

TECHNICAL COOPERATION
ON
THE TECHNOLOGICAL DEVELOPMENT OF COPPER SMELTING
AND
REFINING IN THE REPUBLIC OF CHILE

March 1977

Open-International Cooperation Agency

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1. Introduction

This report is based on "The Agreement of Technology and Duty concerning the Implementation Survey for the Technical Development of Copper Smelting and Refining in the Republic of Chile" which has been agreed between the Japan Mining Industry Association and the Japan International Cooperation Agency. (hereinafter referred to as "JICA").

As the technical cooperation for technological development of copper smelting and refining in Chile was officially required to the Government of Japan by the government of the Republic of Chile in January 1975, the Japanese Preliminary Survey Team and long-term experts were sent to Chile by JICA and investigate the existing conditions and problems in Chilean smelters and refineries.

In November 1967, the Implementation Survey team was sent to Chile by JICA in order to work out the details of the technical cooperation for technological development of copper smelting and refining in Chile, and to take the step of signing the Record of Discussions concerning this cooperation, and the Record of Discussions has been agreed.

In order to sign the above-mentioned agreement, Keiji Itakura (Mitsubishi Metal Co.) and Kazuya Nakayama (Nippon Mining Co.) took part in this survey team from the Japan Mining Industry Association, and Yojiro Ikeda (the Japan Mining Industry Association) went together with them.

2. Basic attitude for the cooperation of non-ferrous smelting and refining technology

As this is the first time to provide non-ferrous smelting and refining technology including copper smelting and refining by an agreement between both governments, smelting and refining industries had to decide how to deal with it.

Japan's technical cooperation on a Government to Government basis is limited to the extent of the publicly generalized technologies,

which therefore rule out the technologies exclusively owned by private sector and individuals, in such forms as patents, technological know-how, and so on. But, in some cases, it is very difficult to draw an exact line between the publicly generalized technologies and the technologies exclusively owned by private sector and individuals in such forms as patents, technological know-how and so on.

On other hand, non-ferrous smelting and refining industries in Japan have introduced a lot of foreign technologies with compensation, and have developed their technologies to the top level of the world with combining organically their own technologies with introduced foreign technologies. On the contrary, non-ferrous smelting and refining industries have exported their technologies to forien countries for ten years back.

Consequentially, technical assistance for copper smelting and refining has been decided to be carried out mainly at the research and development sector, that is to say, the Centro de Investigación Minera y Metalúrgica (CIMM). For the smelting and refining plants, temporary and practical items which do not involve the patents and know-how owned by Japanese industries, were selected as cooperative items with adding some know-how of industries, and an assistance program was written out.

3. Chilean Smelters and Refineries.

There are six copper smelters and refineries in Chile, and the objects of the technical cooperation are five smelters and refineries belonged to CODELCO-Chile and ENAMI except Mantos Blancos.

(1) Smelters and Refineries belonged to Codelco-Chile

(a) Chuquicamara

Biggest mine, and smelter and refinery in the world.

Equipment: reverb - converter, tank house and
acid leaching - electrolyte.

Anode production : 30,000 t/month

Cathode production : 25,000 t/month

Cathode production (from leaching) 1,000 t/mong

(b) Potrerillos

The oldest smelter and refinery in Chile.

Equipment : reverb - converter and tank house.

Anode production : 8,200 t/month

Cathode production: 6,300 t/month

(c) Caltones

Biggest mine, and smelter and refinery

Equipment : roaster - reverb - converter -
pyrometallurgical refining.

Blister production 21,000 t/month

(pyrometallurgical refining copper 10,000 t/month)

Caltones has acid plant for converter gas

(2) Smelters and refinery belonged to ENAMI

(a) Paipote

Custom smelter

Equipment : reverb - converter

Blister production : 4,000 ~ 5,000 t/month

Paipote has acid plant for converter gas.

(b) Las Ventanas

Custom smelter, the up-to-date smelter and refinery
in Chile.

Equipment : reverb - converter, tank house

Cathode production from ore 4,000 t/month

Cathode production from blister 5,000 t/month

Total 9,000 t/month

4. Chilean demands and their contents

The long-term survey members, who have stayed for three months until June, 1976 in Chile, carried back the letter written to Mr. Kuroko, Director of Mining and Industrial Development Cooperation Dept. JICA by the president of CODELCO-Chile, in which the Chilean demands for the assistance of copper smelting and refining technology. This letter is attached in Appendix (1).

The Chilean demands consist mainly of the following three items.

(1) Technical assistance to increase the level of productivity and efficiency in the existing installations.

(2) Technical assistance for future expansion programs of the existing smelters and refineries.

(3) Technical assistance for Centro de Investigacion Minera y Metallurgica.

Additionally, it was desired to dispatch Japanese experts to Chile, for Japanese experts to educate and train the Chilean experts both in Chile and in Japan.

It is also desired to supply the instruments for research department in CIMM.

The contents of the Chilean demands are as follows.

(1) Technical assistance to increase the level of productivity and efficiency in the existing installations.

(a) Item 1 Air pollution

The regulation for air pollution is free in Chile, being different from Japan, but the necessity of regulating air pollution is becoming to recognize in both smelters and refineries of Paipote and Ventanace where are near to farms and habitations.

Generally speaking, the bad working condition caused by dust and gas inside smelters, and prevention and improvement for lossing valuable materials by splashing, are firstly more demanded than to prevent the air pollution.

Item 1.1 Improvement of working condition

All Chilean copper smelters have much dust and gas, and especially old smelters which are installed in dry area such as Chuquicamata, Potrerillos and Caletones, have more.

Item 1.2 Operation of Electrostatic precipitator

At present, only two copper smelters in Chile have electrostatic precipitators which is used only for converter gas. In other smelters except two, converter gas is discharged into the atmosphere through stack after passing through the chamber as well as reverbratory gas.

Of the two places which are installed electrostatic precipitators, the electrostatic precipitator in Caletones does not run well with low recovery of dust and many troubles.

As each smelter is trending to regulate the air pollution and has the plan to produce sulfuric acid from converter gas, he has interest to install electrostatic precipitators and to master the technology for operating them.

Item 1.3 Deleterious effect on ecology

As described before, the necessity of regulating air pollution is becoming to recognized in Paipote and Ventanace.

Accordingly, the data for the delelorious effect on ecology are desired.

(b) Item 2 Use of Oxygen

It is most interesting in Chile to increase copper production easy and quickly with the present equipments. For the reason, it is strongly desired that to increase the ore-smelting capacity by using oxygen in a reverb is anyway put into operation.

Item 2.1 Instrument for oxygen-fuel burner

Oxygen-fuel burners have been used in the reverbratory of Caletones, but their instruments have not run well, that is to say, in the state of blind operation.

The more increase of smelting amount and decrease of oxygen cost are planned to carry out by making system instrumental including automatic control of oxygen-fuel-burners.

Item 2.2 Corrosion-trouble caused by use of oxygen-fuel burner

Use of oxygen-fuel-burner rises SO_3 content in gas, resulting in the dew point of gas becoming higher. Accordingly, it is anxious to corrode the boiler and flue.

Item 2.3 Use of oxy-fuel burners

Almost smelters except Caletones have no experiences in using oxy-fuel burners. Therefore it is necessary for them to learn the using way of to oxy-fuel burners themselves, at first. Caletones has also desired to learn more knowledge and technique for oxy-fuel burners.

(c) Item 3 Preheated air to reverbs

It is possible to increase the smelting capacity of a reverb and to decrease the fuel-cost by using preheated air instead of cold air even in an ordinary reverb.

(d) Item 4 Improvements to the filter cake quality

Chilean copper concentrates have much water because molybdenum flotation is operated and smelters combined with mines are located on high land in which atmospheric pressure is low.

Therefore, it is difficult to treat the copper concentrates, and it is necessary to dry them as a prehandling before charging them into reverbratory.

Operation of these dryers has not been run satisfactorily in some smelters, and they want that improving the filter equipment and their operation results in water content of concentrate decreasing, and if possible, in omitting the dryer equipments.

- (e) Item 5 Process control instrumentation to determine the metallurgical balance

In almost Chilean copper smelters, controlling by scale and instrumentation has not been done at all.

Each smelter does not know exactly the smelting recovery of over-all flow-sheet, and does not nearly calculate metal balance and heat balance, of each flow-sheet.

Therefore, Chilean smelters have satisfactorily recognized the necessity for improving the control by measures and instrumentations, and for grasping the metallurgical balance such as metal balance and heat balance, which the preliminary survey team and the long-term survey team have strongly indicated.

- (f) Item 6 Reverts formation control and prevention

Each smelter has more or less troubles caused by treating reverts. Cold dope is usually treated in a converter, but most of Chilean smelters have treated cold dope not only in a converters but also in reverbs because of too much cold dope. This results in decreasing production because of decreasing treatment amount of new charge ore, and if cold dope of converters are recycled to reverbs, it will have a bad influence of growing the magnetite-accumulation on the bottom of a reverb, upon a reverb.

- (g) Item 7 Prevention of Build-up formations in reverbs

Item 7.1 Up-take accretion in reverb flues

When concentrate is charged into a reverberatory, a part of concentrate is carried away to the flue with the gas-flow, and adheres to the flue.

Gas-draft decreases according to the accumulation of dust accretion and it results in decreasing smelting capacity of a reverb.

Item 7.2 Bottom build-up in a reverberatory

In case of continuing to charge a amount of what contains a lot of magnetite, like reverts of converters into the

reverberatory, or repeating that magnetite-layer which suspends between matte layer and slag layer, in the reverberatory comes in contact with the bottom of the furnace, magnetite accumulation on the bottom grows large and results in making the inside volume of the furnace narrow, and in decreasing the holding capacity of matte and slag. This is called build-up.

Almost Reverberatories in Chilean smelters are in trouble with build-up, which is caused by lack of controlling charge and operation.

(h) Item 8 Refractory masonry

Caletones especially wants the Japanese technical guide for arrangement and custody of refractories in a warehouse and bricking ways.

(i) Item 9 Melting of cement copper in converters

Copper content of cement copper ranges between 50% and 80%, but cement copper is of fine particle.

Therefore, it is charged not in converters without pre-handling, but in a reverberatory.

But, if it is possible to prevent cement copper from scattering in converters, Chilean smelters, especially paipote, wish to melt in converters.

(j) Item 10 Automation and/or mechanization

Smelting and refining equipments in Chilean smelters and refineries, being different from ones in Japan, have not been made automatic and/or mechanical.

Usually, automation and/or mechanization has two aims: One is, that is to say, to use an automatic and/or mechanical equipment instead of labors. Another is to plan to obtain good quality and operation result.

In case of Chile, the aim will be the latter.

Item 10.1 Anode casting

Expect the smelter in which an automatic weighing machine made by Outokumpu Company, has been installed, the weight of anode varies scatteringly. This is one of causes by which electrolytic process has not obtain good result. Smelters wish to install automatic weighing machines.

Item 10.2 Automatic starting sheet machine

Almost Japanese tank houses have automatic starting-sheet machines. From this information, Chilean smelters hope to introduce the automatic starting-sheet machines as same as Japanese smelters.

Item 10.3 Washing and handling of Anode and Cathode

This equipment has made automatic and mechanical in almost Japanese tank houses, and Chilean smelters also wish to introduce the equipment.

Item 10.4 Stripping and treatment of mother sheets.

Stripping starting-sheet from mother sheet is all done by man-power in Chile. Mother sheets made from titanium have been used in some smelters of Chile.

In this case, mother sheet made from titanium is seems to be easier in stripping starting-sheet from mother sheet than one made from electric copper.

Chilean refineries wish to make the stripping of starting sheet automatic and mechanical, and to adopt the treatment of mother sheets, those which have been already realized in Japan.

(k) Item 11 Dust handling and pneumatic conveying systems in Caletones

The pneumatic conveying system for the dust caught by electrostatic precipitator, was installed, but failed.

Caletones wants to use this pneumatic conveying system again, but the equipments which was installed before, have been not nearly remained, and they are considered that the system including is its capacity not suitable of itself.

Therefore, it is necessary to design the pneumatic conveying system again from first stage.

(1) Item 12 Technique of quality control and Japanese Industries Standard (JIS)

In Chile, it is not too much to say there has not been the conception of quality control itself.

Of course, it is seemed that senior engineers graduated from universities, have generally high knowledge and understand conceptionally quality control. However, it has not been put to practical use.

In industrial standard, what is correspond to Japanese Industrial Standard of Japan, has not been established. In order to improve and develop the technique of copper smelting and refining including the improvement of relating industries and their technique, it is very valuable and necessary, to standardize and to obtain the methods of quality control.

(m) Item 13 Use of high current densities

In Chile, there has been the strong consideration that the increase of copper production is wanted to be done without much remodeling the present equipment in refineries. Of refineries, especially ENAMI which is a custom smelter has the strong hope for it.

Item 13.1 Use of high current densities by conventional method (280 ~ 300 A/m²)

If it is difficult to assist the technique of high current

densities by PRC, Chile has desired to be assisted the technique of high current densities by conventional method.

But, as discribed the latter, the technique of high current densities is not that the P.R method is higher in the technique than conventional method, but that both techniques should stand abreast, and it is necessary to decide whether one method of them is adopted after investigating each features.

Item 13.2 High current densities by PR method
(300 ~ 500 A/m²)

Ventanas has introduced the technique of PR method from Bulgaria before, and have a rectifier which obtains PR current.

Therefore, it has a strong desire for use of PR method.

(n) Item 14 Electrolyte purification

Item 14.1 Impurity elimination

In Ventanas, arsenic content in electrolyte is recently high (78/ℓ) and antimony is suturated (0.65 8/ℓ).

Ventanas has wanted the technical guide and assistance for removal impurities in electrolyte, mainly arsenic.

Item 14.2 Removal of suspended particle

The present filter equipments for electrolyte do not run well in every tank houses in Chile. Chilean refineries have desired to adopt continuous filter equipments.

(o) Item 15 Centralized short circuit detection

Usually, short circuit detection has been done for thousands to ten thousands sheet by man, and the major part of labor cost in tank house is covered with this work.

In Japan, centralized short circuit detection has been recently researched and developed, and has been nearing completion.

(p) Item 16 Revise the Potrerillos revamping program

This item essentially contains the range of other item "Assistance for future plan".

In order to investigate urgently potrerillos which has been one of the oldest equipments, and has been most required to improve, this item is contained in this chapter.

(q) Item 17

This item collects the matters which are desired to obtain information and which are not included the forementioned items.

Item 17.1 Concentrate bin design-to prevent stick
Chilean copper concentrates have much water on them, (14 ~ 18% H₂O), accordingly, they adheres inside the bins, and are not discharged smoothly from the bins.

Item 17.2 Sketch of water jacket for matte hole
As Chilean smelters can not obtain the water jackets of good quality, non-water jackets are used in reverberatories. Therefore, the jacket-life is short.

Item 17.3 Scrubber to eliminate dust and fume of
oxygen plant air inlet

As oxygen plant in Caletones is installed in the place which has much dust, dust is absorbed together with air, and adhere on the surface of the heat-exchanger resulting in troubles.

Item 17.4 Crane weight meter

Information of crane weight meter is desired in relation with item 6.

Item 17.5 Drawing or Sketch of ladles and bails to eliminate crane chaser

In order to eliminate crane chaser, smelters want to obtain Drawing or sketch of ladles and bails.

Item 17.6 Distance between pouring spout and mould in anode casting

In order to prevent splashing in anode casting and to even the anode surface, smelters want to obtain information.

Item 17.7 Converter dimension and geometry

In order to prevent splashing in a converter and to make oxygen efficiency high, smelters want to know the information such as the tuyere angle to the converter shell, distance between the tuyere and the surface of matte in a converter, size of mouth and construction of hood.

Item 17.8 Use of reverb slag

Reverb slag is now discarded in Chile. Therefore, smelters want to research the use of reverb slag.

Item 17.9 Lower Cu content in reverb slags

Copper content in reverb slags is high and sometimes becomes to be more than 1%. Smelters want to reduce to half of the present value.

5. Technical investigation for Chilean demands in corresponding with know-how.

Technical investigation is made into the forementioned Chilean demands, corresponding with the presence and technical level of Chilean smelters and refineries, informed by studies of preliminary survey team and long-term survey team, and the technique of smelters and refineries in Japan and the world.

Another investigation is also made into Chilean demands in relation to the patents and know-how of Japanese industries.

(1) Technical assistance for improving production in the present equipments.

(a) Item 1 Air pollution

Item 1.1 Improvement of working condition

The bad working condition is mainly caused by the followings.

o Almost Chilean smelters are located in dry area

The number of gas and dust collectors are too small for the smelter equipments.

o There is no restraint on the working conditions

In this field, Japanese industries have much experience and accumulation which have been improving and developing, and can cooperate with Chilean smelters.

Item 1.2 Operation of electrostatic precipitators

Generally speaking, operation of electrostatic precipitators does not run well without keeping the gas condition in the range of design conditions, and making necessary maintenance. In case of Caletones, the actual result of electrostatic precipitators is about 60% in comparison with the design recovery 98%.

This seems to be caused by a large amount of free-air from the clearance between a converter and its hood, severe variance of gas amount, unsatisfactory maintenance and unsatisfactory discharging of dust from electrostatic precipitators.

In order to make electrostatic precipitators run well, it is necessary not only to maintain the equipment, but also to have a whole countermeasures described as follows.

Countermeasure for improving the electrostatic precipitators of converters in Caletones.

o Converter blowing

It is necessary to keep converter blowing in constant volume in order to hold in constant gas volume. It is required to improve tuyeres panching method, and charging method of cold materials.

o Converter hood

It is necessary to let the clearance between converter and hood as tight as possible.

o Preventing free air in flue

It is desirable to prevent free air with improving discharging method of dust and structure of discharging hole.

o Dust discharge from electrostatic precipitators

It is desirable to avoid the operation in state of adhering dust on the discharge rods and negative plates, and it is necessary to adjust the hammering equipment perfectly. And dust in the hopper should be discharged continuously as possible.

o Maintenance of electrostatic precipitators

It is necessary to watch the voltage and current of an

electrostatic precipitator at all time, and to keep it in normal operation.

In order to run well in operation of electrostatic precipitators, it is required to investigate all gas treating system, and many parts of gas treating system belong to know-how of each industry.

Therefore, this item is not the object of non-commercial assistance.

Item 1.3 Deleterious effect on ecology

Japanese industries are not in a position of leading others for such ecology matter.

If Chilean Government strongly request it to Japanese Government a suitable Japanese Government service should lead and assist for it.

(b) Item 2 Use of Oxygen

Using oxygen in non ferrous smelting has been tried to many kinds of metal smelting and has been realized with success.

The most famous processes are nickel smelting with a flash smelting furnace in INCO Canada, nickel smelting with a rotating converter, and oxygen smelting with a converter in Nippon Mining Co.

The methods of using oxygen can be classified roughly to two directions. One method is to use directly pure or high content oxygen.

Another is to use oxygen enriched air.

Use of oxygen for reverbs is also classified to two directions.

Main burners of using ordinary air which are combined with oxy-fuel burners of using pure or high content oxygen, are more effective than ones of using oxygen enriched air.

In Japan, Onahama Smelter has made use of two oxy-fuel burners in a reverb, and its smelting capacity has been increased 25%.

The oxy-fuel burners have been developed by Shell Research Ltd., and a maker in Japan has obtained the licence and manufactured oxy-fuel burners.

The oxy-fuel burners have been adapted for reverbs.

The technique of this oxy-fuel burners is know-how which Mitsubishi Metal Company Ltd. has held, and has been made technical transfer to Chuquicamata in Chile on commercial base. Therefore, it is naturally impossible to supply this technologies to other Chilean smelters without compensation.

(c) Item 3 Preheated air to reverbs

In Japan, preheated air is used not only to reverbs, but also to many kinds of furnaces, resulting in increasing heat efficiency and capacity.

Use of preheated air to reverbs is realized in Onahama Smelter.

By combining the temperature of preheated air, heat source and many kinds of preheated equipment, there are some technologies including patents and high know-how.

But, through the kindness of Mitsubishi Metal Co. Ltd. use of preheated air to reverbs is offered without compensation.

(d) Item 4 Improvements to the filter cake quality

Smelters which have troubles concerning the filter cake quality are especially three smelters belonged to CODELCO.

The slurry of copper concentrate gained by flotation is thickened in thickeners and is dehydrated by a filter. But, as above-mentioned, Chilean copper concentrates are so fine in size that it is impossible to dehydrate less

than the present water-content in concentrate by ordinary vacuum filters. Accordingly, it is necessary to investigate the use of special dehydrators or the use of dryers for concentrates, in view of cost, and it will be one plan that the filter makers are employed as a consultant.

- (e) Item 5 Process control instrumentain to determine the metallurgiral balance.

To grasp the metallurgical balance such as material balance and heat balance is the base of operation control concerning smelting process, and at all smelters and refineries of Japan, metallurgical balance every each process are ordinary calculated and is made a good use to operation and heat control.

In order to calculate metallurgical balances, it is necessary to grasp the quantity and quality of, not only material and products, but also subproducts.

Further, in order to grasp the quantity and quality of them, it is required to install the necessary instruments, and to make a good use of them.

As it is too expensive to get the necessary instruments at a time, it is desirable to install in order according to the priority ranking, and to get the metallurgical balance according to the important balance.

- (f) Item 6 Reverts formation control and prevention.

Almost amount of reverts produced in copper smelters is to be what matte and slag become solid in the midst of treating, called cold dope. These melting matte and slag are ordinary transferred from a process to the next process with ladles, and if these ladles are not transferred quickly, a part of melting matte and slag will become solid and the cold dope will increase.

Accordingly, in order to prevent the cold dope from increasing, it is indispensable to control the operation

of reverbs and converters, and to shorten the tapping time of reverbs.

(g) Item 7 Build-up formation in reverbs

Item 7.1 Up-take accretion

It may be effective to improve the charging method and charging equipment in reverbs, and it is required to investigate the shape and structure of the flues.

Item 7.2 Prevention of bottom build-up in a reverb

In order to prevent the bottom build-up in a reverb, it is required not to charge what contains a lot of magnetite, not to lower the matte level less than a pre-set level and to strengthen the operation control including converters.

(h) Item 8 Refractory masonry

In Japan, each smelter has been examining respectively what kinds of refractories are adapted to any part of furnaces, in cooperation with refractory makers. Therefore, respective smelter in Chile should consult with refractory makers, and should decide the methods which are suitable for his furnaces and operation.

(i) Item 9 Melting of cement copper in converters

In order to treat fine cement copper in converters, it is necessary to pelletize or to briquette, not so as to splash fine cement copper.

If cement copper is treated in converters, treating amount of other material in converters will decrease proportionally. Therefore, in order to treat cement copper in converters it is required to control strictly the operation of reverb process and converter process, so as to prevent reverbs from producing.

(j) Item 10 Automation and Mechanization

Item 10.1 Anode casting

Item 10.2 Starting sheet preparat

Item 10.3 Washing and handling of anode scrap and
Cathode

Item 10.4 Blank treatment, stripping and care

These automatic and mechanical equipments have been developed and realized as a series of system by Japanese industries respectively. Accordingly, a lot of know-how is included in these equipments, and their technologies should be compensated.

But, as each equipment is respectively made by Japanese machine makers, it is possible to supply the information such as catalogues and specifications of the makers which have already published.

(k) Item 11 Dust handling and pneumatic conveying systems

In Japanese smelters, many pneumatic conveying systems have put into work. As the quality of the dust is difficult every smelter or every producing place, the equipment and treating methods, which are suitable for the quality of the dust, are designed.

Therefore, Chilean smelters should ask consulting to the makers of pneumatic conveying equipment better than to Japanese smelters directly.

(l) Item 12 Quality control procedures and Japanese Industries Standards (JIS)

The technology of quality control is one of basic control technologies for all industries, and Japanese smelters and

refineries have learned it under the experts' guidance for more than twenty years. Accordingly, if Chilean smelters learn the quality control under the Japanese experts' guidance, it will be effective.

For the Industries standards, charging expenses is only a matter, in case of sending Japanese Industries Standards related with copper smelting and refining, to Chile.

Though the assistance to making out the Chilean Industries Standards is very significant, private companies are unable to make them out. So, it is desirable to let the government functions such as Standard Association, make them out.

(m) Item 13 Use of high current density

Item 13.1 Conventional current (280 ~ 300 A/m²)

In ordinary copper electrolysis, in case of making current density higher, copper ions become excess in the vicinity of the anode, and become lack in the vicinity of the cathode. Consequently, the anode become passive, quality of product becomes bad and the current density makes lower.

In Japan, Sumitomo Company Ltd. has succeeded in using high current density (300 A/m²) in ordinary electrolyte cells by improving the recycling method of electrolyte and the electric contacting method between bus-bars and electric poles, and strengthening the electrolyte purification.

The only demerit of high current density electrolysis is to raise the voltage of electrolyte cells, resulting in making electric cost higher.

Item 13.2 High current density electrolysis by P.R.C

High current density electrolysis by P.R.C (Periodically Reversing Current) is to electrolyze in high current

density of more than 300 A/m², with preventing the anode passivity. Manely, periodical reversing current, makes the passive anode surface positive, and gives the time to supply copper ions to the electrolyte in the vicinity of the cathode.

This P.R.C method has been industrially realized in Bulgaria at first, and in Japan, Mitsui Metal Company has introduced this technology from Bulgaria and has put it into operation with improving.

On the other hand, Nippon Mining Company has developed the P.R.C method individually, and has one put it into operation in Hitachi Refinery.

But it seems impossible to manage this method by the present basic technology in Chile. Manely, a wide range of know-how including the technologies improved by Mitsui is necessary to manage it, and this technology should be naturally compensated.

(n) Item 14 Electrolyte purification

Item 14.1 Impurity elimination

Item 14.2 Suspended particles

It is possible to dispatch Japanese experts and to give assistance to Chile concerning general technology not including commercial know-how. Though Chilean refineries have picked up only two items, they will ask the dispatched engineers to the assistance and guidance for all electrolyte technologies.

On the other hand, the published information such as catalogues concerning the filter equipment may be supplied.

(o) Item 15 Centralized short circuit detection

There are two methods concerning centralized short circuit detection, but each method is adaptable for tank houses,

in which countermeasures for preventing short circuit are made and little short circuit takes part. Therefore, in case of Chile, it is necessary to decrease the number of short circuit.

(p) Item 16 Revise the Potrerillos revamping program

This revising work will become a great amount of works which costs tens of thousands dollars, if it goes into details.

What Japanese industries assist to Chile without compensation, is to give simple advice to the revising work realized by Chilean smelters.

(q) Item 17 Informations

Item 17.1 Concentrate bin design to prevent stick

Chilean copper concentrate has so high water content that it is not possible to design the concentrate bin preventing stick. Accordingly, Chilean smelters should investigate the adoption of more effective drying method or drying equipment.

Item 17.2 Sketch of water jacket for matte hole

In Japan, water jackets are adopted for matte holes of flash furnaces and other places. Some sketches can be provided.

Item 17.3 Scrubber to eliminate dust and fume of Oxygen plant air inlet.

Japanese oxygen plants have not experienced any trouble caused by dust and fume. Therefore, it is desirable to consult with the oxygen plant makers.

Item 17.4 Crane weight meters

As there is no technical problems, it is good to investigate the catalogues of the makers.

Item 17.5 Drawings or sketch of ladles and bails to eliminate crane chaser.

Though there is something of being developed at Onahama Smelter, this has been provided to other domestic smelters with compensation. Therefore, this should be compensated.

Item 17.6 Distance between pouring spout and mould in anode casting.

If Chilean smelters examine the distance between pouring spout and mould in anode casting by "trial and error", they will easily grasp the proper distance.

Some sketches can be provided.

Item 17.7 Converter dimensions and geometry.

Though there are some published data of smelters in the world, it is necessary to find out the most desirable dimensions and geometry for each smelter by "trial and error".

Item 17.8 Use of reverb slag

Though the developing degree of Japanese industries except copper smelting and refining is different from one of Chilean industries, it is significant to discuss between Japanese and Chilean engineers at general level.

Item 17.9 Lower copper content in reverb slags

Copper content in slags is said to be one-hundredth of copper content in matte. But copper content in Chilean reverb slags is higher than one-hundredth of copper content in matte.

Therefore, it is significant to discuss between Japanese and Chilean engineers.

(2) Technical assistance for development and expansion of present equipments in future.

As above-mentioned in item 16, Revise the Potrerillos revamping program, Japanese experts will discuss for the period of one week or so.

(3) Technical assistance for Centro de Investigación Minería Y Metallurgica. (CIMM)

Almost part of this theme is in Charge of the proper agencies of universities and research institutes.

Possible scope of Japan's technical cooperation is described as follows.

- (a) Technical cooperation to solve technological problems in plants.
- (b) Technical cooperation in upgrading research and development capabilities of CIMM.

6. Export results of non-ferrous smelting and refining technologies

Export results are shown in appendix (2).

Japanese smelters and refineries have exported many kinds of smelting and refining technologies to various countries.

If there is no special reason, it is difficult to provide smelting and refining technologies which have been exported, without compensation.

Accordingly, in case of technical cooperation to Chile, this time, there was no other way to treat above-mentioned technologies as commercial know-how.

7. Technical assistance proposed by Japan

The Japan Mining Industry Association has deliberated carefully on Chilean demands according to the above-mentioned basic thinking and treating, has chosen the items which are able to be assisted of Chilean demands, and has decided the range of assistance and its method.

The results are shown in appendix (3).

8. Implementation program for cooperation of copper smelting and refining technologies.

The investigated results as discribed heretofore, has been arranged and the implementation program for cooperation of copper smelting and refining technologies has been written out. Professor Goto and assistant Professor Yoshizawa have been in charge of research and development section, and the Japan Mining Industry Association has been in charge of technologies in plants.

This program is shown in appendix (4), outline of implementation program and appendix (5) Stage of actual operation.

Japan International Cooperation Agency has written out Record of Discussions (Draft) and Discussion Paper based on these programs.

9. Negotiation and amendment of technical cooperation program.

(1) Change of Chilean organization

CODELCO-Chile and CIMM have been separated by the change of Chilean organization in April, 1976. Accordingly, CODELCO-Chile has the section of mine, smelters and refineries, and CIMM is independent as a research institute.

As the technical cooperation draft proposed by Japan is

limited to the range in which patents and commercial know-how are not involved, CODELCO-Chile and ENAMI estimated that a quantity of assistance was too less than what they expected.

(2) Amendment of Cooperation

As a result of having a talk extended through several time with persons concerned including CODELCO-Chile, ENAMI and CIMM, this implementation survey team decided to give up the direct technical cooperation to the smelters and refineries which are held by CODELCO-Chile and ENAMI, and agreed to cooperate with CIMM only.

Thereafter, on the base of this agreement, the implementation survey team repeated to have a talk with CIMM, amended Japanese plan of this cooperation and wrote out implementation document.

This implementation document is shown in appendix (7).

(3) Record of Discussions

According to this implementation document, persons concerned of CIMM, CONICYT, the Foreign Office in Chile, the implementation survey team, the ambassador staff in Chile and the Ministry of Foreign Affairs of Japan, discussed together, and agreed.

10. Technical cooperation on the base of Record of Discussions

As the section which Japanese smelters are in charge of, has been considerably amended, the cooperation program was newly written out on the base of new agreement.

The outline is shown in appendix (6) Record of Discussions and appendix (7) Implementation Document.

11. Final

As the Record of Discussion has been put the signature to through the efforts of related persons, this technical cooperation will become into force after the basic agreement of technical cooperation between Japan and Chile come into existence.

This report has been written out in desiring that the basis of Chilean copper smelting and refining technologies will be established by this cooperation.

Finally, the author wishes to thank the following persons for their contributions to this paper: the leader of the implement survey team T. Hotta, the members, H. Yasuki, A. Yoshizawa and JICA, T. Watanabe.

Appendix (1) The letter written by the president of CODELCO.

Santiago, June 23, 1976.

GTEC-73

Mr. Takeo Kuroko
Director of Mining & Industrial
Development Cooperation Dept.
Japan International Cooperation
Agency (JICA)
Japan

Ref.: Technical Assistance to be given by JICA
to the Chilean Mining Industry in the
Smelting and Refining of Copper.

Dear Mr. Kuroko,

Based on the discussions between our plant personnel and the Japanese experts, the preliminary Mission who visited Chile during July-August 1975, and the present Mission, integrated by Messrs. Daiguji, Murakami, and Watanabe, we are pleased to indicate you the areas for a possible technical assistance program and inform you of the requests made by our technical personnel during the present Mission's visits to the installations.

1. Technical assistance to increase the levels of productivity and efficiency in the existing installations.

Appendix N° 1 is a diagram indicating the subjects to be considered in a possible technical assistance program and represents a summary of the different subjects requested by the operators of the Chilean smelters and refineries.

In this diagram the indications are:

Information is requested.

Japanese expertise is required to fulfill this request.

Operational training in Japanese plants is required to fulfill this request.

2.

Priorities of the subjects in a 1 to 3 scale (N°1 is for first priority, and so on) are indicated in this diagram as well as the tentative dates on which same are required, to coincide with the present timetable of the Plants projects.

The training of Chilean personnel will be done according to a program agreed upon by CODELCO-Chile and the next JICA Mission. Each training period should have a duration of 3 to 6 months.

Likewise, the Japanese experts to assist with your country's expertise in the subjects should be done through a similar agreement, and for the same periods of time.

The schedules for the training of the Chilean personnel and the sending of Japanese experts should be determined after the duration of the agreement has been defined.

2. Technical Assistance for future expansion programs of the existing Smelters and Refineries.

It is recommended that the technical assistance should include:

- 2.1. Sending Japanese experts to Chile to perform consulting and guidance work to the engineering staffs on the feasibility studies and investment programs regarding expansion of Smelters and Refineries.
- 2.2. Training of Chilean technicians by visiting Japanese smelters and refineries which use such processes and equipment similar to the projected for expansion of the present Chilean installations.

3. Technical assistance for the Mining and Metallurgical Research Center (CIMM)

It is proposed that this technical assistance for CIMM includes:

3.

- 3.1. Laboratory equipment: Provide CIMM with the equipment listed in Appendix N° 2.
- 3.2. Japanese technical papers: It is proposed to create a way to obtain, through JICA, and at CIMM's request, copies of technical information (translated to English) published by Japanese institutions, regarding subjects being investigated at CIMM.
- 3.3. Training of CIMM researchers in applied research centers which belong either to: the Japanese Government, the Japanese industry or to Japanese universities. Their training should be received in principle for periods of 3 to 6 months and should include the following areas which have been classified by priorities:
 - 3.3.1. Applied Research Management
 - 3.3.2. Hydrometallurgy
 - 3.3.3. Pyrometallurgy
 - 3.3.4. Analysis and characterization techniques
- 3.4. Sending of Japanese experts in principle for 3 to 6 month periods according to the following priorities:
 - 3.4.1. Analysis and characterization techniques.
Instrumental and Conventional Chemical Analysis
 - 3.4.2. Hydrometallurgy - Solvent Extraction, Recovery of rare metals, etc.
 - 3.4.3. Pyrometallurgy
 - 3.4.4. Quality Control Statistical Techniques.
Experimental Design.

In our opinion, these experts should preferably have enough experience so they can also assist the operational and engineering personnel at the Smelters and Refineries on matters of their specialities.

4.

We have also included, as Appendix N° 3, a list outlining information requested to the preliminary JICA Mission, which has not been received at the Plant as of yet.

We have included, for your reference, the minutes of the summary meetings held by our operational personnel with the present JICA Mission.

We want to express our gratefulness for the effort and dedication shown by the present Mission in the accomplishment of their task, and your permanent interest for the success of this project of technical assistance.

Yours faithfully,

Orlando Urbina Herrera
President and Chief Executive Officer
CORPORACION NACIONAL DEL COBRE DE CHILE

SUMMARY OF TECHNICAL ASSISTANCE AND/OR INFORMATION REQUESTED
BY THE PLANTS PERSONNEL








Assistance applicable to:
(X) proposed by)




APPENDIX N° 1

Item	Priority	Code	Subject Description	Chuqui Smelter	Caletones Smelter	Potreri-llos Smelter	Paipote Smelter	Ventanas Smelter	Chuqui Refinery	Potreri-llos Refinery	Ventanas Refinery	Inform. required on or bef.
1	1		Air Pollution 1.1. Improvement of working conditions 1.2. Operation of Electrostatic Precipitators 1.3. Deleterious effect on Ecology	X	X (X)	X X	X X (X)	X X (X)				
2	1		Use of Oxygen 2.1. Instrumentation for Oxy-Fuel Burners 2.2. Problems of dew with Oxy-Fuel Burners 2.3. Use of oxy-fuel burners	(X) (X)	(X) X X	(X)	(X)	(X)				Aug. 76 Nov. 76
3	1		Preheated air to reverbs	(X)			X	X				
4	1		Improvements to the filter cake quality	X	(X)	X						
5	2		Process control instrumentation to determine the metallurgical balances	(X)	(X)	(X)	(X)	(X)				
6	2		Reverts formation control and prevention	X	X	X		(X)	X	X	X	
7	2		Build-up formations in reverbs 7.1. Up-take accretion 7.2. Bottom build-up	X	X			X X				
8	3		Refractory masonry	X	(X)	X	X	X	X	X	X	
9	1		Melting of copper cement in converters				(X)	X				Aug. 76
10	1 1		Automation and/or mechanization 10.1. Anode casting 10.2. Starting sheet preparat.	X		(X)		X	(X)	(X)	(X)	Sept. 76 Aug. 76
	2 2		10.3. Washing and handling of anode scrap and cathde 10.4. Blank treatment, stripping and care					X X	X X	X X	(X) (X)	

Assistance applicable to

(X proposed by)

Item	Priority	Code	Subject Description	Chuqui Smelter	Caletones Smelter	Potreri-llos Smelter	Paipote Smelter	Ventanas Smelter	Chuqui Refinery	Potreri-llos Refinery	Ventanas Refinery	Inform. required on or bef.	
11	2		Dust handling & Pneumatic conveying systems	X	(X)		X	X					
12	1		Quality control procedures and Japanese standards			X				(X)		Aug. 76	
13	2		Use of high current densities 13.1 Conventional A/m ² 13.2 PRC A/m ²						(X) (X)	(X) (X)	(X) (X)	Nov. 76 Sept. 76	
14	3		Electrolyte purification 14.1 Impurity elimination 14.2 Suspended particles						(X)	X (X)	(X) (X)		
15	3		Centralized short circuit detection						(X)	(X)	(X)		
16	1		Revise the Potrerillos Revamping Program			(X)						Sept. 76	
17	3		Information: 17.1 Concentrate Bin design to prevent Stick		(X)							Aug. 76	
	2		17.2 Sketch of water jacket for Matte Hole		(X)								
	1		17.3 Scrubber to eliminate dust & fume of Oxygen Plant Air intake		(X)								
	3		17.4 Crane Weightmeters		(X)								
	2		17.5 Dwg's or sketch of ladles & bails to eliminate crane chaser				(X)						
	3		17.6 Distance between pouring spout and mould in anode casting				(X)						
	1		17.7 Converter dimensions and geometry		(X)								Aug. 76
	2		17.8 Use of reverberatory slags					(X)					
	1		17.9 Lower Cu content in reverb slags			X		(X)					

CODE:  Operational training on Japanese Plants is required to fulfill request
 Information on the subject is being requested
 Japanese expertise on the subject is required to fulfill request

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APPENDIX N°2

LIST OF LABORATORY EQUIPMENT REQUIRED BY CIMM

PROPOSED BY: MUNEO USUI, UNIDO EXPERT
REVISED BY : PETE CADWELL, UNIDO PROJECT MANAGER

<u>PRIORITY AND ITEM N°</u>	<u>QUANTITY</u>	<u>DESCRIPTION</u>
1	1	System to improve the pure water supply to the Center; e.g.: Ion Exchanger unit, demineralizer, or similar.
2	1	Equipment to determine the conductivity of electrolytic copper. It should include: a. Induction furnace b. Spike molds c. Laboratory roller d. Drawing bench e. Wheatstone bridge
3	As many as possible	Multiple-pen recorders for laboratory work provided with strip-chart type record.
4	1	Electronic microscope with scanning devices. It is required with a micro-analyzer. Could be used for mineral research as well as metal testing.

Export results of non-ferrous smelting and refining technologies

	Sumitomo	Dowa	Nippon Mining	Furukawa
Before 1970	Spain: Copper Blast Furnace (Momota process)			1965. China: Flash Smelting Furnace Technology
1971			Chile: Oxygen Smelting Technology	
1972			Korea: Anode Refining Technology	
1973	Australia: Flash Smelting Furnace Australia: Flash Smelting Furnace for nickel	U.S.A.: Pyrite sinter treating (Kowa process)	Taiwan: Copper converter's Operation Technology	Turkey: Flash Smelting Australia: Flash Smelting Furnace Cooling Technology
1974	Spain: Flash Smelting Furnace		Korea: Anode furnace's operation	
1975	U.S.A.: Flash Smelting Furnace Acid plant	Spain: Pyrite sinter treating (Kowa process)	Yugo: Oxygen Smelting Technology	West Germany: Flash Smelting Furnace cooling system
1976	Australia: Copper converter's operation	Yugo: Zinc smelting		Mexico: Flash Smelting Technology

	Furukawa Metal	Mistui Metal	Mistubish Metal	Others
Before 1970			1969, England, Canada: Anode Casting mechanization, computer monitoring technology of tank house 1969, Canada; Treating technology of water grinding slag 1970 USA: Anode casting technology 1970 USA: Waste heat boiler for converter	
1971			USA: Waste heat boiler for converter USA: Stripping technology Australia: Charging technology of reverb Canada: Anode casting technology	
1972	Peru: Construction of tank house		Australia: Treating technology of water granding slag	
1973		USA: Waste gas treating for zinc smelting Korea: Roasting technology for zinc smelting		
1974		U.S.A: Waste gas treating for zinc smelting Peru : Consulting for zinc smelting Mexico: " Philippines: Consulting for copper smelting Burma: "		Mistui metal, Canada: Stripping machine for zinc
1975			Canada: Continuous converting technology Peru: Copper electrolysis technology Sweden: Copper electrolyte treating technology	TOHO Zinc, Korea: Zinc smelting technology Mistui Metal, West Germany: Stripping machine for zinc
1976		Korea: Copper smelting technology		

Item	Subject Description	A	B	C	
1	Air Pollution 1.1 Improvement of Working Conditions 1.2 Operation of Electrostatic Precipitators 1.3 Deleterious Effect on Ecology	○		△	Experts will work for diagnosis and consultation. Supply of this technology should be compensated.
2	Use of Oxygen 2.1 Instrumentation for Oxy-Fuel Burners 2.2 Problems of dew with Oxy-Fuel Burners 2.3 Use of Oxy-Fuel Burners				These technologies incorporate considerable commercial know how. Compensation is required.
3	Preheated Air to Reverbs	○			Experts will work for consultation.
4	Improvements to the Filter Cake Quality				This should be requested to the filter makers.
5	Process Control Instrumentation to Determine the Metallurgical Balances	○		△	Experts will work for general consultation.
6	Reverts Formation Control and Prevention	○			"
7	Build-up Formations in Reverbs. 7.1 Up-take Accretion 7.2 Bottom Build-up	○	○		General consultation will be provided. Skilled and experienced operators may not be despatched.
8	Refractory Masonary				Generally, this technology belongs to the furnace suppliers. As to the sprung-arch roof of reverb. Supply of the design should be compensated.
9	Melting of Copper Cement in Converters			○	Some information will be provided.
10	Automation and Mechanization 10.1 Anode Casting or 10.2 Starting Sheet Preparat. 10.3 Washing and Handling of Anode Scrap and Cathde 10.4 Blank Treatment. Stripping and Care			△ △ △ △	Catalogs or brochures will be provided. Supply of technologies should be compensated.
11	Dust Handling and Pneumatic Conveying Systems			△	The systems are affected considerably by dust properties. Generally, this belongs to the suppliers.
12	Quality Control Procedures and Japanese Industries Standards (JIS)	○		○	
13	Use of High Current Dencity 13.1 Conventional Current 13.2 P.R.C.				This should be compensated for commercial know how. This can not be provided due to contractual obligations with Bulgaris.
14	Electrolyte Purification 14.1 Impurity Elimination 14.2 Suspended Particles	○ ○		△	Experts will work for general consultation. Transfer of continuous filtering should be compensated.
15	Centralized Short Circuit Detection				This should be compensated for commercial know how.
16	Revise the Potrerillos Revamping Program	○			Experts will discuss for the period of one week or so.
17	Informations 17.1 Concentrate Bin Design to Prevent Stick 17.2 Sketch of Water Jacket for Matte Hole 17.3 Scrubber to Eliminate Dust and Fume of Oxygen Plant Air Inlet 17.4 Crane Weight Meters 17.5 Drawings or Sketch of Ladles and Bails to Eliminate Crane Chaser 17.6 Distance between Pouring Spout and Mould in Anode Casting 17.7 Converter Dimensions and Geometry 17.8 Use of Reverb Slag 17.9 Lower Cu Content in Reverb Slags			○ △ ○ ○ ○ ○ ○	Too much moisture content to prevent the sticking. Sketch can be provided. This should be requested to the plant supplier. Catalogue can be provided. This should be compensated. Sketch can be provided. This can be implemented only by "trials and errors" This will be consulted. This will be consulted.

Note:

A: Experts will be despatched.

B: Chilean counterparts will be recieved.

C: Information will be provided. (△ indicates that the information provided will be limited to catalogue or other published paper)

1. The first part of the document is a list of names and titles.

2. The second part is a list of dates and times.

3.

4. The fourth part is a list of names and titles.

5. The fifth part is a list of names and titles.

Appendix (4)

OUTLINE OF IMPLEMENTATION PROGRAM
(PROPOSAL)

- 1 Promotion of Research and Development.
 - a. Analysis and Characterization Technique.
 - i) Instrumental:
EPMA analysis for identification of mineral species, study of chemical variations within mineral grains, rapid quantitative analysis; Atomic absorption analysis for the determination of trace impurities in ores and metals, rapid quantitative analysis of metallic salt solutions; X-ray diffract analysis in chrystallography.
 - ii) Chemical analysis of copper metal and copper ore.
 - b. Pyrometallurgical research in
 - i) Heat utilization in reverberatory,
 - ii) Hydrodynamic behavior in converter,
 - iii) Better design of electrolytic cells.
 - c. Quality control techniques including experimental design
 - d. General support of experimental works such as machining, electronic circuiting, glass works etc.
- 2 Technical Advice and Guidance for Existing Facilities in Plants.
Improvement of operation in existing facilities and planning of future expansion of existing facilities.
 - i) Metallurgical balance:
Reverts formation control. Instrumentation to assist metallurgical balance.
 - ii) Dust prevention and improvement of working conditions
 - iii) Operation of reverberatory:
General assistance for application of preheated air.
Prevention of build-up formations.
 - iv) Operations of electrolytic refining:
Impurity elimination of electrolyte. Removal of suspended particles.

(1)

3 Training of manpower.

Training of researchers; and of engineers and foremen in plants, in Chile will be implemented in above-mentioned fields respectively.

Training of researchers in Japan will be implemented in above-mentioned fields respectively.

Engineers and foremen will be despatched to Japan for training and/or observational study.

Appendix (5)

STAGE OF ACTUAL OPERATION (PROPOSAL)

		1977	1978	1979
Japanese Experts	Promotion of Research and Development			
	Technical Advice and Guidance for Existing Facilities in Plants			
Japan's Provision of Equipments				
Training of Chilean Counterparts	Training of Manpower			
Analysis and Characterization Technology Pyrometallurgy Quality Control Techniques.				
Improvement of Operation in Existing Facilities Planning of Future Expansion of Existing Facilities				
In Chile				
Training of Researchers				
Training of Engineers and Foremen in Plants				
In Japan				
Training of Researchers				
Training of Engineers and Foremen in Plants				

Appendix (6)

RECORD OF DISCUSSIONS BETWEEN THE JAPANESE
IMPLEMENTATION SURVEY TEAM OF THE JAPAN IN
TERNATIONAL COOPERATION AGENCY AND THE CEN
TRO DE INVESTIGACION MINERA Y METALURGICA
OF THE REPUBLIC OF CHILE ON THE TECHNICAL
COOPERATION FOR THE TECHNOLOGICAL DEVELOP
MENT OF COPPER SMELTING AND REFINING IN

CHILE

NOVEMBER, 1976

The Government of the Republic of Chile aims at the technological development of copper smelting and refining for the purpose of promoting and developing copper industries in Chile.

On the basis of the reports and recommendations of the Japanese Preliminary Survey Team and long-term experts sent by the Japan International Cooperation Agency (hereinafter referred to as "JICA") in July, 1975 and in March, 1976, respectively, the Japanese Implementation Survey Team organized by JICA, headed by Mr. TAKAMASA HOTTA, visited the Republic of Chile from November 11 to November 30, 1976, for the purpose of working out the details of the technical cooperation project for technological development of copper smelting and refining in Chile, (hereinafter referred to as "the Project") between the Government of the Republic of Chile and the Government of Japan. The Team discussed and studied with the Chilean counterparts a number of points in question with respect to its effective implementation.

As a result of careful studies and discussions, the Japanese Implementation Survey Team and the Centro de Investigación Minera y Metalúrgica (hereinafter referred to as "CIMM") will recommend to their respective Governments the immediate implementation of the technical cooperation for the technological development of copper smelting and refining in Chile as specified in the Record of Discussions and its Annexes attached hereto.

In the case of CIMM, it will submit this record of discussions and its Annexes attached hereto, to the National Commission of Scientific and Technological Research (CONICYT) and to the Ministry of Foreign Affairs, for its consideration.

Notwithstanding the foregoing internal procedures established in the Republic of Chile, CIMM, with the view to expediting the implementation of the Project with an utmost effectiveness, may present an application for the equipment required for the initial year, as listed in Annex 3.2., to JICA through an official channel in the Republic of Chile, even before the complete approval of the whole project by the pertinent authorities of the Republic of Chile.

Aware of the convenience of concluding a basic agreement of technical cooperation between the Government of Japan and the Government of Chile, that will consider granting privileges, exemptions and benefits for Japanese experts and equipments included in the project, both parties will recommend to their respective Governments the early negotiation of the above mentioned basic agreement

TAKAMASA HOTTA
Head
Japanese Implementation
Survey Team
Japan International Cooperation
Agency, JAPAN

ALEXANDER SUTULOV
Executive Director
Centro de Investigación
Minera y Metalúrgica
Republic of Chile

Date : November 29, 1976.-

RECORD OF DISCUSSIONS

I. Objective of the Project :

The Government of the Republic of Chile aims at the technological development of copper smelting and refining for the purpose of promoting and developing copper industries in Chile. In order to implement this objective, the Project with Japan's technical cooperation has been planned, by making transfer of technology from Japan to Chile successful, in such a way as to strengthen Research and Development capabilities at the Centro de Investigación Minera y Metalúrgica (CIMM), to improve copper industries, and to develop manpower in the fields of copper smelting and refining technologies.

II. Outline of the Project :

The Project is carried out at CIMM, and consists of the following three functional activities :

1. Promotion of Research and Development;

- (1) Analysis and characterization technology,
- (2) Pyrometallurgy,
- (3) Electrometallurgy,
- (4) Quality control techniques.

2. Technical Advice and Guidance to CIMM for the Studies Related with Existing Facilities of Copper Industries in order to;
 - (1) Improve operations,
 - (2) Analyze future expansions.
3. Training of Manpower;
 - (1) Training of Chilean personnel in Chile,
 - (2) Training of Chilean personnel in Japan.

III. Japanese Experts :

1. In accordance with laws and regulations in force in Japan, the Japanese authorities concerned will take necessary measures to provide at their own expense the services of Japanese experts as listed in Annex 1 through the normal procedures under the Technical Cooperation Scheme.
2. In accordance with laws and regulations in force in the Republic of Chile, the Japanese experts listed in Annex 1 and their families will be granted in the Republic of Chile, privileges, exemptions and benefits as listed in Annex 2 no less favourable than those granted to the experts of other foreign countries under the Technical Cooperation Scheme as well as those of the United Nations.

IV. Japan's Provision of Equipment :

1. In accordance with laws and regulations in force in Japan, the Japanese authorities concerned will take necessary measures to provide at their own expense such equipment, machinery, instruments, vehicles, and other materials as listed in Annex 3, required for the Project, through the normal procedures under the Technical Cooperation Scheme.
2. The articles referred to in the above IV-1 will become the property of CIMM upon being delivered c.i.f. to the Chilean authorities concerned at the ports and/or airports of Jisembarkation, and will be utilized exclusively for the Project.

V. Training of Chilean Counterpart Personnel :

1. In accordance with laws and regulations in force in Japan, the Japanese authorities concerned will take necessary measures to receive the Chilean counterpart personnel engaged in the activities of the Project for technical training and/or observational study in Japan through the normal procedures under the Technical Cooperation Scheme.
2. The Government of the Republic of Chile through the authorities concerned will take necessary measures to ensure that the knowledge and experience acquired by the Chilean counterpart personnel from technical training and/or study in Japan will be utilized for the effective implementation of the Project.

VI. Arrangement of the Government of the Republic of Chile :

1. In accordance with laws and regulations in force in the Republic of Chile, the Government of the Republic of Chile through CIMM will take necessary measures to provide at its own expense :
 - (1) Space for laboratories, offices and other incidental facilities necessary for the Project as listed in Annex 4,
 - (2) Supply or replacement of equipment and other materials for appropriate operation of the Project other than those provided by the Japanese authorities concerned,
 - (3) Staffing of the Chilean counterpart personnel.

2. In accordance with laws and regulations in force in the Republic of Chile, the Government of the Republic of Chile through CIMM will take necessary measures to meet:
 - (1) Expenses necessary for the domestic transportation and insurance of the articles to be provided by the Japanese authorities concerned as listed in the above IV-1 as well as for their installations, operation and maintenance thereof,
 - (2) Custom duties, internal taxes and any other charges, if any, imposed in the Republic of Chile upon the articles referred to in the above IV-1 for the Project

- (3) All the running expenses necessary for the effective implementation of the Project.
3. In accordance with laws and regulations in force in the Republic of Chile, the Government of the Republic of Chile through CIMM will take necessary measures to provide, at its own expense, Japanese experts with :
- (1) Each office room,
 - (2) Services of the Chilean secretaries and chauffeurs with vehicles while on duty,
 - (3) Expenses for the internal travel on duty in the Republic of Chile,
 - (4) Free medical service and facilities including for their families, in case of accident or illness resulting from the work or from the conditions of the local environment,
 - (5) Expenses for fully furnished appropriate housing accommodation including for their families.

VII. Responsibility of the Project :

The Executive Director of CIMM of the Republic of Chile, will bear the overall responsibility for the preparation and operation of the Project.

VIII. Claims against Japanese Experts :

In accordance with laws and regulations in force in the Republic of Chile, the Government of the Republic of Chile undertakes to bear claims, if any arises, against the Japanese experts resulting from, occurring in the course of, or otherwise connected with discharge of their official function in the Republic of Chile, except for those claims arising from the willful misconduct or gross negligence of the Japanese experts.

IX. Mutual Consultation :

There will be close consultation between both authorities concerned for the successful implementation of the Project.

X. Terms of Cooperation :

The period of technical cooperation mentioned in this Record of Discussions will be three years starting from the date of the arrival of the Japanese experts.

Annex 1. Japanese Experts

Chief advisor

Experts in the fields of;

- (1) Analysis and Characterization technology,
- (2) Pyrometallurgy,
- (3) Electrometallurgy,
- (4) Quality control techniques,
- (5) Copper smelting and refining operations.

Foot Note :

- (1) Chief advisor will be one of the Japanese experts,
- (2) Japanese experts other than those mentioned above will be dispatched, if necessity arises, for the installation and testing operation of those equipments and machinery provided by the Japanese authorities concerned.

Annex 2. Privileges, Exemptions and Benefits

- (1) Exemption from income tax and charges of any kind imposed on or in connection with the living allowances remitted from abroad,
- (2) Exemption from custom Duties and any other charges imposed on goods in connection with official duty, personal and household effects which may be brought into the Republic of Chile from abroad,
- (3) Automobile import privileges to the Japanese experts during their stay in the Republic of Chile for works connected with the Project.

Annex 3.1. Japan's Provision of Equipment

- (1) Equipment to supply the pure water,
- (2) Automatic recorders for laboratory work,
- (3) Equipment for chemical analysis,
- (4) Equipment for crystal structure analysis,
- (5) Vehicles.

Annex 3.2. Equipment to be installed in the initial
Year of the Project.

- (1) Equipment to supply the pure water,
- (2) Atomic absorption/flame spectrophotometer,
- (3) Multiple-pen recorders for laboratory work,
- (4) Electron probe X-ray microanalyzer with computer control system for data processing.

Annex 4. Space and Others

- (1) Space for laboratories,
- (2) Offices,
- (3) Air conditioning facilities for the precise equipments, if necessary,
- (4) Electrostatically shielded room, if necessary,
- (5) Other incidental facilities.

Appendix (7)

IMPLEMENTATION DOCUMENT

(Draft)

BETWEEN THE JAPANESE IMPLEMENTATION SURVEY TEAM OF THE
JAPAN INTERNATIONAL COOPERATION AGENCY AND THE CENTRO
DE INVESTIGACION MINERA Y METALURGICA OF THE REPUBLIC OF
CHILE ON THE TECHNICAL COOPERATION FOR THE TECHNOLOGICAL
DEVELOPMENT OF COPPER SMELTING AND REFINING IN CHILE.

November, 1976

I. OBJECTIVE OF THE PROJECT

The Government of the Republic of Chile aims at the technological development of copper smelting and refining for the purpose of promoting and developing copper industries in Chile. In order to implement this objective the Project with Japan's technical cooperation has been planned, by making transfer of technology from Japan to Chile successful, in such a way as to strengthen Research and Development capabilities at the Centro de Investigación Minera y Metalúrgica (CIMM), to improve copper industries, and to develop manpower in the fields of copper smelting and refining technologies.

II. OUTLINE OF THE PROJECT

1. Framework of the Project

The Project is carried out at CIMM, and consists of the following three functional activities;

(1) Promotion of Research and Development;

- i. Analysis and characterization technology
- ii. Pyrometallurgy
- iii. Electrometallurgy
- iv. Quality control techniques

(2) Technical Advice and Guidance to CIMM for the studies related with existing facilities of copper industries in order to;

- i. Improve operations
- ii. Analyze future expansion

(3) Training of Manpower;

- i. Training of Chilean personnel in Chile
- ii. Training of Chilean personnel in Japan.

2. The Limit of Japan's Technical Cooperation

Japan's technical cooperation on a Government to Government basis is limited to the extent of the publicly generalized technologies, which therefore rule out the technologies exclusively owned by private sector and individuals, in such forms as patents, technological know-how, and so on.

3. Programs for the Implementation

In principle, Japan's technical cooperation is provided for a period of three years. In order to make sure the effective implementation of the Project, the implementation programs are outlined in Table 1.

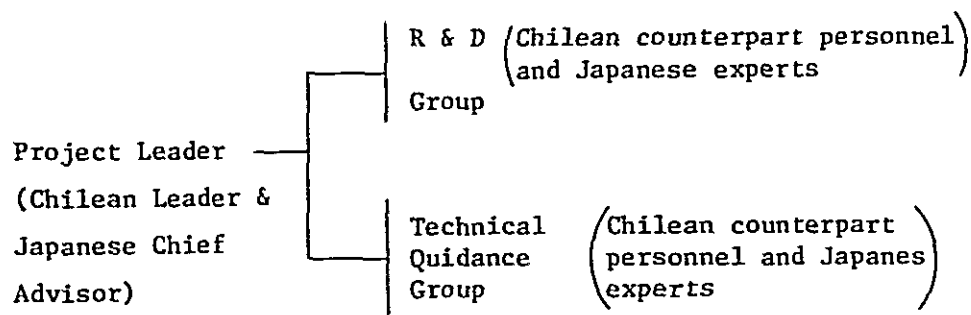
4. Implementation Agencies

Chilean side : Centro de Investigación Minera y Metalúrgica
Japanese side : Japan International Cooperation Agency.

5. Project Team and its Staff

It is planned that within CIMM the Project Team will be set up consisting of Chilean counterpart personnel and Japanese experts.

The Project Team will be as follows;



Both, Chilean and Japanese sides appoint a Project Leader for each side.

For each group in the above, both Chilean and Japanese side will appoint a Group Leader. It must be noted that activities of the Project are mainly carried out by the Chilean counterpart personnel with the assistance of Japanese experts.

6. Equipment to be installed

The following equipment will be installed to achieve the objectives of the Project;

- (1) Equipment to supply the pure water
- (2) Automatic recorders for laboratory work,
- (3) Equipment for chemical analysis,
- (4) Equipment for crystal structure analysis,
- (5) Vehicles.

Equipment to be Installed in the Initial Year of the Project

- (1) Equipment to supply pure water,
- (2) Atomic absorption/flame spectrophotometer,
- (3) Multiple-pen recorders for laboratory work,
- (4) Electronic microscope with scanning devices and micro-analyser (or Electron probe X-ray micro-analyser),
- (5) Mini-computer for experimental data processing.

7. Facilities

CIMM will take necessary measures to provide at its own expense;

- (1) Space for laboratories,
- (2) Offices,
- (3) Air conditioning facilities for the precise equipments,
if necessary.
- (4) Electrostatically shielded room, if necessary,
- (5) Other incidental facilities.

III. PROCEDURES OF THE IMPLEMENTATION

1. Tentative Schedules

Stage of Preparations

Chilean Side ;

- (1) Staffing of the Project,
- (2) Preparation of Application Forms, A-1, A-2, A-3 and A-4,
- (3) Office rooms for Japanese Experts,
- (4) Specifications of and lay-out plan for equipment to be
installed,
- (5) Procurement of equipment,
- (6) Cost estimates and budgeting of local portion of the
Project.

Japanese side;

- (1) List of specification of equipment,
- (2) Procurement of equipment,
- (3) Recruitment of Japanese experts,
- (4) Budgeting for Japanese technical cooperation,
- (5) Training program in Japan for Chilean counterpart
personnel.

2.- Stage of Actual Operation

- 5 -

Subject	YEAR		1977		1978		1979	
		MONTH	1		1		1	
Japanese Experts	Promotion of Research and Development	Analysis and Characterization Technology	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX
		Pyrometallurgy	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX
		Electrometallurgy	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX
Japan's Provision of Equipment	Technical Advice and Guidance to CINM for Studies Related with Existing Facilities of Copper industries	Quality control techniques	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
		Improvement of operations	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
		Analysis for future expansions	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Training of Chilean Counterparts	Training of Manpower	In Chile	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX
		In Japan	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX
		Study tour for visiting plants and discussions	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

OUTLINE OF IMPLEMENTATION PROGRAM

- 6 -

TABLE 1.

<p>Promotion of Research and Development</p>	<p>Analysis and characterization technology Pyrometallurgy Electrometallurgy Quality control techniques</p>	<p>Analysis and Characterization technology</p> <p>i) Instrumental: EPMA analysis for identification of mineral species, study of chemical variations with- in mineral gains, rapid quantitative analysis. Atomic absorption analysis for the determination of trace impurities in ores and metals, rapid quantitative analysis of metallic salt solutions, X-ray diffract-analysis in chryystallography.</p> <p>ii) Chemical analysis of copper metal and copper ore</p> <p>Pyrometallurgical research</p> <p>Electrometallurgical research</p> <p>Quality control techniques including experimental design</p> <p>General support of experimental works such as machining, electronic circuiting, glass works, etc.</p>
<p>Technical Advice and Guidance to CIMM for Studies Related with Existing Facilities of Copper Industries</p>	<p>Improvement of operations Analysis of future expansions</p>	<p>Works in the areas for example:</p> <ol style="list-style-type: none"> 1. Metallurgical balance 2. Dust prevention and improvement of working conditions 3. Operation of Reverbs and convertors 4. Operations of electrolytic refining 5. New processes in smelting and refining
<p>Training of Manpower</p>	<p>In Chile Training of researchers In Japan Training of researchers Study tour for visiting plants and discussion</p>	<p>Training in the fields above mentioned</p> <p>Training and/or observational study</p>

APPLICATION FOR EQUIPMENT

By the Government of _____ to the Government of Japan
under the Technical Co-operation Plan for (1) Near and Middle East and Africa, (2) Latin America, or (3) Other Asian Area

- Notes - (1) This form has been devised for the general guidance of co-operating countries in order to facilitate the supply of relevant information and data necessary to afford an adequate appreciation of the nature of the technical assistance required. The careful completion of this application form will avoid much reference back and lead to speedier action.
- (2) The requisite number of copies of the Form A.4 duly endorsed by the appropriate Foreign Aid Department of the requesting government should be forwarded to the donor government concerned through the appropriate channels.
- (3) The equipment to be supplied by the Government of Japan will become the property of the requesting government upon receipt of the shipping documents through the Japanese Embassy. Since the equipment is supplied on C.I.F. basis, it is requested that the recipient government will meet:
- (a) customs duties, internal taxes and other similar charges, if any, imposed in respect of the equipment, and
(b) expenses necessary for the transportation, installation, operation and maintenance of the equipment.

<p>1. Background Information</p> <p>Please describe as concisely as possible the general outlines of the project for which the equipment is required, indicating whether the latter is (a) for use by an expert in the performance of his duties (b) for a training scheme of institution or (c) for a research institution. If either (b) or (c) please say whether the equipment is for the establishment of a new institution or the expansion or re-organisation of an existing one (e.g., by the provision of a new department, etc.). The name and exact location of the institution, its approximate cost and the authority responsible for it should be stated. Where appropriate details should be given of the availability of any services required for the operation of the equipment. This would include operation by electricity (i.e. type of current, periodicity, voltage and any variations, phases, frequency etc. and if D.C. is the only current available please give full details), water reticulation or steam gas etc. Details of similar equipment already in use should be given.</p>	<p>Multiple pen recorders Minicomputer Atomic Absorption Spectrophotometer Electron Probe & Micro-analyzer Equipment to supply pure water</p> <p>CENTRO DE INVESTIGACION MINERA Y METALURGICA Santiago, Chile, Avda, Parque Institucional N°6500</p> <p>Electric Requirements: 220 V 50 Hz single phase</p>
<p>2. Description of equipment required.</p> <p>Please give a full description of each item and general specifications where possible. The manufacturer and estimated cost of each item if known together with details of the proposed end use of item should be given. Where applicable, give details of any special packing or tropic proofing required and indicate whether handbooks or instruction data supplied in English will suffice. If appropriate, please indicate any required priorities or phasing of deliveries and advise whether adequate facilities exist for maintenance and servicing of the type of equipment requested. (If lengthy, detailed lists should be annexed; it would be convenient to have separate annexures for (a) films; (b) books and (c) other equipment.)</p>	<p>See Annex.</p>
<p>3. Has this equipment request already been directed to any other Agency or country and if so to whom was it addressed and with what result?</p>	<p>No</p>
<p>4. Has the list of equipment already been discussed with representatives of the supplying country/ies? If so, please indicate what stage the discussions have reached.</p>	<p>Yes</p>
<p>5. Furnish full particulars in respect of— (a) Consignee; (b) Official to receive documents and enquiries; and (c) Clearing agent at port of entry.</p>	

<p>6. Where equipment is required for use by an expert Please indicate—</p> <p>(a) The country or agency from which the expert has been requested or obtained.</p> <p>(b) His duties and length of secondment (a reference to the relative Form A. 1 will suffice when the expert is being provided by the country to whom the equipment request is addressed).</p> <p>(c) What use is proposed for the equipment when the expert's period of secondment terminates?</p> <p>(d) By what date is the equipment required?</p>	<p>Yes.</p>
<p>7. Where equipment is required for Training or Research Institutions Please indicate—</p> <p>(a) Nature and standard of training or research to be undertaken</p> <p>(b) Total number of students to be accommodated from within the country or from elsewhere in the Region, the qualifications for admission, the duration of courses, and the annual output of trainees</p> <p>(c) Whether there is already a similar institute(s) in existence in the country. If so, please give details</p> <p>(d) Whether buildings are already available. If not has construction started and when is it expected to be completed?</p> <p>(e) Whether qualified staff to handle the equipment has been recruited or is proposed to be recruited locally. If not is it proposed:—</p> <p>(i) to recruit foreigners under aid programmes?</p> <p>(ii) to train locally recruited personnel abroad in handling equipment? (the reference numbers of any Forms A. 1 or A. 2 relating to such requests should be quoted)</p> <p>(f) Taking into account the answers to (d) and (e) above, what is the date by which the equipment is required and the date on which training or research work is to commence.</p> <p>(g) Whether any assistance in drawing up the Scheme has been obtained from outside experts? (Any specialist reports or Government surveys (e.g., Educational Committee Reports, etc.), bearing on the request should be provided if possible)</p>	<p>Yes</p>
<p>8. Correspondence Name, Postal and Telegraphic Address of official to whom correspondence regarding this application is to be forwarded</p>	<p>CENTRO DE INVESTIGACION MINERA Y METALURGICA Santiago, Chile, Avda, Parque Institucional N°6500</p>

Signed

on behalf of the Government of

Date:

For use only by Donor Government

Application accepted/rejected/withdrawn

on behalf of the Department of

Date:

LIB