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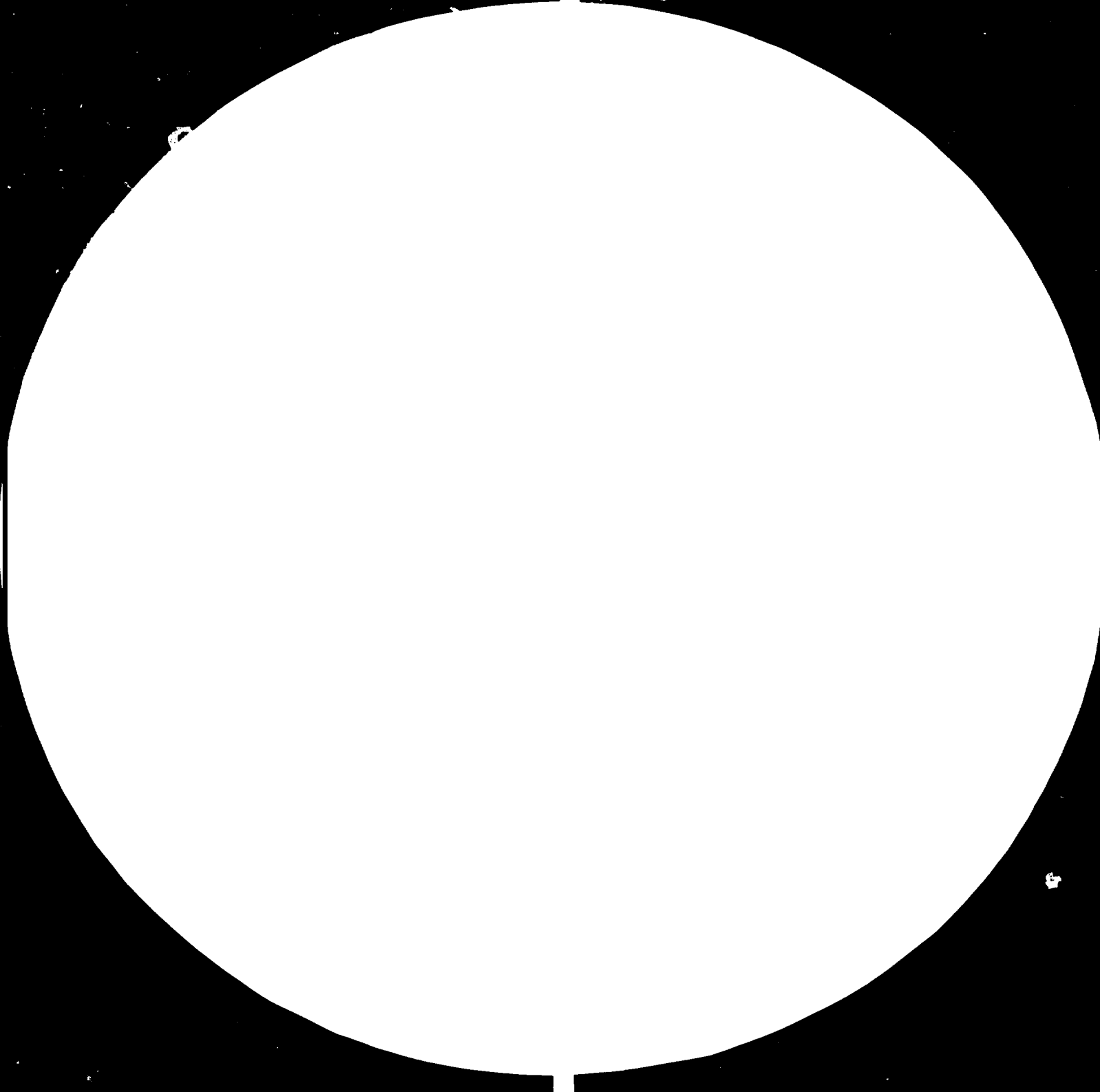

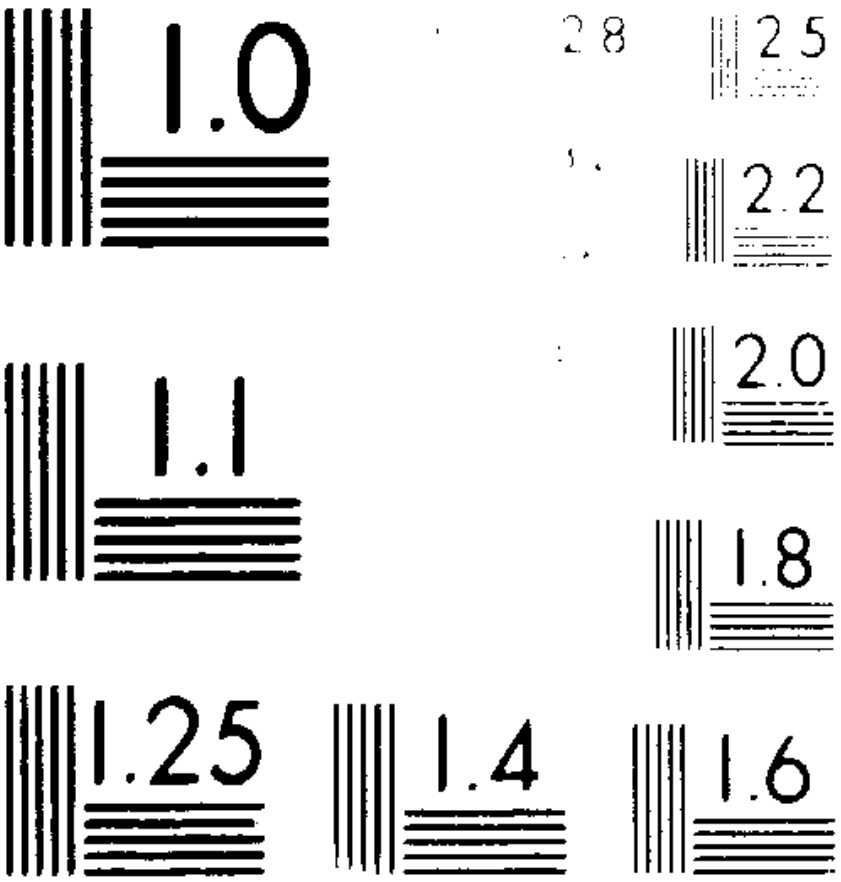
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THE JAMAICA BAUXITE INSTITUTE

ST/JAM/80/001

UPGRADING THE SCIENTIFIC AND TECHNOLOGICAL CAPABILITIES OF THE JAMAICA BAUXITE INSTITUTE

CONSULTANT'S REPORT

BY

DR. KAROLY SOLYMAR
UNIDO CONSULTANT

Period: 28.6.82 to 9.7.82

The Jamaica Bauxite Institute

15 Caledonia Avenue

Kingston 5

PROJECT ST/JAM/80/001

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C O N T E N T S

A C K N O W L E D G E M E N T

I am grateful to Miss Beverley Robinson, Senior Secretary/ Administrative Assistant, Jamaica Bsuxite Institute for typing this report.

SUMMARY

In this report the following have been dealt with:

1. Advice on the completion of the Analytical and Process Research Laboratories with special attention to the installation of new equipment and the related training of JBI's personnel.

   The equipment to be ordered have also been discussed.

2. Advice for designing the main technical outfit of the pilot plant. An up-to-date equipment and instrumentation list was elaborated and attached to this report which can be used for the selection of the equipment and accessories to be ordered.

3. Advice on the content and counter-part institution of the proposed trainings and study tours included the in-house training of the JBI personnel, focused on the Pilot Plant activity.

   It is to be mentioned that the project is very well underway, however, further efforts are to be taken especially relating to the Pilot Plant in the interest of the completion of the project in the planned time.

RECOMMENDATIONS

1) The introduction of the computerised evaluation method of XRD diagrams are recommended by means of the transfer of technology applied at ALUTERV-FKI and using the computer ordered for Soft-Gamma-Ray-Model-Settler.
2) The following laboratory instruments and equipment are recommended to be purchased: centrifuges, Thermatic-Titrator, Oscimhometer OK 10511 and Oscimhotransmitter OK-106 for monitoring the analytical activity required by process research laboratory and Pilot Plant.
3) The completion of the two sets of Four Stage Agitators is necessary by controlled heating system and programmable heating-cooling facility, respectively.
4) The accessories for continuous operation of the autoclaves are to be ordered (excluding the high pressure diaphragm pump) immediately at ALUTERV-FKI taking into consideration batchwise operation in digestion Section in the first phase. However, continuous operation should be implemented after the commissioning period.
5) It is recommended to order all the other accessories and instruments (tanks, pumps, valves, temperature gauge and control, respectively, magnetic flow-rate meters, etc.) as soon as possible after the finalised specification.
6) Special conductivity measurement by means of Oscimhotransmitter OK-106 developed for alumina plants can be preferred to control the blow-off dilution, to determine the solid content in the settler's underflow and to follow the yield of precipitation.

7) The completion of the Pilot Plant with red mud filter is highly recommended in the frame of the red mud utilization programme.

8) It is recommended to prepare a comprehensive manual for the Pilot Plant (before its completion) consisting of general, operation and maintenance parts.

9) It is recommended that the participation (with lectures) of 2-3 Project Staff in the Bauxite-Alumina Session of the 112th AIME Annual Meeting will be held in Atlanta, Georgia, March 6-10, 1983, and on the 5th ICSOBA Congress in Yugoslavia (Zagreb, September 25-30, 1983) combined with the visit of alumina plants (Birac, Mostar, Titograd).

10) In-house training courses are recommended for JBI personnel concerning the activity of the Process Research Laboratory and Pilot Plant.

11) It is recommended to organise a regional (Caribbean) official UNIDO Group Training with a duration of about four weeks between, September and mid-December, 1983, with the participation of about 10-15 JBI personnel and further 10 foreign candidates using the upgraded facilities of JBI including Pilot Plant.

Károly Solymár

DR. KAROLY SOLYMAR
UNIDO CONSULTANT
KINGSTON, JAMAICA

9th July, 1983

INTRODUCTION

My two earlier missions relating to my terms of reference were realized during the periods 15 to 19.9.81 and 31.1 to 10.2.82, respectively. The purpose of my present mission was to continue consultancy activities which were previously initiated.

Since my last visit the project has progressed significantly. The laboratory, which is one of the two main objects of the project, is nearing completion and occupancy is scheduled for October 1982, and research work will commence at that time. Ninety per cent of the laboratory equipment have been ordered and eighty per cent of that amount have been delivered at the project site. About eighty per cent of the equipment for the Pilot Plant have been ordered and fifty per cent have already been delivered. This progress achieved and the new and additional requirements for completion of the project have been taken into consideration during my consultancy and in this report.

My third mission was performed in Jamaica between 20 June and 9 July, however, my official consultancy at JBI began only because a possibility to participate and deliver a lecture on the Fifth International Bauxite Symposium held in Kingston between 27 and 29 June 1982, and organised by the Geological Society of Jamaica was given for me by the UNIDO officers in Vienna using the air ticket purchased by this organization, taking into account the close interrelation between the role and topics of the mentioned symposium and my activity at JBI. I would like to express appreciation for this kind arrangement.

This return mission was performed as a part of the project for Upgrading the Scientific and Technological Capabilities of the Jamaica Bauxite Institute. My assignment embraced the following duties:

1. To define, select and specify the research and pilot plant equipment to be purchased.
2. To provide advice for designing and main technical outfit of the pilot plant from the point of view of laboratory and pilot research requirements.
3. To advise on the content and counterpart institution concerning organization of the training and study tour programme of the project.

The actual activity was focused on the finalization of the equipment and instrumentation list of the pilot plant however other questions are discussed and documented in this report.

My detailed activity schedule as elaborated by the Project Co-ordinator is attached (Appendix 1).

The very careful organization and the good and kind assistance, in a very friendly and cooperative way, made by the Project Co-ordinator, National Director, Consultant/Project Engineer and JBI's Personnel allowed me to perform my special service in all respects. It is to be mentioned our very good collaboration with Dr. McGaw and Dr. T. Kalman who were also on missions to JBI as UNIDO consultants during my mission.

A. ADVICE ON THE COMPLETION OF THE ANALYTICAL LABORATORIES AND PROCESS RESEARCH LABORATORY

Since my last visit in February the construction of the laboratory building is near to completion and most of the selected and specified laboratory equipment were delivered to JBI already. The beginning of the research work is expected however in October 1982 because of the postponed delivery of fume exhausting system.

The actual list of the complementary purchased equipment is the following:

Laboratory Equipment

		US $
1.	Leco Vitrocast Sample Preparator for XRF	26,543
2.	Fritsch Scanning Photo-sedimentograph particle size Analyser	15,102
3.	JEOL Scanning Electron Microscope, Type: JSM-T200	67,653
4.	Thermogravimetric Analyser, MOM, Derivatograph Q-1500D with Thermal gas Titrimetric Apparatus	49,240
5.	Platform Scale	1,269
		159,807

For purchasing Fume Exhausting System US$41,000 is estimated.

Equipment ordered for Process Research Laboratory

1.	Four Stage Agitators (2 set, for desilication and for precipitation each)	14,560
2.	7.5l Autoclave	11,778
3.	Soft Gamma-Ray Absorption Model Settler	50,000
4.	Calculator for Gamma-Ray-Settler	4,070
5.	*4-Q Laboratory Rotary Kiln	11,669
		92,027

*The item 5, was selected for location in the Pilot Plant, however, it is recommended to replace this typically laboratory equipment in the process research laboratory.

All of the actions required are well underway organized by the Project Co-ordinator, National Director, Consultant/Project Engineer and JBI's Personnel. Some actual questions will be discussed as follows:

1. Upgrading of the X-ray Laboratory

In my last report the following steps of the upgrading were recommended in the field of the XRD activity:

- Automated continuous operation (day and night) without any human intervention. (Automated reading of diffractograms).
- Automated evaluation of bauxite diffractograms.
- Common control of XRD and XRF.

Discussing the topics with the experts of further informations and recommendations are to be mentioned.

Updating of the existing X-ray equipment needs some additional units and software. For some purposes only equipment recommended by the original manufacturer can be taken into account, e.g., automatic sample changers for XRF and XRD, respectively.

On the other hand data acquisition or computer control can be easily interfaced by different standard units. I would prefer the use of Hewlett-Packard products because they are found to be reliable and very favourable experiences were collected with them in our institute.

For off-line solution the cartridge tape unit (HP 9875) would be optimal and even the HP 85 personal computer attached to the settling analyser could be used for data processing. However, an independent computer could do the same.

A larger programmable HP desk calculator (HP 9825, 9835 or 9836, 9845) could be coupled on-line. Graphic display, plotter, line printer, same means of mass storage are required as peripherals.

The know-how of the ALUTERV-FKI in the field of the mineralogical (phase) analysis of bauxites extends from the sample preparation to the final evaluation. Software for the HP 85 or other HP desk calculator is included in this package. The computer program covers data reduction, peak search, separation of overlapping peaks, calculation of integrated intensities, a mini-file of diffraction data, identification with the aid of the latter and two kinds of quantitative routines. The first of these uses exclusively the coefficients of intensity conversion (Chung's method) while the second combines the information contained in the X-ray integrated intensities and that of the chemical analysis.

The two sets of data are evaluated by self-consistent linear equations. The error is less than ± 10% relative in the first case and less than ± 8% relative in the other one. A comprehensive English user manual and two weeks of training are included in the system price of 10-12,000 US$ depending on the details of final agreement (site of training, etc.)

It is recommended to accept this reasonable offer and to discuss the further upgrading of the X-ray activity of JBI with Dr. T. Turmezey who will lead the expert group coming from Hungary to JBI in November for the installation of the Soft-gamma-ray Absorption Model Settler.

2. Installation of the Thermogravimetric Analyser, "Derivatograph Q-1500D

Derivatograph Q-1500D and Thermal Gas Titrimetric Apparatus have been delivered to JBI at the end of January and its installation is expected at the end of July in the new laboratory building.

The training of project staff of JBI (Mrs. J.H. Satterthwaite and Mr. E.A. Spence) in connection with purchase order UNIDO 15-1-B 1159 (Q-Derivatograph) was successfully realised in Hungary between 4.4 and 14.5, 1982 at the Research Department for Alumina Production of ALUTERV-FKI, Hungarian Optical Works (MOM) and Technical University. The aim of the programme was to train the Jamaican experts in operating and using Q-Derivatograph which is to be installed in the near future at JBI.

As an item of contract MOM has handed over three copies of "Manual for Thermogravimetric Investigations applied in bauxite Processing" which was prepared by experts of ALUTERV-FKI. Besides this manual several reprints, copies of articles related to the analyses of bauxite, red mud and other materials were given to JBI experts.

The thermogravimetric analysis is a part of the complex phase analysis system of bauxite and red mud samples, therefore the attaching methods like XRD were studied also thoroughly at ALUTERV-FKI.

Four representative bauxite samples and three red mud samples (originated from Jamaica) were analysed by the "complex method". Results, XRD and TG patterns were given to JBI experts. These samples will be taken into consideration as "standards" for quantitative phase analysis at JBI.

The JBI experts had opportunity to meet the inventors of the equipment (Prof. F. Paulink and Dr. F. Paulink), to listen to their explanations and to discuss some special topics.

MOM introduced Mr. Spence into the elementary service and repair techniques which he might need for the maintenance of Q-Derivatograph.

The experts could get acquainted with the activities, equipment and methods applied in the research of bauxite processing at ALUTERV-FKI. On special request the operation of Fritsch Analysette 20 Photosedigraph was also discussed and trained because JBI has the same type of instrument purchased recently.

During the training program the trainees visited the three Hungarian alumina plants and the Bauxite Processing Company whose activity is similar to that of JBI. Plant visits were oriented on process control, laboratory equipment and same general aspects of processing.

The training program was organised by the personnel of my department and by myself. The candidates have completed the training program, they can use Q-Derivatograph and learned the technique of simple service maintenance.

3. Installation of the Soft-gamma-Ray Absorption Model Settler

As a result of the negotiations the purchasing of this non-commercial equipment developed by ALUTERV-FKI combined with a special "know-how" knowledge and training program (as a separate part of this package has been decided.

The preparation of the "manual" is in a good progress in Hungary. This will consist of two parts:

- know-how manual (theoretical background, application in alumina industry and computer software)
- operating manual to the equipment.

The know-how manual will be completed in this time and will be delivered to JBI till the end of July. The operating Manual however, will be given to the selected trainees on the spot only.

It has been agreed that the six-weeks training will be performed at ALUTERV-FKI, Budapest between 15.8 and 30.9.1982. The related reprints and other publications were given to JBI personnel during my present mission.

The lay-out plan for the whole radioisotope laboratory where the equipment will be installed has been delivered by the Hungarian supplier in the required time (till the end of March) with my contribution.

The installation of the equipment is expected at JBI in November 1982.

4. Comments related to other laboratory equipment for further action

Combined with purchasing of valuable equipment a special training program is required as well. One of them has been accomplished already (Thermogravimetry) and another one agreed and prepared (Soft-gamma-ray Absorption Model Settler), however, similar training is required in the field of the Scanning Electron Microscopy as well, at JEOL (supplier).

It is recommended to order the following equipment completion:

1) Voltage Stabilizers for the all valuable equipment taking into account the uncertain electrical power supply. This is required to protect the equipment and to gain comparable data.
2) Centrifuges for the preparation of the samples coming from the process research laboratory and the pilot plant. (Heatable type recommended with steel tubes). At least two pieces!

3) Thermatic-Titrator for the fast analysis of the aluminate liquors coming from the process research laboratory and pilot plant.

Time requirement for one analysis is about 5 minutes only. The sensitivity of the temperature measurement 0.01°C. It can be connected directly to desk computers or to a digital-data processing system. All three Hungarian alumina plants use this method and instrument developed and instrument developed by ALUTERV-FKI for process control. The accuracy of the titration never exceeded ± 0.4-06% relative determining caustic soda and alumina content, respectively. Informative price US$4,800.

4) Oscimhometer OK-10511 (ALUTERV-FKI)

Laboratory instrument with inductive cell, operating with high electrical frequency. The instrument measures the electrical conductivity of electolyte solutions or the changes in component concentration in proportion with this property.
Informative price: US$1,700.

5) Heating and Cooling Control for the two set, four stage tors are to be used for study of predesilication and prec operations, respectively.
Informative prices at ALUTERV-FKI:

Complete heating and cooling system	..	US$4,200
The same but programmable	.. ..	US$5,800
Oscimhometer transmitter	.. ..	US$2,600

Further discussions relating to the equipment developed by ALUTERV-FKI are recommended in November from the occasion of the visit of the Hungarian team.

B ADVICE FOR DESIGNING AND MAIN TECHNICAL OUTFIT OF THE PILOT PLANT

My consultancy focused on the completion and finalisation of the equipment and instrumentation list of the Pilot Plant based on a thoroughly discussed and justified flow-sheet. I had the opportunity to perform this very responsible task with very well organized collaboration with the Project Co-ordinator, National Director, Consultant/ Project Engineer, Dr. D. McGaw and Dr. T. Kalman, UNIDO Consultants and JBI Process Engineers. It was agreed and realized that some further modifications and completion of the flow-sheet, layout plan and equipment and instrumentation list was necessary. As a result of our common activity. The revised drawings and lists mentioned are attached to this report (Appendix 2).

The main technological considerations relating to the completion and finalization of the Pilot Plant documents are summarized in the following chapters.

1. Main Considerations connecting with the revised flow-sheet

It has been stated earlier that the material flow of the Pilot Plant will be determined by the capacity (volume) of thickeners. Consequently, purchasing thickeners of the smallest capacity was recommended. Unfortunately the supplier could deliver only 3'D x 2.5' thickeners instead of 2.5'D x 2.5' ones as originally understood. This means an enlargement of 1.5 times in the settling - washing area and we had to use a nominal total volume of about 1500 litres (1350 operating) instead of 900 litres in this section. It will be necessary to run with a three times larger throughput approaching a quasi-equilibrium therefore of about 400 litres of blow-off liquor to be produced in one working period independently of method of operation of the digesters. The dimensions of the equipment (tanks) in all of the other operations have been based upon this throughput.

Taking into account the batchwise operation, relatively large holding volumes are recommended in each operation. As a basic principle, selection of the minimum numbers (pieces) of tanks however with an enlarged volume was considered. This decision allows for flexibility in the operation; namely to produce material in the given section sufficient enough for the next stage (e.g.predesilicated slurry for digestion, aluminate liquor for precipitation). This is the only way to carry out the batchwise operations during a reasonable working time and to reduce the operating cost, saving pumps, stirrers, lagging, valves and instrumentation as well. Consequently, only two tanks are recommended in the revised flow-sheet and layout plan for the same purpose.

As a consequence of the above mentioned conditions, the total volume of the tanks in the main operation units have been enlarged about twice or even more compared with the originally recommended volume (e.g. in bauxite preparation 2 x 250 l instead of 2 x 331), in predesilication 2 x 500 l instead of 4 x 100 l) and in the precipitation (2 x 1600 l instead of 2 x 500 l). The size of these items were earlier based on reduced throughputs associated with the originally envisaged smaller thickeners. The liquor holding tanks are recommended to be 2 x 800 l instead of 4 x 350 l or 2 x 500 l instead of 3 x 350 l).

Sometimes no changes to the number and dimension of the tanks were necessary (e.g. blow-off tanks, wash water tank, first washer's overflow tank, aluminate liquor tank).

New additional tanks have been justified:

- 2 slurry holding and adjustment tanks 3000 l each agitated, with lagging, to store the desilicated slurry. They are to be covered because they serve as receivers for slurry coming back from autoclaves in emergency case. This large volume is sufficient enough

to charge the autoclaves during whole period. The adjustment of the slurry (control of the expected A/C ratio) that is, the ratio between the bauxite and digesting liquor) will be carried out in these tanks based on the analysis of the taken out samples. (Complete analysis of both solid and liquid required).

- 4 small transfer tanks, 100 l each for pumping the underflows of the thickeners and that of the overflow (aluminate liquor). Direct pumping cannot be recommended.
- Second washer's overflow tank, 200 l. Originally the first and second washer overflows were collected in the same tank which does not allow for use of the liquors of different caustic concentrations separately.
- 2 Filtrate receivers, 250 l each, vacuum proof to the Parr (4-Q) Parr Filter. They are needed for semi-continuous operation of the hydrate filter, periodically interchanged the streams. The delivered one small Pilot Plant operation.
- 1 hydrate slurry receiver, 100 l to control the level of the hydrate slurry during the filtration (level regulation by recycling), for a semi-continuous operation without manual control.

No special equipment are recommended in the revised flow-sheet for the overflow and red mud causticization. The use of the first and second washers overflow tanks and the desilicator tanks respectively is suggested for these purposes.

Lime can be added in solid form into the mill.

The estimated material flow is as follows: (See Dr, McGaw's report).

3 x 75 l slurry = 225 l slurry at three autoclaves' operation
(209 l test tank liquor and 40.6 kg bauxite wet)
Blow-off per batch about 265 - 300 l (with 12 kg solid)

During a day maximum 5 batch digestion can be carried out, it means 1300-1500 l blow-off/day.

The estimated daily consumption and production (5 batch)

1050 litres test tank liquor
200 kg Wet bauxite
(160 kg dry bauxite)
70 kg dissolved Al_2O_3
60 kg red mud
1300-1500 l blow-off

Three whole days are required to produce the required amount of the diluted slurry.

The following schedule can be proposed for batchwise operation:

1st week : grinding, predesilication, storage and adjustment of the predesilicated slurry.

2nd week : digestion, settling-washing, control filtration, precipitation (not completed) 3 shifts required!

3rd week : precipitation, hydrate filtration, evaporation.

2. Comparison of the batchwise and continuous operation in the Digestion Stage

Although batchwise autoclave operation is preferred in the initial period of the Pilot Plant operation, considerations relating to continuous digestion operation are well underway.

After returning to Hungary from my last mission I discussed the completion of the digestion stage of the Pilot Plant both for batchwise and continuous operation with the designer of the autoclaves.

After further discussions and on the basis of the request of the Project Co-ordinator for quotation ALUTERV-FKI prepared an offer for both variants and this was given to him by myself.

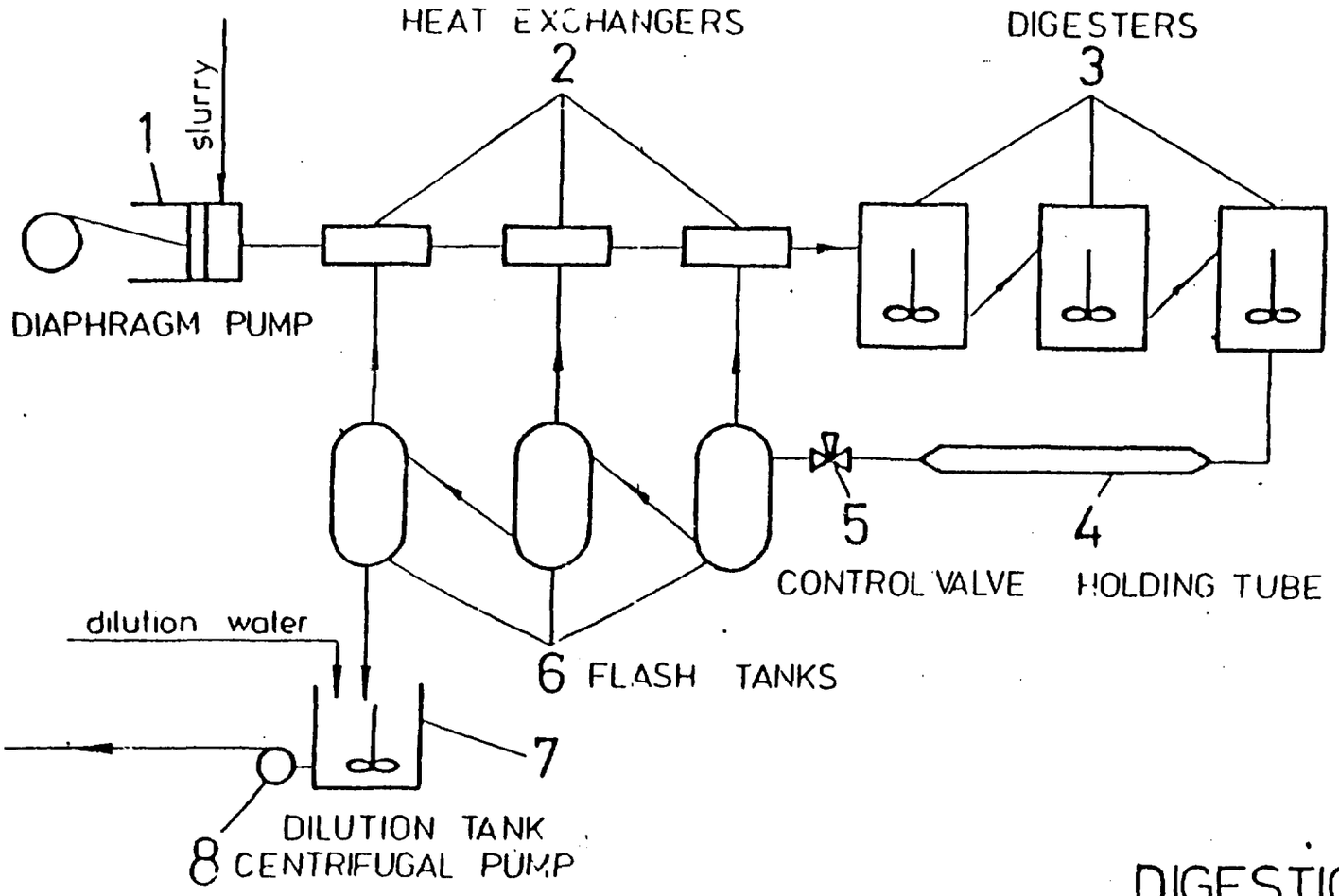
The principal flow-sheets of both variation are presented in the next figures.

The variant "Digestion Pilot Plant I"shows the completed continuous operation where three tube heat exchangers using flash steam and a holding tube serve to avoid the disadvantage of the non-piston-like material steam in the autoclaves because the line would be too short. The slurry is feed to the digester by a high pressure (65 bar) diaphragm slurry pump with a flow rate of 0 - 5 l/minute.

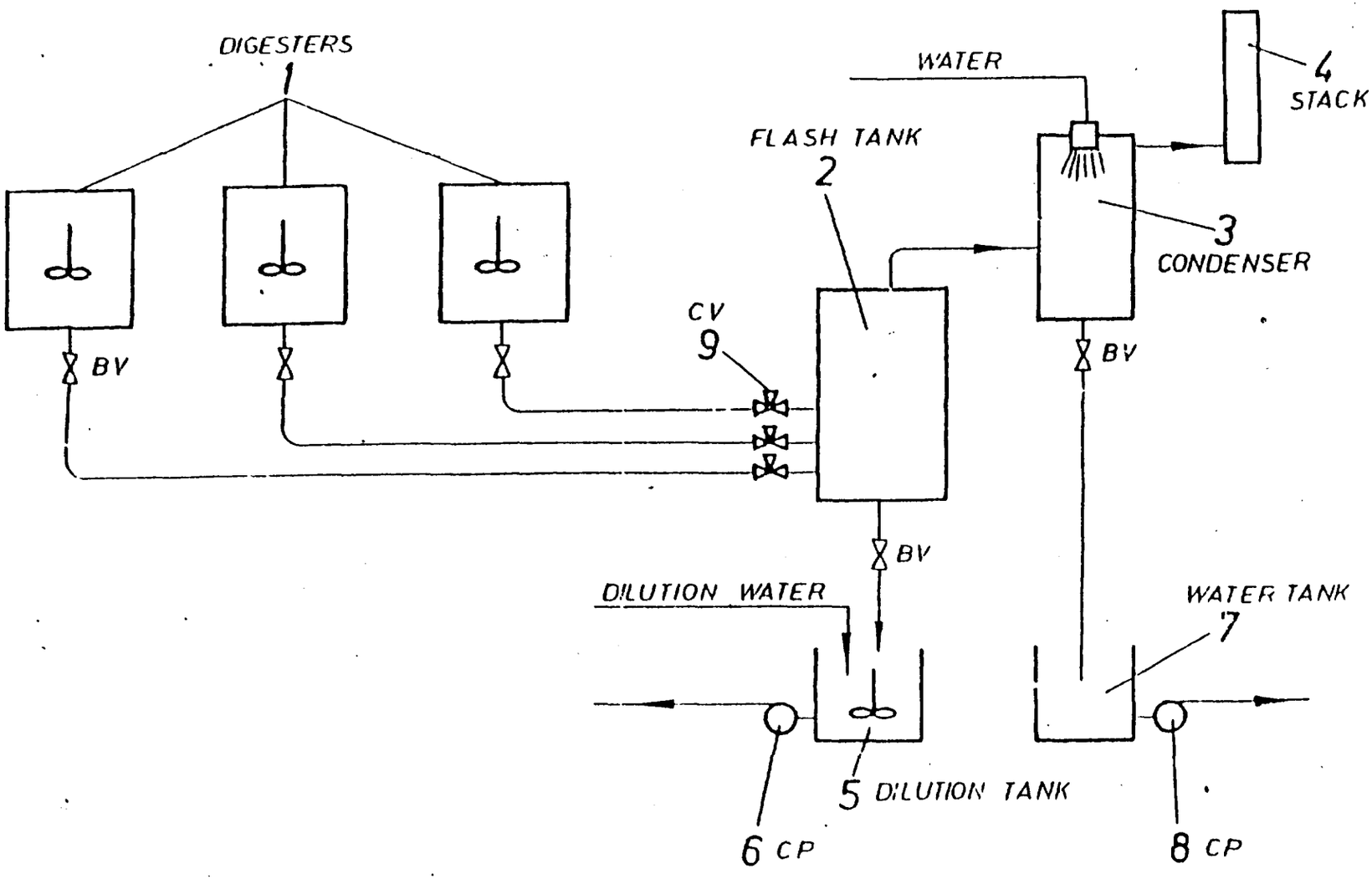
The variant "Digestion Pilot Plant II" demonstrates the batchwise operation with a large common flash tank (1.2m^3), water condenser and venting tube, completed by block valves (BV), control valves (CV) and centrifugal pumps (CP) as well. This variant is much cheaper US$21,500 for all of the accessories to the ordered autoclaves) and the delivery can be realised by ALUTERV-FKI in the first quarter of 1983.

The continuous variant is much more up-to-date, however, more costly US$40,200, and the delivery time longer (second quarter 1983). The batchwise operation is advantageous to train the personnel, however, continuous operation is recommended for later, based on the following considerations:

- The real plant conditions can be modeled better and the laboratory autoclaves are available for the above mentioned investigations in smaller volume.
- The flow rate can be increased significantly (2x). In the Pilot Plant however 120-150 litres/hour flow rate is recommended because of the similarity of the plant autoclave and the selected capacity of the other section (first of all red mud settling and washing).



DIGESTION PILOT PLANT I.



DIGESTION PILOT PLANT II.

It is to be mentioned that the retention time in the case of low temperature digestion at about 190°C cannot be diminished below three hours due to the proper desilication of the liquor!

- The energy consumption of the digestion can be reduced about 50%, heating the preheaters by flash steam (Saving electrical power).

- The labour costs can be decreased as well.

The additional investment cost compared with with the batchwise operation is US$18,700, however in this case a high pressure (65 bar) diaphragm slurry pump (0 - 5 l/minute) will be delivered in the package) too. This investment costs can be repaid in a short operation time.

If the realization of the batchwise operation would be preferred we have to calculate with a US$21,500 loss because the accessories needed for batchwise operation cannot be used for the continuous one. Consequently, it is recommended to make the autoclaves suitable for continuous operation, to order the accessories for this purpose as well without diaphragm pump actually for US$28,100 and to start with them batchwise.

It is to be mentioned as well that the modification of the autoclaves would not be possible later, therefore, this decision has to be justified.

We have discussed the effects of the continuous digestion operation on the other sections of the Pilot Plant as well. It has been proved that only two agitated precipitator tanks are required supplementary.

I would like to emphasize that the autoclaves and their accessories are non-commercial, special high pressure equipment therefore individual designing and manufacturing is necessary. Relating to these conditions the expected and agreed time of delivery seems to be reasonable and acceptable. It is recommended however to send the completed documentation to JBI by ALUTERV-FKI as soon as possible due to the careful preparation of the construction on the spot in time (access points, demands for electrical and water supply, connections with other operation units).

In this case no delay will be caused in the completion of the Pilot Plant because the complete package offered contains all of the equipment, accessories and spare parts needed in the digestion area. The high pressure equipment will be fabricated by a Hungarian manufacturer well experienced in the production of plant size and laboratory scale autocalves. Although the delivery time of the autoclaves was treated as a very critical part of the completion of the Pilot Plant in the Tripartite Review Meeting the common efforts made by the Project Co-ordinator, UNIDO representatives and director of ALUTERV-FKI will allow for the construction of this very important section of the Pilot Plant in the requested time.

3. Special Requirements of the Instrumentation

The main on-line measurements in the Pilot Plant will be temperature, pressure and flow rate. The revised list of instrumentation can be found in Appendix II.

"As special instruments Thermatic Titrator", "Oscimhometer OK-10511", and "Oscimho-transmitters OK-106" are recommended. The Oscimho-transmitter (OK-1061 developed by ALUTERV-FKI) might be attached to the sidewall or inserted from the top of selected tanks. Care should be taken that at the points of application no scaling or deposition is present. Thus the measurement of digestion liquor, recycle liquor, digested slurry, solid concentration of settler's underflow seems to be feasible. If direct concentration measurement is required frequent calibration by thermometric titration (or classical titrimetric methods) might be necessary, otherwise only useful information can be obtained about the changes.

From the point of view of the Pilot Plant operation measurement of the conductivity is recommended:

- to control the dilution of the blow-off (batchwise, in both tanks)
- to determine the solid content in the settler's underflow

- to continuously follow the yield of precipitation.

Oscimhotransmitter provides also for temperature measurement and for control of the A/C ratio of the blow-off also.

The concentration drop of the aluminate liquor in the water - independent range and the conductivity meter can be calibrated directly with A/C ratio, to follow the precipitation.

The following relationship exists between the solids content and conductivity of slurries:

$$C_{solid\ g/l} = a \left[1 - \frac{k}{ko}\right]$$

where "k" conductivity of the slurry,

"ko" conductivity of the liquid phase

"a" a factor depending on the grain size

Therefore the solids content of slurries can be determined by conductometric measurements only if the change in ko, due to a change in composition of the liquid phase, is negligible or if the grain size is constant. In alumina plants, (in this Pilot Plant as well) a single conductivity measurement suffices only to determine the solids content of the Dorr settlers.

The instrument is actually an OK-106 type conductivity tele-transmitter which can be incorporated directly in the cone of the Dorr thickeners, its output signal being directly proportional with the solids concentration of the mud. No special supervision and very little maintenance are required. The instrument will be calibrated on site before assembling.

The comprehensive digrams relating to the changing of conductivity of aluminate liquors in function of caustic soda concentration at different salt (sodium carbonate) levels, at different Al_2O_3 concentrations and at different caustic molar ratios can be found in the "Manual for Laboratory", Volume 8 of the series of the UNIDO Group Training in Production of Alumina held at ALUTERV-FKI, Budapest, Hungary in 1979 (pp. 110-113).

These special conductivity meters are applied in the Hungarian and other alumina plants for on-line control of the alumina production.

It is also recommended to control the height of the clear zone in the thickeners. It is therefore necessary to locate a suitable instrument.

Detailed information and description was delivered to the Project team concerning all instruments developed and made by ALUTERV-FKI which are suitable for application in the Pilot Plant, including price (Analysers, heating and control system, programmable too, level indicator unit with capacito arrangement, temperature measuring and recording unit), to facilitate the selection.

Purchasing, Thermatic-titrator, Oscimhometer and Oscimhotransmitter (one each) is recommended as soon as possible to know their operation and application before the completion of the Pilot Plant under laboratory conditions.

4. Considerations on Red Mud Filtration

Although red mud filtration will not be carried initially in the Pilot Plant because of the extreme shortage in funds, the purchase of a rotary vacuum drum or belt filter is highly recommended based on the following considerations:

- The program of red mud utilization sponsored by UNIDO is well underway and this needs filtered red mud,
- The red mud filtration canbe preferred to open washing being a more economical technology under changing economic conditions (important savings in energy can be reached using less wash water in conjunction with reduced caustic soda losses. It is important to study this technology in the pilot plant.
- The up-to-date storage of red mud can be investigated only after filtration.

- Red mud filtration could facilitate storage and could decrease the amount of water to be evaporated in addition to caustic soda losses in Pilot Plant.

Consequently, the completion of the Pilot Plant with red mud filter (price US$30 - 40,000) is recommended in the frame of the red mud utilization programme.

5. Advice for the content of the Manual for Pilot Plant

It is recommended to write a comprehensive Manual for the Pilot Plant before its completion.

This Manual (called "Pilot Plant Manual" can be divided for three essential parts (volumes):

- General Manual
- Operation Manual
- Maintenance Manual

As a preliminary recommendation (not completed) relating to the content of these three "sub-manuals" the following main chapters are advised:

a) General Manual

- Main flow-sheet
- Main layout
- List of equipment and instruments with all their technical data
- Water, electrical, steam compressed air, drain-networks with access points
- The main fields of activity expected
- Organization of the work, job descriptions (responsibility)
- Working safety requirements, fire safety.

b) Operation Manual

- Detailed technological flow-sheet for each operation unit
- Detailed layout plan for each technological unit
- Detailed description of the handling of the main equipment, separately

- Instructions for the operation's manual control according to technological units.
- Main data of the flow rate (informative material and heat balance of each unit).
- Data sheets, instructions relating to the data and events to be registered.
- Sampling system, sample handling.
- Organization of the collaboration with the process research and analytical laboratory (duties, responsibility).
- Special instructions associated with the handling of the high pressure equipment.
- Instructions for accidents and unexpected irregularities.
- Data collection, data storage, processing and retrieval.
- Appendix 1: Main technical data of the raw materials to be processed, caustic soda solutions, and slurries in the investigated temperature range (e.g. density, viscosity, conductivity, steam pressure, etc.)
- Appendix 2: Examples for the calculation of the required material flow and expected average value of the capacity of the main equipment.

c) Maintenance Manual

- Required frequency of the control of the equipment.
- Methods to be applied detailed according to the main equipment.
- Simple manipulations carried out by the operating personnel.
- Maintenance carried out by specified personnel only.
- Instructions for the regular and irregular shutting down of the operation.
- Cleaning methods to be used, detailed according to the equipment.
- Maintenance of the instruments
- Supervision and control of the maintenance (responsibility)
- Maintenance of the electrical, water, steam, compressed air and drain network.

- Special instructions relating to the high pressure equipment and accessories.
- Method for changing valves, pumps and accessories.
- Data sheets for documentation of the maintenance and its control (supervision)

It is recommended to distribute this Manual for the operating JBI personnel and organise a special examination to control their proper knowledge.

C. ADVICE ON THE CONTENT AND COUNTER-PART INSTITUTION CONCERNING ORGANIZATION OF THE TRAINING AND STUDY TOUR PROGRAMME OF THE PROJECT

Further significant efforts have been successfully made by the Project Co-ordinator in the last period.

The special course for six (6) weeks in the field of Thermogravimetric investigations as part of the equipment purchased package was organised for two (2) selected project staff in Hungary beginning from 4th April, 1982. (For detailed information see sub-section A/2 of this report).

A special course will be organized in the field of modelling of red mud sedimentation by soft-gamma-ray-absorption settler for two project staff for six weeks in ALUTERV-FKI from 15th August, 1982.

Further training and study tours were recommended in agreement with the Project Co-ordinator in my last consultant's report (dated 10th February, 1982) which mostly are actual in this time.

Complementary actions are recommended as follows:

1. Trainings and Study tours abroad

   a) The 112th AIME Annual Meeting will be held in Atlanta, Georgia, between 6 and 10 of March, 1983. The participation of 1-2 Project Staff in the Bauxite-Alumina sessions should be highly recommended.

b) As a special two weeks training of 1-2 Project staff is recommended as an integrated part of the technology transfer package of the comprised quantitative phase analysis of bauxite based on XRD at ALUTERV-FKI depending on the decision relating to this contract (See sub-section A/1).

c) The 5th International Congress of ICSOBA Bauxite, Alumina and Aluminium) sponsored by the Yugoslav Academy of Sciences and Arts will be held in Zagreb, in September 25-30, 1983.

The scope of the Congress includes exchanges of ideas and experiences in the fields of:

- Bauxite and other raw materials; geology, mineralogy and ore deposit exploration.
- Alumina production: developments in the Bayer process and other methods in production technology; activated alumina synthesis, structure and properties.
- Aluminium: developments in metal and alloy production.

The participation of 2-3 Project staff should be highly benefitted. It is recommended to deliver 1-2 lectures and to complete the travel with the visit of some Yugoslave alumina plants (Birae, Mostar, Titograd). For organization of plant units after the congress the UNIDO contribution is requested to get official entry permissions and assistance of the plant experts.

2) <u>In-house Training Course(s) for JBI Personnel</u>

As a first step in this respect it was suggested to prepare a short one (1) week course dealing with "The Technological Evaluation of Bauxites" during my present mission. Although this has not been realised this activity remained actual and very important. The following actions are recommended in this respect:

a) Short course relating to the Technological Investigations of Bauxites and Red muds combined with the extended activity of the Process Research Laboratory, especially focused on the

opportunity of newly purchased equipment and instruments and methods to be applied.

b) Special course, Pilot Plant related before its completion consisting of the up-to-date knowledge relating to the Bayer process and based on the Pilot Plant Manual to be prepared.

Both training courses can be organised by the Project Co-ordinator in co-operation with the National Project Director and UNTA Bauxite Processing Expert. As lecturers and leaders of practice the experts of JBI, JBI and the University of the West Indies can be considered. It is recommended to use the eight booklets of the UNIDO Group Training in Production of Alumina held in Hungary in 1979. Twenty (20) sets of this series were delivered to JBI already.

3) Regional (Caribbean) UNIDO Group Training

It is recommended to organise a regional official UNIDO Group Training in Bauxite Processing using the upgraded JBI facilities after the completion of the project, with about four weeks duration. Due to the maximum benefit of JBI personnel it should be scheduled as soon as possible (reasonably between September and mid-December 1983) with the participation of about 10-15 JBI personnel and further 10 foreign candidates. The practice could include process research and Pilot Plant investigations.

As lecturers, domestic experts and University professors and leaders of the practices, UNIDO consultants assisted at the Project and further 2-3 experts in analytical chemistry and material science can be selected. It is advised to use the booklets of the UNIDO Group Training held in Hungary and the expertise of the Hungarian Party as well.

CONCLUSION

At the time of report writing all activities of the Project are well underway in an advanced stage. Actual efforts are focussed on the finalisation of the Pilot Plant design. Urgent actions are necessary to order all specified complementary equipment and accessories for the Pilot Plant to avoid delay in its completion. The work organized and performed at a very high level and with extremely good cooperation by the Project Co-ordinator and the Project team. Further efforts should be concentrated especially in the Pilot Plant activity included to find additional sources to bring it (and the whole project) to a successful completion.

DR. KAROLY SOLYMAR
UNIDO CONSULTANT

9th July, 1982

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UNIDO CONSULTANT

9th July, 1982

APPENDIX 1

ST/JAM/80/T01

UPGRADING THE SCIENTIFIC AND TECHNOLOGICAL CAPABILITIES OF THE JAMAICA BAUXITE INSTITUTE

ACTIVITY SCHEDULE FOR DR. KAROLY SOLYMAR, CONSULTANT

PERIOD: 20.6.82 - 9.7.82

Date	Activity	Venue	Personnel/Responsibility
Sunday 20.6.82	1. Arrive Jamaica	UNDP	Project Co-ordinator
Monday 21.6.82 Tuesday 22.6.82 Wednesday 23.6.82 Thursday 24.6.82	Participation and lecture on the International Bauxite Symposium V, in Kingston Jamaica (for his own charge) with the permission of UNIDO		Informal discussions with project personnel.
Friday 25.6.82	1. Visit UNDP office 2. Previous discussion of the Hungarian offer for the additional equipment to 3 laboratory autoclaves for the batchwise and continuous operations, resp. 3. Tour JBI Laboratories and construction site 4. Study of the Project Progress Report No. 1 written by Dr. Conrad G.C. Douglas, Project Co-ordinator and that of the Minutes of the Tri-partite Review Meeting.		Project Co-ordinator Project Co-ordinator National Director Consultant/Project Engineer UNTA Bauxite Processing Expert JBI Process Research Engineers Consultant/Project Engineer, UNTA Bauxite Processing Experts Project Co-ordinator
Saturday 26.6.82	Free day		
Sunday 27.6.82	Free day		

Date	Activity	Venue	Personnel/Responsibility
Monday 28.6.82	1. Meeting to review Project status and objectives		Project Co-ordinator National Director Consultant/Project Engineer JBI Process Research Engineers UNTA Bauxite Processing Expert
	2. Advice on the finalization of the analytical and process research laboratory		Project Co-ordinator National Director
	3. Examine actual flowsheet and lay-out plan of the pilot plant and flow rates documented in Dr. McGaw's report		Consultant/Project Engineer UNTA Bauxite Processing Expert
Tuesday 29.6.82	1. Commence final discussion on pilot plant: layout, Bauxite Preparation, Predesilication, units (equipment, tankage and instrumentation)		Project Co-ordinator National Director Consultant/Project Engineer JBI Process Research Engineers UNTA Bauxite Processing Expert
	2. Evaluation and comparison of the batchwise and continuous operations of the digestion unit based on the Hungarian offer.		- " -
Wednesday 30.6.82	1. Continuation of final discussions on pilot plant. Discussions of the red mud settling and washing and control filtration units		- " -
	2. Discussion of the different applications of electro-conductivity measurement in the pilot plant; blow-off dilution, determination % solids, monitoring precipitation yield.		- " -
Thursday 1.7.82	1. Continuation of the final discussions on the pilot plant. Discussion of precipitation, evaporation and liquor units.		- " -

	2. Flocculant preparation and dosage, facilities for causticization of over flow and red mud.	Project Co-ordinator National Director Consultant/Project Engineer JBI Process Research Engineers UNTA Bauxite Processing Expert.
Friday 2.7.82	Completion and summary of the outstanding complementary equipment and instrumentation list of pilot plant for batch-wise operation	Consultant/Project Engineer, UNTA Bauxite Processing Expert.
Saturday 3.7.82	1. Completion and summary of the equipment and instrumentation list of pilot plant for c continuous operation.	
Sunday 4.7.82	1. Begin report writing	
Monday 5.7.82	1. Discussion of the modified and completed equipment and instrumentation lists of pilot plant for batchwise and continuous operations, respectively.	Project co-ordinator National Director Consultant/Project Engineer Consultant UNTA Bauxite Processing Expert.
	2. Estimation of the material flow required in the pilot plant for batchwise and continuous operations, respectively	
Tuesday 6.7.82	1. Further discussion, revision and decision relating to the modified and completed equipment and instrumentation lists of pilot plant.	- " -
	2. Suggestions on operations manuals for pilot plant	
Wednesday 7.7.82	1. Continue report writing 2. Complementary equipment list.	

Thursday 8.7.82	1. Comments and suggestions on the proposed training and study tour programme for counter-part personnel	Project Co-ordinator National Director
	2. Continue report writing	
Friday 9.7.82	1. Complete report	Project Co-ordinator
	2. Departure	

7/7/82

LIST OF EQUIPMENT AND INSTRUMENTATION FOR PILOT PLANT

BATCHWISE OPERATION

OPERATION UNIT	EQUIPMENT No.	Specification	Total Vol.	Ordered	Delivered	US$ Cost	Pumps	No.	Valves	No.	Instrumentation	US$ Cost	Remarks
1. Bauxite Preparation													
a. Bauxite Storage Tanks	50	Steel drums 2'D x 4'H-355.7 litres ea.	17,785 l	To be ordered by JBI			Slurry Pumps 0-500 l/h with 3/4 HP motors	3	Needle Valves	6	2 Scales (100 Kg) 1 Magnetic flow-rate meter (60-90°C, 0-600 l/h 2 level indicators (floating) 2 agitators	2,538 To be ordered by UNIDO after receiving quot.	1 scale already delivered and other to be ordered
b. Lime Storage Tanks	10	Steel drums 2'D x 4'H-355.7 litres ea.	3,557 l	" " " " "					Cock Valves	2			
c. Ball Rod Tube Mill	1	16" Dia. x 48" long		7.12.81	May '82	23,650							
d. Milled Slurry Tanks	2	2' Dia. x 3'H -250 litres ea.	500 l	To be ordered by JBI									
2. Predesilication													
a. Predesilication Tanks	2	3'D x 3'H	1,000 l	To be ordered by JBI			Slurry Pumps 0-200 l/h	2	Needle Valves	9	2 Temp. gauge + Control 2 level indicators; 2 agitators; 2 steam coils, lagging		
									Cock Valves	2			
b. Slurry Holding and Adjustment Tanks	2	5'D x 5'H	5,500 l	To be ordered by JBI			Slurry Pumps 0-500 l/h 3/4 HP	2	Needle Valves	11	2 Temp. gauge (60-100°C	-as above-	
									Cock Valves	2	2 level indicators; 2 steam coils, 1 magnetic flow rate meter (0-600 l/h) 2 agitators, lagging		

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3. Digestion						
a. Autoclaves	3	100 l, 260°C	300 l	7.12.81	Dec. '82	50,000
b. Flash Tank	1	1,200 l Vol.	1,200 l	To be ordered by UNIDO		
c. Blow off Tanks	2	3'D x 4'H	1,600 l	" " " " JBI		
4. Red Mud Settling and Washing						
a. Thickeners	3	3'D x 2.5H	1,500 l	7.12.81	20.4.82	11,112
b. Transfer Tanks	4	1½'D x 2'H	400 l	To be ordered by JBI		
c. Wash Water Tank	1	2'D x 2½'H	200 l approx.	" " " " "		
d. 1st and 2nd Washing overflow tank	2	2'D x 2½'H	400 l approx.	" " " " "		

				Will be delivered by ALUTERV-FKI with instrumentation	To be ordered by UNIDO 28,100 (C & F)	Modified batch-wise
				Will be delivered by ALUTERV-FKI with all accessories	40,200 (C & F)	continue
Centri-fugal Pumps (0-500 l/h) 3/4 HP	2	Needle Valves Cock Valves	10 2	2 Temp. gauge (120°C) 2 Level indicators, 2 Oscimhotransmitter) (for dilution) 2 steam coils, 2 agitators, lagging, 1 magnetic flow-rate meter 0-200 l/hr.	To be ordered by UNIDO after receiving quotations	
Diaph-gram Pumps ½ HP	3	Needle Valves Cock Valves	6	3 Temp. gauge (100°C) 3 Turbidity Meter 3 Interface monitor-ing device 3 Oscimhotransmitter) (for compaction) lagging	To be ordered by UNIDO after receiving quotations	
Centri-fugal Pump for overflow	1	Needle Valves Cock Valves	8) 2)		-as above'	
-		Needle Valves	3	1 Temp. gauge (100°C) 1 level indicator, direct steam sparg-ing, lagging	-as above-	
2 Centri-fugal Pumps	2	Needle Valves Cock Valves	6 1	2 Temp. gauge (100°C) 2 level indicators, 2 steam coils, 2 agitators, lagging	-as above-	

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5. Control Filtration

a. Aluminate Liquor Holding Tank	1	3'0 x 4'H	800 l	To be ordered by JBI	Centri-fugal Pumps 7 Bars Working Pressure	2	Needle Valves Cock Valve	4 1	1 Temp. gauge (100°C) 1 level indicator 1 Steam coil 1 agitator, lagging
b. Lime Addition Unit	1	2'0 x 2½'H	200 l approx.	" " " " "			Needle Valves Cock Valve	3 1	
c. Pressure Filter	1	Pres. Filter 4.18 M^2 Filtering area, 5 bars pressure	11.5 g/ hr.	June '82 Sept. '82 9,500					
d. Filtrate Collection Tank	1	3'D x 4'H	800 l	To be ordered by JBI	Centri-fugal Pump	1	Needle Valves Cock Valve	10 1	1 Temp. gauge (100°C) 1 level indicator 1 Steam coil 1 agitator, lagging

6. Precipitation

a. Precipitator Tanks (one to be isolated)	4	3'D x 8'H	8,600 l	" " " " "	Centri-fugal Pump 12' head				2 Temp. gauge & control 2 level indicators, 1 cooling coil, 1 steam coil, 1 oscillo-transmitter, 1 Temp. program, 2 agitators, lagging.
b. Hydrate Filter	1	Pan type vacuum Filter, 3' x 3'	300 l/ hr.	June '82 Sept. '82 15,806					2 vacuum gauge
c. Hydrate Filter Tank	1		100 l	To be ordered by JBI			Needle Valves	4	1 agitator
d. Filtrate Receivers	2	2'D x 3'H Vacuum proof	500 l	" " " " "			Vacuum Valves Special valves to equalize vacuum to atm. pressure Needle Valves	4 2 4	

e. Hydrate Wash Water Tank	1	1½'D x 2'H	100 l	To be ordered by JBI			Centrifugal Pump	1			1 level indicator and control 1 direct steam sparger 1 rotameter 0-100 l/h lagging
g. Spent Liquor Holding Tanks	2	3'D x 4'H	2,200 l	"	"	"	"	"	"	1	Needle Valve 7 Cock Valve 1	2 Temp. gauge 2 level indicators 1 agitator
7. Evaporation											
a. Evaporator	1	Flash Type	50 l/ hr.	"	"	"	"	"	"	1	Needle Valves 2 Cock Valve 1	
b. Condensate Storage	1	2'D x 3'H	500 l	"	"	"	"	"	"	1	Needle Valves 2	1 level indicator
8. Steam Generator											
Heat Exchangers	2	Operating Pressure 150 p.s.i. to be specified.		15.12.81*Mar.'82			23,340				

*Dispute

EQUIPMENT AND INSTRUMENTATION LIST FOR PILOT PLANT

II CONTINUOUS OPERATION IN THE DIGESTION STAGE

ADDITIONAL REQUIREMENTS FOR COMPLETION COMPARED WITH BATCHWISE OPERATION

OPERATION UNIT	EQUIPMENT						Valves	Pumps	Completion & Instrumentation	Cost. Est.	Remarks
	No.	Specification	Vol./ea.	Total Vo.	Ordered	Delivered					
Predesilication tanks	2	2½'D x 4'	500	1000			11 Needle 2 Cock		2 Temp. gauge + Control (100°C) 2 Level Indicators 2 Agitators 2 Steam Coil		Optional
Completion of the digestion unit	1	Package "according to the offer of ALUTERV-FKI'							Complete package with: 3 preheaters 3 flash tanks 1 holding tube 1 high pressure membrane pump		
Precipitator tanks agitated	2	3'D x 8'	1600	3200			9 Needle 2 Cock	1 Centri-fugal pump 12' head 3/4 HP	2 Level indicator 2 Temp. gauge and control 2 Cooling coil 2 Steam coil 2 Agitators 1 lagging 1 Temp. program 1 Oscimhotrans-mitter		Required