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ASSISTANCE TO LIGAS DE ALUMINIO S.A.

BRAZIL

by

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S/F Aluminium Industry
C/F BRAZIL

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REPORT

on the results of a mission to supply technical assistance to the Brazilian company "Ligas de Alumínio S.A." on certain aspects of a project for a factory to manufacture aluminium-silicon alloys and on the technology of manufacturing such alloys.

I. INTRODUCTION

In September 1969, the Brazilian Government asked the United Nations Industrial Development Organization (UNIDO) to provide technical assistance to the Brazilian company "Ligas de Alumínio S.A.", which was building a factory for the production of aluminium-silicon alloys by the direct reduction of aluminosilicates.

As this process for the manufacture of aluminium-silicon alloys is at present used on a large industrial scale only in the USSR, UNIDO asked the appropriate Soviet organizations to send Soviet experts to provide "Ligas de Alumínio S.A." with technical assistance.

In the original project for the provision of technical assistance to "Ligas de Alumínio S.A." it was envisaged that the assistance should be given in two stages.

The <u>first stage</u> was to consist of a 15-day visit by an expert in metallurgical planning to Belo Horizonte to discuss with the technical staff of the company the final plans for the construction of the factory and the production processes to be used in it, followed by a visit to the Norwegian company "Electrokemisk A/S" in Oslo to inspect and evaluate the electric arc reduction furnaces ordered by the Brazilian company for its factory.

The <u>second stage</u> was to consist of a three-month visit to the town of Pirapora, with a visit to the city of Belo Horizonte, by a metallurgical expert specializing in the production of aluminium-silicon alloys, in order to provide assistance in the start-up of the electrothermic reduction shop and the metallurgical refining shop in the Pirapora factory until operations were proceeding in a completely normal manner.

This second stage of the technical assistance was to be carried out approximately 6 months after the first stage.

The present report deals with the results of the technical assistance supplied to "Ligas de Alumínio S.A." in the first stage, which was carried out between 30 November and 23 December 1970.

The representatives of "Ligas de Alumínio S.A." reported that the electric arc reduction furnace manufactured by "Electrokemisk A/S" had already arrived on the construction site in Pirapora, so that it was no longer necessary for the expert to visit Norway as envisaged in the original technical assistance project.

The author of this report wishes to express his gratitude to the following persons who took part in the organization and execution of the project and made possible the successful completion of the writer's task:

Representatives of UNIDO in Vienna, Austria: Mr. N.K. Grigoriev, Mr. Correa da Silva, Mr. R. Aguilar-Bolanos, Mr. E.T. Balazs, Mr. V. Serebryannikov, Mr. H. Pichler and Mr. Tourov.

Representatives of UNIDO in Rio de Janeiro, Brazil: Mr. E. Albertal, Mr. Balkazar and Mr. Romeo R. Bonini.

Staff of "Ligas de Alumínio S.A." in Belo Horizonte, state of Minas Geraes, Brazil: Mr. Mario Renno Gomez, Mr. Jose Patrusu de Souza, Mr. Gustavo Winkler, Mr. Edio Vieira de Azevedo, Mr. Everaldo dos Santos, Mr. B.A. Zimbloris and Mr. V.Ya. Malkov.

II. THE PRESENT STATE OF TECHNIQUES FOR THE PRODUCTION OF ALUMINIUM-SILICON ALLOYS BY THE DIRECT REDUCTION OF ALUMINOSILICATES

The main principles of these techniques were developed in the Soviet Union in the 1930's and 1940's. Similar work was also carried on in Germany and France. Details of German experience in the production of aluminium-silicon alloys by the electrothermic method during the Second World War are generally known, but this method was developed subsequently on a large industrial scale mainly in the USSR.

The main objective of the work which has been carried on for many years in the USSR on the development of the electrothermic method of producing aluminium-silicon alloys is:

- Broadening of the raw material base of the aluminium industry through the ability to use new types of raw materials, especially aluminosilicates;
- The use of high-power, high-output furnace equipment in the production of aluminium-silicon alloys.

Various kaolins and high-alumina concentrates of cyanitic ores such as cyanites and sillimanites have been tested as initial raw materials for the electrothermic method of producing aluminium-silicon alloys. The chemical composition of these ores is given in Table 1 below.

Table 1

Composition of some aluminosilicate ores and concentrates tested as raw materials for the production of aluminium-silicon alloys

Raw material	Composition, %					
	Al_2O_3	SiO_2	Fe_2O_3	TiO_2	CaO	Other substances
1. Beneficiated kaolin	38.3	47.2	0.84	0.62	0.28	12.6
2. Sillimanite concentrate	55.0	38.0	2.7	1.2	0.5	-
3. Cyanite concentrate no.1	57.8	38.6	0.9	0.9	-	-
4. Cyanite concentrate no.2	57.0	39.7	0.6	0.8	0.7	-
5. Cyanite concentrate no.3	52.9	40.5	0.7	0.5	0.35	-

Table 2 gives the composition of some carbonaceous materials used as reducing agents in the [illegible]duction of alumini[illegible] alloys.

Table 2

Composition of some carbonaceous materials tested in the production of aluminium-silicon alloys

Material	Composition, %				% content in ash				
	W^p	A^c	[illegible]	C^otot	Al_2O_3	SiO_2	Fe_2O_3	TiO_2	CaO
1. Gas coal, type "G"	1.9	4.29	34.0	79.15	29.4	36.2	10.3	0.53	8.4
2. Carbon concentrate, type "D"	9.4	16.5	46.0	76.8	16.9	71.8	4.6	0.5	3.1
3. Carbon concentrate, type "SS"	5.5	5.3	26.6	87.0	27.2	52.8	6.0	1.0	3.9
4. Petroleum coke	0.4	0.75	6.4	91.6	11.0	32.0	13.1	0.35	4.5
5. Wood charcoal	8.2	2.8	22.3	78.9	2.5	14.3	12.0	0.5	4[illegible].7

Investigations into the smelting of aluminium-silicon alloys were carried out on the laboratory and semi-industrial scale in single-phase, single-electrode hearth contact furnaces with capacities of 100kw, 600kw and 900kw. Industrial-scale investigations were carried out in a single-phase, single-electrode hearth contact furnace with a capacity of 10,000kva (a Miguet-Perrou furnace), a two-electrode furnace with a capacity of 11,000kva, and three-electrode furnace with a capacity of 16,500kva.

The industrial shop producing commercial aluminium-silicon alloys is equipped with three-phase furnaces with a capacity of 16,500kva, using self-baking electrodes with a diameter of 1,200mm. Beneficiated kaolin is used as the raw material. A mixture of gas coal and petroleum coke is used as the reducing agent in the thermic smelting process. Sulphite liquor is used for binding the charge into briquettes.

The main operating characteristics of the 16,500kva 3-phase furnaces when smelting aluminium-silicon alloys are shown in Table 3.

Table 3

Main operating characteristics of 16,500kva 3-phase furnaces when smelting aluminium-silicon alloys

Operating characteristic	Unit of measurement	Value
1. Installed capacity of transformers	kva	16,500
2. Current strength at electrodes	kiloamps	60-63
3. Operating voltage	v	139.5-154
4. Effective phase voltage	v	52-58
5. Output of refined alloy by the furnace	tonnes/day	18-22
6. Specific consumption per tonne of refined alloy:		
(a) Electric power	kwh	13,000-14,000
(b) Briquetted charge	tonnes	4.3-4.6
(c) Electrode paste	kg	80-90

The primary alloy produced in the furnace is of approximately the following composition: Al = 60-63 per cent; Si = 35-37 per cent; Fe = 1.5-2.0 per cent; Ti = 0.5-0.7 per cent.

The average content of non-metallic impurities (silicon carbide and oxides of aluminium and silicon) in the primary alloy is 10-13 per cent.

In order to eliminate these non-metallic impurities from the primary alloy, the alloy is refined with chloride and fluoride fluxes containing cryolite and chlorides and fluorides of sodium, potassium and calcium.

The yield of refined alloy with respect to the amount of initial crude alloy is 72-83 per cent (depending on the smelting and refining conditions).

The refined alloy is used for the manufacture of silumin-type alloys by alloying with aluminium and subsequent filtration of the iron and titanium impurities out of the alloy at a temperature close to the eutectic.

The production cost of aluminium-silicon alloys produced by the direct reduction of aluminosilicates can be 5-10 per cent lower than that of alloys produced by the synthetic method.

The existence of large reserves of high-alumina aluminosilicate raw materials and the ever-increasing demand for aluminium-silicon alloys, which are used in various branches of industry, have created extremely favourable prospects for the further development of the electrothermic method of manufacturing aluminium-silicon alloys in the USSR.

III. GENERAL INFORMATION ON THE FACTORY BEING BUILT BY "LIGAS DE ALUMÍNIO S.A."

The private Brazilian company "Ligas de Alumínio S.A." is building in the town of Pirapora, in Minas Geraes state, Brazil, a factory for the manufacture of aluminium-silicon alloys by the direct reduction of aluminosilicates, thus avoiding the stages of the production and electrolysis of alumina. The raw material for the production of the alloys comes from the rich reserves of cyanites located close to the factory: aluminosilicates of the $Al_2O_3 \cdot SiO_2$ type, containing an average of 55 per cent of Al_2O_3 and 44 per cent of SiO_2, with a maximum content of 1.5 per cent of impurities in the cyanite.

It is proposed to use locally-produced wood charcoal as the reducing agent in the thermic smelting of the ore.

The project for the construction of this factory has received a great deal of assistance from State funds and has been approved by the council of SUDENE (the Development Authority for the North-East of Brazil) for a number of reasons of a social and economic nature, including:

(a) The contribution which the project will make to the development of industry in the north

(b) The substitution of imports by domestically produced goods

(c) The fact that the project will provide employment for 231 workers from the locality and

(d) The easy availability of electric power from the CEMIG system (from the Tres-Marias electric power station).

The production process adopted in the project involves the following main operations:

1. Reception and storage of the raw materials: cyanite, wood charcoal and clay (binder).
2. Grinding of the wood charcoal and clay.
3. Pulverization, grinding and flotation of the cyanite ores.
4. Storage in silos of the ground wood charcoal and clay and the flotation-enriched cyanite concentrate.
5. Mixing together of the cyanite concentrate, the wood charcoal and the clay.
6. Pressing of the charge into briquettes.
7. Drying of the briquettes.
8. Storage of the finished briquettes.
9. Smelting of the briquettes in an electric smelting furnace.
10. Production of the primary aluminium-silicon alloy.
11. Refining of the primary alloy in an induction furnace.
12. Separation of the refined alloy from the hypereutectic silicon by filtration.

13. Production of aluminium-silicon alloy containing 13 per cent of Si (silumin).
14. Alloying of the silumin with other metals (in an induction furnace) to produce special aluminium-silicon alloys.
15. Separation of filter residues containing Al, Si and iron for use in the deoxidation of steel.

The main output of the factory will consist of special aluminium-silicon alloys for casting. The project also envisages the production of metallic silicon in the same factory. After the first stage of the factory has been brought into operation, the annual output will be as follows:

1. 3,100 tonnes of special aluminium-silicon alloys
2. 1,100 tonnes of metallic silicon.

The final production capacity of the factory will be:

1. 4,000 tonnes per annum of special aluminium-silicon alloys
2. 2,000 tonnes per annum of metallic silicon.

The following foreign firms are taking part in the planning of the factory, its construction, and the supply of equipment:

- "Denver", USA: development of methods and supply of equipment for the production of cyanite concentrate by the flotation process;

- "Klöckner Humboldt Deutz", Cologne, Federal Republic of Germany: development of methods and supply of equipment for the production of a briquetted charge from cyanite concentrate and wood charcoal;

- "Electrokemisk A/S", Oslo, Norway: design and delivery of equipment for a 10.5 mva capacity electric ore reduction furnace;

- "Lurgi", Frankfurt, Federal Republic of Germany: development of methods and supply of equipment for the filtration of the primary alloy.

According to representatives of "Ligas de Alumínio S.A.", project status on 5 December 1970 was as follows:

1. The final plans for the following sections were not yet ready:
   (a) The cyanite flotation plant
   (b) The raw materials preparation plant
   (c) The briquetting plant
   (d) The primary alloy filtration plant.
2. Construction work on the factory was at the following stage:
   (a) Construction work had been completed on the buildings for the cyanite flotation plant, the raw materials preparation plant, and the briquetting plant, and the installation of equipment in these sections had already begun;
   (b) Construction of the building for the electric furnace section was continuing;
   (c) The equipment for the electric arc reduction furnace and the induction furnace had arrived on the construction site.
3. Start-up of the enterprise (the ore reduction furnace) is scheduled for May 1971.

Because of the delay in the planning construction of a number of sections connected with the production of the aluminium-silicon alloy, it is proposed to start up the ore reduction furnace and use it in the initial period for the production of ferro-silicon.

IV. SUBJECTS OF TECHNICAL DISCUSSIONS

The main subjects of the technical discussions held with representatives of "Ligas de Alumínio S.A." were as follows:

1. The production process to be used.
2. The planning of the factory.
3. The design of individual parts of the ore reduction furnace and its installation.

4. Some specific features of the production process.

"Ligas de Alumínio S.A." submitted the following documents for discussion:

1. Basic details of the production process to be used.
2. A plan of the factory.
3. A plan showing a general view of the ore reduction furnace and working drawings for its erection.
4. Drawings of the induction furnace.
5. A drawing showing a general view of the apparatus for the filtration of the primary alloy.

The following were not submitted in time for the discussion:

1. Data on processing tests of the cyanite raw material, including tests on moulding it into briquettes with wood charcoal and smelting tests.
2. Results of tests on the processing of the primary alloy into silumin by filtering out the hypereutectic silicon.
3. Explanatory notes on the technological part of the project and the design of the ore reduction furnace.
4. Assembly drawings for the following plant sections: flotation of kyanite, preparation of raw materials, briquetting of the charge and filtration of the primary alloy.
5. General specifications of the production equipment.

V. COMMENTS ON THE FACTORY PROJECT

After discussing the material submitted and hearing the additional explanations given by specialists from "Ligas de Alumínio S.A.", the following comments may be made on the project for establishing this factory:

1. The cyanite concentrate was adopted as the main raw material for the production of aluminium-silicon alloys without the necessary processing tests, so that there are as yet no reliable data on the process parameters, the specific consumption of raw material, the consumption of electric power, etc. and it is not possible to give a conclusive verdict on the suitability of the equipment selected.

2. The system adopted in the project for the production of aluminium-silicon alloys of the silumin type by the single-stage or step-wise separation of the primary alloy from the hypereutectic silicon by filtration has not been verified by investigations or industrial experience on the part of "Ligas de Alumínio S.A." or other firms. This system has a number of disadvantages which are as follows:

1. Inadequate yield of the basic product (the silumin filtrate);
2. The production of considerable quantities of by-products (siliceous filter residues) which are of considerably less value than silumin;
3. The difficulty of maintaining a constant temperature throughout the whole volume of alloy to be filtered and the need to prevent blockage of the filter surface by large quantities of crystals of silicon and intermetallic compounds.

3. The furnace selected for smelting the primary aluminium-silicon alloy is a three-phase open-type electric ore reduction furnace with a capacity of 10,500 kva, pressed carbon electrodes with a gap of 1,000 mm, and a rotating bath. The furnace is supplied from three single-phase transformers each with a capacity of 2,750-3,500 kva. The characteristics of the transformers are as follows: voltage on high-tension side: 110-45 kv, voltage on low-tension side: 89-170.3 v, current on high-tension side: 254 a, current on low-tension side: 30,900 a. The inside diameter of the furnace bath varies from 4,900 mm at the level of the taphole to 5,450 mm at the top. The depth of the furnace bath is 2,500 mm.

In its electrical and geometrical characteristics, the furnace is a typical furnace for the smelting of metallic silicon and can only be used for the smelting of aluminium-silicon alloys after a number of modifications in the design and construction of the lining to comply with the specific requirements of the process.

4. The distance decided upon in the project from the taphole of the ore reduction furnace to the floor of the shop means that the metal can only be poured into flat moulds, whereas it is actually more advantageous to pour aluminium-silicon alloys into ladles for further transport in the molten state.

5. The insufficient height (8.4 m) of the ways under the crane in the casting bay of the furnace section may make it difficult to carry out certain technological operations in the processing of the primary alloy.

6. The project provides for the installation of a channelless low-frequency (60 cycles) induction furnace with a capacity of 375 kw, manufactured by the "ASEA" company of São Paulo, Brazil, for the remelting and refining of the primary alloy. This type of furnace is usually used for melting pure aluminium, and the firm has no data on the use of such furnaces for the melting and refining of alloys similar in composition to the primary aluminium-silicon alloy. Nor does the project give any calculations of the electric capacity which the furnace should have in the light of the specific electrical resistance of the primary alloy.

In view of the fact that the primary aluminium-silicon alloy may contain a considerable amount (up to 10-15 per cent) of slag in the form of oxides and carbides of aluminium and silicon, the properties of this alloy will differ from those of pure aluminium, and this may lead to certain difficulties in the operation of the induction furnace.

On the basis of analysis of the documentary material submitted in respect of the project and in the light of the questions raised by the representatives of "Ligas de Alumínio S.A.", technical recommendations are given below regarding certain special features of the technology and the design of the equipment to be used for the manufacture of aluminium-silicon alloys by the direct reduction method.

As "Ligas de Alumínio S.A." failed to submit a number of project documents (listed in section IV of this report) when this question was discussed, these technical recommendations are of a preliminary nature and are subject to modification after the receipt and study by the expert of the missing documents.

VI. TECHNICAL RECOMMENDATIONS

1. <u>The raw materials and their preparation for smelting</u>

1. It would be advantageous to use pneumatic methods of transporting the pulverized raw materials (cyanite, wood charcoal and clay) instead of the conveyors foreseen in the project.

2. In practice, briquettes for smelting into aluminium-silicon alloys use reducing agents pulverized to a particle size of less than 1 mm.

3. The form of the briquettes must be such as to ensure good gas permeability of the charge at the charge hole of the ore reduction furnace. In practice, satisfactory results have been obtained by using briquettes of ellipsoidal shape with dimensions of 70:50:30 mm along their axes. The briquettes are pressed at a pressure of 200-300 kg/cm^2.

4. The proportions of the raw materials in the charge are determined by calculations based on the chemical composition of the raw materials and the composition of the primary alloy which it is desired to obtain. Thus, for

example, in order to obtain a refined alloy containing 60 per cent aluminium and 37 per cent silicon, a charge mixture of the following composition would be used (percentages by weight):

Cyanite concentrate No. 3:	50.3
Reducing agent:	32.2
Kaolin:	9.7
Alumina:	7.8

The compositions of the cyanite concentrate, the kaolin and the reducing agent have already been given in Tables 1 and 2 above.

5. In order to improve the briquetting process, moisture is added to the charge during mixing. The amount of moisture to be added depends on the nature of the charge materials and their fineness of grinding. The use of wood charcoal calls for a larger amount of moisture than the use of other reducing agents. In practice, the amount of moisture added is 10-18 per cent (depending on the composition of the charge mixture and the properties of the raw materials).

The briquettes produced from such a charge mixture must be dried to a residual humidity of 0.5-1.0 per cent. The porosity of the dry briquettes is 30-50 per cent, and their crushing strength is 100-200 kg/briquette. In practice, the temperature of the drying agent is 200-300°C (depending on the type of reducing agent used in the process). The drying time depends on the moisture content of the undried briquettes and is usually 1-2 hours.

6. Because of the unsatisfactory briquette-forming properties of charge mixtures based on cyanite concentrate and wood charcoal (compared with other charge components), the following measures are to be recommended in order to improve the quality of the briquettes:

- The use of compound binders (clay and sulphite liquor) in briquette making;
- Preliminary grinding of the charge in an edge-runner mill before it is placed in the briquetting press;
- Replacement of part of the wood charcoal with petroleum coke;
- Granulation of the charge instead of briquetting.

7. It is essential to make provision, in the technological arrangements for the preparation of the charge, for the possibility of returning to the process part of the slag produced in the ore reduction (smelting).

2. Ore reduction (smelting)

1. The optimum distance between the electrodes in the furnace depends on the nature of the charge and the composition of the alloy which it is desired to produce, and it can only be determined by experience. The design of the reduction furnace, which provides for the possibility of varying the electrode gap over the range 2,000-2,300 mm will make it possible to determine the optimum gap between the electrodes during the start-up stage of production.

2. The working voltage for the smelting of aluminium-silicon alloy from a charge based on cyanite and wood charcoal will probably be within the range 110-130 v, with a current of 45,000-53,000 amps.

3. In order to increase the electric resistance of the charge and improve the electrical conditions under which the furnace operates in the manufacture of aluminium-silicon alloys, the height of the side carbon lining in the bath should be reduced to 400-500 mm above the sole level.

4. In order to avoid difficulties in tapping metal from the furnace, the length of the taphole in the lining should be kept down to 300-400 mm.

5. The rotation of the furnace bath must be begun with a slight reverse. The optimum parameters for bath rotation (angle and speed) can be determined by experience during the start-up stage of production.

6. In order to be able to transport and process the primary aluminium-silicon alloy in the molten state, provision must be made for it to be poured into a ladle, instead of into moulds, as foreseen in the project.

7. In the list of technological operations connected with the servicing of the ore reduction furnace, provision should be made for the operation of loading into the furnace corrective additives (lump quartzite and lump wood charcoal) as well as lump slag from the smelting operation.

3. Refining and filtration of the primary alloy

1. Treatment of the primary alloy with fluxes (refining) must be carried out several times in succession. The fluxes used in practice are various mixtures of cryolite with chloride and fluoride compounds of sodium, potassium and calcium.

2. The amount of flux to be used at each stage of the processing of the primary alloy varies depending on the content of oxides and carbides in the alloy. Generally speaking, however, the amount of flux used is 2-10 per cent by weight of the alloy to be processed. The most advantageous way of introducing the fluxes into the alloy is in the liquid form.

3. In order to secure more complete extraction into silumin of the aluminium and silicon contained in the cyanite, processing of the primary alloy can advantageously be carried out according to the following scheme:

- Treatment of the primary alloy with fluxes;
- Removal of slag from the alloy by decanting;
- Dilution of the refined aluminium-silicon alloy with aluminium until a composition close to the eutectic composition (13 per cent Si) is reached;
- Filtration of the diluted alloy to remove iron and titanium impurities.

The utilization in the ore reduction (smelting) process of carbon electrodes and raw materials which are sufficiently free from iron and titanium will make it possible to simplify considerably or even completely avoid the operation of filtering the diluted alloy. This operation may also be simplified or avoided when special aluminium-silicon alloys with a high iron content (0.7-1.0 per cent) are made from the refined primary alloy.

VII. CONCLUSIONS

1. The private Brazilian company "Ligas de Alumínio S.A.", with the assistance of foreign firms, is building a factory in the town of Pirapora, Minas Geraes state, Brazil, to produce aluminium-silicon alloys from local cyanites by the direct reduction of aluminosilicates without going through the stage of the production and electrolysis of alumina. The production of the factory will consist of special aluminium-silicon alloys (containing 11-13 per cent silicon), which are widely used in the automobile, tractor, aviation and other industries.

2. For the purpose of providing "Ligas do Alumínio S.A." with technical assistance, joint discussions on several aspects of the project and the technology of the factory to be built were held between the author of the present report and representatives of the company. The result of the discussions was a series of technical recommendations made to "Ligas do Alumínio S.A." by the author of this report, concerning certain features of the technology and design of the equipment to be used in the production of aluminium-silicon alloys by the direct reduction process.

3. As "Ligas de Alumínio S.A." did not submit in the course of the above discussions of the project a number of items of information which are of great importance in the evaluation of the project as a whole, the technical recommendations made are of a preliminary nature and are subject to modification after receipt and study by the expert of the various items of information not previously available.

4. A weak point of the project is the lack of data regarding processing tests of the new type of raw material (cyanites) which is to be used. This means that no final conclusions can be drawn on the parameters to be expected in the production process, the specific consumption of raw materials, other process materials and electric power, or the suitability and effectivness of the equipment selected.

5. The system adopted in the project for the production of silumin by the filtration of the hypereutectic silicon from the primary alloy has not been verified by investigations or industrial experience by "Ligas de Alumínio S.A." or by any other firms, and it requires further experimental verification. According to the data at our disposal, such a system gives a reduced yield of the main product and involves some technical difficulties. In our opinion, it would be more advantageous to use the system of processing the primary alloy by melting it together with aluminium and subsequently filtering out the iron and titanium impurities.

VIII. PROPOSALS

1. In view of the large volume of work and the complicated nature of the questions likely to arise in the start-up and initial operation of the factory for the production of aluminium-silicon alloys from this new type of raw material, it would be advantageous to bring in not just one expert to provide technical assitance for the start-up of the enterprise, as envisaged in the original project, but a group of experts made up of production engineers, scientific workers and planning experts.

2. In order to achieve a rapid and economic start-up of the enterprise and to determine the optimum charge compositions, the best briquetting parameters, the most efficient electrical and process conditions for smelting, and the most accurate figures for consumption of raw materials, other process materials and electric power, it is essential to carry out investigations into the processing characteristics of the cyanite raw material from the deposits in the state of Minas Geraes which it is intended to use in the factory.

3. The group of experts who are to take part in the second stage of the technical assitance programme and assist in the start-up and running-in of the new factory must be given a chance to familiarize

themselves with all the information material concerning the project for the establishment of the factory, including the material which was not submitted by the company when the project was discussed during the first stage of the technical assistance programme.

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