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17875

UNIDO-Czechoslovakia Joint Programme,
Non-metallic Industries, Pilsen

DEMONSTRATION OF MOBILE DIAGNOSTIC UNIT (MDU) FOR ENERGY AUDITING IN HUNGARY

FINAL REPORT

Project No. DP/RER/83/003
"Industrial Energy Conservation Network"

Contract No. 89/145

CONTENT

Annexes:

1. Energy Auditing with Mobile Diagnostic Unit (Abstract of the Lecture)

2. Technical Report on Energy Audit in Alföldi Porcelángyár (Hungary)

I. INTRODUCTION

The consultancy services (assistance to the Energy Policy and Management Training Centre, Budapest, Hungary) were subcontracted through UNIDO for the project DP/RER/83/003 "Industrial Energy Conservation Network".

Demonstration of the application of the Mobile Diagnostic Unit (MDU) from Pilsen (CSSR) for energy auditing in a Hungarian industrial enterprise within the first, introductory course of the Energy Policy and Management Training Centre in Budapest, held on 2 - 6 October 1989, was the objective of the subcontracting.

Since the energy auditing represents one of the most important activities of energy management, it was considered strongly advisable to demonstrate an energy audit in industry to the participants in the training course as well as to the staff of the Network Training Centre (NTC) Budapest and to representatives of various Hungarian institutions.

The expected outputs of the subcontract were as follows:

a) Trained personnel of the NTC and participants to the training course in the principles and steps of energy auditing in industry.

b) Technical report on energy audit of one heat consuming unit including the conclusions and recommendations on possible improvements.

c) The energy audit is also expected to bring about benefits in the form of saved energy.

II. PARTICIPANTS

The training course and the in-plant demonstration of the mobile diagnostic unit were attended by the representatives of:

- Bulgaria (2)
- Czechoslovakia (2)
- Poland (1)
- Romania (1)
- Yugoslavia (4)

and by the representatives of Hungarian institutions:

- EGI Budapest (Institute for Energy; Network Training Centre)
- AEEF Budapest (State Authority for Energy Management and Energy Safety)
- EEO Budapest (Energy Efficiency Office)
- Technical University of Budapest
- Digital-Comp Budapest
- Energy Engineering Research and Development Services Ltd., Budapest
- SZIKKTI Budapest (Central Research and Design Institute for Silicate Industries)
- Alföldi Porcelángyár Hódmezörvásárhely

III. LANGUAGE

All the programme was conducted in English and all the delivered and elaborated materials were typed in English, too.

IV. ORGANIZATION

The training course was held in Budapest from 2nd through 6th October 1989, attended by one representative of the subcontractor (Mr. Vladimír Nový), who delivered the lecture "Energy Auditing with Mobile Diagnostic Unit" (abstract of the lecture see in Annex 1 to this Report), some informative materials on the mobile diagnostic unit and also presented the training video programme of the UNIDO-Czechoslovakia Joint Programme, Non-metallic Industries, Pilsen, "Energy Auditing".

The energy audit was carried out in the sanitary ware and porcelain production plant "Alföldi Porcelángyár" at Hódmezörvásárhely from 4th through 6th October 1989. The MDU crew was accompanied by two Hungarian energy auditing experts co-operating with the NTC (and by employees of the factory), who got acquainted with all the details on preparation and implementation of the audit. The participants in the training course and some other Hungarian representatives attended one-day in-plant training on 6th October. The audit was finished by elaboration of the Technical Report (containing conclusions and recommendations on certain improvements of the audited device operation), which was distributed to the "Alföldi" enterprise and to NTC representatives. The Technical Report is enclosed as Annex 2 to this report.

Concerning the financial matters, the DSA of the MDU crew and the cost of diesel oil in Hungarian territory were covered by the host (NTC) organization, while all the other expenses related to delivery and demonstration of MDU in Hungary (including the MDU crew salaries) were covered by the subcontractor.

V. CONCLUSIONS AND RECOMMENDATIONS

1. Successful implementation of the MDU presentation and fulfillment of all the expected aims were enabled by excellent preparatory work and mutual co-operation of all the involved parties.

2. The participants in the MDU presentation consider the MDU concept of energy auditing as very efficient tool of energy management and technological optimization. A great appreciation was also given to the special software package, which had been developed in Pilsen for energy auditing purposes.

3. Experts of the NTC, participants in the training course and representatives of other Hungarian institutions were trained in the principles of energy auditing by means of a lecture, training video programme and mainly in-plant mobile diagnostic unit presentation.

4. The Technical Report on the audit of a tunnel kiln for porcelain glost firing was elaborated (see Annex 2), including a proposal of measures for improvement; higher output of the kiln and reduction of specific heat consumption of the firing process by about 5 - 10 % should be reached after realization of these measures.

5. Hungarian side expressed their interest in further involvment of the UNIDO-Czechoslovakia Joint Programme, Non-metallic Industries, Pilsen and the Research Institute for Ceramics, Refractories and Non-metallic Raw Materials, Pilsen, into the activities of the Network Training Centre in Budapest.

6. Mr. K. Domszky, Director of the Energy Engineering Research and Development Services, Ltd., Budapest will come to Pilsen in November 1989 to negotiate with Mr. Z.A. Engelthaler, Chief Executive of the UNIDO-Czechoslovakia Joint Programme, Non-metallic Industries, Pilsen the possibilities of a joint construction of mobile diagnostic units and exchange of instrumentation for energy audits, available in Hungarian and Czechoslovak markets.

Annex 1

Vladimír Nový, Research Institute for Ceramics, Refractories
and Non-metallic Raw Materials, Pilsen,
Czechoslovakia

Energy Auditing with Mobile Diagnostic Unit

(ABSTRACT)

The principles of Energy Management Programme are explained in the beginning of the lecture with emphasis on utilization of mobile energy auditing means, especially mobile diagnostic units (energy buses) or so called energy auditing kits.

Different goals and approaches to energy audit process are mentioned with the conclusion that the complex engineering approach is the most efficient. The main steps which an energy audit is consisting of are presented, as well as the conclusions and contributions that can be expected.

In the following part of the lecture some technical demands on mobile diagnostic units equipment are discussed together with examples of instrumentation for measurement of basic values, as temperature, pressure, flow velocity, humidity, chemical analysis, electrical values and others. Possibilities of obtained data processing are presented with the stress upon a personal computer utilization for compilation of the final technical report on the audit.

At the end of the lecture some experience and economic results gained with mobile diagnostic units both in Czechoslovakia and abroad are mentioned and readiness of Czechoslovak experts to assist foreign countries in the field of energy auditing is remembered.

Annex 2

Research Institute for Ceramics, Refractories and Non-metallic
Raw Materials, Pilsen, Czechoslovakia

in co-operation with

UNIDO-Czechoslovakia Joint Programme, Non-metallic Industries,
Pilsen

TECHNICAL REPORT

on energy auditing in ALFÖLDI PORCELÁNGYÁR (porcelain production)

Hódmezővásárhely, Hungary 4.10. - 6.10.1989

TABLE OF CONTENTS

I. INTRODUCTION

The energy audit was carried out in the sanitary and porcelain production of ALFÓLDI PORCELÁNGYÁR Hódmezővásárhely from 4 October through 6 October 1989 as a part of demonstration energy audits in Hungary.
The audits were carried out according to the mutual agreement among the Research Institute for Ceramics, Refractories and Non-metallic Raw Materials, Pilsen, UNIDO - Czechoslovakia Joint Programme, Non-metallic Industries, Pilsen, the Energy Efficiency Office of the State Authority for Energy Management and Energy Safety (AEEF) in co-operation with the Ministry of Industry and the Research and Design Institute for Silicate Industry (SZIKKTI), within the activities under the UNDP/UNIDO project DP/RER/83/003 " Industrial Energy Conservation Network ".

Complex measurements of one tunnel kiln for glost firing of porcelain represented the objective of the audit.
The measurements and data processing were carried out by means of the mobile diagnostic unit of the Research Institute for Ceramics, Refractories and Non-metallic Raw Materials in Pilsen, Czechslovakia.

Successful implementation of the audits and fulfillment of all the aims were enabled by excellent preparatory work and mutual co-operation of all involved parties.

TUNNEL KILN FOR GLOST FIRING OF PORCELAIN

II. SELECTED SPECIFICATIONS

- tunnel kiln for glost firing of porcelain
  (VEB Spezialbaukombinat Magdeburg , 1968)
- fuel : natural gas (38.69 kJ.m_n^{-3})
- firing temperature : 1360 Deg.C
- length of the kiln : 76 m
- inside cross-section : 1.1 x 1 m (W x H)
- length of the kiln car : 1.5 m
- number of kiln cars in the kiln : 50
- firing cycle : 29.2 h
- setting : 1618 kg/car
- kiln furniture + lining : 1720 kg/car
- average production : 174.8 kg/hour
  : 4196.6 kg/day

III. MEASURED AND CALCULATED VALUES

A. THERMAL BALANCE OF TUNNEL KILN

1. INPUTS

a. INPUT BY CALORIFIC VALUE OF THE FUEL.

The gas flow meter was used to measure energy consumption of the tunnel kiln, reading average in three days. Average gas consumption 112.14 $m_n^3.h^{-1}$ with very low fluctuations less then 1% corresponds to the input 1205.2 kW. (see Table 1,2)

b. INPUT BY ACCUMULATED HEAT IN GOODS AND KILN CARS.

Entering the kiln at an enhanced temperature (see Table 3) the goods and kiln cars represent further input of 5.2 kW.

c. OTHER INPUTS.

All other media (firing air, air for cooling) enter the kiln at the ambient temperature. Since for the calculation this temperature was taken as zero level, the relevant inputs are equal to zero, too. Combustion air is preheated in cooling zone of the kiln so that it has no effect on the thermal balance.

TOTAL INPUT OF THE KILN : 1210.4 kW

2. OUTPUTS - LOSSES

a. FLUE LOSS.

Velocity (by Anemometers) and temperature of flue gases were measured . Relevant data measured are shown on the pages 12 and 13.

Average flue loss calculated : 235.14 kW

b. LOSS BY COOLING AIR.

This loss was measured and calculated by the same method as in the case of flue loss (e.g. Anemometers measurement and temperature measurement). The air from cooling zone is either used for drying. Relevant data measured are shown on the pages 14 and 15.

The loss by cooling air in the time of measurement was :
492.42 kW

c. SURFACE LOSSES.

The kiln was divided into several sections for the purpose of the measurement. Average surface temperature was calculated from measurements for the left side, right side and roof of the kiln. Radiation, convection and total losses were calculated. For detailed data see Table Nr.4.

Total surface losses of the kiln : 212.5 kW.

d. LOSS BY ACCUMULATED HEAT.

Temperatures of the goods, kiln furniture, kiln car lining and steel chassis were measured to calculate the loss by the heat accumulated in the material leaving the kiln. Data on the mass of these materials were obtained from the plant management. The detailed data gives Table Nr.5.

Total loss by accumulated heat : 74.2 kW

e. OTHER LOSSES.

Losses through the lining of the kiln cars into the inspection tunnel, losses into the fundaments of the kiln, heat for physical-chemical changes in fired material and especially loss by leakage (between kiln cars, through sight holes, through opened outlet of the kiln) play a decisive role in this item.

Table Nr.6 shows the thermal balance of the kiln. Graphically it is presented by Senkey's diagram on the page 23

B. SPECIFIC HEAT CONSUMPTION.

Total input of the kiln : 4357 MJ/h
Production (average) : 174.8 kg/h
Specific heat consumption : 24925 kJ/kg (5953 kcal/kg)

C. TECHNOLOGICAL PARAMETERS.

Pilot kiln car, equipped with three Pt-PtRh 10 thermocouples was used to measure firing curves in the tunnel kiln.

Pressure curve, firing curve, CO_2 and CO contents in the kiln atmosphere, body composition of porcelain and scheme with positions of individual thermocouples in the pilot kiln car are presented in the next pages. Comments on technological parameters are mentioned in the chapter IV.

Table Nr. 1 .Fuel comp. and results after combustion of 1 mn^3.

CH_4	85.87	%
C_2H_6	5.66	%
C_3H_8	2.32	%
C_4H_{10}	1.16	%
C_5H_{12}	.32	%
C_6H_{14}	.06	%
N_2	1.16	%
CO_2	3.45	%
Calor.value	38.6911	MJ/mn^3
Data of stechiometric combustion - n=1		
Air	10.18	mn^3
CO_2max	12.42	%
Dry flue gases	9.20	mn^3
Wet flue gases	11.26	mn^3

Table Nr. 2 .Volume,composition and properties of flue gases.

Gas consumption	112.14	mn^3/hod
Air excess coeff.	6.00	
Total air cons.	6850.62	
Flue gases temp.	113	Dgr.C
Input	4338.82	MJ
Specific heat cont.	1.322	kJ/mn^3.K
Absolute humidity	0.0188	kg/mn^3

		Dry	Wet
Vol.of flue gases	[mn^3/hod]	6740.20	6971.37
Density	[kg/mn^3]	1.30	1.28
O_2	[%]	17.50	16.92
N_2	[%]	80.60	77.93
CO_2	[%]	1.90	1.84
H_2O	[%]		3.32

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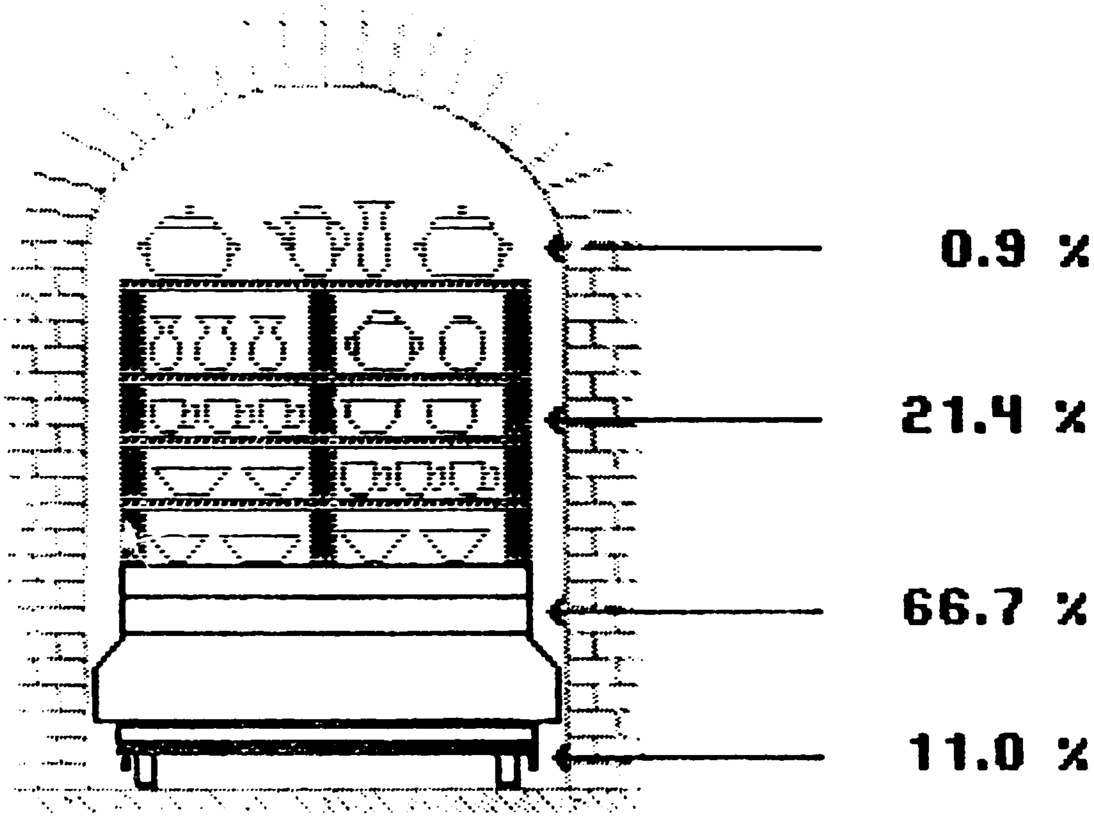
Table Nr. 3 .Input heat accumulated in kiln cars.

COMPONENT	AV.TEMPERATURE [Degree C]	MASS [kg]	HEAT [%]	ACCUM.HEAT [MJ]
Goods		102	0.9	0.1
Porcelain	27	102		0.1
Auxil. material		614	21.4	2.4
Plate	30	614		2.4
Car lining		634	66.7	7.3
Bricks	38	634		7.3
Car		370	11.0	1.2
Steel	32	370		1.2

Total accumulated neat	11.0	[MJ/kiln car]
Kiln car interval	35.0	[min]
Total loss by acc.heat	5.2	[kW]

IBM PC-XT



INPUT HEAT ACCUMULATED IN KILN CAR

[illegible] : [illegible]

Test

Tunnel kiln No.2 - Chimney

Pipe diameter 67 cm

Measurements each 10 cm

Measured values [m/s]

Test Nr. 1
6.55 , 7.59 , 7.7 , 8.5 , 8.62 , 9.41 , 9.71 , 9.71

TEST Nr.	1	2	3	Average
Gas temperature[Deg.C]	113.00			113.00
Static pressure [Pa]				
Mean velocity [m/s]	8.47			8.47
Gas volume [Nm 3/s]	1.90			1.90
Heat loss [kW]	235.14			235.14
Heat amount [MJ/h]	846.52			846.52
Heat amount [illegible]	7.42			7.42

IBM PC-XT

VELOCITY PROFILE IN THE CHIMNEY

[illegible] = [illegible]

Test

Tunnel kiln No.2 - Outlet of cooling air

[illegible] diameter [illegible] cm

Measurements each [illegible] cm

Measured values [m/s]

Test Nr. 1
12.48 , 16.25 , 17.15 , 16.4 , 18.9 , 17.65 , 16.2 , 16

TEST Nr.	1	2	3	Average
Gas temperature[Deg.C]	124.00			124.00
Static pressure [Pa]				
Mean velocity [m/s]	16.38			16.38
Gas volume [Nm^3/s]	3.56			3.56
Heat loss [kW]	492.42			492.42
Heat amount [MJ/h]	1772.71			1772.71
Heat amount [TJ/year]	15.53			15.53

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VELOCITY PROFILE IN THE OUTLET

Table Nr. 4 .Surface losses.

SECT.	SURFACE TEMPER. [Deg.C]	AMBIENT TEMPER. [Deg.C]	SURFACE [m^2]	EMISSIVITY	RAD. [kW]	CONV. [kW]	TOTAL LOSSES [kW]
inp. L	27	24	8.4	0.80	0	0	0
inp. R	27	24	8.4	0.80	0	0	0
in.roof	37	33	7.0	0.85	0	0	0
preh. L	56	33	43.2	0.80	6	6	11
pr.roof	74	51	34.3	0.85	6	6	11
preh. R	46	28	43.2	0.80	4	4	8
fir1. L	74	42	51.3	0.80	11	10	20
fi.roof	93	59	46.8	0.85	13	13	26
fir1. R	66	32	51.3	0.80	11	11	21
fir2. L	74	49	36.0	0.80	6	5	11
f2.roof	99	61	32.9	0.85	11	10	21
fir2. R	77	35	36.0	0.80	10	10	19
cool. L	59	42	107.4	0.80	11	9	21
c.roof	67	53	98.0	0.85	10	9	18
cool. R	56	35	107.4	0.80	13	12	25

TOTAL SURFACE LOSSES = 212.5 [kW]

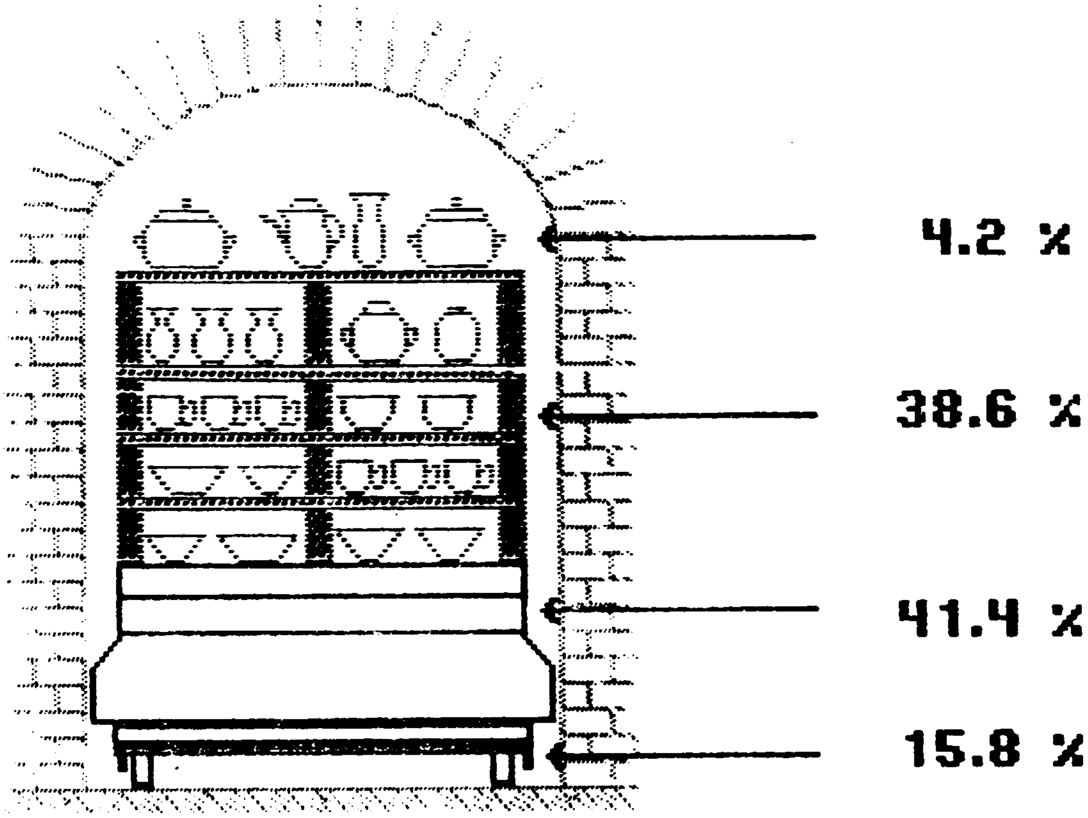
IBM PC-XT

Table Nr. 5 .Output heat accumulated in kiln cars.

COMPONENT	AV.TEMPERATURE [Degree C]	MASS [kg]	HEAT [%]	ACCUM.HEAT [MJ]
Goods		102	4.2	6.6
Porcelain	97	102		6.6
Auxil. material		614	38.6	60.2
Plate	130	614		60.2
Car lining		634	41.4	64.5
Bricks	132	634		64.5
Car		370	15.8	24.5
Steel	150	370		24.5

Total accumulated heat	155.8	[MJ/kiln car]
Kiln car interval	35.0	[min]
Total loss by acc.heat	74.2	[kW]

IBM PC-XT

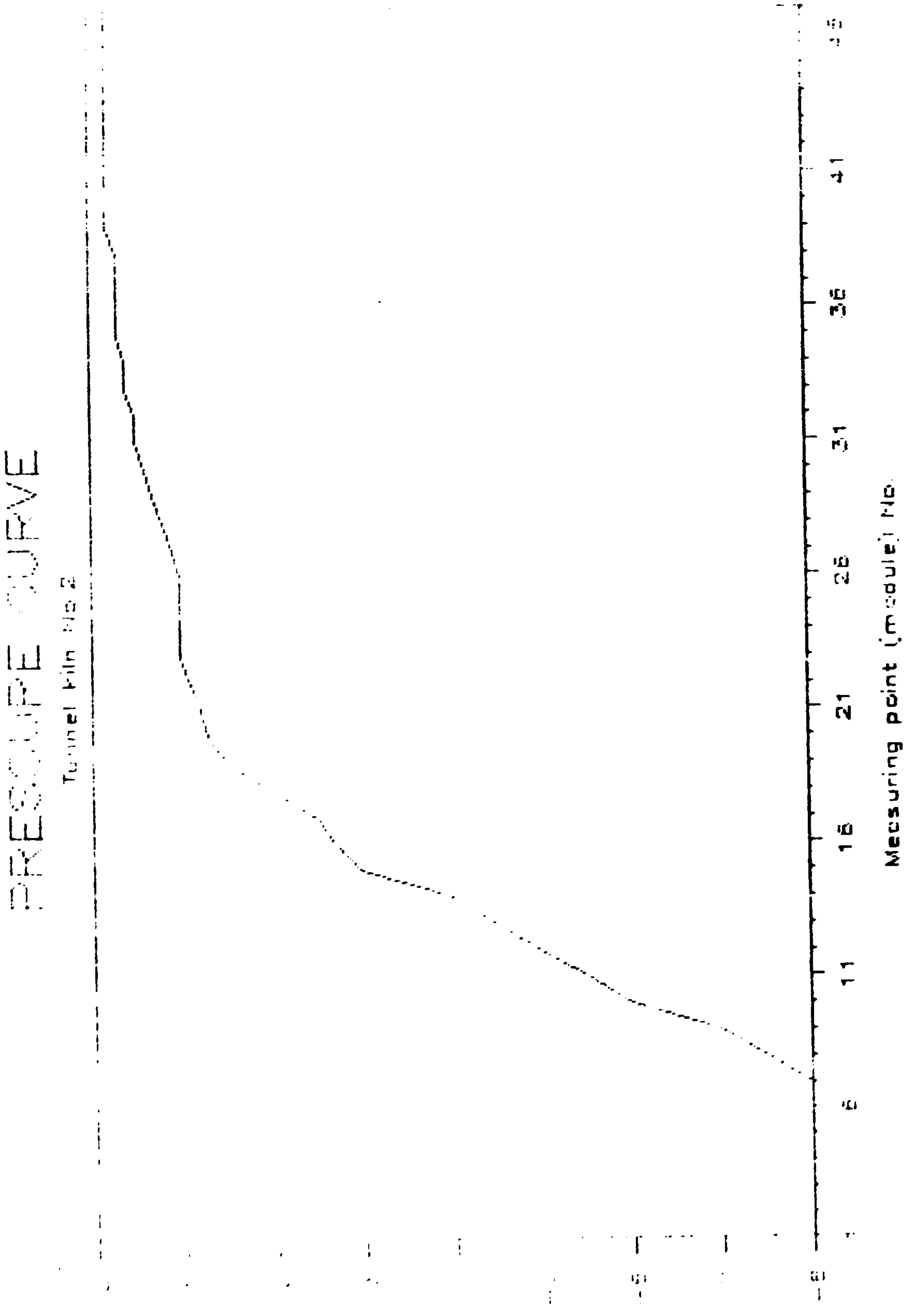


OUTPUT HEAT ACCUMULATED IN KILN CAR

PARAMETERS OF THE KILN

[illegible]
[illegible]
[illegible]

Measuring point No.	Temperature in T1 [deg.C]	T2	T3	Pressure [Pa]	CO2 [%]	CO [%]
1	27	27	27			
[illegible]	27	27	27			
[illegible]	27	27	27			
4	28	54	28	-8	13	
5	28	100	28	-8	13	
6	29	200	29	-8	13	
7	30	260	30	-8	13	
8	80	320	70	-8	13	
9	160	400	140	-6	13	
10	340	500	240	-8	13.5	
11	420	600	350	-7.5	13.5	
12	550	700	540	-7	13.6	
13	630	800	620	-6	13.7	
14	690	900	680	-5.5	13.8	
15	740	960	730	-5	13.9	
16	840	970	800	-4.5	14	0.1
17	900	1010	880	-4	13	3.3
18	950	1050	930	-3	12	5.1
19	1000	1070	980	-2	11.2	5.2
20	1040	1080	1030	-2	10.5	6.2
21	1080	1100	1070	-2	9.9	6.3
22	1150	1110	1150	-1.5	9.7	6.4
23	1180	1115	1180	-1	9.3	6.5
24	1260	1160	1260	-1	9	6.5
25	1220	1190	1200	-1	8.7	6.4
26	1220	1210	1210	-1	8.5	6.3
27	1240	1240	1230	-1	8.3	6.2
28	1280	1320	1270	-1	8	6.2
29	1330	1350	1320	-1	11.5	1.2
30	1380	1380	1360	-1	13	0
31	1300	1330	1300	-0.8	13	0
32	1100	1200	1100	-0.7	12.8	0
33	1000	1100	1000	-0.6	12.5	0
34	920	1000	910	-0.5	12	0
35	840	900	830	-0.5	11	0
36	800	850	800	0.4	9.5	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.5	[illegible]
39	[illegible]	680	[illegible]	[illegible]		
[illegible]	600	640	620	0.3		
41	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	500	[illegible]	[illegible]		
[illegible]	420	[illegible]	450	[illegible]		
44	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]			[illegible]	[illegible]		
	[illegible]		[illegible]	[illegible]		
	[illegible]		[illegible]	[illegible]		


PRESSURE CURVE
Tunnel Film No 2
1
6
11
16
21
26
31
36
41
46
Measuring point (module) No.

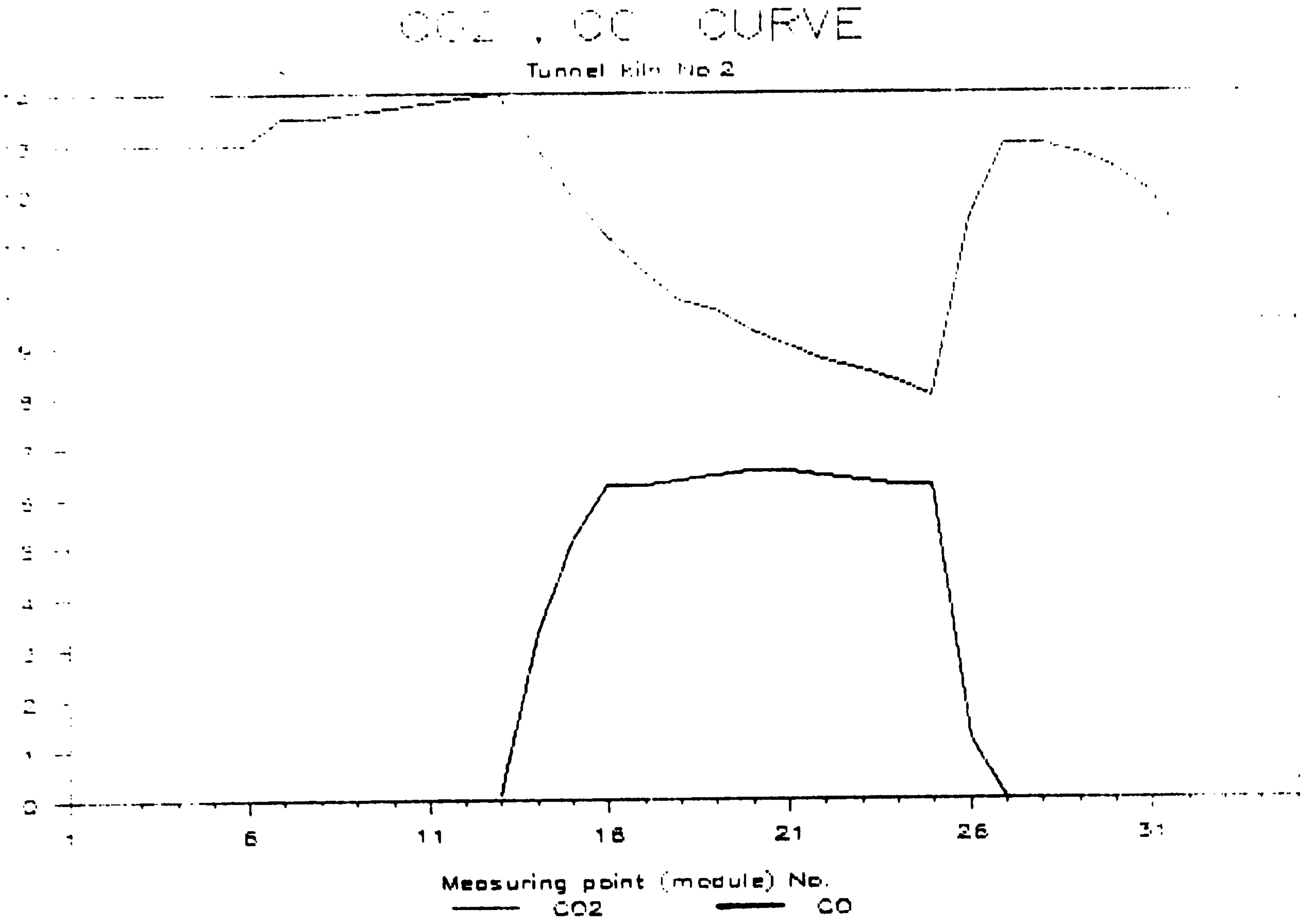
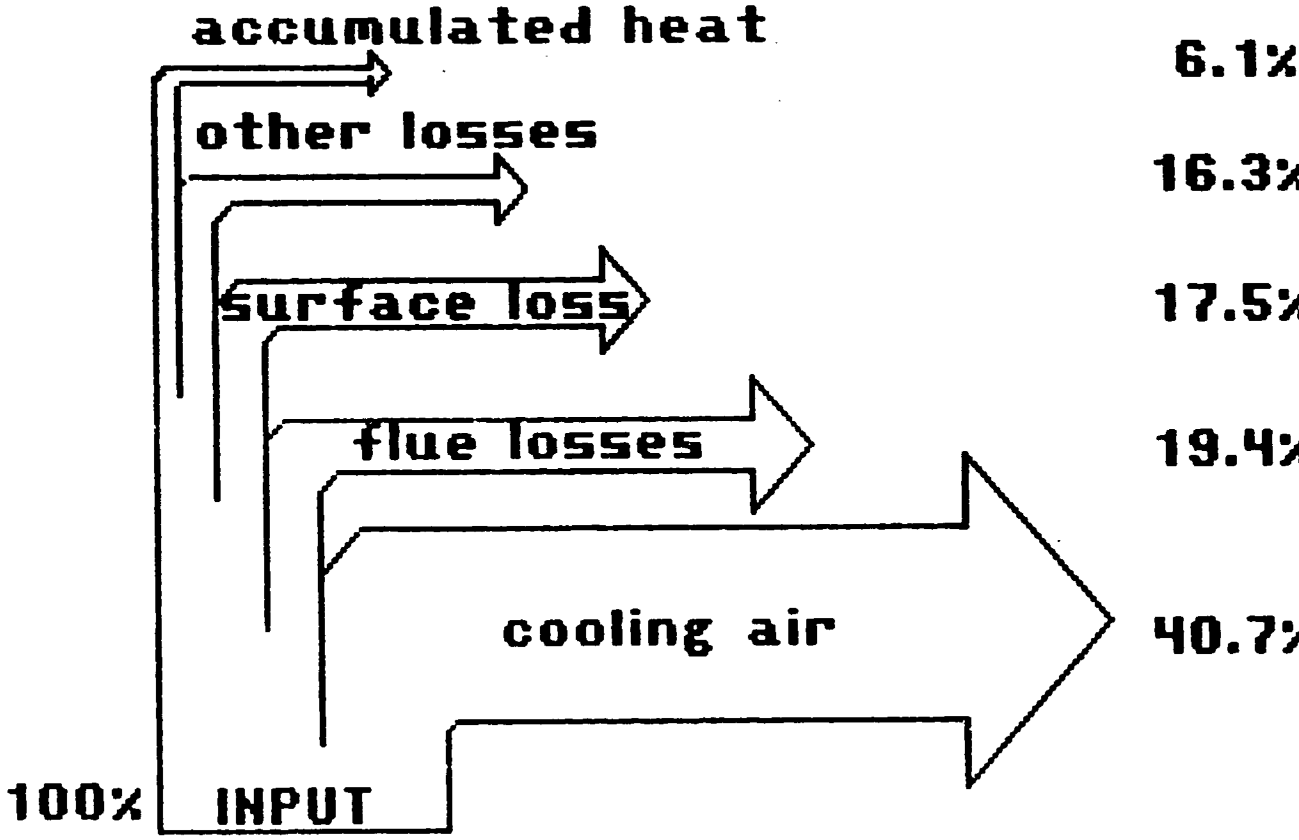

CO2 , CO CURVE
Tunnel Kiln No 2
0
1
2
3
4
5
6
7
8
9
1
6
11
16
21
26
31
Measuring point (module) No.
CO2
CO

Table Nr. 5. Heat balance of the tunnel kiln No. 2

ITEM		kW	%
INPUT :	by calorific value of the fuel	1205.2	99.6
	by accumulated heat in goods and kiln car	5.2	0.4
LOSSES:	flue losses	235.14	19.4
	cooling air	492.42	40.7
	surface losses	212.5	17.5
	accumulated heat	74.2	6.1
	other	196.14	16.3

THERMAL BALANCE OF THE TUNNEL KILN No.2



IV. CONCLUSIONS AND RECOMMENDATIONS

Results of measurements carried out on the tunnel kiln No.2 have shown, that this kiln is run at quite optimum firing conditions determined for the firing of chinaware. During measurements the kiln unit has shown very good results with respect to specific fuel consuption and quality of fired products.

Despite this some imperfections have been revealed after the evaluation of measurements:

a) a great quantity of false air is sucked through the kiln entrance which results in considerable dilutation of flue gases and cooling of tunnel kiln cars in the modules 1 - 4 (see the heating curve)

b) results of the pressure curve measurements show the all the kiln is run in underpressure

c) certain concentration of CO_2 was found in the cooling zone, which is the consequence of partial exhaust of flue gases through the direct cooling of the kiln

Proposed measures:

a) to seal the kiln by means of an entry gate

b) to raise the power of the back curtain to create an overpressure of approximately 5 Pa at the end of the hot zone

c) after the previous measures are carried out the exhaust of flue gases should be adjusted (lowered) to enhance the pressure in preheating zone in order to obtain value of about - 5 Pa at the kiln entrance.

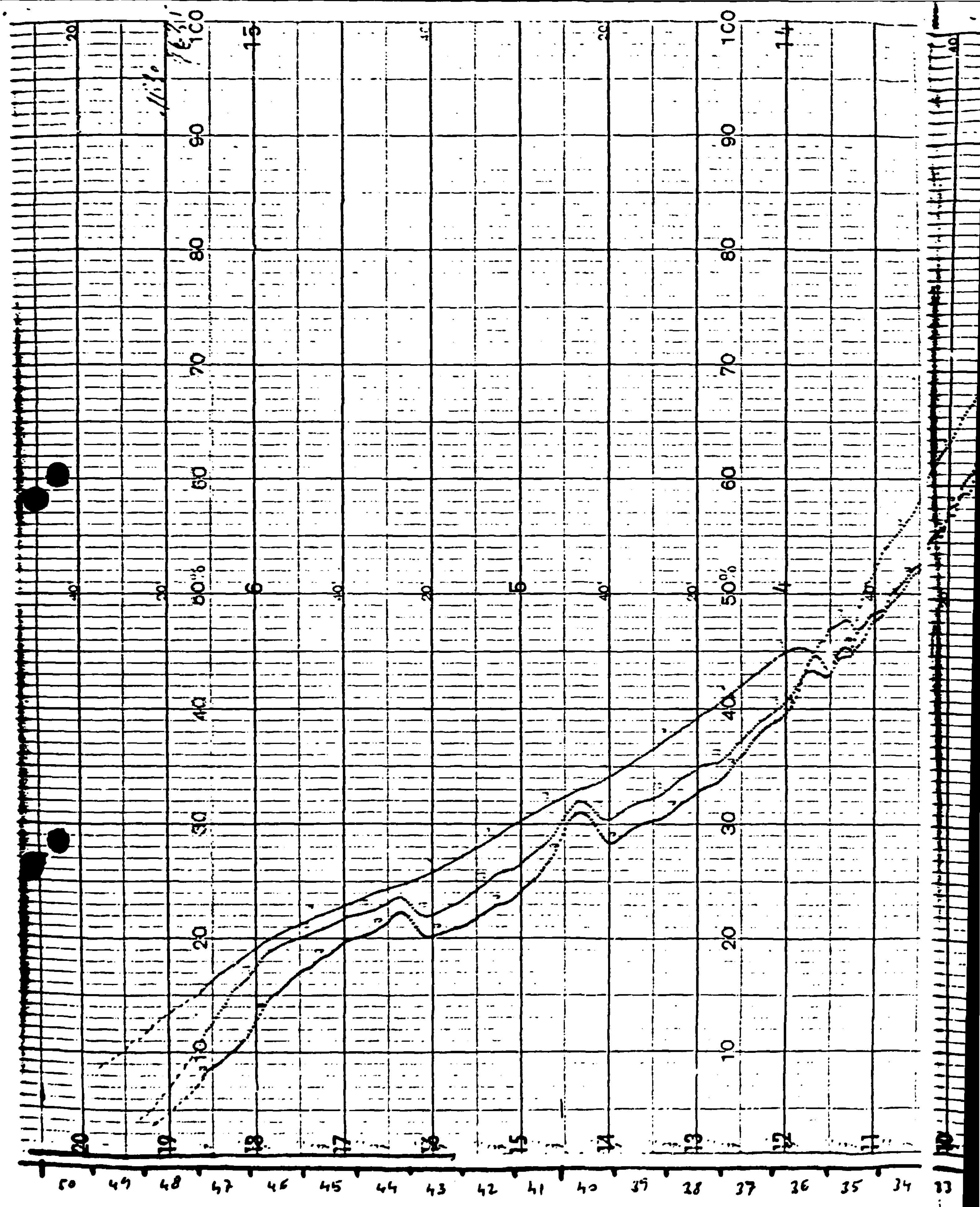
Contributions expected:

Better sealing of the kiln and lower pressure difference between ambient and kiln atmosphere will lower the amount of cold air sucked into the kiln in preheating zone. This cold air causes at present relatively high temperature difference between top and bottom of the setting (about 200°C) in preheating zone.

Better temperature equalization will enable higher speed of kiln cars and hence also lower specific heat consumption of the kiln by about 5-10%.

We thank to employees of the ALFOLDI PORCELAIN factory and Mr. Bacsa and Mr. Szulyok from SZIKKTI Budapest for establishment of excellent working conditions for our experts.

Head of the group	Ing. Zdeněk Voráček
Coworkers	Ing. Milan Neustupný Josef Marek Miroslav Beneš
Advisers	Ing. Vladimír Nový Ing. Milan Nový


100
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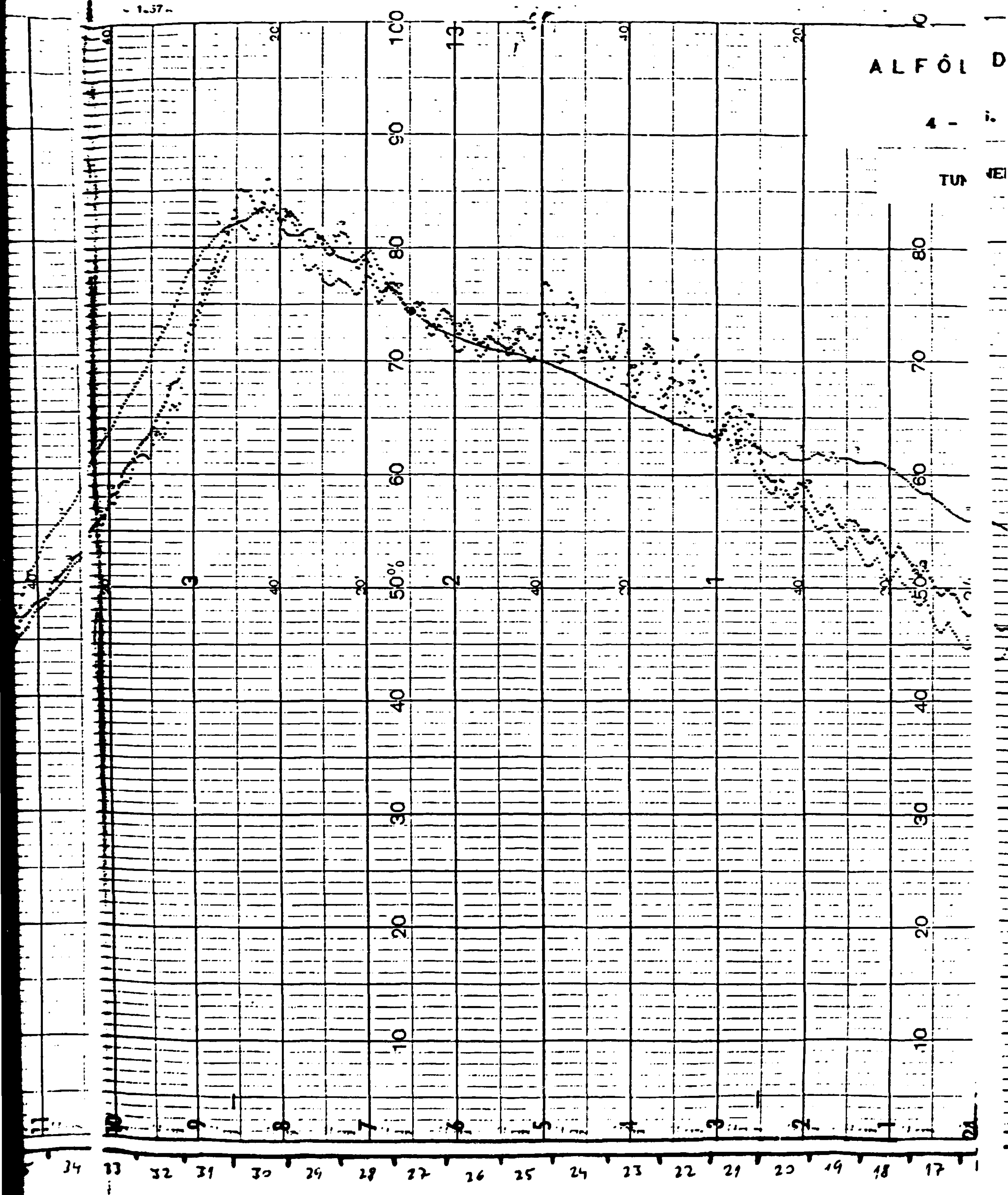
SECTION 1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SECTION 2

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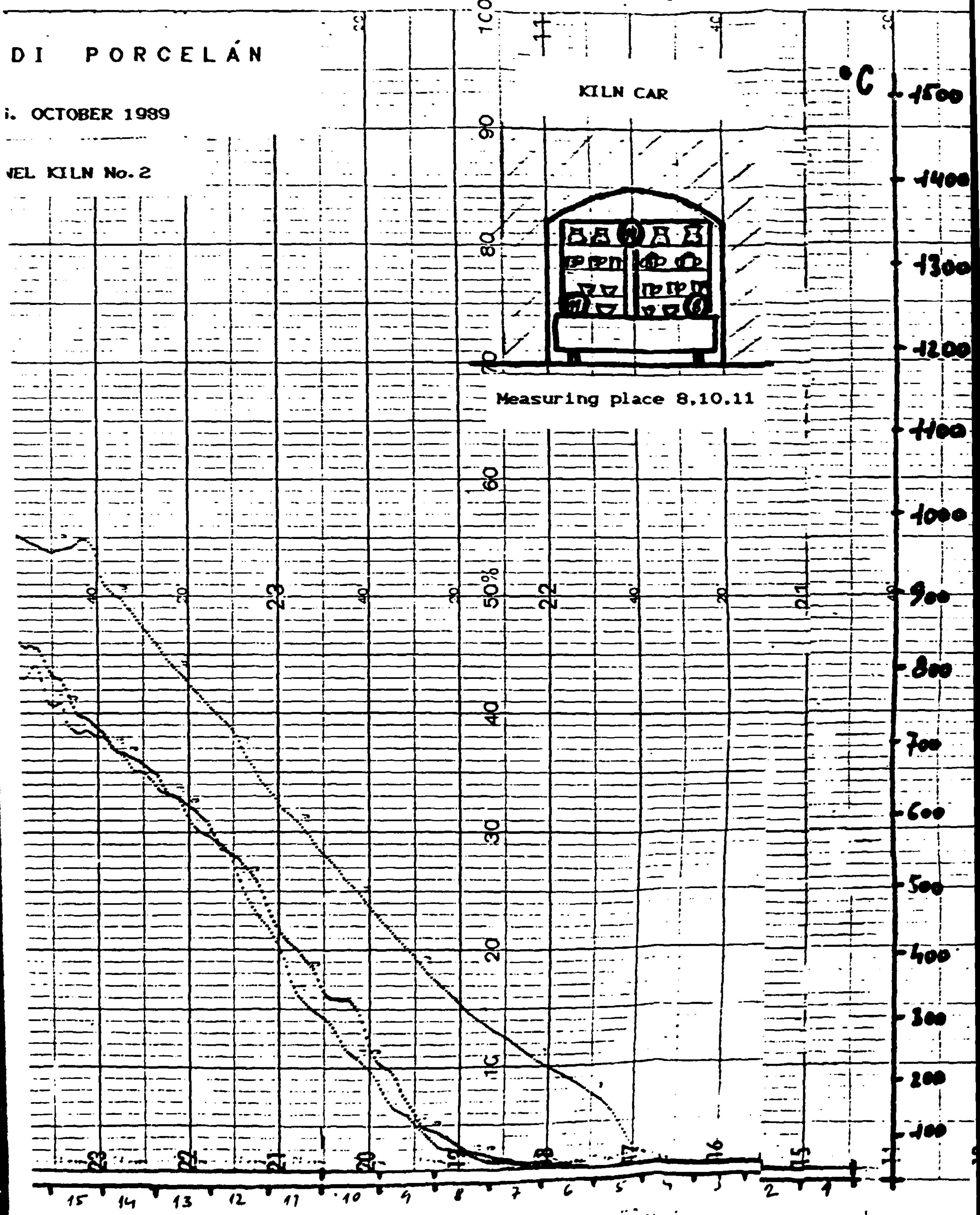

SECTION 3