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FINAL REPORT

Contract No. 86/30

Experimental Tube Digestion of Bauxite in the PEOPLE'S REPUBLIC OF CHINA

Budapest, 1988. December

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FINAL REPORT

Contract No. 86/30
between

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
(UNIDO)

and

ALUTERV-FKI

UNIDO Project No. DP/CPR/85/076
Activity Code: DP/02/31.8

This Final Report comprises this title page, a table of contents and thirty three (33) pages of text and 11 Annexes (A through K.)

TABLE OF CONTENTS

List of Annexes

1.00 INTRODUCTION

The subject of the Project: "Experimental Tube Digestion of bauxite" was to carry out industrial scale tube digestion experiment in China, in Zhengzhou Aluminium Complex. The experiment was completed in June 1983. The performance data collected in the course of the experiment show favourable values permitting the designing of tube-in-tube heat exchange units both for reconstruction of existing digestion lines and construction of new tube-digestion units for diasporic chinese bauxite.

This report gives detailed information about the activities of the whole project implementation, about the perfomance data collected during the experiments and about their evaluation further gives suggestions for the reconstruction of the existing digestion facilities in the digestion section of Zhengzhou Alumina Plant.

The purpose of this experimental pilot unit was to observe and determine the maximum permissible velocity of diasporic bauxite slurry, the rate of erosion of heating tubes and the effect of cyclical caustic liquor cleaning. As a result of the experiments it can be stated that in case of 2,5-3,0 m/s slurry velocity the erosion and the scale formation in the heated slurry pipes is not significant and the value of the heat transfer coefficient shows good value. The effect of the cyclical caustic liquor cleaning could not be experienced as the rate of the scale formation did not make it necessary in the course of the experiment.

The experiment proved that the tube-in-tube type heating elements are suitable for preheating the diasporic bauxite slurry to the digestion temperature, so they are applicable to the reconstruction of the existing direct heating digesting facilities.

It can be stated that the steam consumption can be decreased by at least 1 to 2 tons per ton of alumina if a multi-stage flash tank system is applied with the required number of tube digestion stages.

2.00. ABSTRACT

Development objective of the Project: to reduce the energy consumption in the Aluminium Industry of China.

Immediate Objectives: To determine and demonstrate experimentally on industrial scale the main technological parameters of tube digestion of diasporic chinese bauxite to the extent required for the reconstruction of the existing facilities of bauxite digestion in the Zhengzhou Aluminium Complex.

China's bauxite is mostly diasporic in its mineralogical character which is the most problematic type for industrial processing. New advanced technologies such as indirect heating of autoclave digesters and tube digestion have been developed in some contries, but these new achievments had not yet been tested for the bauxite of and applied to the alumina plants in China. Introduction of indirect heating tube digestion elements of industrial scale requires plant tests with the specific type of diasporic chinese bauxite slurry. For this purpose two industrial scale experimental tube preheating /digestion units have been inserted in the 5th existing operating autoclave digestion line of the Zhengzhou Alumina Plant.

Aluterv-FKI with MOTIM WORKS carried out tube digestion experiments at Mosonmagyaróvár between 1974-1978. This experiment provided reasonable and sufficient data for Aluterv-FKI to design an industrial-scale tube digestion system which was realized later during the updating of the MOTIM WORKS digesting unit. The equipment has been in continuous operation since May of [illegible] with a capacity utilization of [illegible] %. Capacity of the unit is 10 t

Al_2O_3/hour which - at the same time - represents the full capacity of the plant. Heat energy supply to the tube digestion is assured by the existing boyler-house allowing digestion temperature of 260 °C. During the 6-year operation Aluterv-FKI have gained reasonable experience in the field of the plant operation and the technological and mechanical maintenance.
In the last years, the facilities being in operation at the MOTIM WORKS were visited by and introduced to the experts of Zhengzhou Aluminium Complex.

Development activities in progress at present.

- DAZ (Soviet Union): Experiments to determine the abrasive effects of diasporic bauxites. For this purpose tube sections of different diameters were installed in the system (similar to M04 heating element) providing possiblity to determine the extent of abrasion at differeent flow rates. These experiments have been carried out since February of 1982.

- Ajka (Hungary): The size of the tube digestion elements operating in this plant more than two years is suitable for digestion lines of 150-200 tpy alumina production capacity (similar to M01 heating element). Experiments are carried out mainly with the aim to determine the relationship between the flow-rates and the heat transfer coefficient of different temperatures.

- Almásfüzitő (Hungary): Here is an experimental tube digestion equipment suitable for processing 3 m^3/h slurry at 300 °C or at somewhat higher temperature. The equipment is a three-tube system with molten salt heating.

3.00. IMPLEMENTATION OF THE "PROJECT"

Implementation of the "Project" was carried out in three distinct phases as specified.
Summary of the more important activities performed in the individual phases are given below.

3.01. Phase I.

a.) Preparation by Subcontractor of the designs for the non-standard equipment and documents for invitation of tenders for the equipment to be procured from foreign sources with the participations of 4-man Chinese team at the Subcontractor's headquarters.
4-man Chinese team:

Yin Xie Cheng	leader of the delegation, vice director (Zhengzhou Aluminium Plant)
Li Juan Jie	dy chief engineer (Zhengzhou Aluminium Plant. National Project Director)
Wang En Bo	manager (Zhengzhou Alumina Plant)
Lin Qi Wen	dy manager of the design division (Zhengzhou Aluminium Plant)

took part in the first phase of design of the below listed non-standard equipment:

Denomination. dimension	Maschine No.	Drg.No.
1. Heating element O.D.273x13000 mm	M01	252.12K-3.02 00-00/E
2. Liquor tank O.D.3150x3150 mm	M02	252.12K-3.04 00-00/E
3. Heating element L=6500 mm	M04	252.12K-3.01 00-00/E

Further Parties fixed up the basic technological data for design the detailed engineering drawings.

Main technological design data (average data)

- Feed slurry:

Volumentric flow:	75-80 m^3/h
Temperature:	80 °C
Density:	1,56 t/m^3
Solids content:	250 g/l
Pressure after H.P. piston pumps:	3,4-3,5 MPa
Slurry temperature after the 3rd stage of preheaters:	155 °C
Pressure in the 1st autoclave:	2,87 MPa
Slurry temperature after the 1st autoclave:	220 °C

- Heating steam (before the conditioning valve)

Pressure:	3,34 MPa
Temperature:	346 °C

- Heating steam (after the conditioning valve)

Flow rate:	2,5 t/h
Pressure:	1,85 MPa
Temperature:	215 °C

- Digestion liquor:

Caustic Na_2O concentration:	275 g/l
Molar ratio:	3,3
Temperature:	90-95 °C

Further design data, statements:

- Installation place of experimental tube digestion elements: by the existing 5th digestion line.

- Design of equipment pipe system and instrumentation: as per MSZ 52 (Hungarian Standard)

A preliminary flow-sheet of experimental tube digestion system was made and accepted by the Parties. Further they agreed upon battery limits both for designing and supply of equipment and pipe system with instrumentation.

Experts of the Zhengzhou Aluminium Plant were given the opportunity t visit several production facilities of HUNGALU the Hungarian Aluminium Corporation (MOTIM Alumina and Electrocorundum Plant, Almásfüzitő Alumina Plant, Ajka Alumina and Aluminium Works, Székesfehérvár Light Metal Works and the research facilities of Aluterv-FKI).

On designing of non-standard equipment and the other activities of the Chinese experts during their stay in ALUTERV-FKI a MINUTE was put down and a copy of that submitted to UNIDO.

Subsequent to the tender invitations for the non-standard equipment and the evaluation of the offers submitted the manufacturing of non-standard equipment started.

b.) Before the site mission of the Subcontractor's design team started the team leader T.Ferenczi visited the UNIDO Headquarters in Vienna (16-18, 07.1988) for briefing.
He had discussions with Dr.E.T.Balázs, the Head of the Division of Industrial Operations and Mr.S.Morozov, chief Contract Unit Division of Industrial Operations.

c.) Design work on the sport in China by Subcontractor's team and Chinese team on installation, pipeworks, utilities' connections and automatization.

Between July. 28- Aug.31. 1988 an Alutery-FKI's team of 5 designers;

T. Ferenczi	Team leader
Gy.[illegible]	Process Engineer
P. Bodnár	Mechanical Engineer
P.Vona	Process Control Engineer
T.Golyán	Civil Engineer

visited Zhengzhou Alumina Plant.

At the first day of the site mission the Subcontractor's design team visited the office of UNDP in Beijing on 29.07. 1988 and getting information at the beginning and reporting on their work.
Mr. A.M.[illegible], Resident Representative of UNDP received the delegation.

The design team had several discussions with the Representatives of Zhengzhou Alumina Plant in connection with the Project Implementation.
They surveyed the site of installation, collected the necessary data for detailed designs, measured the place for erection of experimental equipment, piping and instrumentation system. Based on this they prepared major part of the mechanical arrangement, piping, electric designs and instrumentation drawings, moreover data supply for construction engineering. The activities carried out there and the agreements in connection with the design are detailed in a separate Minutes. A copy of this Minutes was handed over to Mr.A.W.Siccingh the Resident Representative of UNDP in Beijing at the end of the site mission of the Subcontractor's design team on 2[illegible].1986.

d.) After completion their site mission Subcontractor's designers made detailed engineering drawings of mechanical arrangement, pipe system and instrumentation. They wrote the [illegible] REPORT and submitted to UNIDO Vienna while Team leader T.[illegible] visited there for the purpose of debriefing on 22-24. Oct. 19[illegible].

- Detailed engineering drawing for installation.
  i) Piping and lay-out plan Drg. No. 2[illegible].12K-3.03/00-[illegible]
  The Flow-sheet shows all the technological connections between the experimental tube digestion system and the existing 5th digestion line. The Flow-sheet is attached hereto as ANNEX "A" Drg.No. 2[illegible].12K-3.07/0000
  Sheet No. 2[illegible].
  The more important pipe [illegible] of the experimental tube digestion system:

Item No.	Denomination of pipe
P1	Slurry pipe to heating element M01
P2	Slurry pipe to heating element M04
P3	Liquor pipe from pump to heating element
P4	Liquor pipe from heating element to caustic liquor storage tank M02
P5	Steam pipe to heating elements M01 and M04
P6	Condensate water pipe from heating elements
P7	High-pressure water pipe to steam - conditioning valve M05
P8	High-pressure water pipe to tank M02
P9	Low pressure steam pipe to tank M02
P10	Slurry discharge pipe from heating element M01
P11	Slurry discharge pipe from heating element M04
P12	Air-went pipe from heating element M01
P13	Air-went pipe from heating element M04
P14	Slurry discharge pipe from liquor pump and tank
P15	Heating steam pipe to digester

On the Lay-out plan the arrangement of experimental equipment and the more important pipe connections can be seen.
The Lay-out plan Drg.No. 282.12K-3.03/00-00 Sheet No.26/2 is attached hereto as ANNEX "B".
The Project has been implemented by installation of the following equipment and accessories, instrumentation and control system.

Equipment code	Pcs	Denomination, dimensions
M01	1	Heating element O.D.273x13000 mm Heating tubes: 3 pcs dia 76x5
M02	1	Liquor storage tank dia 3,15x3,15 m $V=25\ m^3$
M03	1	Liquor pump $Q=60\ m^3/h$, $H=40\ m$, $N=30\ kW$
M04	1	Heating elements (three elements in one unit) a) O.D. 273x6500 mm, heating tube: 1 pc. dia 159x8 mm b) O.D. 219x6500 mm heating tube:1 pc.dia 133x7,1 mm c) O.D. 219x6500 mm heating tube:1pc.dia 114,3x7,1mm
M05	1	Steam conditioning valve consisting of control valve, steam cooler, water control valve. DN 65, PN 100
M06	2	Centrifugal pump (7 stages) $Q= 0,63\ m^3/h$, $H= 322\ m$, $N= 4\ kW$
-	-	Pipes, fittings, valves, pipe supports (as per detailed specification)
-	-	Steel structures with equipment items M01 and M04
-	-	Electrical and instrumentation system

Upon request of the [illegible] party, [illegible] supplied an ultrasonic tube wall-thickness measuring instrument instead of liquor storage tank dia 3,15x3,15 m ([illegible]) given in the List of Equipment. Copy of the relevant "Agreement" is enclosed hereto as ANNEX "[illegible]".

ii) Instrumentation drawing. No. 252.12K-6.16/R

Measuring and control loops:

Code	Denomination
PIC 01	Steam conditioner pressure controller
TIC 02	Steam conditioner temperature controller
TIR 03	Temperature measurements on heating elements
PIA 04, PIA 05	Digestion pressure guard.

Components of measuring and control loops:

- PIC 01 Steam conditioner pressure controller:
  Pressure transmitter with fastening element and manifold.
  Electronic three joint controller
  Steam conditioner valve with electromotor operation.

- TIC 02 Steam conditioner temperature controller:
  Platinium 100 resistance thermometer
  Electronic three joint controller
  Electromotor operated control valve.

- TIR 03 Temperature measurements on heating elements M01 and M04
  Joint elements for resistance thermometers
  Resistance thermometer
  Multipoint six channel recorder
  Electronic digital temperature measuring instrument.

- PIA 04, PIA 05 Digestion pressure guard
  Manometer with adjustable limit switch

- Control panel with accessories:
  - Control panel
  - On/off switch
  - Protecting fuses
  - Terminal points
  - Field terminal boxes.

3.02 Phase II.

a.) Manufacturing and transportation of imported and locally manufactured equipment to the spot of installation at Zhengzhou in China.

Based on the prepared detailed engineering drawings and specifications a part of equipment and components of the whole experimental tube digestion system were manufactured or procured from domestic, the other part from foreign suppliers.

Equipment and components supplied by domestic suppliers:

- Heating element O.D. 273x13000 mm M01
- Caustic liquor pump Q= 60 m^3/h, H=40 m M03
- Heating element L=6500 mm M04
- Straight pipes, pipe fittings, supports
- Valves, steam traps
- Instrumentation panel, instrumentation loops
- Local pressure and temperature gauges
- Steel structures

Imported items:

- Steam conditioning valve with control system M0[illegible]
- High-pressure water pumps M05
- Steam valves, special slurry valves safety valves, non-return valves
- Instruments
- Ultrasonic wall-thickness measuring device

First the goods supplied by domestic suppliers were transported to the spot of installation. Due to difficueties of getting import licence, the imported items were transported later which caused about 3 months delay in the project implementation. On Aluterv-FKI's request UNIDO agreed to that.

b.) Installations of the industrial - experimental unit at the Zhengzhou Alumina Complex under supervision of 2 Hungarian experts.

T.Ferenczi Team leader (mech.eng.)

Cs.Orbán Erection Supervisor Engineer

between Oct.6-Dec.17, 1987.

On taking over the equipment, machinery parts and other installation materials, moreover on the most important events of installation, erection a separate MINUTES was put down, and a copy of that was handed over to the Resident Representatives of UNDP in Beijing when Hungarian experts visited there on 14th Dec. 1987.
At the installation of the experimental tube digestion system the following requirements were taken into consideration:

- The experimental equipment have been placed as close as possible to the existing/oper[illegible] digestion line to ensure easy handling and smooth operation of both systems.

- The pipe connections between the existing and the experimental equipment have been designed and realized with optimum routes,

- Installation of the equipment and erection of pipe routes will not affect the [illegible] of the existing digestion [illegible],

- The 13 m length tube digestion element (M01) and the 6.5 m length heating element (M04) consisting of three different dia sections were placed on the 12.6 m level digester handling platform, inside the steel structure building near to the slurry preheaters and digesters,

- The steam conditioning valve has been erected in the vertical section of the existing steam pipe between the levels of 6.2 and 12.6 m

- The high pressure water pumpes supplying water to the steam conditioner are placed on the 6.2 m level near the steam conditioning valve,

- The caustic liquor storage tank (M02) and the liquor pump (M03) have been set up on the ground floor,

- The instrumentation panel of experimental tube digestion system is placed into the existing control room near the 12.6 m level,

- The pipe sections have been erected according to the technological requirements and local conditions.

In the last stage of the installation the specified works:

- pressure test of equipment and pipe system,
- non-destructive testing of welding seams,
- heat treatment of the marked welding seams,
- steam flushing of steam pipes and heating side of heating elements were performed.

3.03 Phase III.

a.) Start-up and experimental operation of the industrial experimental unit in China, collection of perfomance data of experimental operation:

The start-up procedure and the first stage of the experimental operation were carried out between January 16 March 27, 1988 with participation of two experts of Aluterv-FKI

T.Ferenczi	Team leader (Mech.eng.)
I.Cziniel	Shop leader (Chem.eng.)

i.) Activities of start up procedure:

Training of the staff.

A detailed operating instruction for the whole experimental tube digestion system was prepared and handed over to the members of the operating staff.

Mechanical operations.

Equipment and armatures were checked for the purpose of proper operation.

Pressure test.

Cold water pressure test of equipment and connecting pipe system including safety valves.

Electrical and mechanical testing of pumps were executed according to the relevant maschine books.

Blow-out of steam pipes.

The steam pipes as well as the heating side of the heating elements was cleaned by means of fresh steam flow.

Testing of the process control elements.

Their test occured as per relevant specifications.

Recording of the technical condition of the experimental equipment.

The places for wall-thickness measuring were marked and the initial wall-thicknesses were measured and recorded.

Cold water test.

Cold water was circulated by caustic liquor pump from caustic liquor tank through P3 pipe, M01 heating element, P4 pipe back to the tank, and similary through M04 heating element.

Hot water test.

After the cold water test, the water having been circulated was preheated by low-pressure steam and then hot water test was executed.

After the succesful preparatory works the slurry test and later the slurry experiment started.

ii.) The slurry experiment was executed according to the relevant Technical descriptions and operating instructions. When the slurry experiment started, collection and registration of performance data and calculation of the heat transfer coefficient started, too. The chart of the most characteristic performance data and the figure of heat transfer coefficient are enclosed hereto as ANNEX "[illegible]" and ANNEX "[illegible]" respectively. After 7-8 days of slurry experiment the caustic liquor cleaning of M01 heating element was stopped as the calculated heat transfer coefficient value [illegible].

A detailed MINUTES was put down of the start-up procedure and the first phase of slurry experiment. A copy of this MINUTES was handed over to the Resident Representative of [illegible] in [illegible] when the [illegible] experts visited there on [illegible] March, 19[illegible].

iii.) The second phase of the slurry experiments was executed between April 26 - June 09, 1988 with the participation of two experts of Aluterv-FKI:

T.Terenzri	Team leader (mech.eng.)
J.[illegible]eck	Production Manager (mech.eng.)

The second phase of slurry experiment was executed on the same way as the first one and similar performance data were collected. The registration of performance data and the calculation of heat transfer coefficients continuoud and charts containing of these data are enclosed hereto as ANNEX "D" and ANNEX "C" respectively. Wall-thicknesses of slurry pipes of heating elements and their connecting pipes were measured at the marked places several times in case of both phases of slurry experiments.
The value of the measured wall-thicknesses as well as the pl[illegible] of wall-thickness measurement are enclosed herewith as [illegible] "F" and ANNEX "G". A detailed MINUTES was put down of the second phase of slurry experiment. A copy of this MINUTES was submitted to the Resident Representative of UNDP in Beijing when Hungarian expert visited there on 9th June 1988.

b.) Processing of experimental data at Subcontractor's Headquarters. Evaluation with participation of the team of Chinese representatives.
Processing of the performance data and evaluation of slurry experiment were executed between September 16 - October 07, 1988 in Aluterv-FKI's Headquarters in Budapest with participation of five Chinese experts:

Mr.Li [illegible]	Dy Chief Engineer of Zhengzhou Aluminium Plant National Project Director

Mr.Fang Qiu Long	Dy Manager of Zhengzhou Alumina Plant
Ms.Hu Qili	Senior Engineer, Vice Director of Process Research Department of Zhengzhou Alumina Plant
Ms.Ding Shuze	Senior Engineer, Section Chief of Technique and Energy Sources Division of Zhengzhou Alumina Plant
Ms.Juo Jie	Interpreter of China National Non-Ferrous Metals Industry Corp.

The Parties have thoroughly considered and discussed in details the activities carried out during the three phases of the Project implementation in connection with the engineering, machinery supply, erection, start-up and experiments, and evaluated the technological and operational data measured and registered during the experiments. The detailed evaluation is included in this Report.

Referring to the Project Document No. DP/CPR/85/076/A01/37 Part II, para B and D the following comments can be given in connection with the tube digestion experiment.

- The immediate objectives are specified in Project Document as follows:

"To determine and demonstrate on industrial experimental scale the main technological parameters of tube digestion of diasporic Chinese bauxite to the extent required for the reconstruction of the existing facilities of the bauxite digestion in Zhengzhou Aluminium Complex". Further to this in Para D; Project Outputs point 3.:

"Determined values of maximum permissible bauxite-slurry velocity of diasporic Chinese bauxite, of rate of erosion of the heating tubes and of the effect of cyclical caustic cleaning on the special technological equipment applied."

In point 4. of Project Outputs: "Sufficient data and experience permitting designing of tube-in-tube heat-exchanger units both for reconstruction of existing digestion lines and for construction of new tube-digestor units for diasporic Chinese bauxite."

The above specified prescriptions were the key to design, to construct the experimental tube digestion system and to carry out the experiment on that.

The experiment was carried out in two stages.

The first stage started on 5th February and lasted to 21st March 1988. The performance data collected during the first stage as well as the preliminary evalution were given in the Minutes drawn up by the end of the first stage of experiment, dated 22nd of March 1988.

The second stage of experiment started on 3rd May and lasted to 3rd June 1988.

The most important results of both experimental stages:

- <u>H01 heating element</u>

Experiment on this heating element lasted:

in the first stage:

663 hours, (slurry experiment 627, caustic cleaning 36.0)

in the second stage:

644 hours, (slurry experiment 643.5, caustic cleaning 0.5)

Total operating hours:

1307	1270.5	36.5

The inlet slurry flow during the second stage changed between 64.4 and 94 m^3/h, (average 80.82 m^3/h) Velocity of slurry: between 1.75-2.59 m/sec, (average: 2.19 m/sec).
The inlet slurry temperature changed between 108-120 °C, and 130-152 °C range respectively. The heat transfer coefficient calculated daily showed good value (1500-1850 W/m^2K and 3100-3400 W/m^2K, characteristic value 2400-2600 W/m^2K).
When the slurry flow was too low or condensate water discharge from heating element was not proper, the value of theat transfer coefficient showed less value. At the average slurry velocity the value of "k" was 2400-2600 W/m^2K.
On the basis of heat transfer coefficient value caustic liquor cleaning or acid solution cleaning was not needed on this heating element, as scale formation in the heated slurry pipes could not be observed at a proper slurry velocity. By visual examination of inside surface of heated slurry pipes unmeasurable colouration could be experienced. Sample from scaling could not be taken.
On the basis of wall thickness measurement of the three heated slurry pipes negligable wear could be experienced. In the inlet side the inside surface of pipes at about on 300 mm length were polished, the manufacturing surface roughness disappeared. On the other part of pipes including the outlet pipe side the lower 1/3 surface became smooth.
The inside pipe diameter of slurry pipes were measured at the inlet side. The rate of erosion was 0.15-0.3 mm after 1307 working hours.
The scale formation and wear of slurry pipes were less than they had been supposed. Performance data collected and processed on the course of experiment proved that this heating element was suitable for preheating diasporic bauxite slurry, and at an optimal slurry velocity (2.5-3 m/s) in a temperature range of 100-152 °C its thermal duty showed good value.

Its operation could be controlled with the help of the installed instruments.
Slurry operation of this heating element was stopped only once for the purpose of rectification of one welding seam in the connected slurry pipes.

The rate of scale formation was less than it was supposed the efficiency of cyclical caustic cleaning could not be experienced. It can be supposed that longer operational period could go on on this heating element without custic liquor cleaning or acid solution cleaning would be sufficient occasionally to remove the the scaling. To have sufficient data about this further experiment and its extension to higher temperature range might be reasonable.

- <u>M04 heating element</u>

Slurry experiment lacted on this heating element:

in the first stage	935 hours
in the second stage	667 hours
Total operating time	1602 hours

The inlet slurry flow during the second stage of experiment changed between 64.4 and 94.6 m^3/h (average 80.8[illegible] m^3/h).
The inlet slurry temperature changed between 198-222 °C and the outlet temperature 200-228 °C.
The planned function of this heating element was to have performance data about the rate of scale formation, the rate of erosion at various slurry velocities in high temperature range of the digestion process of diaspore bauxite slurry.

The realistic thermal duty could not be experienced, the valuable heat transfer coefficient could not be calculated on this heating elements as the inlet slurry temperature was nearly the same or higher than the temperature of the heating steam, moreover it was realized that from the first digester slurry-steam mixture flowed to this heating element resulted that direct and indirect heating was there even after making overheated steam connection to this heating element.

The wall thicknesses of this heating element and its connecting slurry pipes were measured several times, further the inside surface of the various diameter sections and their connecting pipe fittings could be visually examined.

The results of visual examinations and of wall thickness measurements are as follows (taking into account the average slurry flow or slurry velocity):

After 1602 working hours:

Section DN 100: average slurry velocity 2.95 m/s
min. slurry velocity 2.36 m/s
max. slurry velocity 3.46 m/s

Straight pipe section:

Scaling: Could not be experienced

Erosion: Could not be experienced in the straight pipe only on root welding of welding seam.

Reducer DN 100/125

Scaling: No scaling

Erosion: Erosion could be seen on the upper edge of the flange (DN 100) because of excentric matching of flanges.

Pipe bend DN 125:

Scaling: At the outlet side 0.8-1.0 mm thick hard unbroken scaling, in the pipe bend spotted scaling

Erosion: No erosion

Section DN 125:	average	slurry velocity	2.09 m/s
	min.	slurry velocity	1.66 m/s
	max.	slurry velocity	2.44 m/s

Straight pipe section:

Scaling: there was 0.2-0.4 mm thick scaling

Erosion: could not be experienced

Reducer DN 125/150:

Scaling: 0.4-0.6 mm scaling

Erosion: Could not be experienced.

According to the above observations it can be stated that the optimum velocity for the processed diasporic bauxite slurry is 2.5-3.0 m/s when the rate of erosion is low or min. scale formation is there.

Slurry experiment on this heating element could be controlled with the help of the installed instruments.

Operation of this heating element was stopped when the welding seam of the connecting slurry pipe had to be rewelded and when due to other operational difficulties the slurry valve erected into connecting slurry pipe failed.

The operation of this heating element was suitable for its planned function.

Other equipment:

Caustic liquor tank: M02

Its operation was suitable to the planned function

Caustic liquor pump: M03

Its operation was suitable to the planned function, its sealing was exchanged two times.

Steam cooling system:

- High pressure condensate water pumps: M06
  On the first period of the experiment their operation were going on as per specification. Later, due to operational reasons they were failed. After exchanging some of their parts (impellers, shaft, bearings, sealings) their operation was suitable to the planned function.

- Steam conditioning valve, high pressure control valve M05:
  Their operation with the whole pressure and temperature control system were suitable to the planned function.

Multipoint resistant thermometers:

They measured and indicated no realistic temperature values even after modification of the tapping points. Temperatures of slurry, condensate water and steam were measured by means of newly installed local mercury thermometers.

Pipe system with armatures:

The erected pipe system served properly for the technological function. Some of the welding seams in the slurry pipes failed several times but after their rectification the slurry experiment could be continued.
Special angle slurry valves erected to slurry pipes of M01 heating element failed and caused operational difficulties. Gate valves made in China (4 pcs) were erected in their places. This kind of slurry valves were not suitable for the processed diasporic bauxite slurry operation at this operational conditions for longer period.

On the disc of two special angle slurry valves erected in the connecting pipe of H04 heating element measurable erosion could be observed after 1300 working hours. One of them was exchanged with the spare one. This valve would need some modification for using in diasporic slurry operation.

The other valves in general, like steam valves, valves in condensate water pipes, safety valves, check valves ... were suitable to their planned function.

The tube digestion experiments were carried out according to the given requirements.

4.00 ANALYSIS OF SAMPLES TAKEN FROM TUBE HEAT EXCHANGERS

ALUTERV-FKI has performed analyses of the samples of processed bauxite and those of scalings and sediments deposited at certain points of the tube type heat exchanger preheaters to determine their chemical and mineralogical composition. The results obtained are summarized in Annex "H".

The examined bauxite sample was found corresponding to the bauxite processed in February 1988. The analysis revealed that the Al_2O_3 content is present mainly in the form of diaspore, while the SiO_2 content was present in the form of kaolinite, chamosite and illite. The kaolinite accounts for the 25-30 % of the silicates.

The sediment taken in March 1988 from the position after the H01 element was a sandy-like formation and on the basis of its chemical and mineralogical composition is considered to be undigested bauxite.

On May 20, 1988, sample was taken from points at H01 element and D125 portion of H04 element. The sediment at H01 was deposited, undigested bauxite, while the thin, bark-like sediment at H04 was a calcium-titanate formation overlapped with considerable amount of magnetite. The latter is supposed to originate from transformation of goethite.

The thin bark-like sediment taken on June 4th from the D125 portion of H04 element shows similar composition to the sample taken in May. The sandy-like sediment deposited after the supply valve of the H04 element contains mainly sodalite and cancrinite, at the same time, however, the calcium-titanate phase is also considerable. It is particular with this sample that - according to our experiences gained so far - the above mentioned phases were characteristic to the bark-like sediments.

5. SUGGESTION FOR RECONSTRUCTION OF EXISTING DIGESTION LINE

The present steam consumption in the Bayer circle of the Zhengzhou Alumina Plant is almost double the value attained in other alumina plants operating at standard medium level. This is caused mainly by the poor utilization of heat content of the digested slurry, moreover by the direct heating applied at the digestion, condensate of which is required to be removed by evaporation from the circuit.

The tube heat exchanger elements succesfully proved during the experiments could make possible to decrease considerably the heat consumption of the Bayer circle. A variant of the possible solutions is shown on Fig.No.1. ANNEX "I". In this variant, the existing steam supply system is considered, this way the final digestion temperature is unchanged, i.e. 245 °C. The notable increase of recuperation efficiency is achieved by increasing the number (from 3 pcs to 12) of the flashing stages. The heat transfer area required for utilization of the flashing steams can most economically be provided by a slurry preheating system build up from tube heat exchangers. This is explained by the high heat transfer coefficient, as justified also by the experiments. Due to the good recuperation efficiency, the digestion slurry can be heated by flash steams up to a temperature of about 200 °C, against the temperature of 150 °C, achieved at present. Live steams are required for futher heating only, namely up to 225 °C by tube heat exchanger system, and from there to 245 °C by direct heating in autoclaves.
Accordingly, using this system, only such amount of condensate would get into the digestion slurry that is produced by a direct heating corresponding to a temperature difference of 20 °C, compared to that amount originating from the present temperature difference of 95 °C.

As a result of this, the primary heat energy consumption of the digestion and the evaporation can considerably be decreased representing altogether 2.0-2.2 t amount of steam per 1 t of alumina produced.
The advantage offered by the implementation of the tube digestion can be increased further by using heating steam of higher pressure (80 bar).

6.00 CONCLUSIONS

Parties agreed upon and stated that the tube digestion experiments have provided useful and important results necessary for design the reconstruction of the digestion system.
Considering, however, that the M01 heat exchanger was operated at low temperature range, the experiments performed could not provide sufficient data to determine the amount and chemical composition of the sediments forming and depositing in the temperature range of 150–220 °C. Further on, the experiment failed to give information on the operational cycle times to be considered for digestion of diasporic bauxites on tube digestion element.
Taking the above into consideration, extension into higher temperature ranges of the experiments are felt necessary by the Parties.

At a later date, the Chinese Party shall make a decision considering one of the digestion lines on which the further experiments are required to continue. Moreover, they deem it necessary to introduce a more efficient desilication process which would result in smaller amount of deposits and sediments in the heated slurry pipes.

Remark:

Chinese Party accepted the Draft Final Report.
See telex No. 121 40320.48 as ANNEX "K".

7.00 REFERENCES

1.) CONTRACT No.86/30 between THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION (UNIDO) and Aluterv-FKI

2.) PROJECT DOCUMENT No.DP/CPR/85/076/A/01/37

3.) PROTOCOL on the discussions held by Mr.Lin Ying and Mr. Shen Wenrong of UNIDO with the representatives of Aluterv-FKI in Budapest on 10th and 11th September, 1985.

4.) OFFER Subject: Experimental tube digestion of bauxite in the People's Republic of China (DP/CPR/85/076) Dates 31st January, 1986.

5.) WORK PLAN. TITLE: EXPERIMENTAL TUBE DIGESTION OF BAUXITE

6.) PROGRESS REPORT Contract No. 86/30

7.) MINUTES of meetings held with Chinese experts visiting Hungary 25.May-20.June, 1986 in the frame of Ctr.No. 86/30. UNIDO/Aluterv-FKI: "Experimental Tube Digestion of Bauxite in the People's Republic of China" (Project No. DP/CPR/85/076 and with representatives of Aluterv-FKI.

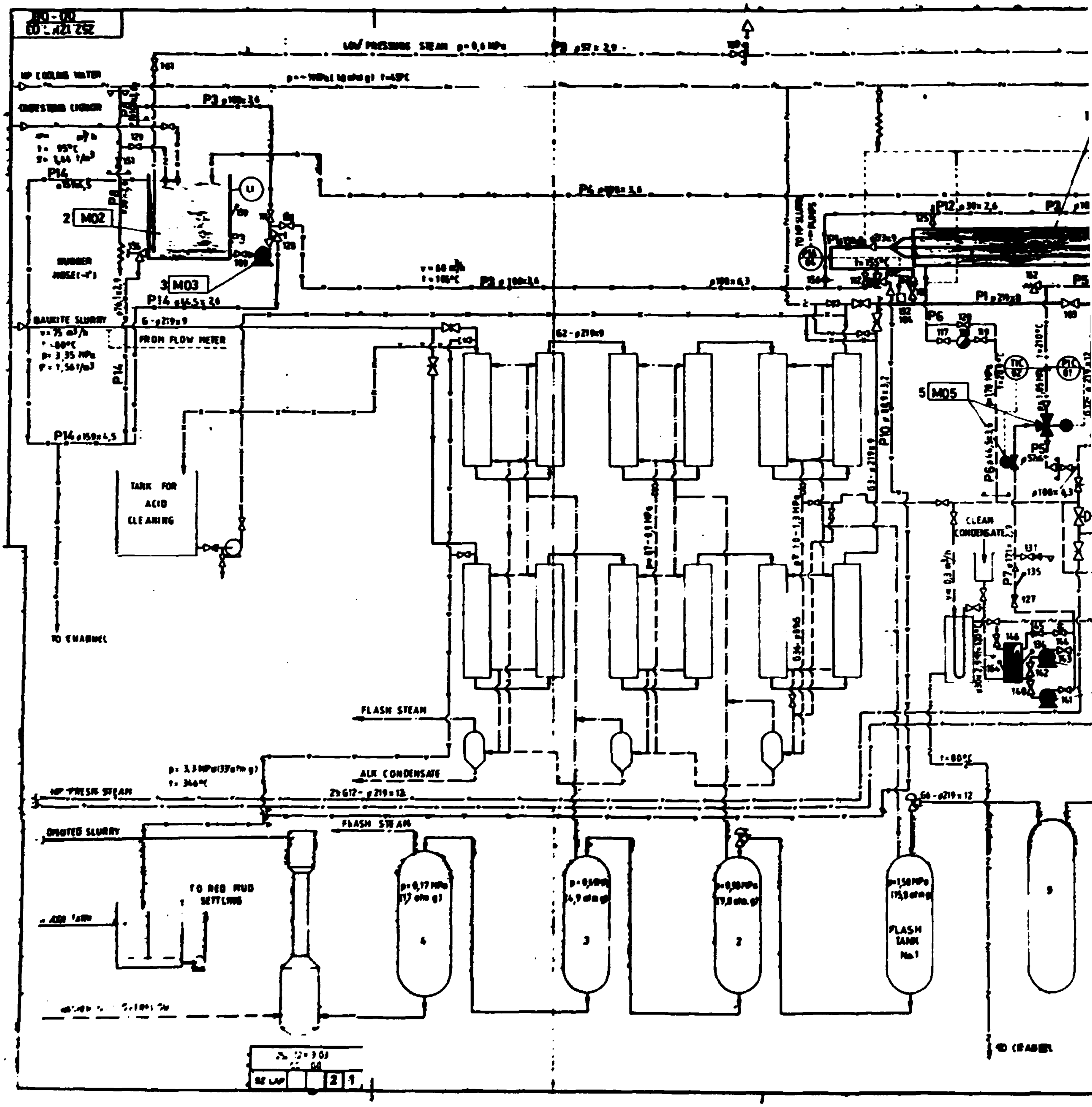
8.) MINUTES of meetings held with Hungarian Experts visiting People's Republic of China Henan Province in Zhengzhou Alumina Plant 28.July - 31. August 1986. in the frame of Ctr.No. 86/30 UNIDO/Aluterv-FKI: "Experimental Tube Digestion of Bauxite in the People's Republic of China" (Project NO. DP/CPR/85/076) and with representatives of Zhengzhou Alumina Plant.

9.) MINUTES of meetings held with Hungarian Experts visiting People's Republic of China, Henan Province in Zhengzhou Alumina Plant between 6th October-17th December 1987, in the frame of Ctr.No. 86/30 UNIDO/Aluterv-FKI: "Experimental Tube Digestion of Bauxite in the People's Republic of China" (Project No.DP/CPR/076 and with Representatives of Zhengzhou Alumina Plant.

10.) MINUTES of meetings held with Hungarian Experts visiting People's Republic of China, Henan Province in Zhengzhou Alumina Plant between 16th January-27th March 1988, in the frame of Ctr.No. 86/30 UNIDO/Aluterv-FKI: "Experimental Tube Digestion of Bauxite in the People's Republic of China" (Project No.:DP/CPR/85/076) and with Representatives of Zhengzhou Alumina Plant.

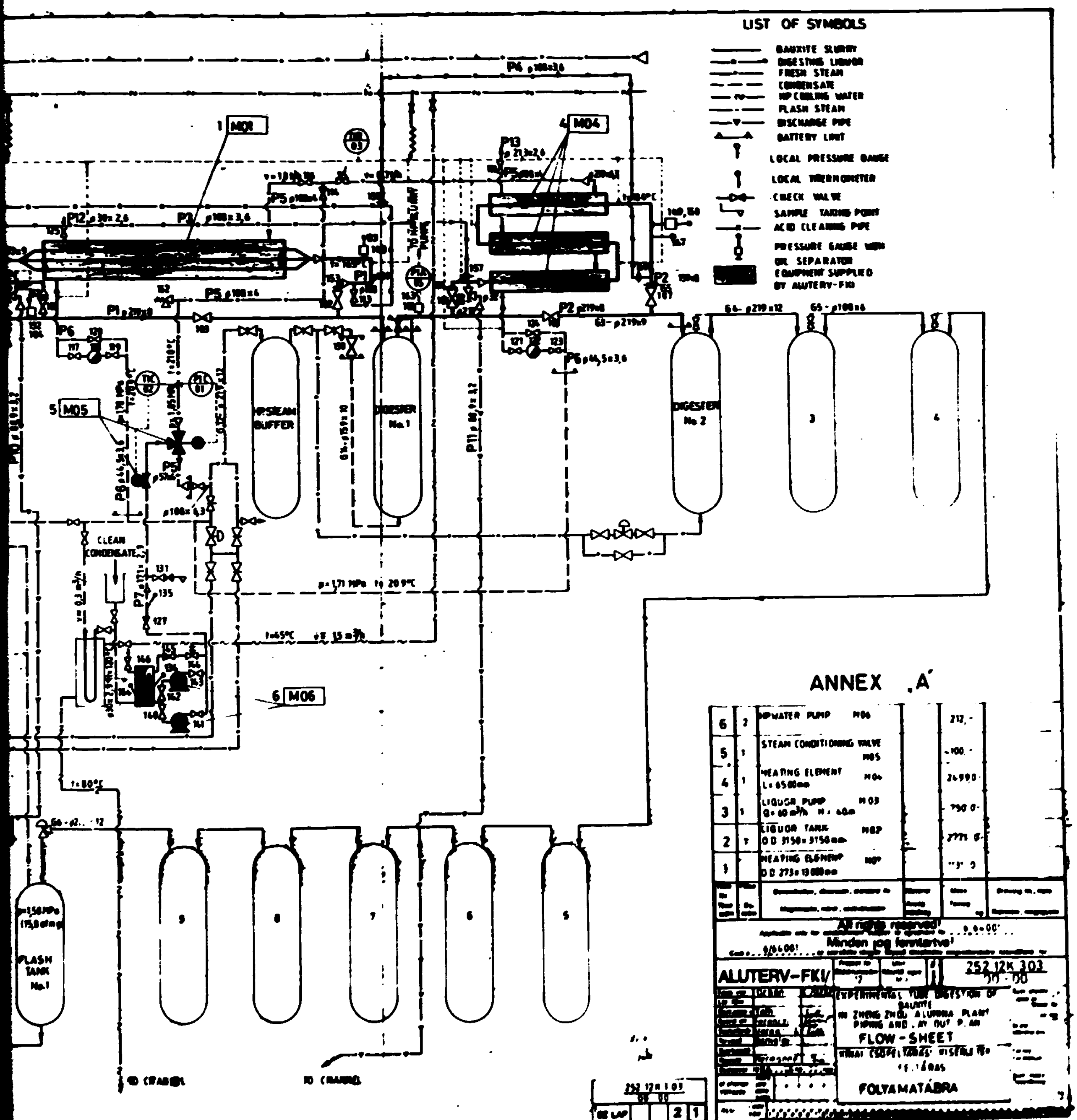
11.) MINUTES of meetings held with Hungarian Experts visiting People's Republic of China, Henan Province in Zhengzhou Alumina Plant between 26th April-9th June 1988, in the frame of Ctr.No.:86/30 UNIDO-Aluterv-FKI: "Experimental Tube Digestion of Bauxite in the People's Republic of China" (Project No.DP/CPR/85/076) and with Representatives of Zhengzhou Alumina Plant.

12.) MINUTES According to the Contract No.86/30 between the United Nations Industrial Development Organization (UNIDO) and Aluterv-FKI (Contractor) concerning the UNIDO Project No.DP/CPR/85/076 experts of China National Non-Ferrous Metals Industry Corporation visited Aluterv-FKI, Hungary for study tour between 16.09.1983 and 07.10.1983.

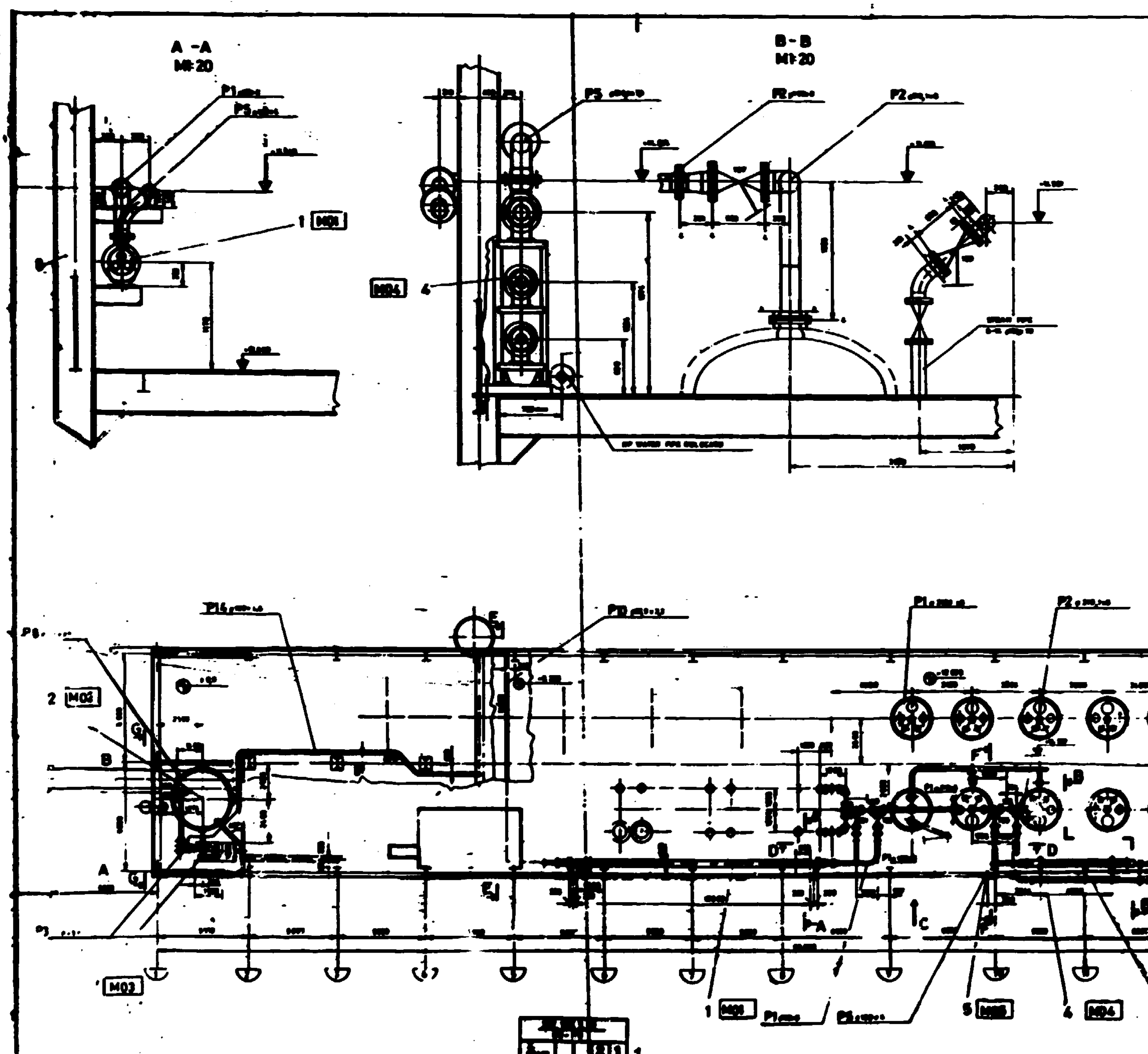


LOW PRESSURE STEAM
HP COOLING WATER
DIGESTING LIQUOR
RUBBER HOSE
BAUXITE SLURRY
FROM FLOW METER
TANK FOR ACID CLEANING
TO CHANNEL
FLASH STEAM
ALK CONDENSATE
HP FRESH STEAM
DILUTED SLURRY
TO RED MUD SETTLING
FLASH TANK No.1
CLEAN CONDENSATE
M02
M03
M05

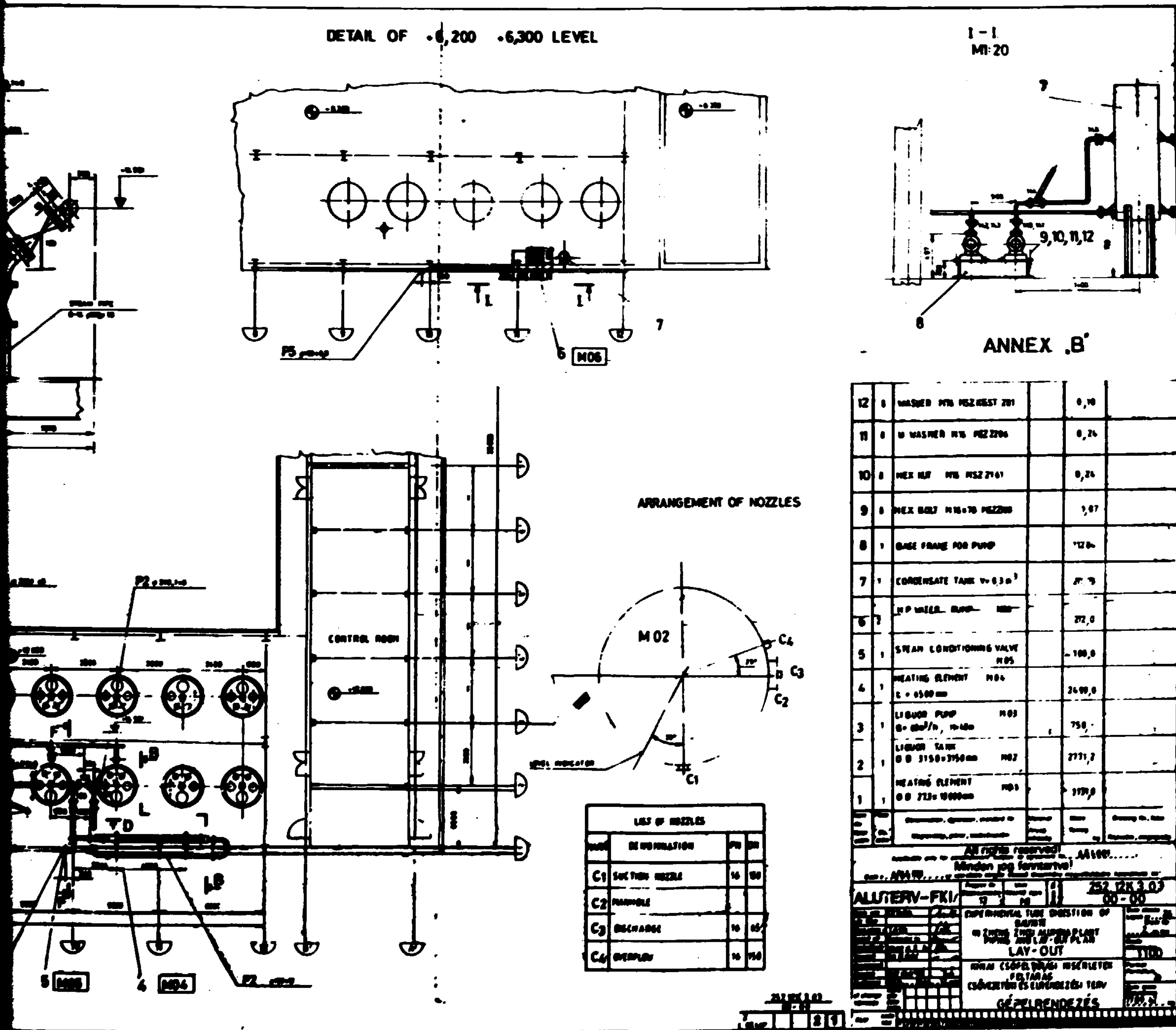
SECTION 1


LIST OF SYMBOLS
BAUXITE SLURRY
DIGESTING LIQUOR
FRESH STEAM
CONDENSATE
HP COOLING WATER
FLASH STEAM
DISCHARGE PIPE
BATTERY LIMIT
LOCAL PRESSURE GAUGE
LOCAL THERMOMETER
CHECK VALVE
SAMPLE TAKING POINT
ACID CLEANING PIPE
PRESSURE GAUGE WITH OIL SEPARATOR
EQUIPMENT SUPPLIED BY ALUTERV-FKI
1 M01
4 M04
5 M05
6 M06
HP STEAM BUFFER
DIGESTER No.1
DIGESTER No.2
FLASH TANK No.1
CLEAN CONDENSATE
TO CHANNEL
ANNEX .A
HP WATER PUMP
STEAM CONDITIONING VALVE
HEATING ELEMENT
LIQUOR PUMP
LIQUOR TANK
HEATING ELEMENT
All rights reserved!
Minden jog fenntartva!
ALUTERV-FKI
252 12K 303
EXPERIMENTAL TUBE DIGESTION OF BAUXITE
FLOW-SHEET
FOLYAMATÁBRA
252 12K 103

SECTION .2



SECTION 1



12	8	WASHER M16 MSZ KGST 201		0,10
11	8	WASHER M16 MSZ 2206		0,24
10	8	HEX NUT M16 MSZ 2161		0,24
9	8	HEX BOLT M16×70 MSZ 2180		1,07
8	1	BASE FRAME FOR PUMP		120
7	1	CONDENSATE TANK V= 0,3 m³		[illegible]
6	2	HP WATER PUMP M06		272,0
5	1	STEAM CONDITIONING VALVE M05		100,0
4	1	HEATING ELEMENT M04 L = 6500 mm		2490,0
3	1	LIQUOR PUMP M03 Q= [illegible] m³/h, H=40m		750,-
2	1	LIQUOR TANK ØD 3150×3150mm M02		2771,2
1	1	HEATING ELEMENT ØD 273× 10000mm M01		3179,0

LIST OF NOZZLES

	DENOMINATION		
C1	SUCTION NOZZLE	16	150
C2	MANHOLE		
C3	DISCHARGE	16	65
C4	OVERFLOW	16	150

SECTION .2

ANNEX "C"

EXPERIMENTAL TUBE DIGESTION OF BAUXITE
(PROJECT NO. DP/CPR/85/076)

A G R E E M E N T

ON THE CHANGE IN THE SCOPE OF
THE EQUIPMENT SUPPLY OF
HUNGARIAN SUBCONTRACTOR

On the basis of the Chinese Party's request described in the Report on the Mission of the Hungarian Team at Zheng Zhou Aluminium Plant in August, 1986 discussions were held in Zheng Zhou about the subject of the change in the scope of the Hungarian equipment supply. Chinese Party requisted the Hungarian Subcontractor to deliver a wall thickness measuring instrument instead of the liquor storage tank which was specified in the UNIDO contract of the Hungarian Subcontractor.

During the discussions held between 4th and 13th of December, 1986 the Parties agreed that in the frame of the UNIDO Project No. DP/CPR/85/076 an ultrasonic wall thickness measuring equipment including measuring head suitable for measuring the wall thickness of steel from 4 mm to 60 mm to a temperature of 600 °C, a cable for connection between the equipment and measuring head , one test piece, contact paste and the operating manual in english language will be supplied by the Hungarian Subcontractor instead of the tank.

Hungarian Subcontractor handed over the catalogue of the said instrument as well as the preliminary drawings of the liquor tank and will prepare and hand over the detail drawings of the tank on the basis of which the tank will be fabricated and supplied by the Chinese Party.

Zheng Zhou, 09.12.1986.

Li Yuan Jin

On behalf
of Chinese Party

[signature]

On behalf
of Hungarian Subcontractor

ANNEX "D" 3/1 TECHNOLOGICAL DATA OF SLURRY EXPERIMENT OF HEATING ELE

Date 1988.	Slurry flow: (m^3/h)	Steam after conditioning: Pressure (bar)	Temp. (°C)	Condensation temp. (°C)	Heating element M01. Slurry temp. Inlet (°C)	Outlet (°C)	Steam inlet temp. (°C)	Condensate water temp. (°C)	Heat transfer coeff. (W/m^2K)	Heating Slurry t… Inlet (°C)	O…
05.02.	85	25,0	235	223	146	156	200	196	2611	222	
06.02.	88	25,0	240	223	133	141	178	176	2632	208	
	80	24,0	240	221	147	155	188	188	2524	224	
08.02.	84	25,0	245	223	139	144	172	139	2100	222	
	83	24,0	240	221	141	151	193	190	2699	224	
	80	25,0	245	223	144,5	154,5	190	196	2465	222	
	88	26,5	242	225	140	150	198	194	2550	210	
13.02.	99	27,0	242	226	147	156	200	199	2743	214	
	98	25,5	245	224	152	159	194	192	2704	224	
	99	25,0	240	223	152	159	194	192	2750	230	
07.03.	96	25,5	245	224	155,5	162	202	192	2298	225	
	[illegible]	25,5	245	224	155,5	162	202	196	2299	228	
	[illegible]	25,5	245	224	153	158,5	192	198	2412	229	
	95	25,5	245	224	151	157	193	184	2477	228	
	--	13,0	198	190	156,5	164	192	190	2780	-	
10.03.	68	25	245	223	136,5	147	194	188	2144	230	
	68	25	245	223	134,5	146	192	188	2327	230	
12.03.	95	25,5	245	224	151,5	158	188	188	2389	232	
	95	12,8	195	189	134,5	142	190	174	2431	-	
14.03.	96	25,5	245	224	136,5	144	188	176	2548	220	
	95	13,0	200	190	143	150,5	190	190	2434	-	
17.03.	[illegible]	8,2	178	171	123	131,5	[illegible]	172	2555	-	

SECTION 1

EXPERIMENT OF HEATING ELEMENTS M01 AND M04. (FIRST EXP.STAGE)

		Heating element M04.					Condensate quality	Remarks
Condensate water temp.	Heat transfer coeff.	Slurry temp.		Steam inlet temp.	Condensate water temp.	Heat trans. coeff.		
		Inlet	Outlet					
(°C)	(W/m²K)	(°C)	(°C)	(°C)	(°C)	(W/m²K)	pH	
196	2611	222	224	226	224	-	7	Heat t. on M04 can't be calculated. (*)
176	2632	208	210	227	222	1687	7	
188	2524	224	226	227	221	-	7	Heat t. on M04 can't be calculated. (*)
139	2100	222	223	227	223	-	7	(*), Condens. outl. pr.
190	2699	224	224	226	222	-	7	(*)
196	2465	222	223	226	222	-	7	(*)
194	2550	210	212	229	225	2079	7	
199	2743	214	215,5	230	226	2173	7	
192	2704	224	224	215	224	-	7	(*)
192	2750	230	230	220	225	-	7	(*)
192	2298	225	225	225	224	-	7	(*)
196	2299	228	228	225	226	-	7	(*)
198	2412	229	229	229	225	-	7	(*)
184	2477	228	228	228	224	-	7	(*)
190	2730	-	-	-	-	-	7	(*), No heat. on M04.
188	2144	230	230	229	223	-	7	(*)
188	2327	230	230	[illegible]	229	-	7	(*)
188	2389	232	232	230	224	-	7	(*)
174	2431	-	-	-	-	-	7	(*), No heat. on M04.
176	2548	220	228	230	226	-	7	(*)
190	2434	-	-	-	-	-	7	(*), No heat. on M04.
172	2555	-	-	-	-	-	7	(*)

SECTION .2

ANNEX "D" 3/2 TECHNOLOGICAL DATA OF SLURRY EXPERIMENT ON M01 AND MO

Date, 1988.	Slurry flow:	Steam after steam conditioner:			Heating element M01.					Heating el	
		Pressure	Tempr.	Condensation tempr	Slurry tempr.		Steam inlet tempr.	Condensate water tempr.	Heat transfer coeff.	Slurry tempr	
					Inlet	Outlet				Inlet	Outl
	(m^3/h)	(bar)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(W/m^2K)	(°C)	(°C
03.05.	79,6	13,0	210	191	132	138	179	143	2849		
04.05.	78	10,4	210	183	144	154	188	177	3496		
05.05.	100	20	235	212	156	164	198	194	3158		
06.05.	98	20	235	212	146	156	198	190	3245		
	70	20	230	212	157	164	194	164	2326	214	224
	100	20	230	212	147	156	192	180	3096	213	221
07.05.	92	20	220	212	142	148	196	160	2495	224	229
10.05.	80	18	220	207	142	150	184	178	2428	223	230
11.05.	75	16	230	201,6	136	146	186	184	2553	224	231
12.05.	65	17	230	203,4	144	153	190	198	2160	218	226
	60	17	230	203,4	145	155	190	187	2325	215	228
13.05.	70	17	230	203,4	150	168	201	186	2035	228	234
	46	17	230	203,4	146	156	191	188	1380	229	237
14.05.	74	17	230	203,4	148	156	192	192	2206	230	236
	80	17	230	203,4	140	150	194	190	2543	215	221
15.05	62	17,5	225	205	148	157	190	188	2291	235	242
	90	17	230	203,4	149	157	190	188	2[illegible]92	222	228
16.05.	50	17	230	203,4	145	156	190	188	1967	235	241
17.05.	85	16	220	201,6	130	139	146	144	2490	217	223
	85	16,5	230	203	[illegible]	154	[illegible]	130	2509	221	229
18.05.	90	17,5	230	205	132	140	178	176	2630	214	222
19.05.	85	17,5	230	205	144	157	[illegible]	132	25[illegible]7	224	232
20.05.	90	17,5	230	205	[illegible]	[illegible]	[illegible]2	[illegible]	2595	224	232
21.05.	95	9	175	174	[illegible]	146	164	148	2455		

SECTION 1

RRY EXPERIMENT ON M01 AND M04 HEATING ELEMENTS. (SECOND EXP. STAGE)

		Heating element M04.					Condensate quality	Remarks.
ondensate water tempr.	Heat transfer coeff.	Slurry tempr. Inlet	Slurry tempr. Outlet	Steam inlet temp.	Condensate water temp.	Heat transf. coeff.		
(°C)	(W/m²K)	(°C)	(°C)	(°C)	(°C)	(W/m²K)	pH	
143	2849						7	No heating on M04, (*)
177	3496						7	(*)
194	3158						7	(*)
190	3245						7	(*)
164	2326	214	224	214	216	-	7	Heat tr. can't be calc. on M04. (**)
180	3096	213	221	215	217	-	7	(**)
160	2495	224	229	214	217	-	7	(**), Condens. outlet pr.
178	2428	223	230	208	210	-	7	(**)
184	2553	224	231	204	208	-	7	(**)
198	2160	218	226	202	198	-	7	(**)
187	2325	215	228	206	196	-	7	(**)
186	2055	228	234	204	198	-	7	(**)
188	1380	229	237	206	197	-	7	(**)
192	2206	230	238	206	204	-	7	(**)
190	2543	215	221	206	206	-	7	(**)
188	2291	235	242	198	206	-	7	(**)
188	[illegible]	222	228	198	201	-	7	(**)
188	1967	235	241	200	206	-	7	(**)
[illegible]	2490	217	223	200	206	-	7	(**)
190	2509	221	229	205	210	-	7	(**)
176	2630	214	222	205	208	-	7	(**)
[illegible]	[illegible]	224	233	205	208	-	7	(**)
[illegible]	[illegible]	224	233	205	208	-	7	(**)
148	[illegible]						7	(*)

SECTION .2

ANNEX "D" 3/3 TECHNOLOGICAL DATA OF SLURRY EXPERIMENT ON MO1 AND MO4 HEATING ELEME

Date 1988	Slurry flow (m^3/h)	Steam after steam conditioner: Pressure (bar)	Tempr. (°C)	Condensation tempr. (°C)	Heating element MO1: Slurry tempr. Inlet (°C)	Slurry tempr. Outlet (°C)	Steam inlet tempr. °C	Steam inlet bar	Condensate water tempr. (°C)	Heat transfer coeff. (W/m^2K)	Heating elem[ent]: Slurry tempr. Inlet (°C)	Slurry tempr. Outlet (°C)
22.05.	80	17	230	203,4	146	154	190	13	190	2385	225	232
23.05.	60	13,5	230	193,3	144	151	189	8,5	168	2028	221	226
24.05.	76	13,5	230	193,3	142	150	194	10	174	2394	218	222
	75	13,5	225	193,3	144	153	194	12	186	2434	224	228
25.05.	85	13,7	225	193,8	141	150	194	12	185	2598	219	225
26.05.	90	14	225	194,1	147	155	194	12	180	2992	219	223
27.05.	95	14	230	194,1	138	146	190	10	174	2832	211	218
	95	14	230	194,1	140	146	183	10	171	2507	211	218
28.05.	92	14	225	194,1	148	154	188	11	184	2661	214	219
29.05.	95	13,5	220	193,3	136	144	185	11	175	2832	195	201
30.05.	82	14	220	194,1	138	147	188	11,5	177	2764	210	217
31.05.	86	15	225	198,4	143	151	189	12	179	2786	213	213
01.06.	90	13,5	220	193,3	130	138	190	11	176	2442	213	213
	95	14	220	194,1	128	135	173	9	168	2521	212	213
02.06.	80	14	220	194,1	142	150	195	11	174	2850	223	224
03.06.	92	14	220	194,1	142	148	183	11	175	2413	218	219

REMARK: The value of heat transfer coefficients calculated for MO4 heating element are ve
They are not realistic due to special operational circumstancies of direct steam
1st digester.

SECTION 1

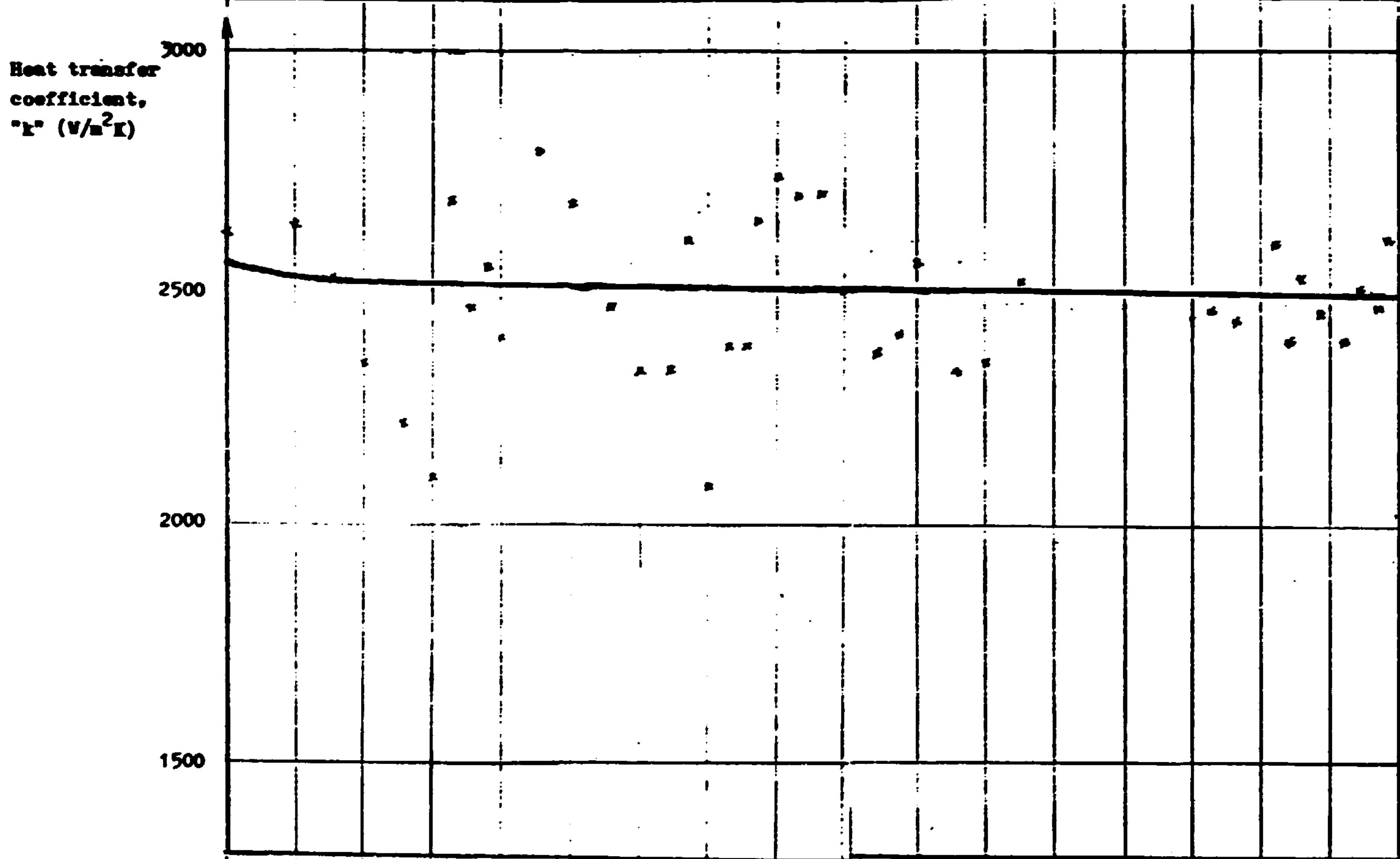
ENT ON M01 AND M04 HEATING ELEMENTS. (SECOND EXP. STAGE)

		Heating element M04					Condensate quality	Remarks
Condensate water tempr.	Heat transfer coeff.	Slurry tempr.		Steam inlet tempr.	Condensate water tempr.	Heat transfer coeff.		
		Inlet	Outlet					
(°C)	(W/m²K)	(°C)	(°C)	(°C) / bar	(°C)	(W/m²K)	pH	
190	2385	225	232	207 / 19	208		7	(**)
168	2028	221	226	244 / 34	225	4595	7	Condens. outlet pr. M04 heated with h.p.s.
174	2394	218	222	249 / 32,5	229	5095	7	Condens. outlet pr.
186	2434	224	228	241 / 32	229	5607	7	
185	2598	219	225	245 / 32	228	5900	7	
180	2992	219	223	248 / 32	232	3142	7	
174	2832	211	218	243 / 30	214	7958	7	
171	2507	211	218	246 / 31	224	5340	7	
184	2661	214	219	251 / 31,5	227	3394	7	
175	2832	195	201	245 / 26	200	3964	7	
177	2764	210	217	249 / 31	221	4450	7	
179	2786	213	213	245 / 29,5	210		7	(**)
176	2442	213	213	236 / 30,5	218		7	(**)
168	2521	212	213	255 / 30	208		7	(**)
174	2850	223	224	256 / 30	226		7	(**)
175	2413	218	219	248 / 31	220		7	(**)

d for M04 heating element are very high value.
circumstancies of direct steam heating in the

SECTION .2

ANNEX "F" 2/1.FIGURE OF HEAT TRANSFER COEFFICIENT [illegible] HEATING ELEMENT DURING FIRST STAGE OF [illegible]

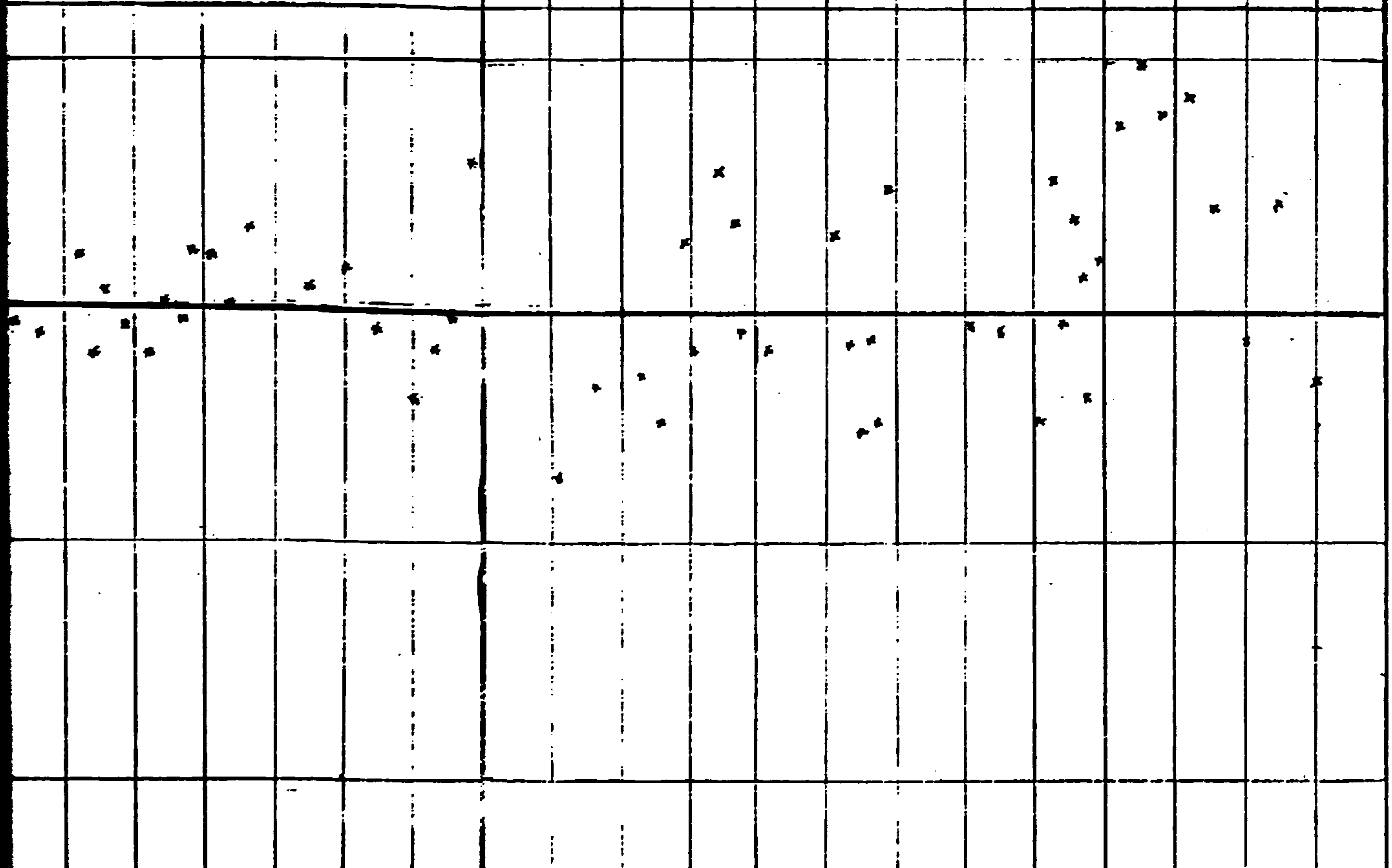


Data,	05.02	06.02	07.02	08.02	09.02	10.02	11.02	12.02	13.02	14.02	15.02	16.02	17.02	—	01.03	02.03	03.03
Slurry flow: (m^3/h)																	
Average	84	83,8	84,4	84,9	83,5	83,3	78,2	85,3	101,7	107	103	85,6			86	90	94
Maximum	112	107	98	103	106	100	98	102	110	112	109	100			111	103	100
Minimum	58	62	67	71	60	64	63	66	76	78	82	76			60	60	70
Operating temperature: (°C)	156	150	145	141	133	143	150	149	157	152	153	152			146	152	147
Total operating hours	24	48	72	96	120	144	168	192	216	240	264	288	294		314	338	362
Slurry operation	24	18	18	18	18	19	19	24	22	24	24	24	6	-	20	24	24
Caustic liquor cleaning	-	6	6	6	6	5	5	-	2	-	-	-	-	-	-	-	-

SECTION 1

FIRST STAGE OF THE EXPERIMENT.

86	90	94	91	97	87	94,5		82,5	89	84	85	85	87	87	86	82	78	84	89
111	103	100	100	100	98	96		95	97	95	96	96	100	87	95	100	95	90	90
60	60	70	66	76	60	60		55	65	64	74	65	60	87	53	55	60	76	76
146	152	147	152	147	154	155		145,6	156	150	148	150	142	146	150	162	155	159	159



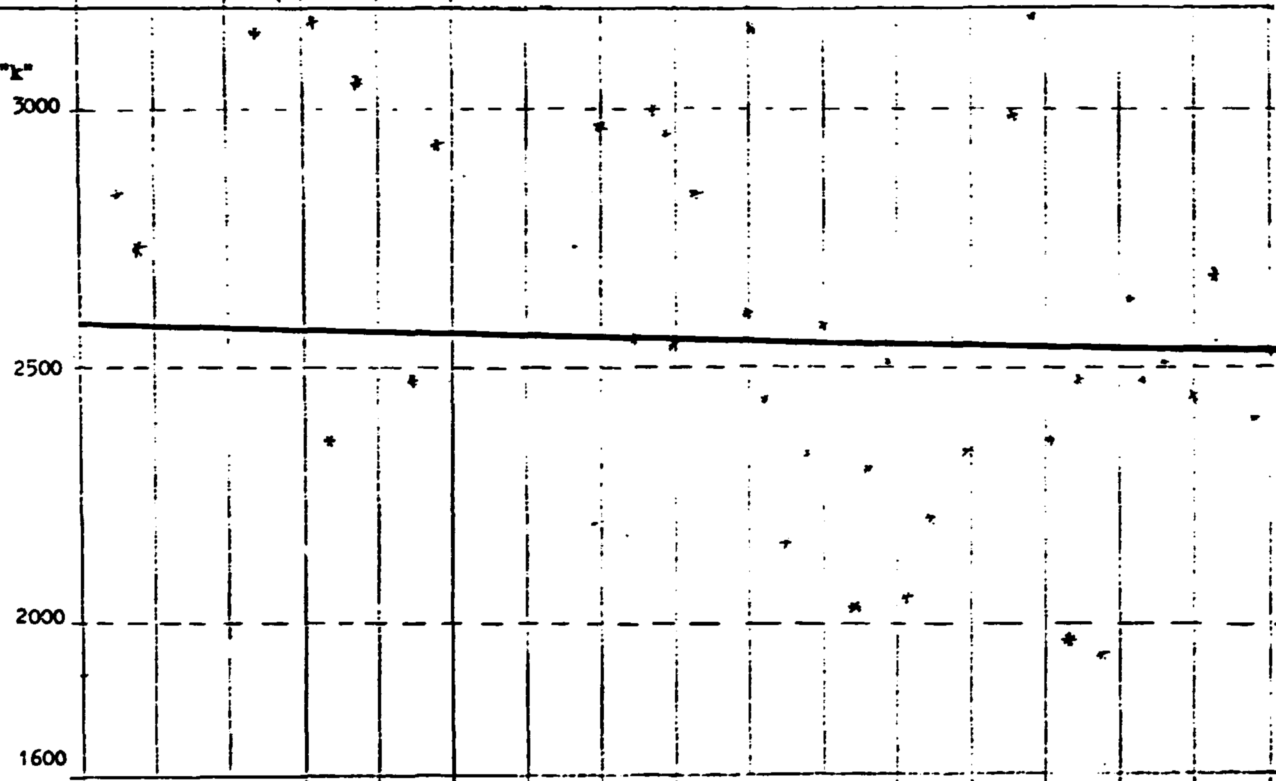
.03	02.03	03.03	04.03	05.03	06.03	07.03	---	10.03	11.03	12.03	13.03	14.03	15.03	16.03	17.03	18.03	19.03	20.03	21.03
14	338	362	386	410	434	446	---	461	485	509	533	551	565	569	590	614	638	662	663
0	24	24	24	24	24	12	-	15	24	24	24	18	14	4	21	24	24	24	1
-	-	-	-	-	-	-													

SECTION .2

ANNEX "B" 2/2. FIGURE OF HEAT TRANSFER COEFFICIENT OF KO1 HEATING ELEMENT DURING THE SECOND S

	03.05.	04.05.	05.05.	06.05.	07.05.	08.05.	09.05.	10.05.	11.05.	12.05.	13.05.	14.05.	15.05.	16.05.	17.05.	18.05.
Slurry flow: (m^3/h)																
Average		81,0	94,6	92,5	80,4			72,0	69,8	66,2	67,1	64,4	72,1	70,6	79,8	75,3
Maximum		94,0	100,0	100,0	92,0			84,0	80,0	80,0	80,0	80,0	90,0	85,0	85,0	90,0
Minimum		72,0	86,0	70,0	65,0			50,0	50,0	50,0	46,0	45,0	35,0	50,0	67,0	58,0
Operating temperature: (°C) (outlet)		148,1	157,4	157,5	161,2			148,5	150,2	153,1	151,1	154,5	150,8	137,2	147,1	152,3

Heat transfer coefficient: "k" (W/m^2K)

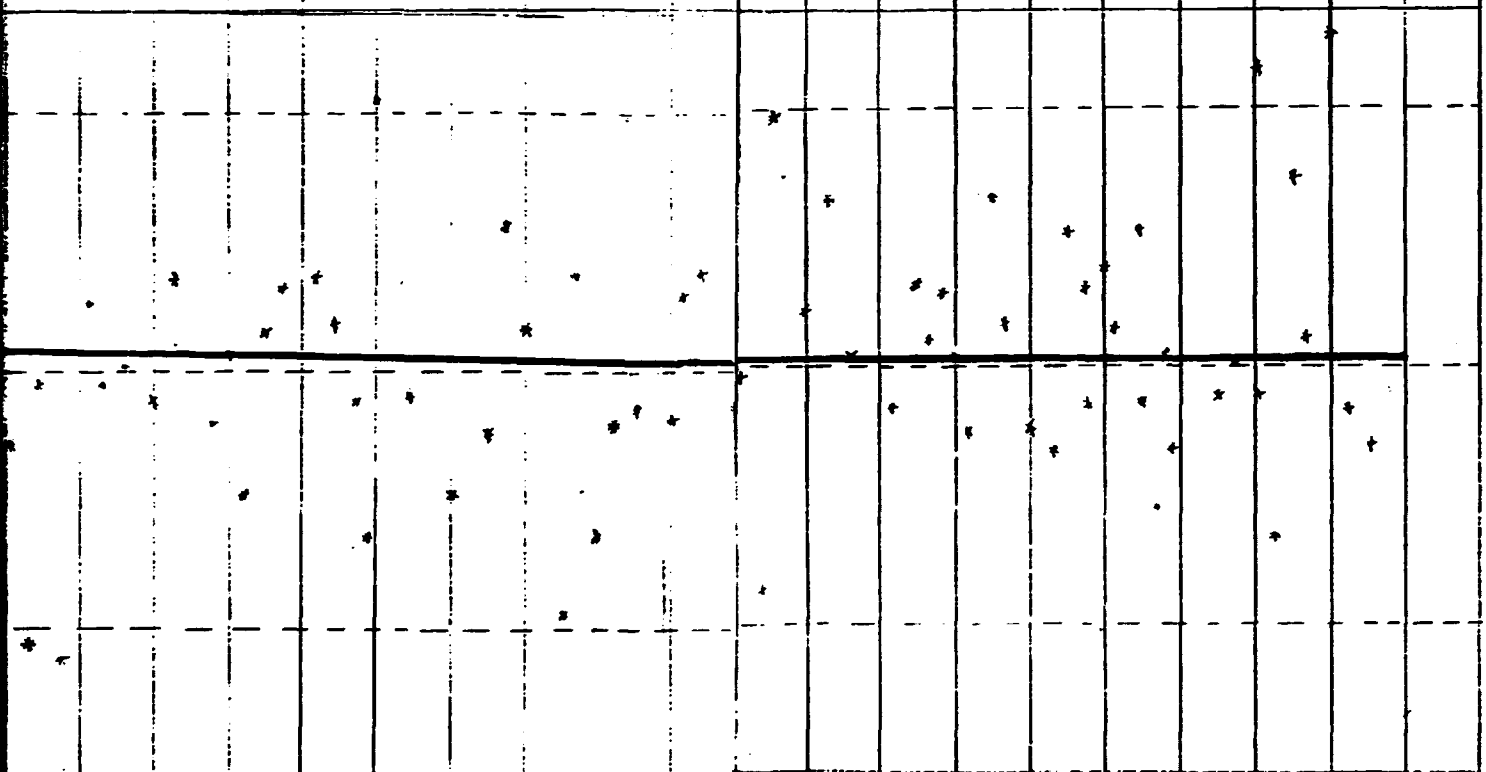


Data: 1988.	03.05.	04.05.	05.05.	06.05.	07.05.	08.05.	09.05.	10.05.	11.05.	12.05.	13.05.	14.05.	15.05.	16.05.	17.05.	18.05.
Total operating hours: (663+)	672	696	720	744	752	757	757	779	803	827	851	875	899	922	946	970
Slurry experiment	9	24	24	24	8	5	0	22	24	24	24	24	24	23	24	24
Caustic liquor cleaning	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

SECTION 1

URING THE SECOND STAGE OF THE EXPERIMENT.

70,6	79,8	75,3	86,8	93,2	75,0	72,8	71,9	76,6	81,0	85,5	86,5	91,8	85,7	82,98	87,72	93,4	90,5	90,5
85,0	85,0	90,0	90,0	96,4	95,0	84,0	80,0	80,0	90,0	90,0	95,0	95,0	95,0	95,0	92,0	98,0	98,0	90,0
50,0	67,0	58,0	83,3	90,0	55,0	50,0	60,0	75,0	56,0	60,0	65,0	65,0	60,0	65,0	80,0	88,0	80,0	88,0
137,2	147,1	152,3	152,9	149,4	150,8	145,2	152,7	149,1	151,2	150,7	146,6	151,5	151,8	147,1	144,0	137,9	151,6	148,2
16.05.	17.05.	18.05.	19.05.	20.05.	21.05.	22.05.	23.05.	24.05.	25.05	26.05	27.05	28.05	29.05	30.05	31.05	01.06	02.06	03.06.
922	946	970	994	1008	1018	1037	1061	1085	1109	1133	1157	1181	1205	1229	1253	1277	1301	1307
23	24	24	24	14	10	19	24	24	24	24	24	24	24	24	24	24	24	6
-	-	-	-	0,5	-	-	-	-	-									



SECTION .2

SECTION 1

ANNEX "F" VALUE OF MEASURED PIPE WALL THICKNESSES, AVERAGE VELOCITY OF BAUXITE SLURRY

DATE OF WALL THICKNESS MEASURING.

05.06.1988.			04.06.1988.			20.05.1988.			11.05.1988.					
Rate of erosion mm/	Average slurry velocity (m/s)	Average slurry flow (m^3/h)	Wall thickness of pipes (mm)	Average slurry velocity (m/s)	Average slurry flow (m^3/h)	Wall thickness of pipes (mm)	Average slurry velocity (m/s)	Average slurry flow (m^3/h)	Wall thickness of pipes (mm)	Average slurry velocity (m/s)	Average slurry flow (m^3/h)	Wall thickness of pipes (initial) (mm) 21.03.1986.	Cross section of slurry pipes. (x 10^{-3} m^2)	No. of measuring place.
0,4	1,29	85,56	17,4	1,27	84,55	15,0	1,10	72,7	17,0	1,27	84,1	17,3	18,38	1
0,0	1,44	85,56	7,6	1,42	84,55	7,0	1,22	72,7	7,2	1,41	84,1	7,2	16,5	2
0,15	2,31	85,56	5,25	2,28	84,55	4,9	1,97	72,7	5,1	2,27	84,1	5,0	10,26	3/1a
0,25	2,31	85,56	5,25	2,28	84,55	5,2	1,97	72,7	5,5	2,27	84,1	5,6	10,26	3/1b
0,3	2,31	85,56	4,5	2,28	84,55	5,1	1,97	72,7	5,2	2,27	84,1	5,1	10,26	3/2
0,3	2,31	85,56	4,8	2,28	84,55	5,3	1,97	72,7	5,3	2,27	84,1	5,2	10,26	3/3
0,0	2,31	85,56	5,2	2,28	84,55	5,0	1,97	72,7	5,0	2,27	84,1	5,0	10,26	4/1a
0,7	2,31	85,56	5,2	2,28	84,55	5,6	1,97	72,7	5,6	2,27	84,1	5,6	10,26	4/1b
0,6	2,31	85,56	5,0	2,28	84,55	5,6	1,97	72,7	5,6	2,27	84,1	5,6	10,26	4/2
0,15	2,31	85,56	5,45	2,28	84,55	4,7	1,97	72,7	5,4	2,27	84,1	5,9	10,26	4/3
4,2	1,44	85,56	13,3	1,42	84,55	12,7	1,22	72,7	14,4	1,41	84,1	17,2	16,50	5
0,2	1,3	85,56	7,4	1,27	84,55	7,3	1,10	72,7	7,4	1,27	84,1	7,5	18,38	6
0,0	1,3	85,56	16,7	1,27	84,55	16,7	1,10	72,7	17,5	1,27	84,1	16,3	18,38	7
0,3	0,76	85,56	11,3	0,75	84,55	11,5	0,65	72,7	11,5	0,75	84,1	11,3	31,10	8
1,1	1,3	85,56	16,7	1,27	84,55	16,5	1,10	72,7	17,4	1,27	84,1	17,4	18,38	9
1307			1307			1001			779			M01 work. hours.		
0,5	1,44	85,56	8,1	1,43	84,55	8,0	1,22	72,7	8,2	1,41	84,1	8,3	16,50	10
0,3	3,12	85,56	7,2	3,09	84,55	7,0	2,65	72,7	7,2	3,07	84,1	7,1	7,60	11

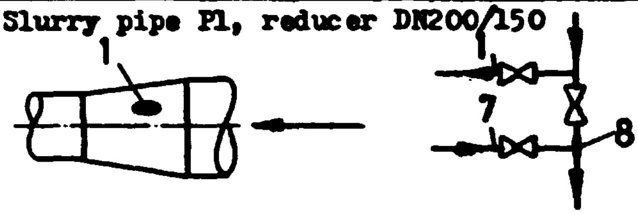
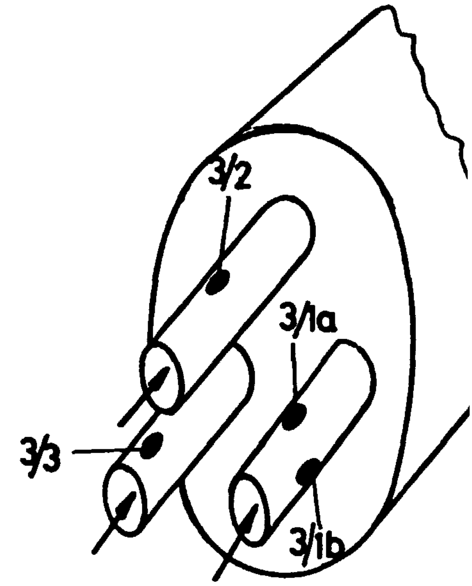
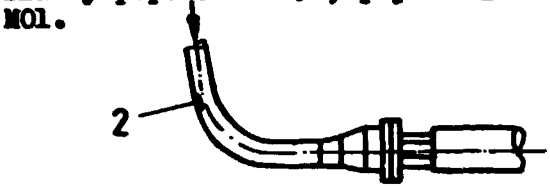
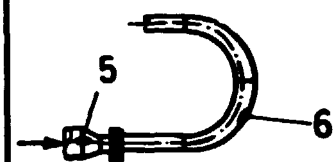
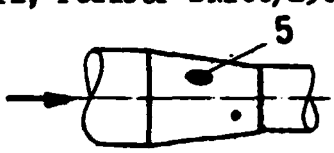
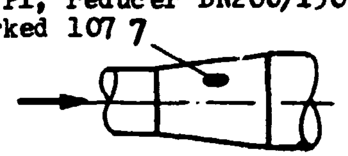
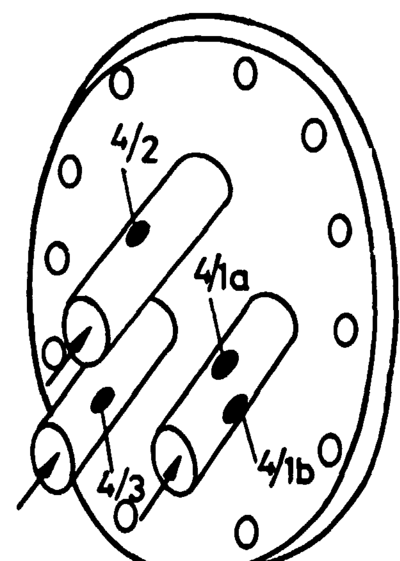
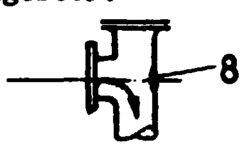
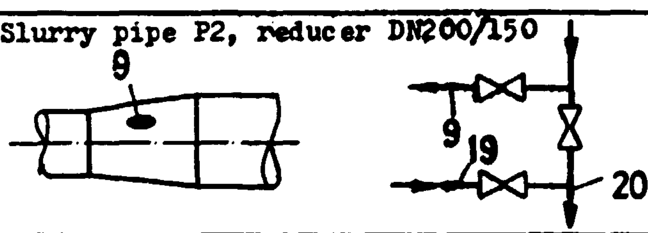
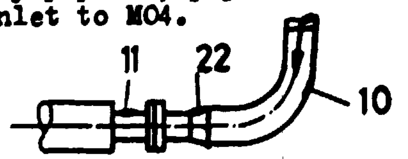
SECTION .2

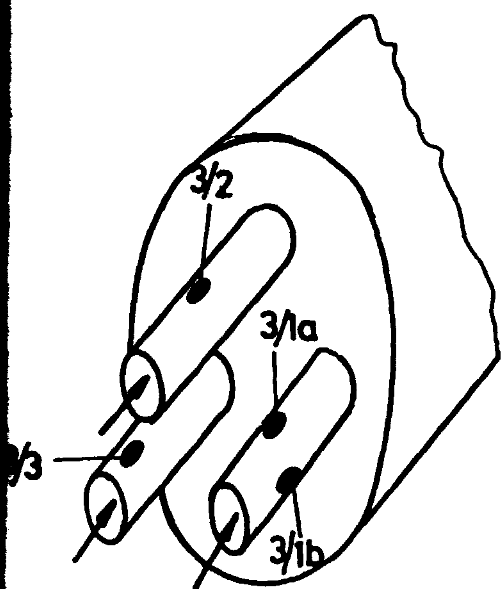
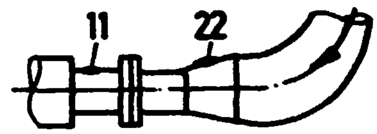
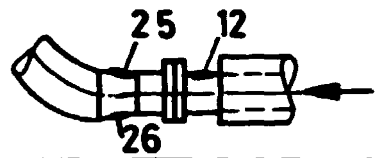
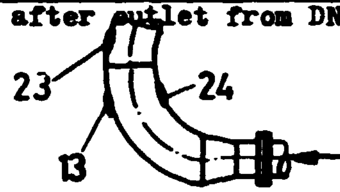
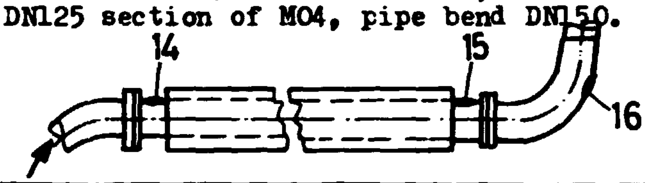
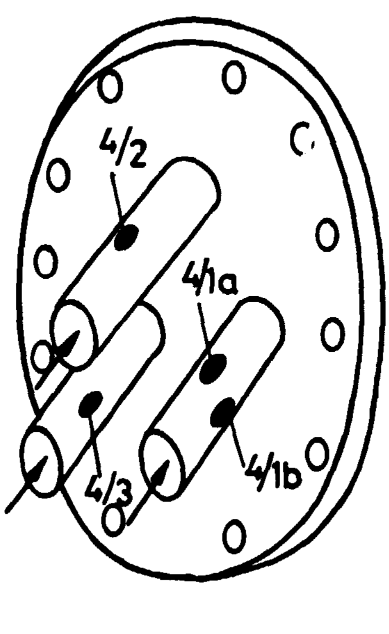
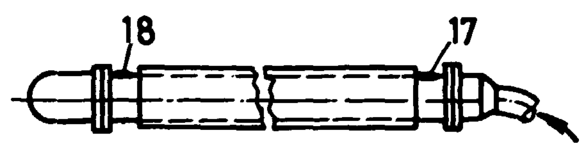
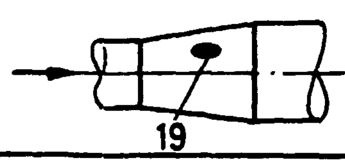
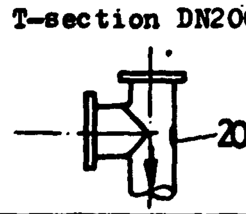
0,3	0,76	85,56	11,3	0,75	84,55	11,5	0,65	72,7	11,5	0,75	84,1	11,3	31,10	8
1,1	1,3	85,56	16,7	1,27	84,55	16,5	1,10	72,7	17,4	1,27	84,1	17,4	18,38	9
1307			1307			1001			779			M01 work. hours.		
0,5	1,44	85,56	8,1	1,43	84,55	8,0	1,22	72,7	8,2	1,41	84,1	8,3	16,50	10
0,3	3,12	85,56	7,2	3,09	84,55	7,0	2,65	72,7	7,2	3,07	84,1	7,1	7,60	11
0,0	3,12	85,56	8,66	3,09	84,55	8,4	2,65	72,7	8,2	3,07	84,1	7,9	7,60	12
0,0	2,21	85,56	7,5	2,18	84,55	6,8	1,88	72,7	7,0	2,98	84,1	6,8	10,75	13
0,0	2,21	85,56	8,4	2,18	84,55	7,8	1,88	72,7	8,4	2,98	84,1	8,1	10,75	14
0,1	2,21	85,56	8,0	2,18	84,55	7,9	1,88	72,7	8,2	2,98	84,1	8,0	10,75	15
0,4	2,21	85,56	9,0	2,18	84,55	9,2	1,88	72,7	9,6	2,98	84,1	9,6	10,75	16
0,3	1,48	85,56	7,9	1,46	84,55	7,8	1,26	72,7	8,0	1,45	84,1	7,9	16,06	17
0,0	1,48	85,56	7,8	1,46	84,55	7,6	1,26	72,7	7,6	1,45	84,1	7,9	16,06	18
0,4	1,3	85,56	17,5	1,27	84,55	17,4	1,10	72,7	17,4	1,27	84,1	17,5	18,38	19
0,6	0,76	85,56	11,3	0,75	84,55	11,1	0,65	72,7	11,8	0,75	84,1	12,1	31,10	20
0,3	0,72	85,56	6,9	0,71	84,55	7,0	0,61	72,7	7,0	0,71	84,1	7,2	33,[illegible]	21
0,8	2,37	85,56	9,2	2,34	84,55	9,1	2,01	72,7	9,4	2,33	84,1	9,9	10,02	22
0,0	2,21	85,56	7,6	2,17	84,55	6,8	1,88	72,7	6,6	2,17	84,1	6,8	10,75	23
1,5	2,21	85,56	7,8	2,17	84,55	9,0	1,88	72,7	9,2	2,17	84,1	9,0	10,75	24
0,4	2,37	85,56	6,4	2,34	84,55	6,5	2,01	72,7	6,6	2,33	84,1	6,8	10,02	25
0,1	2,37	85,56	6,4	2,33	84,55	6,1	2,01	72,7	6,1	2,33	84,1	6,5	10,02	26
1609			1609			1463			1088			M04 work. hours.		

REMARKS:

1. Places of pipe wall thickness measurement are shown on ANNEX "G"
2. Initial wall thickness of pipes measured before the first stage of experiment started on 04.02.1988. is given in Minutes of the first stage , in ANNEX No.8.
3. Places of wall thickness measurement changed in some cases.

ANNEX "G" WALL THICKNESS MEASURING PLACES.

Mark.	Place of measuring Denomination /Figure/	Mark.	Place of measuring Denomination /Figure/
1.	Slurry pipe P1, reducer DN200/150 	3/1a	Slurry pipe P1, 3xDN65 inlet to 
2.	Slurry pipe P1 DN150, pipe bend inlet to M01. 	3/1b	
5.	Slurry pipe P1 DN150, outlet from M01. 	3/2	
6.	Slurry pipe P1, reducer DN200/150, outlet from M01. 	3/3	
7.	Slurry pipe P1, reducer DN200/150 in front of valve marked 107 	4/1a	Slurry pipe P1, 3xDN65 outlet f 
8.	Slurry pipe P1, T-section DN200/200 in front of inlet to 1st digester. 	4/1b	
9.	Slurry pipe P2, reducer DN200/150 	4/2	
10.	Slurry pipe P2, pipe bend DN150 in front of inlet to M04. 	4/3	

Place of measuring Denomination /Figure/	Mark.	Place of measuring Denomination /Figure/
…y pipe P1, 3xDN65 inlet to M01.  	11. 22.	Slurry pipe P2: inlet to M04 and reducer DN150/100 in front of inlet to M04. 
	12. 25. 26.	Outlet from DN100 section of M04. 
	13. 23. 24.	Pipe bend DN125, after outlet from DN100 section of M04. 
	14. 15. 16.	Inlet to DN125 section of M04, outlet from DN125 section of M04, pipe bend DN150. 
…ry pipe P1, 3xDN65 outlet from M01.  	17. 18.	Inlet and outlet sections DN150 of M04. 
	19.	Slurry pipe P2, reducer DN150/200, in front of valve marked 107. 
	20.	Slurry pipe P2, T-section DN200/200 
	21.	Slurry pipe P2, pipe bend DN200, in front of inlet to digester No.2. 

ANALYSES OF SAMPLES TAKEN FROM TUBE HEAT EXCHANGERS

I. Time of sampling:

1. 20.05.1988
2. 04.06.1988

Position of sample point:

1.a. M01 element
1.b. M04 element ND 125 (in the bend)
2.c. M04 element ND 125
2.d. M04 element (after feed valve)

Chemical composition (in weight %)

	1.a.	1.b.	2.c.	2.d.
Loss on Ignation	14.2	3.8	4.9	6.0
Al_2O_3	67.8	5.1	3.9	22.8
SiO_2	5.3	1.8	2.1	17.8
Fe_2O_3	4.3	57.0	51.4	15.7
TiO_2	3.2	10.3	12.2	9.8
CaO	1.5	9.6	13.8	11.2
MgO	0.5	11.0	9.4	1.6
Na_2O	0.8	1.2	1.5	7.5
K_2O	--	--	--	4.6

Mineralogical composition (in phase %)

	1.a.	1.b.	2.c.	2.d.
Sodalite	3.5	--	--	22.0
Cancrinite	--	--	--	26.0
Diaspore	75.0	4.0	--	6.0
Ca-Al-silicate	3.2	--	--	7.0
Goethite	3.0	--	--	2.0
Hematite	2.0	~ 5.0	~ 5.0	14.0

$CaTiO_3$	--	18.0	20.0	16.0
Calcite	2.0	--	--	2.0
Magnetite	--	52.0	50.0	--
$Mg(OH)_2$	--	17.0	14.0	--
Illite	5.0	--	--	--
Anatase	3.2	--	--	--
Rutile		--	--	--
others	3.0	4.0	10.0	4.0

II. Time of sampling:

March 1988

Position of sample point:

1. Bauxite (February 1988)
2. M01 element (sediment)

Chemical composition (in weight %)

	1.	2.
Loss on Ignation	14.50	14.09
Al_2O_3	66.10	64.83
SiO_2	5.77	5.27
Fe_2O_3	5.79	6.29
TiO_2	3.60	3.05
CaO	1.50	1.60

Mineralogical composition (in phase %)

Diaspore	71.7	73.0
Silicates	12.5	10.0
Goethite	5.0	3.0
Hematite	0.8	3.3
Anatase + Rutile	3.6	3.0

Calcite	2.7	3.0
others	3.8	5.0

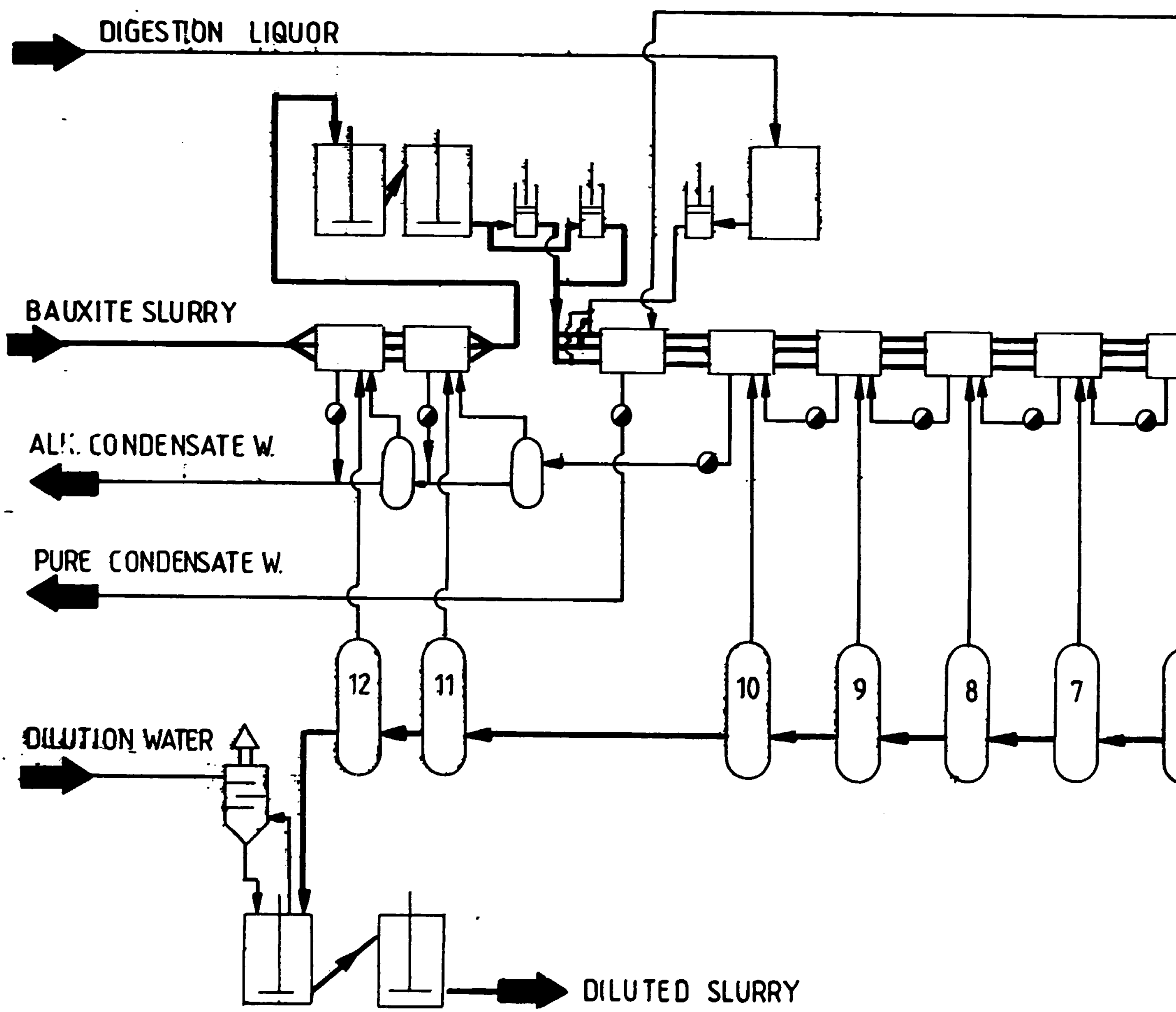
Remark: The silicates are kaolinite, chamosite, illite overlapped very much.
Kaolinite is about 25-30 % of silicates.

Sreen test of sediment

+ 315 μm	6.5 %
250 - 315	3.5
160 - 250	25.7
125 - 160	20.4
80 - 125	23.8
- 80	20.1

SUGGESTION FOR RECONSTRUCTION OF EXISTING DIGESTION LINES IN ZHENGZHOU ALUMINA PLANT

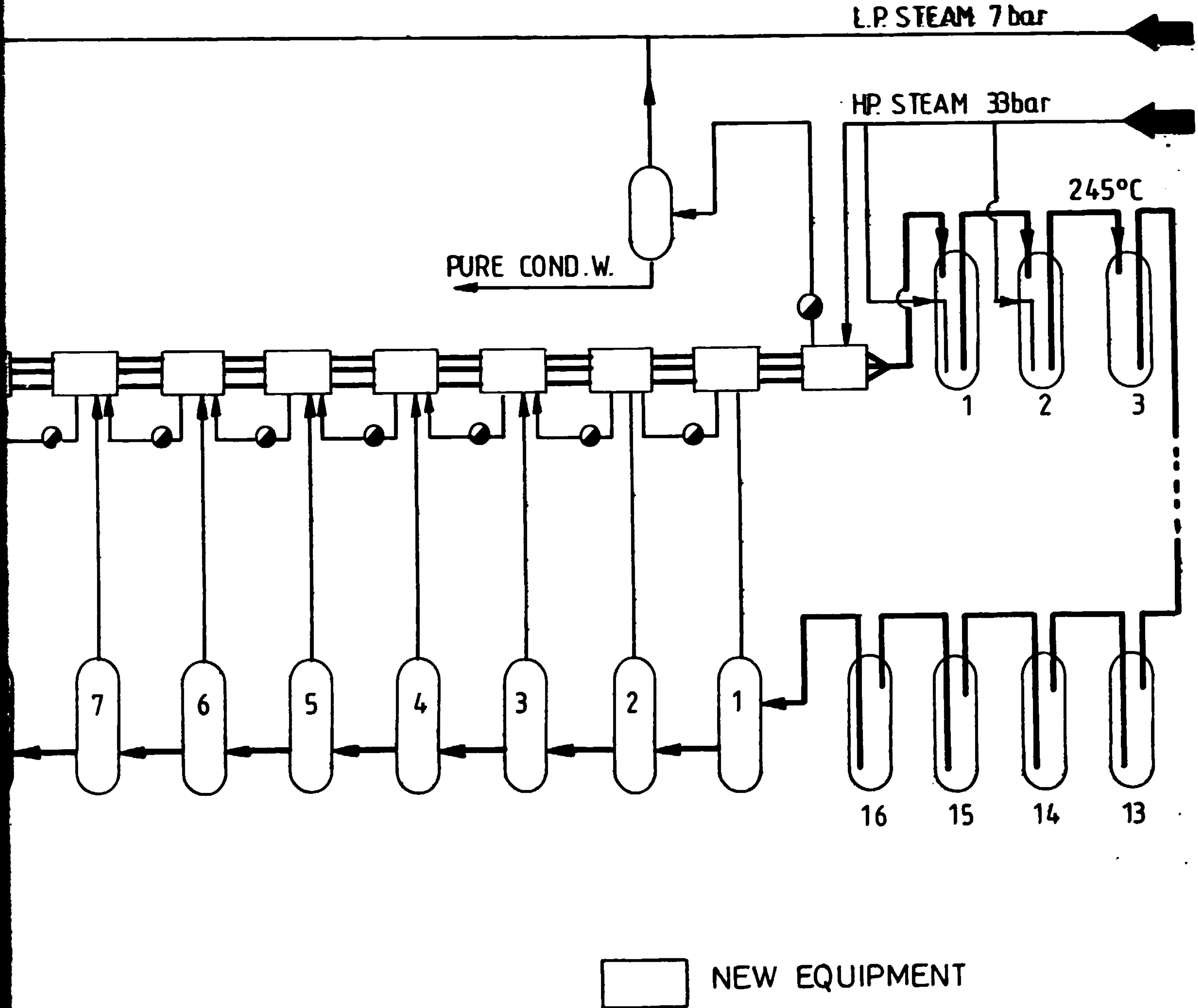
FLOW - SHEET



SECTION 1

RUCTION OF
ES
PLANT

ANNEX „I"



SECTION .2

Fig. 1.

ANNEX "J"

ALUTERV-FKI
Budapest

D. GENERAL TIME SCHEDULE /modification No.2/

Activity	Timing /months after award of contract
1. /a/ Preparation of the design drawings and specifications for the non-standard equipment and the package for bidding	A + 3 months
/b/ Training of 4 Chinese nationals in Contractor's institute at the design stage for one month	A + 3 months
/c/ Preparation of the engineering drawings for installation, pipeworks, electric connections and automation equipment	A + 5 months
2. /a/ Evaluation of the equipment bidding and selection of subcontractor	A + 3 months
/b/ Manufacture of non-standard equipment and delivery of equipment	A + 17 months
3. /a/ Installation of the equipment and supervision of the erection	A + 20 months
/b/ Commissioning of the experimental tube digester	A + 20.5 months
/c/ Experimental stage	A + 24 months
4. /a/ Evaluation of the test results with the participation of 4 Chinese nationals	A + 27 months
/b/ Preparation of the Draft Final Report	A + 28 months
/c/ Tripartite discussion of the Draft Final Report in the project area	A + 29 months
/d/ Submission of Final Report	A + 30 months

ANNEX "K"

Telex No. 121 40320.48

225471A MAT H ryppr zzap cn
telex. 225471 mat h

aluterv-fki
budapest . hungary
att. dr. v.mohar

ref. to unido project no. dp/cpr/85/076 experimental tube digestion of bauxite. we have received and studied draft final report. we found it correct and it can be accepted for final report. no comment and question necessary to be discussed in beijing. please take necessary steps in order to finalise the project according to the contract no. 86/30.

best regards

mr. li yuanjie national project director

14.12.1988.