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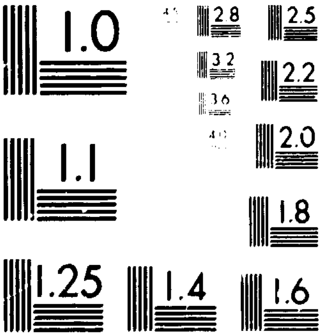

MICROCOPY RESOLUTION TEST CHART

→ Maria Dietrich ea

UNIDO-CZECHOSLOVAKIA JOINT PROGRAMME FOR INTERNATIONAL CO-OPERATION IN THE FIELD OF CERAMICS, BUILDING MATERIALS AND NON-METALLIC MINERALS BASED INDUSTRIES

11926

ENERGY CONSERVATION IN NON-METALLICS
/MOBILE DIAGNOSTIC UNIT/

by

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with the assistance of

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12 September, 1979

CONTENTS

ABSTRACT

Discussions held by UNIDO Representatives with the Chief Executive of the UNIDO/CSSR Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries in Pilsen on 27 - 28 August 197[illegible] on energy conservation in ceramics, building materials and non-metallic based industries resulted in the following conclusions:

Mobile Diagnostic Unit owned by the Research Institute for Ceramics, Refractories and Raw Materials in Horni Briza - Czechoslovakia could be used in developing countries on the request of their government for immediate advisory services and recommendations on improvement of the industrial use of energy.

The possibility of sending this unit with a team of CSSR specialists for pilot project activities in the field of energy conservation was suggested.

The enclosed technical documents highlighting the activities of the Mobile Diagnostic Unit should give sufficient background information to show this activity as being in line with the UNIDO energy conservation programme.

If the pilot project is successful the Joint Programme would be required to assist with the experience acquired in recent years with the Mobile Diagnostic Unit in providing designs of similar units to be stationed in particular areas of the world.

If such approach is acceptable to UNIDO's energy programme, UNIDO should officially request governmental authorities of CSSR for their support and collaboration in this endeavour.

[illegible], Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-Metallic Minerals Based Industries

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Minutes of the Discussions
within the framework of the UNIDO/[illegible] Joint Programme
for International co-operation in the Field of Ceramics,
Building Materials and Non-Metallic Minerals Based
Industries held in [illegible] on 27 - [illegible] 197[illegible]
on energy conservation in ceramics, building materials
and non-metallic minerals based industries

[illegible]

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[illegible] Secretary of [illegible]
[illegible]

In accordance with UNIDO [illegible] Energy Conservation in Industry UNIDO mission (Mr. [illegible] and Mr. [illegible] of UNIDO headquarters) visited [illegible] with the special purpose to discuss the possibility of utilization a mobile diagnostic unit which is the property of the Institute for Ceramics, Refractories and Raw Materials in [illegible]. The unit was in operation in CSSR during the recent years in the field of consultancy and diagnostic services for the Czechoslovak industry with a major activity of heat transfer. This unit might be successfully applied for consultancy services and for preparing serious recommendations on improvement of existing technologies in the field of heat transfer and heat processes in kilns, furnaces, driers and other heat generating equipment. In the course of negotiations UNIDO representatives were briefed about practical results achieved by this mobile unit and also about technical installation of this unit as well as about the team of CSSR specialists working with this unit.

In our joint opinion this unit which need very small additional calibration work, taking into consideration local conditions in the specific developing countries, could be used in these countries on the request of their governments for immediate advisory work and recommendations on improvement of the industrial use of energy which will lead to a better utilization of the available energy resources in their industrial processes.

The agreement was reached on the [illegible] possibility [illegible] this unit with a team of C[illegible] specialists [illegible] project activities in the field of energy conservation. [illegible] this pilot project is successful [illegible] in the above mentioned area. [illegible] should start with the implementation [illegible] possible [illegible] can see this activity to [illegible] completely [illegible] the [illegible] UNIDO energy conservation programme. General technical description and measurement possibilities of the unit and specification on the equipment will be sent to them in two weeks time together with the technical questionnaire which is usually sent some time before the practical work can be started.

As the follow-up of these joint activities two additional subjects were discussed:

1. Preparation of a study by the UNIDO/CSSR Joint Programme as a guidance material for developing countries on state-of-the-art and possibilities of energy conservation in non-metallic minerals based industries by [illegible].

2. It is taken into consideration to promote with the energy conservation programme a meeting, or a training workshop, or a seminar in which the measures for energy conservation in industry are emphasized.
   Within the scope of these activities, in so far as the energy programme is concerned, we would suggest that the meeting should be limited to the ceramics, building materials and non-metallic minerals based industries on the basis of experience and activities already achieved in the Czechoslovak industry (which is represented in this area by the Institute for Ceramics, Refractories and Raw Materials in Pilsen).
   Suggested time schedule for this seminar would be in the last quarter of [illegible].

It is further recommended that the Institute [illegible] made funds available to improve the [illegible] unit in a more elaborated testing unit through the experience obtained in recent years. The [illegible] of the Czechoslovak industry [illegible] also be expanded [illegible] could be under certain [illegible]
[illegible]

to be stationed in particular areas in the world [whereby it is thought to promote the support of the international community through making available the funds necessary to produce several units to be utilized on certain present local conditions.] (deleted.)

If such approach is acceptable to UNDP's energy programme, UNDP should officially request governmental authorities of USSR for their support and collaboration in this endeavour.

Ahmad - BE

Review of the Equipment of the Mobile Measuring Laboratory

1. Measuring the temperatures

Recording -
Compensation recorder with exchangable range
Sensors -
Pt 100 thermometer
Thermocouples Pt Rh-Pt Ni-Cr Fe-Co
Optical pyrometers 150 - 2000°C
Contact thermometers for measuring surface temperature

2. Measuring the temperature and the dew point

Compact unit
plotting recorder + source - Feutron
Sensors -
Pt 100 thermometer
Li-Cl sensor of the dew point

3. Measuring the flow velocity

Recording - plotting recorder
Sensors for recording - propeller anemometers
Anemometers for direct measuring without recording
Pittot's tubes + micromanometers for direct measuring

4. Measuring the burnt products composition

Recording - plotting recorder
Instruments - Infralit - CO_2
- CO^2
Permolit - O_2

5. Measuring the gas quality

Gas composition - Orsatchromatograph
Measuring the heating value - instrument for direct measuring the Wobbe's number

Instruments for Equipment of the Mobile Measuring Laboratory of the Institute for Ceramics, Refractories and Raw Materials at Horní Bříza - Czechoslovakia

The urgent need of a mobile equipment for checking thermal processes in the plants of Czechoslovak Ceramic Works was felt in the Institute in connection with the elaboration of the assignment "Research of the rational utilization of energies". In the initial phase the utilization of such an equipment was considered only for the following of thermal economy of heating processes. Later, however, this issue was reconsidered in a complex way, i. e. an equipment capable of measuring both the power and technology parameters was taken into account.

The whole equipment of the mobile measuring laboratory was installed in the van IFA and its trailer. Measuring instruments were selected with regard to the possibility to conduct power measurements, i.e. for determination of thermal balances and for ascertainment of technological conditions in thermal processing of ceramic materials.

Besides measuring in driers and kilns also other heat processing equipment can be measured, e.g. boilers and generators.

The instrumental equipment of the van contains also devices for checking and calibrating the instruments and for minor repairs.

The measurements are extensive and heterogenous. The most important equipment available and its application is as follows:

1) <u>Measuring the temperature</u>

In measuring the temperature most frequently measurements of atmosphere temperature and of surface temperature are required. For the atmosphere measurement orthodox sensors are applied: for the range up to 600°C - resistance Pt thermometers, up to 1200°C - thermocouples Ni-NiCr are applied. In this case so called coated thermocouples are used to a considerable extent. The advantage of these thermocouples is a substantially shorter time constant in comparison to orthodox wells. These thermocouples are also flexible and measurements can be conducted even in spaces with difficult access. These thermocouples are delivered in length up to 5 m and even longer (on request). The possibilities of application are considerable. For example the firing curves in the multi-channels can be measured by these thermocouples. In this case they are applied in a similar way as in measuring the heat field in the gradient furnace. By inserting the thermocouple into the kiln and by its gradual withdrawing immediate firing curves on the followed channels were obtained within a few minutes. The measurements by the usual method would take some tenths of hours.

For temperatures up to 1400°C the thermocouple wire PtRh 10 - Pt is applied, for higher temperatures the wire PtRh 30 - PtRh 6.

For the measuring proper and for the recording of indications through the resistance and thermocouple sensors the equipment is provided by compensation recorders. These recorders have a large precision (0.5%). The width of the record is 25 cm. A great advantage of this recorder is the possibility of a prompt exchange of measuring ranges and of arbitrary combinations of two different ranges.

One recorder can measure 12 measuring points. These recorders can be applied for measuring and recording of temperature indications, besides they are provided by standard ranges in mV. These ranges enable a series of further measurements. For example simultaneous temperature measurements and temperature differences with increased sensitivity can be conducted. This measuring method can be applied in following the heating rate of a setting.

For measuring the surface temperature the van is equipped by thermoelectric contact thermometers. For higher temperature 3 fully radiating pyrometers with mutually overlapping ranges are applied which enables to take measurements and temperature recording if need be within the temperature range of 150 - 2000°C.

2) Measuring the gas flow

The van is equipped by orthodox mechanical anemometers and mechanical-electrical anemometers for measuring the flows in driers and the sucking of fans. The anemometers can be connected to a specially adjusted recorder which enables to conduct a long-term investigation of flow conditions. These anemometers can be applied also in measuring cars in channel driers. The van is also equipped by some types of Prandtl's tubes for measuring in the tubing. These tubes can be applied also for measuring the flow of the generator gas.

3) Measuring the pressure

The most frequent task is the measurement of low pressures both in pneumatic equipment and in the ascertainment of draught conditions. To this purpose inclinable liquid micromanometers are applied. In case of need to record the indication annular balance with the basic range I 50 Pa can be applied. For measuring higher pressures the van is equipped by a series of precise manometers.

4) Measuring the dew point

The knowledge of the dew point in the drying equipment is of a great importance. To this purpose transportable sets were applied produced by the form Feutron Greiz in GDR. The equipment consists of 3 probes and one plotting recorder. Every probe consists of a temperature resistance sensor (temperature of dry thermometer) and of a dew point sensor (temperature of wet thermometer). The sensor of the dew point is based on the tension compensation of vapour produced by the LiCl electrolyte and vapour of the ambient. The stabilized temperature equilibrium corresponds to the temperature of the dew point. This set in connection with mechanical-electrical anemometers represents an equipment by which the basic parameters of the drying process - the temperature, the dew point and the flow velocity of the drying medium - can be measured and recorded.

5) Measuring the properties of combustion gases - analysis of combustion products

For ascertainment of heating gases composition the van is equipped by an Orsatchromatograph. With regard to the difficult transport of this instrument the application of the Wobbe's number meter seems to be more suitable. The instrument delivered by the firm Junkaler Dessau determines the Wobbe's number (the ratio of the heating value and the second root of the gas density) by measuring the temperature rise of a constant quantity of the air flowing through the combusted gas. The output signal is the voltage of the thermobattery which is registered by the recorder directly in values of the Wobbe's number. The measurement precision reaches 5 - 10% with regard to the applied calibration. The precise calibration is carried out by means of calibration gas mix delivered by the producer. The instrument is adjusted for measuring the Wobbe's number of the generator and natural gases.

This instrument was successfully applied in measuring tunnel kilns in one of our plants where the reasons of fluctuating firing temperature had to be ascertained.

For checking the firing process the mobile laboratory is equipped by transportable analyzers and by instruments installed in the van. The Instrument Infralit is applied for the determination of the Co and CO_2 content where the selective absorption of the infrared radiation by the measured gas is utilized for the determination of the content of the component looked for. For measuring the oxygen content the instrument Permolit was applied working on the increased permeability of oxygen with regard to other gases.

The instrument for the determination of CO_2 and O_2 contents consists of cleaning and drying filters, switcher of withdrawal points, analyzers and plotting recorders. The operation of recorders and switcher is synchronized, consequently measurements can be taken simultaneously in 3 points. The extraction of combusted products is conducted by pumps through extraction probes from a corrundum material.

Analyzers are applied in checking combustion conditions and in inspecting the function of burners. Also the ascertainment of the air sucked in by leakages of kilns is important. It is applied especially in tunnel kilns where the tightness of sand grooves can be checked. The measurement of the kiln atmosphere in the preheating zone shows the economy of kiln operation and potential reasons of great temperature differences in the kiln profile.

Analyzers are delivered with the calibrating gas mix in pressure bottles enabling a prompt and precise checking.

The basic equipment of the mobile measuring laboratory has been abridgedly presented. The measuring activity proper has been performed for some years. During this time measurings in tunnel kilns, channel driers, drying mills and electric kilns have been taken. The measurements are of different character according to the requirements of the plants. Every measurement is accompanied by a complex assessment of the equipment and oriented to the objective followed by the client. The conducted measurements are evaluated from the following view-points:

a) Heat balances
b) Firing curves related to technology
c) Waste heat utilization for drying
d) Heat losses through the lining into the ambient

e) Substitution of fuels of high quality by lower quality combustibles

It may be concluded that the measurements are oriented to the improvement of firing processes, heat savings, intensification of heat processes and higher ware quality with regard to established technology.

UNIDO-Czechoslovakia Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries

Technical Questionnaire for the Testing of Industrial Energy Conservation

(by the Mobile Diagnostic Unit)

Specification of initial information for planning and preparation of measurement of heat generating equipment by the Mobile Diagnostic Unit is specified as follows:

1. Country, establishment, kind of production
2. Type of the equipment to be tested, producer of the equipment
3. Characteristic of the equipment to be tested
4. Technical parameters
   a) energy supply (voltage, periods/sec., gas pressure, temperature of delivered medium - e.g. drying air)
   b) of the thermal process on the equipment
5. Year of the putting the equipment into operation
6. Description of present technical condition of the equipment
7. Kind of the product, its input and output qualitative or technological properties (if dealt with semiproduct)
8. Time course of heat process
   a) according to the project
   b) according to the actual situation - average of the last 6 months
9. Average output of the equipment (machinery)
   a) projected
   b) actual average of the last 6 months, related to the working time of the equipment

10. Method of the output measurement of the equipment (available applied equipment with measuring technique)

11. Technical parameters and consumption of fuel (energy), its calorific value evaluated as the average of the last 6 months

12. Method of energy consumption measuring, available equipment with measuring technique

13. Contributions expected:
    - energy conservation
    - quality improvement
    - immaterial (heat balance, information for reconstruction, etc.)

14. Basic drawings - assembly drawings, conception studies, prospectuses of the producer, guaranteed parameters, lay-outs, etc.

TECHNICAL REPORT

ON THE INVESTIGATION OF OPERATION CARRIED OUT ON A TUNNEL KILN FOR FIRING CERAMIC MOZAIC TILES

/based on research activities of the Research Institute for Ceramics, Refractories and Raw Materials at Horní Bříza - Czechoslovakia/

September 1979

CONTENTS

1. INTRODUCTION

The measurement of the tunnel kiln for firing glazed mosaics was taken by the measuring team of the Institute for Ceramics, Refractories and Raw Materials. This team is permanently engaged with research and investigation of thermal processes in the field of ceramics, building materials, non-metallic based industries and energetics.

The target of the measurement was to appreciate the economy and quality of the firing process and to investigate the reasons of increased breaking of support plates for firing mosaics.

2. TECHNICAL PARAMETERS OF THE PLANT

	project	present state
Type of the kiln	tunnel semimuffled kiln	
Fired product	glazed mosaics 2 x 2 cm	glazed mosaics 4 x 4 cm, 4 x 8 cm
Fuel	town gas 14445,0 kJ/Nm^3	
Output in mosaics	550 kg/h	505 kg/h
Output including firing furniture	1997 kg/h	1923 kg/h
Firing temperature	1050°C	
Year of putting into operation	1975	
Number of burners	10 pairs of auxiliary burners plus 11 pairs of main burners	
Number of cars in the kiln	27	
Mass of the setting on the car	489,6 kg	427,4 kg

3. METHOD OF MEASUREMENT

Firing curve - measuring kiln car:

The measurement was taken by four jacketed thermocouples Ni-NiCr place as shown in Annex No. I. With regard to a considerable high temperature in the inspection tunnel (more than 250°C) a compensation line NiCr could not be used. Therefore the connection without compensation was applied and temperatures of the heads of thermocouples were registered and corrections of measured values additionally calculated. This arrangement had partly negative influence upon the accurancy of measurement.
The offtake of combustion products for analysis as well as the checking of the firing curve were done through the sight holes of the kiln.

4. MEASURING CONDITIONS

The measurement was taken in the course of stabilized state of the kiln operation. (Uniform advance of kiln cars, no interventions with the kiln were carried out).
The average kiln car advance: each 46,5 min. 1 car

Basic operating values and setting of basic regulating elements is shown in the following table (see next page).

Average gas pressure:	Main burners	39,24 kPa
	Auxiliary burners	3,43 kPa
	Radial burners	1,08 kPa

Section	Main burners		Radial burners		Auxiliary burners
	Gas	+ Air	Gas	Air	
5	switched off				
6					switched off
7	switched off				
7-8					ignited
8	D9	4			open-not ignited
8-9	C 1.5	4			
9					ignited
9-10	A9	4			
10	A 8.5	4			switched off
11	B2	4			ignited
12			1/4	5/8	open-not ignited
12-13					ignited
13			1/4	1/2	
13-14					open-not ignited
14			1/2	1/4	
14-15			1/2	3/8	switched off

+ opening of the inlet (cm)

5. MEASURED AND CALCULATED VALUES

5.1 Firing curves measured in the cross-section of the kiln are indicated in the table No. 1. For comparison indications measured through the sight holes of the kiln are given and the indication of the permanently installed operation measuring instruments.
The location of thermocouples on the measuring kiln car and the graphical demonstration are shown in the Annex No. 1.

Table No. 1 <u>Course of temperature in the kiln (°C)</u>

time /h/	section	position of thermocouples 1	2	3	4	through sight holes	operation measuring
3	3.7	728	678	467	400		545
3.5	4.4	809	748	496	468		740
4	5	859	813	569	542		
4.5	5.6	829	837	656	629		
5	6.2	883	897	783	757		795
5.5	6.8	945	960	942	951		
6	7.5	1024	1024	1040	1026		
6.5	8.1	1035	1040	998	1013	1030	885
7	8.7	1060	1065	1025	1035	1050	
7.5	9.4	1080	1055	1037	1034	1020	975
8	10.0	1080	1058	1050	1055		1010
8.5	10.6	1060	1050	1071	1081	1055	
9	11.2	1075	1072	1092	1105		1010
9.5	11.9	1045	1055	1065	1092	1030	
10	12.5	1003	1020	1019	1030		
10.5	13.1	1042	1067	1058	1078	1080	1040
11	13.7	1045	1065	1045	1092	1055	
11.5	14.3	960	1008	966	1024	1030	
12	15.0	819	888	813	904		1000
12.5	15.6	725	785	839	870		
13	16.2	735	786	851	877		
13.5	16.9	715	794	768	789		
14	17.5	648	708	698	713		645
14.5	18.1	546	584	613	643	630	
15	18.7	494	532	589	613		
15.5	19.4	513	550	580	608		490
16	20.0	513	580	613	652		
16.5	20.6	522	570	584	642		

5.2 Draught curve and kiln atmosphere

The draught curve and the kiln atmosphere were measured by sight holes. The kiln, however, has not sight holes along the whole length of the kiln which is a certain shortcoming.
The measured values are given in table No. 2.

Table No. 2 Pressure curve and composition of combustion products

section	% CO_2	pressure /Pa/
8	9.5	8.7
8-9	9.0	11.0
9-10	7.5	15.0
10 H	5.5	19.7
12 H	6.0	22.8
12 D	-	17.3
13 H	5.5	23.6
13 D	-	18.9
14 H	4.8	24.4
14 D	-	18.9
14-15 H	4.1	24.4
14-15 D	-	19.7
18 H	-	25.2
18 D	-	19.7

5.3 Outlet temperatures of the setting

The outlet temperatures were measured by the contact thermometer along the length of the car immediately after drawing it out of the kiln.
The found indications incl. the temperature of the metal bogie are given in the table No. 3.

Table No. 3 Outlet temperatures of the setting and the metal bogie

	setting		bogie (°C)
	upper part (°C)	lower part (°C)	
car No. 1	87	140	65
	130	173	82
	140	170	8C
car No. 2	95	153	76
	121	167	80
	135	175	82
average	118	163	77.5

Average outlet temperature of the setting: 140.5°C
Average temperature of the car linings: 109°C

5.4 Gas consumption

The consumption of gas was determined by the indications of gas meters.

Date	Consumption /Nm^3/	Average per hour /Nm^3/h/
19.3	6907	288
20. 3.	7277	303
21.3.	7563	315
22.3.	7265	303
Average	7253	302

5.5 Quantity of combustion air

The air - the quantity was measured by anemometers located in front of sucking fans.

The air for auxiliary burners:

Diameter of the sucking opening: 0.3 m, i. e. the surface $S = 0.0707\ m^2$

Temperature: 26°C

Average velocity: $v_a = 7.66$ m/s

Volume $V_a = S \cdot v_a = 0.541\ m^3/s$

After recalculation to normal conditions:

$V_a^o = 1730\ Nm^3/h$

The air for burners of the preheating zone.

Diameter of the sucking opening: 0.34 m

Temperature: 26°C

Average velocity: $v_a = 5.66$ m/s

Quantity: $V_a = 1849\ m^3/h$

$V_a^o = 1642\ Nm^3/h$

The air for burners of the heating zone.
Diameter of the sucking opening: 0.34 m
Temperature: 26°C
Average velocity: 5.52 m/s
Quantity: $V_a = 1803\ m^3/h$

$V_a^o = 1601\ Nm^3/h$

After correction regarding the leakage of the inlet (by 10%): $V_v^o = 1440\ Nm^3/h$

The air for radial burners.
Diameters for the sucking openings: 0.245 m
Temperature: 35°C
Average velocity: 6.54 m/s
Quantity: $V_a = 1109\ m^3/h$

$V_a^o = 956\ Nm^3/h$

The total air quantity for burners $V_{a\ total}^o = 5929\ Nm^3/h$

5.6 Air quantities for entrance and exit air lock

The air for the kiln entrance air lock.
Diameter of the sucking opening: 0.26 m
Temperature: 30°C
Average velocity: 5.24 m/s
Quantity: $V_a = 1001\ m^3/h$

$V_a^o = 877\ Nm^3/h$

The air for the kiln exit air lock.
Diameter of the sucking opening: 0.34 m
Temperature: 25°C
Average velocity: 9.5 m/s
Quantity: $V_a = 3103\ m^3/h$
$V_a^o = 2766\ Nm^3/h$

5.7 Firing conditions in the kiln

Average air consumption of the kiln: $V_{dg} = 302\ Nm^3/h$

Air excess in firing: $n = \dfrac{V_a^o \text{ total}}{V_{at} \cdot V_{dg}} = \dfrac{5929}{302 \cdot 3.42} = 5.7$

Theoretical quantity of moist combustion product.
$V_m = 4.10\ Nm^3/Nm^3$ d.g.
Theoretical quantity of combustion products for the above consumption: 1237.3 Nm^3/h
The maximum attainable CO_2 content in combustion products: CO_2 max. = 14.88 %
Actual CO_2 content measured in the chimney exhaust: 1.8%

For the high air excess n_k is calculated by the formula:

$$n_k = 1 + \frac{CO_2\ \text{max.}}{CO_2} - 1 \cdot \frac{\text{theoretical quantity of dry combustion products}}{\text{theoretical quantity of air}} =$$

$$= 1 + \frac{14.88}{1.8} - 1 \cdot \frac{3.20}{3.42} = 7.80$$

5.8 Quantity of combustion products

Dry combustion products:

$$\bar{V}_d = \bar{V}_{at} (n_k - 1) + V_{dt} = 3.42 \cdot (7.8 - 1) + 3.20 =$$
$$= 26.46\ Nm^3/Nm^3 \text{ of dry gas}$$

$\bar{V}_{at}$ .... theoretical air quantity Nm^3/Nm^3 of gas

$\bar{V}_{dt}$ .... theoretical quantity of dry combustion products Nm^3/Nm^3 of gas

Moist combustion products:

$$V_m = V_d + \text{water} = 26.46 + 0.90 = 27.36\ Nm^3/Nm^3 \text{ of dry gas}$$

The outgoing quantity of moist combustion products

$$V_m^o = V_m \cdot V_{dg} \cdot \frac{1}{3600} = 2.30\ Nm^3/s$$

5.9 Air quantity exhausted from the kiln cooling zone

Temperature: $t = 44.5^{\circ}C$
Diameter of piping: 700 mm
Specific mass: 1.13 kg/m^3

P_d/Pa/	3.15	4.7	6.3	6.3	6.3	6.3	6.3	7.9	7.9	7.9	6.3	6.3
v /m/s/	0.8	1.0	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.1	1.1

4.7	4.7	4.7
1.0	1.0	1.0

+ The direct kiln cooling and auxiliary exhausts on the boundary between the cooling and heating zone were closed during this measuring.

v_a = 1.056 m/s graphically integrated

Quantity: $V_a = v_a \cdot \frac{\pi \cdot d^2}{4} = 0.406\ m^3/s$

$$V_a^o = V_a \cdot \frac{273}{273 + t} \cdot \frac{p_a + p_s}{p_n} = 0.350\ Nm^3/s$$

p_a - atmospheric pressure

p_s - static pressure

p_n - normal atmospheric pressure

6. HEAT BALANCE OF THE KILN - SPECIFIC CONSUMPTION

Heat input by gas combustion

$$Q_g = V_{dg} \cdot H_{dg} = 302 \cdot 14445 \cdot \frac{1}{3600} = 1212\ kW$$

H_{dg} ... calorific value of town gas (kJ/Nm^3)

Heat losses by heat contained in combustion products

$$Q_{cp} = V_m^o \cdot c_{cp} \cdot (t_m - 20) = 2.3 - 1.34 - (130 - 20) =$$
$$= 339\ kW$$

c_{cp} ... specific heat of combustion products ($kJ/Nm^3\ ^oC$)

By heated air from the cooling zone

$$Q_{wa} = V_a^o \cdot c_a \cdot (t_a - 20) = 0.35 - 1.30 \cdot (44.5 - 20) - 11 \text{ kW}$$

c_a ... specific heat of air (kJ/Nm^3 ^{o}C)

t_a ... temperature of air (^{o}C)

By outgoing materials

By ware: $Q_w = m_w \cdot c_w \cdot (t_w - 20) = 0.14 - 1.13 \cdot 120.5 =$

$= 19$ kW

By auxiliary materials:

a) Kiln furniture:

$$Q_f = m_f \cdot c_f \cdot (t_f - 20) = 0.394 \cdot 1.13 \cdot 120.5 = 54 \text{ kW}$$

b) Lining of the kiln car:

$$Q_e = m_e \cdot c_e \cdot (t_e - 20) = 0.305 \cdot 1.13 \cdot 89 = 31 \text{ kW}$$

c) Metal bogie:

$$Q_{Fe} = m_{Fe} \cdot c_{Fe} \cdot (t_{Fe} - 20) = 0.093 \cdot 0.55 \cdot 57.5 = 3 \text{ kW}$$

m_w, m_f, m_e, m_{Fe} ... masses of ware and auxiliary materials (kg/s)

c_w, c_f, m_e, m_{Fe} ... specific heats (kJ/kg ^{o}C)

t_w, t_f, t_e, t_{Fe} ... temperatures of ware and auxiliary materials (^{o}C)

Total: $Q_t = Q_w + Q_f + Q_e + Q_{Fe} = 107$ kW

Table No. 4 Heat balance of the kiln

Item		Heat quantity /kW/	Heat quantity /%/
Heat input	By gas combustion	1212	100
Heat losses	By flue loss	339	27.97
	By heated air from the cooling zone	11	0.91
	By heat accumulated in ware, kiln furniture and kiln car bogie	107	8.83
	Losses through kiln lining, kiln foundations, inspection tunnel, distribution and leakage; losses on physical and chemical transformation of products	755	62.29

6.1 Specific consumption

Table No. 5 — Ascertained values of specific consumption

Kiln	19. 3.	20. 3.	21. 3.	22. 3.	Ø
Output (m^2/h)	42.75	40.75	44.75	41.25	42.38
(kg/h)	509	486	535	492	505
Gas consumption (m^3/h)	288	303	315	303	302
Specific consumption related to final product (kJ/kg)	8156	8987	8487	8877	8626
(kcal/kg)	1952	2151	2031	2125	2064
Specific consumption related to final product + auxiliary materials (kJ/kg)	2154	2294	2325	2286	2264
(kcal/kg)	516	549	556	547	542

7. EVALUATION OF TESTING RESULTS

7.1 Course and quality of firing

The measuring results of firing curves (see Annex No. 2) show that considrably rapid heating is realized in the preheating section. The extreme velocity is in the upper parts of the setting; the average increase of temperature is 241°C/hour. The actual velocity is probably higher, considering that the first section is not heated with regard to the setting of control elements and the cold air being blown in the air lock of the entrance, the material is not preheated in this section. The high heating rate causes here the breaking of plates in the kiln. The difference between the temperatures of the lower and the upper part of the setting is also considerable. This difference amounts to 280°C in the 3rd section. This temperature difference is lowered in the 7th section by the first ignited burner. In the area of semimuffles the temperature of the lower part of setting is permanently lower than under the arch of the kiln. Equalizing and on the contrary an increase of temperatures in the lower part of the setting takes place in the area of radial burners.
From the results of firing curves measurement and the scattered results of water absorption tests of ware in the profile of the kiln that are shown in the table No. 6 the following evaluation of the quality of firing can be accomplished.

Table No. 6 Absorption capacity of products sampled in the profile of the kiln /view in the direction of the advance of kiln cars/ %

4.06	4.48	3.68
4.90	6.39	4.60
5.88	7.50	5.62

The lower parts and the centre of the setting show the worst firing results.
Auxiliary burners which are to equalize the temperatures of the lower parts of setting have not evidently a sufficient output. According to the measured firing curves the radial burners act for a short time and the setting is not sufficiently heated. In this way apparent discrepancy between the absorption capacity and the course of firing curves can be explained. The centre of the setting in the lower part should be equalized only by auxiliary burners which again have insufficient output and outlet velocity of combustion gases. The assessment of burners requires a deeper analysis. At present, however, the parameters of burners are not available. Nevertheless, it can be concluded that in principle the possibilities of improving the uniformity of firing rests in increasing the thermal input and the outlet velocity of combustion gases in the kiln car grate if need be.
In the cooling zone irregularities appear caused evidently by unsuitable setting of control elements of the cooling zone. Unjustified is the slow cooling immediately after the firing zone. Outlet temperature of the car is relatively high. In principle these temperatures can be lowered by setting the kiln control properly.

Pressure conditions

The kiln runs in a considerable overpressure starting from the 8th section /1st sight hole/. The pressure in the lower part of the kiln in the firing zone amounts almost to 20 Pa. In the upper part of the kiln is the overpressure even higher. In the direction to the cooling zone the pressure still increases due to the pressure produced by the exit air lock. These overpressures are very high. The overpressure in the zone of maximum temperatures should not exceed 10 Pa in the low part of the kiln.

Contemporary higher pressure causes the penetration of the kiln atmosphere to the inspection tunnel, through the gaps between cars and sand seals. It brings about considerable overheating of bogies and reduction of the life time of cars and bearings of wheels.

Combustion conditions of the kiln

The comparison of the theoretical air requirement and the actual air amount supplied by fans to the burners shows a considerable excess of air, n = 5.7. This excess corresponds partly also to the measurement of kiln atmosphere as shown in the table No. 2. It deteriorates the combustion economy but it can be partly justified from the technological point of view as it might ensure the ware from being locally overfired with regard to a comparatively high temperature of the flame.
The comparison with the operation of a kiln of similar design applied for a more sensitive bisque firing of carbon silicate wall tiles justifies the conclusion that the excess of air for burners should be decreased.
The air excess in the chimney exhaust (n = 7.8) is even more unfavourable. This increased surplus, however, is caused also by additional air applied for the kiln entrance air lock as well as by the air driven into the kiln through the preheating not ignited burners.

Heat balance of the kiln

In the heat balance all items could not be specified. The determination of the heat losses through the furnace brickwork is very problematic in this kiln due to non-typical design of walls, especially in the cooling zone.
The determination of the heat loss to the foundations and to the inspection tunnel is also problematic. These losses are comprehended in the item of undetermined losses' (62.3%). From the other losses the flue loss (27.97%)

is comparable with other kilns but the possibility of its reducing cannot be eliminated.

The increased loss by accumulated heat in the ware and firing furniture leaving the kiln is caused by considerably high temperature of this material. The loss by accumulated heat can be reduced by the proper setting of control elements for the cooling zone.

A slender loss is also included among losses, namely the loss by the air from the cooling zone (0.91%). This air is permanently discharged out of the kiln to the atmosphere above the roof of the factory building. The amount of this air and the ensuing heat loss is reduced to an extremely low value due to the closed direct exhaust and the limitation of indirect cooling.

The cooling is performed mostly by the air from the kiln exit air lock. This air is heated in the cooling zone and blasted into the firing zone. This method of operation considerably improves the economy of operation but high pressure of kiln atmosphere increases the temperature in the inspection tunnel. This fact is documented by the specific consumption.

Specific consumption

The specific consumption related to all heated materials above the platform of the car amounts to 2264 kJ/kg (542 kcal/kg). This value is unusually low. The actual specific consumption for the firing of products is considerably higher (8626 kJ/kg) due to great proportion by weight of firing furniture.

8. PROPOSALS OF ARRANGEMENTS

a/ The reduction of support plates breaking

To reduce the plates breaking it is necessary to lower the heating rate in the upper parts of the setting in the first four sections of the kiln. This operating order can be implemented by the following measures:

8.1. The exhaustion of combustion products needs to be concentrated into the exhausts of the first two sections of the kiln. Some exhausts immediately behind the kiln entrance are nowadays closed and consequently the ware in this part of the kiln is unsufficiently heated.

8.2. To improve heating immediately behind the kiln entrance the present kiln entrance overpressure air lock requires to be converted in the under pressure air lock by reversing the air discharge and the sucking of the fan. This provision will reduce the present cooling effect of the entrance air lock and simultaneously the combustion products will be drawn into the entrance part of the kiln. The closing effect of the entrance air lock will not be affected. The air dischadge of the fan can be attached to the chimney of the kiln.

8.3. The present state would be improved by setting up a preheating tunnel above the supply track of loaded cars. If the preheating of the kiln cars to at least 50°C is reached, the heat shock could be eliminated to which nowadays the support plates are subjected. The preheating tunnel may be heated by the lost heat from the cooling zone which would be utilized.

In this case however, the temperature of the cooling zone must be adjusted so as to attain 80 - 100°C.

b/ Reduction of temperatures in the inspection tunnel, improving the service life of kiln cars.

8.4. The existing permanent overpressure in the kiln atmosphere is not acceptable. The overpressure should be lowered by the adjustment of cooling /opening direct exhausts by reducing the power of the kiln exit air lock/. Only in extreme case the kiln draught should be adjusted.

c/ Improvement of firing uniformity

8.5. To improve the firing uniformity it is necessary to increase the quantity and possibly the velocity of combustion products delivered to the lower part of the kiln cross section. Simultaneously only the inlet holes in the lower part of semimuffles should be kept opened. In this way the outlet velocity of combustion products will be increased and a greater amount of combustion products will reach the central part of the car and central gap in the setting.

Auxiliary burners should be checked with regard to their output power. If possible, all these burners should operate. It should be also ascertained whether these burners do not operate with a too high air excess which might cool the setting.

d/ Adjustment of cooling

It is recommended to increase the intensity of cooling by use of direct exhausts so that the reduction of exit temperature and simultaneously the reduction of overpressure in the cooling zone may be reached. The indirect cooling in the first third of the cooling zone should be fully opened by setting accordingly the control elements of the cooling zone. In the direction of the exit direct cooling would be preferable.

9. EXPECTED CONTRIBUTIONS

Specific consumption related to heated material is very low and no further reduction can be expected. The increase of specific consumption because of technological reasons is not out of the question.

The contributions in this case will be mostly in the reduction of operation costs. Especially the item of support plates reproduction should be considerably reduced. Improved firing conditions should be reflected in higher quality and salability of products.

10. CONCLUSION

The accomplished testing and general evaluation reveal that the short preheating zone is an imperfection in the design of the kiln. This failure brings about operation complications with intense heating and breaking of plates as well as unequal firing in the cross-section of the kiln.

The report contains proposals which can to a certain extent solve the existing problems, improve the quality and reduce the costs on auxiliary materials.

TABLE OF ABBREVIATIONS

c_a	-	specific heat of air
c_{cp}	-	specific heat of combustion products
c_f	-	specific heat of kiln furniture
c_l	-	specific heat of kiln car lining
c_{Fe}	-	specific heat of kiln car bogie
c_w	-	specific heat of ware
d	-	diameter
Hdg	-	calorific value of dry gas
m_f	-	mass of kiln furniture
m_{Fe}	-	mass of kiln car bogie
m_l	-	mass of kiln car lining
m_w	-	mass of ware
n_k	-	excess air coefficient
p_a	-	atmospheric pressure
p_n	-	normal atmospheric pressure
p_s	-	static pressure
Q_{ep}	-	flue loss
Qg	-	heat input by burning gas
Q_f	-	power losses by heat accumulated in the kiln furniture
Q_{Fe}	-	power losses by heat accumulated in the kiln car bogie
Q_e	-	power losses by heat accumulated in the kiln car lining
Q_w	-	power losses by heat accumulated in the ware
Q_{wa}	-	power losses by the air from the cooling zone

Q_t - total power losses by accumulated heat

S - surface

t - temperature

t_a - temperature of air

t_f - temperature of kiln furniture

t_{Fe} - temperature of kiln car bogie

t_l - temperature of kiln car lining

t_w - temperature the ware

v_a - average velocity

V_a - air volume

V_a^o - air volume recalculated to standard conditions

$\bar{V}_{at}$ - theoretical air volume

V_a^o total - total recalculated air volume

V_d - volume of dry combustion products

V_{dg} - folume of dry gas

V_{dt} - theoretical volume of dry combustion products

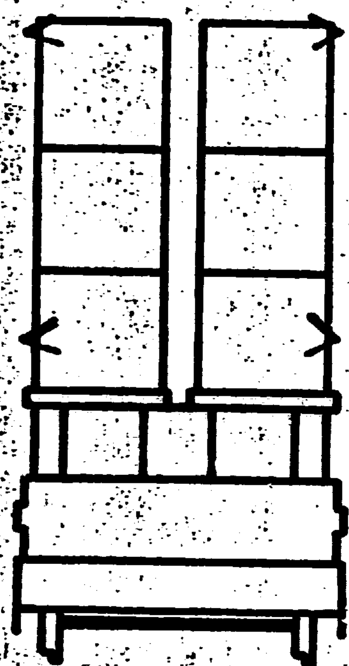
V_m - volume of moist combustion products

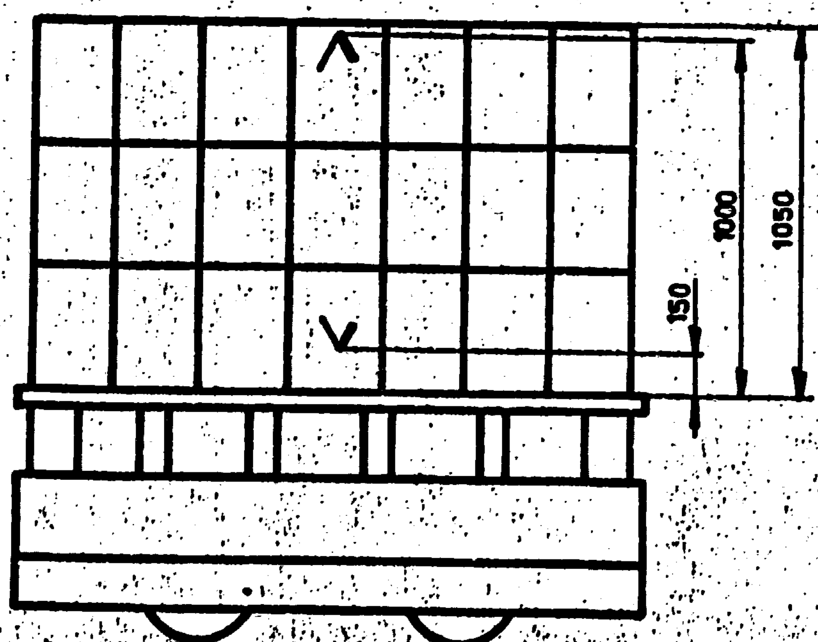
V_{mt} - theoretical volume of moist combustion products

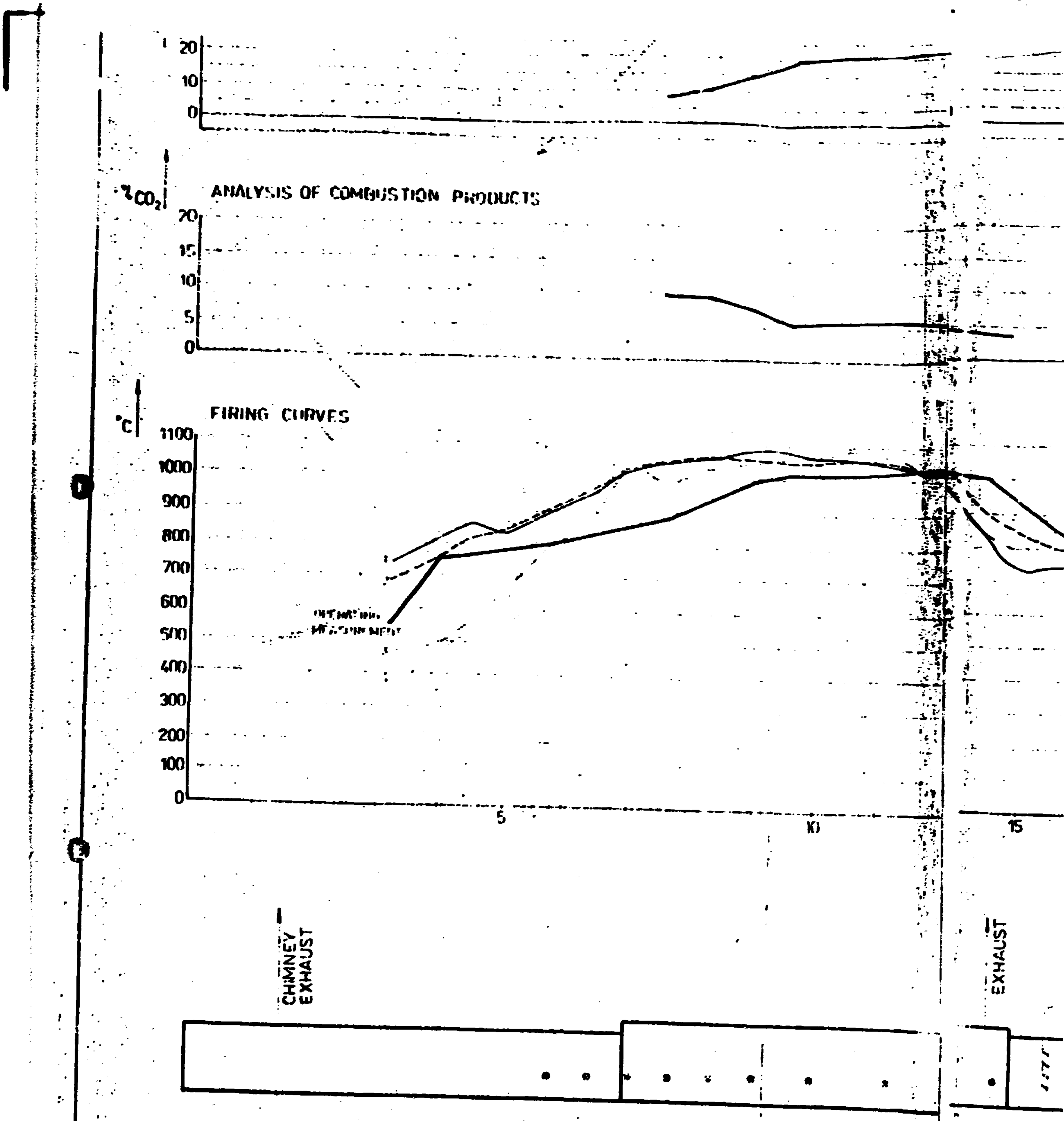
List of tables

ANNEX No. 3

SCHEME OF THE MEASURING CAR

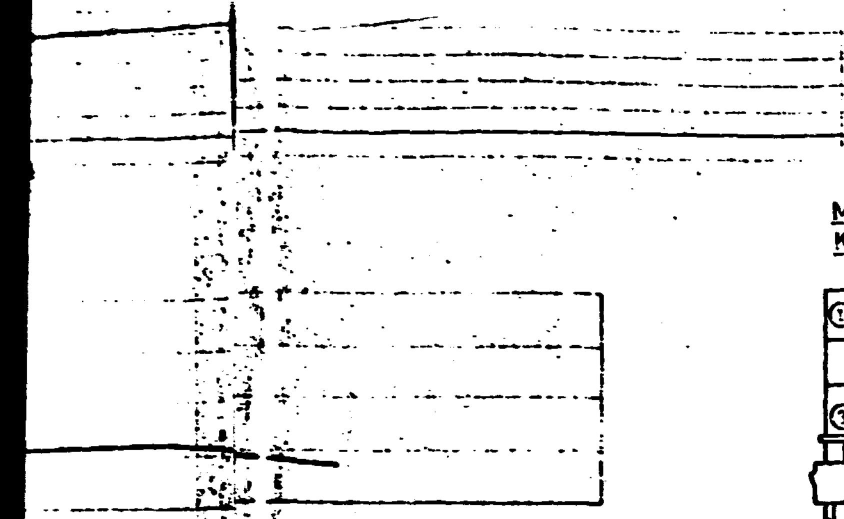




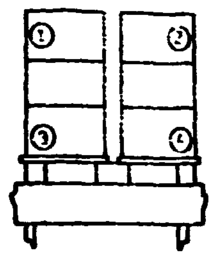


ANALYSIS OF COMBUSTION PRODUCTS
% CO2
FIRING CURVES
°C
1100
1000
900
800
700
600
500
400
300
200
100
0
5
10
15
CHIMNEY EXHAUST
EXHAUST

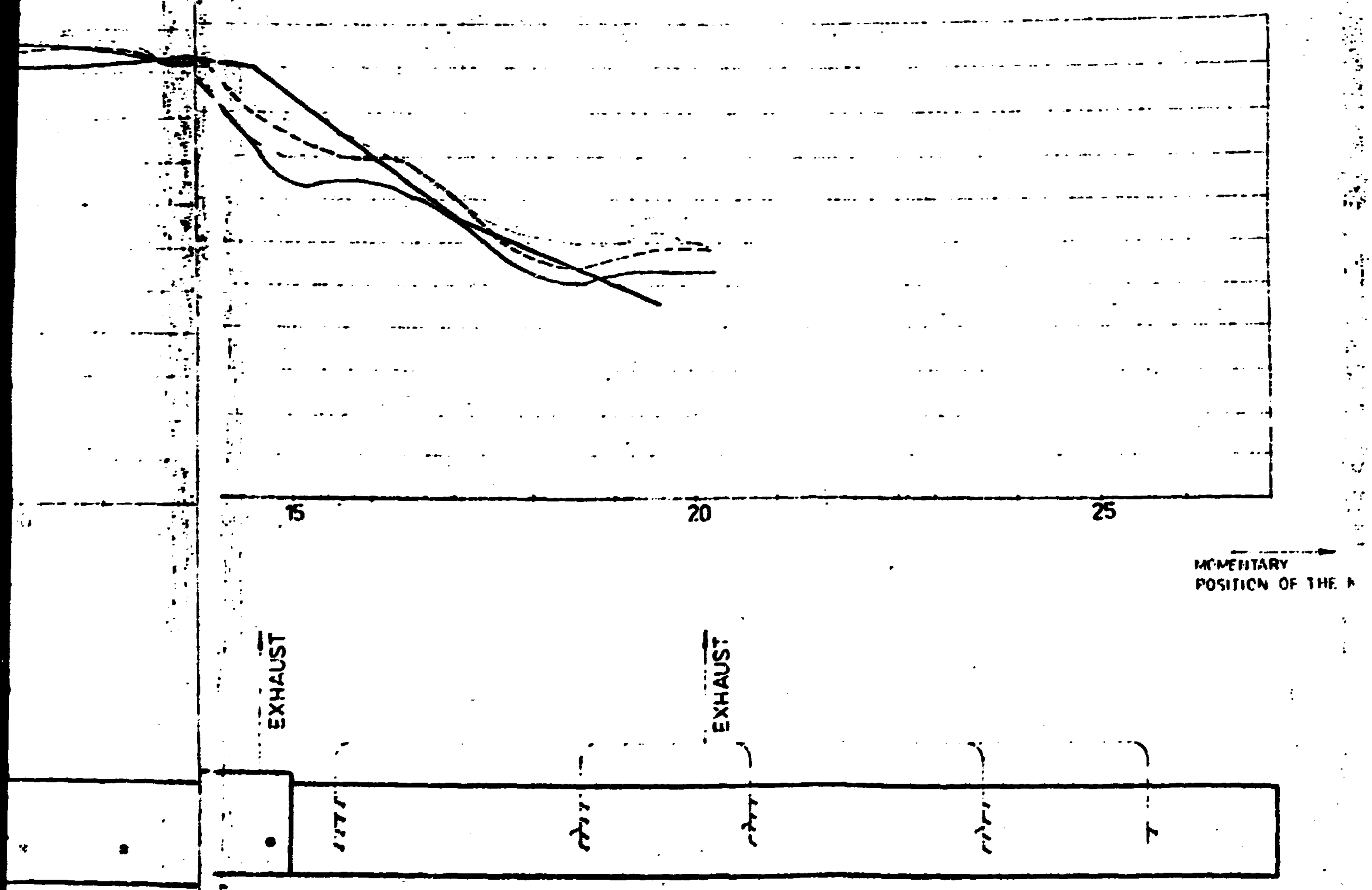
SECTION 1



MEASURING KILN CAR



DATE	22.3.1979
KILN	TUNNEL KILN
FVEL	TOWN GAS
WARE	MOSAIC
KILN CAR ADVANCE	47 min
CONSUMPTION	302 Nm³/h
INPUT	1212 KW
OUTPUT	506 Kg/h
SPECIFIC CONSUMPTION	8626 KJ/Kg



measured by	
date	
draught by	

SECTION 2

TECHNICAL REPORT

ON THE INVESTIGATION OF [illegible]

CARRIED OUT ON [illegible] D[illegible]

W[illegible]

/based on research activities of the Research Institute for Ceramics, Refractories and Raw Materials at Horní Bříza – Czechoslovakia/

September 197[illegible]

C O N T E N T S

1. Introduction

The measurements of the kaolin conveyor driers [redacted] were accomplished by the measuring team of the Institute for Ceramics, Refractories and Raw Materials. This team is permanently engaged with research and investigation of thermal processes in the field of ceramics, building materials, non-metallic-based products and power engineering. The objectives of the measurement was to asses the quality and economy of drying processes and to determine the specific heat consumption.

2. Technical parameters of the equipment

Type of drier: conveyor drier with forced circulation, [redacted]

Drying medium: air

Heating the air: Oil-fired heat exchanger

Output of drier: 5.13 t/h /[illegible] % output humidity/

Guaranteed output: 4.61 t/h of dry substance

Inlet humidity: [illegible] %

Outlet humidity: [illegible] %

Guaranteed specific consumption: max. [illegible] kJ/kg /[illegible] kcal/kg/ of evaporated water

Parameters of heat /[redacted]/ exchanger

Fuel: Oil - [illegible] kJ/kg

Heat input: [illegible] kW

Heat power output: [illegible] kW

Quantity of heated air: 5.83 Nm^3/s

Air outlet temperature max. [illegible] °C, permanently [illegible] °C

3. Measuring method - applied instruments

Consumption:

The installed operation meter was applied for determination of consumption. The indications were compared with records of purchased fuel in the first half of the year 1978.

Power output of driers:

The weighing of the processed material is not included in the technological line. Therefore the calculation was based on the number of filterpressed cakes. An average mass of dried cake = 67.49 kg was taken into account. /This average is related to the first half of the year 1978/.

For further measurements the instruments of the Institute were applied. Humidities of taken samples were determined in the plant laboratory. The measurements of fuel consumption were carried out jointly for both the driers. The output of particular driers could not be reliably determined. Therefore the whole measuring and evaluation was effected for both the driers as a whole.

4. Measuring conditions

Measuring in driers was carried out twice. In the first measuring the operation was disturbed by reduced sedimentation in sedimentation tanks. For this reason the output of filter presses was reduced and the inlet humidity of material for driers increased. In the course of measuring the belts of driers were often stopped. During the second measuring the output was very good and the operation perfectly stabilized.

The throttling valves in the inlets of drying air were set as follows:

Section	Setting of the valve /scale lines/ Drier 1	Drier 2
1	4	[illegible]
[illegible]	3	3
6	3	[illegible]
7	[illegible].5	[illegible]
8	2	3

Section	Drier 1	Drier 2
11	3,5	4
12	4	4
14	4	4
16	4	4
18	3,5	3
20	3	3
22	4	4
24	3	3
26	0	4

First of all temperature and humidity were measured by a probe in the surface of kaolin layer on the belt. The results of measuring are indicated in the tables 1 and 2 as well as indications of temperature. The graphical demonstration is in annexes No. 1 and 2.

Applied fuel: Light fuel oil of the following parameters:

Heat value	4[illegible] kJ/kg
Density /20 °C/	0,[illegible] kg/m³
The critical air consumption	11 Nm³/kg
Quantity of dry combustion products	10,[illegible] Nm³/kg
Quantity of moist combustion products	11,65 Nm³/kg
CO_2 max.	15,6 [illegible]

Table No. 1 | Order No. 1

Temperatures and relative moisture contents

Section	Operation measuring /°C/	Measured temperature /°C/	Relative Moisture content /%/
0			
2	-	18	5.6
4	62	68	35.5
7	-	-	-
8	85	74	[illegible]
10	-	-	[illegible]
12	-	66.5	[illegible]
14	114	-	17.5
16	-	[illegible]	16.-
18	-	-	16.4
20	[illegible]	81	27.-
22	-	-	[illegible]
24	-	[illegible]	[illegible]
26	[illegible]	-	[illegible]
28	-	80	[illegible]
30	-	-	

Table No. 2 Brief No. [illegible]

Temperatures and relative moisture contents

Section	Operation measuring /°C/	Measured temperature /°C/	Relative Moisture Content /%/
0	-	-	-
2	[illegible]	-	[illegible]
4	-	76	[illegible]
6	103	-	[illegible]
8	-	[illegible]	[illegible],6
10	[illegible]	-	17,5
12	-	[illegible]	[illegible]
14	-	-	17,3
16	110	[illegible]	[illegible]
18	-	-	17,[illegible]
20	-	[illegible]	1[illegible],6
22	110	-	17,1
24	-	[illegible]1	[illegible]
26	72	-	[illegible]
28	-	46	[illegible]
30	[illegible]	-	-

5. Review of measured and calculated values

The survey of measured indications is given in tables 3 and 4. Additional tables referring to measurements by Prandtl's tube inclusive of calculated values are given in tables No. 5-8. The review of calculated basic parameters of driers is presented in the table No. 9.

Table No. 3

Survey of measured values - 1st testing

Time /h/	Output /moist material inlet/ /t/	Consumption of oil /kg/	Moisture /%/		Temperature of material /°C/		Composition of combustion products				Temperature of /°C/ combustion products	
			average-entry	average-exit	average-entry	average-exit	Drier No.1		Drier No.2		Drier No.1	Drier No.2
							CO_2	O_2	CO_2	O_2		
8.00			30,7	16,4			10,5	6,5				
9.00			30,1	14,3			10,5	6,4			[illegible]	[illegible]
10.00					17,5	[illegible]			5,1	7,[illegible]		
11.00			31,4	10,6					5,1	[illegible]	[illegible]	[illegible]
12.00					17,6	[illegible]	10,4	[illegible]				
13.00			[illegible]	13,5			10,4	6,6			[illegible]	[illegible]
14.00					17,5	17,5			[illegible]	7,[illegible]		
15.00			31,5	15,9			[illegible]		[illegible]	7,7		
16.00					17,0	[illegible],5			5,1	7,[illegible]	[illegible]	[illegible]
17.00	133,56	5245,9	31,2	6,4			10,2	6,4				
Average	14,80t/h	360,0kg/h	31,2	14,1	17,0	20,0	10,4	6,5	5,1	7,8	201,4	[illegible]

Table No. 3

Survey of measured values - 1st testing - continuation

- parameters of exhausted air from driers and primary air for burners

Time	Measured value													
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]														
[illegible]	7?	77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
1?^00													[illegible]	[illegible]
11^00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
1?^00														
1?^00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]
1?^00														
1?^00														
16^00	63	63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
17^00													[illegible]	[illegible]
Average	71,3	70	[illegible]	57,3	[illegible]	[illegible]	[illegible]	[illegible]	3,74	3,61	[illegible]	[illegible]	[illegible]	[illegible]

x exhausts near by exit are marked 1

Table No. 4

Survey of measured values – [illegible]nd testing

Measured value

Time /h/	Output /material inlet/ /t/	Consumption of oil /kg/	Moisture /%/				Temperature of material /°C/				Composition of comb. products /%/				Temperature of comb. products	
			entry	exit	entry	exit	entry	exit	entry	exit	[illegible]	[illegible]	[illegible]	[illegible]	D 1	D 2
7^{00}			30,4	16,0	33,4	11,0					11,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8^{00}							18,3	[illegible]	19,5	[illegible]						
9^{00}			30,3	14,0	30,5	15,7										
10^{00}											11,[illegible]	[illegible]	[illegible]	7,[illegible]		
11^{00}			30,1	13,1	30,0	14,4										
[illegible]							18,6	[illegible]	18,5	31,0						
[illegible]			30,7	[illegible]	30,5	11,3					10,[illegible]	5,5	[illegible]	7,[illegible]	[illegible]	285
[illegible]																
[illegible]			30,6	[illegible]	30,0	15,2										
[illegible]							18,0	[illegible]	18,0	30,0						
7^{00}	183,473	3015,4	30,5	16,0	30,4	17,6					10,0	5,6	9,5	7,0	[illegible]	265
verage	18,840 t/h	381,5 kg/h	30,9	14,3	30,6	13,6	18,3	23,0	18,7	30,2	11,0	5,3	9,2	7,3	[illegible],5	284,3

Table No. 4

Survey of measured values - 2nd testing - continuation

Time /h/	Measured value: Temperature of exhausted air /°C/ – exhaust No.1x	exhaust No.2	exhaust No.1	exhaust No.2	Pressure of exhausted air /Pa/ – exhaust No.1	exhaust No.2	exhaust No.1	exhaust No.2	Quantity of air /Nm3/ – exhaust No.1	exhaust No.2	exhaust No.1	exhaust No.2	Primary air flow rate /m/s/ – 1	2
7^{00}													[illegible]	0,[illegible]
8^{00}	53	63	61	58	814,0	7[illegible]0,5	472,0	50[illegible],1	4,16	3,[illegible]	3,16	3,37		
9^{00}														
10^{00}	60	64	59,5	58	804,2	778,0	401,3	510,3						
11^{00}														
12^{00}													0,12	[illegible]
13^{00}	57	62,5	60	58	821,3	705,3	466,0	422,3						
14^{00}														
15^{00}	53	63,5	58,5	57	805,0	778,0	468,9	498,2	4,12	4,18	2,98	3,32		
16^{00}														
17^{00}														
Average	58,5	63,2	59,8	58	812,1	705,0	473,0	498,2	4,14	4,0	3,07	3,24	0,02	0,[illegible]

x exhausts near-by cat are marked 1

Table No. 5 Order No. 1, quantity of exhausted air - 1st exhaust

												va /m/s/	Q /m³/s/	Q /m³/s/
1st testing	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	v	16,3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17,1	[illegible]	[illegible]	3,[illegible]
	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	v	[illegible],3	[illegible],1	[illegible]	[illegible]	[illegible],1	[illegible],1	[illegible]	[illegible]	[illegible]	[illegible],7	[illegible]	3,84	[illegible]
nd testing	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	v	[illegible],3	[illegible],3	[illegible],3	[illegible],1	[illegible],7	[illegible]	[illegible]	[illegible],7	[illegible],6	[illegible]	[illegible]	[illegible]	4,1[illegible]
	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	v	[illegible]	[illegible],3	[illegible]	[illegible],1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible],3	[illegible]	[illegible]	[illegible]	[illegible]

va - evaluated by graphical integration from calculated values of velocity
Particular values of velocity are calculated by the formula $v = \sqrt{\frac{2pd}{\rho}}$
pd - dynamic pressure /Pa/
ρ - specific density of air /kg/m³/
Diameter of pipes: [illegible] mm

Table No. 6 Order No. 1 - quantity of exhausted air - nd exhaust

												va /m/s/	Q /m³/s/	Q /m³/s/
1st testing	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	v	17,7	[illegible]	[illegible]	[illegible],3	[illegible]	[illegible]	[illegible]	[illegible],4	[illegible],1	[illegible],4	[illegible]	[illegible],07	3,47
	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]7	[illegible]7	[illegible]71	[illegible]	[illegible]	[illegible]			
	v	[illegible]	[illegible]	[illegible],1	[illegible]	[illegible]	[illegible],3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible],7	[illegible],77	[illegible],74
nd testing	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	v	[illegible],3	[illegible]	[illegible]	[illegible],1	[illegible],1	[illegible]	[illegible]	[illegible],3	[illegible],5	[illegible],1	[illegible]	[illegible]	3,[illegible]
	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	v	[illegible],7	[illegible],4	[illegible]	[illegible],4	[illegible]	[illegible]	[illegible],3	[illegible]	[illegible]	[illegible]	[illegible],7	[illegible]	[illegible]

Table No. 7 — Drier No. 2 - quantity of exhausted air - 1st exhaust

												[illegible]	[illegible]	[illegible]
1st testing	pd	[illegible]	144	[illegible]	[illegible]	157	[illegible]	[illegible]	[illegible]	164	[illegible]			
	v	[illegible]	17,3	17,4	17,7	[illegible]	17,7	17,2	[illegible]	[illegible]	[illegible]	[illegible]	3,17	[illegible]
	pd	[illegible]	[illegible]	[illegible]	[illegible]	157	[illegible]	157	[illegible]	[illegible]	147			
	v	[illegible]	17,3	17,4	17,7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17,4	[illegible]	[illegible]
2nd testing	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	157	[illegible]	[illegible]	117			
	v	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17,6	17,1	[illegible]	17,2	[illegible]	[illegible]
	pd	[illegible]	[illegible]	131	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7[illegible]			
	v	[illegible]	17,3	17,4	17,7	17,6	17,3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3,7[illegible]	[illegible]

Table No. 8 — Drier No. 2 - quantity of exhausted air - 2nd exhaust

1st testing	pd	155	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	v	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17,7	17,1	16,7	[illegible]	[illegible]	[illegible]	[illegible]	3,11
	pd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	145	157	[illegible]	151			
	v	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17,5	17,1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2nd testing	pd	[illegible]	157	157	[illegible]	176	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
	v	17,3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17,3	[illegible]	[illegible]	3,27
	pd	133	[illegible]	155	140	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	163			
	v	[illegible]	[illegible]	17,6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table No. 9

Survey of calculated essential parameters of driers for both the driers

	1st testing		2nd testing	
	D_1	D_2	D_1	D_2
Output – inlet material /t/h/		14,68		20,[illegible]
in dry matter /t/h/		10,24		13,[illegible]
Evaporated water /t/h/		2,56		3,7[illegible]
Residual water /t/h/		1,88		2,1[illegible]
Consumption of oil /kg/h/		300		[illegible]2,5
Quantity of air for burners /Nm^3/s/	0,237	0,[illegible]	0,[illegible]	0,[illegible]
Excess air coefficient	1,5	1,71	1,[illegible]	1,70
Quantity of combustion products /Nm^3/s/	0,[illegible]	1,[illegible]	0,[illegible]	1,[illegible]
Quantity of medium in exhausts /Nm^3/s/	1	13,[illegible]		14,[illegible]
Quantity of dry air in exhaust /Nm^3/s/		1[illegible],46		13,26
Relative moisture content in exhaust /%/		[illegible]5		49

Demonstration of calculation method /1st testing/

Mass of the dry matter:

$$Mdm = Mml \cdot \left(1 - \frac{w_1}{100}\right) = 14.08 \cdot (1 - 0.312) = \underline{[illegible]\ t/h}$$

Mml - mass of entering material

w_1 - entry moisture content

Mass of evaporated water:

$$Mwe = Mml \cdot \frac{w_1 - w_2}{100 - w_2} = 14.08 \cdot \frac{31.2 - 14.1}{100 - 14.1} = \underline{[illegible]\ t/h.}$$

Mw = mass of water at the entry into the drier

w_2 = exit moisture content

Mass of residual water

$$Mwr = Mml - Mdm - Mwe = 14.08 - 10.[illegible] - [illegible] = \underline{[illegible]\ t/h}$$

Volume of the dry air in the exhaust

$$Vda = Vma - Vv = 13.40 - \frac{[illegible]}{[illegible]} \cdot \frac{[illegible].4}{[illegible]} = \underline{[illegible]\ Nm^3/s}$$

Vma - volume of moist air

Vv - volume of water vapor

Air for the burner /exchanger No.1/

$$V_a^o = k.S.\bar{v}_a.\frac{273}{273+t}.\frac{pb}{pn} = 0.95.0.100.9.0.\frac{273.[illegible]}{[illegible]} = 0.[illegible]7 \; Nm^3/s$$

Surface of sucking opening: $S = 0.245.0.44 = 0.100 \; m^2$

$\bar{v}_a$ - average velocity of air flow

t - temperature of air

pb - barometric pressure

pn - normal barometric pressure

k - correction coefficient for switching off the thermoregulation

Excess air coefficient:

Chimney exhaust of the 1st exchanger

$$n = \frac{\% \; CO_2 \; max}{\% \; CO_2} = \frac{15.6}{10.4} = 1.5$$

Volume of combustion products

Separation of oil consumption for individual driers must be done for the purpose of the determination of combustion products volume of particular exchangers.
The following method of separation was applied with regard to suspition of leakage of the exchanger No. 2.

Consumption of the 1st exchanger

$$Mol = \frac{3600.V_a^o}{n.V_a^t} = 10[illegible].4 \; kg/h$$

V_a^o - volume of air for burner /Nm^3/s/

n - excess air coefficient

V_a^o - theoretical need of air for burner /Nm^3/s/

Consumption of the 2nd exchanger

$M_{o2} = M_o - M_{o1} = 368.0 - 182.4 = 185.6$ kg/h.

Volume of the combustion products

$$V_s^o = \frac{M_{o1}}{3600} \cdot \left[V^o_{mt} + V_{at} \cdot (n-1) \right] = \frac{182.4}{3600} \cdot \left[11.65 + 11.(1.5-1) \right] =$$
$$= 0.869 \ Nm^3/s$$

V^o_{mt} - theoretical volume of moist comb. products /Nm^3/kg/

V_{at} - theoretical volume of air /Nm^3/kg/

5. Heat balance

Heat balances of the both testings are presented in table No. 10. Presented values stand for the both driers as one unit.

Table No. 10

Heat balance of driers

	1^{st} testing		2^{nd} testing	
Heat input				
By burning oil	4323 kW	100	4481 kW	100
Useful heat output				
For evaporation of water	2169 kW	50,17	2726 kW	60,83
Lost heat output				
Flue loss	721 kW	16,68	717 kW	16,00
Lost heat output				
By exhausted air from driers	867 kW	20,06	751 kW	16,76
Lost heat output				
By heat accumulated in dry matter	20 kW	0,46	24 kW	0,54
Lost heat output				
By heat accumulated in residual water	16 kW	0,37	18 kW	0,42
Heat radiation losses				
undetermined losses	530 kW	12,26	244 kW	5,45
Specific consumption /kJ/kg evap. water/	5250 kJ/kg (1250 kcal/kg)		4338 kJ/kg (1036 kcal/kg)	

Example of the heat balance calculation

5.1. Heat delivered by firing fuel

Mass of oil: Mo = 368 kg/h

Heat input by firing oil:

$Qo = Ho \cdot Mo \cdot \frac{1}{3600} = 42207 \cdot 368 \cdot \frac{1}{3600} = \underline{4323\ kW}$

Ho - heat capacity of oil

5.2. Heat output power necessary for evaporation of water

Heat necessary for evaporation of 1 kg of water:

$$q_{wa} = 2638\ kJ$$

Heat output necessary for evaporation of water:

$Q_{wa} = M_{wa} \cdot q_{wa} \cdot \frac{1}{3600} = 2960 \cdot 2638 \cdot \frac{1}{3600} = \underline{2169\ kW}$

5.3. Fluo loss /drier No. 1/

$Q_{cp} = c_{cp} \cdot V_{cp} \cdot (t_{cp} - 20) = 1.425 \cdot 6.009 \cdot (281.4 - 20) =$ [illegible] kW

c_{cp} - specific heat of combustion products

V_{cp} - volume of combustion products

t_{cp} - temperature of combustion products

5.4. Heat output lost by exhausted air /drier No1/

Exhaust No. 1:

$Qa_1 = c_a \cdot V_a^o \cdot (ta_1 - 20) = 1.3 \cdot 3.74 \cdot (71.8 - 20) = \underline{252\ kW}$

Exhaust No. 2: $Qa_2 = \underline{235\ kW}$

Total: $Qa = Qa_1 + Qa_2 = \underline{487\ kW}$

c_a - specific heat of air

t_a - temperature of exhausted air

5.5. Heat losses by accumulated heat

By heat accumulated in dry matter:

$$Qd = M_{dm} \cdot C_m \cdot (tox - 20) = 10230 . 0.87 . (28-20) \cdot \frac{1}{3600} =$$

$$= \underline{20\ kW}$$

M_{dm} - mass of dry matter

C_m - specific heat of dry matter

tox - exit temperature of material

By residual water:

$$Q_{wr} = M_{wr} \cdot c_w \cdot (tox-20) = \frac{1[illegible]}{3600} \cdot 4.187 . (28-20) = \underline{16\ kW}$$

c_w - specific heat of water

6. Evaluation of measurements

6.1. Drying conditions

In annexes I and II drying conditions in drying canals are graphically plotted. The parameters of the drying medium are approximately identical in the both canals.
The temperature on the surface of dried kaolin layer attains 90°C. Here a difference of 40°C appears between the operation measurement by permanently installed meters and the actual temperature over the material layer.
The relative air humidity lies between 10–30 % along the whole length of active drying.

6.2. Basic operation parameters of driers

The tables No. 3, 4 and 9 show that the driers were operated with an output which was in the first measuring by 11 % and in the second measuring by 41 % higher than the originally planned output.
During particular measurements the required outlet humidity of 10 % was not achieved. The comparison of outputs and outlet humidities of kaolin is of interest. Here the decisive influence of inlet humidity at the entry into the noodle making machine is evident. With the inlet humidity up to 30.3 % short noodles showing a disturbed surface are produced. These noodles have a considerably larger surface for evaporation and they cover evenly the belt of the drier. The degree of dewatering is in this case considerably higher.

The relative humidity of outlet air from the driers was low - 25 % in the first and 45 % in the second measuring. This fact shows that the parameters of the drying medium /temperature, relative humidity, flow velocity do not constitute unoptimum for the required output. The reason rest predominantly in the design of driers and may be summarised as follows:

a/ Application of perforated sheet for the conveyor belt. The wire-woven belt is more advantageous from the view point of air permeability.

b/ Unavailability of a tool for turning over the kaolin layer in a position of the belt where the kaolin surface became dry.

c/ Low drying temperature.

The overloading of equipment affects evidently also the quality of drying. This fact is confirmed by the average output in the first-half-year.

Production in the first half-year	35 562 t
Operation time	3 452 h
Average output in dry substance	10,30 t/h
Planned /projected/ output in dry substance	9,25 t/h

6.3. <u>Heat balance of driers</u>

The table No. 10 shows that the heat input power was nearly equivalent in the both measurings. This is also due to the fact that the exchangers are operated with full output.
The input power of exchangers is reduced by 15 % in comparison with the projected output. With regard to their higher capacity if compared

to their rated power the actually delivered power to driers is lower by only 7 %. /The increase of output power of the exchanger is limited by the quantity and air temperature at the outlet where the limit parameters are maintained./ In the heat balance the useful heat represents 56,17 and 60,83 %. Here again more favourable operation conditions during the measurement No 2 are reflected.

The chimney exhaust losses of the exchangers represent 16 % of heat input power. The rated loss of producer makes [illegible] %. This favourable state is achieved by the optimum setting of firing conditions. A certain reserve exists in the exchanger No. 2. Its tightness is disturbed and the drying air leaks into the firing space. This is manifested by excess of air in the chimney. The loss makes 6,77 % of the total input power of driers /[illegible] kW/.

A further important item of losses is the heat drawn off by the draught air from the drier. Higher losses are indicated by the measuring No 1 which was caused by repeatedly interrupted operation and consequently by higher temperatures on the exhaust of driers. Unidentified losses represent 6 % of the total and they may be result of admitted inaccuracies of the other measurements.

6.4. Specific consumption

The table No. 10 indicate that different operation conditions of driers influence the specific heat consumption the difference being [illegible] kJ /222 kcal/ per kg of evaporated water.

The obtained data give the survey of the operation of driers:

	Average state for 1st half-year 1978	Measurement No.1 Increased input humidity	Measurement No.2 "Optimum" input humidity
Output in dry substance /T/h/	10,38	10,[illegible]	13,[illegible]
Fuel consumption /kg/h/	369	366	361,5
Fuel consumption per ton of dry substance /kg/	35,5	35,9	[illegible]
Specific heat consumption on water devaporation /kJ/kg/	5264x	5150	4550

x Approximately determined value based on average inlet humidities of the measurements No. 1 and 2. There are no records of humidities for longer periods in the plant.

Conclusions based on the above data:

a/ The fuel consumption and consequently the heat input power fluctuate insignificantly.

b/ The specific heat consumption is in the existing method of operation only the function of dosing and inlet humidity of the dried material.

c/ The average state is nearly equivalent to measuring conditions No. 1.

d/ The equipment does not fulfil the specific heat consumption indicated by the producer in any case. The measurement No. 2 shows the smallest difference from the rated /projected/ value of 4100 kJ/kg /water/. The measured consumption of 45[illegible] kJ/kg /water/, however, was achieved with substantially increased production output. There is no guarantee to achieve this result and preserve the inlet quality of raw material under nominal output.

The possibility of improving the average specific heat value lies in the endeavour to achieve the value found by the measurement No. 2. under supposition of observing the suitable humidity of raw material and regular operation of the whole line.

7. Proposals of arrangements

7.1. The supply of hot air to the drying space should be changed according to the picture No.1. This change consists in bringing the hot air as close as possible to circulation fans. By this measure the temperature of the drying medium will be increased by approximately 10°C.

7.2. The leakage of the exchanger No. 2 should be removed. If the experiment of welding cracks was not successful ceramic cements can be verified.

7.3. Continuous inspection of operation of driers and closing noodle making machines should be introduced so to avoid operation of empty driers. In case of necessary intervals the heat exchangers should be stopped.

7.4. Recorders should be installed to record outlet temperatures of the drying medium. In this way every stopping of the belt and the duration of standstill would be reliably registered. Also the operation of empty driers would be signalled.

7.5. The knob for regulating outlet temperature should be arrested on the value of 80-100°C. The precise value should be determined with regard to para 7.4.

7.6. In the entry of driers the inlet humidity up to 30,5 % should be maintained. The fulfilment of this point is decisive for economic operation of driers. To this requirement the operation of filterprocess should be adjusted.

7.7. The combustion products from the exchangers are driven out with the temperature [illegible] °C. and discharged from the chimney over the roof of the premises. In ducting the combustion gases through exchangers and cooling them by 50 °C a power of cca 100 kW would be obtained equalling 1570000 MJ in a yearly operation for 6000 hours. The application of this heat for drying would save 45 tons of heating oil per year. It would be necessary to propose and manufacture a suitable exchanger.

8. <u>Expected contributions</u>

8.1. The implementation of the adjustment according to para 7.1. would accelerate the drying process and reduce the specific consumption.

8.2. The implementation of measures proposed in para 7.[illegible]. - 7.6. would reduce the specific average consumption down to the value obtained by the measurement No. 2. The actual savings cannot be backed by a calculation in this case. The reduction of specific consumption is assessed to be upto 4 %.

8.3. The implemention of the measures as per para 7.2. and 7.7. would bring about savings of heat power amounting to 2,[illegible].000 MJ/year /equalling 6[illegible] tons of heating oil/.

9. Conclusion

The results of measurements have shown that the heat generating equipment of the plant is run with a higher specific consumption than guaranteed by the producer.

Moreover, the processed material is permanently dried to higher humidity than required. This is due to technical shortcomings of the equipment. On the other hand the output of the equipment is over the rating capacity of the producer which affects unfavourably. the operation parameters.

To improve the existing state, measures were proposed aimed to reducing energy consumption and improving drying process. The most important measure consists in keeping the inlet parameters of dried material within stipulated limits and supplying continuously the driers.

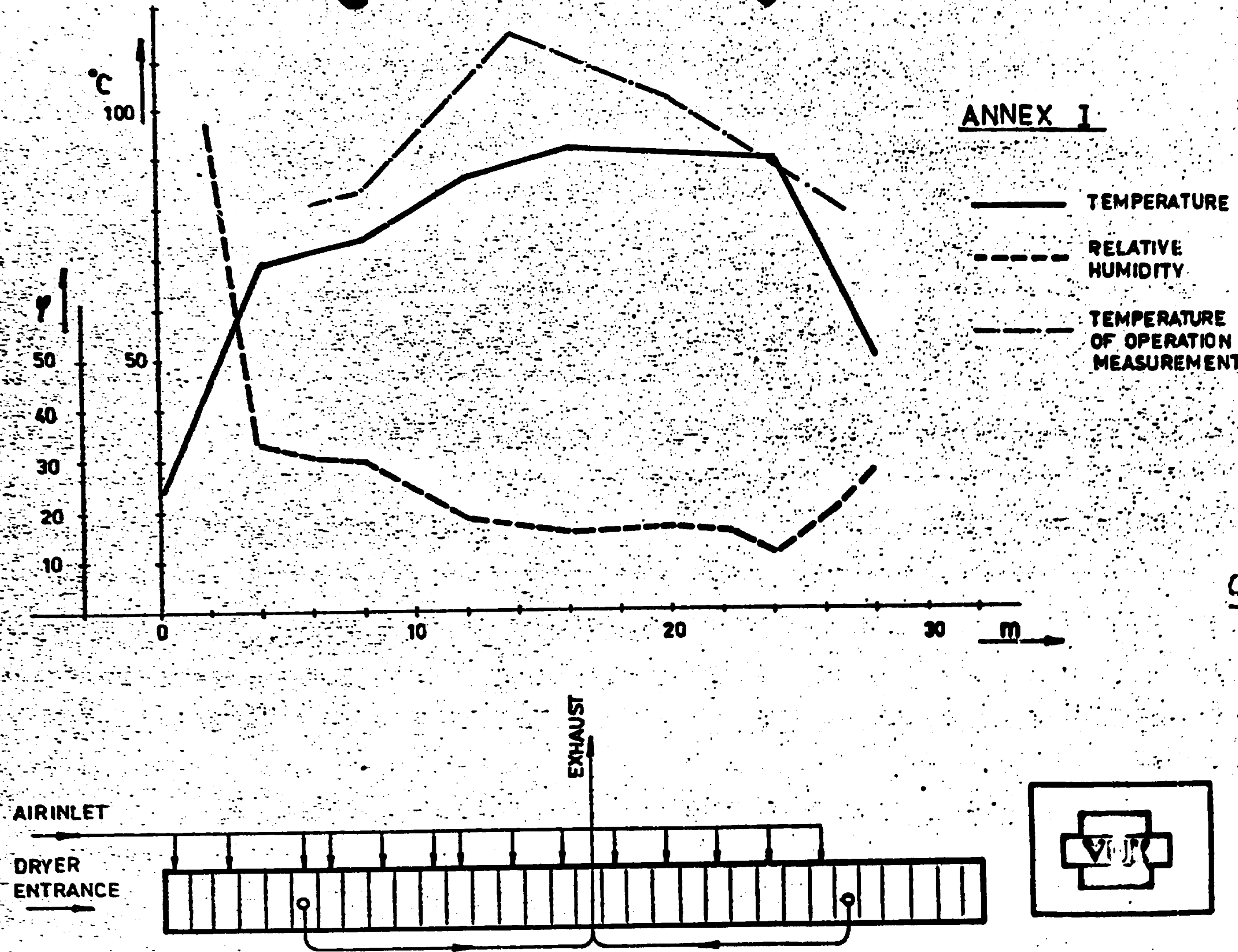
TABLE OF ABBREVIATIONS

c_a	-	specific heat of air
c_{cp}	-	specific heat of combustion products
Cm	-	specific heat of matter
Cw	-	specific heat of water
Ho	-	heat capacity of oil
Mdm	-	mass of dry matter /substance/
Mm_1	-	mass of material inlet
Mo	-	mass of oil
Mwr	-	mass of residual water
Mwe	-	mass of evaporated water
Mw	-	mass of water content in material inlet
Qa	-	heat output lost by warm air
Qcp	-	flue loss
Qd	-	heat output power lost by heat accumulated in dry matter
Qo	-	heat input power by firing oil
Qwe	-	heat output power for evaporation of water
q_{we}	-	heat necessary for evaporation of 1 kg of water
Qwr	-	heat output power lost by heat accumulated in residual water
t_a	-	temperature of air
t_{cp}	-	temperature of combustion products
t_{ex}	-	exit temperature
V^{o}_{g}	-	volume of air for burners recalculated on normal conditions

$\bar{v}_a$	-	average velocity of air flow
V_{at}	-	theoretical volume of air
V^o_{at}	-	theoretical need of air for burners
Vcp	-	volume of combustion products
Vda	-	volume of dry air
$\overset{o}{Vm}$	-	recalculated volume of moist combustion products
Vma	-	volume of moist air
V^o_{mt}	-	theoretical volume of moist combustion products
Vv	-	volume of water vapour
w_1	-	inlet moisture content
w_2	-	outlet moisture content

List of tables

ANNEX I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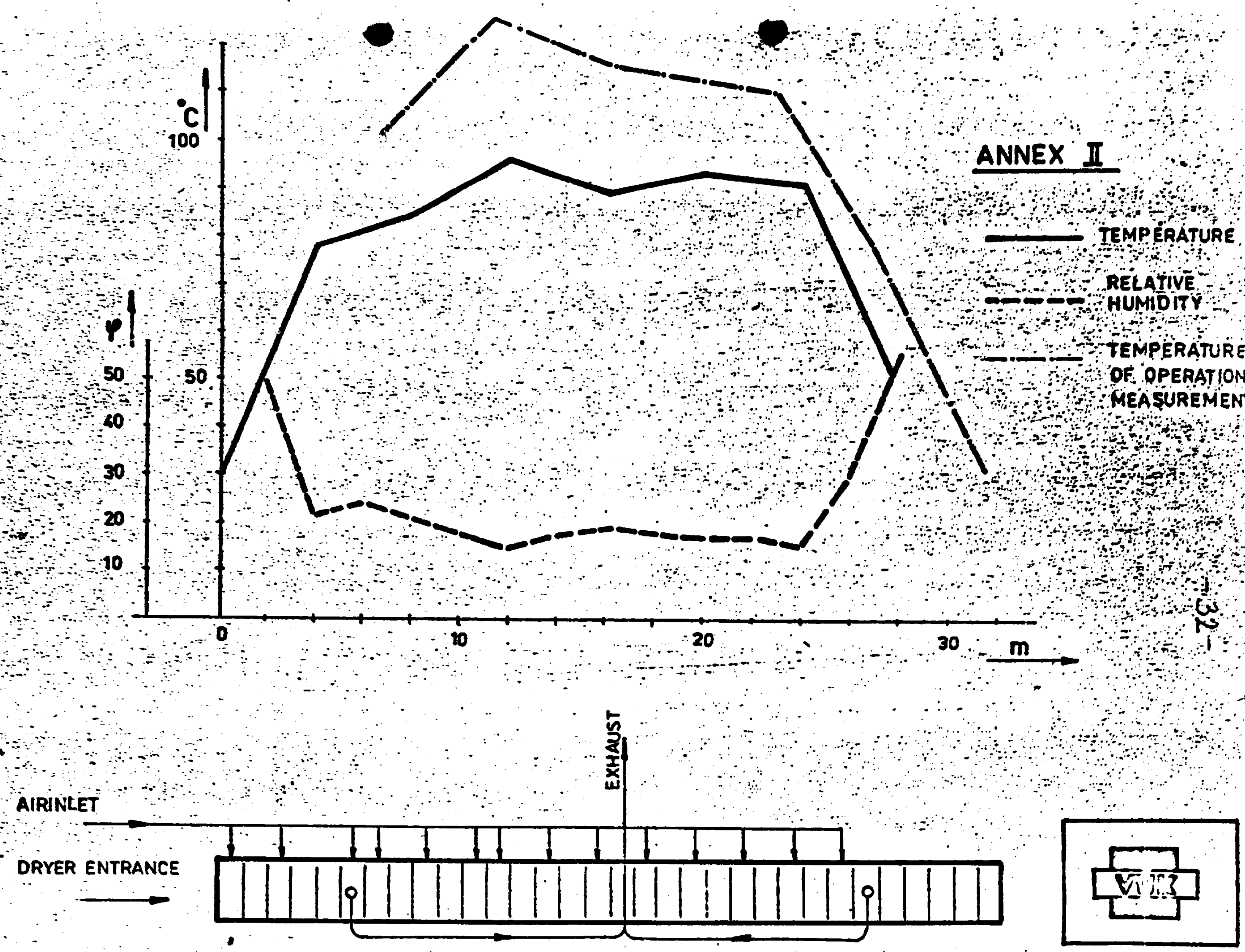
RELATIVE HUMIDITY
TEMPERATURE OF OPERATION MEASUREMENT
°C
100
50
φ
50
40
30
20
10
0
10
20
30
m
EXHAUST
AIR INLET
DRYER ENTRANCE

ANNEX II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RELATIVE HUMIDITY
TEMPERATURE OF OPERATION MEASUREMENT
°C
100
50
φ
50
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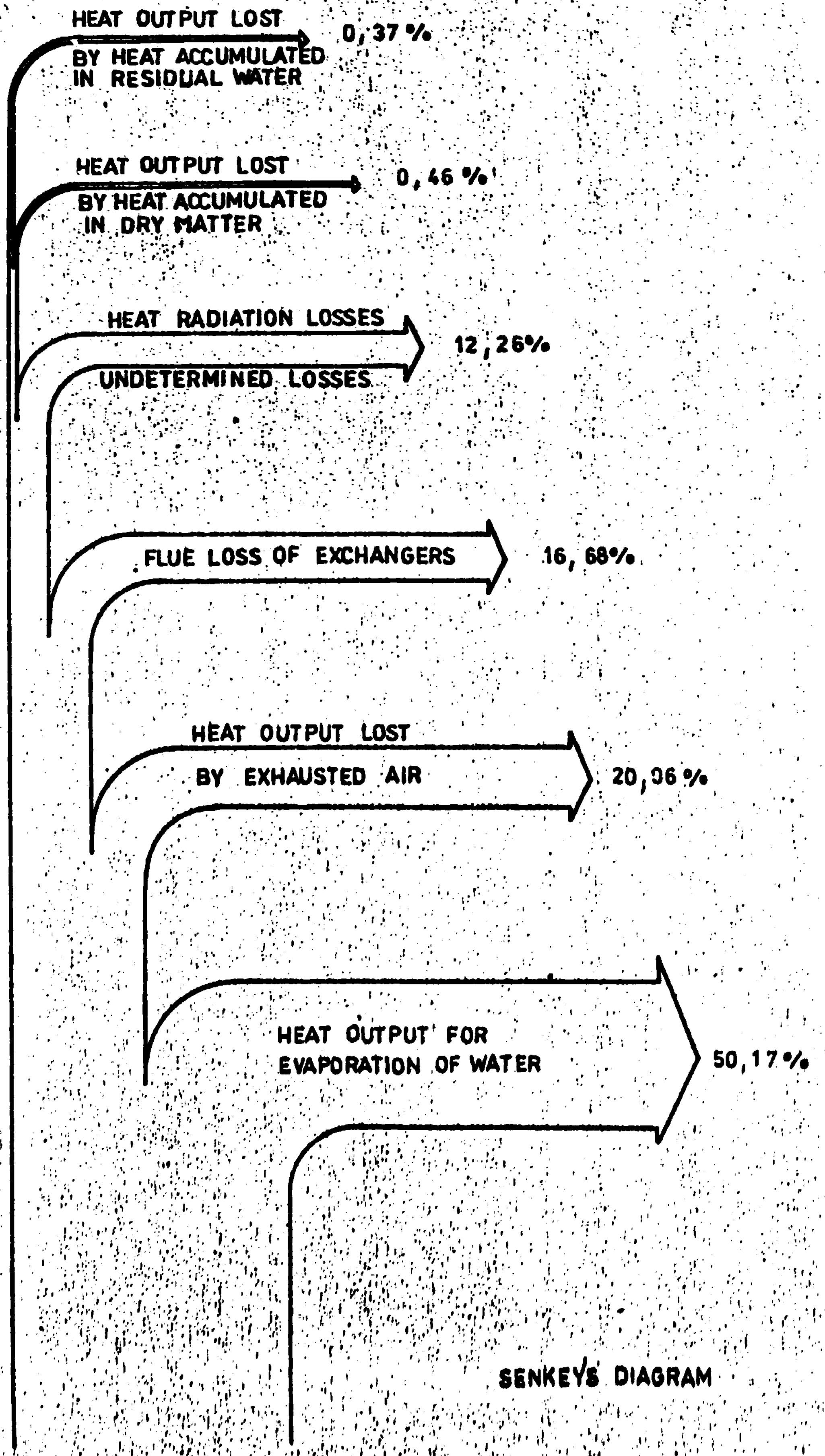
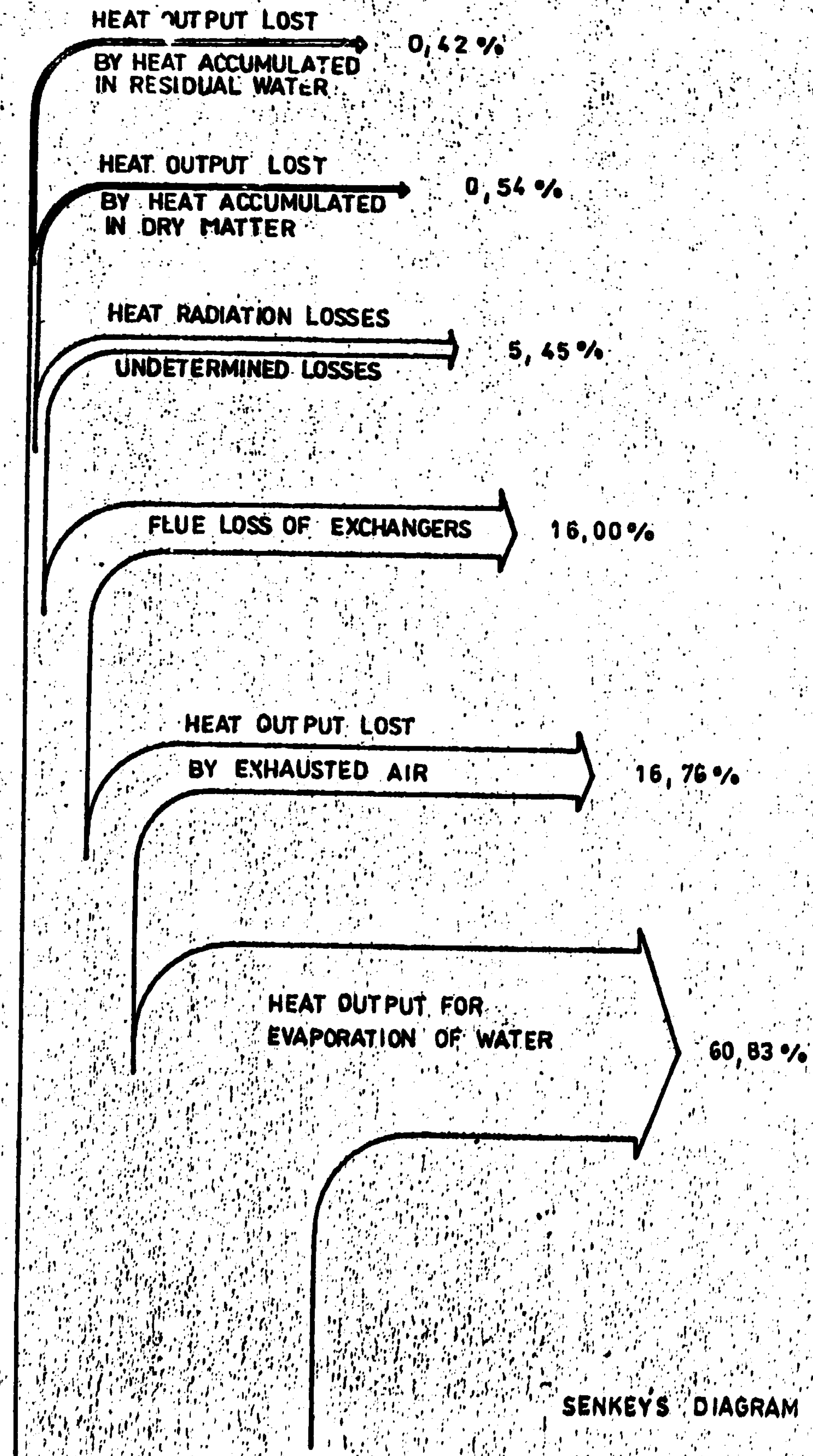
EXHAUST
AIRINLET
DRYER ENTRANCE

HEAT BALANCE - 1st TESTING



HEAT BALANCE - 2nd TESTING



SENKEY'S DIAGRAM

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

Mobile Diagnostic Unit - Pilot Project on Energy Conservation in Ceramics, Building Materials and Non-metallic Minerals Based Industries

JOB DESCRIPTION

Post title: Expert in heat processes in ceramics, building materials and non-metallic minerals based industries - team leader

Duration:

Date required:

Duty station:

DUTIES

The expert will be team leader of the team of experts conducting the investigations of heat processes in industrial plants by means of the Mobile Diagnostic Laboratory according the the pilot project. He will be in contact with the counterpart nominated in the country of destination to ensure conditions for activities of the Mobile Diagnostic Unit. Specifically he will be expected to:

1. control the team work, prepare the work programme,

2. contact the company heads to get the data and basic documents required for the preparatory steps for the measurements,

3. specify the measurement conception and selection of tests which are to be carried out,

4. maintain contacts with the company heads so that all conditions to find all the required values could be made,

5. be responsible for the elaboration of the final report on the measurements and its completeness to meet the ordering party's requirements. To specify the main conclusions and remedial steps.

QUALIFICATIONS: Mechanical or electrical engineer having wide experience in the field fo thermal cum power engineering capability to elaborate the measurement conception in dependence on the technological analysis of the production in question.

LANGUAGE: English and other as per the territory in which the measurements are to be undertaken,

BACKGROUND INFORMATION: The inquired information should be delivered by the country of destination requesting the consultancy services. It should be specified in the Questionnaire of the Mobile Diagnostic Unit.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
U N I D O

Mobile Diagnostic Unit - Pilot Project on Energy Conservation in Ceramics, Building Materials and Non-metallic Minerals Based Industries.

JOB DESCRIPTION

Post title: Expert in measuring techniques

Duration:

Date required:

Duty station:

DUTIES: The expert will be a team member working under the supervision of the team leader and is expected to:

1. specify the measuring method to get the values as required by the team leader;
2. select proper measuring technique /sensors, connection elements, measuring and registration instruments/;
3. specify the points of measurement on the equipment to be tested and the most suitable placement of the sensors;
4. supervise and check the measuring process proper;
5. specify the process of further measuring according to the partial results elaborated by the engineer in charge of evaluation;
6. elaborate the main parts of the technical report according to the values read and calculated from the registration instruments and to propose the individual points of the conclusion.

QUALIFICATIONS: Electrical engineer having experience in measuring and thermal technique, conversant with operation measurements.

LANGUAGE:

BACKGROUND INFORMATION: The inquired information should be delivered by the country of destination requesting the consultancy services. It should be specified in the Questionnaire of the Mobile Diagnostic Unit.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
U N I D O

Mobile Diagnostic Unit - Pilot Project on Energy Conservation in Ceramics, Building Materials and Non-metallic Minerals Based Industries.

J O B   D E S C R I P T I O N

Post title: Expert in technical calculations and evaluations.

Duration:

Date required:

Duty station:

DUTIES: The expert will be a team member working under the supervision of the team leader and is expected to:

1. carry out routine calculations and evaluations of the measured values as a basis for specifying further measurement process;

2. find out the capacity data as to the quantity and quality of the production from the manufacturer required for the summary calculations;

3. verify the correctness of the measured values;

4. compile the evaluations from the individual measured values and to carry out the main calculations for the final measurement report;

./.

QUALIFICATIONS: Electrical engineer, mathematician, experienced in the field of measurement and calculation technique, conversant with the operational measurement evaluations.

LANGUAGE: English and other as per the territory in which the measurements are to be undertaken.

BACKGROUND INFORMATION: The inquired information should be delivered by the country of destination requesting the consultancy services. It should be specified in the Questionnaire of the Mobile Diagnostic Unit.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
U N I D O

Mobile Diagnostic Unit - Pilot Project on Energy Conservation in Ceramics, Building Materials and Non-metallic Minerals Based Industries.

J O B   D E S C R I P T I O N

Post title: Technician for measuring instruments

Duration:

Date required:

Duty station:

DUTIES: The expert will be a team member working under the supervision of the team leader and is expected to:

1. ensure a troublefree operation of the measuring instruments during the measuring process;

2. check and calibrate the measuring instruments;

3. collaborate with the operator in the installation of the measuring sensors on the equipment to be tested if and when necessary.

QUALIFICATIONS: Electrical technician experienced in the field of the measuring technique.

LANGUAGE:

BACKGROUND INFORMATION: The inquired information should be delivered by the country of destination requesting the consultancy services. It should be specified in the Questionnaire of the Mobile Diagnostic Unit.

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
U N I D O

Mobile Diagnostic Unit - Pilot Project on Energy Conservation in Ceramics, Building Materials and Non-Metallic Minerals Based Industries.

J O B   D E S C R I P T I O N

Post title: Measuring laboratory operator

Duration:

Date required:

Duty station:

DUTIES: The expert will be a team member working under the supervision of the team leader and is expected to:

1. install the measuring sensors on the equipment to be tested and to connect them with the measuring and registration instruments as directed by the engineer in charge of the measurement;

2. drive the measuring diagnostic unit truck to the individual spots of measurement and to do the routine maintenance of the truck.

QUALIFICATIONS: Technician mechanical or electrical experienced in operational testing. Driver.

LANGUAGE:

BACKGROUND INFORMATION: The inquired information should be delivered by the country of destination requesting the consultancy services. It should be specified in the Questionnaire of the Mobile Diagnostic Unit.

F I N A L   N O T E

The presented documents furnish the basic information on advisory services in energy conservation in ceramics, building materials and non-metallic based industries. The method of this activity is based on the application of a mobile diagnostic laboratory enabling deep operation analyses of heat generating equipment in situ and the recommendation of implementable improvements. Its application should be very effective in developing countries where technical services are unsufficient and the impact of inflation fuel prices on local economies is disastrous.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards even though the best possible copy was used for preparing the master fiche.

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