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**Pre-Investment advisory services for the selection of raw materials and technology for processing local alumina into refractory grade aluminates**

Consolidated Report of Team of Consultants

Team Leader

Chief Technologist

June 1992

*CONTENTS*

## 1. INDUSTRIAL AND PROJECT BACKGROUND IN VENEZUELA

The metallurgical industry in Venezuela was developed from its very beginning to increase the export revenues of the country and also to diversify the exports that were previously based mainly on oil. It was also strongly linked to the programme of the Government to create a concentration of development in the Guayana region, where abundant electric energy has become available from the huge hydropower scheme of Guri on the Caroni river (second cheapest hydropower of the world). Other favourable conditions present are the closeness and abundance of sources of raw materials, the low cost of labour, the growing demand from the continuously developing national industry and the closeness of the country to the markets of central and north America, also convenient see transport connections to Europe and Japan.

One of the large, new enterprises built by the public holding company CVG (Corporacion Venezolana de Guayana) is the Interalumina Plant, operating now on a capacity of about 1.3 million tpy alumina and planning to increase the capacity to 3 million tpy until 1995 in order to meet the needs of the steadily growing aluminium smelter industry in the area, planned to achieve a capacity of 2 million tpy at the end of the century. It is also to be noted that steel production capacity has reached a level of 3.1 million tpy and cement production about 7 million tpy in 1991.

The new and steadily growing metallurgical, cement and glass sectors of the industry are the largest consumers of high quality refractory materials. Venezuela presently imports great portions of these products, consuming the hard currency revenues of the country. It is therefore a justified trend to elaborate possibilities for import substitution in the fast developing branches of national economy mentioned. As long as the overall development of the economy in the Guayana Region consumes most of the human resources of CVG, the private sector is encouraged to develop the production of smaller scale products.

Among the refractory materials, aluminate cements have been playing a very important role as binding materials and for cast refractory applications. These products are produced from smelter grade pure alumina, specially activated alumina, limestone and other additives. Calcium aluminate cements continue to become more important as binders for high strength refractory castables and mixes because they combine good shelf life and relative simplicity of installation. The trend towards monolithic structures is accelerating because the large variety of speciality fired shapers needed for repair are becoming too expensive to inventory and, thus, are not available for unscheduled shutdowns. While lower grade cements and even some complicated chemical bonding systems will continue to expand in use, the most notable area of growth will be cements with high alumina content as process requirements push operating conditions to higher temperature limits in increasingly severe environments. As a favourable local condition, the new Interalumina Plant operating in Puerto Ordaz on a 1.3 million tpy of alumina production, may be a close and low price source of the bulk of raw materials required for these and other alumina based materials.

The private company "Corporacion Grupo Marques Barry" has decided to start the production of these materials, aiming to achieve 5,000 metric t/year production volume mainly consumed in Venezuela and partially in the neighbouring countries. The company operates the following plants in the related field, being one of the important private ferro-alloy and refractory materials producer of the country:

- Hornos Electricos de Venezuela, S.A.
- Refractarios Venezolanos, S.A.
- Flocon de Verezuela, S.A.
- C.E. Minerales de Venezuela, S.A.
- Coporaction Guayanesa de Silico Guayasil, C.A.
- Industria Siderquimica Venezolana, C.A.
- Corporacion Selee de Venezuela, S.A.

Recently, the Corporacion Grupo Marques Barry started up in their plant C.E. Minerales de Venezuela, S.A. the production of fused aluminas (white corundum) in joint venture with the company Combustion Engineers USA, using the technology know-how and marketing abilities of the North American partner.

The fused aluminas are produced by melting the pure smelter grade alumina in electric arc furnace and cooling it afterwards to room temperature. For the production of aluminate cements, also electric arc furnaces are used; hence, not only the raw materials, but the basic technological equipment are very similar in both cases. The aluminate production is intended to be organized also in the new fused alumina plant C.E. Minerales de Venezuela, S.A. which is situated in Puerto Ordaz, at the vicinity of the Interalumina refinery, facilitating thereby easy raw material supply. These are the main advantages of, and the reasons for the Company to start up the production of aluminate cement and also silicates.

The company has decided to seek neutral international advice for its investment decision. Thus, it turned to UNIDO, at the same time requesting also some financial support for the initiation of the project. The project is - as requested - aimed at the selection of the most suitable type of raw materials available in Venezuela (mainly alumina and limestone), and recommend on the viability of introduction of aluminate cement production. In this regard, the main features of adaptation of the production technology, selection of main equipment, estimation of investment costs are undertaken, thus providing the National counterpart important inputs to make an investment decision.

## 2. ALUMINATE CEMENTS: CHEMISTRY, MAIN PRODUCERS, GRADES, FIELDS OF APPLICATION

### 2.1. Phases of aluminate-cement in the $CaO-Al_2O_3$ system

Refractory cements are the most widespread binders of monolithic refractory materials. Similar to cements used in the field of traditional architecture, they solidify by mixing with water and subsequent crystallization of hydrated phases developed.

The most widespread refractory cements belong to the binary system $CaO-Al_2O_3$ (pictures 1 and 2) [1]. The most important phases, their melting point and composition are shown in the table below:

TABLE NO. 1

Characteristics of calcium-aluminates

| Phase | CaO (%) | $Al_2O_3$ (%) | Melting point (°C) |
|---|---|---|---|
| $C_{12}A_7$ | 48,5 | 51,5 | 1,450 |
| CA | 35,5 | 64,5 | 1,605 |
| $CA_2$ | 21,6 | 78,4 | 1,750 |

**Note:** C = CaO; A = $Al_2O_3$; S = $SiO_2$

Table No. 1 shows data of aluminate-cement clinkers manufactured from pure raw materials. Many times, however, limestone occurrences in the nature are contaminated with $SiO_2$. In this case, tertiary or three-component phases develop, which are shown on the Rankin diagramme of picture no. 3. Gehlenite ($C_2AS$) and Anorthite ($CAS_2$) are tertiary crystalline compounds of this system. In case of aluminate cements one can count, first of all, on the crystallization of Gehlenite. This crystallization may happen in a state of equilibrium, especially if the aluminate-cement is produced from a molten phase.

The other impurities of the raw materials of aluminate cement production ($Fe_2O_3$, alkalies) do not influence basically the composition of phases. They deserve attention, first of all, because of their effect of lowering the melting point.

### 2.2. The hydratization of aluminate-cements

The process of setting starts with the dissolution of water-soluble oxides, salts and the broken-off Ca-ions. Thereafter, with the progress of hydratization of clinker minerals water-containing compounds develop, partly by crystallization, partly as amorphe, CaO–Al₂O₃

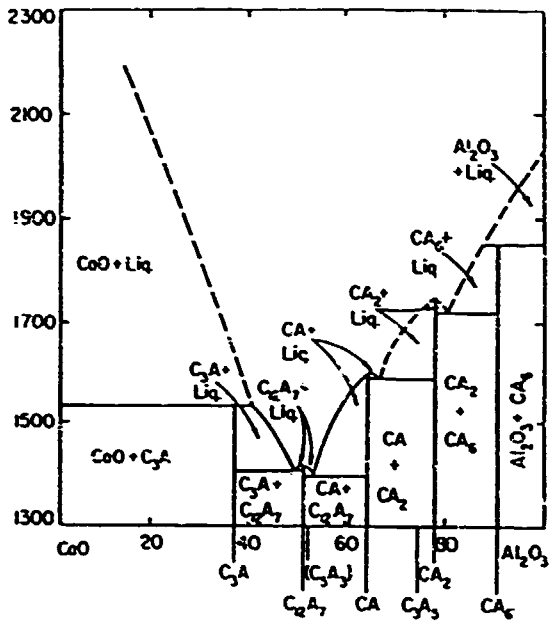



FIG. 231.—System CaO–Al₂O₃. C = CaO; A = Al₂O₃. F. M. Lea and C. H. Desch, The Chemistry of Cement and Concrete, 2d ed., p. 52. Edward Arnold & Co., London, 1956.

**PICTURE 1**

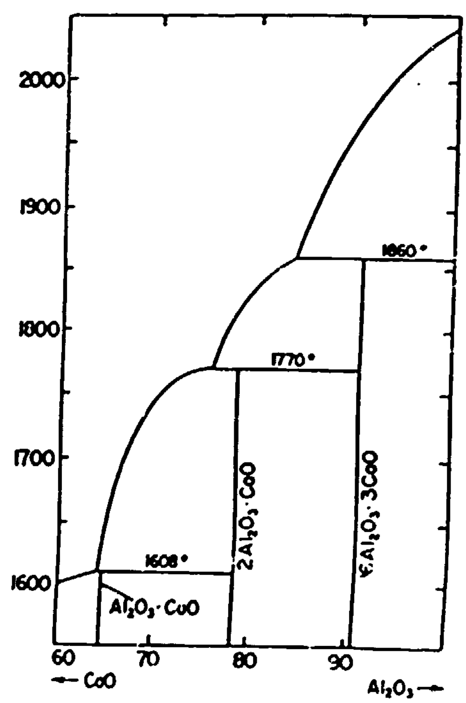



FIG. 232.—System CaO–Al₂O₃.

A. Auriol, G. Hauser, and J. C. Wurm, private communication, Nov. 19, 1961.

**PICTURE 2**

CaO–Al₂O₃–SiO₂

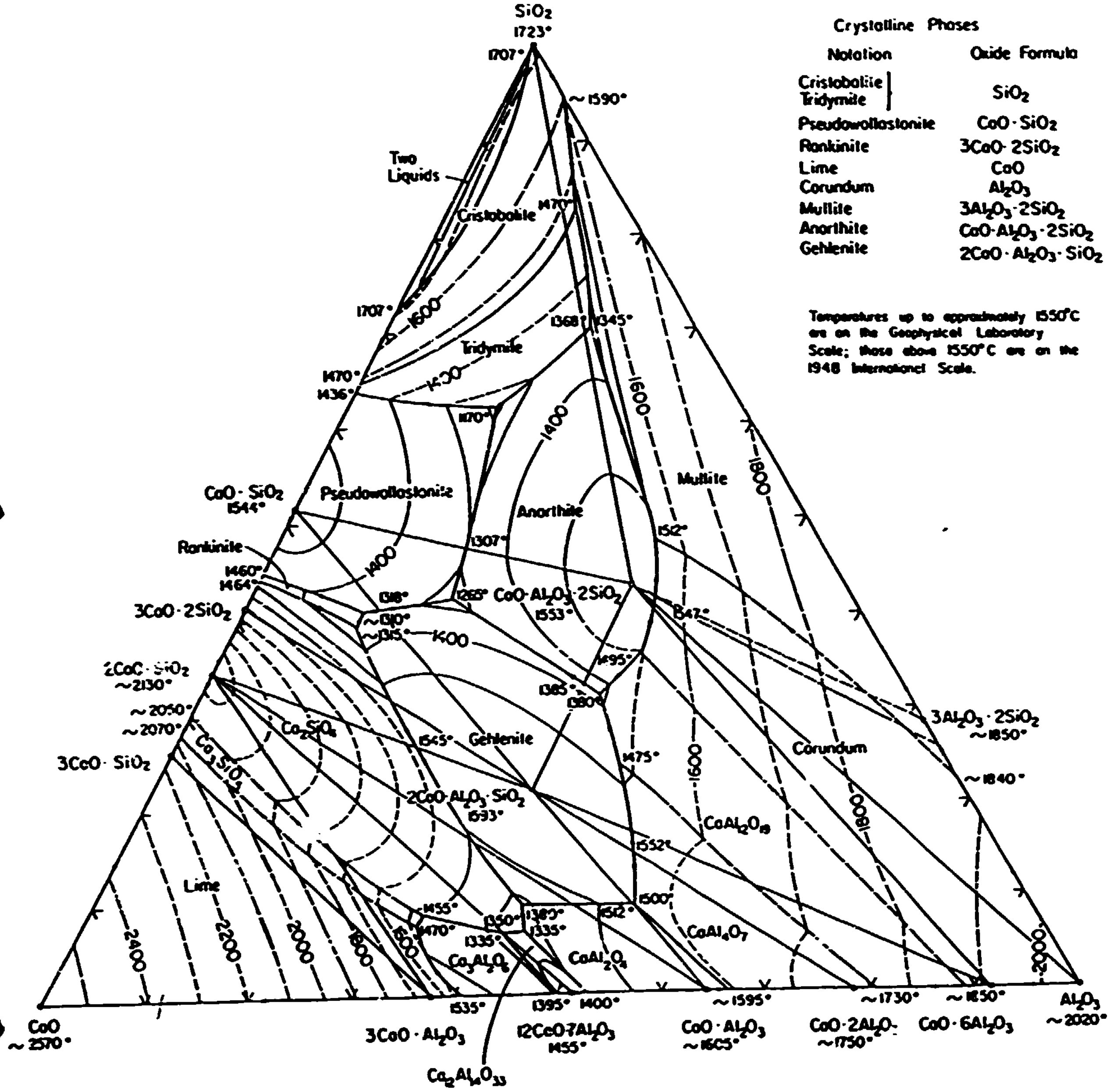



Fig. 630.—System CaO–Al₂O₃–SiO₂; composite.

E. F. Osborn and Arnulf Muan, revised and redrawn "Phase Equilibrium Diagrams of Oxide Systems," Plate 1, published by the American Ceramic Society and the Edward Orton, Jr., Ceramic Foundation, 1960.

**PICTURE 3**

gel-like material, separating from the oversaturated solution [3].

During the course of hydratization, considerable energy will be liberated, e.g.

| | |
|---|---|
| for $H^{+}$ | 1,17 MJ/kg |
| for $OH^{-}$ | 0,40 MJ/kg |
| for $Ca^{2+}$ | 1,57 MJ/kg |

Dissolution, hydrolysis and hydratization are processes characteristic for the setting of cement.

As it is known, the exact mechanism of hydratization and crystallization of Portland cement is that complex that it could not yet been fully clarified. The same is valid for the aluminate-cements, too. The most important phases are the octa-, hepta- and deca-hydrates, whose ratio of presence depends on many of the prevailing circumstances (e.g. $CaO/Al_2O_3$ ratio, temperature, free CaO a.o.).

## 2.3. Aluminate cements: Main producers, grades and fields of application

Aluminate cements are produced by a number of companies in many countries. The pace-setting producers are, however, two of them, Alcoa and Laforge Fondu International. Out of the many different grades, Alcoa's CA-25 Regular Grade and Laforge's Secar 80 - both with an approx. 80 % alumina content - are the most widespread and they have remained the mainstay for refractory users of high alumina cement. The chemical composition, as provided by the producers, may be seen in table 2 below:

TABLE NO. 2

| **Product/component, %** | **$Al_2O_3$** | **CaO** | **$SiO_2$** | **$Fe_2O_3$** | **$Na_2O$** |
|---|---|---|---|---|---|
| **Secar 80**<br>**Average values**<br>**Value range** | 79,5-81,5<br><br>>79 | 17,5-19,5<br><br><20 | 0,4 | 0,25 | <0,7[1] |
| **Alcoa Ca-25**<br>**Standard deviation** | 81[2]<br>- | 17<br>0,69 | 0,7<br>0,22 | 0,05<br>0,01 | 1,0<br>0,20 |

---

[1] $Na_2O + K_2O$

[2] by difference

The mineralogical composition, physical properties, hydraulic properties, sample preparation and methods of testing and other information are provided in the published description of the companies - see attachments no.3 and no. 4.

The aluminate cements have multi-purpose applications in the field of refractory materials for industry. They can be used for refractories, employing corundum, tabular alumina or alumina silicate aggregate compositions and applied in the form of bonding or for castables including monolithic blocks, layers etc. in metal producing, petrochemical and cement industries. By the wide utilization of additives for acceleration or retarding or improvement of workability, a series of different sorts or grades may be produced and utilized. Some of the additives used are shown in attachment no. 4.

## 3. ALUMINATE-CEMENTS: QUALITY REQUIREMENTS AND SELECTION OF MAIN RAW MATERIALS

The refractory properties of aluminate-cements are the result of their high $Al_2O_3$-content and low concentration of impurities. This condition poses a limitation to the choice of raw materials, suitable for the production, that is, of lime, metallurgical grade alumina, active alumina, graphite electrodes.

The CaO-content should be secured mostly from pure limestone (56 % CaO, 44 % $CO_2$) or burnt lime (90 to 95 % CaO). Mostly products of limestone carriers, free of contaminations by marl, clay and quartzite are suitable for this purpose. Typically, the converter-grade lime of good quality, used in steel production, could be utilized for the purpose.

The $Al_2O_3$-content is secured exclusively from alumina, especially for cements of high refractory grade. The most important requirement is the low content of $Na_2O$ (max. 0.5) and $Fe_2O_3$(max. 0.1 %), characteristic for the alumina product of the Bayer process.

The graphic electrodes are to be of common international standards. The electrodes of Union Carbide, used now by the company for production of white corundum fully fit the purpose.

The most important characteristics of the usual raw materials are collected in the table below:

TABLE NO. 3

Main characteristics of raw materials of production of refractory cements

| Data | Alumina | Burnt lime | Activated alumina |
|---|---|---|---|
| Chemical composition (%) | | | |
| $Al_2O_3$ | min. 98 | | min. 98 |
| CaO | | min. 87 | |
| $SiO_2$ | | max. 3 | |
| Alkalines | max. 0,5 | | max. 0,5 |
| $Fe_2O_3$ | max. 0,1 | | max. 0,1 |
| Physical parameters: | | | |
| Grain-size | o 45 mkm | 0-2 mm | To be set according to requirement |
| Adhesive moisture (for electric arc melting) | max. 0,2 % | max. 2 % | |

3.1. The main characteristics of Venezuelan alumina, produced in the Interalumina plant and available for the production of aluminate cements are as follows:

Chemical composition (%):

| | |
|---|---|
| $Al_2O_3$ | 98,8 |
| $SiO_2$ | 0,011 |
| $TiO_2$ | 0,003 |
| $Fe_2O_3$ | 0,013 |
| CaO | 0,025 |
| $Na_2O$ | 0,45 |
| LOI | 0,70 |
| Moisture | 0,55 |
| Water absorption | 1,06 |
| Specific surface area | 70,1 $M^2/g$ |
| Particle size (average) | 38 microns |
| Grain distribution + 150 microns | 8 |
| - 45 microns | 8 |
| Alpha $Al_2O_3$ | 3 |
| Density | 3,56 $g/cm^3$ |

It may be concluded that this alumina is suitable for the production by fusion of aluminate cement.

3.2. The main characteristics of lime available are the following:

Chemical analysis (%):

| | |
|---|---|
| CaO | min. 88 |
| $SiO_2$ | max. 4 |
| $Ca_2$ | max. 5 |
| Residuals | max. 2,5 |
| Moisture | max. 1 |
| Particle size-100 microns | 75 |

It may be concluded that this lime is suitable for the production by fusion of aluminate cement.

3.3. The active alumina, required and used as additive to the clinker, cannot be substituted directly by the same metallurgical grade alumina of Interalumina, used for the fusion unless a product of refractory quality significantly lower than that of the internationally marketable class would be acceptable. This was shown already by testing and experiments, carried out in 1991 bilaterally by a Hungarian manufacturer of fused alumina products. These tests showed at the same time the suitability of a special, active alumina produced in Hungary.

Although is was not included in the terms of reference of our team, we have carried out new, complementary laboratory investigations which showed that

a) the intermediate clinker fused from the metallurgical grade alumina of Interalumina and from local lime, selected according to the quality requirements, matches fully the requirements of the aluminate-cement production;

b) when using the same alumina also as additive, the quality of the aluminate-cement product proved to be much inferior to those produced by the internationally leading manufacturers;

c) when using a sample of the special active alumina produced in Hungary as additive, the characteristics of aluminate-cement obtained were close to that of the internationally leading manufacturers;

d) the activation of the metallurgical grade alumina of Interalumina proved to be possible to the extent required, by the introduction of a treatment of moderate costs, which can be realized within the premises of the existing corundum plant. The specimens prepared from alumina of Interalumina, Venezuelan lime and such activated Interalumina alumina used as additive to the clinker, showed properties close to that of the internationally leading manufacturers. The elaboration of this activation technology for industrial scale should be completed in the near future.

The summary of results of our new, complementary laboratory tests is annexed to this report.

## 4. ELABORATION ON PROCESS TECHNOLOGY, CONCEPTUAL FLOW SHEET OF THE FUSION TECHNOLOGY SELECTED (4,5,6,7,8)

### 4.1. Process technology

The production of high alumina-content cements may be organized by two different technologies - sintering and fusion. These processes differ on the temperature applied for the development of clinker phases. In both cases the first step of technology is the preparation of a crude meal by weighing, dosing, blending and homogenization of the raw materials.

In the sintering process, the meal is to be ground further in ball mills, eventually also by wet grinding. Thereafter, the ground meal is pelletized with the addition of water, then it is sintered in rotary calcining kiln. The temperature of sintering varies around 1,450 to 1,500°C. The temperature of sintering is to be selected depending on the composition of the clinker, carefully avoiding the temperature zone of clogging and sticking of the feed to the furnace wall.

At the fusion process, the meal is fed into a water- or air-cooled three-phase electric arc furnace continuously and fused at a temperature of about 1,700°C. The melt will either be poured out of the furnace (tilt-pour furnace) and crystallized and cooled in moulds, mounted on four-wheeled steel framework, or in case of assembled furnace shell construction, the melt will solidify on the mobile, four-wheeled furnace bottom and the solidified ingot is transported further by crane to the cooling site.

The clinker produced in the form of sinter by the sintering process or in ingots by the fusion process, will be broken and crushed (e.g. by jaw breaker) and ground in ball and vibration tube mills. The mill may be 3- or 4- chamber type.

After grinding, the cement product will be forwarded to silos, then weighed, packed and shipped out of the plant.

The flow-sheet of the fusion process is shown on picture No. 4. The existing similar operation of producing white corundum in electric arc furnace by fusion, the low price of electric energy and the scale of demand of the market for the cement product (which may be technically also one of the products of diverse fusing operations), has led to the conclusion to proceed with the implementation of the fusion process of calcium-aluminate cement production at the plant C.E. Minerales de Venezuela S.A.

In the following, two alternatives of investment are assessed - one is the case of establishment of a 5,000 tpy separate, new production unit, including the establishment of a new furnace of relevant, relatively small capacity, the other is the case of partial utilization fo- cement production (5,000 tpy) of a larger capacity new furnace, of the same capacity and construction as the No. 1 operating for white corundum production. The site (building construction) of the second furnace was prepared already together with that of the operating one, however, the procurement and putting in operation of the second furnace has been delayed. As it stands now, this second furnace unit will be started up in August this year.

4.2. Some basic parameters of production and specific consumption

Input of raw materials: 4,000 tpy alumina (metallurgical grade and activated)

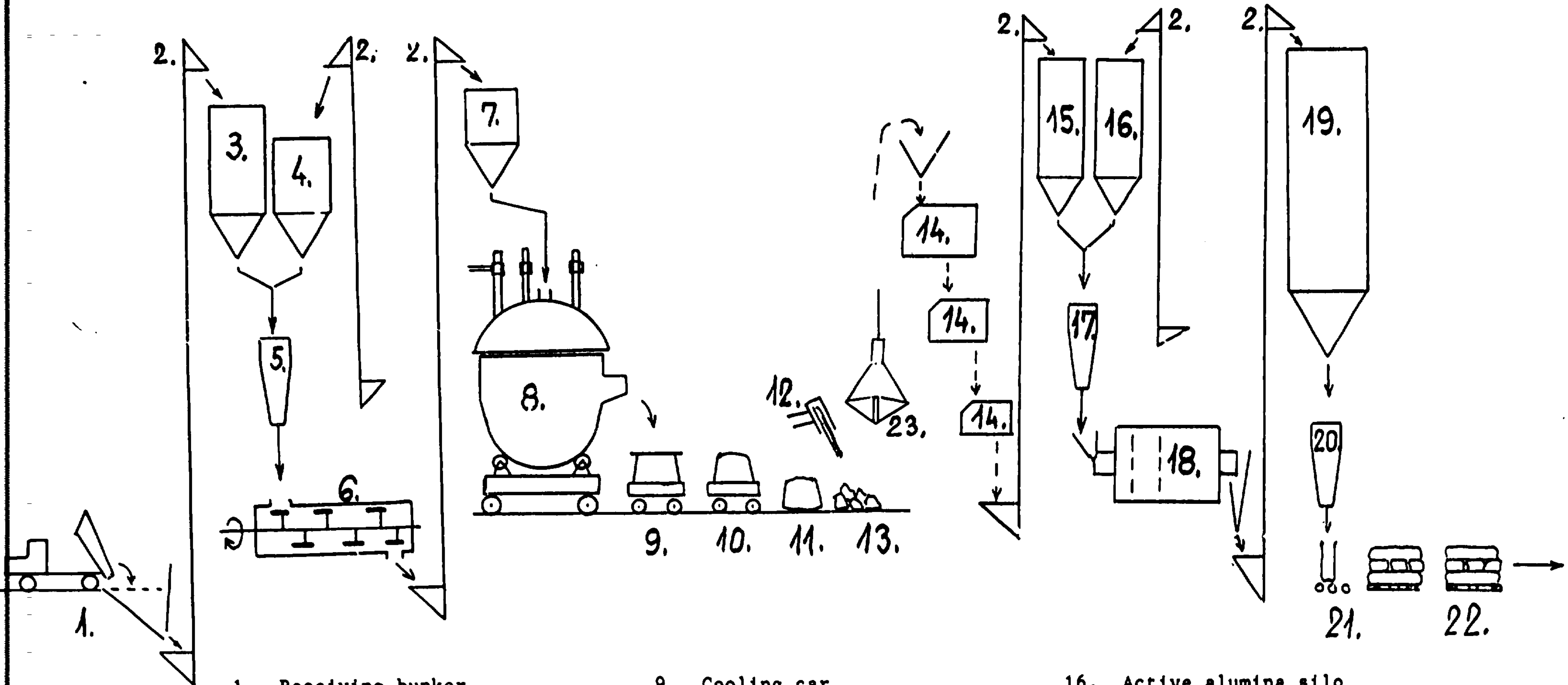
1,080 tpy lime (100 % CaO) or
1,230 tpy lime (88 % CaO)

Output: 5,000 tpy cement (80 % $Al_2O_3$-content)

TABLE NO. 4

| | 1. Separate production unit | 2. Furnace No. 2 |
|---|---|---|
| Furnace electric capacity, about | 1 MVA | 4 MVA |
| Specific electric power consumption | 1,7 kwh/kg | 1,7 kwh/kg |
| Average duration of production per year | 300 days | 60 days |
| Weight of ingot | 2 tons | 7 tons |
| Timing of lifting the mould (after pouring) | 2 hours | 10 hours |
| Duration of cooling | 7 days | 7 days |

**FLOW-SHEET OF THE FUSION PROCESS**

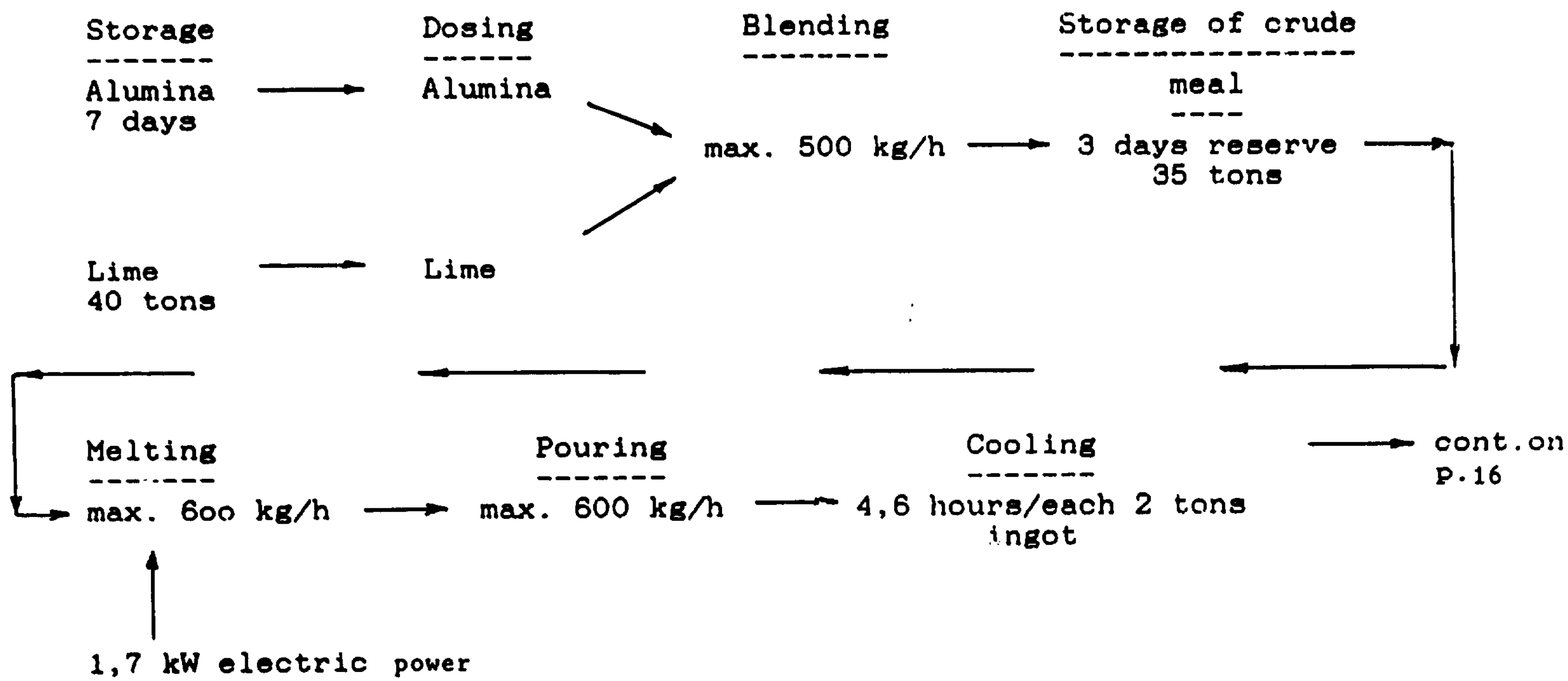


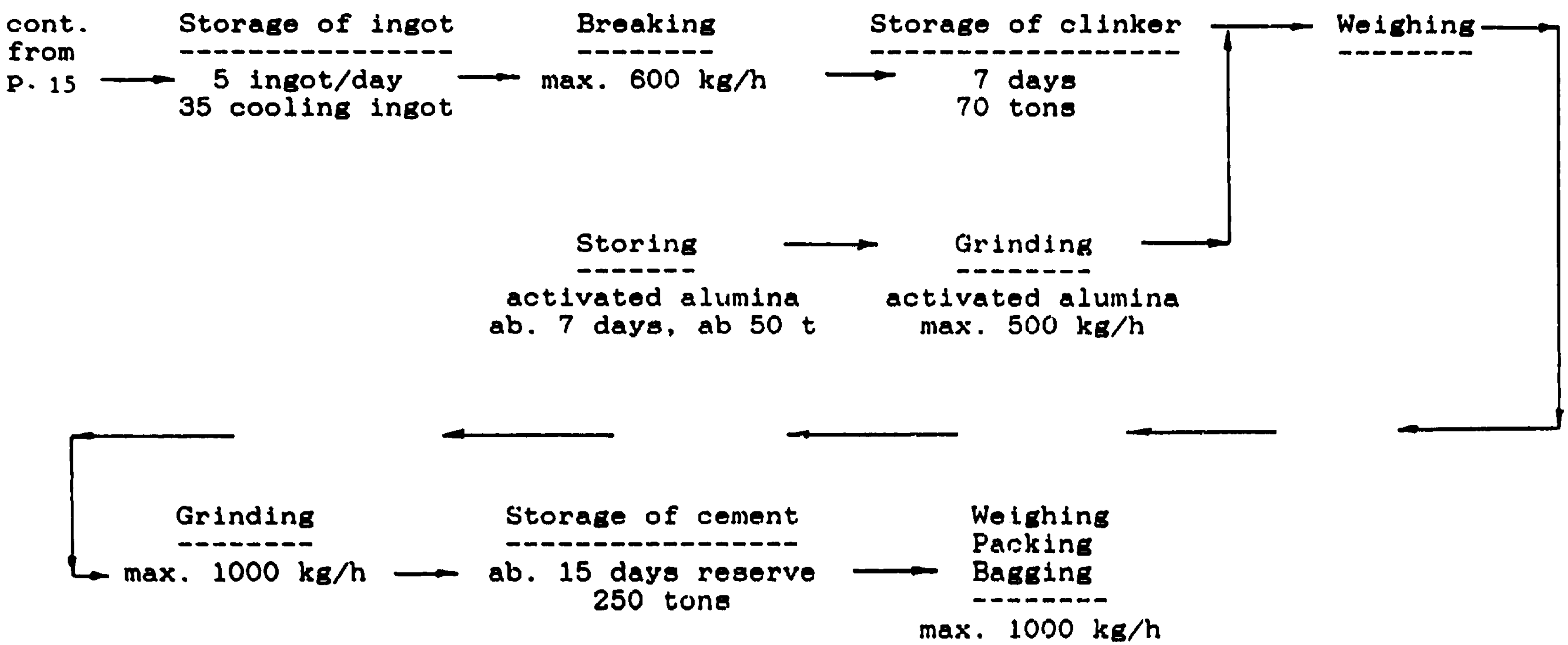

1. Receiving bunker
2. Elevator
3. Alumina silo
4. Lime silo
5. Scale
6. Mixer
7. Meal silo
8. Furnace
9. Cooling car
10. Block without mould under cooling
11. Block under cooling
12. Hammer-breaker
13. Crude fraction
14. Breaker line
15. Clinker silo
16. Active alumina silo
17. Scale
18. Ball mill
19. Cement silo
20. Cement scale
21. Bagging
22. Finished product
23. Crane

**PICTURE 4**

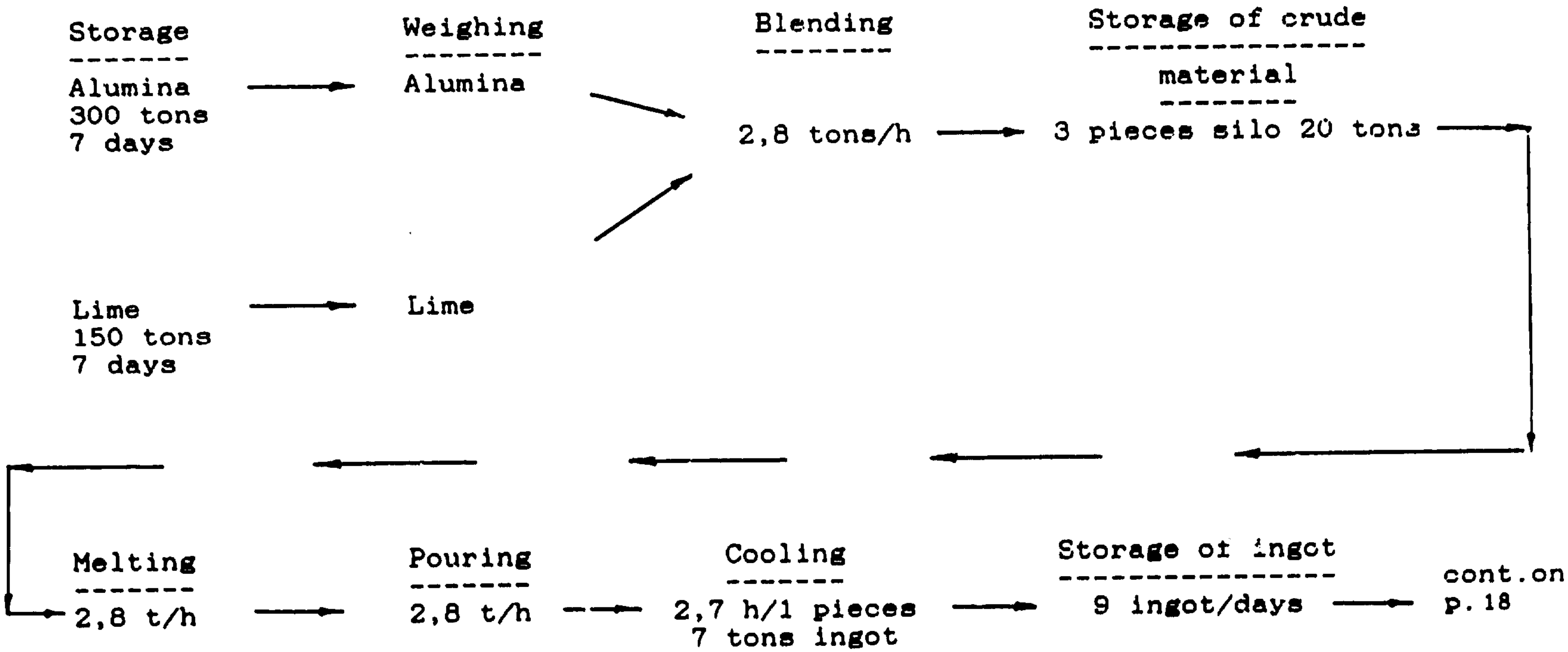
## 5. THE BALANCE AND FLOW OF MATERIALS OF THE FUSION PROCESS FOR THE TWO CASES OF PRODUCTION OF 5,000 TPY

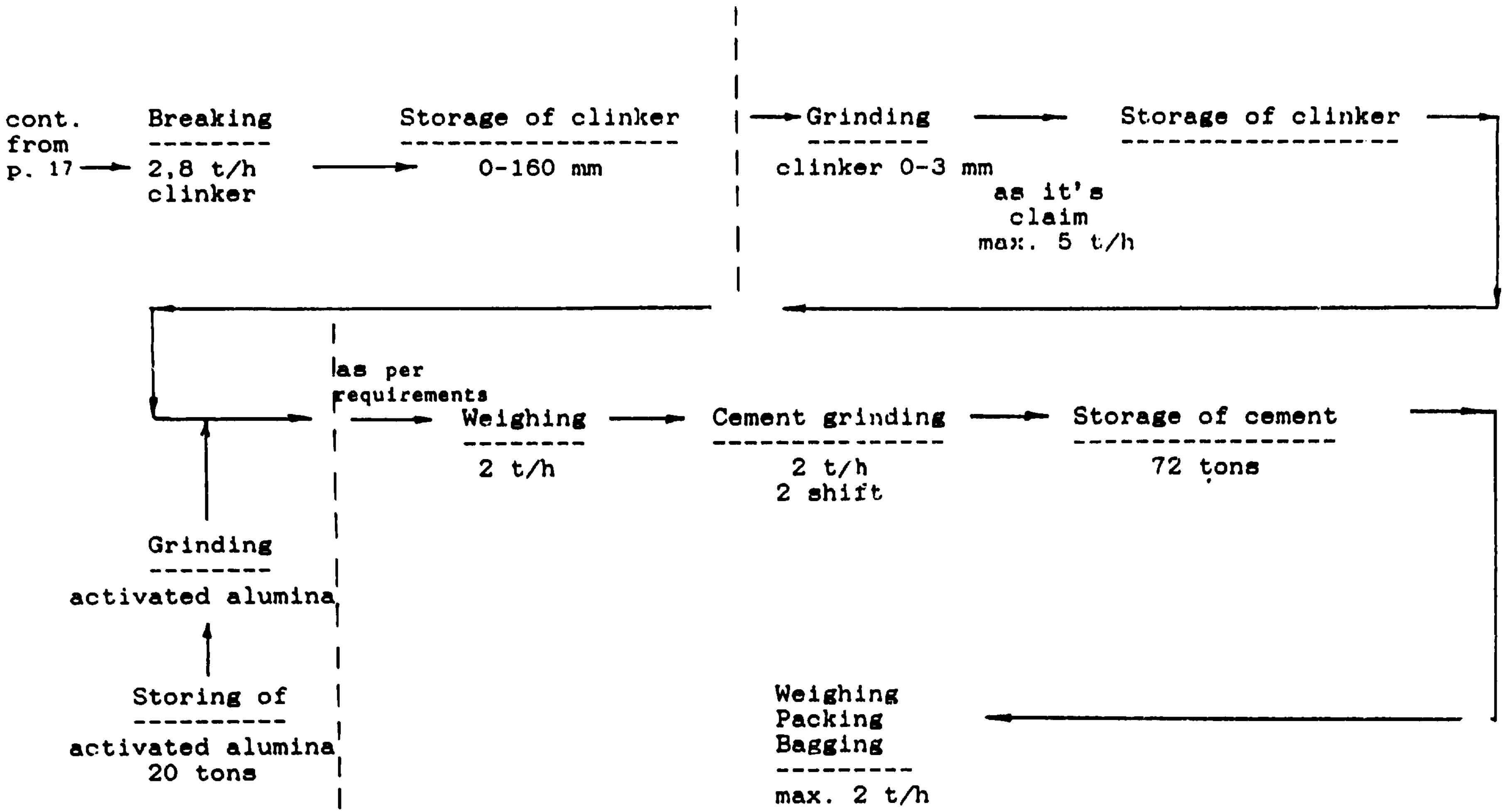
### 5.1. Case of separate new production unit




cont. from p. 15
Storage of ingot
5 ingot/day
35 cooling ingot
Breaking
max. 600 kg/h
Storage of clinker
7 days
70 tons
Weighing
Storing
activated alumina
ab. 7 days, ab 50 t
Grinding
activated alumina
max. 500 kg/h
Grinding
max. 1000 kg/h
Storage of cement
ab. 15 days reserve
250 tons
Weighing
Packing
Bagging
max. 1000 kg/h

## 5.2. Case of partial utilization of furnace No. 2.




cont. from p. 17
Breaking
2,8 t/h clinker
Storage of clinker
0-160 mm
Grinding
clinker 0-3 mm
as it's claim
max. 5 t/h
Storage of clinker
as per requirements
Weighing
2 t/h
Cement grinding
2 t/h
2 shift
Storage of cement
72 tons
Grinding
activated alumina
Storing of
activated alumina
20 tons
Weighing
Packing
Bagging
max. 2 t/h

## 6. ELABORATION ON PLANT DESIGN AND EQUIPMENT: LIST OF MAIN TECHNOLOGICAL AND SUPPORTING EQUIPMENT AND STAFF FOR THE TWO CASES OF PRODUCTION

### 6.1. List of equipment for a 5,000 tpy separate unit

The list below shows the main and the significant auxiliary equipment and it was assembled based on local study made and information collected during the plant visit on 10 through 15 May 1992.

#### 6.1.1 *Storage silos*

These are bins, manufactured from surface treated (from the outer side) steel sheets, with minimum-maximum level indicators:

| Material | Pieces | Volume ($m^3$) |
|---|---|---|
| Lime storage | 1 | 40 |
| Clinker-grade alumina | 1 | 60 |
| Crude meal | 1 | 50 |
| Crushed clinker (0-3 mm) | 1 | 60 |
| Active alumina | 1 | 60 |
| Cement product | 1 | 250 |

#### 6.1.2 *Electronic scales for dosing*

| | Pieces |
|---|---|
| For two-component raw material dosing, doses of up to 100 kgs | 1 |
| For two-component intermediate material dosing (clinker and active alumina) doses of up to 100 kgs | 1 |
| Automatic scales for bagging, doses of up to 25/50 kgs | 1 |

#### 6.1.3 *Blending equipment*

| | |
|---|---|
| From steel sheet for crude meal, electric motor for 380 V, 8 kw-s | 1 |

#### 6.1.4 *Equipment for melting*

1 MVA capacity, water-cooled or air-cooled, electric arc melting furnace with segmented steel shell, lined, with cooled lined furnace lid, hydraulic tilt pour construction, with a volume for pouring 2 tons of melt, on rollable 4-wheel frame, with auxiliary equipment

(hydraulic station, piping, dosator, etc.) 1

Three-phase internally sited melting transformer with oil cooling, for 1 MVA melting capacity, with stage-wise voltage regulation on the high tension side, switches and protection devices 1

Electrode holding and lifting mechanism (for three graphite electrodes, 150 mm diameter each), with electric drive, connected with the installation of automatic regulation of furnace power capacity 1

Low voltage power distribution cable network, with about 40 loops for a total of about 180 kw installed capacity, with contact protection system

Central electric instrumentation, control and regulation panel, operating for:
- furnace and its auxiliaries
- storage and preparation of raw materials
- crushing and grinding including storage
- dust and gas collection and handling 1

6.1.5 *Cooling moulds*

For casting and cooling of ingots of 2 tons' individual weight, with water-cooled steel shell and separate lined bottom plate, mounted on 4-wheeled car frame 10

6.1.6 *Crushing and grinding equipment*

Hydraulic hammer-breaker, suitable for breaking up of the clinker ingots to -160 m/m 1

Jaw crusher 3

Triple-chamber ball mill, with grinding balls, for 1 tph grinding capacity 1

6.1.7 *Installation for activation of Bayer alumina* 1

### 6.1.8 *Transportation*

| | |
|---|---|
| Vibrating chutes and pipes for dosage of raw materials and meal, transportation of clinker and active alumina, feeding of crushing/grinding units, etc. | min. 11 |
| Band elevators for serving the processing and storage equipment | 7 |
| Steel sheet chutes | min. 10 |
| Installation for hauling of furnace and ingot moulds' holding 4-wheel frames | 1 |
| Crane for lifting mould shells and ingots | 1 |
| Diesel cars for internal transportation of raw materials, ingots, packed products | 3 |

### 6.1.9 *Dust separation*

| | |
|---|---|
| Bag filter unit, with exhausting fans and pipe network, serving lime and alumina dosing and transporting system | 2 |
| Bag filter unit with exhausting fans and pipe system for the crushing of crude meal and clinker and grinding of clinker | 1 |
| Bag filter unit, serving fine grinding | 1 |
| Fan and filter unit for furnace gas | 1 |

### 6.1.10 *Requirements of site and utilities*

| <u>Site requirements:</u> | <u>Size</u> |
|---|---|
| - storage silos (open air installation) | 100 $m^2$ |
| - furnace hall building | 80 $m^2$ |
| - cooling yard (concrete floor, open air location) | 150 $m^2$ |
| - crushing, grinding (roof-covered) | 150 $m^2$ |
| - dust separation (open air) | 50 $m^2$ |
| - product storage (roof-covered) | 250 $m^2$ |

| | |
|---|---|
| - office, social rooms | 60 $m^2$ |
| TOTAL | 804 $m^2$ |
| - road network | 420 $m^2$ |

6.1.11 *Utilities*

| | |
|---|---|
| Electric power supply and illumination | about 200 Kw |
| Power for melting | 1,000 KVA |
| Cooling water for furnace shell, electrode holders and ingot moulds | 25 $m^3$/h |

6.1.12 *Shop-level staff*

In case a separate and technically independent shop unit is to be operated, the personnel and their qualification required is provided below (excluding maintenance, guards and plant administration):

| Number of persons | Qualification | Duties |
|---|---|---|
| 1 | shop-floor workers | production supervisor |
| 4 | unskilled workers | mixing/ preparation of raw material feed |
| 4 | skilled workers | activation of alumina |
| 8 | skilled workers | operator (metallurgy) |
| 8 | skilled workers | operator (breaking-cooling), |
| 4 | unskilled workers | bagging, packing |
| 4 | unskilled workers | transportation |
| 1 | chemist/technician | quality control (laboratory) |
| 1 | secretary/typist | administrator to |

production
supervisor

TOTAL 35

6.2. List of additional equipment for the case of partial utilization of capacity of furnace No. 2

The list below shows the main and the significant auxiliary equipment and it was assembled based on local study made and information collected during the plant visit on 10 through 15 May 1992.

6.2.1. *Storage silos*

| Material | Pieces | Volume |
|---|---|---|
| Lime storage | 1 | 150 $m^3$ |
| Crushed clinker (0-3 mm) | 1 | 60 $m^3$ |
| Active alumina | | |
| Steel sheet storage | 1 | 20 $m^3$ |
| Containers for clinker and cement | 20 | |

6.2.2. *Electronic scales for dosing*

| | |
|---|---|
| Two-component intermediate material dosing (clinker and active alumina) - doses of up to 500 kgs | 1 |
| Automatic scales for bagging - doses of 25/50 kgs | 1 |

6.2.3 *Crushing and grinding equipment*

| | |
|---|---|
| Hydraulic hammer-breaker, suitable for first stage breaking-up of the clinker ingots to -160 mm | 1 |
| Jaw breaker for clinker to -80m/m | 1 |
| Vibration mill for clinker grinding with a capacity of 2 t/h | 1 |

6.2.4 *Installation for activation of Bayer alumina* 1

6.2.5 *Transportation*

| | |
|---|---|
| Vibrating chutes and pipes for transportation of clinker and active alumina to crushing unit | min. 4 |

| | | |
|---|---|---|
| Band elevators for serving the processing and storage equipment | | 3 |
| Steel sheet chutes | min. | 10 |
| Diesel cars for internal transportation of raw materials, cooling ingots and packed product | | 2 |
| Pneumatic transportation system for forwarding alumina to intermediate storage before activation | | 1 |

6.2.6 *Dust separation*

| | |
|---|---|
| Bag filter unit with exhausting fan and piping, serving clinker crushing and grinding line | 1 |
| Bag filter unit, serving fine grinding | 1 |

6.2.7 *Site requirements*

| | |
|---|---|
| Storage silos (open air installation) | 60 $m^2$ |
| Crude crushing (roof covered) | 100 $m^2$ |
| Dust separation at fine grinding (open air installation) | 30 $m^2$ |
| Product storage (roof covered) | 250 $m^2$ |
| TOTAL | 590 $m^2$ |
| Road network | 40 m |

6.2.8. *Utilities*

No addition is required.

6.2.9 *Additional shop-level staff*

In case of partial utilization of furnace no. 2 for a 5,000 tpy production, we do not consider additional operating staff required beyond those operating already the furnace and its cooling yard, also crude and fine breaking/grinding. For the case of two operating shirts per day, the additional staff requirements are:

| Number of persons | Qualification | Duties |
|---|---|---|
| 3 | skilled | activation of alumina |
| 3 | skilled | grinding of cement |
| 3 | unskilled | bagging, transportation |

No additional supervisory personnel is contemplated.

## 7. PRODUCT QUALITY ASSURANCE AND CONTROL (PROPERTIES TO BE CONTROLLED, METHODS AND EQUIPMENT)

The basic condition of producing product of good and consistent quality is the guaranteed quality of raw materials utilized. The purchase of raw materials from reliable supplier will pay off in the stage of utilization even if the prices are higher.

### 7.1. System of routine quality control recommended:

- Control of raw materials by shipment:
  - lime:
    - analysis of $CaO/CO_2$ content
    - determination of adhesive moisture
    - ad-hoc control of $SiO_2$ content
  - alumina - acceptance of shipment with certificate attached
  - control of meal with analysis of CaO and $Al_2O_3$ content
  - Qualification of product:
    - Measurement of setting time (by shipment) *)
    - Determination of free lime content (by shipment) *)
    - Granulometric analysis (continuously) *)
    - Measurement of mechanical strength with standard grain (ad-hoc) *)
    - Analysis of $Al_2O_3$, CaO, $Na_2O$, $SiO_2$ and MgO content (ad-hoc) *)
    - Measurement of temperature of softening under load (ad-hoc) *)

---

*) Indication that the necessary measurement apparatus and instruments are locally available.

7.2. Summary of methods of quality control analyses and measurements

| No. | Name | Principle of Method | Material to be investigated | Investments and apparatus required |
|---|---|---|---|---|
| 1 | Sample preparation | Crushing, screening | Raw materials, clinker | Jaw crusher, planetary mill, screens |
| 2 | Chemical analyses | | | |
| | CaO content | Quantometry | lime, clinker, cement | ARL X-ray quantometer |
| | $CO_2$ content | Thermal analysis | lime | LECO thermal analyzer |
| | MgO content | Quantometry | cement | ARL X-ray quantometer |
| | $Al_2O_3$ content | Quantometry | cement | ARL X-ray quantometer |
| | $Na_2O + K_2O$ content | Flame-photometry | cement | Chemicals, photometer (589 nm, 766 nm), glassware |
| | $SiO_2$ content | Quantometry | lime, cement | Chemicals, photometer, glassware, heating furnace (up to 1,200°C) |
| | $Fe_2O_3$ | Quantometry | cement | ARL X-ray quantometer |
| 3 | Physico-mechanical testing | | | |
| | Setting time | Needle immersion | Cement | Vicat apparatus |

| No. | Name | Principle of Method | Material to be investigated | Investments and apparatus required |
|---|---|---|---|---|
| | Screen analysis | Screening | Cement | Screens |
| | Specific surface area | Air propulsion | Alumina | Blain apparatus |
| | Cold bending strength | Breaking load | Cement + grains | Breaking machines, metallic mould |
| | Cold compressive strength | Breaking load | Cement + grains | Mixing machine, breaking machine, metallic mould |
| | Compressive and bending strength after burning | Breaking load after burning | Cement + grains | Dryer, heating furnace |
| 4 | <u>Application properties, measurement</u> | | | |
| | Resistance to thermal shock | Cyclic heating, weighing | Cement + grains | Mixing machine, heating furnace, metallic mould |
| | Softening under load | Measurement of change in size at heating under load | Cement + grains | Apparatus for measuring softening under load |
| | Derivatographic measurements | Registration of change in weight and temperature under thermic load | Clinker, cement, cement + grains | Derivatograph |

## 8. INVESTMENT COST ESTIMATE

This estimate is based on unit prices prevalent in April 1992 in Hungary (civil and building construction) and in Hungary and Europe (machinery and equipment). They may be easily converted to conditions of other unit prices. The estimate is made for the production of the grade of 80 % alumina-content CA refractory cement. Deviation permitted as per UNIDO practice ("Opportunity-Study"): ± 30 %.

### 8.1. For a 5,000 tpy separate production unit, US$

The availability at plant site within the premises of C.E. Minerales de Venezuela and Refractorios Venezolanos S.A. of the following items of infrastructure at no significant additional investment cost to the subject project is taken as a pre-condition.

- electric energy
- water supply
- canalization/sewage system (technological, sewage, rain)
- land
- organization of quality control, including laboratory
- social premises
- office space

#### 8.1.1 *Civil and building construction*

| | | |
|---|---|---|
| - furnace hall | 100 m² | |
| - breaking, crushing, grinding | 100 m² | |
| - storage of products | 250 m² | |
| | 450 m² x US$ 200 = | 90,000 |
| - road network | 420 m² x US$ 130 = | 55,000 |
| TOTAL | US$ | 145,000 |

#### 8.1.2 *Equipment*

| | |
|---|---|
| - 6 steel silos (250, 60, 60, 50, 40, 40 m³) | 250,000 |
| - triple-chamber ball mill (1) | 80,000 |
| - jaw breakers (3) | 150,000 |
| - vibration dosators (11) | 100,000 |
| - chutes, gates | 30,000 |
| - hydraulic hammer-breaker | 85,000 |
| - bag filters for dust separation (4) | 140,000 |
| - installation for activation of alumina | 150,000 |
| - transportation (diesel trucks, band elevators, crane for mould shells, hauling of moulds, etc.) | 150,000 |
| - 1 MVA electric arc furnace with | |

| | | | |
|---|---|---|---|
| | transformer, electrode holding/ lifting mechanism, gas fan, etc. | | 450,000 |
| | TOTAL | US$ | 1,585,000 |

8.1.3 *Automation and electricity network*

| | | | |
|---|---|---|---|
| - | automatic scales (30) | | 60,000 |
| - | silo level indicators | | 40,000 |
| - | central electric instrumentation, control and regulation panel and system (1) | | 120,000 |
| - | electric power transmission network (1) | | 45,000 |
| - | illumination | | 15,000 |
| | TOTAL | | 280,000 |

8.1.4 *Erection and installation*

| | | | |
|---|---|---|---|
| - | steel structures | | 35,000 |
| - | automation (electricity) | | 30,000 |
| - | craning, scaffolding | | 40,000 |
| - | start-up costs | | 35,000 |
| | TOTAL | US$ | 140,000 |

8.1.5 *Engineering design and supervision* US$ 145,000

8.1.6 *Estimated total investment*

| | | |
|---|---|---|
| | US$ | 145,000 |
| | | 1,585,000 |
| | | 280,000 |
| | | 140,000 |
| | | 145,000 |
| GRAND TOTAL | | 2,295,000 |
| Say | | 2.3 million |

This estimate does not include items required for operation such as

- filtering cloth
- furnace lining
- bags, palettes, labels, packing foil, etc.
- spare parts
- staff safety protection gear
- office equipment etc.

It does not contain cost of working capital either.

8.2. <u>In case of partial utilization of the capacity of the newly established furnace No. 2</u>

Based on information collected on the visit to the plant on 10 through 15 May this year, the availability at plant site of the following items at no significant additional investment cost to the subject project is considered.

- electric energy
- water
- sewage system (technological, waste, rain)
- land
- organization of quality control, including laboratory
- social premises
- office space
- melting site with furnace and auxiliary equipment
- fine crushing
- cooling yard

8.2.1 *Civil and building construction*

| | | |
|---|---|---|
| - crude crushing and grinding | 100 $m^2$ | |
| - storage of product | 250 $m^2$ | |
| - | 350 $m^2$xUS$ 200 = | US$ 70,000 |
| - road network | 40 $m^2$xUS$ 130 = | US$ 5,000 |
| TOTAL | | US$ 75,000 |

8.2.2. *Equipment*

| | |
|---|---|
| - 3 steel sheet silos (150, 60 and 20 $m^3$) | 150,000 |
| - steel sheet storage containers | 50,000 |
| - pneumatic transportation piping to activating unit (1) | 12,000 |
| - vibration mill (1) | 120,000 |
| - jaw breaker (1) | 50,000 |
| - vibration dosators (4) | 38,000 |
| - chutes, gates | 25,000 |
| - steel structures for operators | 24,000 |
| - hydraulic hammer breaker (1) | 85,000 |
| - bag filters for dust separation 2) | 120,000 |
| - internal transportation diesel trucks (3) | 40,000 |
| - installation for activation of alumina (1) | 150,000 |
| TOTAL US$ | 864,000 |

8.2.3 *Automation and electricity network*

| | |
|---|---|
| - automatic scales (2) | 40,000 |

| | | | |
|---|---|---|---|
| - | silo level indicators | | 25,000 |
| - | electronic regulation systems for dosing, grinding and dust separation (1) | | 15,000 |
| - | electric power transmission network | | 25,000 |
| - | illumination | | 10,000 |
| | TOTAL | US$ | 115,000 |

8.2.4 *Erection and installation*

| | | | |
|---|---|---|---|
| - | steel structures | | 30,000 |
| - | automation (electricity) | | 20,000 |
| - | craning, scaffolding | | 35,000 |
| - | start-up costs | | 25,000 |
| | TOTAL | US$ | 110,000 |

8.2.5 *Engineering design and supervision* 80,000

8.2.6 *Estimated total investment costs*

| | | |
|---|---|---|
| | | 75,000 |
| | | 864,000 |
| | | 115,000 |
| | | 110,000 |
| | | 80,000 |
| GRAND TOTAL | US$ | 1,244,000 |
| Say | US$ | <u>1.3 million</u> |

This estimate, made on the prices of April 1992, does not include items required for operation, such as

- graphite electrodes
- filtering cloth
- bags, palettes, labels, packing foil, etc.
- spare parts
- staff safety protection gear, etc.

It does not contain cost of working capital either.

## 9. SUMMARY AND CONCLUSIONS

9.1. On the assignment of UNIDO, we have studied the availability and suitability of raw materials, the selection of technology and a number of other important conditions of establishment of production of refractory grade aluminate cements in the plant C.E. Minerales de Venezuela S.A. of the company Corporacion Grupo Marques Barry in Venezuela. The results of our study and our new, complementary laboratory investigations and testing are described in this report which, at the same time, does not contain explicit know-how information.

9.2. In the first part of the report, among others, the chemistry and grades of aluminate cements and requirements and other information on quality of raw materials, production technology, material balance, flow-sheet of production were described.

9.3. Detailed elaborations were made on system of quality assurance for the products, including properties to be controlled and the necessary methods and equipment. This was complemented by laboratory investigations and preparation and testing of specimens made using the cements prepared by us on laboratory scale from the available local raw materials.

9.4. Based on data collection and assessments on the spot the investment costs were estimated for the case of establishment of a separate production unit of 5,000 tpy capacity. As an alternative, similar assessment was made also for the case of partial utilization on the same annual scale of the new, additional capacity (furnace no. 2) of white corundum production, being now established in the plant. For both cases, lists of new main and auxiliary technological equipment and operating staff requirements were also elaborated.

9.5. As a result of collection of all the necessary information, including personal visit to the industrial plant under scrutiny and detailed consultations with the Venezuelan counterpart, we have reached the conclusion that the necessary conditions are present and very favourable for the organization and realization on relatively moderate costs and in a short time period of the production of refractory grade aluminate cements on a quality level.

9.6. Already now, most of the major, important conditions required for establishing this production by the company, are present, such as:

- Availability of raw materials of suitable quality and favourable price;

- Availability of electric energy of favourable price;

- Availability of professional staff of engineers and workers, experienced in the operations of melting, breaking, grinding;

- availability of experienced professional staff and special equipment for quality control of raw materials and fused products;

- favourable conditions of location and space for a separate production unit and - on the other hand - favourable circumstances for the alternative case of respective, partial utilization for the same purpose of the new furnace no. 2 now under installation;

- significant available local/national market for the cement product.

Since the first two conditions (raw material and energy) represent approximately two third of the internationally known production costs, it may be expected that the competitiveness of the new cement products will be at least as high as that of the white corundum produced now by the company.

9.7. The only missing major local condition of organizing and starting of the production of refractory grade aluminate cement of internationally acceptable high quality is the non-availability of local active alumina to serve as additive. This problem can be solved either by import or by organization of local production in cooperation with the neighbouring alumina plant (which is a general practice) or by the company itself. Our exploratory laboratory investigations and relevant specimen testing carried out in addition to the tasks prescribed by the UNIDO assignment, prove that the required activation of the available Interalumina alumina product may be organized and carried out even within the premises of the corundum plant at moderate costs, with a process of two stages resulting in stage by stage consecutive improvement of properties and promising and end-product by quality, close to that of the cement product of internationally leading manufacturers. The relevant know-how is accessible.

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ANNEX

## Summary report on laboratory investigation of fused aluminate-cement, prepared from samples of Venezuelan alumina and lime

Samples of alumina, produced by the Interalumina plant of Puerto Ordaz and also lime of Venezuelan origin, put at our disposal by Corporacion Grupo Marquez Barry, were blended in a ration according to analytical data provided also by the company, homogenized and fused in a laboratory furnace of 30 Kw and 22 V and single phase. The mixture functioned also as crucible, so contamination by other component was excluded.

The fusion proceeded quickly and undisturbed, no intensive development of gases was experienced. No boiling of the melt was observed. The small fused block produced, weighing about 1 kg, was not removed before it cooled down. It was ground in jaw breaker to the size of 0 to 3 mm and by adding Hungarian active alumina, Venezuelan alumina and activated Venezuelan alumina respectively, and fine grinding in vibration mill, cement samples were produced.

The following investigations were carried out:

- X-ray diffractometry for clinkers and cement samples (see Pictures 5 and 6);
- BET specific surface area determination;
- VICAT setting time measurements;
- Compression strength on room temperature of specimens of concrete 48 hours after preparation and after heating to 1,200° C/

Specimens of concrete were prepared from 85 % standard corundum grains and 15 % cement. Water was added to the extent of plus 7.5 %. Results of the measurements and investigations are shown in the table below.

| Measurement | Type of cement | | | |
|---|---|---|---|---|
| | CH | CV1 | CV2 | CA25 |
| Specific surface area ($m^2/g$) | 1.2 | 27.6 | 25.2 | 10.8 |
| Setting time<br>start<br>end | 3h40min<br>5 h | 3h<br>4h30min | 2h40min<br>4h40min | 1h50min<br>3h55min |
| Compression strength ($N/cm^2$)<br>- after 48 hours<br>- burned on 1200°C | 1,864<br>1785 | 1,113<br>1,164 | 1,407<br>1,643 | 1,550<br>1,512 |

Note: CH - cement with additive of active alumina oaf Hungarian origin.

CV1 - cement with additive of untreated Interalumina alumina.

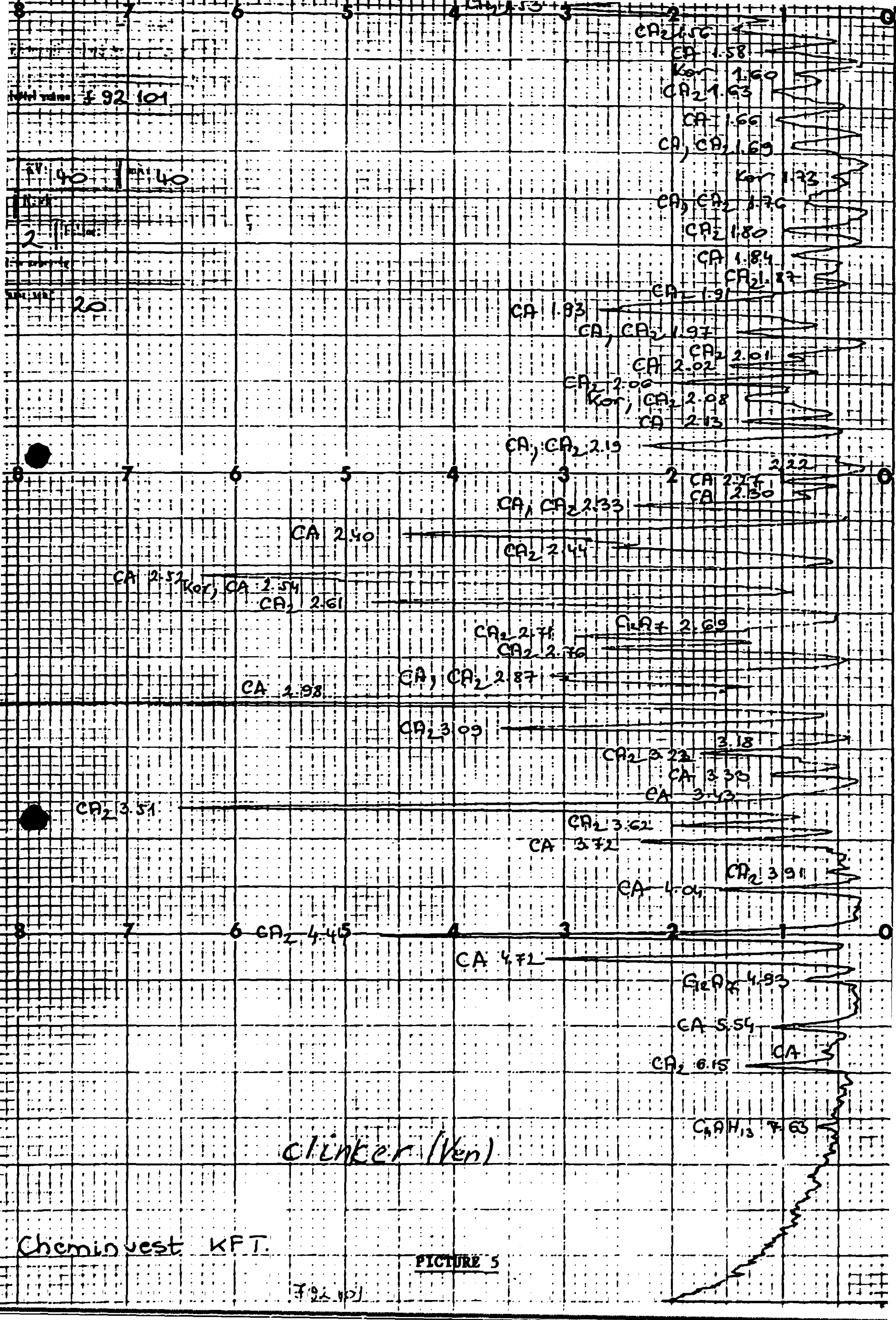
CV2 - cement with additive of activated Interalumina alumina.

CA25 - cement of Alcoa CA25 type.

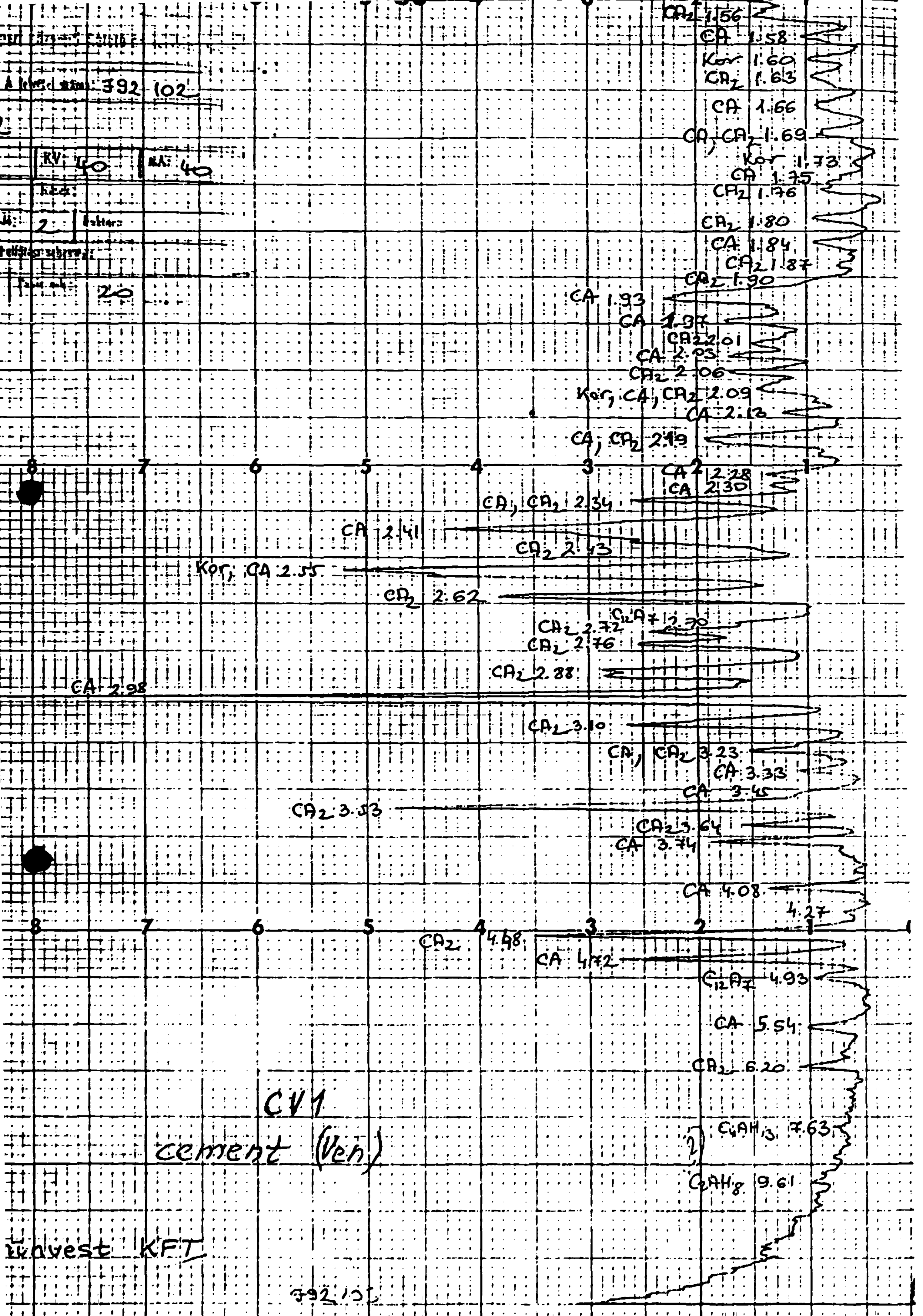
Conclusions:

1. The X-ray diffractograms show that the quality of Interalumina alumina and lime of Venezuelan origin are suitable for production of aluminate-cement (no presence of silicates or other undesired compounds).

2. Although the CV2-cement shows a quality comparable already to CA25, the investigations will continue with a cement similar in composition to CV2, but with more strongly activated additive of Interalumina alumina (CV3). We expect from the respective specimens an even larger compressive strength, close to that of CH.


92 101
40
40
2
20
CA 1.58
Kor 1.60
CA2 1.63
CA 1.66
CA, CA2 1.69
Kor 1.73
CA2 1.80
CA 1.84
CA2 1.87
CA 1.91
CA 1.93
CA, CA2 1.97
CA2 2.01
CA 2.02
Kor, CA2 2.08
CA 2.13
CA, CA2 2.19
2.22
CA 2.30
CA, CA2 2.33
CA 2.40
CA2 2.44
Kor, CA 2.54
CA2 2.61
CA2 2.71
CA2 2.76
CA, CA2 2.87
CA 2.98
CA2 3.09
3.18
CA2 3.23
CA 3.33
CA 3.43
CA2 3.51
CA2 3.62
CA 3.72
CA2 3.91
CA 4.04
CA2 4.45
CA 4.72
CA 5.54
CA
CA2 6.15
clinker (Ven)
Cheminvest KFT.

PICTURE 5



392 102
KV: 40
mA: 40
2
20
CA₂ 1.56
CA 1.58
Kor 1.60
CA₂ 1.63
CA 1.66
CA, CA₂ 1.69
Kor 1.73
CA 1.75
CA₂ 1.76
CA₂ 1.80
CA 1.84
CA₂ 1.87
CA₂ 1.90
CA 1.93
CA₂ 2.01
CA 2.03
CA₂ 2.06
Kor, CA, CA₂ 2.09
CA 2.13
CA, CA₂ 2.19
CA 2.28
CA 2.30
CA, CA₂ 2.34
CA 2.41
CA₂ 2.43
Kor, CA 2.55
CA₂ 2.62
CA₂ 2.72
C₁₂A₇ 2.70
CA₂ 2.76
CA₂ 2.88
CA 2.98
CA₂ 3.10
CA, CA₂ 3.23
CA 3.33
CA 3.45
CA₂ 3.53
CA₂ 3.64
CA 3.74
CA 4.08
4.27
CA₂ 4.48
CA 4.72
C₁₂A₇ 4.93
CA 5.54
CA₂ 6.20
C₄AH₁₃ 7.63
C₂AH₈ 9.61
8
7
6
5
4
3
2
1
CV1
cement (Ven)
Invest KFT
392/13


PICTURE 6

**ATTACHMENT NO. 1**

JOB DESCRIPTIONS

UC/VEN/91/189/11-51, 11-52, 11-53, 11-54

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

UC/VEN/91/189/11-51/J13207

***

| | |
|---|---|
| *Post Title:* | Refractory material specialist |
| *Duration:* | 2 months |
| *Date required:* | As soon as possible |
| *Duty Station:* | Home base |
| *Purpose of project:* | Enable the National Counterpart - Corporacion Grupo Marques Barry - to evaluate the technical and economic viability of the production of aluminate silicates from indigenous raw materials and take an urgent investment decision. |
| *Duties:* | The specialist should prepare for Corporacion Grupo Marques Barry's fused alumina plant in Puerto Ordaz, Venezuela |

1. the raw material requirements of the aluminate cement production;

2. participate in the selection of most suitable indigenous raw materials;

3. discuss questions related to aluminate-cement product quality, fields of applications and market questions.

*Qualifications:*

Metallurgical or chemical engineer

*Language requirements:*

English

..../2

*Applications and communications regarding this Job Description should be sent to:*

Project Personnel Recruitment Section, Industrial Operations Division
UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. BOX 300, Vienna, Austria

BACKGROUND INFORMATION

The Venezuelan aluminium industry was developed from its beginning to increase the export revenues of the country and also to diversify the exports that were previously mainly based on petroleum. It was also strongly linked to the desire of the Government of Venezuela to create a pole of development in the Guayana region. Presently, the aluminium industry of Venezuela operates in a uniquely favourable position.

Advantages of Venezuela in the aluminium production:

- Availability of abundant electrical energy on the Caroni River (second cheapest of the world).
- Huge reserves of high quality bauxite and locally produced alumina.
- Favourable geographical location of the country - close to the markets of Central and North America, convenient connections to Europe and Japan.
- Location of industry close to sources of energy, raw materials and Orinoco River navigation facilities - low transportation cost of inputs.
- Low cost of labour.
- Experience in aluminium production and trade, trained personnel.

The Venezuelan aluminium industry has a vertical structure and with the exception of the processing sector, it is controlled by the holding company CVG (Corporacion Venezolana de Guayana).

There are four enterprises in the aluminium sector of CVG:

(i) CVG BAUXIVEN - responsible for the exploitation of bauxite in the Los Pijiguaos area.

(ii) CVG INTERALUMINA - alumina plant operator.

(iii) CVG ALCASA - aluminium reduction and rolling plant operator.

(iv) CVG VENALUM - aluminium reduction and products plant operator.

As a result of the continuous increase in production capacity, the current output of alumina is about 1.3 million metric tonnes per year, and that of aluminium is 655,000 metric tonnes. CVG INTERALUMINA will increase its capacity to three million metric

tonnes per year until 1995 in order to meet the growing demand of the smelters for alumina. It is expected that by the end of this century, smelting capacity will have reached two million metric tonnes per year, requiring more than four million metric tonnes of alumina annually. Mining of bauxite will have to reach the level of eight million m.t./year. Fortunately, the abundant Venezuelan reserves of this mineral will ensure complete self-supply for decades to come.

The present efforts of the State-owned CVG are naturally concentrated on the development of the primary aluminium production, and some of the areas of semi-finished product fabrication making up for the highest production and export volume. At the same time, there is an ever growing demand from the constantly developing domestic industry for different kinds of raw materials and products based on aluminium and its derivates. Besides the aluminium industry, other sectors of metallurgy too - like iron and steel and ferroalloy industries - are developing steadily and have already achieved high levels in Venezuela. This is related to the abundant raw material (iron, non-ferrous metals, etc.) and energy resources. The market possibilities of these sectors are very promising even on a long-term basis.

The metallurgical sector of the national economy is one of the largest consumers of high quality refractory materials. Venezuela presently imports great portions of these products, consuming the insufficient hard-currency revenues of the country. It is therefore a justified trend to elaborate possibilities for import substitution in the fast developing branches of national economies. As long as the overall development of the economy in the Guayana Region consumes most of the human resources of CVG, the private sector is encouraged to develop the production of smaller scale products.

Among the refractory materials, aluminate silicates, which are often called aluminate cements, are playing a very important role as binding materials and for cast refractory applications. These products are produced from specially ground high purity alumina, smelter grade pure alumina, limestone and other additives. Due to the high quality bauxite and very up-to-date technologies used for the aluminium production in Venalum, it seems feasible that after some special, inexpensive treatment the raw materials available in Venezuela can be used for the production of aluminate silicates.

The private Company "Corporacion Grupo Marques Barry" has decided to start the production of these materials, aiming to achieve 5,000 metric t/year production volume mainly consumed in Venezuela and partially in the neighbouring countries. The Company operates the following plants in the related fields, being one of the important private ferro-alloy and refractory materials producer of the country:

Hornos Electricos de Venezuela, S.A.
Refractarios Venezolanos, S.A.
Flocon de Venezuela, S.A.
C.E. Minerales de Venezuela, S.A.
Coporaction Guayanesa de Silico Guayasil, C.A.
Industria Siderquimica Venezolana, C.A.
Corporacion Selee de Venezuela, S.A.

Recently, the Corporacion Grupo Marques Barry, by establishing a new factory, started up the production of fused aluminas (white corrundum) in joint venture with the company Combustion Engineers USA, using the technology know-how and marketing abilities of the North American partner.

The fused aluminas are produced by smelting the pure smelter grade alumina in electric arc furnaces and cooling it afterwards to room temperature. For the production of aluminate silicates, electric arc furnaces are also used; hence the raw materials, basic technological equipment are very similar in both cases. The aluminate silicate production is intended to be organized on the new fused alumina plant (Refractarios Venezolanos, S.A.) which is situated in Puerto Ordaz, and connected to the Interalumina refinery with an alumina conveyor for the easy raw material supply. These are the main advantages of, and the reasons for the Company to start up the production of aluminate silicates.

The project is aimed at the selection of the most suitable type of raw materials available in Venezuela (mainly alumina and limestone), and recommend on the viability of introduction of aluminate silicate production. In this regard, the main features of adaptation of the production technology, selection of main equipment, estimation of investment and production costs will be undertaken, also thus providing the National counterpart important inputs to make an investment decision.

The urgency of the project is related to the following factors:

a) The Venezuelan metallurgy and other branches of industry are demanding more and more high quality refractories which enable to reduce production costs, smoothen their operation, improve product quality and enhance their overall efficiency. These materials are presently not produced in Venezuela and must be imported. The import of refractories is sometimes difficult, or a lengthy procedure, due to import restrictions and regulations. Thus, the industry faces economic losses in its everday operations.

b) The import substitution is one of the first priorities in Venezuela due to its present heavy debt burden.

c) The Company Corporacion Grupo Marques Barry has recently

started up the production in its fused alumina plant. It wants to take an urgent investment decision on the diversification of its product-line. If the manufacturing of this new and important product shows up technical and economic viability, the Company is ready to invest its only presently available limited funds to solve this problem of the National economy.

d) The use of domestic high quality alumina only for aluminium smelting is a waste of possible added value component for the country. It is well proved by the experience of highly developed countries, that the production of increased added value speciality aluminas and their derivates brings high economic effect to the producers. The diversification of the Venezuelan aluminium industry is an important and urgent issue, while the regional markets are still not sufficiently covered.

National Counterparts Inputs

The National counterpart will:

(a) Procure and deliver to the UNIDO consultant all necessary raw materials to be tested in due time and quantity, as specified by the consultant.

(b) Ensure all the necessary background, technical and economic information and data as required by the UNIDO consultant for the successful implementation of the project.

(c) Collect and compile all marketing informations including quantities, quality requirements and assortment.

(d) Nominate a full-time expert in charge of the project and responsible for the organization of the services and submission of informations to the UNIDO consultant.

REPORTING AND EVALUATION REQUIREMENTS, FOLLOW-UP

After finishing the laboratory and industrial technological tests, the specialist with the other members of the team shall prepare a report reflecting the findings and recommendations related to the proposed technology, selected raw materials, estimated investment and production costs, sources of know-how and training requirements.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

UC/VEN/91/189/11-52/J13207

***

*Post Title:* Plant design specialist

*Duration:* 2 months

*Date required:* As soon as possible

*Duty Station:* Home base

*Purpose of project:* Enable the National Counterpart - Corporacion Grupo Marques Barry - to evaluate the technical and economic viability of the production of aluminate silicates from indigenous raw materials and take an urgent investment decision.

*Duties:* The specialist should prepare for Corporacion Grupo Marques Barry's fused alumina plant in Puerto Ordaz, Venezuela

1. requirements towards plant site;
2. information regarding the infrastructure and utilities required for an alumina cement plant;
3. equipment list, plant layout design;
4. information on engineering and construction works and cost;
5. investment cost estimation;

*Qualifications:*

Mechanical engineer

*Language requirements:*

English

..../2

*Applications and communications regarding this Job Description* should be sent to:
Project Personnel Recruitment Section, Industrial Operations Division
UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. BOX 300, Vienna, Austria

BACKGROUND INFORMATION

The Venezuelan aluminium industry was developed from its beginning to increase the export revenues of the country and also to diversify the exports that were previously mainly based on petroleum. It was also strongly linked to the desire of the Government of Venezuela to create a pole of development in the Guayana region. Presently, the aluminium industry of Venezuela operates in a uniquely favourable position.

Advantages of Venezuela in the aluminium production:

- Availability of abundant electrical energy on the Caroni River (second cheapest of the world).
- Huge reserves of high quality bauxite and locally produced alumina.
- Favourable geographical location of the country - close to the markets of Central and North America, convenient connections to Europe and Japan.
- Location of industry close to sources of energy, raw materials and Orinoco River navigation facilities - low transportation cost of inputs.
- Low cost of labour.
- Experience in aluminium production and trade, trained personnel.

The Venezuelan aluminium industry has a vertical structure and with the exception of the processing sector, it is controlled by the holding company CVG (Corporacion Venezolana de Guayana).

There are four enterprises in the aluminium sector of CVG:

(i) CVG BAUXIVEN - responsible for the exploitation of bauxite in the Los Pijiguaos area.

(ii) CVG INTERALUMINA - alumina plant operator.

(iii) CVG ALCASA - aluminium reduction and rolling plant operator.

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As a result of the continuous increase in production capacity, the current output of alumina is about 1.3 million metric tonnes per year, and that of aluminium is 655,000 metric tonnes. CVG INTERALUMINA will increase its capacity to three million metric

tonnes per year until 1995 in order to meet the growing demand of the smelters for alumina. It is expected that by the end of this century, smelting capacity will have reached two million metric tonnes per year, requiring more than four million metric tonnes of alumina annually. Mining of bauxite will have to reach the level of eight million m.t./year. Fortunately, the abundant Venezuelan reserves of this mineral will ensure complete self-supply for decades to come.

The present efforts of the State-owned CVG are naturally concentrated on the development of the primary aluminium production, and some of the areas of semi-finished product fabrication making up for the highest production and export volume. At the same time, there is an ever growing demand from the constantly developing domestic industry for different kinds of raw materials and products based on aluminium and its derivates. Besides the aluminium industry, other sectors of metallurgy too - like iron and steel and ferroalloy industries - are developing steadily and have already achieved high levels in Venezuela. This is related to the abundant raw material (iron, non-ferrous metals, etc.) and energy resources. The market possibilities of these sectors are very promising even on a long-term basis.

The metallurgical sector of the national economy is one of the largest consumers of high quality refractory materials. Venezuela presently imports great portions of these products, consuming the insufficient hard-currency revenues of the country. It is therefore a justified trend to elaborate possibilities for import substitution in the fast developing branches of national economies. As long as the overall development of the economy in the Guayana Region consumes most of the human resources of CVG, the private sector is encouraged to develop the production of smaller scale products.

Among the refractory materials, aluminate silicates, which are often called aluminate cements, are playing a very important role as binding materials and for cast refractory applications. These products are produced from specially ground high purity alumina, smelter grade pure alumina, limestone and other additives. Due to the high quality bauxite and very up-to-date technologies used for the aluminium production in Venalum, it seems feasible that after some special, inexpensive treatment the raw materials available in Venezuela can be used for the production of aluminate silicates.

The private Company "Corporacion Grupo Marques Barry" has decided to start the production of these materials, aiming to achieve 5,000 metric t/year production volume mainly consumed in Venezuela and partially in the neighbouring countries. The Company operates the following plants in the related fields, being one of the important private ferro-alloy and refractory materials producer of the country:

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<u>National Counterparts Inputs</u>

The National counterpart will:

(a) Procure and deliver to the UNIDO consultant all necessary raw materials to be tested in due time and quantity, as specified by the consultant.

(b) Ensure all the necessary background, technical and economic information and data as required by the UNIDO consultant for the successful implementation of the project.

(c) Collect and compile all marketing informations including quantities, quality requirements and assortment.

(d) Nominate a full-time expert in charge of the project and responsible for the organization of the services and submission of informations to the UNIDO consultant.

REPORTING AND EVALUATION REQUIREMENTS, FOLLOW-UP

After finishing the laboratory and industrial technological tests, the specialist with the other members of the team shall prepare a report reflecting the findings and recommendations related to the proposed technology, selected raw materials, estimated investment and production costs, sources of know-how and training requirements.

**UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION**

**JOB DESCRIPTION**

**UC/VEN/91/189/11-53/J13207**

***

*Post Title:* Material testing specialist

*Duration:* 2 months

*Date required:* As soon as possible

*Duty Station:* Home base

*Purpose of project:* Enable the National Counterpart - Corporacion Grupo Marques Barry - to evaluate the technical and economic viability of the production of aluminate silicates from indigenous raw materials and take an urgent investment decision.

*Duties:* The specialist should prepare for Corporacion Grupo Marques Barry's fused alumina plant in Puerto Ordaz, Venezuela

1. quality requirements of the raw materials and should participate in their selection;
2. the quality requirements of the final product;
3. recommendation on the quality assurance procedures and system, list of quality control, measuring and testing equipment, quality assurance personnel.

*Qualifications:*

Chemical engineer or physicist

*Language requirements:*

English

..../2

*Applications and communications regarding this Job Description should be sent to:*
Project Personnel Recruitment Section, Industrial Operations Division
UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. BOX 300, Vienna, Austria

BACKGROUND INFORMATION

The Venezuelan aluminium industry was developed from its beginning to increase the export revenues of the country and also to diversify the exports that were previously mainly based on petroleum. It was also strongly linked to the desire of the Government of Venezuela to create a pole of development in the Guayana region. Presently, the aluminium industry of Venezuela operates in a uniquely favourable position.

Advantages of Venezuela in the aluminium production:

- Availability of abundant electrical energy on the Caroni River (second cheapest of the world).
- Huge reserves of high quality bauxite and locally produced alumina.
- Favourable geographical location of the country - close to the markets of Central and North America, convenient connections to Europe and Japan.
- Location of industry close to sources of energy, raw materials and Orinoco River navigation facilities - low transportation cost of inputs.
- Low cost of labour.
- Experience in aluminium production and trade, trained personnel.

The Venezuelan aluminium industry has a vertical structure and with the exception of the processing sector, it is controlled by the holding company CVG (Corporacion Venezolana de Guayana).

There are four enterprises in the aluminium sector of CVG:

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As a result of the continuous increase in production capacity, the current output of alumina is about 1.3 million metric tonnes per year, and that of aluminium is 655,000 metric tonnes. CVG INTERALUMINA will increase its capacity to three million metric

tonnes per year until 1995 in order to meet the growing demand of the smelters for alumina. It is expected that by the end of this century, smelting capacity will have reached two million metric tonnes per year, requiring more than four million metric tonnes of alumina annually. Mining of bauxite will have to reach the level of eight million m.t./year. Fortunately, the abundant Venezuelan reserves of this mineral will ensure complete self-supply for decades to come.

The present efforts of the State-owned CVG are naturally concentrated on the development of the primary aluminium production, and some of the areas of semi-finished product fabrication making up for the highest production and export volume. At the same time, there is an ever growing demand from the constantly developing domestic industry for different kinds of raw materials and products based on aluminium and its derivates. Besides the aluminium industry, other sectors of metallurgy too - like iron and steel and ferroalloy industries - are developing steadily and have already achieved high levels in Venezuela. This is related to the abundant raw material (iron, non-ferrous metals, etc.) and energy resources. The market possibilities of these sectors are very promising even on a long-term basis.

The metallurgical sector of the national economy is one of the largest consumers of high quality refractory materials. Venezuela presently imports great portions of these products, consuming the insufficient hard-currency revenues of the country. It is therefore a justified trend to elaborate possibilities for import substitution in the fast developing branches of national economies. As long as the overall development of the economy in the Guayana Region consumes most of the human resources of CVG, the private sector is encouraged to develop the production of smaller scale products.

Among the refractory materials, aluminate silicates, which are often called aluminate cements, are playing a very important role as binding materials and for cast refractory applications. These products are produced from specially ground high purity alumina, smelter grade pure alumina, limestone and other additives. Due to the high quality bauxite and very up-to-date technologies used for the aluminium production in Venalum, it seems feasible that after some special, inexpensive treatment the raw materials available in Venezuela can be used for the production of aluminate silicates.

The private Company "Corporacion Grupo Marques Barry" has decided to start the production of these materials, aiming to achieve 5,000 metric t/year production volume mainly consumed in Venezuela and partially in the neighbouring countries. The Company operates the following plants in the related fields, being one of the important private ferro-alloy and refractory materials producer of the country:

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The fused aluminas are produced by smelting the pure smelter grade alumina in electric arc furnaces and cooling it afterwards to room temperature. For the production of aluminate silicates, electric arc furnaces are also used; hence the raw materials, basic technological equipment are very similar in both cases. The aluminate silicate production is intended to be organized on the new fused alumina plant (Refractarios Venezolanos, S.A.) which is situated in Puerto Ordaz, and connected to the Interalumina refinery with an alumina conveyor for the easy raw material supply. These are the main advantages of, and the reasons for the Company to start up the production of aluminate silicates.

The project is aimed at the selection of the most suitable type of raw materials available in Venezuela (mainly alumina and limestone), and recommend on the viability of introduction of aluminate silicate production. In this regard, the main features of adaptation of the production technology, selection of main equipment, estimation of investment and production costs will be undertaken, also thus providing the National counterpart important inputs to make an investment decision.

The urgency of the project is related to the following factors:

a) The Venezuelan metallurgy and other branches of industry are demanding more and more high quality refractories which enable to reduce production costs, smoothen their operation, improve product quality and enhance their overall efficiency. These materials are presently not produced in Venezuela and must be imported. The import of refractories is sometimes difficult, or a lengthy procedure, due to import restrictions and regulations. Thus, the industry faces economic losses in its everday operations.

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National Counterparts Inputs

The National counterpart will:

(a) Procure and deliver to the UNIDO consultant all necessary raw materials to be tested in due time and quantity, as specified by the consultant.

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(c) Collect and compile all marketing informations including quantities, quality requirements and assortment.

(d) Nominate a full-time expert in charge of the project and responsible for the organization of the services and submission of informations to the UNIDO consultant.

REPORTING AND EVALUATION REQUIREMENTS, FOLLOW-UP

After finishing the laboratory and industrial technological tests, the specialist with the other members of the team shall prepare a report reflecting the findings and recommendations related to the proposed technology, selected raw materials, estimated investment and production costs, sources of know-how and training requirements.

# UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

## JOB DESCRIPTION

## UC/VEN/91/189/11-54/J13207

***

*Post Title:* Alumina technologist

*Duration:* 2 months

*Date required:* As soon as possible

*Duty Station:* Home base

*Purpose of project:* Enable the National Counterpart - Corporacion Grupo Marques Barry - to evaluate the technical and economic viability of the production of aluminate silicates from indigenous raw materials and take an urgent investment decision.

*Duties:* The specialist should prepare for Corporacion Grupo Marques Barry's fused alumina plant in Puerto Ordaz, Venezuela

1. information regarding alumina quality requirements;
2. material balance, material and energy consumption data of aluminate cement production;
3. conceptual drawings of selected process technology.

*Qualifications:*

Metallurgical or chemical engineer

*Language requirements:*

English

..../2

*Applications and communications regarding this Job Description*
**should be sent to:**
Project Personnel Recruitment Section, Industrial Operations Division
UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. BOX 300, Vienna, Austria

BACKGROUND INFORMATION

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The Venezuelan aluminium industry was developed from its beginning to increase the export revenues of the country and also to diversify the exports that were previously mainly based on petroleum. It was also strongly linked to the desire of the Government of Venezuela to create a pole of development in the Guayana region. Presently, the aluminium industry of Venezuela operates in a uniquely favourable position.

Advantages of Venezuela in the aluminium production:

- Availability of abundant electrical energy on the Caroni River (second cheapest of the world).

- Huge reserves of high quality bauxite and locally produced alumina.

- Favourable geographical location of the country - close to the markets of Central and North America, convenient connections to Europe and Japan.

- Location of industry close to sources of energy, raw materials and Orinoco River navigation facilities - low transportation cost of inputs.

- Low cost of labour.

- Experience in aluminium production and trade, trained personnel.

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National Counterparts Inputs

The National counterpart will:

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(c) Collect and compile all marketing informations including quantities, quality requirements and assortment.

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REPORTING AND EVALUATION REQUIREMENTS, FOLLOW-UP

After finishing the laboratory and industrial technological tests, the specialist with the other members of the team shall prepare a report reflecting the findings and recommendations related to the proposed technology, selected raw materials, estimated investment and production costs, sources of know-how and training requirements.

ATTACHMENT NO. 2

KERA progress

Intersilicate Engineering Office

1031 Budapest III., Monostori u. 23.

Telex: 22-4-42-
Phone: 686-616

Our ref.:
Your ref.:
Your letter of:

Budapest, 198 24th January, 1992

Mr. J. Krouzek
Head,
UNIDO
Department of Industrial Operations
Metallurgical Industries Branch

A-1400 Vienna.

Dear Mr. Krouzek,

Subject: Pre-investment advisory services to the Corporation Grupo Marques Barry, Venezuela.

Reference is made to your subject letter to us, dated 9.January, 1992with the enclosed four job descriptions, covering the tasks to be tackled, and also to our personal discussions with Mr.Grof and Mr.Tarzejev held in UNIDO, Vienna on 20.01 this year.
As we understand, the Venezuelan counterpart is interested in urgent evaluation of the technical and economic viability of extending their existing operations of production of fused aluminas in Puerto Ordaz (Refractarios Venezolanos S.A.)
In positive case the evaluation will be followed by an investment decision. We are expected to assist the counterpart in this endeavour, by providing proper information and necessary elaborations on the following:

1. Requirements on selection of local raw materials, used for the production and on the quality of the calcium-aluminate cement product(s), specifically:

   a) determination of quality of raw materials required;

   b) participation in the selection of the optimal local sources for covering the requirements, relying on laboratory testing results available;

   c) discuss questions related to the demands on aluminate cement product quality posed by main fields of application and market conditions,

2. Elaborations on selection of the process technology to be adopted: specifically:

   a) identification of optimal process technology under the prevaling conditions of availability of raw materials, power and market outlets for the product(s);

b) elaboration of material balance and material and energy consumption data of aluminate-cement production;

c) preparation of conceptual drawings of selected process technology.

3. Recommendations on quality assurance procedures and systems, list o quality control, measuring and testing ~~experiment~~ equipment and quality assurance personnel to be employed.

4. Main features of plant design and equipment, specifically:

a) requirements towards plant/operation site;

b) information regarding the infrastructure and utilities required for an alumina-cement plant;

c) list of main technological and supporting equipment;

d) information on engineering and construction works and their cost;

e) estimation of investment cost on the basis of equipment, engineering and construction costs.

All the informations and elaborations will be prepared in English, first in a draft form and then (after its acceptance by the counterpart) as a final report, in a form and structure which would be agreed directly with the counterpart to enable him to incorporate into their feasibility -study-report. Specific consideration will be given to fit into the requirements and pre-conditions valid in the international practice of making investment decisions by companies and institutions.

The expected duration of the work is four months, starting from the date of award of the contract.

The team of specialized experts and consultants, mobilized by KERAprogress Intersilicate Engineering Office to undertake the work is the following:

1. Endre T. Balázs, aluminium metallurgist, ex-head and senior interregiónal adviser of the Metallurgical Industries Branch of UNIDO - team leader

2. Ferenc Puskás, chemical engineer, specialist in ceramics and refractory materials

3. László Gergely, industrial economist, specialist in project evaluation

4. Attila Rácz, process engineer, specialist in production of alumina-cement

5. László Szabolcs, plant designer, specialist in alumina plant equipment

6. Walter Harrach, specialist in industrial plant management and material testing of products of fused alumina products.

7. Svetlana Kos material testing specialist

The personal history statements of the team memebers prepared on UNIDO forms are attached.

The implementation of the project, as described in the above, will be undertaken by KERAprogress Intersilicate Engineering Office according to the UNIDO scheme of Reimbursable Loans; for a total contractual fee of USD 48.000.

Payment conditions:

- 50 % or USD 24.000 upon the conclusion of the contract;
- 30 % or USD 14.400 upon the sumbission of draft final report;
- 20 % or USD 9.600 upon the acceptance of the final report by UNIDO.

We are looking forward to your early positive decision to enable us to start implementation as soon as possible.

Yours sincerely,

F. Puskás
Managing Director

25. Jan 1992

Minutes

of meeting and discussions held on [illegible] May 1992 in Puerto Ordaz, Venezuela between members of Unido consultant - team and representatives of Corporation Grupo Marquez Barry on implementation of the Unido project VC/VEN/91/189 "Pre-investment advising services for processing local alumina into refractory grade alumina silicates".

Participants:

Mr. Pedro Marquez Barry
President of Marquez Barry Group

Mr. Benjamin Sanchez-Re[illegible], Director of Refractarios Venezolanos, S.A.

Mr. Gerald Williams, Manager of CE-Minerales de Venezuela, S.A.

Mr. E.T. Balazs
Unido Consultant, Team Leader.

Mr. A. Radz, Unido consultant.

1. The content of report of Unido's team of consultants on VN/VEN/91/189 was discussed and agreed in details - see table of contents attached. No transfer of know-how is envisaged in this initial stage of cooperation.
   The alternative of periodical production of Calcium - Aluminate Cement in the furnace No. 2 was confirmed.

2. The production facilities and operation of Refractarios Venezolanos, S.A. and CE-Minerales de Venezuela were visited and observed.

3. Subjects of possible further cooperation were discussed.

4. Written materials were submitted to the Venezuelan counterpart as follows:

   - Mullite production of low temperature using a new energy - saving technology.
   - Sintered aluminium - oxide products manufacturing at low temperature.
   - Offer for an aluminium oxide ceramic products' manufacturing small plant, using the injection - moulded technology.

Puerto Ordaz, 15 May 1992.

Contents

of consultants' team Report on UNIDO project UC/VEN/91/189.

1. Calcium- aluminate cements - chemistry, grades , fields of application. Industrial and project background in Venezuela.

2. Quality requirements and selection of main raw materials (lime, aluminas, graphite electrodes).

3. Elaboration on process technology to be selected, material balance, material and energy consumption, conceptual flow-sheet.

4. Elaboration on plant design and equipment, list of main technological and supporting equipment.

5. Product quality assurance and control (properties to be controled, methods and equipment).

6. Investment cost estimate for individual plant unit and for alternative utilization of furnace unit of larger capacity.

7. Conclusions and recommendations.

Annex: Results of laboratory testing of Venezuelan raw materials.

15/05/92.

# SECAR 80

REFRACTORY APPLICATIONS

## General characteristics

Secar 80 is a hydraulic cement, with an alumina content of approximately 80%.

The principal components of Secar 80 are calcium aluminates which make it an ideal binder for refractory applications.

The specific properties of Secar 80 give high performance concretes the following properties:

- high refractoriness.
- excellent mechanical performance.

The very high purity level of Secar 80 makes it particularly suitable for certain refractory applications eg. low levels of silica and iron oxides are vital where hydrogen or carbon monoxide are present.

Secar 80 may be combined with numerous high alumina or aluminosilicate aggregates to make a wide range of refractory concretes.

Its rheological properties allow good workability even when very small quantities of mixing water are used.

Secar 80 is normally supplied in sacks which incorporate a protective film. However, the cement must be stored in dry conditions, preferably off the ground.

When correctly stored, the shelf life of Secar 80 is at least 6 months. In most cases, its properties are retained for over a year

## Typical properties

1

### Chemical analysis

- Main constituents (%)

| | $Al_2O_3$ | CaO |
|---|---|---|
| Typical average values | 79.5-81.5% | 17.5-19.5% |
| Value range | >79% | <20% |

- Minor constituents (%)

| $TiO_2$ | $SiO_2$ | $Fe_2O_3$ | MgO | $K_2O+Na_2O$ | $SO_3$ |
|---|---|---|---|---|---|
| <0.1% | <0.4% | <0.25% | <0.2% | <0.7% | <0.2% |

2

### Mineralogical composition

C = CaO A = $Al_2O_3$

- Principal mineralogical phases
  CA Monocalcium aluminate
  $CA_2$ Calcium bialuminate
  A Aluminate
- Secondary phase
  $C_{12}A_7$

3

### Physical properties

- Pyrometric cone equivalent (on neat cement paste): approx 1750°C
- Bulk density: approx 0.7 g/cm³
- Specific gravity: approx 3.2
- Fineness: specific surface area (Blaine): 10000 cm²/g (indicative value).
- Residue at 90 microns: <5% maximum value limit

It is not possible to give value ranges for fineness because of the wide dispersion of results obtained at high Blaine value.

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4

## Hydraulic properties

On modified AFNOR (P15401) standard mortars:

- Mortar 1/2.7 cement aggregate ratio
- Water/cement ratio = 0.36
- Siliceous AFNOR sand P15403 = 1350g
- Secar 80 = 500g
- Water = 180g

■ Setting time measured at 20°C by VICAT needle (acc. AFNOR P15431).

| | Initial set | Final set |
|---|---|---|
| Typical average values | 0h45 - 1h40 | 1h30 - 2h20 |
| Value range | >40min. | <2h40 |

■ Workability at 20°C

The rheological properties of Secar 80 are of primary importance when considering its use in classic refractory mortars and concretes.

From the numerous methods used to evaluate the suitability for use in concrete (slump test, flow values, etc.) the flow test (ASTM C230 and C860 standards) has been chosen to evaluate the workability of Secar 80.

In order to assess the possible effect to refractory aggregates on the hydraulic properties of Secar 80, flow tests are carried out using the standard mortar defined in AFNOR P15401 (as used for measuring setting time).

| | % of spread after 25 shocks |
|---|---|
| Mortar after 30 minutes of rest in a truncated cone mould: (1) | 30% |

(1) diameter of cone: 100mm.

## Mechanical strength at 20°C

80% relative humidity.

| Compressive strength (Mpa) | | |
|---|---|---|
| Age | 6hours | 24hours |
| Typical average values | 5 - 15 | 27 - 37 |
| Value range | - | >25 |

Note: The value ranges shown in the tables are determined according to normal sampling procedures given in ISO 3951 with an acceptable quality level, defined by this standard, fixed at 2.5%.



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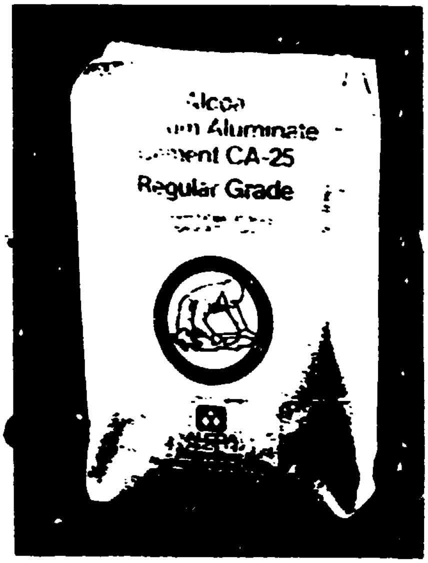
# CA-25 Calcium Aluminate Cement

**CHEMICALS PRODUCT DATA**

Regular Grade

March 1990




## Product Information

***CA-25 Calcium Aluminate Cements are high-purity, high-alumina refractory bonding agents developed by Alcoa for use in refractories designed for service above 3000 F. They can be used for refractories employing both tabular alumina or alumina-silica aggregate compositions. Alcoa® CA-25 Cements have excellent refractoriness and bond strength, even in the intermediate (1500 F to 2000 F) temperature range. Tabular alumina and alumina-silica refractories bonded with CA-25 cements have a high degree of dimensional stability, develop high fired strengths, and show an excellent resistance to erosion/abrasion and good resistance to wetting and penetration by molten metals. CA-25 Regular Grade Cement is formulated for multipurpose versatility with various aggregates and emplacement techniques.***

## Product Description

Alcoa Calcium Aluminate Cement CA-25 Regular Grade is a high-purity, 80 percent alumina, hydraulically setting refractory cement. It is unique in its design for having high strength throughout the intermediate and high temperature ranges. It has a useful service limit above 3200 F and above 3400 F when used with tabular alumina. CA-25 Regular Grade is used as a binder in castable refractories with a variety of aggregates and emplacement techniques to serve multipurpose requirements. CA-25 conforms to the empirical molar formula $CaO \cdot 2.5Al_2O_3$. The predominant hydraulic bonding phase is monocalcium aluminate ($CaO \cdot Al_2O_3$). Minor secondary phases are $12CaO \cdot 7Al_2O_3$ and $CaO \cdot 2Al_2O_3$. Fluxing impurities are restricted to very low levels by using pure alumina and lime. Iron is typically only 0.05 percent, which ensures excellent resistance to CO.

## Product Benefits

- High strength through intermediate and high heat ranges – above 3200 F.
- Low water requirement for greater density, lower porosity, and less shrinkage of the refractory monolith.
- Consistent Vicat working time (average 60 minutes).
- Multipurpose versatility with a variety of aggregates and emplacement techniques.

**Since its introduction in 1955, CA-25 cement has been the mainstay for refractory users of high-alumina cement.**

## Applications

CA-25 Regular Grade Cement is ideal for maintenance and multipurpose uses that may require a variety of emplacement techniques. Applications include refractories in the metal-producing, electric utility, petrochemical, and cement industries.

## Typical Properties of Alcoa CA-25 Cement

| Chemical Analysis | Avg. % | Std. Dev. |
|---|---|---|
| $Al_2O_3$ by difference | 81 | - |
| $CaO$ | 17 | 0.69 |
| $SiO_2$ | 0.7 | 0.22 |
| $Fe_2O_3$ | 0.05 | 0.01 |
| $Na_2O$ | 1.0 | 0.20 |

| Physical Characteristics | | Std. Dev. |
|---|---|---|
| Minus 325 Mesh, Wet,% | 88 | 1.9 |
| Loose Bulk Density, lb/ft³ | 56 | - |
| P.C.E.[1] | 34 | - |

| Neat Test: | | Std. Dev. |
|---|---|---|
| VT Neat[2] - Min. | 60.2 | 8.95 |
| XOT-H Neat - Hrs. | 11.3 | 2.51 |
| CCS-C Neat (psi) | 4258 | 752 |
| (MPa) | 29.36 | 5.19 |

**Caltab 15 Castable:**

| | | |
|---|---|---|
| Casting water - % | 9.5 | - |
| Working time - min. | 58.9 | 7.1 |

Transverse Strength:

| | | |
|---|---|---|
| Cured: 6h @ 90°F (psi) | 428 | 128 |
| (MPa) | 2.95 | .88 |
| Cured: 24h @ 230°F (psi) | 703 | 60 |
| (MPa) | 4.85 | .41 |
| Fired: 5h @ 1500°F (psi) | 1140 | 170 |
| (MPa) | 7.86 | 1.17 |

[1] Pyrometric Cone Equivalent ASTM C24-84

[2] The VT test was developed by Alcoa and has been introduced as a measurement for the setting characteristic of CA-25 Cement. VT added due to improved test precision of VT method over Caltab 15 WT test method.

ALCOA

## ...and Cured Strength

| Composition of standard tabular alumina castable (15% cement) | Weight |
|---|---|
| Tabular alumina T-64, 4-10 mesh | 22.0 |
| Tabular alumina T-64 8-14 mesh | [illegible] |
| Tabular alumina T-64 14-28 | 18 [illegible] |
| Tabular alumina T-64, minus 48 mesh | 34.5 |
| Calcium aluminate cement CA-25, CA-25C, CA-25GG or CA-14 | 15.0 |

## Preparation of Test Specimens

In order to prepare a working time specimen and four 1 x 1 x 7-inch specimens for the strength determination, a dry batch weight of 1800 grams is required. The weighed, dry ingredients (70-80°F) are placed in a non-porous (metal or ceramic)mixing bowl and thoroughly dry-mixed. Distilled water(70-80 F) is added to the batch until the entire mass can be formed into a ball. The use of too much or too little water will result in a consistency other than normal ball-in-hand consistency (ASTM C 860-83). Usually 8 to 11 percent water is required to attain this critical end-point with Caltab 15 castable using CA-25, CA-25C, CA-25GG or CA-14.

After mixing according to ASTM C 862 83, a portion of the batch is placed in the hard rubber Vicat mold in the manner prescribed in the Vicat setting time test (ASTM C 191-83). After placing the molded specimen on a plastic base plate and subsequently striking off the plastic cover plate is placed on top of the mold to reduce evaporation losses from the specimen during the test.

The remainder of the batch is cast in bar molds using a spatula or trowel according to ASTM C 862-83. After striking off the surface, the bars are placed in a curing chamber controlled to 90 F ±1 F and 90 percent relative humidity ±5 percent and held for 24 hours 0.5 hour. It is necessary to record the time water was first added to the mixture. The volume of water used to obtain the ball-in-hand consistency and the temperature of the water and dry ingredients.

## Working Time Determination

The test used for determining cement setting time (time available for mixing, placement, and working the castable without causing significant defects) is an adaption of the Vicat needle setting time n=method (ASTM C 191). The cement sample is mixed with 30 percent water and molded under controlled conditions for the VT Neat test. After the specimen has been molded, the distance the Vicat needle is supported above a datum (plastic base plate) is determined at approximately five-minute intervals. Both the time elapsed since water was first added to the castable and the needle height at that time are recorded. As long as the needle completely penetrates the casting, it is necessary to make just one plunge for each reading.

Once the needle is supported in the specimen, four readings (one at each of the compass points) are taken and averaged. Readings are continued until the needle is supported more than 30 millimeters above the datum. Occasionally, the needle will strike a large grog particle and thereby produce an unreasonable reading. Such readings are rejected and ... position. The time required for the needle to be supported 30 millimeters above the datum is determined by interpolation and reported as the working time. The percentage casting water and the temperature of the water and dry castable should also be reported along with working time. The percentage casting water and the temperature of the water and dry castable should also be reported along with working time.

## Flexural Strength Determination

After the four 1 x 1 x 7-inch test bars are cured 24 hours ±0.5 hour at 90°F and 90 percent relative humidity, the rupture load is determined on a five-inch span using a mechanical testing machine having a cross-head speed of 0.05 inch per minute. The breadth and depth of the bars are measured by calipers in centimeters to the nearest 0.01 centimeter. Modulus of rupture is then calculated from the general formula:

$$\text{M.R. (psi)} = \frac{3WL^*}{2bd^2}$$

When the span (L) is five inches, the general expression reduces to the following working formula:

$$\text{M.R.} = \frac{122.9W}{bd^2}$$

Four individual modulus of rupture values are calculated and averaged. The average modulus-of-rupture value and the four-bar range of individual values are reported along with percentage casting water and temperature of the casting water and dry castable.

*W = rupture load (pounds)
b = breadth (cm)
d = depth (cm)

## Effect of Some Additives on Properties of CA-25 Cement

| Additive: Description | Additive: Amount - %[2] | Properties in Caltab 15 Castable[1] - % of Control Valve: Casting Water | Working Time | Transverse Strength: Cured 24 hrs. at 90°F | Transverse Strength: Fired 5 hrs at 1500°F |
|---|---|---|---|---|---|
| Control | No additives | 100 (10%) | 100 (5. min.) | 100 (700 psi) | 100 (1400 psi) |
| | **Accelerators** | | | | |
| Plaster of Paris | 2.0 | 104 | 50 | 94 | 84 |
| Plaster of Paris | 4.0 | 106 | 34 | 85 | 71 |
| Lithium chloride | 0.5 | 101 | 25 | - | - |
| Calcium chloride | 0.5 | 113 | 42 | 77 | 26 |
| | **Retarders** | | | | |
| Isopropyl Alcohol | 1.2 | 98 | 129 | 93 | 102 |
| Isopropyl Alcohol | 3.5 | 95 | 171 | 80 | 85 |
| Sodium gluconate | 0.1 | 102 | 143 | 94 | 85 |
| Sodium gluconate | 0.2 | 101 | 251 | 46 | 64 |
| Boric Acid | 0.25 | 103 | 132 | 94 | 90 |
| Boric Acid | 1.0 | 109 | 155 | 85 | 74 |
| Plastiment[3] | 0.25 | 99 | 230 | 86 | 97 |
| Plastiment[3] | 1.0 | 97 | 118 | 79 | 93 |
| | **Workability Improvement** | | | | |
| Methocel (4000 cp.) | 0.063 | 100 | 105 | 94 | 94 |
| Methocel (4000 cp.) | 0.125 | 100 | 10[illegible] | 97 | 87 |
| | **Air Entrainment** | | | | |
| Santomerse No. 85[4] | 0.02 | 80 | 7[illegible] | 92 | 109 |
| Santomerse No. 85[4] | 0.04 | 78 | 87 | 85 | 104 |

Notes: 1 - 15% (wgt.) CA-25, 85% T-60, minus 1/4 inch
2 - Cement wgt. basis
3 - Sika Chem. Corp., Passaic, NJ
4 - Now marketed as Calsoft E-90 by Pilot Chemical Co., Lockland, OH

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