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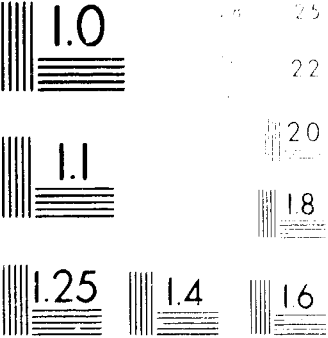
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UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

China.

GROUP TRAINING ON ALUMINA PRODUCTION

UC/CPR/84/138

CHINA

Terminal report*

Prepared for the Government of China
by the United Nations Industrial Development Organization

P. Gado

Based on the work of ALUTERV-FKI
UNIDO consultant

* This document has been reproduced without formal editing.

CONTENTS

INTRODUCTION

After several Group Trainings held on behalf of UNIDO in Budapest, Hungary on Alumina Production for participants recruited from developing countries all around the world, recently it was decided to organize a similar training directly in a developing country.

Also, the scope of the training had been enlarged as compared to the previous ones, including problems of aluminium electrolysis, too.

In accordance with the contract 84/102 ALUTERV-FKI carried out a Group Training in China on Alumina Production and Aluminium Electrolysis. The activities consisted from two parts.

First, the Contractor had to organize home office support services for the preparation of the project.

Second, a team of the Contractors personnel had to go on mission into the project area to implement the project.

Having completed both parts of the project the present report gives account of the relevant activities and the results achieved.

Budapest, 1984.12.14.

P. Gadó

Dr. P. Gadó
team Leader

ABSTRACT

The PROJECT could be accomplished successfully, thereby contributing to the fulfillment of the aims:

I. to increase the national capability of the People's Republic of China to assess and evaluate their deposits and improve their knowledge of technologies for alumina production and aluminium electrolysis,

II. to increase the awareness in China of energy saving possibilities in alumina production and aluminium electrolysis and of environmental considerations.

The conclusions drawn after the completion of this first Group Training in a developing country as well as the recommendations put forward might be applied usefully in other trainings planned for the future.

THE GROUP TRAINING IN CHINA
ON ALUMINA PRODUCTION AND ALUMINIUM ELECTROLYSIS
held in ZHENG ZHOU, P.R. of China, from 29.10.1984
to 07.12.1984.

The United Nations Industrial Development Organization /hereinafter referred to as "UNIDO"/ in response to a request from the Government of the People's Republic of China / hereinafter referred to as "GOVERNMENT"/ has decided to provide assistance to the GOVERNMENT in carrying out the project entitled "Group Training on Alumina Production and Aluminium Electrolysis" / hereinafter referred to as the "PROJECT" / in China / hereinafter referred to as the "PROJECT AREA" /.

UNIDO engaged ALUTERV-FKI / hereinafter referred to as the "CONTRACTOR" / to provide services and carry out the PROJECT.

Preparatory work for the Group Training / the PROJECT /.

Within the PROJECT the CONTRACTOR's personnel prepared a detailed training programme which was accepted both by UNIDO and the GOVERNMENT. A copy of this programme is attached to this report as Appendix I.

A training kit was prepared by updating, typing, printing of four text books used already in earlier group trainings of similar character and also four new volumes which were especially written for the present PROJECT under SSA's concluded with the individual authors.

Another part of the training kit consisted of slides, a videorecord with videoscript for audio-visual presentation on "Energy and Environment in Bauxite Processing" and a 16 mm movie film about a previous group training.

All these items, as listed in detail in Appendix II, were handed over to the representative of the GOVERNMENT.

Copies of the text books corresponding to the number of participants in the training were distributed to them, the surplus text books and the slides, films were kept by the representative of the GOVERNMENT for further use as deemed appropriate.

Implementation of the Group Training / the PROJECT/.

A team of the CONTRACTOR's personnel consisting of seven experts visited the PROJECT AREA in order to hold lectures and conduct laboratory practices as planned in the training programme. The team members and the duration of their stay in the PROJECT AREA had been as follows:

Name:	Function:	Period of stay:
Dr.Pál Gadó	Consultant in mineralogical analysis / Team Leader /	25.10-09.12
Dr.Károly Solymár	Alumina Technologist	25.10-23.11
Dr.János Horváth	Smelter Technologist	25.10-23.11
Dr.László Tomcsányi	Consultant in Chemical Analysis	25.10-23.11
Dr.Dénes Bulkai	Testing of Technology	12.11-09.12
Dr.Péter Siklósi	Alumina Technologist	12.11-09.12
Mr.László Tikász	Smelter technologist /instrumentation, automation /	12.11-09.12

The GOVERNMENT selected 32 engineers for participation in the Group Training. Some personal data are listed in Appendix III; 21 from among them attended the alumina course and 11 the smelter technolgy course. Nevertheless, the number of listeners on the lectures in both sections had been regularly higher than this figures, because co-workers from the host institute and the local plant joined, too.

The PROJECT was carried out essentially according to the schedule submitted and approved in advance. The minor changes which had to be made are the following:

1./ The Opening Meeting on the first day /29.10/ could be arranged only in the afternoon, therefore the content of the lecture scheduled for this time was built into the content of the related lactures given later.

2./ Since right before the start of the training only 25 participants were registered and the many practices planned originally seemed to overload the local laboratories, the Team Leader accepted the proposal to form only three groups / A1, A2 and A3 / among the participants of the alumina course. When the additional seven participants gradually arrived with some delay during the first days of the training they joined the existing groups and the schedule of the practices was not changed any more. The time alloted previously to the group A4 could be used later very well for other purposes /see 4./

3./ The plenary lecture on Wednesday, 14.11 was given by Dr.Károly Solymár on the topic: "Alumina Specifications and Smelter Use".

4./ The laboratory practice E4 "Bauxite Grinding Test" was changed in content to "Evaluation of the Digestion Test, Calculations on Stoichiometry".

5./ Because of vis major from the air flight and railway timetables the training had to be terminated on Friday, the 7th December. Therefore some rearrangements were carried out in the programme of the last days using also the time set free by the deletion of group A4 and utilizing the advantageous possibility that groups B1 and B2 could enter for two days the Smelter in the Zheng Zhou Aluminium Plant for common practice.

Relation between the CONTRACTOR's Team Leader and the Resident Representative of the UNDP in the PROJECT AREA

Leaders of the Zheng Zhou Light Metals Research Institute /ZLMRI/ and the Zheng Zhou Aluminium Plant, representatives of the Government of Henan Province and the China National Non-Ferrous Metals Industry Corporation participated in the Opening Ceremony. Besides them the opening of the Group Training was also attended by Li Qiming SPO, representing the Resident Representative of UNDP in the PROJECT AREA. She stayed for several days at the site of the training assisting in the successful launching of the PROJECT activities.

After the closing of the training the CONTRACTOR's Team Leader visited the UNDP office during his stopover in Peking. Consulting with Mr.A.W.Sissingh SIDFA, full information was provided about the events of the PROJECT in an oral report.

Since the programme had been implemented smoothly with the effective co-operation of the leaders and staff of ZLMRI and the National Project Manager: Mr.Liu Ying, there was no need for ad hoc contacts between the Team Leader and the UNDP office.

Observations concerning the PROJECT
/Evaluation and conclusions/

According to the judgement of the members of the executing team /lecturers/ the Group Training was benefitial to the participants in several respects:

a/ The text books are available to each of them even for further studies. These, as well as the lectures and practices based on them and partially supplementing the written material, conveyed a great deal of up-to-date information about the state-of-the-art in the bauxite/

alumina/aluminium industry. Thus they definitely advanced in professional skills.

At the end of each week the participants passed a written test. The questions prepared for these tests for the alumina production and the aluminium electrolysis topics, respectively, can be seen in Appendix IV. A short summary of the results achieved by the participants in solving the problems is given in Appendix V. This justifies an optimistic view on the acceptance of the teaching. The average score above 70% in the first five tests is rather good by any standards. The result of the last test is on the other hand not representative. In this test it was tried to increase the speed of answering and therefore more question were given than could be responded in average during the time made available. Thus, reaching a high score was irrealistic.

b/ The participants were surrounded by an English speaking environment for six weeks. They practicized in listening to English lectures in topics of their profession, they studied the textbooks continuously, they tried to use actively English speaking-out comments and raising as well as answering questions. They had to write test papers in English.

Since English became the international language of science and technology and China decided to open towards the international community it seems to be essential that Chineese technical intellectuals should be aole to communicate in this language. The progress is doubtless in this field.

c/ An internal exchange of information was brought about by the Group Training. 32 people from different departments of ZLMRI and other institutions of the country spent together a substantial period and they were familiarized with laboratories which they heve never visited before. The equipment installed in ZLMRI under UNIDO assistance became widely known first time during this training.

Similar conclusions were drawn by director Shu in his talk given at the Closing Meeting.

Furthermore it can be stated, that

- organizing the Group Training at a research institute / ZLMRI / proved to be advantageous;
- the topic of aluminium electrolysis was first time included into the programme of a Group Training concerning the aluminium industry and this rendered it more rewarding to the participants;
- the four new textbooks gave a rich contribution to the training kit, in this way the material on alumina production was completed and modernized;
- the recurring tests and control of the note-books encouraged the participants to work hard, thus this practice should be standardized in further trainings;
- the condition that most of the participants and the lecturers were accommodated close to the site of the training permitted regular consultations beyond the official working hours. In this manner they individual studies could be aided;
- due to the above facts and the commitment of the participants with excellent background education this Group Training seemed to be more successful than the previous ones;
- organizing this Group training UNIDO assisted in the deepening of the good relation between the Chineese and Hungarian aluminium industries, which might be fruitful in the future for the benefit of both nations.

Finally some difficulties met during the implementation of the project should also be mentioned.

The main problem was that the English knowledge of the participants was very unequal. A few were quite good / 20%/, the majority rather poor / 50 %/ and some very poor in this foreign language. The lecturers found very difficult to explain sophisticated technical procedures and concepts in simplified English. It had been found necessary to speak very slowly with frequent repetitions, which limited the amount of information that could be included into the lectures. Using of visual, audio-visual methods counterbalanced to some extent this difficulty and therefore should be applied extensively in the future, too. Interpretation was not used. This can be accepted as a part of an enforcement policy to provide the students the experience of understanding spoken English.

During the proposal for and preparation of the Group Training to be organized in a developing country a regional event had been envisaged, affecting a broader territorial distribution. China is huge enough to reach this goal within a single country, however, in this case the majority of the participants came from the same industrial basis i.e. from Zheng Zhou / ZLMRI + the alumina/aluminium plants /. In this way the dissemination of the skills obtained will take more time as if they could be transferred by engineers going back to very different units of the Chineese aluminium industry. On the other hand it must be admitted that the ZLMRI is responsible for research and development in the entire Chineese aluminium industry and the plant in Zheng Zhou produces more than half of the total alumina quantity of the country. Therefore, the high weight in the participation from this area is perhaps justified.

As a matter of fact this PROJECT contained not one but two separate Group Trainings: one complete programme for alumina technologists and another complete course for smelter technologists. This has put a high load on the small number of lecturers, first of all on the technologists. Still harder work was required from the smelter experts as among the four team members being present at one time only a single one had to carry the responsibility for this part of the training. The others were ready to take their share but being trained and experienced in different fields, little support could be given. It was concluded that in further trainings the number of lecturers must be increased.

Recommendations

1. Preparations in advance at the site, checking of the possibilities for practices seem to be indispensable. The preparatory visiting team should include one alumina expert and one smelter expert.

2. The organization of Group Trainings should be started in due time, the selection of participants should be made together with UNIDO, advance information should be collected about the background and transferred to the lecturers.

3. The training materials should be sent to the site using economical means of transportation / air freight/.

4. The textbooks should be regularly updated and completed.

5. The team of lecturers should count minimum 5-6 members besides the leader at any time / 2 alumina technologists, 2 smelter technologists, leaders for the practices, materials scientist/.

5. The number of members in a practicing group should not exceed 4-5.

6. Part of the printed material should be translated in advance to the local language. It had been very helpful that the Chineese party issued in their own language two volumes containing selected materials from previous Group Training textbooks. Copies of these two volumes will be

deposited at the UNIDO Industrial Operations Section together with the present Final Report.

Acknowledgements

Leaders and staff of the ZLMRI took extreem care to provide adaquate accomodation and catering for the UNIDO team during the Group Training. The lecturers appreciated very much the cultural activities offered to fill up their leisure time. Special thanks are due to Mr.Gan Yi Ren who sacrificed many hours even from his free time to realize high level Chineese hospitality for the sake of the lecturers.

U N I D O

GROUP TRAINING, 1984

ZHENG ZHOU, CHINA

DETAILED TRAINING PROGRAMME

Group Training on Alumina Production and Aluminium Electrolysis

Group A : ALUMINA PRODUCTION

Monday, 29.10	Opening talks Film presentation on previous group trainings Laboratory safety /lecture and test/ Bauxite types and reserves, their evaluation for alumina production /Dr.K.Solymár/
Tuesday, 30.10	Circuit of the BayerPProcess /Dr.K.Solymár/ Chemical analysis of main components of bauxite and red mud / Dr.L.Tomcsányi / Practice
Wednesday,31.10	Evaluation of the aluminium industry: present status and tends / Dr.K.Solymár / Practice
Thursday, 1.11	Bauxite digestion /Dr.K.Sólymár/ Qualitative analysis of bauxite and red mud by x-ray diffraction /Dr.P.Gadó/ Practice
Friday, 2.11	Red mud separation and storage /Dr.K.Solymár / Chemical analysis of main components of aluminate liquor /Dr.L.Tomcsányi / Practice
Saturday, 3.11	Test I. on Bayer process
Monday, 5.11	Precipitation /Dr.K.Solymár/ Quantitative x-ray diffraction analysis of the mineral components of bauxite and red mud samples /Dr.P.Gadó / Practice
Tuesday, 6.11	Calcination and evaporation /Dr.K.Solymár/ Chemical analysis of trace elements in bauxite, red mud, and alumina /Dr.L.Tomcsányi/ Practice
Wednesday,7.11	General aspects of analytical chemistry of alumina aluminium production / Dr.L.Tomcsányi / Practice

Thursday, 8.11	Contaminants and by-products of the Bayer process /Dr.K.Solymár/ Application of infra-red spectrometry in the control of Bayer process /Dr.P.Gadó/ Practice
Friday, 9.11	Processing of diasporic bauxite I. /Dr.K.Solymár/ Determination of different components for material balances /Dr.L.Tomcsányi/ Practice
Saturday, 10.11	Test II. on Bayer process
Monday, 12.11	Processing of diasporic bauxite II /Dr.K.Solymár/ Chemical analysis for environmental protection /Dr. L.Tomcsányi/ Practice
Tuesday, 13.11	Energy saving aspects of technology /Dr.K.Solymár/ Information obtained by scanning elektron microscopy for the alumina industry /Dr.P.Gadó/ Practice
Wednesday, 14.11	The main trends in aluminium smelter technology /Dr.J.Horváth/ Practice
Thursday, 15.11	Reduction of NaOH consumption /Dr.K.Solymár/ Special analytical procedures /Dr.L.Tomcsányi/ Practice
Friday, 16.11	Review of the Bayer process /Dr.K.Solymár/ Special analytical procedures II /Dr.L.Tomcsányi/ Practice
Saturday, 17.11	Test on chemical and physico-chemical investigations applied in the Bayer technology

Monday, 19.11	Feasibility satudy, evaluation of bauxite /Dr.P.Siklósi /
	Laboratory investigations on technological evaluation of bauxite /Dr.D.Bulkai/
	Practice
Tuesday, 20.11	Selection of process technology on the basis of technological tests / Dr.P.Siklósi/
	Thermal analysis of bauxite samples /Dr.D.Bulkai/
	Practice
Wednesday, 21.11	Modern laboratory techniques /Dr.P.Gadó/
	Practice
Thursday, 22.11	Infrastructure and socio-economic envèronment of an alumina plant /Dr.P.Siklósi/
	Aspects of environmental protection /Dr.D.Bulkai/
	Practice
Friday, 23.11	Energy survey and audits of the Brayer Process /Dr.P.Siklósi /
	X-ray spectrometry in the aluminium industry /Dr.P.Gadó /
	Practice
Saturday, 24.11	Test on process technology and energy problems.
Monday, 26.11	Structure of the technological model of the Bayer Process /Dr.D.Bulkai/
	Input-output data of the material and heat balances of the Bayer process /Dr.D.Bulkai/
	Practice
Tuesday, 27.11	Material balances of precipitation and aluminate liquor cooling /Dr.P.Siklósi /
	Evaluations of technological laboratory investigations I. / Dr.D.Bulkai /
	Practice
Wednesday, 28.11	Organization of R & D activities /Dr.P.Gadó/
	Practice
Thursday, 29.11	Caloric calculations and material balances of digestion and evaporation /Dr.P.Siklósi/
	Evaluation of technological laboratory investigations II. /Dr.D.Bulkai /
	Practice

Friday, 30.11	Various uses of the mathematical model and the balances /Dr.P.Siklósi /
	Evaluation of technological laboratory investigations III. /Dr.D.Bulkai /
	Practice
Saturday, 1.12	Test on balances
Monday, 3.12	Trends and development of the Bayer technology /Dr. P. Siklósi/
	Interpretation of grain size distribution analytical data /Dr.D. Bulkai/
	Practice
Tuesday, 4.12	Physical properties of alumina /Dr.D.Bulkai/
	Consultation on calculations /Dr.P.Siklósi /
	Practice
Wednesday, 5.12	Energy and environment in bauxite processing /Dr.P.Siklósi - L.Tikász /
	Video presentation
	Practice
Thursday, 6.12	Instrumentation in Bayer alumina plants /Dr.P. Siklósi /
	Survey of technical litterature /Dr.P.Gadó /
	Practice
Friday, 7.12	Process control in the alumina plant /Dr.P.Siklósi/
	Test on instrumentation and process control
	Practice
Saturday, 8.12	Evaluation of the Group Training
	Closing talks

ALUMINIUM ELECTROLYSIS

1ST WEEK

Monday : -Structure and Physical Chemistry of the Bath for Aluminium Production

Tuesday : -Electrode Reactions in Aluminium Electrolysis

Wednesday:

Plenary Session

Thursday : -Anode Consumption

Role of Anode Paste Properties

Friday : -Solution Process and Transport Properties in the Electrolyte

Saturday : Weekly Test on Physico-Chemistry

2ND WEEK

Monday : -Cell Voltage and Energy Balance of Aluminium Reduction Cells

Tuesday : -Theoretical Energy Requirement for Production of Aluminium

Wednesday:

Plenary Session

Thursday : -Determination of Heat Losses on Construction Elements

Friday : -Measureing Method for Determination of Local Losses

Saturday : Weekly Test on Energy Problems

3RD WEEK

Monday : -Possibilities for Energy Saving on Aluminium Production I.

Tuesday : -Possibilities for Energy Saving on Aluminium Production II.

Wednesday:

Plenary Session

Thursday : -Different Research and Developing Programs

Friday : -Future Trends in Process Metallurgy of Aluminim

Saturday : General Test on Electrochemical Properties

ALUMINIUM ELECTROLYSIS

4TH WEEK

Monday : -Cell Types
Smelter Arrangement
-Discussion of Operational Data

Tuesday : -Potroom Operation
Cell Failures
-Detailed Work-Routines

Wednesday:
Plenary Session

Thursday : -Importance of Electrical Measurements
-Measurements in the Cathode

Friday : -Preparations for Process Control
-Measurements in the Anode and Bath

Saturday : Weekly Test on Basic Electrical Measurements

5TH WEEK

Monday : -Process Control Realisations I.
-Identification of a Process Model

Tuesday : -Process Control Realisations II.
-Practice in Data Processing

Wednesday: Computer Applications in Aluminium Electrolysis plenary session

Thursday : -Optimal Operation
-Real-Plant Data Processing

Friday : -Modeling and Digital Simulation
-Basic Instrumentation

Saturday : Weekly Test on Process Control Problems

6TH WEEK

Monday : -Electromagnetic Interactions
-Current Distribution in Anode and Cathode

Tuesday : -Construction Aspects
-Magnetic Induction Measurements

Wednesday:
plenary session

Thursday : -Environmental Aspects of Hall-Heroult Electrolysis
-Fluoride and Dust Emission
Gas Cleaning Systems

Friday : -Future Trends in Construction and Reconstruction
-Final Consultation

Saturday : General Test on Electrical Measurements,
Process Control and Electromagnetic Interaction

EXERCISES

Group A

E1 Determination of main components of bauxite and red mud

E2 Determination of caustic soda and aluminium content of aluminate liquor

E3 Alumina and metal analysis by AAS /Zn and Fe/

E4 Bauxite grinding test

E5 Thermal analysis of bauxite

E6 Predesilication tests

E7 Digestion test

E8 Settling of red mud

E9 Precipitation test

E10 Grain size distribution analysis

E11 Causticization of red mud

E12 Examples of break down of investment and operation costs

E13 Calculation practice on material balances

E14 Calculation practice on heat balances

E15 Consultation on calculations

E16 X-ray diffraction analysis of bauxite and red mud

E17 Infra red spectrometric analysis of bauxite

E18 Application of scanning electron microscopy

E19 Fluorescent x-ray spectrometry of alumina samples

Group B

P1 = E3

P2 Calculation of equilibrium potential anode and cathode over-voltage

P3 Calculation of current efficiency and cell voltage of an operating reduction cell

P4 Methods for calculation of heat losses on different cell constructions and construction elements

P5 Relation between current efficiency and technological parameters

P6 Electrochemical measurements of graphite and aluminium in cryolite-alumina melts

P7 Study of solution processes / alumina, aluminium, aluminium-carbide, sludge / in cryolite-alumina melts

P8 Basic instrumentation in aluminium smelters

P9 Measurements for determination of different physicoechemical properties in cryolite-alumina melts

P10 Basic electrical measurements

P11 Practice in data processing

P12 Real plant data processing

P13 Identification of a process model

P14 Magnetic induction measurements

P15 General consultation

P16 X-ray diffraction analysis in smelter technique I.

P17 X-ray diffraction analysis in smelter technique II.

P18 X-ray fluorescence analysis, pot flux analyser

P19 Scanning electron microscopy in smelter technique

Appendix I.

UNIDO GROUP TRAINING: Order of practices

No. of day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Date	30	31	1	2	5	6	7	8	9	12	13	14	15	16	19	20	21	22	23	26	27	28	29	30	3	4	5	6	7
To / Bu	E1	E2	E2	E3	E3	E1	E2	E1	E3	E1	E2	P1	E3	P1	E5	E5	E10	E10	E5	E15	E10	E14	E11	E9	E5	E11	E10	E7	E15
	A1	A1	A2	A1	A2	A3	A3	A2	A3	A4	A4	B1	A2	B2	A1	A4	A1	A2	A3	A2	A4	A1	A1	A3	A4	A2	A3	A3	A1
So / Si	E6	E6	E6	E11	E4	E4	E6	E7	E7	E4	E9	E9	E11	E7	E12	E13	E12	E14	E12	E13	E14	E13	E14	E13	E15	E12	E4	E15	-
	A4	A2	A3	A4	A1	A2	A1	A1	A2	A3	A1	A2	A3	A4	A3	A3	A2	A3	A1	A1	A2	A4	A4	A2	A3	A4	A4	A4	
Gi	E17	E16	P16	E16	E17	P18	E18	E19	P17	E8	E8	E8	E16	E17	P16	P19	E8	P17	E9	P19	E18	E19	E16	P18	E17	E18	E18	E19	E19
	A3	A4	B1	A3	A4	B1	A4	A4	B1	A1	A2	A3	A1	A2	B2	B2	A4	B2	A4	B1	A2	A3	A2	B2	A1	A1	A2	A1	A2
Ho / Ti	P2	P2	P3	P3	P4	P5	P4	P5	P6	P6	P7	P8	P7	P8		P9	P9	P10	P11	P10	P11	P12	P12	P13	P14	P13	P14	P15	P15
	B1	B2	B2	B1	B2	B2	B1	B1	B2	B1	B2	B2	B1	B1		B1	B2	B1	B1	B2	B2	B1	B2	B1	B1	B2	B2	B1	B2

Appendix II.

ZLMRI 郑州轻金属研究所

CHINA Zheng-Zhou Light Metal Research Institute

RECEIPT

We acknolowledge the receival from ALUTERV-FKI in connection with the UNIDO GROUP TRAINING hold by a team of Hungarian experts in ZLMRI ,Zhengzhou, P.R.China,between 29.10.1984 and 7.12.1984, the following items:

1) 1 copy of the 16mm colour sound film "UNIDO GROUP TRAINING on Bauxite Processing,Budapest,'83'", length:180m,16min.
   Reg.No.:019301/1984(Medea)
2) 1 copy of the colour video"U" matic (KCA60) record:"Energy and Environment in Bauxite Processing", length:28 min.
   Reg.No.:01876(Interpress)
3) 35 copies of a series of text books as part of the training kit, including the following eleven (11) volumes:
   a) Chemical Background and Technology of Processing Bauxite to Alumina
      Vol.2 of Group Training, 1979
   b) Technological Investigation of Bauxites and Red Muds
      Vol.6, of Group Training, 1979
   c) Evaluation of Bauxite Investigations for the Selection of Alumina Processing Technology. Brief Outline of Feasibility Studies
      Vol.7 of Group Training, 1979
   d) Laboratory Practice in Alumina Production, Group Training,1983
   e) World Review on Energy Conservation in the Bauxite/Alumina Indus-

Appendix II.

ZLMRI

CHINA

郑州轻金属研究所

Zheng-Zhou Light Metal Research Institute

try, Group Training ,1983

f) World Review on Environmental Aspects and Protection in the Bauxite/ Alumina Industry, Group Training , 1983

g) Process Instrumentation and Control in alumina Plants
Group Training, 1984

h) Mathematical Modell of the Technology of the Bayer Alumina Manufacturing Process
Group Training , 1984

i) Physical Chemistry and Practice of Aluminium Electrolysis
Group Training, 1984

j) Electrical Measurements,Process Control and Electromagnetic Interactions in Aluminium Electrolysis
Group Training, 1984

k) Energy and Environment in Bauxite Processing, Video Script,1984
Text for the Record mentioned as item 2) above.

l) Two series of 5x5 cm slides to be used for illustration during lectures based on the text books mentioned as items 3) a-j, above.
Parts of the training kit,

a) Alumina technology 256 pieces

b) Smelter technology 36 pieces

刘英

Liu Ying
UNIDO Project Director

Zhengzhou, 19.11.1984

GROUP TRAINING ON ALUMINA PRODUCTION AND

ALUMINIUM ELECTROLYSIS

ZHENG ZHOU, 29 Oct - 8 Dec 1984

LIST OF PARTICIPANTS

Group A 1

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Group A 2

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Group B 1

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Group B 2

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ZHANG Xuan Xu	Eng.	ZLMRI	"

Appendix IV.

TEST 1 (ALUMINA)

1) NAS formula (1)

2) CAS formula (2)

3) Bayer process equations for gibbsite, boehmite, diaspore and goethitic bauxite. Bayer process flow-sheet. (4)

4) Na_2O =260 g/l, α_k=3.5 A/C ratio=? (1)

5) Al_2O_3 content in NAS in %=? if its SiO_2 content is 8.2%. (1)

6) Expected world aluminium consumption in 2000? and the actual value? Bauxite demand? Alumina production? (1)

7) Value of the bauxite? (formula) (2)

8) Please calculate the bauxite demand, required to produce 1T aluminium from the bauxite with an Al_2O_3 content= 65% and with a yield of alumina: $\eta_{Al_2O_3}$=92% (2)

9) Which is the minimum energy consumption of the alumina production actually? distribution of the energy consumption among the process stages? (1)

10) Please illustrate the Bayer-cycle in the Na_2O-Al_2O_3 system with the following data:

	Na_2O_k	α_k	
strong liquor	250	4.0	103
test tank liquor	280	4.5	102
digested slurry liquid	250	1.64	250
aluminate liquor	140	1.64	
spent liquor	150	4.0	

1 cm = 10 g/l (5)

ALUMINA

TEST No.2

10.11.1984

1, Formula of hydrogarnet. (1)

2, Flow-sheet of the preheater-digestion system and that of tne tube digester system. (2)

3, Calculate the expected yield of alumina for the bauxite with Al_2O_3 =60%, SiO_2 =10%. What is the specific consumption of wet bauxite with a moisture content of 15%. (1)

4, Compare the main parameters of the European(floury) and American (sandy) hydrate precipitation technology. (2)

5, Schematic flow-sheet of the imprwved precipitation process to produce sandy type alumina-hydrate at higher Na_2O_k concentration. (2)

6, Calculate the degree of agglomeration in the following aluminate liquor : Na_2O_k =130 g/l, Al_2O_3 =150 g/l, if the grain size distribution is the following :

Fraction	Seed	Agglomeration product
0 -10 μm	3%	0%
10-20 μm	5%	3%
20-45 μm	20%	8%
45-60 μm	52%	56%
60 μm	20%	33%

What is the mass of wet seed if its moisture content is 12% and the seed ratio 0.4 ?

Please calculate the efficiency of the pricipitation and the value of the liquor productivity if thr final α_k=3.5. (3)

7, Schematic flow-sheet of the caleination. Formula of the heat content of the hydrate filter cake (Q_{FC}) (2)

8, Flow-sheets and/or the main characteristics of the three different types of evaporators. (3)

9, What is the sensitivity of an analytical method and why is it important ? How can you give the result of a determination if the method has 10% random error and the average of the readings is 36.512? (2)

10, There are several differences and similarities in the basic principles and possible applications of X-ray diffraction and IR spectrometry. Write some

Similarities: Differences : (2)

TEST (3) /1

ALUMINA PRODUCTION

1) What is the fomula of the bauxite value considering caustic soda losses? (1)

2) Please calculate the expected bound caustic soda losses(in NaOH kg/t Al_2O_3), if the bauxite has 60% Al_2O_3 ,5% reactive SiO_2 and 4% total TiO_2content and reactivity of the TiO_2 is 40%, the yield of alumina 88%. (2)

3) What are the main applications of SEM in alumina technology? (2)

4) What are the main parameters of digestion when processing diasporic bauxite ? (1)

5) Please calculate the amount of the wet seed (moisture content 12%); the efficiencyof the pricipitation, the liquor productivity; the seed ratio and the total amount of alumina hydrate at the end of precipitation; if the composition of the aluminate liquor is:
140g/l Na_2O_k, α_k=1.56, the seed ratio 2 and the final concentrations are:Na_2O_k=147g/l; Al_2O_3=65g/l. (3)

6) What is the one-number-average property of alumina? What is the formula of the attrition index? (1)

7) What kind of methods can be used for the determination of alumina and gallium content in bauxite and red mud? (2)

8) Please calculate the yield of alumina; the specific consumption of wet bauxite (with a moisture content of 14%); the specific amount of red mud; the specific consumption of NaOH (bound) and that of CaO using the following data:

	Bauxite	Red Mud
Al_2O_3%	62	24
Fe_2O_3%	10	18
CaO%	1.2	12
Na_2O%	0.8	16

(3)

9) Please illustrate the Bayer cycle inthe $Na_2O-Al_2O_3$ system and explain the diagram based on the following data of the characteristic liquors:

α_k	Al_2O_3 g/l
2.9	150
3.5	130
1.6	240

The aluminate liquor contains 140g/l Na_2O_k. (3)

10) Please calculate the amount of the decausficised losses of Na_2O (expressed in NaOH kg/t alumina) for a bauxite with 2.5% calcite content, if its reactivity is 75%, the Al_2O_3 content of the bauxite is 56% and the yield of alumina is 85%. (2)

TEST (3) /2

ALUMINA PRODUCTION

1) What kind of methods can be used for the determination of alumina and gallium content in bauxite and red mud? (2)

2) Please calculate the yield of alumina, the specific consumption of wet bauxite(with a moisture content of 14%), the specific amount of red mud the specific consumption of NaOH (bound) and that of CaO using the following data:

		BAUXITE	RED MUD
Al_2O_3	%	58	16
Fe_2O_3	%	6	14
CaO	%	1.5	9
Na_2O	%	1.3	11

(3)

3) What is the one-number-average property of alumina? What is the formula of the attrition index? (1)

4) Please illustrate the Bayer cycle in the Na_2O-Al_2O_3 system and explain the diagram based on the following data of the characteristic liquors

α K	Al_2O_3 g/l
3.5	125
1.7	230
3.0	140

The aluminate liquor contains 130 g/l Na_2O_k (3)

5) What is the formula of the bauxite value considering caustic soda losses? (1)

6) What are the main applications of SEM in alumina technology? (2)

7) Please calculate the amount of the decausticized losses of Na_2O (expressed in NaOH kg/t alumina) for a bauxite with 3.2% calcite content, if its reactivity is 92%, the Al_2O_3 content of the bauxite is 50% and the yield of alumina is 92%. (2)

8) What are the main parameters of digestion when processing diasporic bauxite? (1)

9) Please calculate the expected bound caustic soda losses(in NaOH kg/t alumina) if the bauxite has 52% Al_2O_3, 7% reactive SiO_2 and 3% total TiO_2 content and the reactivity of the TiO_2 is 87%, the yield of Al_2O_3 is 83%. (2)

10) Please calculate the amount of the wet seeds(moisture content 11%), the efficiency of the precipitation, the liquor productivity; the seed ratio and the total amount of alumina hydrate at the end of precipitation, if the composition of the aluminate liquor is: 140g/l Na_2O_k, α_k=1.56, the seed ratio 2 and the final concentrations are : Na_2O =147g/l; Al_2O_3=65g/l. (3)

TEST No. 4

ALUMINA PRODUCTION   24.11.1984

1) There is a bauxite deposite of 30-35-40 million (dry)tons. We want it to last for 40-50 years. The bauxite contains 50-55% of Al_2O_3 and 4-6% of (reactive)SiO_2 .Digestible Al_2O_3=Total Al_2O_3-Reactive SiO_2 .The Total energy requirement of the plant(steam+electric energy+ calcination fuel) is covered by 300 kg fuel oil per ton of alumina. Bauxite costs 6$/t, NaOH 200 $/t,fuel oil 200 $/t. 500 people are employed in the plant, their average salary is 10000 $/Y. The investment cost of the alumina plant is I=0.5xC+75 million $. Where C is the plant capacity in thousand t/Y. Maintenance is 4% of the investment costs. Interest rateis 10%. The selling price of alumona is 250 $/t. Other cost items are neglected.

a) How much alumina can be produced in 1 year ? (2)

b) How much is the specific NaOH consumption ? (2)

c) How much are the material costs(bauxite+NaOH+fuel) per year ? (2)

d) How much are the operating costs per year ? (2)

e) How much is the operating profit per year ? (1)

f) In how many years can the investment costs be repayed ? (2)

2) Which method(s) can be used to determine the amount of the following minerals in a bauxite sample ? (Make a table like below and put a + sign in the appropriate box)   (3)

	XRD	IR	TA		XRD	IR	TA
Gibbsite				Kaolinite			
Boehmite				Quarz			
Diaspore				Alunite			
Goethite				Muscowite			
Hematite				Illite			
Siderite				Lithiophorite			
Anatase				Pyrite			
Rutile				Calcite			

3) In what grain size range can you use for the determination of grain size distribution ?   (3)

%

	Range
Sieve analysis	
Air jet sieve	
Sedimentation	
Optical microscope	
SEM	

4) Write some important characteristics of instruments ? (2)

5) For what purposes can be used a microcomputer in the lab ? (2)

ALUMINA PRODUCTION

TEST No.5 1.12.1984

1) Please draw a flow-sheet of a

a, Four-effect co-current evaporator set.

b, Four-effect counter-current evaporator set.

c, four-stage multiflash evaporator set. (3)

2) An aluminate liquor contains 120-130-140 g/l k.Na_2O and 125-135-145 g/l Al_2O_3. Mo.is 0.1, 200-300 g/l seed(as Al_2O_3) is added with a specific surface area of 0.07 m^2/g (spherical). This slurry is decomposed in a continuous pricipitation line. The temperature of the first tank is 55-65 C,the retention time in it is 3-5 hr. What is the Al_2O_3 concentration of the liquor leaving the first tank of the line? (7)

3a) What information can you obtain in alumina technology from X-ray fluorescence spectrometry?

b, What kind of X-ray spectrometers you know? (2)

4) a, Explain the meaning of the word:INNOVATION.

b, Give some goals of product/technology/social innovation. (3)

5) What are the main reactions of red mud causticization (NAS,sodiumtitanate) and that of soda causticization? (2)

6) Which are the most important physical properties of alumina? Give some measuring methods and range of parameters for floury and sandy alumina ! (3)

ALUMINA PRODUCTION

Test No.6 7.12.1984

1. Calculate TO andT25 temperatures and Δt_{bpe}, Δt_1, and Δt_s temperature differences from the following data:

   K8 = T13=230=250°C; K9=T24=130°C; K15=400 m^2;K19=10 flash stages; K21=600kt/a;

   Y2=t=20°C; Y72=n=2 operating lines; Y74=K=0.5Mcal/m^2hc°; Y76=2°C; Y77=T59=100°C;

   Y83 (correction factor)=1; Y88=2 flash stages.

   MO=0.1 (=10%; W59=14.0 Mcal/t°c; w13=14.1 Mcal/t°c; C13=150/1k.Na_2Q:

   C24=205/1k.Na_2O

   Plot the results in a graph similar to Figure 2. (6p)

2. What is TRCA? (1p)

3. Draw the flow-sheet of the advanced solution of concentration control of digestion liquor. (3p)

4. During the practice in the SEM laboratory you observed some kind of floury and sandy alumina samples. What difference you could see? (compact/loose, cracks, sites of primary/secondary particles, forms, surfaces and so on) What is your opinion about SEM? (5p)

5. You need an 800 MWat power station. Please give the following costs:

	Investment, 10^6 US$	OPERATION COST S/MWatt Hour
OIL FIRED		
COAL FIRED		
NUCLEAR ENERGY		

6. Please give in a drawing the principal functions of
   - gas suspension calciner by Lurgi, Germany (3p) and GJ/tAL_2O_3.

TEST 1 (Aluminium)

1) Calculate the equilibrium potential value for following reaction?

$Al_2O_3 + C = Al + CO_2$ at given parameters:

Bath temperature : 980°C

Alumina content of bath : 8 %

Saturated concentration of alumina : 10 % WT

2) Which are most important additives of the bath for production of aluminium ?

3) Calculate the electrical conductivity value of bath at following parameters :

Bath temperature : 970°C

AlF_3 content : 8 %

Al_2O_3 content : 5.0 %

CaF_2 content : 2.5 %

4) Which method do you know for the determination of equilibrium potential ?

5) what is the cause of anodic overvaltage and approximetly how many mV is on operating aluminium smelter ?

ALUMINIUM ELECTROLYSIS

TEST No.2

10.11.1984

1. Calculate the solubility of metal using the following parameters:

   Bath composition : NaF/AlF_3 =1.4 Wt ratio

   Temperature of electrolyte : 975°C

   CaF_2 content : 3.5 Wt%

   NaCl content : 1.3 Wt%

2. In a smelter we have in the electrolyte , 4 Wt% Al_2O_3, the molar ratio is 2.5 ,and the temperature is 975°C, then the value of equilibrium potential will be 1.225V. Calculate the CEMF value.

   i_a =0.75 A/cm^2 i_k =0.45 A/cm^2 i_{dh} =2.8 A/cm^2

3. What are the differences between the sandy-alumina and floury-alumina?

4. Plot a scheme of the different components of cell voltage and energy.

TEST (3)

ALUMINIUM ELECTROLYSIS

1) What is the value of molar ratio when the NaF content is 113g and the AlF_3 content is 84g?

2) Which are the most important physicochemical properties of the electrolyte used for aluminium production? What are the effects at the different additives on the physicochemical properties of the electrolyte?

3) Plot a scheme of the anode-potential current-density relationship on grafite electrode? Which are the main chemical reactions in different parts at the polarization curve?

4) Which methods do you know for the determination of the rate of reoxidation reaction?

5) What are the requirements against alumina on the base of ALCAN's and Pechiney's alumina specifications?

6) Plot the relationship between the the current efficiency and anod-cathode distance for "good" conditions of magneto-hydrodynamics ~~and~~ and for "bad" ones.

7) Approximetely how many per centage is the pitch content in the prebaked anode and in the Söderberg anode?

8) Two aluminium electrolysis cells are operating at the following parameters:

	CELL 1	CELL 2
Voltage	4.25 V	4.15 V
Current Efficiency	82%	89.5%
Bath Temperature	977°C	977°C

For which will be better the energy efficiency?

9) Calculate the total heat losses of a aluminium electrolysis cell, using the following parameters:

Amperage 160 KA Cell Voltage 4.4 V

Equivalent valtage for the aluminium production 1.9 V

10) What is the distribution of heat losses (approximatly in per centages) at different construction elements of a prebaked anode cell?

11) What is role of the ledge or freezing profile in increasing of current efficiency? Plot a good freezing profile.

12) What are the main elements of modern prebaked anode technology?

13) What are the advantages of the point feeder system?

14) What none-electrolytic processes do you know for aluminium production?

15) What are the main parts of an AAS instrument and the most important instrumental conditions?

ALUMINIUM ELECTROLYSIS

TEST No.4 1984. 24.11

1) Give the main technological data which characterise the cells of the last century, of the period 1950-1960 and of the present days. (3)

2) Draw the scheme of the electric preheating method and the heating current versus time diagram for the first 30 hours. (3)

3) List the important safety instructions relating to electric measurements. (2)

4) Draw the scheme of the resistance meter for pastes . (2)

5) Calculate the voltage drop in the ramming layer,in the cathode steel bar and in the whole fixing.

Parameters are the followings:

Current of the cathode block : 1800 A

Ramming layer : width=15mm
specific resistivity= 73 $\Omega mm^2/m$

Steel bar : width =60 mm
height =160 mm
lenght = 1800 mm

The simplified temperature distribution and the specific resistances for the parts of the steel bar :

Part	Lenght mm	Temp. °C	Spec. resistivity $\Omega mm^2/m$
1	400	100	0.16
2	400	450	0.49
3	1000	800	1,00

part 1 : outside
part 2 : in the cell, up to the block
part 3 : in the carbon block (7)

6) The anode current distribution was measured. Write a short program which calculates the followings from the anode stub current:
- total serial current
- average stub current
- choose the anode stub which has the higest current. (4)

7) Write some important characteristics of instruments ? (2)

8) For what purposes can be used a microcomputer in the lab ? (2)

ALUMINIUM ELECTROLYSIS

TEST No.5 1.12.1984

1)Plot the typical magnetic field patern in a cell. (X,Y,Z components) (3)

2) Plot the magnetic forces and flow directions in the case of uncompensated Bz field and horizontal crrent (2)

30 How does a hall-plate operate? Draw a scheme. (2)

4)Give the main difficulties related to the magnetic measurements in the melt. (3)

5) Plot the stability-limit curve for a cell. Parameters are the followings:

$A= 5.10^{-6} \frac{M^2}{KA.gauss}$

I_ρ=100KA

Bz =20gauss

Do = 0.04m

Give the D values for the next metal heights:

Hm =5cm, 10cm, 15cm, 20cm.(4)

6) Calculate the stability figures and evaluate the stability form for the next cases:

-funaamental stability

-waves over hal ves left/ right

-waves over halves upper/lower

-waves inside the quadrants

Parameters:

D = 0.05m

Do =0.04m

Hm =0.25m

I_ρ= 80KA

$A =5.10^{-6} \frac{M^2}{KA.gauss}$

Mean quadrant values in gauss:

B_{z1}= -19.08

B_{z2}= -37.35

B_{z3}= -47.04

B_{z4}= -9.85

1	3
2	4

(7)

7)Draw the scheme of a mathematical model system which calculates the mag-neic and flow propertis. (2)

8) Explain the meaning of the word:INNOVATION. What is the relation between innovation and R&D? (2)

Aluminium Electrolysis

Test No. 6. 7,12,1984

1. which are the main Parts of a data acquisition system ? (2)

2. Plot the following diagrams for a cell under resistance and alumina feeding control:

   — alumina feeding rate versus time

   —Al_2O_3 content versus time

   — resistance versus time (4)

3. Plot the cell resistance as a function of Al_2O_3 concentration for a cell. Which are the main operation limits? (3)

4. For a current decreasing experiment the measured cell-voltage and line current data were the followings:

   U_1=4.25 (V) I_1=80(KA)

   U_2=3.8 I_2=70

   U_3=3.45 I_3=60

   U_4=3.25 I_4=50

   U_5=2.9 I_5=40

   Calculate the polarisation voltage, the resistance and the correlation coefficient (6)

5. Give the hierarchical structure of a production control system. (2)

6. Which are the main connections in a cell control unit? (3)

7. What are the advantages and disadvantages of dry/wet scrubbing ? (2)

8. Which are the important physical properties of alumina? (1)

   Give the values of these physical properties for sandy/floury alumina. (2)

Test Results

	1.	2.	3.	4.	5.	6.	Sum
Group A1							
Zhang Liya	14.5	17.5	14	20	17.5	13.5	97
Liu Xiang Ming	13	13.5	13	19.5	15	8.75	82.75
Shu Jian Yi	15	12	12.5	15	18	8.75	81.25
Ma Shen Li	16	16.5	12.5	18	17.5	14	94.5
Wang Liuzhu	12	14.5	12.5	14.5	15	9.75	78.25
Xing Shuya	14.5	14	16.5	18	14.5	12.75	90.25
Zhang Xi Ping	13	15.5	11	15.5	12.5	8.75	76.25
Group A2							
Jiang Xinhua	20	18	16	15	13.5	10.5	93
Li Jiang	19.5	18.5	17	14.5	14.5	11	95
Liu Bao Wei	11	14	14.5	12	10	15	76.5
Sun Zhiang	14	17	11.5	17	16	5.25	80.75
Wang Jing Yu	8	16.5	16.5	12	14.5	3.75	57.25
Zhou Huifang	12	10.5	14	12.5	12.5	9	70.5
Qiu Shilin	16.5	16.5	16.5	8	14.5	7.75	79.75
Group A3							
Chen Xiao Dong	10	15.5	13.5	14	12	4.5	69.5
Liu Keyi	13.5	14	12	7.5	13	8	68
Shang-Guan Zheng	16.5	17	14	12.5	12	6	78
Xei Zhong	11	17.5	13	14.5	16	14	86
Wang Hong Biao	15	16	14.5	15.5	16.5	5.75	83.25
Yang Zhiyong	14.5	17	12.5	13.5	16.5	8	82
Yang Quiao Fang	13	16.5	14.5	14	16	10.25	84.25
Average for the "alumina" groups	14.1	15.5	14	14.6	14.6	9.27	
% effectivity	70.4	77.5	70.o	73.1	73	46.4	
Group B1							
Liu Feng Yin	18	14	55	25	25	25	162
Lu Ting Xoung	20	16	57	22	25	25	165
Wang You Lai	14	12	47	21	21	25	140
Wu Ying Ming	16	15	51	20	23	24	149
Zhang Zhong Lin	14	14	50	22	25	25	150
Han Ying	arr.later		43	18.5	25	25	86.4
Group B2							
Cheng Geng	17	13	42	17	21	21	131
Du Yian Yong	10	13	43	16.5	23	23	128.5
Wu Yi Feng	17	11	45	20	24	20	137
Yuan Xian Pei	20	16	60	25	22	25	168
Zhang Xuan Xu	10	12	39	20.5	22	19	122.5
Average for the "smelter" groups in % effectivity	78	85	80.5	82.7	93	93.4	85.6 %