3.4.4 Instruction & Training

1) Foundry Shop

Div. El Teniente has spared considerable times for all types of training in the whole workshop department. However, the technical training in the foundry shop are mainly OJT, but it is desirable to pay more attention to fundamental technical education judging from the present technical and quality situation. Therefore, the followings are limited to technical educations:

(1) In-house training

a) Acquisition of fundamental knowledge on casting

The fundamental knowledge on casting shall be provided to all workers in the foundry shop. Most field skilled workers know only narrow field of casting through the job of the workshop assigned. It is necessary to provide the minimum fundamental education to workers as far as they are engaged in casting works.

Training shall be provided separately in each workshop (for example, molding workshop, melting workshop, etc.) to let workers understand the previous and after processes. For example, workers in the molding workshop shall understand not only molding, but also manufacturer of patterns in the previous process and the finishing of casting in the after process. This will let them consider what they can request to the previous process and what they should do to prevent troubles or inconvenience in the after process.

In this foundry shop, they produce many castings of special steel like wear resisting castings. So it is necessry for them to have knowledge on material properties from metallurgical point of view. The properties of special steel or high alloy steel are changed by heat treatment, and improper heating or cooling may cause cracks on these steels. So, it is necessary to provide the workers in this workshop with these knowledge. Workers in the finishing process should learn these more closely. These education shall be provided by the management of this company, specialist engineers or lecturers from university or other research institutes.

b) OJT in each workshop

As already explained, various standards on casting works shall be prepared, and OJT shall be provided in each workshop according to these standards. At first, foremen and group leaders shall understand the work well and then educate their group members. At that time, if there are any knacks or the ropes which cannot be expressed sufficiently in such standards, they shall show them the ropes and let them understand them completely.

c) Training through samll QC group activities

Small QC group activity shall be considered to be an opportunity to provide training, and this activity shall be fixed and activated among members. For that purpose, the management shall give useful advices to the activity and make efforts to promote the activity. They shall give small QC groups the opportunities for offering necessry information and for making public the results of small QC group activities and also make efforst so that workers can study hard together, for example, at study meetings of technical improvements. One-way education is not effective. So, it is important to make each worker engaged in production aggressive to his or her work and to let him or her have positive learning attitude.

d) Education to new graduates assigned to workshop

New graduates who are to be brought up to foremen or group leaders shall receive technical education in various field. For example, a graduate who is expected to become a leader of the molding group shall experience molding for four to five years, learn casting planning for one yer and then return to the molding group. Such arrangement will give him the knowledge to distinguish good and bad casting methods by himself and also to give instructions to other group member. This type of education shall be provided systematically from a long-term viewpoint.

e) Education to middle-class engineers

Casting technology has been developing constantly, through the progress is rather slow among other industries. So, sticking to conventional technologies will leave engineers behind the present development, and they should positively attend technical lecture classes outside the company to absorb new knowledge.

It is advisable to hold technical study meetings to let them study hard together inside the company.
Also, overseas technical information should be obtained positively, and it is recommended to study participating in international meetings on casting in case of necessity.

(2) Advice on establishment of public training organization (for casting) in the Republic of Chile

At present this country has no public organization to provide training on casting skill (lecture and practical training), and it is desirable to establish a national or public casting skill training center and to provide training of casting skill to new graduates, re-training to engineers in service and to hold lecture meeting on casting.

This matter may not be of direct concern of CODELCO, but, as a national enterprise, CODELCO should make this proposal to the nation. And, if established, such organization will greatly contribute for raising the casting technology not only of CODELCO but also of the whole republic.

2) Plate Shop

In this Division, the competency Development Department and staffs under the direct control of the plant manager are playing important roles for providing training systematically. They utilizes various training organizations such as university, professional school and National Vocational Training Center and have attained remarkable results. Therefore, only a few problems will be studies concerning knowledge and skill of mainly direct workers *requiring training in this modernization program.*

(1) Quality level

As mentioned in the second chapter, most finished products compare unfavorably with others from the point of commodity value since the products are all used in their own mines. In view of future competition with private enterprises, it is necessary to know the general quality level in the market.

The quality betwen processes degrades the products and also lowers the productivity.

So, it is necessary to provide education to workers on the general level of commodity value in the market and the quality between processes.

(2) Fundamental knowledge on welding

It is necessary to provide fundamental knowledge to not only welders but also workers in the plate shop concerning the matters to be noted in handling welding materials and the treating method of nonconforming groove at weld zone.

(3) Re-training of welder by using the result of X-ray test at butt-welded zone

The X-ray test at butt-welded zone provides the only opportunity to see the inside of the weld zone. When defects are found, they can be used as a teaching material to study the cause, countermeasures and the preventive measures. So, this will give high class welders a best educational chance.

(4) Basic method to read drawing

It is very effective for accuracy improvement and prevention of mistaken works to provide fundamental training to read drawing especially to fitters. For that purpose, fitters are shifted as loftmen for six months and they will surely acquire the knowledge to read basic drawings.

3.4.5 Safety management

1) Underlying principles

"Total freedom from failure" is something that is not practically realizable. Even supposing an equipment or a structure that is ideally conceived, human error is not absolutely preventable, nor are natural disasters like volcanic eruption and earthquakes. What can be aimed at is "adequate safety", which is a state that is judged in comparison with the risk presented by other dangers.

It is not human nature to deliberately create or incur danger, and a normal human being can be expected to behave in a more or less similar manner when faced with a similar situation, and adopt a strategy that should minimize the greatest conceivable loss.

It cannot of course be denied that, the industrial environment undoubtedly involves dangers that do not exist in nature. For this reason, the personnel charged with working in industry must be given specific instruction and training on the perils affecting their trade and on notions of safety at work. An the personnel in charge of equipment operation and manipulation, on their part, are expected to be thoroughly versed in the substance of their respective functions, and to perform their duties diligently and responsibly. Consequently, safety at work is inseparably premised upon the implementation of a consistent and strictly administered instruction and training program.

2) Target of safety management

Arrangement of the risks involved in the every day life of a normal citizen—in the order of their probability of occurrence—results in diagrams such as reproduced in Figs. 3.4.5-1 and -2. These examples may call for further scrutiny in such aspects as:

(a) Whether the term "accidental" is applied in the strict sense of the word, or else accidents imputable to negligence are included

(b) Whether or not deaths occurring after long medical treatment are counted, and

(c) What discrimination is made between the deaths of persons directly engaged in the operations and of pure passers by having the misfortune of getting involved in the accident.

The generally accepted notion of a "safe" situation is one in which the risk of death is 10^{-6}/year of below, i.e. a person remaining in that situation during 12 months runs a risk of death with a probability of 1 in 1,000,000 or less. When this risk amounts to 10^{-5}/year or more, it is the generally acknowledged that some measure for enhancing safety requires to be adopted.

Table 5 Accidental Death Risk

Type of Accident	Risk/person/year $\times 10^{-6}$
All accidents	345
Road Transport	145
Falls	111
Fires	18
Choking and Suffocation	16
Poisoning	16
Drowning	11
Natural and Environmental	3·6
Air Transport	3·3
Rail Transport	3·1
Water Transport	2·6
Electrocution	2·4
Delayed effects of accidents	2·2
Medical misadventure	1·6
Lightning	0·17

Notes: 1. Risks for Great Britain 1973 derived from Griffiths and Fryer.
2. Total number of accidental deaths in 1973 was 18947.
3. Individual risks based on population of Great Britain.

Fig. 3.4.5-1 Probability of encountering fatal accident in normal civil life
(Source: Lloyds Register Technical Report No. 82)

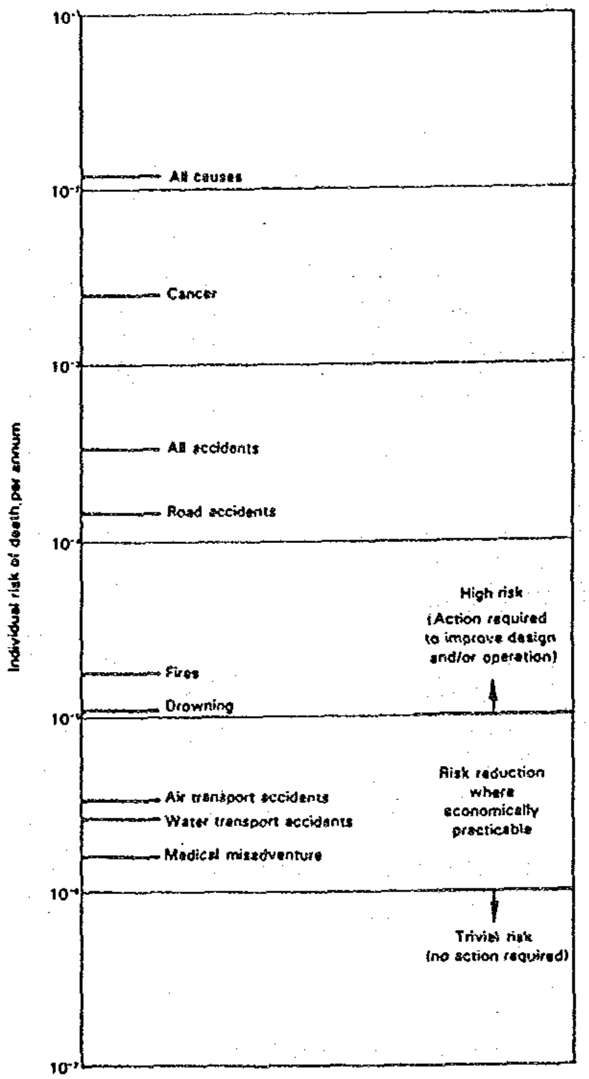

FIG. 8

Individual risks

Fig. 3.4.5-2 Risk of death facing an individual in normal civil life (Source: Lloyds Registers Technical Report No. 82)

Apart from the foregoing mode of quantifying the risk incurred by individuals, there is the notion of multiple fatality—i.e. the number of persons meeting death in a single accident. The diagrams reproduced in Figs. 3.4.5-3 and -4 relate the frequency f of accidents of a given degree of severity to the degree of severity — "severity" measured in terms of the number N of persons meeting death in one accident.

In Fig. 3.4.5-4, the line representing

$$fN = 10$$

is drawn to indicate the general trend shown by the curves. It means that when there are 10 accidents occurring in a year involving the death of 1 person, an accident involving 100 deaths is likely to occur once in 100/10 = 10 years. It would appear from these statistics that, whether public service vehicle or railroad passenger, an accident involving the death of 100 persons or more has to be expected to occur once in 10 years, as an invitable fact of life.

Today, the sole country in the world that has stipulated by statutory act the quantitative degree of safety to be ensured in an industrial activity is Norway, where the "Guideline for Safety Evaluation of Platform Conceptual Designs 1981–9", of the Norwegian Petroleum Directorate, which contains the stipulation in respect of "catastrophic failures" involving loss of human life that the "total probability of (their) occurrence should not exceed 10^{-4} per year". Taking this figure adopted in oil drilling—one of the world's leading heavy industry and mining activities—and further applying the empirical rule that minor accidents without loss of working manhours occur at a frequency of 300 to 600 times that of a catastrophic failure lurking behind them, the immediate target of safety that should be adopted at CODELCO, —and which would befit the representative enterprise of the Chilean Republic—should be 300×10^{-4}/year maximum, or assuming the total operating workload to be 2,000 manhours/year:

Frequency ratio of minor accidents $300\times10^{-4}/2{,}000 = 15\times10^{-6}$ manhours,

to be further lowered to the order of 10^{-6} manhours by 1989—the last year of implementation of the Plan of Modernization.

Such a degree of safety at work has already been achieved by the bulk of the leading manufacturing enterprises in the world, and could and should be realizable at CODELCO.

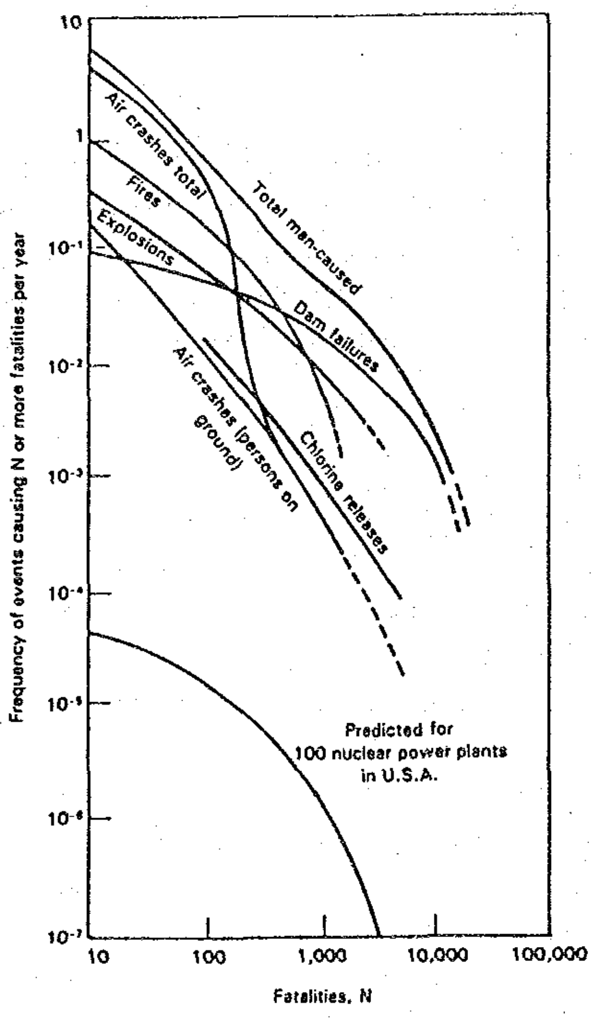

FIG. 9
Comparison of risks for fatalities (7)

Fig. 3.4.5-3 Frequency of events causing N or more fatalities per year
(Source: Lloyds Register Technical Report No. 82)

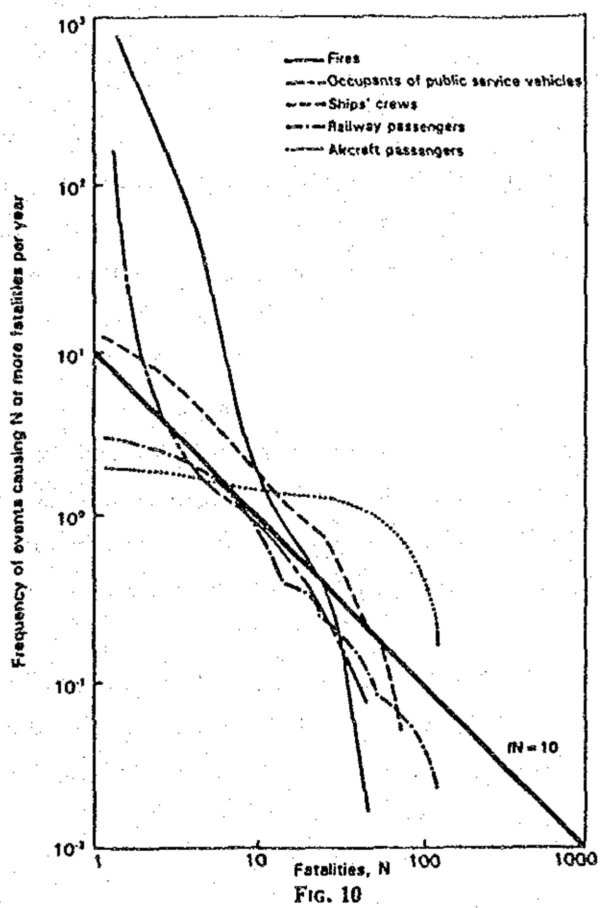

FIG. 10
Frequency of multiple fatality accidents in the U.K. (34)

Fig. 3.4.5-4 Frequency of multiple fatality accidents in the U.K.
(Source: Lloyds Register Technical Report No. 82)

3) Practical measures

The Foundry and Plate Shops show particularly poor records in respect of safety at work. What requires to be noted is that accidents frequently occur in "situations that are intrinsically safe". These accidents are the first to be suppressed. An accident that has "occurred in a 'safe' situation" is a "manipulative" accident, i.e. imputable to human action performed in discharging a function—in other words, due to inattention, inadvertence or disregard of safety instructions. Suppression of such deeds is often simple-mindedly considered realizable simply by forcing the personnel to obey rules more strictly, but in practice strictness alone will is not likely to succeed in lowering the accident rate. Discipline and respect of rules of safety is a matter of employee morale and of spirit of alertness pervading the enterprise: It is for the management to set the example with a serious approach to the problem of safety, to incite response on the part of the employees down the line in a truly motivated sense of the responsibility of each for this own safety and for that of others.

(1) Hardware

No accident must be allowed to occur due to insufficiencies in the equipment and in the system of shop management: Such occurrences run flagrantly counter to the concept of respect for human life, which is the basic principle underlying safety management at CODELCO, as well as against the social responsibility of any enterprise.

With the system of shop management well established at CODELCO, it should be possible to enforce the discipline necessary to have each and every member of the personnel never fail to follow the safety rules he has pledged to respect. As instances of what could immediately be put to practice:—

- Suppression of;
  = Overloading of cranes
  = Poorly maintained sling wires
  = Haphazardly inspected tooling
  = Inaccurately calibrated measuring instruments.

Such failures should be eliminated by reviewing the current organization for management of shop equipment, by reexamining or reconfirming the relevant written instructions, and by having each employee in charge pledge respect of the stipulated rules.

- Active utilization of the audit system, to undertake audits regularly and periodically on management* and systems** aspects affecting work safety, with the view to preventing accidents.

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*) Management audit: To determine how well safety policy and objectives are being met by the current management system.

**) Systems audit: To determine how well safety planning has been implemented, and to identify areas where changes should be beneficial to protect safety and safety cost. "Systems" includes manufacturing processes.

Individual items calling for implementation on the responsibility of enterprise based on regulations governing work safety, in order to enhance safety at work, in view of the rising work load brought by the increasing volume of equipment requiring to be supplied to support the mining operations—renovation of works buildings, of material handling/transfer facilities, ... are given in the Appendix.

(2) Software—Safety engineering

Established occasions require to be instituted for reviewing the design prior to proceeding with manufacture.

The Workshops Department does not by nature require to have its own design section, but it already possesses the capability of preparing production drawings from the functional drawings issued by the design group, and also guidance drawings containing instructions for the production floor workers.

The design review should take place at the stage where the production and guidance drawings are generated. The review meetings should gather together representatives from all the groups associated with production, to see that the production/guidance drawings contain—or will contain—all the design data and requirements in clear and understandable form.

In respect of work safety, the items to be reviewed include:—

- Whether ample consideration is incorporated in the design for the safety of production personnel/product user/persons who may be in the vicinity.

- Whether *sufficient consideration has been given to ease of production*; whether the design could not be modified to permit more mechanized/automated production techniques to be adopted

- Whether, in the light of past accident records (injuries, material damage, environmental destruction), the design does not leave room for improvement.

(3) Software—Guidance drawings

Guidance drawings, in particular, require careful examination prior to proceeding with manufacture, to ensure safety at work. True engineering can be considered to start at the stage of basic design: "All starts with design and is finalized in design". The drawings must contain all the information necessary for manufacturing and on required product quality. A production drawing laid on the table should be such as to permit the person reading it to mentally assemble and inspect the product.

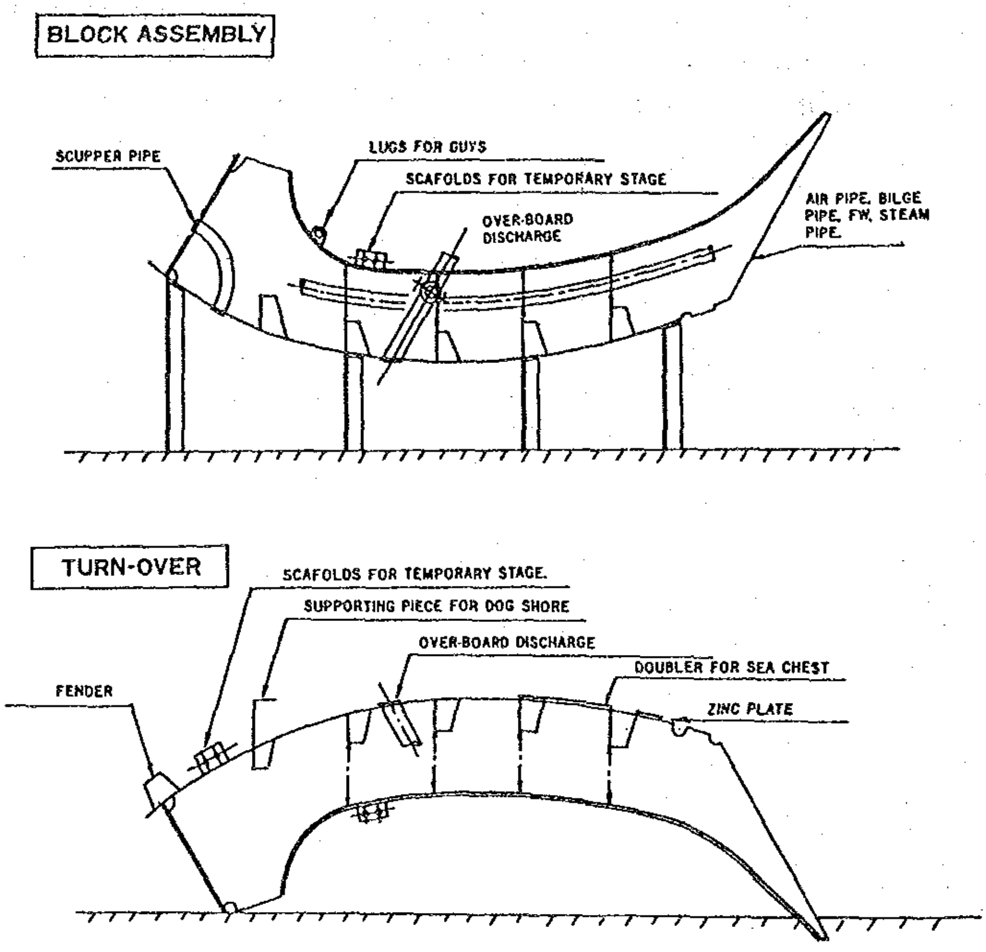
For instance, scaffolding and scaffolding lugs to prevent falls of personnel and of pieces of material, the positions of scaffolding lugs and pieces must be carefully examined on the drawings to ensure good arrangement in view of work safety: Examining the scaffolding means studying the position of the person working on scaffold in relation to his work; working in an easy and relaxed bodily position spells safety at work, as well as high performance and high productivity.

Concrete instances of points calling for consideration include:—

- Transferring as much as possible of the work from the erection yard to workshop, to permit more operations to be performed in the more comfortable, safer and surer downward position—i.e. welding in flat position, not in precarious overhead position. The products should be assembled at shop into larger assemblies.

- Outfitting work—attaching lifting lugs, fenders, ... —should be planned to permit its performance in comfortable position. For this purpose, the timing of such work in relation to that of turning over should be closely studied, together with the timing of rolling out to erection yard (Figs. 3.4.5-5, -6).

OUTFITTING WORKS IN
SIDE SHELL AT ASSEMBLY STAGE



Figs. 3.4.5-5, -6 Timing of turning over in outfitting work

What should be avoided is individual engineers examining their work individually, isolated from others, by providing ample occasions for overall coordination among all concerned, with due consideration to the interacting operations involved, but without undue expenditure of time for the purpose, such as to compromise the overall work schedule. The work site should not be excessively scattered: A compact though not overcrowded site of operations is favorable for ensuring close supervision and attendance to work safety.

4) Employee motivation and participation

Safety at work cannot be satisfactorily realized without labor and management coming to be of one mind on the matter of accident prevention. Management must set the example by strictly maintaining the equipment in safe operating condition, and by establishing clear and understandable written instructions; the employees should be instructed and trained to understand and feel the necessity of strictly following the instructions given to them and the established rules relevant to safety at work.

No one comes to work with the intention of getting injured; the desire to perform good work is a feeling shared by all: "Enhancement of safety at work" is a target that should not be difficult for management and labor to agree upon at CODELCO.

The employees should be made aware of what consequences their doing a poor job will bring on their colleagues and on their employers. Clear concrete targets should be indicated for each employee or small group of employees, and tangible targets should be indicated for workers on shop floor and for middle management, to provide a goal toward which to strive and to permit feeling the satisfaction of achievement. The participation of employees should be obtained at the stages of production planning and product improvement, to inspire them with the sense of sharing in the undertaking of production and of producing better products.

An effective means is to publicly proclaim and reward individuals and groups that have achieved commendable records in the matter of safety at work. Also, constructive suggestions from employees should be actively taken up, to let the authors of the suggestions feel the satisfaction of seeing their ideas brought into tangible reality.

Thus considered, the measures and techniques for ensuring safety at work is identical with those for enhancing productivity. They contribute to improving the human relations on the shop floor and in office, and the establishment of a spirit of solidarity and cooperation pervading the entire enterprise. The Productivity Circles existing at CODELCO should be able to play a vital role in this connection.

5) Examples of concrete measures to be adopted at Workshops

While the El Teniente Division as a whole could boast of its system for safety control, with rules governing work safety considerably well established, conditions at the Workshops—as noted in §2.7—leave room for improvement in respect of safety control.

The improvements require to be brought to aspects of both personnel and equipment. The first step in ensuring work safety is for those in supervisory position to think seriously about what can and should be done to let each of the workers under their charge execute his everyday duties in safety: Each supervisor must be imbued with a strong zeal for realizing an environment around him that is safe to work in, and possess the personal capacity to carry his conviction into effective action. The individual workers, on their side, must be awakened to the fact that it is none other than himself that must look to his own safety and to the safety of those around him, and be firmly resolved never to perform work in unsafe manner. The concerted action of supervisor and individual workers, joining hands to promote safety in their work is the essence of ensuring work safety.

Safety control simply enforced through the hierarchical system or by orders from above will not function effectively, still less if those directly in charge let detected deviations pass unchallenged. A typical impediment to proper safety control is to shelve or to delay adoption of measures in response to observations presented by front-line workers on unsafe conditions of work, or suggestions for enhancing work safety.

A spirit of mutual reliance between supervisor and worker is indispensable, based on which to exchange ideas on how their work could be performed more safely, and to be firmly resolved in following all rules of safety, including the use of safety equipment and apparel.

Such are the fundamental notions based on which labor and management should join forces in picking out the points calling for improvement in the current conditions at the Workshops in respect of work safety.

(1) Picking out points calling for improvement, and measures to be adopted

a) Picking out points calling for improvement

The procedure must begin with picking out the points calling for improvement, through a thorough study of prevailing conditions. What is essential here is to break off from the ruts of customary thinking, and strive to examine matters from a completely new angle. If not, one is tempted to justify the status quo—even if obviously involving unsafe working conditions—on such grounds as costly outlay incurred, or of inconveniences that would be introduced by changes, or difficulty in having operations interrupted for bringing about the necessary change, etc., etc., all of which risk preventing an objective and proper judgement to be brought on the situation under examination.

For this reason, it is advisable when considering safety measures to call in persons from other sections—e.g. the Safety Control group, other groups with a good record of work safety—to invite their contribution to deriving an objective judgement.

The examination should cover every detail, even minute points that might appear ridiculous—in all aspects of equipment, of human action, of the working environment, ...

b) Safety standards

Upon picking out the points considered to call for improvement in work safety, the next step is to find out whether standards have been established for judging the condition of work safety relative to the point in question. If not, the standard must be established.

Safety standards are drawn up in two forms:—

- General standards applicable in common to all workshops, established by the Safety Control group

- Particular standards applicable to specific kinds of work.

An example of particular safety standard applicable to iron melting process is presented in Table 3.4.5-1.

c) Follow-up of safety standard observance

When safety standards are found to be ignored in shop practice, every effort must be spent to trace the factors that are causing this neglect. Those in supervisory position must, on one hand, strive to create a working environment and atmosphere that are conducive to respect of established rules of safety, and on the other hand, consistently and insistently instruct those under their charge in the notions of work safety, through incessant persuasive dialog.

On the shop floor, the wearing of safety helmets, for instance, is sometimes shirked on grounds of their being hot, or heavy: It does not suffice to force the use of safety apparel by rule or by order; those who are to wear the apparel must be convinced of necessity, through explanation and persuasion. Audiovisual aids could be effectively utilized for this purposes: For instance, if stipulated wearing of masks is found not to be strictly practiced, slides illustrating the symptoms presented by pneumoconiosis and silicosis could be aptly shown to the workers concerned, in order to awaken their personal interest in protecting their own lungs.

Table 3.4.5-1 Standard operating procedure governing work safety in iron melting

		Foundry Shop Standard No. 20106-01 Drawn up (Amended) May 4, 1984
Operation: Iron melting by high-frequency induction furnace		Substance: General melting operation with high-frequency induction furnace
Apparel/tools used : Goggles, gaiters, leather gloves Material handled : Cast iron		
I T E M	GRADE	KEY POINTS (criteria for proceeding with work, safety precautions, quality, cost,...)
1. Checking, preparing for work		1. Properly wear safety apparel 2. Check cooling water system 3. Check induction coil/core and conductor parts for freedom from adhering spatters of metal 4. Check furnace lining for erosion 5. Check tap hole condition 6. Check oil-hydraulic system 7. Check furnace front pit, work floor conditions 8. Check furnace door functioning.
2. Furnace charging		1. Open furnace door 2. Charge furnace, beginning with materials melting easily (pig iron, casting returns), add small fragments; fully fill furnace. NOTES: (1) Never touch by hand materials being hoisted by crane. (2) To prevent material from striking furnace walls, have good communication established between sling operator and craneman. (3) When charging by hand, do not throw in roughly: Charge gently from a low position. 3. Avoid using material soiled with water, oil. 4. Avoid excessive mingling of rusty material, sand, dust.

3. Preparing to switch in	1. Turn ON synchronized power source. 2. Turn ON AC control power source. 3. Turn ON motor power source.
4. Switching in	1. Turn furnace selector switch to envisaged furnace (No. 1 or 2) NOTE: Switching over from one furnace to the other cannot be performed while furnace in operation. 2. Turn ON cut-off switch 3. Turn to OPERATION frequency modulation control switch. 4. Adjust to prescribed level the output voltage control rheostat. NOTES: (1) When furnace is cold: Operate for about 10 min. at 200 kW, then for about 10 min. at 400 kW, after which operate at full power. (2) When furnace is hot: Furnace may be operated at full power from outset. 5. Check that the dustcollector is functioning; open the ring hood damper of furnace in operation; leave remaining damper closed.
5. Additional feed to furnace	1. Open furnace door. 2. Whenever possible, let the additionally charged material fall still unmelted blocks remaining in furnace, to avoid splashing. 3. Particularly, large lumps should be laid on unmelted blocks, to let them preheat. 4. Never touch by hand material hoisted up by crane.
6. Heating up; adjusting melt composition	1. Never leave furnace front unattended after melt-down: This is particularly important in view of rapid heating-up (23°C/min for 1,000 kg charge). If required to leave furnace front for unavoidable reason, either - - have a substitute operator stationed in replacement in furnace front, or - lower furnace output power to 200 kW while unattended.

		2. Add recarburizer, ferrosilicon, other prescribed additives correctly according to calculation. NOTE: When adding recarburizer, close the damper. 3. When charging additives, and when measuring temperature, beware of sparking, and complete the operation as quickly as possible.
7. Tapping	C,D	1. Open the furnace door. 2. Check absence of foreign matter on tilting rack. 3. Turn OFF frequency modulation control switch. 4. Check position of ladle. 5. Switch furnace tilting hydraulic pressure to furnace in operation. 6. Tilt furnace, carefully adjusting the furnace angle in keeping with the flow of melt from furnace. 7. Crane operator to keep constant watch of ladle position. 8. Restore furnace correctly to original position. 9. Check furnace interior for remaining melt, wall condition. 10. Repeat melting cycle, beginning with easily-melting materials. NOTE: The furnace is still hot: Beware of scalds.
8. Finishing up		1. Switch OFF current: Following the sequence given under 1 above, in inverse order. 2. Tidy up and clean furnace front and surrounding work spaces. 3. Restore tools to prescribed storage positions.

9. Additional precautions applicable to alloy iron	1. After adding alloying material, and analyzing melt, supplementary additives to be charged must be - - preheated in vicinity of furnace, or - by burner. CAUTION: Do not touch preheated additive by hand. REMARK: The reason for preheating is to remove moisture adhering to surface and for dehydrating the additive. An instance is known of such moisture causing the melt surface in furnace to rise and overflow out of furnace.

REMARKS

1. Work standards are to be established individually for each unit operation.
2. In the event of accident, or upon a change brought to the work procedure or to material, the relevant work standard must be reviewed without fail.
3. The space for marking the grade of work is to be filled in with the applicable grade (A, B, C or D); if the work in question is not relevant to any of the four grades, the space is to be left blank.
4. When a work standard is drafted, approval thereof is to be obtained from the superior in charge, after which, copies are to be distributed to all relevant operators, to have them well understand the substance. The original sheets are to be retained by the assistant foreman.

(2) Action to be initiated by Workshops

The Workshop management should organize meetings and shop floor rallies on work safety, to provide occasion for recalling instances of equipment or operations of precarious nature, to pick out points calling for improvement, to consider remedial measures. The management should also establish safety patrols around the premises, and undertake action conducive to instilling safety-mindedness in all personnel, in consistent, continuing and active efforts.

a) Safety rallies/meetings

(a) Shop floor rallies

Shop floor rallies should be organized once a month, calling together the entire Shop personnel. The Shop manager should himself announce the principles and targets set for his Shop for the month. The rallies should then proceed with discussions on the conditions on shop floor relevant to work safety, and on measures for preventing work accidents, as well as on the manner of dealing with problems of work safety.

(b) Shop-Floor Work Safety Committee

The Shop-Floor Work Safety committee is to be constituted of Shop manager, foremen, assistant foremen, and persons in charge of individual shops—molding, melting, ...—and the group in charge of health and safety should also be represented. The committee should hear reports on work safety conditions at the different shops, and discuss measures to improve the safety and health of the employees working in the different shops.

(c) Team rallies

Each team working on shop floor should hold a 5-minute safety rally before starting the daily shift, to hear reports and to discuss daily occurrences and measures relevant to work safety. Operations planned to be undertaken during the shift should be scrutinized, to pick out elements presenting risk of accident, and to work out measures for eliminating the risk—i.e. preventive action.

Monthly meetings should be held, to determine what should be the target for the coming month, and what was accomplished during the past month, to follow up the established decisions and see how are they have been realized, and to serve in renewing the resolution of all members to enhance safety in work.

b) Shop safety patrols

Independently of the safety patrols organized on Workshop level, each shop should undertake patrols within their own shops. A team of two workers—with membership rotated daily to cover all the workers on shop floor in so far as possible—should make the rounds of the shop floor, once a day, taking say 2 hours to cover the whole shop.

During the patrol, the team should point out on the spot any unsafe operation or condition they may notice, and have the situation immediately corrected. Upon completing the daily round, the safety patrol teams should fill out a daily report on work safety, such as exemplified in Table 3.4.5-2.

c) System for declaring near-misses

Heinrich's law points out that, for every actually occurring accident, "near-misses" of very much higher frequency will have occurred previously. Experience of such near-misses can be made to serve effectively in adopting measures to prevent actual occurrence of the accident.

An example of format for reporting near-misses is presented in Table 3.4.5-3. Submission of such a report must not be followed by admonition given to the author for what he had done. What is important is to let him participate in drawing up measures for preventing recurrence of the near-miss, by having him relate in detail all the circumstances and conditions relevant to the occurrence in question. Simple admonition will not only obstruct such frank disclosure of circumstances, but further lead to a general reluctance to submit such reports.

d) Means of publicizing information relevant to work safety

At El Teniente, information relevant to work safety is displayed by telop, but this form of information has the shortcoming of being noted only by those who happen to pass by that particular location.

No practice appears to have been established of setting forth concrete principles to be followed and target figures to be attained relevant to work safety. Standards governing slinging, hoisting and handling for transfer are common to all shops, and relevant data such as allowable loads applicable to wire ropes and chains should be posted on a large board, for all to see.

e) Small-group action for promoting safety-mindedness

Effective enhancement of work safety can only be realized by implanting in the minds of individual members an active will to contribute by performing their work surely and safely.

To this end, small-group action can be effective, with the flexibility that can be accorded to the actions that can be taken, and with the feeling of participation that can be instilled in the members.

Table 3.4.5-2 Daily Report on Work Safety

	...day, 19..
I T E M	OBSERVATIONS MADE, REMEDIAL ACTION REALIZED
OBSERVATIONS: Patrol member :	.../100 ______ (Self-evaluated mark of accomplishment)
Assistant Foreman:	
Foreman:	
Section Manager:	

Table 3.4.5-3 Near-Miss Report

IMPORTANT: This report will be utilized as valuable data to serve in eliminating the factors that risk causing accidents lurking in every shop floor. Do not hesitate to report all near-misses that are experienced --to contribute to a safer working environment.	.... 19.. ....Section
NEAR-MISS REPORT	
To be filled in personally When : ...day ......19.. about : am/pm Where : Building: Shop: at/near: Experienced/observed (Cross out whichever not applicable) by: Name: Team/Shop/Section:	
To be filled in personally or by Assistant Foreman What happened (describe succinctly): What immediate measures were taken	
To be filled in by Foreman What countermeasures should be adopted	
Do not fill in this space Operation involved: Type of potential accident Report No.	
Assistant Foreman Foreman Section Manager i/c work safety - (copy to) Safety Section	

Group action can begin with brainstorming, to gather suggestions and ideas of measures that might be adopted, and proceeding to put them into practice starting from items that are simple and easy to carry out. The results obtained are then examined, and further improvements are brought as necessary to prevent recurrence of mishap or occurrence of potential accident. For further details, see under §3.4.3 Quality Control.

(3) Designing with work safety taken into consideration

In the Plate Shop, most of work is on spot orders from the El Teniente Division, with relatively little repetitive work. This calls for particular examination beforehand of the individual product designs from the standpoint of safety in production, which should not be sacrificed for reasons of production efficiency or ease of manufacture.

Considerations to be given for enhancing work safety should include:—

- Elimination of operations in enclosed spaces where operators working inside might risk asphyxiation—particularly when operation involves CO_2 welding.

- Minimizing operations in elevated position: Modification of working procedure or design, where possible, to have as much as possible of operations done on ground.

- Adoption of standardized scaffolding for articles of similar form manufactured in multiple units—e.g. inside ore cars.

(4) Criteria to govern the discarding of hoisting rig

For reference, examples are given in Table 3.4.5-4 of criteria to govern the discarding of hoisting rig—wire rope, chain/ring, shackles/hooks, huckers.

Table 3.4.5-4 Criteria for discarding Hoisting Rigs

A. Wire rope

I T E M	CRITERION FOR DISCARDING	KEY POINTS TO BE HEEDED IN INSPECTION
Broken elements	10 % or more wire elements broken in any braid	As rough guide, discard if more than 10 elements found broken Check in particular spliced parts
Wear	Diameter reduced by 7% or more from original diameter	Measure parts that appears particularly worn
Kinking	Ropes kinked by untwisting	Particularly, check splices and parts that are subjected to frequent bending
Denting, scratch-ing	Deep scratches and other deformations above 20% of wire diameter	Straighten parts that are tending to kink, particularly check slings used for hoisting articles with sharp edges.
Rusting	Rusty, dried-up surfaces	Check also for rusted wire in inner strands
Splices	Strands insufficiently inserted, deformation, damage, cracks	Strands twined in less than 3 times

B. Chains, rings

ITEM	CRITERION FOR DISCARDING
Wear	Thinned down by 10% or more of original diameter
Damage, dents	Attaining 10% or more of original diameter
Cracks	Cracks detectable by eye at joints and other parts
Elongation	By 5% or more of original length
Hardening	Hardened material

C. Shackles, hooks

ITEM	CRITERION FOR DISCARDING
Wear	Thinned down by 10% or more of original diameter
Deformation	Deformation detectable by eye
Cracks	Cracks detectable by eye at joints and other parts
Damage	Damage detectable by eye. Hooks opened out.
Damaged pins	Bent, worn thread
Hardening	Hardened material

B. Hacker

ITEM	CRITERION FOR DISCARDING
Wear	Thinned down by 5% or more of original diameter
Deformation	Devoid of wire stopper; significantly deformed
Cracks	Cracks detectable by eye at joints and other parts
Hardening	Hardened material

3.5 Raw Materials

1) Foundry shop

Among raw materials used in the foundry shop, the quality of silica sand (mainly composed of Sio) to be used for producing molding sand is a very important problem, and the following covers silica sand:

(1) Conditions of molding sand

For the selection of molding sand, the following criteria should be considered.

- Easy to mold.
- Mold shall have the required room temperature strength and the hot strength at the time of pouring.
- Molding sand shall have sufficient refractoriness so that no burned-on-sand is caused when molten metal of high temperature comes in contact with the sand at the time of pouring.
- Molding sand shall have sufficient permeability so that gas can pass through the mold at the time of pouring.
- Molding sand shall hardly be expanded or shrinked by coming in contact with the molten metal of high temperature at the time of pouring.
- Molding sand can be repeatedly used. In the other words, it shall be hardly crushed and shall be reproducible.
- Molding sand shall be easily collapsible at the time of knock-out.
- Molding sand shall not generate gas suddenly at the time of puring.
- The PH value shall be stable.

The aboves are main requirements for molding sand, and raw materials used for steel castings and satisfying these conditions are silica sand, zircon sand, chromite sand, olivine sand, etc.

(2) Composition of silica sand

According to JIS (Japanese Industrial Standard) code on material, material silica sand is divided to molding silica sand and molding natural sand. And JIS G5901-1974 (Molding silica sand) stipulates that the molding silica sand for producing steel castings shall contain less than 2% of clay (a fine particle smaller than 20 um stipulated in JIS G2601).

JIS G5901-1974 stipulate six types of silica sands, which are shown in Table 3.5-1. And Table 3.5-2 shows the silica sand used at present in foundry shop (Talleres).

Table 3.5-1 Stipulation of JIS G5901 on Chemical Components of Silica Sand

(Unit: %)

Type	Chemical Components	Chemical Components of Impurities		
	SiO_2	Fe_2O_3	Al_2O_3	CaO + MgO
1 Type	98 min.	0.5 max.	1.0 max.	1.0 max.
2 Type	96 - 98	1.0 max.	2.0 max.	1.5 max.
3 Type	93 - 96	1.5 max.	4.5 max.	2.0 max.
4 Type	90 - 93	2.0 max.	6.0 max.	2.5 max.
5 Type	85 - 90	3.0 max.	8.0 max.	3.0 max.
6 Type	70 - 85	5.0 max.	15.0 max.	5.0 max.

Table 3.5-2 A Example of Components of Silica Sand used at the Foundry Shop of E1 Teniente Workshop Department

(Unit: %)

	SiO_2	Fe	Al_2O_3	CaO	MgO	Na_2O	K_2O	Ti	P
Silica No. 0	86.4	1.4	7.2	1.5	0.35	0.90	1.00	0.3	0.012
Silica No. 1	83.9	9.0	1.4	1.4	0.32	0.85	0.90	0.3	0.011

In Japan, Class 1 (over 98% of SiO_2) to Class 3 (over 93% of SiO_2) are mainly used for core, and Class 4 (over 90% of SiO_2) is used sometimes. For application to products, Class 1 is used for thick and large castings because high refractoriness is required, and Class 3 is used for thin castings.

On the other hand, a shown in Table 3.5-2, the SiO_2 content of silica sand used in this foundry shop is as low as 86%, and this silica sand is not suitable for steel castings which require hot refractoriness.

(3) Grain Size of sand

The JIS G5901-1974 classifies the finess of sand into ten types from No. 10 to No. 200, and the number indicates the peak mesh number.

Table 3.5-3 shows the provision concerning the grain size of sand.

Table 3.5-3 Provision Concerning the Grain Size of Silica Sand in JIS G5901-1974

Type	Nominal Size of Sieve			Weight Ratio of Peak %	Weight Ratio of 3 Sieves %
#10	2380 (8)	1680 (10)	1190 (14)	40 min.	70 min.
#14	1680 (10)	1190 (14)	840 (20)		
#20	1190 (14)	840 (20)	590 (28)		
#28	840 (20)	590 (28)	420 (35)		
#35	590 (28)	420 (35)	297 (48)		
#48	420 (35)	297 (48)	210 (65)		
#64	297 (48)	210 (65)	149 (100)	30 min.	
#100	210 (65)	149 (100)	105 (150)		
#150	149 (100)	105 (150)	74 (200)		
#200	105 (150)	74 (200)	53 (270)		

Value in ( ) indicates the numbe of mesh.

As shown in the Table 3.5-4, #48 (Peak = 48 meshes) is now most used in Japanese foundry shops.

In view of the molding property and the high density of molding sand, the desirable finess composition is 4-screen or that close to it. But if this is not available with one type of silica sand, two types are mixed.

Table 3.5-4 Application Ratio per Grain Size (for Steel Castings)

(Unit: %)

Investigation Period	Number of Factory Investigated	Grain Size												
		#10	#14	#20	#28	#35	#48	#48-#65	#65	#65-#100	#100	#150	#200	Indefinite
1979 (Oct. to Dec.)	62	0.8	0.4	1.0	6.6	7.5	41.1	6.6	21.3	5.5	5.7	0.7	0.3	2.5
1980 (")	68	-	-	1.4	4.2	6.9	39.5	2.1	26.0	7.7	7.7	0.7	2.7	1.1
1981 (")	67	-	0.2	0.4	2.9	5.8	48.4	1.8	18.2	8.3	8.9	-	1.2	3.9
1982 (")	56	-	0.2	0.1	3.1	11.7	48.8	3.5	11.2	8.5	7.1	0.2	0.1	5.5
1983 (")	59	-	-	0.4	2.3	4.6	49.3	1.2	10.8	2.1	12.9	0.9	1.4	14.1
1984 (")	59	-	0.1	0.6	2.3	7.3	38.6	2.4	16.8	-	16.4	0.3	3.0	12.2
1985 (")	55	-	1.9	0.2	2.7	9.3	42.8	0.6	14.2	2.5	16.0	1.5	0.2	8.1

Table 3.5-5 Finess of Silica Sand at E1 Teniente Workshop Department

Sand	Grain Size
Silica sand	48 - 53

Judging from the above table, we consider the grain size is acceptable.

(4) Conclusion

In the above, we compared various properties of silica sand, and we have come to the conclusion that the present silica sand is not suitable for producing good castings. So, we recommend you to study the following methods as the countermeasures for improvement:

a) Contact specialist of geology at university, or material sand suppliers to investigate the availability of good sands and to study them.

b) Select important and/or thick parts, and use chromite sand as facing sand for them.

c) Change the facing sand for steel castings to all chromite sand. This can be used repeatedly by eans of a collector. This mthod is applied in Japan.

d) If proper sand is not available, it is recommended to import flattery sand or freemantle sand from Australia. they are very pure, and their cristals are very hard and resistant to clushing. these sand can be collected thorugh a collector after use and can be repeatedly used. the closed system is applicable.

The following cover problems caused when chromite sand is used together with silica sand:

- Burned-on sand phenomenon due to mixture of chromite sand and slica sand

Chromite sand is sectionally ued in this plant, and the burned-on-sand phenomenon occurs sometimes though the chromite sand is hot refractory. The reason may be considered as follows:

Chrome ore, the material of chromite sand, contains various impurities such as magnesium and silicate. Table 3.5-6 shows examples of compositions of thse impurities.

Table 3.5-6 Composition of impurities Contained in Chromite Sand

Composition (%) / Specimen	SIO_2	MgO	Al_2O_3	Fe_2O_3	CaO	Cr_2O_3
Impurity A	50.8	30.2	3.80	12.8	1.86	Trace
Impurity B	69.6	11.0	8.24	1.65	tr.	-

The melting point and the vitrification point are important problems in connection with the burned-on-sand phenomenon. Figure 3.5-1 and 3.5-2 show the constitutional diagrams of SiO-MgO-FeO system and SiO-MgO-Al_2O_3 system.

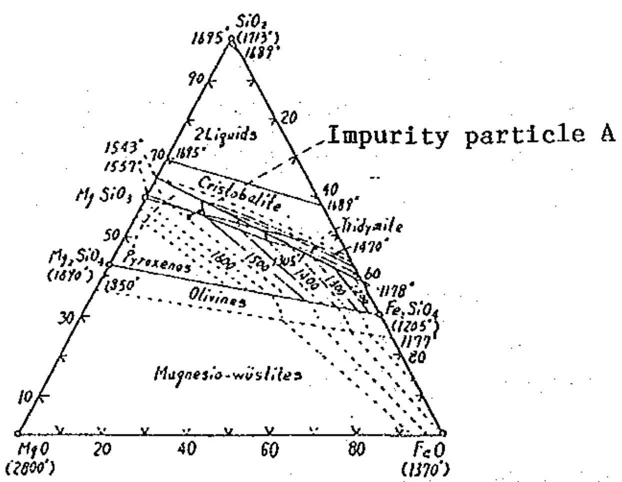


Figure 3.5-1 Constitutional diagram of SiO_2-MgO-FeO System

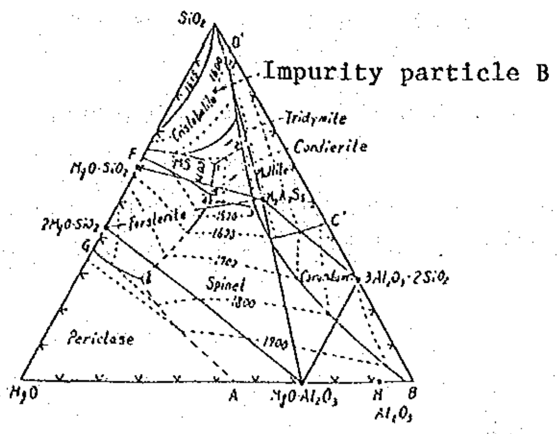


Figure 3.5-2 Constitutional Diagram of SiO_2-MgO-Al_2O_3 System

These constitutional diagrams show compositions or respective systems on the assumption that the brown impurity A and the white impurity B are pure ternary system minerals, and the melting points of these impurities obtained from the ternary system constitutional diagram are 1540°C and 1580°C respectively and are considerably low as compared with the one of chromite, 1900°C to 2000°C. Also, if the influence of other trace oxides is taken into account, these melting points will be much lower.

In the relation with penetrating type burned-on-sand phenomenon, vitrification point is also considered an important factor in addition to the melting point of refractories. In the other words, chromite sand is sintered by the solid phase reaction in high temperature and has high hot strength, and, therefore, effective for the prevention of penetrating type burned-on-sand. but if impurities are included in the chromite sand, impurities or other materials including between sand particles are softened or melted near the surface of the mold. So, the mold's resistance against the penetration of molten metal is lowered, molten metal comes to penetrate in the mold easily, and the mold is sintered remarkably. This face can explain that the more impurities are contained, the deeper the molten metal penetrates in the mold. Therefore, it is a general tendency that the more impurities are contained, the more remarkably the mold is sintered and the more remarkably the burned-on-sand resistance is degraded.

The proper contents of impurities cannot be decided equally because such contents differ with size and shape of applicable steel casting. But when SiO_2 content is less than 1.5%, chromite sand is fully effective for preventing the burned-on-sand phenomenon.

Therefore, when the chromite sand is partially used for mold,

- It should be molded using care that chromite sand does not mix with silica sand.
- When chromite sand mixes with collected silica sand, the molding sand is degraded. So, it is desirable to use a chromite separator/silica sand collector.

In the above, we have explained the burned-on-sand phenomenon due to combined use of chromite sand and silica sand, the generating mechanism and cautions at the time of molding.

2) Plate shop

(1) Steel material

In view of rust prevention and mistaken use prevention, steel materials shall be stored by the followng procedures:

a) Material identification

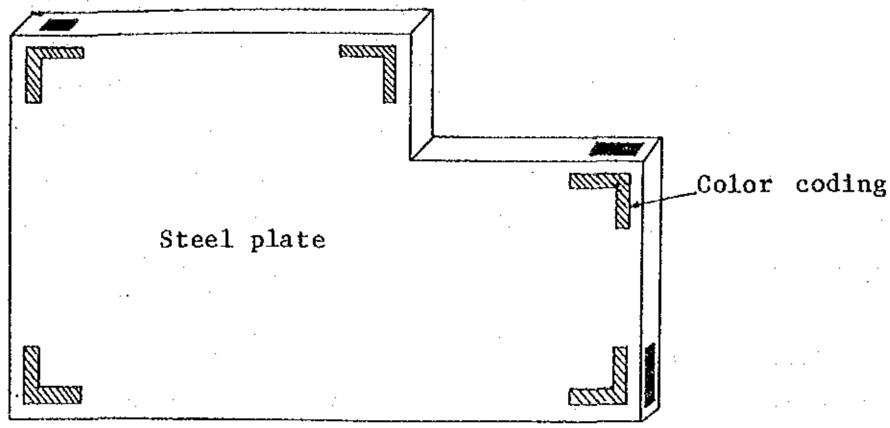
In the worst case, material misuse will result in a serious accident. therefore, it is necessary to pay the greatest attenion to misuse in the control of materials. The plate shop does not handle many materials, and the control is not so difficult.

For example, color coding on matrial can prevent most of misuses.

A-37-24ES	—	White
A-42-27ES	—	Blue
A-52-34ES	—	Yellow
T-1 Steel	—	Red

.
.
.

Color coding shall be decided as above, and square marks are shown on the four corners so that anybody can identify them easily. Also, if marked on sections (edge), materials can be piled up and be identified. Also, if marked on sections (edges), materials can be piled up and identified them.



b) Piling method

Materials shall be piled up per type or plate thickness (6 to 8 mm, 9 to 12 mm, ...) so that necessary materials can be easily taken out. When piling materials, take a space of at least 300 mm between materials and ground surface to prevent rust due to rebound of rain water. Also, keep a space of over 50 mm between steel plates to prevent rust due to water drops retained on steel plates adhered. These spaces are necessary for the transportation by forklift and the slinging work by mobile crane.

c) Material yard

Materials shall be stored clearly not in a spacious area but in a minimum area at a given range. Semifinished products and scraps shall not be stored in the material yard.

(2) Welding materials

Even if most of the weldig materials are changed to flux-cored wire for CO_2 gas weling due to the modernization, the annual consumption of the covered electrode will be 7.4 tons in 1989. Most of them will be changed to low hydrogen type electrode, it is recommended to use a small warehouse for drying and preservation.

Therefore, a small dry warehouse with the capacity of 50 kg shall be constructed in the tool warehouse adjacent to the plate shop, and the specified drying shall be carried out.

Electrode delivery to welders shall be made once a day except in winter. That is to say, unused electrodes delivered in a day shall be returned to the tool warehouse at the end of the work. The returned electrodes shall be dried again fro reuse. In winter, it is recommended to apply the rule which is widely used in Japan, i.e, electrodes are delivered and returned every four hours becuase it is very humid in winter. Also, it is recommended to use a delivered electrode keeping in an "Ingdryer" or holding in an electrode can.

Electrodes scattered in the workshop are really waste and are serious problems for quality control and for safety management. The management should never over-look such situations and should make efforts to keep the workshop in trim order by giving stringent advices to subordinates.

3.6 Personnel Training Program

The followings explain the training to personnels who handle directly new technologies and equipments introduced to the plate shop:

1) Foundry shop

The technology and the equipment to be introduced this time to the finishing process of casting are selected from a short-term view-point, and the equipments include the swing grinder and the high frequency grinder. The operations of these equipments are not so different from those of the equipments which have been used till today, and new personnel training for these new equipments are not considered necesasry.

2) Plate shop

The followings are the trainings required for the new technology and equipment introduced to the plate shop to personnels who handle them directly:

(1) Flux-core CO_2 Welding

As detailed in Paragraph 3.2.2, welders in charge of semi-automatic welding can basically accept the flux-core CO_2 welding without any resistance. So, as for the operating method, it is not necessary to invite an engineer from abroad or to go abroad to acquire the technique.

However, since this welding method is introduced in a large scale, it will be necessary the factory will provide some systematic training to their workers.

a) Lecture course

The lecture contents shall be edited referring to Paragraph 3.2.2, Welding process in plate shop, various technical papers, manufcturers' catalogs, etc. The main items are as follows.

(a) Features of flux-core CO_2 welding

- Explanation of welding method
- Efficiency comparison
- Construction and handling of welding machine
- Welding conditions (Current, voltage, speed, and gas flow rate)
- Basic matters concerning welding (distance between chip and base metal, torch angle, arc striking method, weaving, crater treatment and electrode connection, measures against wind)
- Defect at weld zone and countermeasures
- Maintenance and inspection (conduit, chip, nozzle, shielded gas, feeding, pressure roller)

(b) CO_2, CO gas

(c) Safety

b) Skill training

(a) Selection of instructor

Select a welder who is best versed in semi-automatic welding in the plate shop, and left him acquire the flux-core CO_2 welding method by practically welding test pieces.

(b) Skill training

This welder shall teach this new welding method to general welders as an instructor. Speaking from the experience in Japan, trainees of basic education on CO_2 at the training center of INACAP or others will come to use this new method sufficiently only in a day.

(2) Automatic welding by means of positioner and mainpulator

This welding is for repair by welded overlay. Especially for build-up welding of bowl and thread secton of the adjustment of ring, hard welding conditions are required due to the shape. So, every preparation should be made carefully before the introduction.

a) Necessity of full time welding engineer

For the period from introduction planning to complete fit of automatic welding in the workshop, a full time welding engineer shall be selected and shall be responsible for facility planning, machinery selectionfor introduction, its installation, confirmation of welding conditions, preparation of training text, training of welder, troubleshooting after commencement of operation, and various improvement in the workshop.

b) Invitation of experienced foreign engineer of this welding method for instruction

In order to teach the full time welding engineer of the Workshop Department, to smoothly introduce the new technology and also to bring about the effect, it is necessary to invite an experienced engineer from the supplier country of the machine introduced. The term will be about three months.

c) Instruction by engineer of introduced macine manufacturer

It is necessary to invite an engineer from the manufacturer of the introduced machine who can provide instructions on installation, operation and other mechanical matters, and also to receive various advices on maintenance and inspection from him so that perfect machine operation is possible. The term will be around one month at most.

3.7 Estimated Cost of Modernization

3.7.1 Conditions assumed for Estimation

The followings are the conditions to calculate the estimated costs required for the workshop modernization plan of Div. El Teniente of CODELCO.

1) Basic conditions

* Currency exchange rate : US$1 = ¥160
* Import duties : 20% of the CIF price is included as import duty.
* Basis of price : All prices are based on prices in 1986.

2) Details of estimated cost

The costs were estimated in the following items both for the plate shop and the foundry shop separately:

(1) Machinery

Prices (CIF) of machinery required for the workshop modernization including grinding machine to be installed in the finishing process of the foundry shop and automatic welding machine to be installed in the welding process of the plate shop were included.

Note: Insurance premium and freights were calculated referring to Table 3.7.1-1.

(2) Expenses for customs clearance and landing charges

1% of CIF price was included as expenses for customs clearance and landing of the imported machinery.

(3) Inland transportation costs

The transportation charges from VALPARAISO Port to the workshop were calculated based on US$6.4 per ton.

(4) Local construction costs

Expenses for installing machinery and foundation were calculated as follows:

Required quantities and amounts of materials and manhours were calculated referring to the experience in Japan, and prices were estimated based on the information obtained in the Republic of Chile (Table 3.7.1-2).

(5) Utilities

Utilities including electricity and water supply were regarded that the present facilities have enough capacity.

(6) Expenses for installation and operation instructor

The expenses for installation and operation instructor were estimated due to the introduction of new facilities.

(7) Expenses for technical instructor

The expenses to employ instructor were estimated in order to acquire new technology required for the introduction of automatic welding machine.

Table 3.7.1-1 Calculation Method of CIF Price (1/2)

(Unit : US$)

Products / Type of Charges	Machinery	Electric Items	Steel Structure	Steel Products	Pipes	Welding Rods
1. Base rate (*1)	188.0	188.0	92.0	180.25	99.5	206.25
2. Heavy (*2)	(*5)	(*5)	(*5)	(*6)	(*5)	(*5)
3. Length (*3)	(*7)	(*7)	(*7)	(*7)	(*7)	(*7)
4. Banker surcharge (*4)	8.0	8.0	8.0	8.0	8.0	8.0
5. Currency adjustment factor	Use the following formula for the calculation respectively. (1. + 2. + 3. + 4.) *0.25					
6. Freight total	Use the following formula for the calculation respectively. = (1. + 2. + 3. + 4. + 5.)					
7. Insurance	Use the following formula for the calculation respectively. = (FOB Price + 6.) *0.00331					
8. CIF	Use the following formula for the calculation respectively. = (FOB Price + 6. + 7.)					

Table 3.7.1-1 Calculation Method of CIF Price (2/2)

(*1) ... Per freight ton

(*2) ... Both the range and the price were based on weight

(*3) ... The range was based on length and the price based on freight ton

(*4) ... Per freight ton

(*5) ... As per the following Table

Range	Price
Up to 7 tons	0
7 tons - 8 tons	22.5
8 tons - 9 tons	25.0
9 tons - 10 tons	27.5
10 tons - 11 tons	30.0
11 tons - 12 tons	32.0
12 tons - 13 tons	34.0
13 tons - 14 tons	36.0
14 tons - 15 tons	38.0

(*6) ... As per the following Table

Range	Price
Up to 6 tons	0
6 tons - 7 tons	11.0
7 tons - 8 tons	13.5
8 tons - 9 tons	16.0
9 tons - 10 tons	18.5
@*2.5	

(*7) ... As per the following Table (The price based on freight ton)

Range	Price
Up to 11 m	0
11 m - 14 m	7.5
14 m - 17 m	15.0
17 m - 20 m	22.5

Table 3.7.1-2 Estimating Method of Local Construction Costs

Local construction cost

$$= \text{Construction cost in Japan} \times \frac{\text{Unit price in the Republic of Chile}}{\text{Unit price in Japan}}$$

Local construction cost

$$= \text{Material cost in Japan} \times \frac{\text{Unit price in the Republic of Chile}}{\text{Unit price in Japan}}$$

$$+ \text{Wage in Japan} \times \frac{\text{Unit price in the Republic of Chile}}{\text{Unit price in Japan}}$$

Local construction cost = (Material cost in Japan x A) + (Wage x B)

A and B were supposed to be 1 and 1/2 respectively.

3.7.2 Estimated Cost

The investment cost required for the execution of the modernization program of the finishing process in the foundry shop and the welding process in the plate shop shall be estimated separately per shop. The costs shown here cover the modernization program in view of profitability which is mentioned under the section of 3.3 Production Facilities. Though shop rebuilding, layout improvement and introduction of high performance facilities are explained in the Paragraph 2) Desirable Shop Plan in the Future under the Section 3.3.2 Finishing Process in Foundry Shop, the investment costs for these plans in the finishing process are outlined for reference in the Paragraph 3) of this Section.

1) Finishing process in foundry shop

Table 3.7.2-1 shows the names, specifications, quantities, delivery term and estimated amounts of new machinery necessary for the finishing process.

Table 3.7.2-1 Estimation of New Machinery Necessary for Finishing Process

CIF

No.	Name	Specification	Quan-tity	Delivery term	US$
1	Constant peripheral speed suspension grinder	Motor power : 15 HP Grinding stone: ϕ510 x 50 t x ϕ50.8 mm Peripheral speed:50 m/s	4	6 months	78,096
2	Turn table	Movable load : 3 TON Table diameter: ϕ1,000 mm Electric driving	2	4 months	20,646
3	Turn table	Movable load : 1 TON Table diameter: ϕ800 mm Electric driving	2	4 months	14,720
4	*High frequency* grinder	*Power unit: Inverter* Grinder : Pot type, 1.4 KW, ϕ180 mm, etc.	6	4 months	15,983
				Total	129,445

2) Welding process in plate shop

Table 3.7.2-2 shows the names, specifications, quantities, and estimated amounts of new machinery necessary for the welding process.

Table 3.7.2-2 Estimation of New Machinery Necessary for the Welding Process (1/2)

CIF or local construction cost

No.	Name	Specification	Quantity	Delivery term	US$
1	CO_2 welder	500 A, Wire diameter 1.2, 1.6 ϕmm Composition: Power unit, wire feeder, welding torch, gas governor, remote controller, accessory cable, spare parts (for two years)	16	4 months	96,896
2	CO_2 welder	600 A, Wire diameter 1.2, 1.4, 1.6, 2.0 mm Composition: Power unit, wire feeder, welding torch, gas governor, remote controller, cooling water chiller, accessory cable, spare parts (for two years)	2	4 months	22,938
3	Positioner	15 TON Table size: 2,500 x 2,500 ϕmm Table height: 2,450 mm	1	4 months	91,733
4	Manipulator	Horizontal stroke: 3,000 mm Vertical stroke: 3,000 mm Movable load: 150 kg	1	4 months	67,265
5	Automatic profile controller	Carrying capacity: 75 kg Control functions: Vertical, horizontal (manual), horizontal profile, tack welding detection, end detection	1	4 months	7,987

Table 3.7.2-2 Estimation of New Machinery Necessary for the Welding Process (2/2)

CIF or local construction cost

No.	Name	Specification	Quantity	Delivery term	US$
6	Table lifter	1,000 kg Table size: 1,500 x 2,500 mm Lift: 3,000 mm	1	4 months	7,132
7	CO_2 gas piping	ø1 1/4" x 100 m ø1" x 300 m with header (Local construction)	1	2 months	5,850
8	Submerged arc welder	1,200 A, Wire diameter 4, 4.8, 6.4 ømm Composition: Power unit, wire feed head, travelling truck, rail	1	4 months	22,464
9	Electrode dryer	50 kg x 400°C Capacity: 200H x 300W x 580L mm	1	4 months	1,585
10	Assembling and welding surface plate	0.15t x 6.5W x 20L mm Concrete surface plate for burying shape steel (local construction)	1	2 months	13,100
11	Instructor for machine erection and operation	Instruction for erection and operation of new machinery	1		18,750
				Total	355,700

3) Approximate estimated cost for future plan of finishing process

No.	Name	Specification	Quantity	US$
1	Remodeling of finishing shop	12 x 114 m, concrete floor	1	625,000
2	Overhead travelling crane	10 TON x 12 m span	2	312,500
3	Overhead travelling crane	5 TON x 12 m span	1	137,500
4	Traverser	10 TON, including rail	2	62,500
5	Moving of shot blasting machine	Existing 2 units	2	62,500
6	Automatic grinder	20 HP, ϕ510 x 50 x 50.8 mm	1	375,000
7	Constant peripheral speed fixed grinder	5 HP, ϕ455 x 50 x 50.8 mm	2	25,000
8	Dust collector	For automatic grinder, constant peripheral speed fixed grinder, and suspension grinder	2	187,500
			Total	1,787,500

3.7.3 Amounts of Cost

The amounts of the investment costs required for the modernization are shown in Tables 3.7.3-1 (Total), 3.7.3-2 (Foundry shop) and 3.7.3-3 (Plate shop). The investment costs required for the modernization of the foundry shop and the plate shop are US$156,000 and US$467,000 respectively, and the total of the both shops comes to US$623,000.

The base project costs excluding the import duty are US$130,000for the foundry shop and US$403,000 for the plate shop, and the total comes to US$533,000. The import duty occupies 14% of the total investment amount. Foreign currencies out of the total investment amount comes to US$510,000 or 82%.

Table 3.7.3-1 Investment Costs Required for the Modernization (Total)

(Unit : US$1,000)

Item	Foreign Currency	Domestic Currency	Total
Machinery costs (CIF)	447		447
Customs clearance and landing charges		4	4
Inland transportation costs			
Local construction costs		19	19
Expenses for installation and operation instructor	19		19
Expenses for technical instructor	44		44
Base project cost	510	23	533
Import duty		90	90
Total project cost	510	113	623

Table 3.7.3-2 Investment Costs Required for the Modernization (Foundry Shop)

(Unit : US$1,000)

Item	Foreign Currency	Domestic Currency	Total
Machinery costs (CIF)	129		129
Customs clearance and landing charges		1	1
Inland transportation costs			
Local construction costs			
Base project cost	129	1	130
Import duty		26	26
Total project cost	129	27	156

Table 3.7.3-3 Investment Costs Required for the Modernization (Plate Shop)

(Unit : US$1,000)

Item	Foreign Currency	Domestic Currency	Total
Machinery costs (CIF)	318		318
Customs clearance and landing charges		3	3
Inland transportation costs			
Local construction costs		19	19
Expenses for installation and operation instructor	19		19
Expenses for installation and operation instructor	44		44
Base project cost	381	22	403
Import duty		64	64
Total project cost	381	86	467

3.8 Schedules

3.8.1 Project Implementation

1) Basic master schedule

As the practical and highly realizable method of factory modernization with the least investment for the largest effect, the following steps are generally taken:

- To review the current situation both from the control side such as production control, process control and quality control and from the technical side such as production technology and production facility.
- To improve productivity and increase production by eliminating waste and carrying out various improvements based on thorough engineering, and then
- To introduce new facilities gradually to further the productivity.

In factories of job-shop type production, the operation rate of main equipments purely for product machining is generally very low, and the main reason why they cannot contribute for production increase is the low efficiency of auxiliary equipments around main facilities and of working procedures in most cases. This tendency can be observed in this plant as well, and it is desirable to take this step.

However, since the production should be increased in a short time in this case, this step shall be taken together with the introduction of new equipments, be continued even after the introduction, and then lead to a next modernization program.

This basic schedule is shown in Table 3.8.1.

2) Execution plan

When the execution of this project is decided, the constructors shall take care of the followings as their roles in order to make the tie-in with related facilities, equipments and utilities and the consistency with new products and the machining method most suitable for the accepting factory:

1. To make out the implementation plant to introduce the new machinery.
2. To decide the detailed specifications of new machinery.
3. To design related jigs and tools.
4. Management of foundation construction, utility construction and installation of machinery.
5. To make out and execute training plans of technical persons and workers for smooth operation

Though these jobs can be executed under the current organization, it is desirable to organize a project team to promote the equipment works consisting of suitable persons who can work exclusively for the project. The details are on the following page.

Table 3.8.1 Basic Master Schedule

Item		1986	1987	1988	1989	1990
Production program TON (%)	Foundry shop	5,540 (100)	6,370 (115)	7,200 (130)	8,000 (144)	8,000 (144)
	Plate shop	4,554 (100)	5,054 (111)	5,555 (122)	6,100 (134)	6,100 (134)
Review of current situations, and improvement		Study of report Review of current				
Introduction of new technology and equipment		Preparation of project execution plan Budgetary measures Material procuring measures Introduction of equipment and machinery Training				
Next modernization program				Review and improvement Making-out of next rationalization program		

(1) Organization of project team

The project team is the execution body of the equipment and should be organized at first.

1. To have the knowledge of products (work pieces)
2. To have the knowledge of machining technology.
3. To have the knowledge of (long term) production planning.

In addition, it is desirable to have enough knowledge on safety and health, operation of machinery, civil engineering, building, machine installation and electric works. However, these knowledges can be provided by specialists for proper arrangements, if necessary. So, suitable members will be selected from the section governing the relevant process, maintenance department and production planning department.

(2) Detailed works of project team

The project team takes care of the whole project from the establishment of detailed plan of equipment work to construction management and the commencement of operation.

The concrete works are as follows:

1. Establishment of equipment work schedule satisfying the target shown by the top management.
2. To make out the engineering schedule to execute the equipment works based on the above.
3. To design the layout of equipments and machinery.
4. To decide the detailed specifications of equipments and machinery.
5. To design related necessary jigs and tools.
6. *Various works to select suppliers of equipments and machinery.*
7. Various work to select local constructor
8. Execution management of suppliers and constructors
9. Adjustments between suppliers and constructors
10. Various works to select training instructor
11. Instructions to and cooperation with training instructors
12. Adjustments between related departments in the company

In the execution of the equipment works, however, the project members are required to order necessary related items, receive items delivered to them, to store such items, pay to suppliers and constructors and to adjust the production line under equipment work in addition to the aboves, and it is necessary to carry out these by design in concert with the existing organization.

3.8.2 Construction and Civil Works

It is important to make out execution schedules of the equipment works and the installation of machinery in the execution of this modernization program and to carry out execution management, taking the followings into account.

1) Finishing process equipments in foundry shop

Since large fixed equipments are not introduced, special large scale foundation work and equipment work are not required for the finishing process equipments. So, the introduced machinery has only to be installed after the removal of the existing machinery.

a) Matters to be considered in schedule

Constant peripheral speed swing grinder, turn table and high frequency grinder are all single machines and can be used independently. So, they can be introduced regardless of the order.

Since only a power source is required as utility, a switch box or a plug receptable has only to be prepared near its location.

b) Matters to be considered in execution management

The installation place of a turn table should be made level, and it is necessary to fix it (at two places with anchor bolts) to prevent slippage. Also, it has built-in electric parts and should be protected from water leakage and shock during transportation and operation.

2) Welding process equipment in plate shop

The welding process equipments require floor concrete work for assembling and welding surface plate, local laying construction of CO_2 gas pipe and installation works of welding machine and machinery for automatic welding.

a) Matters to be considered in schedule

(a) Shape steel frame should be prepared in advance, and the schedule should be arranged so that the assembling and welding surface plate can be installed at the same time when the shop floor is excavated. Also, machinery for automatic welding is installed on this surface plate, and the plate should be completed before the delivery of the machinery taking the curing term of concrete (about three weeks) into account.

(b) The CO_2 gas pipe is extended from the CO_2 gas generator in the foundry shop. This piping takes considerable time because the pipes are laid along the inforcing bars of the construction building under operation.

This piping work is also for welding and, therefore, should be completed before the welder is delivered.

(c) Other machinery is placed on the floor separately, and only power switch box or plug receptacles have only to be prepared.

b) *Matters to be considered in execution management*

Since the piping work for CO_2 gas is executed at high place in the plate shop under operation, it is required to fully study the safety measures for interference with crane and the security of scaffolding before starting the work.

Welder and other machinery have built-in electric parts, and they should be protected from water leakage and shock during transportation and operation.

3) Supervisor

Since the installation and the trial operation of automatic welding units should be witnessed by a supervisor, arrangements should be made to ask for dispatching a supervisor.

Supervisor's witness is required for the followings:

Automatic welding unit = Positioner,
Manipulator,
CO_2 welder, and
Automatic Profile Controller

In addition, automatic welding work should be carried out in the trial operation of the automatic welding unit, and workpieces should be prepared for the trial operation. Supervisor will not be dispatched for the purchased items other than the aboves, and only instruction manuals in English will be attached to respective items.

3.8.3 Scope and Schedule of Construction

1) Scope of construction

The scope of construction in a new equipment work shall be as follows:

(1) Construction by CODELCO

a) Building construction and its appurtenant works
b) Machine foundation and pit construction
c) Primary and secondary piping works and the appurtenant works
d) Primary and secondary wiring works and the appurtenant works
e) Local customs clearance
f) Local unloading
g) Local procurement of machinery
h) Installation and trial operation of machinery
i) Preservation of machinery
j) Procurement of machines and materials for installation
k) Construction management

(2) Execution by supplier (Imported items)

a) Procurement of machinery (Ex CIF)

b) Procurement of jigs and tools (Ex CIF)
(For some equipments, instructors will be dispatched for installation and adjustment in trial operation.)

2) Work schedule

Works for this modernization project are roughly divided into the following two works. Their respective work schedules are shown in Table 3.8.3-1 and -2.

(1) Finishing process equipments for foundry shop

(2) Welding process equipments for plate shop

Table 3.8.3-1 Machine Installation Work Schedule in the Finishing Process of the Foundry Shop

Item \ Month	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Master Plan													
1) Basic conception of equipment	—	→											
2) Conception of equipment layout		—	→										
2. Detailed plan													
1) Detailed design of layout				→	Purchase order								
2) Decision of detailed machine specification				—	→	▼							
3. Foundation and wiring works										—	→		
4. Machine installation						- - -	- - -	- - -	- - -	- - -	↓ —	↓ →	
5. Trial operation													→
6. Turnover													◎

Table 3.8.3-2 Machine Installation Work Schedule in the Welding Process of the Plate Shop

Item \ Month	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Master Plan													
1) Basic conception of equipment	—	→											
2) Conception of equipment layout		—	→										
2. Detailed plan													
1) Detailed design of layout				→	Purchase order								
2) Decision of detailed machine specification				—	→								
3. Foundation, piping and wiring works								—	→				
4. Machine installation										→			
5. Trial operation											→		
6. Turnover											◎		

3.9 Points to be Heeded in Implementing the Project

General Understanding of Modernization

It is desirable to take the following steps for the modernization of existing factories:

1) When a process in a production line is modernized, a modernization plan should be established from the view-point that this modernization is only a step to the future image of the whole production line.

2) The first step of the modernization should make the flow of production rational and economical. In the other words,

   a) To rationalize the machine layout so that materials flow in the order of manufacturing process.
   b) To improve the control method so that materials flow smoothly between processes.
   c) To improve the quality and proceed with the productions smoothly by raising the current technology.

3) Introduction of new technology and capacity increase of production facilities

   a) To acquire technology and skill by introducing new technology.
   b) To introduce high performance equipments matching to the new technology
   c) To renew intentionally outworn and old-fashioned equipments (long-term plan).

4) Effective use of introduced equipments and pursuing of improvement

3.9.1 Foundry Shop Modernization

For the execution of the modernization program mainly of the finishing and polishing process in the foundry shop, take heed of the followings:

1) This finishing process is the object of the feasibility study on the modernization program of the foundry shop, and the modernization program has been explained through this report up to the above section. These facilities shown here are obtained from our research based on the production program upto 1989 and the analysis of the economy. But they are not satisfactory for the real modernization and just for a short-term program. Therefore, it is desirable to work out a plan with the long-term perspective.

2) This time, the investigation was limited to the finishing process, prior to which there are most of the manufacturing process of castings. They did not include in the investigation this time, but they will be also modernized in the due course. Therefore, it is necessary to fully study the optimum finishing process in view of the modernization of the whole foundry shop from a long-term view point, especially such equipments which cannot be easily laid out and moved.

3) It is a general tendency in the world that the modernization of the finishing process has been delayed. Especially, the automation of the polishing work could not be easily developed due to its work character, and the process could not be improved for a long time. These years, the process has been gradually automated due to the development of electronic technology, but on the other hand, it has not paid sometimes. However, it is necessary to proceed with the modernization in view of the profitability of the whole foundry shop, but not only of the profitability of one section as well as safety, working environment, heavy works, etc.

4) Modernization is not attained only by the installation of the latest equipments, and the improvement of software such as for production technology, quality control, production control, etc. is a large factor. When these softwares and hardwares of equipments are efficiently combined, true modernization is said to have been attained. Especially in the finishing process of casting, the workability and the efficiency greatly depend on the quality of castings produced in the previous processes, and therefore great efforts should be made to improve the quality and the accuracy of castings.
When the finishing work is automated in the future, more and more severe quality will be required, and for that purpose we should have enough technology to meet such requirements.

5) Since this modernization program is for a short term up to 1989, it is necessary to make a close plan both for the softwares and the hardwares and also to establish a checking function for reviewing the progress of the project.

6) Equipments related to the finishing process of castings do not necessitate large foundation for the installation and do not hinder daily production activities, but it is important to make the work plan and procedures clear to all workers in advance of carrying-in and installation and to use care not to occur any accident during the work taking proper safety measures according to the preliminary arrangements with the Safety Section.

7) As for the operation of the equipment installed, prepare a safety work standard in advance, and provide workers with proper training.

3.9.2 Plate Shop Modernization

The plate shop has many processes including lofted drawing, marking-off, gas cutting, bending, drilling, fitting, coating, etc. in addition to the welding process, the object process of the investigation. These processes are organically connected for the production activity. Upto the previous chapter, we had explained the modernization program centering on the object products of the investigation in the welding process corresponding to the production increase program up to 1989. It is quite natural to modernize the welding process from the point of stepped-up production and of safety. However, the plate shop should map out by themselves the modernization program of processes and products other than the object process and products of this investigation. Well-balanced modernization of each process can bring about the expected safe factory with high productivity at last.

1) Software and hardware

Modernization is often misunderstood to be the introduction of the latest equipment. Even if a factory is equipped with modern equipment, the intended factory cannot be realized without efficient operation f such equipment and systematic management of the whole factory. In the other improvement of the production technology including machining method, scheduling and quality control can at last bring about a modernized factory.

2) Effective equipment improvement for future

Use care that the equipment to be modernized this time will not hinder future improvement plans of the plate shop and will use easily removable foundations so as to prevent double investment for the future improvement plans when planned as the technology advances.

3) Influence of new equipment work on production activity

Since the equipment work is required only in the welding process, it does not seem to exert influence on the production activity in the plate shop. At the time of the floor work to install the positioner and of the piping work for CO_2 gas pipe, however, the production schedule should be adjusted to leave some room, and also the construction period should be shortened to the minimum under the cooperation of the constructor.

4) Special attention to the safety of new equipment

At the time of facility planning or trial operation, or after the commencement of operation, personnels concerned shall thoroughly study the safety so as to prevent any accident with the new equipment. Especially, it is necessary for the administrator to inspect and confirm the following three points:

: Adhesion of the positioner to workpiece.
: Works at elevated spot on the table lifter.
: Automatic welding by manipulator while rotating the turn table.

4. FINANCIAL ANALYSIS & ECONOMIC EVALUATION

4. Financial Analysis and Economic Evaluation

4.1 Financial Analysis

This financial analysis evaluated the modernization plans of foundry and plate shops as an independent project, respectively.

1) Basic policies of financial analysis

(1) Adoption of discounted cash flow method

The discounted cash flow method is used as a technique of financial analysis, which has widely been used as a profitability evaluation or equipment investment determing technique of projects.

First from the following calculation formula, "X" (IRR = Internal Rate of Return) is obtained, followed by the further calculation of net present value (NPV) at the official discount rate = 15% to determine the goodness or not of investment.

$$I = Q1/(1+X) + Q2/(1+X)^2 + \ldots + Qn/(1+X)^n + S/(1+X)^n$$

Where: I = Amount of investment

Q1−Qn: Amount of production cost savings per annum (not including the depreciation, interest and tax)

S: Residual value

(2) Adoption of cost saving amount as a profit to be gained from the project

For determining the effect of modernizing the existing factory, the effects from the previous and new investments are overlapped. The workshops subject to this modernization project are positioned as the service department in Div. EL. Teniente. The following method was, therefore, adopted for the purpose to measure the profit to be gained from the project.

The cost (A) was estimated, which may be spent when the objective production under the production plan was achieved with the existing equipment and machines and without implementing this modernization plan, while the cost (B), with implementing this modernization plan. A difference of (A−B) was determined as a profit yielded from the investment when this modernization plan was implemented.

2) Basic conditions of financial analysis

The basic conditions of financial analysis are as follows.

- Project period

  10 years (after completion of investment for modernization plan)

- Price

  Fixed price based on the 1986 price

- Residual value of equipment and machines

  Depreciation period: 10 years
  Residual value: 5% of purchase price

- Production plan

  The production plan prepared based on the shop production capacities planned upon the market survey is given in Table 4.1-1 below.

Table 4.1-1 Production Plan

(Unit: Ton)

Shop \ Year	1987	1988	1989
Foundry	(80) 6,370	(90) 7,200	(100) 8,000
Plate	(85) 2,351	(91) 2,539	(100) 2,780
Structure	1,841	1,989	2,180
Repair	510	550	600

( ): Figures in parentheses represent the production vs. 100 of 1989 production.

3) Cost (A) without implementing the modernization plan of the shops

(1) Foundry shop

Table 4.1-2 below gives the unit cost per ton for the 1989 objective production under the production plan with existing equipment and machines.

Table 4.1-2 Unit Cost per Ton of Products in Foundry Shop

(Unit: US$)

Cost Element \ Product	Cast Steel	Cast Iron	Nonferrous
1. Raw material cost	292.9	304.7	958.1
Melting	242.5	254.3	907.7
Molding	37.9	37.9	37.9
Pattern	4.3	4.3	4.3
Finishing	8.2	8.2	8.2
2. Variable indirect cost	53.5	63.2	31.4
Electric power	43.9	42.5	30.2
Fuel oil	7.0	20.7	1.2
Oxygen	2.6		
3. Fixed indirect cost	5.3	5.3	5.3
Electric power	4.2	4.2	4.2
Fuel oil	1.1	1.1	1.1
4. Labor cost	193.2	193.2	193.2
5. Other indirect cost	198.9	198.9	198.9
Maintenance and repair cost	129.3	129.3	129.3
Equipment/machines service cost	16.5	16.5	16.5
Administrative cost allocation	49.9	49.9	49.9
Other cost	3.2	3.2	3.2
6. Total	743.8	765.3	1,386.9

The cost per ton of products in the foundry shop was calculated based on the following.

- Raw material cost

  Assumed as same as the 1986 plan (treated as a variable cost)

- Variable indirect cost

  Assumed as same as the 1986 plan (treated as a variable cost)

- Fixed indirect cost

Assumed as same as the 1986 plan, subject to no change in the fixed indirect cost (fixed electric power cost and fixed fuel oil cost), regardless of production level, so that the cost per ton decreases as the operating rate increases (5,540 to 8,000 tons).

- Labor cost

Assumed to increase the total number of employees to 204 as the operating rate increases.
Further, the required number of employees was estimated based on productivity of the 1985.

- Other indirect cost

The "maintenance and repair" was broken down as follows.

Service from the maintenance shop in the workshop (A+B)		58.1%
Breakdown:	Labor cost (A)	37.3%
	Other cost (B)	20.8%
Maintenance service from all other segments (C)		41.9%
Total (A+B+C)		100.0%

The cost per ton, (B) and (C) above, was assumed to be same as the 1986 plan (treated as a variable cost), while the labor cost was assumed to be increased as the operating rate increases, as shown in Table 4.1-3 below, to estimate the cost per ton.

Table 4.1-3 Personnel Increase of Maintenance Shop and Personnel Increase Sharing Ratio

Personnel Increase of Maintenance Shop		Personnel Increase Sharing Ratio	
ROL "B" ROL "C"	8 persons 2 persons	Foundry shop Plate shop	85% 15%
Total	10 persons	Total	100%

- "Equipment/machines service cost" and "Other cost"

Assumed as same as the 1986 schedule.

- "Administrative cost allocation"

Since this is a fixed cost, the cost per ton decreased as the operating rate increased.

(2) Plate shop

Table 4.1-4 below gives the unit cost per ton for the 1988 objective production under the production plan with the existing equipment and machines.

Table 4.1-4 Unit Cost per Ton of Products in Plate Shop

(Unit: US$)

Cost Element \ Product	Structure	Repair
1. Raw material cost	793.0	36.0
Plate	793.0	36.0
2. Variable indirect cost	13.4	25.0
Electric power	4.0	9.0
Fuel oil	3.0	
Oxygen	5.0	11.0
Gas	1.4	5.0
3. Fixed indirect cost	0.2	0.2
Electric power	0.2	0.2
4. Labor cost	311.7	311.7
5. Other indirect cost	78.8	78.8
Maintenance and repair cost	36.5	36.5
Equipment/machines service cost	0.4	0.4
Administrative cost allocation	39.2	39.2
Other cost	2.7	2.7
6. Total	1,197.1	451.7

The cost per ton of products in the plate shop was calculated based on the following.

- Raw material cost

  Assumed as same as the 1986 plan.

- Variable indirect cost

  Assumed as same as the 1986 plan.

- Fixed indirect cost

  Fixed, regardless of production level.

- Labor cost

Assumed to increase the total number of employees to 124 as the operating rate increases.

Further, for estimating the required number of employees, the 1985 productivity was referred.

- Other indirect cost

For the "maintenance and repair cost," see the calculation basis of cost/ton of products in the foundry shop.

The "equipment service cost" and "other cost" were assumed as same as the 1986 plan. Since the "administrative cost allocation" is a fixed cost, the cost per ton decreases as the operating rate increases.

4) Cost (B) with implementing the modernization plan of the shops

(1) Foundry shop

Table 4.1-5 below gives the unit cost per ton for the 1989 production of 8,000 tons under the production plan through the implementation of modernization plan.

Table 4.1-5 Unit Cost per Ton of Products in Foundry Shop

(Unit: US$)

Cost Element \ Product	Cast Steel	Cast Iron	Nonferrous
1. Raw material cost	292.9	304.7	958.1
Melting	242.5	254.3	907.7
Molding	37.9	37.9	37.9
Pattern	4.3	4.3	4.3
Finishing	8.2	8.2	8.2
2. Variable indirect cost	53.5	63.2	31.4
Electric power	43.9	42.5	30.2
Fuel oil	7.0	20.7	1.2
Oxygen	2.6		
3. Fixed indirect cost	5.3	5.3	5.3
Electric power	4.2	4.2	4.2
Fuel oil	1.1	1.1	1.1
4. Labor cost	189.2	189.2	189.2
5. Other indirect cost	198.9	198.9	198.9
Maintenance and repair cost	129.3	129.3	129.3
Equipment/machines service cost	16.5	16.5	16.5
Administrative cost allocation	49.9	49.9	49.9
Other cost	3.2	3.2	3.2
6. Total	739.8	761.3	1,382.9

Further, the cost per ton of products in the foundry shop was calculated based on the following.

- Same as the case without implementing the modernization plan, except for the labor cost.

- Labor cost

Assumed to increase the total number of employees to 198 as the operating rate increases.

Further, for estimating the required number of employees, the effect of modernization was considered with reference to the 1985 productivity.

(2) Plate shop

Table 4.1-6 below gives the unit cost per ton for the 1989 objective production under the production plan through the implementation of modernization plan.

Table 4.1-6 Unit Cost per Ton of Products in Plate Shop

(Unit: US$)

Cost Element \ Product	Structure	Repair
1. Raw material cost	801.3	60.8
Plate	801.3	60.8
2. Variable indirect cost	11.2	20.0
Electric power	1.8	4.0
Fuel oil	3.0	0
Oxygen	5.0	11.0
Gas (acetylene)	1.4	5.0
3. Fixed indirect cost	0.2	0.2
Electric power	0.2	0.2
4. Labor cost	258.8	258.8
5. Other indirect cost	78.8	78.8
Maintenance and repair cost	36.5	36.5
Equipment/machines service cost	0.4	0.4
Administrative cost allocation	39.2	39.2
Other cost	2.7	2.7
6. Total	1,150.3	418.6

Further, the cost per ton of products in the plate shop was calculated based on the following.

- Labor cost

Although the production increases, it was assumed that the total number of employees can be limited to 99, because of the rationalization effect through modernization. Further, for estimating this number, the 1985 productivity was referred.

- Welding material cost and electric power cost

For estimating the welding material cost and electric power cost, reference was made to the cost comparison between the shielded metal arc welding method and flux core wire CO_2 welding method in Japan and to the current cost in the workshops. Further, the welding material cost was included in the raw material cost.

- The other cost was made as same as the case without implementing the modernization plan.

5) Amount of cost saving

(1) Foundry shop

Through the comparison of achieving the 1989 production of 8,000 tons under the production plan with implementing the modernization plan vs. without it, the amount of cost saving is as follows.

- Labor cost

The amount of labor cost saving is as shown in Table 4.1-7 below.

Table 4.1-7 Amount of Labor Cost Saving

(Unit: US$)

Class	No. of Personnel Saving	Amount of Labor Cost Saving
ROL "A"	0	0
ROL "B"	0	0
ROL "C"	6	32,058
Total	6	32,058

(2) Plate shop

Through the comparison of achieving the 1989 objective production under the production plan with implementing the modernization plan vs. without it, the annual amount of cost saving is US$121,744, whose breakdown is as follows.

- Labor cost

The amount of labor cost saving is as shown in Table 4.1-8 below.

Table 4.1-8 Amount of Labor Cost Saving

(Unit: US$)

Class	No. of Personnel Saving	Amount of Labor Cost Saving
ROL "A"	0	0
ROL "B"	0	0
ROL "C"	25	146,922
Total	25	146,922

- Welding material cost and electric power cost

For estimating the amounts of increase and saving in the welding material cost (including CO_2 gas) and electric power cost, reference was made to the cost comparison between the shielded metal arc welding method and flux core wire CO_2 welding method in Japan and to the current cost of the workshops.

Cost increase = US$25,178 per annum based on the 1989 production plan

(3) 1987 and 1988 amounts of cost saving

Since 1987 is the year when the work under the modernization plan is to be executed, assumption was made to incur no effect of cost saving through the implementation of modernization plan. The 1988 amount of cost saving was calculated in proportion to the production (90% for both of the foundry and plate shops) based on the foregoing amount of cost saving estimated based on the 1989 production.

6) Analyses on the internal rate of return (IRR) and the net present value (NPV)

The results of calculating the IRR of modernization plan for the foundry and plate shops are given in Tables 4.1-9 and 4.1-10 below. Further, the results of calculating the NPV at 15% of official discount rate are given in Tables 4.1-11 and 4.1-12 below.

The foregoing tables indicate 15.8% IRR of modernization plan for foundry shop, and 22.3% IRR for plate shop. The NPV's at 15% discount rate of modernization plan for foundry and plate shops are US$3,000 and US$123,000, respectively.

Tables 4.1-13 and 4.1-14 below gives the IRR's and NPV's on the assumption that the modernization plans for foundry and plate shops are a project, respectively, indicating the IRR = 20.7% and NPV = US$126,000.

Table 4.1-9 Calculation of Internal Rate of Return (Modernization Plan for Foundry Shop)

(Unit: US$1,000)

Item \ Year	1986 (0)	'87 (1)	'88 (2)	'89 (3)	'90 (4)	'91 (5)	'92 (6)	'93 (7)	'94 (8)	'95 (9)	'96 (10)	'97 (11)
Cash in-flow (A = B + C)			29	32	32	32	32	32	32	32	32	40
Amount of cost saving (B)			29	32	32	32	32	32	32	32	32	32
Residual value (C)												8
Cash out-flow (D)		156										
Net cash flow (A - D)		(156)	29	32	32	32	32	32	32	32	32	40
Discount rate = 15%	1.0	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759	0.3269	0.2843	0.2472	0.2149
Present value		(136)	22	21	18	16	14	12	10	9	8	9
Cumulative present value	1.0	(136)	(114)	(93)	(75)	(59)	(45)	(33)	(23)	(14)	(6)	3
Discount rate = 16%		0.8621	0.7431	0.6407	0.5523	0.4761	0.4104	0.3538	0.3050	0.2630	0.2267	0.1954
Present value		(134)	22	21	18	15	13	11	10	8	7	8
Cumulative present value		(134)	(112)	(91)	(73)	(58)	(45)	(34)	(24)	(16)	(9)	(1)

Figures in parentheses represent a minus.

The cumulative present value becomes a plus between 15% and 16% of official discount rate. IRR = 15.8%

Table 4.1-10 Calculation of Internal Rate of Return (Modernization Plan for Plate Shop)

(Unit: US$1,000)

Item \ Year	1986 (0)	'87 (1)	'88 (2)	'89 (3)	'90 (4)	'91 (5)	'92 (6)	'93 (7)	'94 (8)	'95 (9)	'96 (10)	'97 (11)
Cash in-flow (A = B + C)			110	122	122	122	122	122	122	122	122	142
			(22)	(25)	(25)	(25)	(25)	(25)	(25)	(25)	(25)	(25)
Amount of cost saving (B)			132	147	147	147	147	147	147	147	147	147
Residual value (C)												20
Cash out flow (D)		467										
Net cash flow (A - D)		(467)	110	122	122	122	122	122	122	122	122	142
Discount rate = 23%	1.0	0.8130	0.6610	0.5374	0.4369	0.3552	0.2888	0.2348	0.1909	0.1552	0.1262	0.1026
Present value		(380)	73	66	53	43	35	29	23	19	15	15
Cumulative present value		(380)	(307)	(241)	(188)	(145)	(110)	(81)	(58)	(39)	(24)	(9)
Dicsount rate = 22%	1.0	0.8197	0.6719	0.5507	0.4514	0.3700	0.3033	0.2486	0.2038	0.1670	0.1369	0.1122
Present value		(383)	74	67	55	45	37	30	25	20	17	16
Cumulative present value		(383)	(309)	(242)	(187)	(142)	(105)	(75)	(50)	(30)	(13)	3

Figures in parentheses represent a minus.

The cumulative present value becomes a plus between 22% and 23% of official discount rate. IRR = 22.3%

Table 4.1-11 Calculation of Net Present Value (Modernization Plan for Foundry Shop)

(Unit: US$1,000)

Item \ Year	1986 (0)	'87 (1)	'88 (2)	'89 (3)	'90 (4)	'91 (5)	'92 (6)	'93 (7)	'94 (8)	'95 (9)	'96 (10)	'97 (11)
Net cash flow		(156)	29	32	32	32	32	32	32	32	32	40
Discount rate = 15%	1.0	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759	0.3269	0.2843	0.2472	0.2149
Present value		(136)	22	21	18	16	14	12	10	9	8	9
Cumulative present value		(136)	(114)	(93)	(75)	(59)	(45)	(33)	(23)	(14)	(6)	3

Figures in parentheses represent a minus.

NPV at 15% discount rate = US$3,000

Table 4.1-12 Calculation of Net Present Value (Modernization Plan for Foundry Shop)

(Unit: US$1,000)

Item \ Year	1986 (0)	'87 (1)	'88 (2)	'89 (3)	'90 (4)	'91 (5)	'92 (6)	'93 (7)	'94 (8)	'95 (9)	'96 (10)	'97 (11)
Net cash flow	0	(467)	110	122	122	122	122	122	122	122	122	142
Discount rate = 15%	1.0	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759	0.3269	0.2843	0.2472	0.2149
Present value	0	(406)	83	80	70	61	53	46	40	35	30	31
Cumulative present value	0	(406)	(323)	(243)	(173)	(112)	(59)	(13)	27	62	92	123

Figures in parentheses represent a minus.

NPV at 15% discount rate = US$123,000

Table 4.1-13 Calculation of Internal Rate of Return (Total)

(Unit: US$1,000)

Item \ Year	1986 (0)	'87 (1)	'88 (2)	'89 (3)	'90 (4)	'91 (5)	'92 (6)	'93 (7)	'94 (8)	'95 (9)	'96 (10)	'97 (11)
Cash in-flow (A = B + C)			139	154	154	154	154	154	154	154	154	182
Amount of cost saving (B)			139	154	154	154	154	154	154	154	154	154
Residual value (C)												28
Cash out flow (D)		623										
Net cash flow (A - D)		(623)	139	154	154	154	154	154	154	154	154	182
Discount rate = 20%	1.0	0.8333	0.6944	0.5787	0.4823	0.4019	0.3349	0.2791	0.2326	0.1938	0.1615	0.1346
Present value		(519)	97	89	74	62	52	43	36	30	25	24
Cumulative present value		(519)	(422)	(333)	(259)	(197)	(145)	(102)	(66)	(36)	(11)	13
Discount rate = 21%	1.0	0.8264	0.6830	0.5645	0.4665	0.3855	0.3186	0.2633	0.2176	0.1799	0.1486	0.1228
Present value		(515)	95	87	72	59	49	41	34	28	23	22
Cumulative present value		(515)	(420)	(333)	(261)	(202)	(153)	(112)	(78)	(50)	(27)	(5)

Figures in parentheses represent a minus.

The cumulative present value becomes a plus between 20% and 21% of official discount rate. IRR = 20.7%

Table 4.1-14 Calculation of Net Present Value (Total)

(Unit: US$1,000)

Year / Item	1986 (0)	'87 (1)	'88 (2)	'89 (3)	'90 (4)	'91 (5)	'92 (6)	'93 (7)	'94 (8)	'95 (9)	'96 (10)	'97 (11)
Net cash flow		(623)	139	154	154	154	154	154	154	154	154	182
Discount rate = 15%	1.0	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759	0.3269	0.2843	0.2472	0.2149
Present value		(542)	105	101	88	77	67	58	50	44	38	40
Cumulative present value		(542)	(437)	(336)	(248)	(171)	(104)	(46)	4	48	86	126

Figures in parentheses represent a minus.

NPV at 15% discount rate = US$126,000

7) Sensitivity analysis

Regarding the modernization plans for foundry and plate shops, the sensitivity analysis was made by changing the figures of following factors.

- Change of total investment amount
- Change of cost saving amount

Figure 4.1-1 shows the result of the sensitivity analysis.

(1) Foundry shop

A 15% increase in the total investment amount results in a decrease to 12.2% in the IRR, while a 15% decrease in the total investment amount results in an increase to 19.8% in the IRR.

A 10% increase in the amount of cost saving results in an increase to 18% in the IRR, while a 10% decrease in the amount of cost saving results in a decrease to 13.3% in the IRR.

(2) Plate shop

A 15% increase in the total investment amount results in a decrease to 19.5% in the IRR, while a 15% decrease in the total investment amount results in an increase to 25.5% in the IRR.

A 10% increase in the amount of cost saving results in an increase to 25% in the IRR, while a 10% decrease in the amount of cost saving results in a decrease to 19.4% in the IRR.

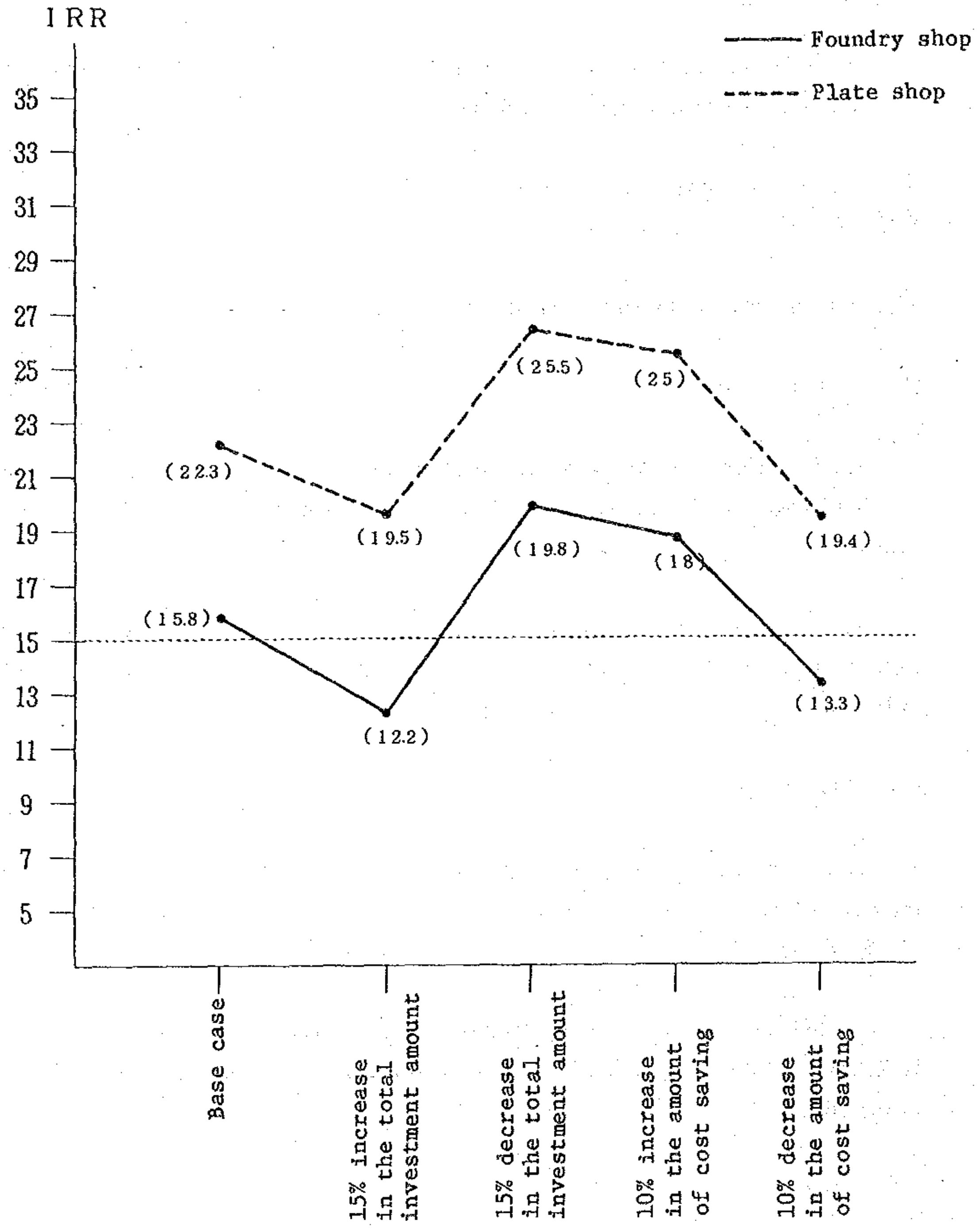


Figure 4.1-1 Sensitivity Analysis Chart

8) Conclusions

This project is financially concluded as follows.

- The both projects for foundry and plate shops are feasible, because of IRR indication above 15%.

- The project for plate shop maintains the IRR above 15% even upon worsening the conditions (increase in the total investment amount and decrease in the amount of cost saving), based on the sensitivity analysis results, indicating that the profitability is very high. While, the project for foundry shop indicates a decrease to around 13% in the IRR, when the total investment amount increases by 15% and/or when the amount of cost saving decreases by 10%, according to the sensitivity analysis results, i.e. it is slightly unstable in the financial feasibility, viewing from the CODELCO standards. Taking into consideration that the IRR above 10% may often be judged financially feasible in general, the project for foundry shop can be said a project having a sufficient profitability.

4.2 Economic evaluation

The principal circumstance that has introduced the trend to perform economic as well as financial analyses in feasibility studies is the change seen of recent years in the substance of the projects envisaged, in such aspects as:—

- Nature: From relatively small-scale independent projects of set pattern to large-scale interdependent projects embodying innovative concepts

- Participating organizations: From what used to be limited to the organizations undertaking the project and financing establishments to a much wider participation including international organizations, national governments, consultant establishments.

The foregoing changes have rendered it insufficient to evaluate the feasibility of such projects solely from their financial profitability, and have come to require advocacy of the projects in the light of social or national benefits that would be expected to accrue from their adoption and implementation.

The present study concerns a nationalized enterprise that holds a predominant position in the copper production of Chile, with vast influence on the nation's economy. However, the particular subject of survey in this instance is limited to a sole Department of a sole Division among CODELCO's four Divisions, and furthermore, the survey is to be restricted mainly to two specific Processes of Finishing in the Foundry Shop and Welding in the Plate Shop.

For this reason, economic analysis in the sense adopted for large-scale projects affecting entire industries or the entire infrastructure of a region or a nation will not be undertaken in this instance.

1) Overview of Chilean economy

(1) Economic 3-year plan

From 1975 to 1984, three national plans for economic development have been undertaken:—

- 1st: 1975–80
- 2nd: 1978–83
- 3rd: 1979–84.

In 1984, a 3-year plan covering the period 1984-86 was established, which in June 1985 was revised into a new 3-year plan covering the period 1985-87. This latest Plan sets as the three key targets to be achieved:—

- Creation of employment: To generate by 1987, 500,000 new jobs to reduce the unemployment rate to 10% or below

- To promote exports: To enhance the exportation of Chilean products, and reduce the deficit of current account balance of payments

- To encourage domestic savings and investment.

The target figures stipulated for the 1985-87 3-year Plan are summarized in Table 4.2-1. The figures given in Table 4.2-1 indicate a target yearly GDP growth averaging 4.6%, with the mining sector envisaged to average an appreciably lower yearly growth of 2.6%, but with its share in the GDP to be maintained through the period at 8% level (which is the same as for the agricultural sector).

The role of CODELCO in stimulating national economy is clearly manifested in the salient figures given for CODELCO's financing programs.

Table 4.2-1 Outline target figures of 3-year Plan 1985–87

ITEM \ YEAR	1984	1985	1986	1987
GDP growth rate (%/year)	6.3	2 - 4	3 - 5	3 - 5
GDP (1977 value in Ch$ billion)	348.0	354.9-361.8	365.5-379.9	376.5-398.9
Domestic savings (% of GDP)	2.9	3.7 - 5.6	4.6 - 8.4	7.2 - 12.3
Balance of payments (1984 value in US$ million)	2,060	1,353 - 1,353	1,167 - 1,167	889 - 889
GDP of mining sector (Ch$ billion)	30.4	30.6	32.3	32.9
Growth of mining sector GDP (%/year)	4.4	0.8	5.4	1.8
Share of mining sector GDP (%)	8.7	8.4	8.5	8.2
Investment programs (10^6 US$) -				
- CODELCO (copper mining)		409	327	440
- ENDESA (electric power)		172	139	97
- ENAP (petroleum)		124	170	144

NOTE: Values marked by underlining represent deficit.

(Source: 3-year Plan)

(2) Recent economic trends

The progress of key Chilean economic indexes in recent years is reproduced in Table 4.2-2. It is revealed that, despite the wild fluctuations that have affected GDP growth, that of the mining sector has, in comparison, remained remarkably stable.

The share of this sector in the overall GDP has been 7 to 9%, which is at a level with the agriculture/fisheries sector, and ranks after manufacturing (abt. 20%), commerce (abt. 17%) and education/health/miscellaneous services (abt. 11%).

Table 4.2-2 Key economic indexes recorded in recent years

ITEM \ YEAR	1980	1981	1982	1983	1984
GDP growth rate (%/year)	7.8	5.5	14.1	0.7	6.3
GDP (1977 value in Ch$ billion)	363	384	330	327	348
Growth of mining sector GDP (%/year)	5.2	7.7	5.7	1.9	4.4
GDP of mining sector (Ch$ million, 1977 value)	26.1	28.1	29.7	29.1	30.4
Share of mining sector GDP (%)	7.2	7.3	9.0	8.9	8.7
Current balance of payments (US$ million)	764	2,677	63	1,009	293
Current account balance of payments (US$ million)	1,971	4,733	2,304	1,073	2,060

NOTE: Figures marked by underlining represent negative values.
(Source: Statistical Synthesis of Chile, 1980-84, Banco Central de Chile)

(3) Principal products of the mining sector

Various minerals are produced in Chile with relative ascendancy in the world market:—

- Copper: Predominant position in world market
- Molybdenum, rhenium, iodine: 2nd in the world
- Lithium: 3rd ditto.

According to data published by the National Bureau of Statistics, Mineral Production grew from 1980 to 85 at an average yearly rate of about 4%, the advances being particularly rapid for silver, lead, zinc and gold.

The progress of copper production in recent years is given in Table 4.2-3 and forecasted progress of same in the coming years in Table 4.2-4.

From Table 4.2-3, copper production is seen to have been growing at an average rate of about 4%, and from Table 4.2-4, to continue growing in the coming years.

Table 4.2-3 Past progress of copper production

(Unit: 1,000 tons)

YEAR	1979	1980	1981	1982	1983	1984
CODELCO -						
- Chuquicamata	507	511	472	553	559	563
- Salvador	78	75	77	90	87	96
- Andina	47	53	53	54	61	105
- El Teniente (A)	278	266	292	336	305	285
Share of El Teniente						
in CODELCO* (%)	31	29	33	33	30	27
Ditto in Chile** (%)	26	25	27	27	24	22
Total CODELCO (B)	910	905	894	1,033	1,012	1,049
Other Chilean enterprises	153	163	187	209	245	241
Grand total (C)	1,063	1,068	1,081	1,242	1,257	1,290

*) Share of El Teniente in CODELCO: (A)/(B) x 100%

**) Ditto in Chile : (A)/(C) x 100%

(Source : CODELCO)

Table 4.2-4 Forccasted progress of future copper production

(Unit: 1,000 tons)

YEAR	1986	1987	1988	1989	1990
CODELDO -					
- Chuquicamata	573	573	752	852	852
- Salvador	100	100	100	100	100
- Andina	105	105	105	105	168
- El Teniente (A)	383	383	383	337	369
Share of El Teniente					
in CODELCO* (%)	33	33	29	24	25
Ditto in Chile** (%)	27	27	23	19	19
Total CODELCO (B)	1,161	1,161	1,340	1,394	1,489
Other Chilean enterprises	277	277	309	391	443
Grand total (C)	1,438	1,438	1,647	1,785	1,932

*) Share of El Teniente in CODELCO: (A)/(B) x 100%

**) Ditto in Chile : (A)/(C) x 100%

(Source : CODELCO)

Table 4.2-5 Past progress of mineral exports

(Unit: US$ million)

YEAR / ITEM	1983	1984	1985
Total Chilean exports	3,835.5	3,657.2	3,795.5
Total mineral exports	2,296.6	1,982.5	2,125.2
- Copper	1,835.7	1,386.6	1,761.3
- Iron ore	112.0	110.6	90.8
- Silver	114.4	87.2	73.6
- Other minerals	234.5	198.1	199.5

(Source : Central Bank of Chile)

The mineral exports—Table 4.2-5—contributes 50 to 60% of total exports, with copper alone providing 40 to 50%. Copper thus constitutes a stable export commodity, that plays and will continue to play a preeminent part in the acquisition of needed foreign currency.

2) Position occupied by CODELCO in the Chilean economy; CODELCO's program of development

(1) Position occupied by CODELCO in the Chilean economy

From the values given in Table 4.2-3, the share of CODELCO in Chilean copper production is seen to be about 80%. The proved reserves of CODELCO's copper mines are as cited in Table 4.2-6.

Assuming the current rate of metal extraction to be maintained, the reserves will last more than 50 years in all the mines except Salvador.

The production forecasts for Chilean copper mines, given in Table 4.2-4 indicated CODELCO's share to be maintained in the coming years at around 80%. A similar share of 80% has been recorded of CODELCO's contribution to Chilean copper exports, as seen from Table 4.2-7.

The foregoing observations attest the vast influence exerted by CODELCO on Chilean economy, with its predominant contribution to the country's copper production and export.

With respect to competitiveness in the world market, the cost of producing a pound of copper is appreciably lower in Chile than in other countries, and even among the Chilean mines, CODELCO's figures are significantly advantageous, as seen in Table 4.2-8.

The share of the El Teniente division within CODELCO, as indicated from Tables 4.2-3, -4 and -6, is around 30%, both in the past and future, and within the global Chilean copper production, around 25%.

This evidences the influential position occupied by the El Teniente Division in Chilean copper production.

Table 4.2-6 Proved reserves of CODELCO mines

DIVISION	PROVED RESERVES (mill. tons copper metal)	METAL EXTRACTED IN 1983 (mill. tons copper metal)	REMAINING MINE LIFE (years)
Chuquicamata	44.9	558.8	64
Salvador	3.2	87.0	30
Andina	16.9	61.4	229
El Teniente	47.6	304.9	125
TOTAL	112.6	1,012.1	

(Source: CODELCO)

Table 4.2-7 Copper exports by Chilean enterprises

(Unit: FOB US$ million)

ENTERPRISE \ YEAR	1982	1983	1984
CODELCO	1 335.8	1 487.0	1 252.8
ENAMI	155.8	192.5	155.2
Other mines	178.2	172.2	162.6
TOTAL	1,669,8	1,851.7	1,570.6

(Source: CODELCO)

Table 4.2-8 Copper production cost in Chilean copper enterprises

(Unit: US$/lb. copper)

ENTERPRISE \ YEAR	1982	1983	1984
CODELCO	44.0	46.3	43.6
Mantos Blancos	51.9	40.6	48.7
Disputada	119.1	96.9	93.5

(Source: Mining, Chile—Foreign Investment Committee)

NOTE: The above production cost figures do not include tax.

2) CODELCO's program of development

The ultimate aim held in view in CODELCO's program of development is to consolidate its position in the world copper market through further enhanced competitiveness, by expanding its production and rationalizing its production processes. In concrete terms, the anticipated lowering of the content of copper in ore to be excavated in the coming years is to be compensated by increasing the amount of ore excavated and processed, and by enhancing productivity, with the introduction of new techniques and processes.

All the four divisions of CODELCO are pursuing their respective programs of development. That of the El Teniente Division covers the following items:—

- Mine and concentrator expansion—completed 1985
- Replacement of flotation facilities at Sewell—under contemplation
- Tailings dam at Caren—in service since 1986
- Modification of converters at Caletones—under contemplation.

Research and development projects maintained at CODELCO have laid emphasis on:—

- Reduction of energy consumption
- Environmental control
- Geological exploration techniques
- Mining operations
- Ore processing
- Modification of gas collecting system in Caletones—ditto.

Investments in equipment are realized within the program of development. The investments made in recent years in the four Divisions are as cited in Table 4.2-9.

The El Teniente division holds second place among the four Divisions of CODELCO, spending about 20% of CODELCO's global investment.

The foregoing observations have presented an overview of economic background on which CODELCO and its El Teniente Division operate. The El Teniente Division—the object of survey in the present Feasibility Study—constitutes a part of the service subdivision of the El Teniente division, with the mission of furnishing the Division with mining equipment and of ensuring their maintenance and repair. Moreover, the scope of study is restricted mainly to the two Processes of Finishing in the Foundry Shop and Welding in the Plate Shop. This precludes the means of quantitatively evaluating the effect to be expected of Project implementation on Chilean economy, but it can still be clearly affirmed that the modernization and operational improvements that will be brought to the Processes, with resulting enhancement of production that will be ensured for the El Teniente Division, will indirectly but definitely contribute to the development of Chilean economy.

Table 4.2-9 Investments in CODELCO

Unit US$ million

YEAR	1980	1981	1982	1983
Chuquicamata			146.6	108.8
Salvador			18.2	18.9
Andina			27.4	33.1
El Teniente			38.0	38.9
Head Office			3.5	0.8
TOTAL	266.7	309.5	233.7	200.5

(Source: CODELCO)

APPENDIX

Appendix 1

Plan (Draft) of Crane Capacity Increase and New Factory Construction for Plate Shop

In the plate shop, the maximum crane capacity at present is 10 tons, and the weights of charging products often exceed the crane capacity. So, it is necessary from the safety view-point to increase the capacity. The following shows a proposed view on the crane capacity increase and the result of the design for estimate:

1. Present Crane Capacity and Factory Building

The most part of the factory building of the Workshops Department of CODELCO's Div. El Teniente was built more than 40 years ago, and the overhead travelling crane was also equipped at that time. On the other hand, mining crusher and ladle in refinery have recently been replaced by larger models of their own products, and some of them exceed the crane capacity. This plate shop has performed wear resistant welded overlay for large steel castings and also welded overlay repair on worn section, but recent large castings cannot be brought in the factory. So, they have borrowed the neighboring machine shop where large crane is equipped, or load tests have sometimes carried out with the conventional crane with overloads as exceptions. It is natural under the situation that good workability cannot be expected, and furthermore overload should be avoided for the safety purpose.

This crane with the capacity of 10 tons is no longer a large crane for a plate shop, and, since the demands for larger products will increase gradually, it is necessary to increase the capacity as soon as possible.

For the increase of crane capacity, building pillars and runway girder should be improved at the same time to support the crane. It is possible to increase the capacities of building pillars and runway girder to some extent by employing reinforcement, but for a drastic capacity increase, the construction should be started from the foundation. In this case, the influence to the production line should be taken into account, and the expenses will naturally reach a considerable amount, probably as large as in case of constructing a quite new factory.

2. Crane Capacity Increase New Factory Building

The present large ladle and parts of large crusher weight 15 tons respectively, and a factory handling such heavy items should take the weights of hoisting accessories and jigs to be fitted on products into account. Therefore, a crane with the capacity of about 20 tons will come to be necessary. But, in view of future demands for much larger products and the facts that, for this large (twice) capacity increase, a new factory should be constructed, and also that, in case of constructing a new factory, a bit larger capacity increase does not bring about a big difference between expenses, it shall be quite reasonable to equip a crane of 25 ton capacity in the new factory.

3. Specifications of Crane and New Factory

From the reason mentioned above, the crane capacity shall be increased to 25 tons while a new factory shall be constructed. As for the specifications of crane span, factory scale and structure for estimate, those of the present plate shop shall be adopted this time from the following reasons:

- When constructing a new plate shop, the scale and structure should be studied, in fact, according to the factory modernization program corresponding to the future production program, but the study is difficult this time.
- If estimate conditions are clear, the cost can be calculated by comparison even if the scale and structure are changed.

Therefore, this estimate of a crane and a factory building does not show a new plate shop but just a guide of the construction costs for this scale of factory.

The estimate specifications are as follows:

1) Overhead travelling crane

The specification shall be 25/5 ton×15 m span, and the details as per Figure 3.1 and Table 3.1.

2) Factory Building

* The basic structure and sizes of the factory building shall be same with those of the present plate shop, nd the main building shall be 15 m×90×while the accessory buildings on the both sides shall be 7 m×90 m. An overhead travelling crane of 5-ton capacity shall go through the adjacent accessory buildings.

The design conditions of the factory building shall conform to the Building Standards Act of Japan and the steel structure calculation standard of the Institute of Architecture. The main conditions are shown in Table 3.2. The structural dimensions of the factory building are shown in Figure 3.2, but the crane in this figure is not included.

Table 3.2 Design Conditions of Factory Building

Applicable Materials and Allowable Unit Stress		Against Stationary Load	Short Time Loading
Steel, SS41 (mild steel 41 kg/mm^2 class)	Compression, tension, bending	1,600	2,400
	Shearing	920	1,300
Reinforcing bar, SD30	Compression, tension	2,000	3,000
Concrete Fc = 210 kg/cm^2	Compression	70	140
	Shearing	7	10.5
Floor concrete FC = 180 kg/cm^2	Compression	60	120
	Shearing	6	9
Allowable bearing power of soil (t/m^2)		10	20

4. Estimate

4.1 Estimate Conditions

1) Overhead travelling crane

Same with the Conditions assumed for Estimation, Paragraph 3.7.1 of this report.

2) Factory building

All constructions are carried out locally in the Republic of Chile, but the unit prices of material and construction costs are not clear to the study team. So, these costs in Japan are simply converted in to the U.S. currency at the exchange rate of US$1 = ¥160.

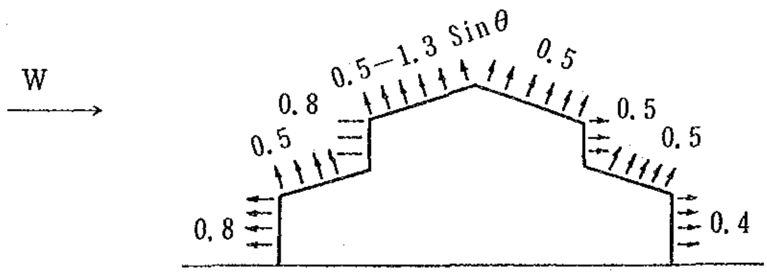
Building Standards Act and the steel structure calculation standard of the Institute of Architecture:

1. Wind load (short time)

Wind pressure $P = q.\ C.\ A$ kg   A: Projected Wind Area (m^2)

Velocity pressure $q = 60\ \sqrt{H}$ kg/m^2 H: Height from the ground (m)

Coefficient of wind force C



2. Earthquake load (short time)
   Horizontal acceleration   aH = 0.2 g

3. Crane load impact (stationary)

Vertical direction		20% of wheel pressure
Horizontal force	Travelling direction	15% of wheel pressure
	Right angle direction	10% of wheel pressure

4.2 Estimated Price

The estimated prices are shown in Table 4.2-1.

Table 4.2-1 Estimate of Crane and Building of the Plate Shop

No.	Name	Specification	Q'ty	Terms of Delivery	Amount
1	Overhead travelling crane	25/5 TON 15 m Composition: Crane body, Travel stringing Items excluded from the estimate: Crane rail, Installation cost, Travelling expenses of installation instructor	1	8 months	250,000
2	Factory building	30 M x 90 M Composition: Complete building Floor concrete Weld assembling surface plate Items excluded from the estimate: Crane	1	-	1,575,000

Remarks: For the detailed estimated prices of the factory building see Table 4.2-2, detailed estimate of factory building.

Table 4.2-2 Detailed Estimate of Factory Building (1/5)

Name	Specification	Unit	Quantity (¥)	Unit Price (¥)	Amount (¥)	Amount (US$)	Remarks
A) Building construction		Complete set	1		169,995,000	1,062,469	
B) Equipment work		Complete set	1		33,500,000	209,375	
C) Temporary work overhead		Complete set	1		34,505,000	215,656	203,495,000 (¥) x 17%
D) Design fee		Complete set	1		14,000,000	87,500	238,000,000 (¥) x 6%
Total					252,000,000	1,575,000	

Table 4.2-2 Detailed Estimate of Factory Building (2/5)

Name	Specification	Unit	Quantity (¥)	Unit Price (¥)	Amount (¥)	Amount (US$)	Remarks
A) Building construction							
1. Civil work		Complete set	1		3,210,000	20,063	
2. Concrete work		Complete set	1		14,520,000	90,750	
3. Reinforcing bar work		Complete set	1		4,950,000	30,938	
4. Steel work		Complete set	1		99,720,000	623,250	
5. Floor work		Complete set	1		12,500,000	78,125	
6. Roofing work		Complete set	1		7,980,000	49,875	
7. External wall work		Complete set	1		2,565,000	16,031	
8. Joiner's work		Complete set	1		20,660,000	129,125	
9. Other works		Complete set	1		3,890,000	24,313	
Total					169,995,000	1,062,467	

Table 4.2-2 Detailed Estimate of Factory Building (3/5)

Name	Specification	Unit	Quantity (¥)	Unit Price (¥)	Amount (¥)	Amount (US$)	Remarks
B) Building construction							
1. Lighting facilities		Complete set	1		13,000,000	81,250	
2. Fire alarm		Complete set	1		7,000,000	43,750	
3. Ventilating system		Complete set	1		5,500,000	34,375	
4. Fire hydrant		Complete set	1		8,000,000	50,000	
Total					33,500,000	209,375	

Table 4.2-2 Detailed Estimate of Factory Building (4/5)

Name	Specification	Unit	Quantity (¥)	Unit Price (¥)	Amount (¥)	Amount (US$)	Remarks
Civil work							
Trench	with surface place	m^2	1,200	1,000	1,200,000	7,500	
Back filling		m^2	700	900	630,000	3,938	
Removal of surplus soil		m^2	500	1,800	900,000	5,625	
Gravelling work		m^2	80	6,000	480,000	3,000	
Total					3,210,000	20,063	
Concrete work							
Homogeneous concrete		m^2	50	14,900	745,000	4,656	
Foundation concrete		m^2	365	14,000	5,110,000	31,938	
Surface concrete		m^2	130	14,000	1,820,000	11,375	
Mold		m^2	1,850	3,700	6,845,000	42,781	
Total					14,520,000	90,750	
Reinforcinb bar work							
Deformed bar		t	45 0	110,000	4,950,000	30,938	

Table 4.2-2 Detailed Estimate of Factory Building (5/5)

Name	Specification	Unit	Quantity (¥)	Unit Price (¥)	Amount (¥)	Amount (US$)	Remarks
Steel frame work							
Steel frame	With crane rail and surface plate	t	350	250,000	90,000,000	562,500	
Finishing OP			360	27,000	9,720,000	60,750	
Total					99,720,000	623,250	
Floor work							
Concrete floor		m^2	2,500	5,000	12,500,000	78,125	Concrete 385 m^3, Reinforcing bar 10 t
Roofing work	Backing of insulator, long corrugated color steel sheet	m^3	2,850	2,800	7,980,000	49,875	
External wall work	Asbestos cement corrugated sheet	m^3	1,350	1,900	2,565,000	16,031	
Joiner's work							
Steel shutter	With OP	m^3	84	35,000	2,940,000	18,375	
Steel door	With OP	m^3	12	30,000	360,000	2,250	
Steel sash	With glass and OP	m^3	620	28,000	17,360,000	108,500	
Total					20,660,000	129,125	

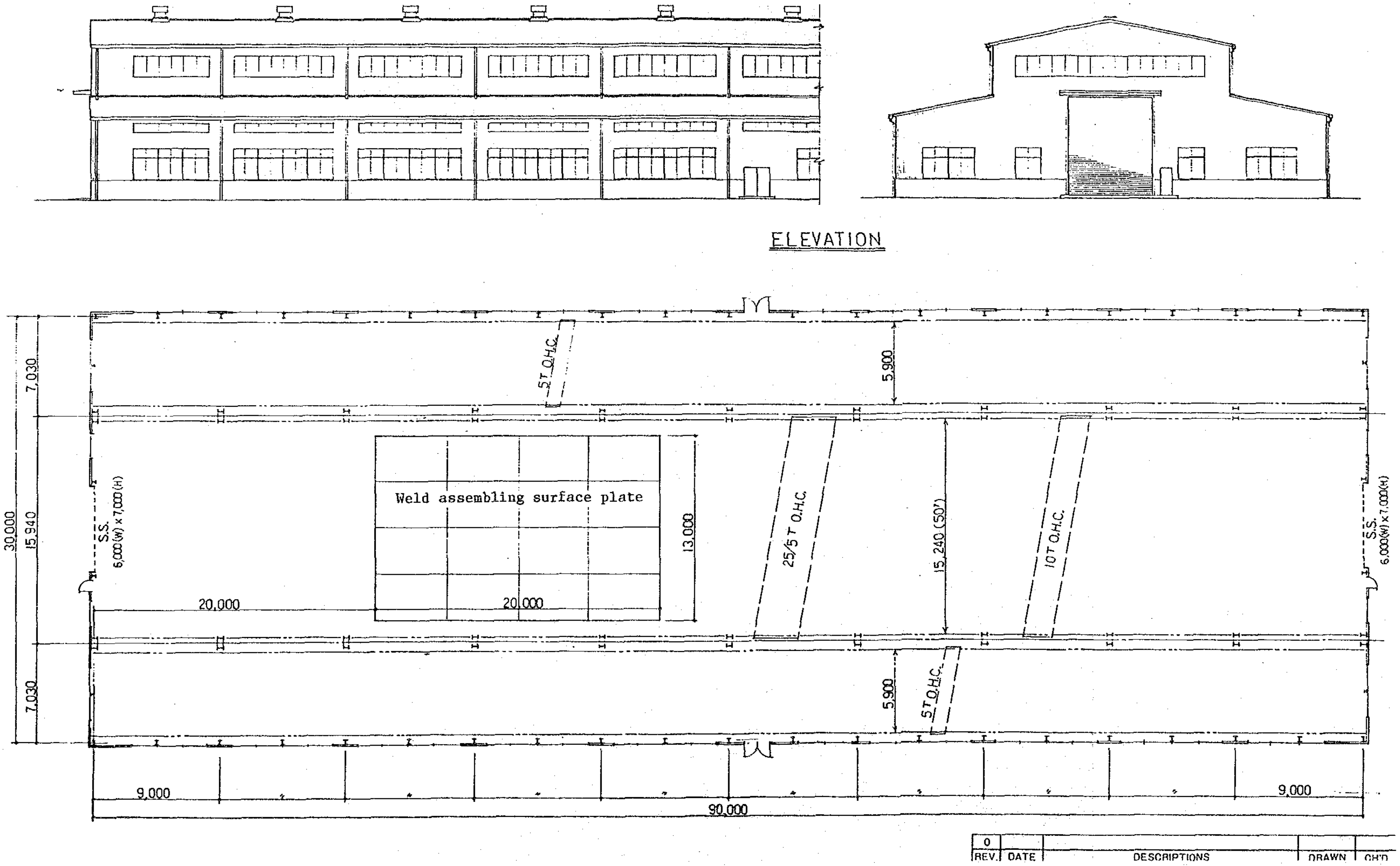
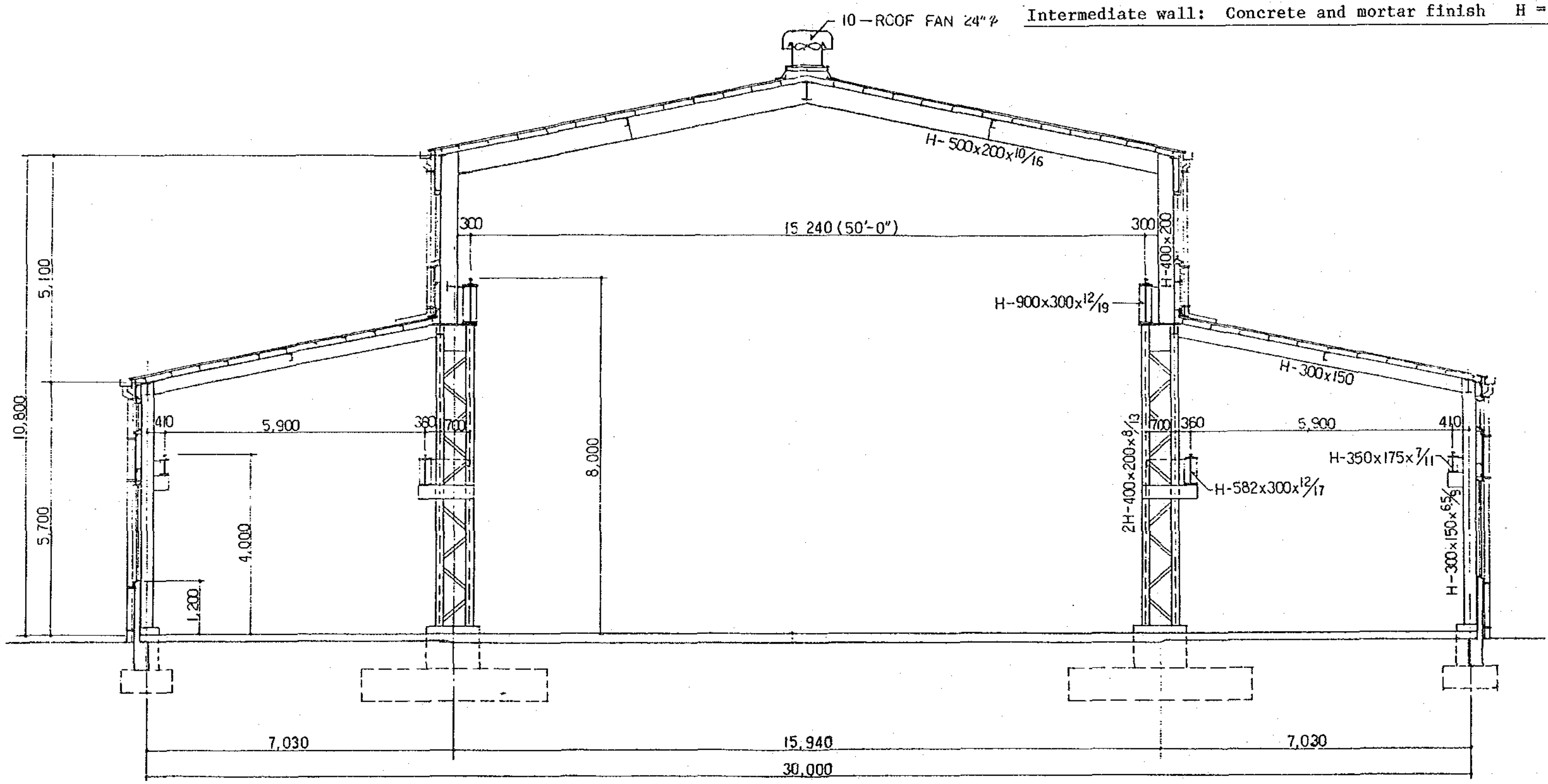


Figure 3.2-1 Structure and Dimensions of Factory Building (1/3)

Roof: Long corrugated color steel sheet, backing of insulator

Wall, Asbestos cement corrugated sheet

Intermediate wall: Concrete and mortar finish H = FL + 1200



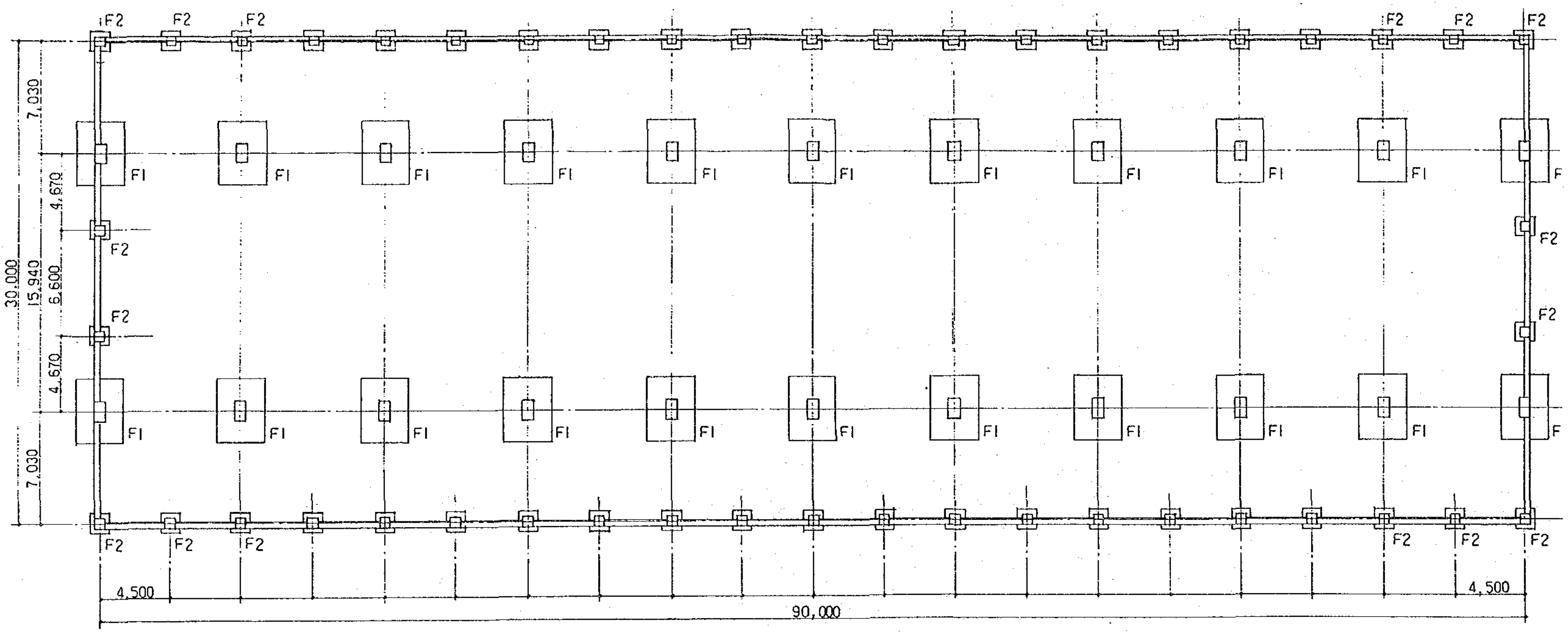
SECTION

The design is based on the followings:

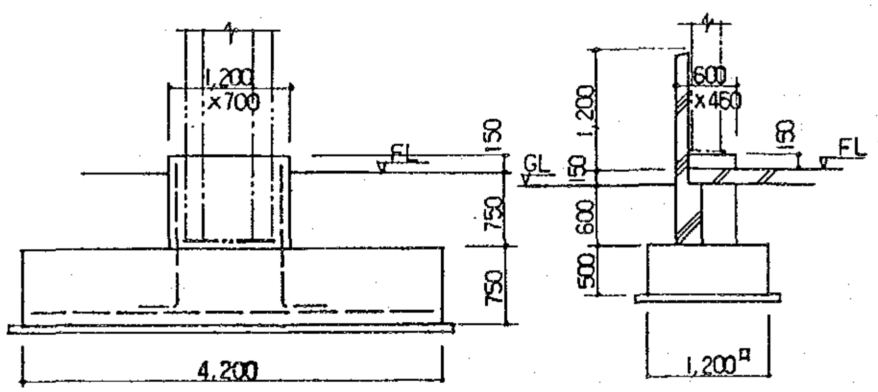
Building Standards Act and the Enforcement Ordinance

Steel structure calculation standard of Japanese Institute of Architecture

Figure 3.2-1 Structure and Dimensions of Factory Building (2/3)



FOUNDATION PLAN



Allowable bearing power of soil 10 t/m^2

Figure 3.2-1 Structure and Dimensions of Factory Building (3/3)

Appendix 2

2.1 Members of the Site Survey Mission

Team leader	Koji Chikaraishi
Team member in charge of foundry technology/process	Norio Okawa
Team member in charge of welding technology/processes	Yukio Isemoto
Team member in charge of mechanical equipment	Takeshi Kimura
Team member in charge of financial analysis/economic evaluation	Katsushi Miyamoto
Team member in charge of market/demand survey	Yoshihiro Muraki

2.2 Chilean Counterpart Members

CODELCO Head Office

Raul Poblete	Gerente Tecnico
Nicolas Queirolo	Subgerente Ingeniera
Lumie Zuniga	Subgerente Procesos
Marcelo Lira	Ingeniero, Coordinator

Workshops Department, Div. El Teniente

Raul Gualda	Subgerente Servicios
Ricardo Cortes	Superintendente Talleres
Hernan Figueroa	Jefe Control y Programacion
Carlos Caviedes	Jefe General de Produccion
Macros Jara	Jefe Operaciones Fundicion
German Schwarz	Jefe Seccion Terminacion
Luis Opaso	Jefe Maestranza Caldereria
Hugo Martinez	Jefe Turno Caldereria
Roberto Urtubia	Contador Talleres