples will have to be divided into groups of narrow size ranges for each of which a calibration curve is required.

2. The curves obtained for anthracite and coal do not correspond.

3. Because of temperature effects, calibration curves must be obtained at various temperatures to provide complete coverage.

Thus for the practical application of this instrument a complete set of calibration curves covering all required particle size and temperature ranges normally encountered, must be compiled.

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The instrument probably is satsifactory if one deals with a coal of consistent characteristics. In the case of the Institute, with the wide variation in the properties of the coals dealt with, the apparatus is not very suitable.

SCHARFETTER'S METHOD.

This method is fully described in T.M. No. 7 of 1960. It may be briefly recapitulated here that coal samples of 100 grams are dried in a muffle at 250°C. The weight loss corresponding to the "standard" moisture content depends on the drying time and on the initial moisture content, which is unknown. This introduces some uncertainty, but will, for technical purposes, usually lead to acceptable results.

Disadvantages are that the muffle must always be at the "ready" and that an analytical balance is required to determine the weight loss. This requires the presence of personnel which can be trusted to operate the balance, and although the drying time is short, the actual determination takes a time of the order of 5 minutes.

THE BALANCE AND LAMP METHOD.

This method, used overseas, was tried at the Institute and gave fairly satisfactory results.

The apparatus used for this method consists of a 250 W, Infra Red lamp with built-in reflector, as the heat source, and a suitable balance, preferably direct reading, to indicate the weight loss.

The procedure applied was to spread a 50 gm sample on a flat shallow metal container placed on the balance and then to record the total weight. The heat source is set up to radiate heat onto the coal sample. A distance of six inches between the heat source and the metal sample container provided adequate transfer of heat. After approximately twenty minutes of heating the moisture is evaporated and the weight remains constant. The weight loss observed represents the moisture content of the sample.

The samples used were prepared by mixing known quantities of water and coal by shaking thoroughly in a sealed bottle. The various samples used, included sand, coal, anthracite and coke of particle size - 1/16" + 30"# and - ¼" + 1/16".

To determine the accuracy of the method, the moisture content of the prepared samples was determined by the standard method of heating in a vacuum oven at 105°C for two hours.

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During the heating process, the temperatures of the samples on the balance varied between 160 - 200°C.

From the results obtained it is evident that an accuracy of ± 0.5% can be expected with this method. See Fig. 2 - 6 and table 2.

It can be concluded that the balance lamp method provides a means of determining the moisture content of coal samples within a short period and with acceptable accuracy for use in industrial applications.

G.S. VAN EEDEN.

Technical Officer.

PRETORIA,

26th May, 1965.

/LNS.

TABLE 1.

SHAW MOISTURE METER.

(Sample = 50 gms.)

	Actual Moisture	Observed Moisture.			
1	0.25	0.2	0.2	0.4	0.5
2	3.92	4.2	4.6	4.4	4.5
3	5.40	5.4	5.4	6.0	5.4
4	7.01	6.5	6.8	7.0	6.9
5	8.17	7.1	7.3	7.4	7.2

Table 2/.....

TABLE 2.

LAMP BALANCE METHOD.

Sample	Percentage Moisture	
	Balance-Lamp	Standard Method
Sand	5.4 10.3	5.60 10.40
Coal	2.74 6.68 9.62	2.00 5.70 8.90
Natal Amm. Anthracite (- 1/16" + 30#)	1.86 4.80 7.22	1.48 4.44 6.70
Coke	0.96 4.28 7.86 9.60	0.74 4.18 7.60 9.23
Natal Amm. Anthracite (- ¼" + 1/16")	1.90 4.80 7.40	1.64 4.40 6.82

September, 1962.

SHAW PRESSURE MOISTURE METER

INSTRUCTIONS.

INSTALLATION

Connect black and red wires to mains supply. The green wire can be earthed if required. No mains adjustment is needed as the instrument is fully stabilized for 190/260 V 50 cycles. Consumption 20 watts.

INSTRUCTIONS FOR USE.

Switch on the instrument, allow 15 minutes to warm up. Place Plastic Disc in container, fill container and place under plunger, depress handle and note the dial reading. Don't hold handle whilst reading. Clean disc and electrodes after each test.

INSTRUCTIONS FOR INITIAL ADJUSTMENTS ONLY.

Switch on and allow to warm up for 15 minutes or more. Undo the small chrome screw (which locks the 10 turn dial knob in position) by turning the screw to the left. Place metal sample cup on electrodes and insert plastic disc.

Take a sample to be tested, having a moisture content mid-way between the range of moisture required to be tested, and fill the container, with it. This can conveniently be done by pouring the sample on to a folded sheet of paper or card. Lift up the handle and swing the pressure assembly to the right. This enablesthe sample cup to be easily filled and placed in position on the central electrode system. Choose a suitable amount of sample which will fill the container 2/3rds to 3/4 full, having a convenient standard weight. This weight should then be used for all subsequent tests.

Swing back the pressure assembly to locate the plunger over the electrodes and lower the handle so that the plunger enters the sample container. Make certain that the pressure assembly is as far to the left as it will go and touching the central locating stop as accurate positioning of the sample cup is essential. Screw down the lower ring until it touches the sample container then give it another half turn.

Next screw down the upper locking screw so that the lower ring is securely locked in position.

The 10 turn potentiometer should next be rotated so that the reading obtained is mid-scale (turning anti-clock-wise reduces the reading and vice-versa) and carefully note the reading for reference. If dry samples and wet samples are now tested in the meter it will be seen that the dial indication moves to the left for dry and to the right for wet samples.

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September, 1962.

The amount of dial movement is controlled by the adjustment of a pre-set sensitivity control which will be found under the hexagon nut at the left hand side of the cabinet. To alter the amount of dial movement, remove the nut and adjust the pre-set control as follows:-

If the indication between the wet and dry samples is too great i.e. if the needle indication is off-scale turn the pre-set adjustment anti-clockwise 5 degrees at a time, noting the readings obtained for the three samples between each adjustment of the sensitivity control. The medium sample should then be re-inserted and the dial needle adjusted to read mid-scale by means of the 10 turn potentiometer and then the wet and dry samples checked as before. This procedure should be repeated until the required indications are obtained. The 10 turn dial is then finally locked in position by turning the small chrome screw clockwise.

Make a note of the reading on the 10 turn dial as this will be needed later to check the meter. This is the reference 10 turn dial setting (See Accuracy).

IMPORTANT All the dial readings can be moved up or down the scale (in a LINEAR manner) by moving the 10 turn dial as required!

TESTING VARIOUS SAMPLES.

If it is desired to test various samples, suitable volumes must be chosen which will give satisfactory results, according to the foregoing instructions. For each different sample the helical potentiometer reading must be noted exactly for reference as adjustment of the 10 turn dial will be needed on the different samples. The reading on the dial can be converted to moisture content, if required, by placing a scale on the dial glass of the instrument or by constructing a graph or numerical table of dial readings of moisture equivalents. The dial can, of course, read 0-10% directly if the 10 turn dial and sensitivity controls are suitably adjusted.

MAINTENANCE.

Very little attention is required apart from keeping the container and electrode surface perfectly clean and dry.

Do not clean electrodes with wet cloths unless meter is switched off!

ACCURACY

This is the most accurate moisture meter ever made. To maintain the original accuracy check the 10 turn potentiometer reading when dial needle reads exactly zero on scale. This must be done when the meter has been switched on for 20 minutes or more, making certain that the electrode area is empty and the operating lever fully raised. Make a note of this. Should this reading ever vary, the reference 10 turn dial setting (as described on page one for medium samples) should be altered by the same amount. If it

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September, 1962.

increases, add the increase to the reference number, if it decreases, subtract it.

We will willingly give our advice and assistance free, should you ever require it.

DRY SAMPLES.

Use a ring type container (without base) for readings on dry samples only. For other samples, the disc should be used to prevent overloading the electronic circuit.

CAUTION

The metal ring or cup must be kept clean on the top and bottom so as to maintain a good electrical contact with the Plunger and the base of the instrument.

Placing the hand around the metal sample container should not affect the dial reading at all, if it does, then perfect electrical contact is not being made.

SHAW MOISTURE METERS - RAWSON ROAD - WESTGATE-

BRADFORD - YORKS.

PHONE - BRADFORD 24959.

/LNS.

CALIBRATION CURVES

FOR A.E.I. MICROWAVE MOISTURE METER

X BAND, 10·688 Mc/s

SAMPLE MASS: 1625 gm

AT ± 45°C

$-\frac{1'}{8}+\frac{1}{16}''$

$-\frac{1}{16}''+\frac{1}{18}''$

MAJUBA ANT.

$-\frac{1}{16}''+30\#$

SPRINGBOK

FIG. 1

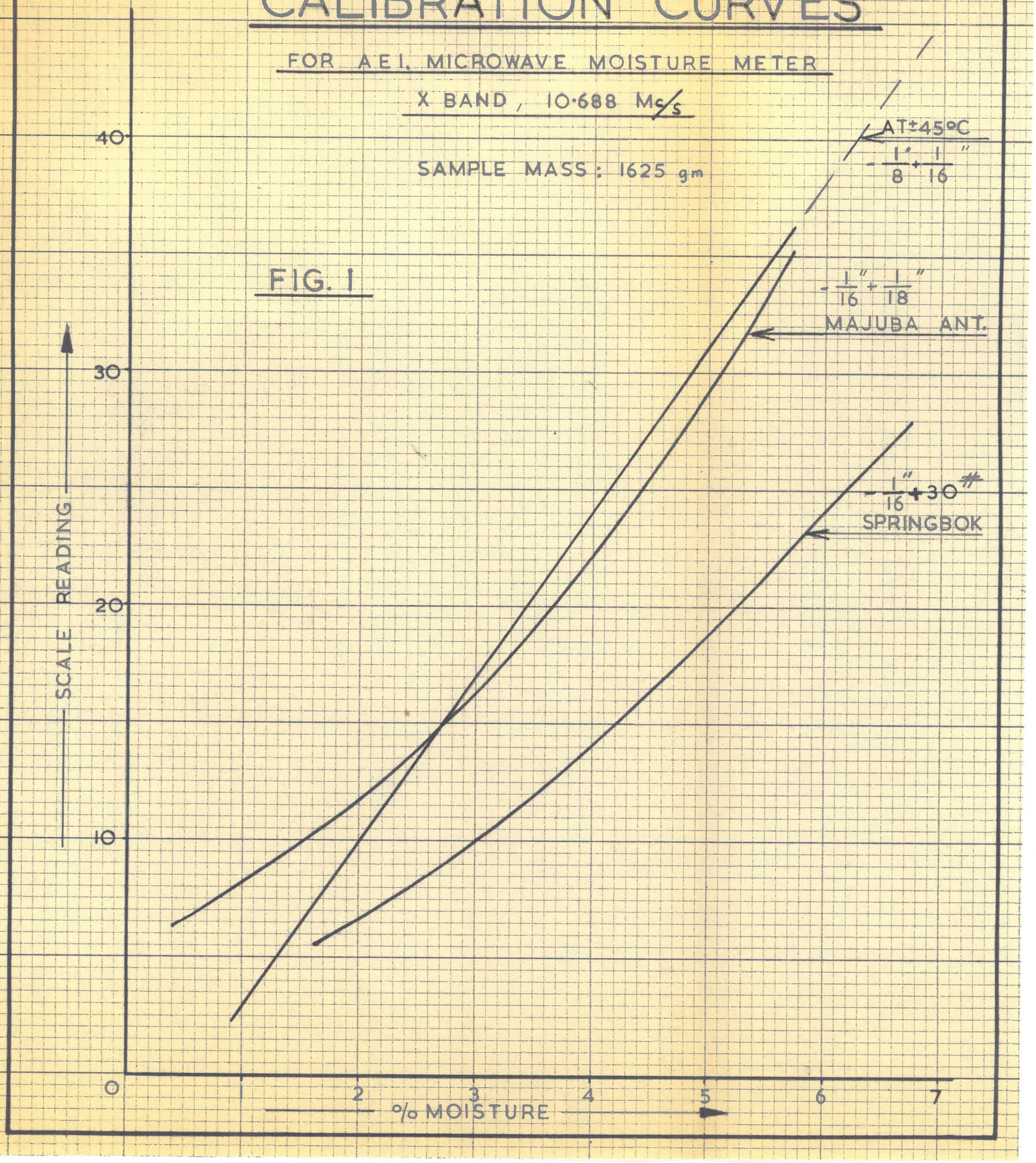

FIG. 2

SAND

WEIGHT = 50 gm.

TEMP. = 160 - 200 °C

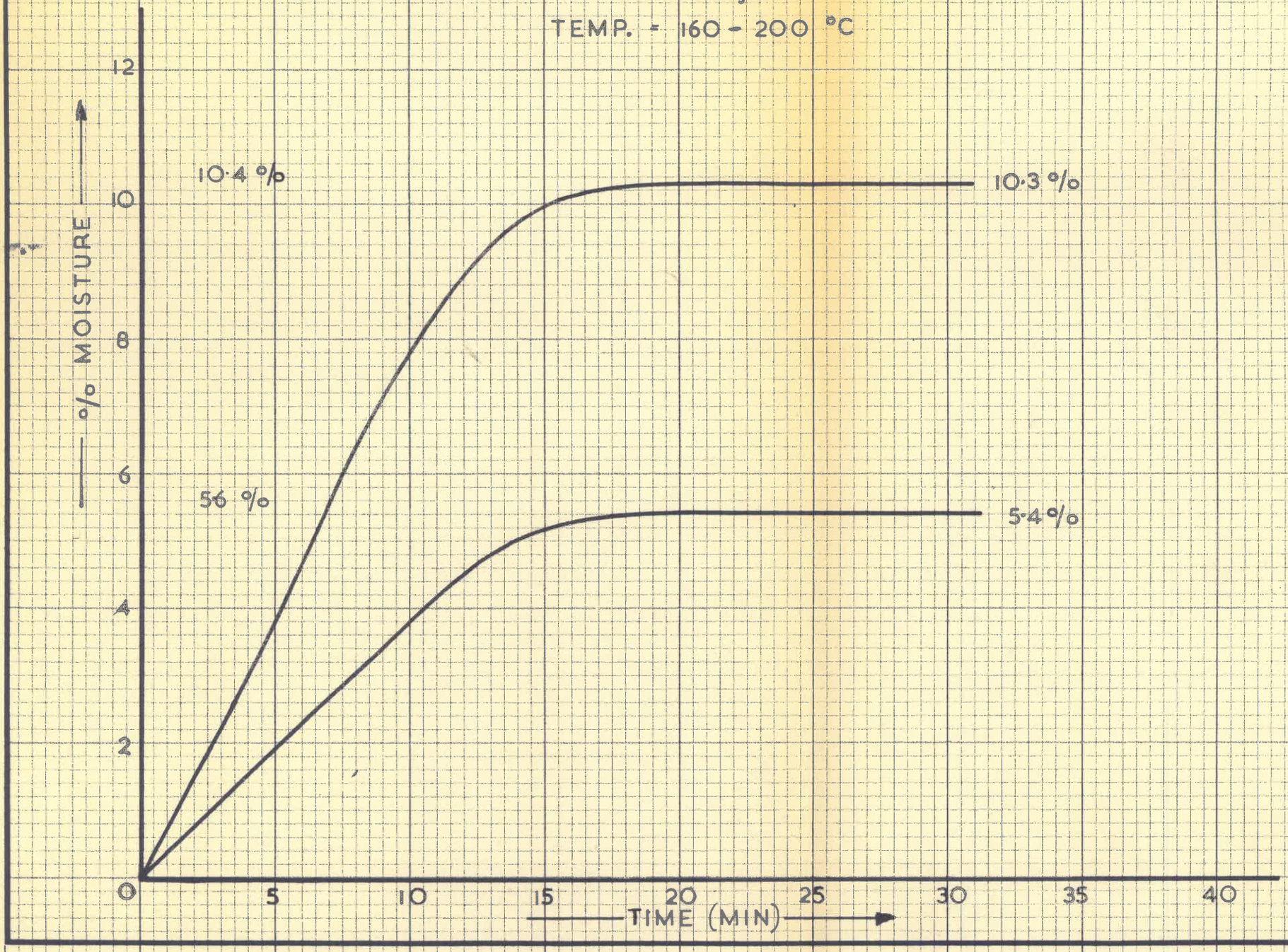

FIG. 3

COAL

WEIGHT = 50 gm
SIZE = -30# - 1/16"
TEMP. = 180 - 200 °C

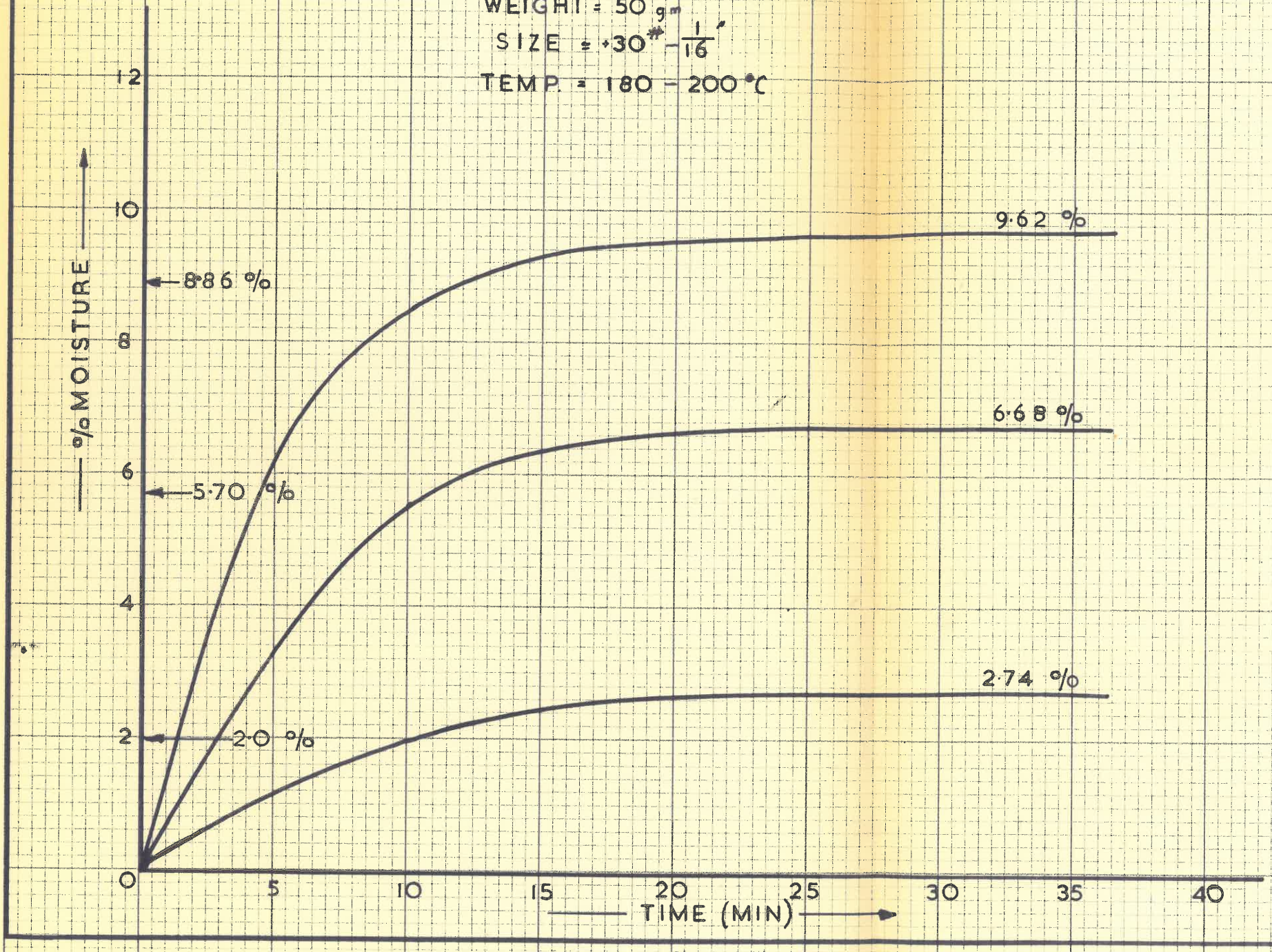

FIG. 4 COKE

WEIGHT = 50 gm. SAMPLE
SIZE = $-\frac{1}{16}$" + 30#
TEMP. = 180 - 200 °C

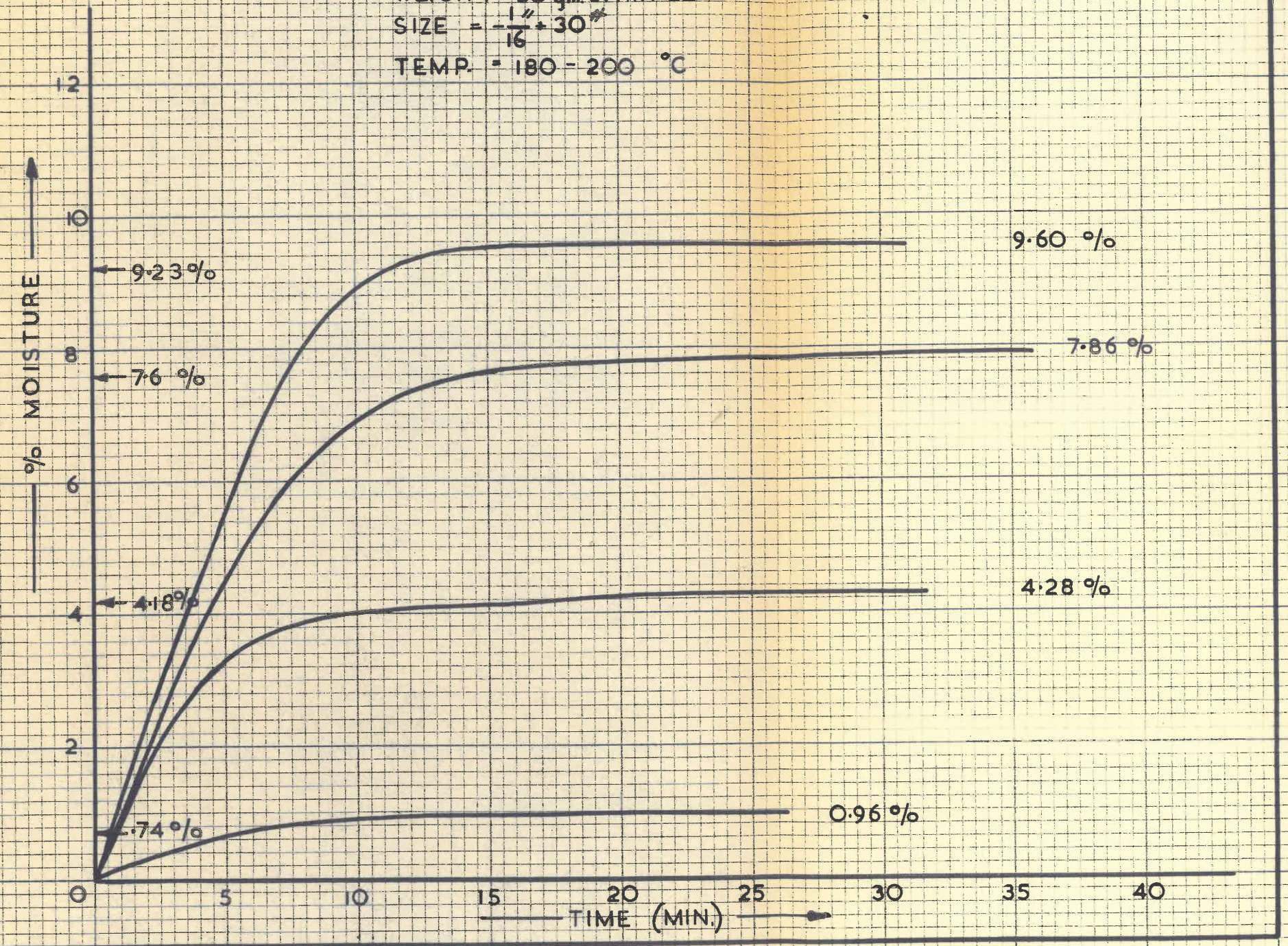

FIG. 5

NATAL AMM. ANT.

WEIGHT = 50 gm
SIZE = $-\frac{1}{16}''+30\#$
TEMP. = 180 - 200 °C

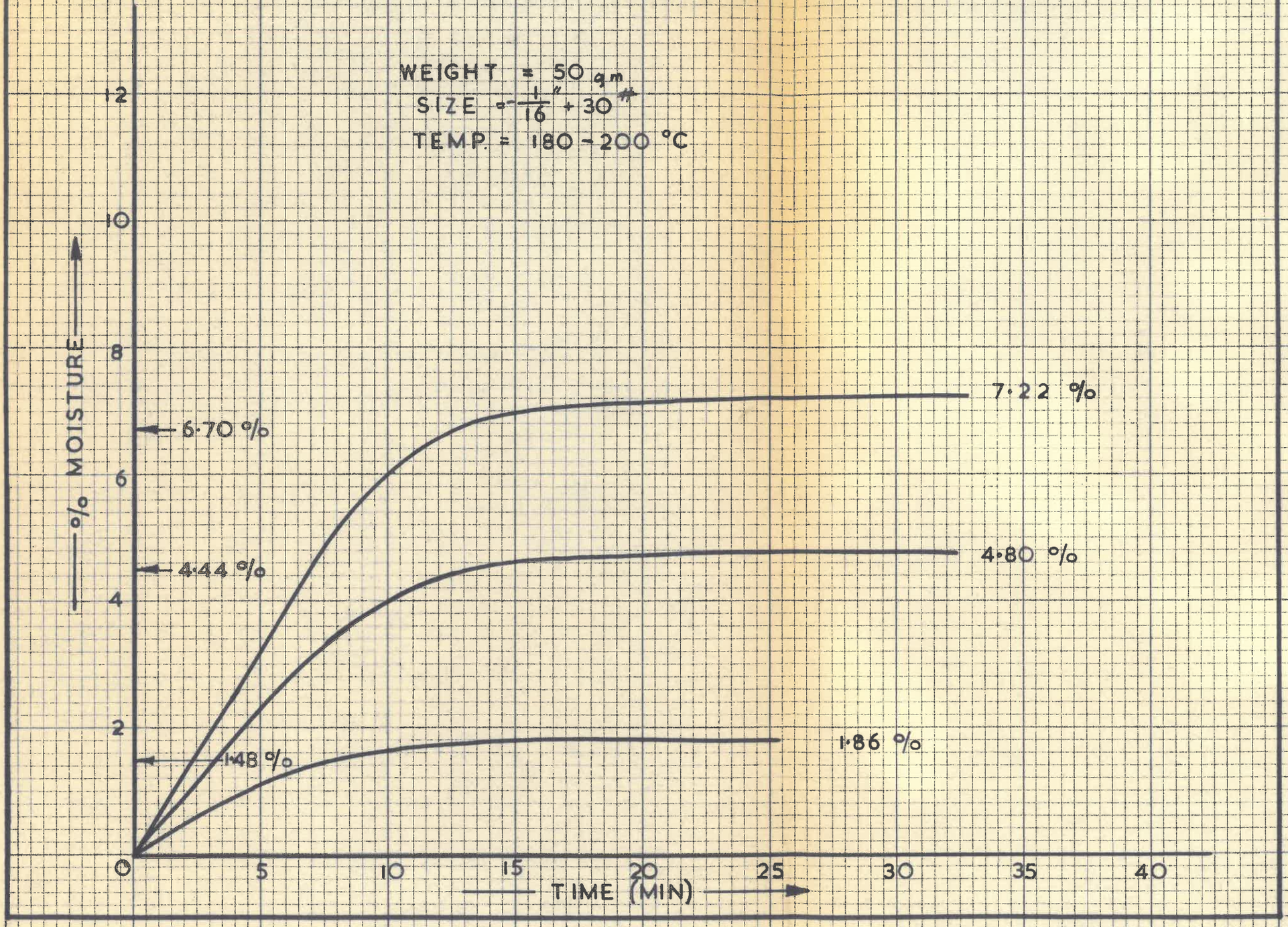

FIG. 6

NATAL AMM ANTHRACITE

SIZE :- 1/4" + 1/16"

SAMPLE: 50 gm.