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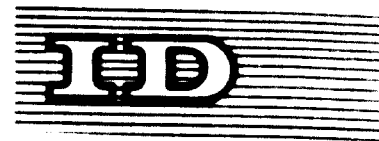
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Workshop on Case Studies of Aluminium Smelter
Construction in Developing Countries
Vienna, Austria, 27 - 29 June 1977

PRELIMINARY REPORT *

BACKGROUND AND ORGANIZATION OF THE MEETING

1. The Second General Conference of the United Nations Industrial Development Organization (UNIDO), held at Lima, Peru, in March 1975, stressed the important role of industrial development and outlines various actions to be undertaken at the national, regional and global levels to enhance a more effective contribution of industry in the introduction of a new international economic order. The Lima Declaration and Plan of Action has established a target whereby the share of the developing countries in world industrial production is to reach a minimum of 25 per cent by the year 2000. To achieve this objective, efforts will have to be made by all concerned, that is the developed and developing countries, the UN system and UNIDO in particular. The Lima Declaration and Plan of Action calls on the developing countries to establish production facilities covering all branches of industry aimed at meeting the basic needs of their peoples, whilst UNIDO is to prepare a concrete co-operative programme of action to promote the creation, the transfer and the use of appropriate industrial technology for developing countries primarily related to specific branches of industry as well as their social conditions.

2. In the effort of developing national capabilities and capacities, co-operation between the industrialized and the developing countries and, especially, among the developing countries themselves is of fundamental importance since it would help bring about an exchange of information and the sharing of relevant experience and know-how at all levels.

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The present text was adopted by the participants in the meeting on 29 June 1977.

3. In line with the above considerations, keeping in mind that developing countries should devote all attention to the development of basic industries, UNIDO convened a Workshop on Case Studies of Aluminium Smelter Construction in Developing Countries, held in Vienna, Austria, from 27 to 29 June 1977.

4. The Workshop was opened by Mr. G.P. Veliky, Director of the Industrial Operations Division of UNIDO.

OBJECTIVES OF THE WORKSHOP

5. The Workshop had the following three main objectives:

(a) to assess up-to-date experience in activities related to the planning, construction and operation of aluminium smelters in developing countries;

(b) to provide a forum for the first-hand exchange of the above experience;

(c) to help to identify fields of priority for UNIDO's technical assistance in the primary aluminium smelter industry field.

MODUS OPERANDI

6. Eleven background papers on case studies of aluminium smelter construction including one paper by the UNIDO Secretariat, had been prepared and were distributed to the participants well in advance of the meeting. Another two papers were distributed on the first meeting day. Participants who had presented background papers elaborated on their main statements and ideas; each presentation was followed by a discussion.

7. The following background papers were presented:

- | | |
|-------------|---|
| ID/WG.250/1 | Indonesian Asahan Aluminium Smelter Project
by B. Siahaan, Vice Chairman of the Asahan Hydro Power and Aluminium Smelter Development Authority, Indonesia |
| ID/WG.250/2 | Background Paper on the Volta Aluminium Company (VALCO)
by A.F. Garcia, Vice President, Aluminum Division, Kaiser Aluminum and Chemical Corporation, Oakland, California |
| ID/WG.250/3 | Planning of Aluminium Smelter
by Y. Ismail, Chairman of the Aluminium Company of Egypt |
| ID/WG.250/4 | Background Paper on the Iranian Aluminium Company (IRALCO)
by F. Shahvarani, Project Director, Iranian Aluminium Company (iralco), Expansion Project, Iran |
| ID/WG.250/5 | Aluminium Smelter Construction in Developing Countries
by the Secretariat of UNIDO |
| ID/WG.250/6 | Background Paper on the Aluminium Bahrain (ALBA) Project
by P.U. Fischer, Director, M + F Engineering AG, Switzerland |
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- ID/WG.250/7 Construction of an Aluminum Smelter and Related Facilities in a Developing Country - The Brokopondo Project, Suriname by H.F. Robey, Jr., Vice-President - Construction, Aluminum Company of America, Pittsburgh, USA
- ID/WG.250/8 Considerations for a Major Aluminum Smelter Project by J.A. Lang and E.P. White, Aluminum Company of America, Pittsburgh, USA
- ID/WG.250/9 Background Paper on the Planning of the Aluminium Smelter for Guyana by P.A. Thompson and E.L. Carberry, Chairman and Executive Secretary, respectively, Bauxite Industry Development Company Limited, Guyana
- ID/WG.250/10 Background Paper on the Construction of the Balco Aluminium Smelter at Korba, India by T.B. Singh, Resident Director, Bharat Aluminium Company.Ltd. India
- ID/WG.250/13 Background Paper on the Puerto Madryn Aluminium Smelter Argentina by N. Angelucci, ALUMETAL S.p.A., Milan, Italy
- ID/WG.250/14 Background Paper on the Dubai Aluminium Smelter in Dubai, United Arab Emirates by H.E. Niehaus, General Manager, DUBAL, UAE
- ID/WG.250/15 Development of the Aluminium Industry in Brazil by R. de Campos Machado, Consultant, Companhia Vale Rio Doce, Rio de Janeiro, Brazil

8. After highlighting some points of the background papers and project case histories, respectively, the sessions were devoted to a detailed discussion of the main issues of the agenda, which followed the headings outlined below:

- (a) General problems and opportunities for aluminium production in developing countries
- (b) Planning of smelters
- (c) Selection of technology and equipment
- (d) Fitting a smelter in the environment
- (e) The human factor.

9. A Final Report designed to reflect all important details of the debate will be prepared by the UNIDO Secretariat before the end of 1977.

ELECTION OF CHAIRMAN AND VICE-CHAIRMEN

8. Mr. Youssef ISMAIL (Egypt), Chairman of the Aluminium Company of Egypt, was elected Chairman of the Workshop. Mr. R. de CAMPOS MACHADO (Brazil) Consultant, Companhia Vale Rio Doce, and Mr. H.F. ROBNEY, Jr. (USA), Vice President - Construction, Aluminum Company of America, were elected Vice-Chairmen of the Workshop. They were unanimously accepted.

ADOPTION OF THE AGENDA

9. The meeting adopted the following Agenda as suggested by the UNIDO Secretariat:

- Election of Officers
- Adoption of the Agenda
- Presentation of Cases by Participants
- Detailed discussion of the main issues -
(a) to (e) of modus operandi
- Discussion on conclusions and recommendations, inter alia concerning UNIDO's technical assistance in the aluminium smelter sector
- Adoption of the draft report of the Workshop

PRESENTATION OF CASES BY PARTICIPANTS

10. The Workshop was attended by 26 participants from 17 developing and developed countries and UNEP.

After presentation by the Chairman of the main points of the case history of the Aluminium Company of Egypt, delegates from the following countries informed on their experiences in the planning or establishment of aluminium smelters: Brazil, Canada, France, Guyana, Hungary, India, Indonesia, Iran, Iraq, Italy, Mexico, Philippines, Switzerland, United Arab Emirates, United States of America.

DETAILED DISCUSSION OF MAIN ISSUES

Highlights of Discussions

Important problems of aluminium smelter construction were discussed and relevant experiences and opinions presented.

Among the main highlights of the discussions the following topics and opinions appeared to deserve special attention. (This presentation is not complete and serves as a quick preliminary information).

(a) General problems and opportunities for aluminium production in developing countries

1. It was the participants' opinion that, in judging the domestic market situation in developing countries, the boosting factor of the metals availability on aluminium consumption had to be taken into account when planning establishment of an aluminium industry in a developing country. This was proved by examples such as Cameroon and Iran, where aluminium consumption per capita rose to levels of 1.5 to 2 and 3 to 4 kgs, respectively, after establishment of the smelter.
2. It was questioned whether a turn-key basis was the best solution in the purchase of know-how and equipment. A dialogue between buyer and supplier was considered essential, possibly on equal levels. This implied that a nucleus of expertise should already be available in the developing country before embarking on aluminium industry ventures. The advantage of using consultants and, as far as possible, competitive bidding, also from countries with different social systems was mentioned.
3. Stress should be laid on the involvement of local personnel, local management and local contractors, at all levels, from the stage of planning and design of the plant through the different stages of construction and commissioning. Provision should be made that this will function not only formally.
4. An important possibility for the training of personnel could be offered through co-operation among the developing countries themselves. Examples of Iraqi personnel trained in Egypt and Algeria in the iron and steel industry sector were cited as having been successful in this respect.

5. Energy saving through recycling of aluminium has gained importance and should not be neglected when the developing countries design new aluminium industries and desire to boost their domestic aluminium consumption. Efficient plants with proper economy of scale should be provided.

6. Since in developing countries in most cases significant additional expenditures concerning infrastructure appeared; when considering priorities, the overall national impact had to be taken into consideration. The additional cost above the battery limit investment should be regarded as a separate contribution to national development in order to avoid conflicts in judgement which may lead to unjustified shelving of the project. In other words, in such cases sacrifice was needed and this should be separate from the comparable cost increments.

(b) Planning of smelters

1. Important aspects for decision making on smelter construction appeared to be the judgement on plant economy, i.e. competitiveness and the judgement on the markets for aluminium. This latter point appeared in many cases to be essentially the judgement of an export market since the domestic markets of many developing countries, even thinking in regional dimensions, were often small compared to minimum economic plant capacities which were generally supposed to be around 100,000 to 150,000 tons/yr.

2. The opinion was expressed that besides raw materials, energy, know-how and finance efforts in better judgement of the market and also efforts to increase domestic demand appeared as important ingredients.

3. Plant location appeared mainly as a question of economics, taking into account location of the market, the source of raw material and energy. From this point, the human factor should not be neglected. Only areas and conditions were acceptable where properly skilled people were ready to live.

4. In the context of energy supply it was noted that proper co-ordination of the construction of smelters and their energy sources deserved special attention and proper scheduling (examples of Argentina and India).

5. In the case of combustible hydrocarbons as source of energy the competitive economy for different uses (to sell, to use as fuel, to make petrochemicals or produce energy and aluminium) needed proper review.

6. Actual experience has proved that efficient construction management can be significantly facilitated through the application of proper organisatory models like having all staff of sub-contractors working on the project on a single payroll of the chief contractor or main supplier (example of ALCOA's Brokopondo project).

7. Considering economy of scale and minimum economic plant size for aluminium smelters, alumina plants and carbon anode plants, it appeared as a reasonable solution to consider the establishment of joint alumina and carbon anode plants for several smelters in neighbouring countries.

Similarly, possibilities of regional co-operation appeared as prima facie reasonable concerning: (a) the training of specialized technical staff and (b) the establishment of research and development capabilities.

8. It was expressed that in the case of new smelters in developing countries, which are mainly designed to utilize local resources as raw material and/or energy and will export a great share of their output, as main problems to the investor government usually appeared: (a) the competitiveness of their product; (b) the judgement of the world market's absorption capacity for primary aluminium; (c) financing.

Generally valid formulas or answers for these could not be given, each project is a specific case, for which specific solutions must be sought. These could be elaborated only through detailed techno-economic feasibility and market studies taking also into consideration the growing world demand in aluminium.

(c) Selection of technology and equipment

1. For successful operation of an aluminium smelter the selection of appropriate technology, i.e. technology suited to the conditions in the country was considered essential. Issues such as the climatic conditions, a reasonable choice of automation and mechanization, proper selection of the product mix in the casthouse, optimal solutions for maintenance facilities and provisions (sources in inventories of spare parts, repair shop, etc.) had to be carefully considered.

2. Opinion was expressed that caution was advised in the selection of technology and equipment on the basis of the "appropriate" principle. In many countries additional adjustments were needed to improve originally applied more primitive solutions. It was advised to keep in view the selection of the best and most efficient.

3. New processes for aluminium metal production including the ALCOA chloride electrolysis process and the new versions of the Hall-Heroult electrolysis like constant dimension anodes were briefly reviewed and there was consensus that these technologies were not yet in a stage to be considered as viable alternatives for plant construction in developing countries.

Smelters to be constructed all over the world would not be endangered within the next decade through eventual competition by these processes.

4. There was consensus that in the case of new plants, smelters with prebake anodes and current intensities around 150,000 amp., possibly with central feeding appeared as an optimal solution.

5. By some participants preference for short potlines was expressed, possibly pot types proven on a commercial scale.

In the case of plant expansion the selection of the type of the additional cells should be a question of economics. In most cases identical cells should be preferred.

6. In the use of automation, the general opinion was that extensive automation was advised. The objective of this was primarily not to save labour but to optimize the potroom operation and facilitate environmental control. In the case of developing countries maintenance requirements of such systems should be carefully considered. In countries where the necessary skill for repair and maintenance of electronics was available no difficulties were expected.

7. Experience of investors proved that it was easily possible to find sources for know-how whereby in actual cases no significant differences in technical performances appeared. Actual prices for offers concerning technical services showed, however, significant discrepancies.
8. Casthouse design appeared as a complex problem. Too much flexibility results in unnecessarily costly design. Therefore, it was considered essential to carry out a well-based market study in time.
9. Just because of the uncertainties and risks in product mix determination, casthouse layout should be flexible and should provide for expansion.
10. Advantages and disadvantages of horizontal and vertical casting were compared. In the case of variable production programmes vertical DC casting is advisable.
11. Concerning casthouse operations, proper sequence of alloys should be taken into consideration because of contamination factors.
The production of master alloys was generally not advised for smelters, some alloys may be made in pots depending on actual economy (e.g. iron or silicon).
12. Opinions differed concerning optimum solutions for metal purification. Chlorination appeared as replaceable by in-line fluxing or the application of large holding furnace capacities. In-line fluxing was claimed to be within the trend of modern development.

(d) Fitting a smelter in the environment

1. From the point of environmental pollution in case of aluminium smelters, besides fluorides and the hydrocarbons originating from the anode plant or the Söderberg anodes themselves, SO_2 is causing increased concern. Today 2 - 3 % sulphur in petroleum coke are quite normal and a further increase up to 5 % or more appears as possible.

2. Problems of the dry scrubber system appeared to be: (a) it does not eliminate SO_2 ; (b) Impurities, entering the metal are recycled by the alumina. This latter problem can be easily tackled by selective feeding of cells to produce high purity or electrical conductor grade metal with fresh alumina from store.

3. Possibilities for compliance with increasingly strict control standards should be foreseen in order to avoid unnecessary additional expenditures. Furthermore, environmental management and protection measures when incorporated at the inception of new constructions are less costly and often more effective than retrofitting of control equipment. Every attempt should be made to ensure that these measures are incorporated when planning new installations.

4. A committee, working at the request of UNEP has elaborated on a draft recommendation on environmental factors that should be considered for siting and operation of new primary aluminium reduction plants, new plants for refining bauxite to alumina and environmental recommendations for bauxite mining. This should be a useful instrument for selecting appropriate environmental management and control systems for the aluminium industry. UNEP will evaluate and expedite the availability of this important document.

5. As a simplified formula for main alternatives of smelter pollution control these were suggested (in the order of increasingly strict pollution control requirements)

Case

- (a) desert, or lonely peninsula
- (b) remote area
- (c) agricultural, well populated area
- (d) pristine, sensitive area (e.g. fish breeding, etc.)
- (e) special cases where super-strict standards are applied

Technique most frequently advised

- Cases a, b: hooding plus cyclone plus tall stack;
Cases c, d: hooding plus dry scrubber;
Cases d, e: dry scrubber plus wet scrubber (the latter for SO₂), sometimes additionally wet scrubber on the roof.

6. UNEP is developing capabilities to provide advice and assistance on environmental management with regard to the aluminium industry. Every country with such needs is invited to contact UNEP's Industry Programme.

(e) The human factor

1. Discussion on principles revealed that the importance of the human element and the benefit of working staff should have first priority. An underestimation of local staff in developing countries should be avoided.
2. Proper planning and implementation of training of the staff should have top priority. Good examples of success stories have proven this. In training programmes the system of split simplified jobs proved successful. Training activities were advised to be dealt with separately from construction and operation. The concepts of different potential suppliers for aluminium smelter plant has shown in actual cases significant differences as to the volume of man-months involved. Elaboration of standard programmes was mentioned as desirable. Such training programmes should also define basic educational background, the manner of training required and suitable practical experience in existing smelters.
3. It was advised to prepare staff in the frame of a long term planning, including the assignment of young, highly qualified people to jobs which enable them to contribute after a few years to the perfection and development of the process.
4. Cases were referred to when training services of a complex nature were provided, including participation of nationals in detailed design, in the preparation concerning research and development activities and by granting scholarships at university levels.

5. In addition to in-plant training of staff in existing smelters in developed countries, training in developing countries was stressed as having several advantages. This should not be confined only to engineers but also cover foremen and skilled craftsmen of sensitive jobs like in maintenance. Stage-wise training first in developing countries and then in a developed country proved successful. In organizing such training proper regard should be taken of the plant supplier's responsibilities and requirements.
6. The number and share of non-indigenous personnel varies widely by projects, depending on the local background and the character of the foreign partner's participation.
7. It was recognized that a good way to diminish this figure was through proper counterpart training. Proper selection of the expatriate experts was stressed. Their proper motivation and capability to act as trainers and teachers should be ascertained. Early and proper preparation of the expatriates and their family members including indoctrination concerning local social, political and cultural aspects was considered important. A prerequisite for their efficiency is also the proper selection of the counterparts assigned. Integration of expatriates into the local community usually increases their motivation.
8. Criteria for the recruitment in developing countries require specific standards whereby besides educational background, physical stature and experience in hard work may have priorities. Potroom workers' jobs have different requirements than maintenance workers' jobs.
9. It was considered an accepted fact that smelter operation in developing countries needs more staff than in developed areas. Differences of 25 vs. 15 man-hours per ton of aluminium were quoted by one of the big internationals. This differences can be assigned to factors like additional infra-structural services, local production of spare parts, etc. In some cases high turn-overs and absenteeism may contribute. It proved as a wise policy to start with excess personnel up to a share of 50 to 70 % of scheduled staff.

Discussion on conclusions and recommendations, inter alia concerning UNIDO's technical assistance in the aluminium smelter sector

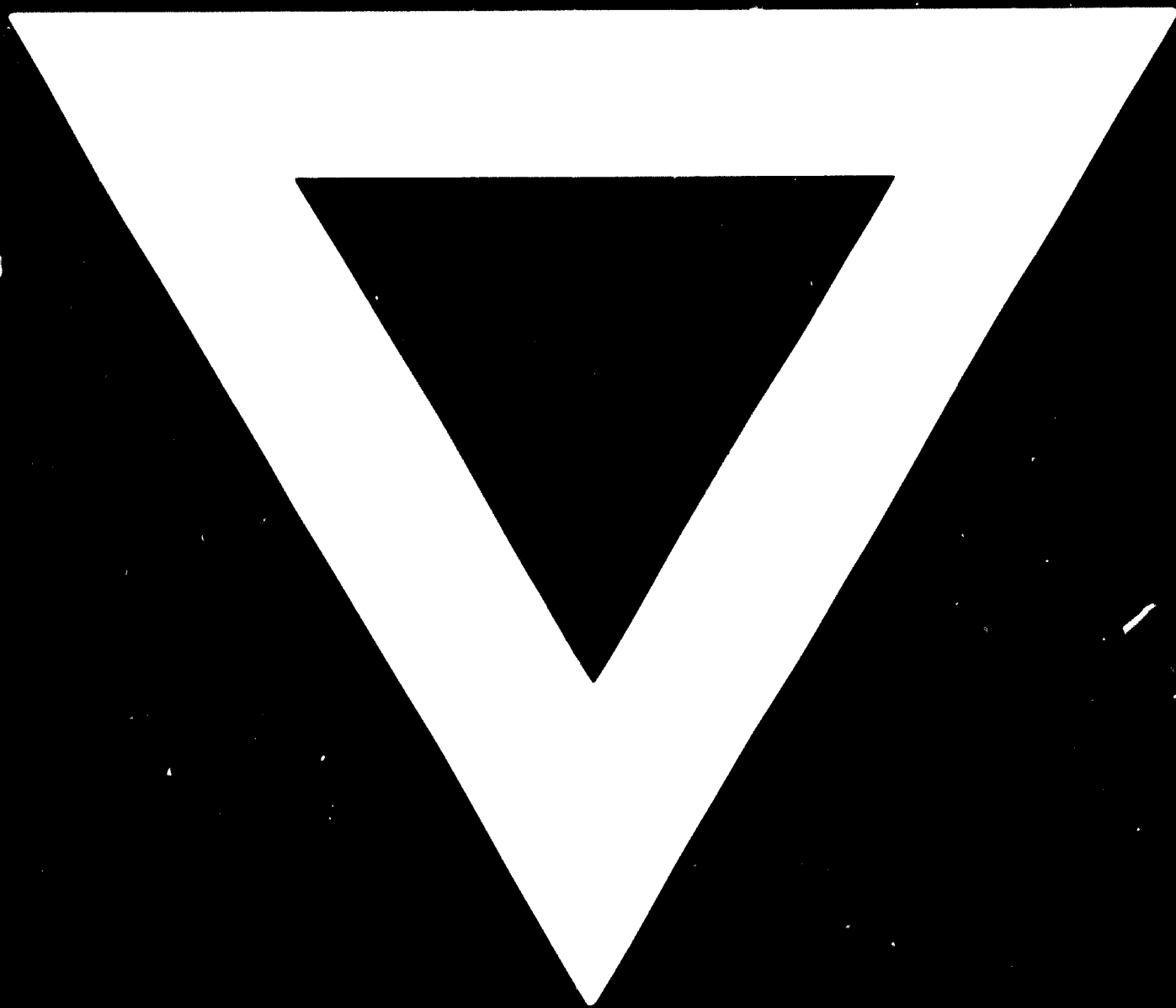
1. Aluminium consumption in developing countries and the dynamics of its development deserved special attention. It was advised that UNIDO, possibly through a system of questionnaires, elaborated on this matter. A relevant study which also reflected actual developments in more advanced developing countries might be a useful tool for more realistic assessment of the domestic demand.
2. The UN system, UNIDO in particular, should be assisting, as far as possible, in providing necessary project monitoring expertise.
3. It was recommended that UNIDO undertakes the preparation of a working document facilitating the training of aluminium smelter staff in developing countries. This document was recommended to compile a set of education and experience qualifications and also to elaborate typical training programmes, possibly in several alternatives. It should also include a standard set of manning and training schedules, possibly on the basis of standard capacity of about 100,000 t/yr aluminium smelter. Compilation of experience in training in operating smelters in developing countries could supplement this document.

Participants from developing and developed countries offered to provide contributions for the preparation of such a document.

A chapter on environmental control is advised to be provided where-
by a contribution from the side of UNEP was offered.
4. It was suggested that UNIDO takes initiative and co-ordinates training in existing smelters in developed and developing countries.
5. It was recommended that UNIDO intensifies its expert assistance to countries planning to build aluminium smelters and which lack the properly qualified personnel to make the proper decisions.



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