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TECHNICAL ASSISTANCE IN
ELECTRIC ARC FURNACE STEELMAKING

SI/ETH/84/801

ETHIOPIA

Final report

Prepared for the Government of Ethiopia by the United Nations Industrial Development Organization acting and executing agency for the United Nations Development Programme

Based on the work of TESCO/HUNGARY, as subcontractor

United Nations Industrial Development Organization
Vienna

This report has not been cleared with the United Nations Industrial Development Organization which does not, therefore, necessarily share the views presented.

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Explanatory Notes:

The value of the Ethiopian currency in United States dollars is given herewith:

One US Dollar = 2,07 Ethiopian Bir

S U M M A R Y

Post Title: Technical Assitance in Electric Arc Furnace Steelmaking

Project Number: SI/ETH/84/801

The obove project was conceived in the year 1985 as a part of UNIDO'S programme of Technical Assistance to the Least Developed Countries.

Purpose of the Project: To provide technical assistance for improving existing scrap handling, quality control, steel melting practice and to establish proper Metallurgical Laboratory.

Duration: The three experts fielded for 9 man-month /Annexure A/ from February to May 1985.

Main Conclusions and Recommendations

Although it has been a long time since the plant was commissioned the production is carried out nearly according to the original technology introduced upon commissioning the electric arc furnace, how ver, adjustments have been found to be needed.

The level of production could be improved if up-grading of both scrap handling, steelmaking and teeming f ingots; rolling practice quality control as well as preventive maintenance were implemented.

On the other hand manpower training also should be given priority, taking into account local resources and assitance ya government bodies and international organizations like UNIDO.

INTRODUCTION

Project Background

The Government of Socialist Ethiopia has recognized the acute needs of up-gradation of electric arc furnace steelmaking at the Ethiopian Iron and steel Foundry under the jurisdiction and control of the National Metal Works Corporation.

Started in 1961, the factory is located 20 km from Addis Ababe; produces steel nails, plain and ribbed reinforcement bars and steel wire netting. On two-shift basis, about 12.000 tonnes of reinforcement bars /6-32 mm dia/ and 4.000 tonnes of nails were produced in 1984 a total workforce of 450 including supervisors.

The molten steel is bottom-poured through a central trumpet into 14 pencil ingot moulds. The pencil ingots /85-90 kg/ are then reheated and rolled in a merchant mill into rounds to be used either as reinforcements or for further processing into wire coils for nail production.

The steel scrap is purchased from various sources in the country and is heteregenous in character. No facilities have been used for its classification, segregation and preparation; and nor for quick chemical analysis and control of the steelmaking process in the electric arc furnace. Visual inspection of the fractured surfaces of broken samples hasbeen the only method employed to determine the carbon content.

Prior to the establishment of a full-scale metallurgical laboratory, a spectrometer has already been purchased.

As far as the establishment of the new laboratory is concerned the Metal Works Corporation has located funds for the erection of a laboratory building at the Ethiopian Iron and steel Foundry.

Work done on this field

Previously experts from Ziscosteel /Zimbabwe/ carried out a Draft Report on: Assessment of the Operations at the Ethiopian National Metal Works Corporation's Steel Plant in January 1985. Project Number: UNIDO P 84/48-SI/RAF/84/804

Cooperating Counterpart

The Ethiopian Iron and Steel Foundry was the cooperating counterpart.
Experts received every assistance required from the factory management.

They were cooperative and ready to accept proposals and introduce them. Fruitful discussions were held and without their active support working programme could not have been done to the extent as it was.

Objectives of the Project

a/ To improve the existing scrap handling practice and specially the entry, quality control, procurement, segregation, chemical composition and preparation.

b/ To improve the steel melting practice, and particularly the quality control.

c/ To establish a proper metallurgical laboratory with appropriate equipment and facilities for quick chemical analysis.

I MAIN DUTIES OF THE PROJECT DOCUMENT

During the mission the duties of experts were: to provide day-to-day practical advices and on the job training through direct participation in the production processes.
As a result of their work, in co-operation with the national counterpart personnel both the level of productivity and especially the quality of steel would be noticeably improved.

The experts, and particularly the Team Leader, and the expert on metallurgical laboratory equipment/operation will be expected to advise the counterparts on proper specification, layout, manning and other pertinent problems to establish a full-scale laboratory.

II ACHIEVEMENTS OF IMMEDIATE OBJECTIVES

Achievements of the assignment were in close relation with the objectives of the mission.

In the course of the field-work, however, due to the introduction of running the electric arc furnace and the rolling mill in separate shifts because of the weakness of power line from the substation, some technological modifications to improve quality of steel could not be introduced. The melting furnace was operating in the second and third shift.

Scrap handling with the use of bailing machine improved; and the carbon content of scrap was analyzed in the up-graded laboratory. When preparing the charge it is good to know what is the carbon content of the charge approximately and if necessary iron castings are added to assure required value of carbon.

The existing laboratory, which had been out of use for many years, with the involvement of national counterpart personnel was put back on its feet capable to analyze carbon and sulphur content being able to serve scrap segregation and steelmaking.

For the establishment of a full-scale metallurgical laboratory experts advised proper specification, layout, manning and other relevant informations /see Chapter FINDINGS/.

According to a programme, a training course was held which included laboratory staff training, direct participation in the production processes and classroom-training. /See Annexure C/, D/, E/, F/.

Technological instructions and production-technical documentation applied throught the everyday on the job training were presented in e.g. Annexure G/.

III UTILIZATION OF PROJECT RESULTS

A/ Scrap handling practice and its quality control

Arrangements were made by the factory management to allocate one bailing machine which upon its arrival to the premise commenced pressing the light scrap.

The quality control of scrap was improved by the introduction of Poldi-type hardness tester, spark testing, and permanent magnet as well as carbon and sulphur analysis in the upgraded gas-volumetric laboratory.

Due to the shortage of oxygen supply heavy steel scrap was not processed at all.

B/ Establishment of a proper Metallurgical Laboratory

For the set-up of a proper Metallurgical Laboratory steps have been made as follows:

- A Spectrometer has already been purchased, which after commissioning will take over the job from the gas volumetric laboratory and will be able to carry out quick analysis of elements such as Carbon, Sulphur, Manganese, Silicon, Phosphorous, Chromium, Molibdenium, Nickel, Copper, etc. serving scrap segregation, steelmaking process and grading concrete bars and other final products.

- The National Metal Works Corporation has located funds for the construction of a new laboratory building where the Gas Volumetric the Spectrometer Laboratories and the Tensile Testing Unit with Probe Preparations Shop will be implemented.

- National counterpart personnel were trained by the experts to carry out carbon and sulphur analysis in the Gas-Volumetric Laboratory which was put back to operation with the involvement of the local personnel. This laboratory is capable to serve production of steel until the Spectrometer will have been commissioned, however certain modernization is needed.

- In order to modernize the existing Gas-Volumetric Laboratory Quality Control UNIDO has earmarked USD 4,000 for purchasing equipment and standard samples /see Annexure B/.

- Some of the would be Laboratory staff had received special training in Spectrometer Laboratory activities in Italy. For the up-dating of their knowledge Faculty of Natural Sciences at Addis Abeba University and Ethiopian Standard Institute can be approached.

C/ Electric Arc Furnace Sttelmaking

- Prior to steelmelting the weight of steel scrap charge should be known for to be sure that there will be enough liquid steel when teeming of ingots and for making calcui-ations of metallurgical purposes. The weighing bridge for measuring was recommended to mend and before experts left it was in use again.

- In order to be able to monitor the efficiency of steelmelt-ing process a "Melting Log" for easy to follow recording system was discussed and handed over /see Annexure G/. Its introduction will provide essential data for the on going assessment of production features.

- Slag removing technique was improved by the introduction of using a special tool which was made according to experts design.

- When the oxidation is to be finished and no further carbon is expected to leave the liquid steel the reaction is stop-ped by adding Silicomanganese to the steel bath. Prior to doing this oxidised slag should be removed. It was achieved however only when experts were monitoring the steelmaking process.

- For the complete deoxidation experts advised to put the Fer-rosilicon into the furnace rather than into the ladle and to put broken pieces of Aluminium castings selected from the scrap into ladle. This suggestion was introduced toc for some time, however, its practical introduction should be checked at each charge.

- The temperature control of liquid steel before tapping, the preheating of ladle, more careful mould assembly viz. com-plete elimination of sand and mortar residue, mechanical cleaning and lime wash or black wash treatment of moulds should be solved to improve the quality of steel ingots, hence the quality of concrete and smooth bars.

However the fully introduction of recommendations for improving production processes might face failure if cost effective, items, e.g. Hardness Tester, Analytical Balance, Tensile Testing machine, Temperature Control Device and finally the implementation of a Full-Scale Laboratory Complex cannot be involved in the budget and/or if they are not involved in the use of the daily operational activities.

IV. FINDINGS

A/ Preparation of Scrap

The Ethiopian Iron and Steel Foundry has been given priority to utilize the scrap of different origin, converting it into ingots from which coils /raw material for nail production/, and reinforcement bars are manufactured.

1. Source of Scrap

Charactersitic and sources of scrap /see Annexure H/

- Light Scrap: from Crown Corks, Oil Refinery, Ethiopian Household Utility.
- Medium Heavy Scrap: suppliers are the Ethiopian Highway Authority and Private Suppliers.
- Heavy Scrap: sources are Government Enterprises and Private Suppliers
- Miscellaneous Scrap: from Private Dealers.

2. Processing

Scrap segregation and processing was not carried out when experts arrived to the factory. The scrap piled up in the premises of the factory and charged into the electric arc furnace in bulky form by the use of electromagnet effecting longer tap-to-tap time and higher energy cost.

There was an alligator shear operating occassionally, cutting only the rolling mill returns.

More than 40 per cent of scrap coming to the factory was very light /see Annexure I/.

Due to the lack of oxygen and acethylene heavy scrap was not processed.

Non-ferrous Metals:

Since the presence of non-ferrous metals such as Copper, bronze, aluminium with steel scrap going into the furnace has negative effects the quality of steel their removal needs careful attention.

Dangerous Materials:

With the bulty non-segregated scrap containers containing oil, gas, and/or other chemicals may have been charged into the Electric Arc Furnace. On high temperature these containers exploded destroying furnace roof.

Scrap Processing Team:

Actually, group of people occasionally was set together engaged in scrap handling. They could not fulfil their task due to the lack of expertise and facilities.

Layout of Scrap Processing:

A great area is covered by unprocessed scrap in the premises of the plant. The characteristic and layout of existing scrap processing is displayed in Annexure I.

Machines and Equipment:

For the time being for scrap processing there are

- ONE, Mobile bailing machine /Operating/
- THREE, Torch cutting equipment - not used since oxygen is in shortage
- ONE, Alligator shear - Operating but it is processing only the rolling mill returns
- ONE, Mobile crane - Operating
- ONE, Crusher steel ball for braking iron castings - Not used.

Classification of scrap is based on routine practice basing on visual inspection.

3.3 Charging Method

Scrap was charged unprocessed into the electric arc furnace by the use of electro magnet by which non desired materials e.g. pressure vessels, automobile schock absorbers filled with oil, etc., might also go in being able to cause explodings. This charging system is unsatisfactory and creating longer tap-to-tap time and rising energy costs.

There were two charging buckets but only stand-by, rarely used since with the unprocessed scrap it cannot be filled. The weighing-bridge was out of order.

Charge Composition :

Bulky Light, heavy scrap mixed with non ferrous materials, schock absorbers, non metallic materials were very much mixed in charge.

Charge Calculation :

Only estimation and not calculation was in practice.

Charging:

The furnace roof swing aside and the crame magnet transported the bulky unprocessed scrap into the furnace. This method is unsatisfactory.

B/ Electric Arc Furnace Steelmaking

The whole process of steelmaking was found to be based on long years of workshop experience rather than following a precisely controlled technology. The implementation of controlled steelmaking was commenced by providing day-to-day practical advices and classroom training during the assignment.

1. Melting Practice

The furnace was charged full of light scrap, and the roof left in lifted position for about 20 minutes.

When the scrap was semi-melted roof was lifted and swang aside and an other quantity was carried by magnet-crane into the furnace.

Not only the heat-loss but the electrode consumption were much more than required with this technology.

Burnt lime used for slag forming both at the end of melt-in and later during oxidizing was very dusty and contained mosture as well. The effect of this powderous lime are:

- it is increasing the volume of dust leaving the furnace
- a good part of it is rising to the roof

reducing its lifetime considerably.

The moisture of the lime will be absorbed by the liquid steel in the form of oxygen and hydrogen, destroying the quality of steel.

First Probe: at the end of melt-down liquid steel was poured onto the surface of a steel plate. Cooled down in water the fractured surface of broken sample gave information of the carbon content for the melters.
This method is unsatisfactory.

Oxidizing:

Basing on the estimation of carbon content shown by the probe, melters started adding limestone, burnt lime and if carbon content found high mill scale.

Since the exact carbon content was not known this method of oxidizing could not be controlled.

Second Probe: Melters took th. second probe out when they thought the carbon content was right. When it was found too low electrodes were deepened into the liquid steel for carbon pick-up in switched off position.

This is a very expensive way of carburizing. Further probes were taken out until the carbon content was found to be the final value.

Slag Removel:

Melters removed slag occasionally by tilting the furnace.

Desoxidation

For blocking further oxidation of carbon 50 kg Silicomanganese was added into the furnace and 15 kg of Ferrosilicon into the ladle.

From commencing desoxidation until the start of teeming the time passed was not more them 5 minutes which was not enough for inclusions to leave the steel for the slag.

Tapping of Steel

Steel was tapped into cold ladle. 15 kg of Ferrosilicon went to the stream of steel and finally silico-sand sometimes moistures added to the surface of the slag.

2. Ingot Teeming

With one ladle 14 moulds were filled with liquid steel making a total of 56 pencil ingots. It always happened that sand was dropped by chance into moulds during the assembly of mould set which could be captured by liquid steel resulting defects in steel ingots.
The inside surface of moulds was not treated at all.

At the end of teeming steel remaining in the ladle was carried back to the melting furnace and if the temperature was not high enough it solified on the bottom of the ladle, which removal needed oxygen and damaged the refractory lining seriously.

C/ Refractories and Arc Furnace Electrodes

Refractories and electrodes are among the top cost bearing items.

1. Lining of Furnace and Ladle

Furnace roof: was made of silica or alimina bricks. Lifetime of silica was an average of 70 melts, however it should have reached between 120 and 150 melts.
Electrode cooling rings were missing, therefore graphite electrode loss was higher.

Bottom and wall of the melting furnace

The bottom and wall lined by dolorite were not repaired after each melt hence their lifetime was shortened.

Ladle

The ladle was lined with alumina bricks, repaired with kaoline-mortar and dried by oil burner.

Due to power supply difficulties the electric arc furnace was working in the second and third shifts. Every morning the furnace lining cooled down and excess energy was needed to raise its temperature again to working value, making the cost of production higher.

2. Electrode Consumption

Electrode consumption was found high because of the following reasons:

- Electrode cooling rings were removed.
- Electrodes were used for carburizing the liquid steel if the carbon was found very low.

D/ Operation of the Electric Arc Furnace

1. Capacities and Operational Techniques

However, commissioned in 1961, the 5-ton capacity electric arc furnace was in a rather good condition. From the 15 kV--line through a reactor the 2620 kVA transformer supplied energy for melting steel scrap.

Due to the limited availability of power the yearly production of pencil ingots was less than the nominal capacity.

Capacity figures:

Nominal capacity: 10,300 tpy /3-shift/
Production of ingots: /1983/1984/
5,200 tpy /2-shift/
Target of ingot production: /1984/1985/
6,000 tons /2-shift/

Operation techniques

At start-up of melting, for at least 20 minutes the roof was not seated hence reducing the lifetime of roof lifting and swinging mechanism.

The controly system of electrode moving mechanism was not functioning satisfactory and the electiodes were operating very slowly. Therefore the tap-to-tap time extended.

Despite the periods of metallurgical processes in the furnace required different volumes of electric power, this need was not fulfilled, viz. the reactor was all the time full-tapped, and the position of transformer tap changer was varied according to the long years of experience rather than to the real demand /see Annexure K/.

2. Condition of different Units

Furnace Body: Its solid state was preserved, only the cradle seats seemed to need replacement.

Roof: Water cooled, however, could not be seated in the sand bed on the rim of furnace body because the guiding steel belt was deformed.

Door and Tapping Canal: Door frame watercooled but the moving part of it did not close properly in down position.

Electrode Supporting System and Conductors:

Graphite electrodes firmly held by bronze headed clamps and connected with water-oil emulsion network, were moved up and down by supporting arms the movement of which was interrupted if air bubles were not released from electrode moving cylinders before each cold start.

The elbows of copper conductor tubes were being bent by both the heat reflection of the furnace and the weight of flexible copper cables close to being able damaging themselves when electrodes are in the lowest position.

Roof Lifting and Swinging Mechanism:

It was functioning properly, however, being vibrated when furnace roof was not seated during the melt-down period.

Flexible Cables:

Performance of these copper flexible cables was good, but insulating rings were missing. If too many these rings are lost on the cables short cut may happen between them resulting damages.

Cooling System:

Furnace roof, electrode holding clamps and slagging door frame were watercooled. Adequate network supplied fresh water for cooling purposes.
Electrode cooling rings were missing.

Oil Emulsion Network:

Movements of roof lifting and swinging, furnace tilting, electrode moving and holding, door moving were all controlled by water-oil emulsion system under pressure maintained by safety pressure tank served by pumps.
There were there types of problems:

- Sealings at many joints of the network were damaged. As a result of releasing of oil-water emulsion through sealings the concrete-cabins under the furnace were filled of it which had created dangerous situation if any drop of liquid steel could have reached there.

- In the safety pressure tank no proper volume of air cushion was formed which should be existing for emergency case if by electric cut-off pumps stop functioning.

- Steel frames supporting the electric motors and pumps did not have fixed connection, and there was a vibrating effect existing which could cause damages both to the electric engines and pumps.

Transformes and Reactor:

Both were found in good condition.

- Tapping of the transformes and reactor in the course of steelmaking was not according to the technological requirements /see Annexure K/.
- The reactor was not switched off after the steel scrap melted completely.

Measuring and Indicating Instruments:

The kilowatt register and indicating instrument was out of order. However, this device gives useful informations of the changing of electric energy consumption in the course of steelmaking, if it operating.

3. How maintenance is carried out for the Electric Arc Furnace

The lifetime of electric arc furnace and its accessories is very much dependent on the maintenance system applied.

At the Ethiopian Iron and Steel Foundry a maintenance basing on routine practice was introduced.

The existing electric maintenance shop was not furnished with special instruments and spare parts of basic need such as toroid transformer, current generator, resistance measuring bridge, isolation tester, etc.

E.g. two of the three electrodes were working very slowly influencing the electric symmetry and the length of melting time.

E/ Quality Control

1. Operating Practice

Practically the quality control was far from acceptance level. The scrap segregation, steelmelting technology, carbon determination, temperature control of liquid steel and preheated billets, and qualification of rolled products were based on only experimental tests such as visual inspection.

2. Resources Available

When arriving in the works experts found a gas-volumetric laboratory which had not been working for 4 years. Originally it was commissioned in order to carry out the chemical analysis of steel scrap, liquid steel during steelmaking, and rolled products.

First of all the availability of chemicals and facilities was checked and it was found that all the chemicals and facilities required for analyzing carbon and sulphur existed /see Annexure N, O/. Knowing the value of these two elements during steelmaking is basically important.

However, for the modernization of this laboratory /Annexure P/ certain equipment and chemicals should be purchased /see Annexure B/.
For example the balance was damaged, although it was working but not precisely. In a continuous basis of operation this balance could not work properly.
UNIDO has already allocated funds for purchasing items needed and when they are available this old gas volumetric laboratory would be stand-by for routine analysis of carbon and sulphur of steel scrap, liquid steel and rolled products.

With the resources available, Ethiopian engineers learned practically how to analyze carbon. Due to the short period of assignment experts could not up-grade the function of this gas volumetric laboratory to a level being able to serve steelmaking process. The reasons were as follows:

- Probe preparation could not be implemented.

- Carbon analysis could not be introduced routine-like and it took longer time than acceptable by melters for controlling the steelmelting technology.

V CONCLUSIONS AND RECOMMENDATIONS

A/ General

Up-grading of production techniques in the Ethiopian Iron and Steel Foundry is in an urgent need in order to meet the requirements of product standards of rolled products.

For a satisfactory solution of scrap handling it is recommended to set-up a Scrap Processing Plant separated from the Ethiopian Iron and Steel Foundry, from where processed scrap will arrive for steelmaking.

The implementation of a Full-scale Metallurgical Laboratory is necessary for the establishment of a reliable quality control system.

One of the most important things to do is working out a special practical oriented training programme. Both the international organizations like UNIDO, Economic Commission for Africa, etc. and local parastatals such as Faculty of Natural Sciences at Addis Abeba University, and Institute of Standards should be contacted for assistance in training of engineers and workers. An other source of help could derive from government agreements between Ethiopia and other countries concerned.

B/ Development of Production Techniques

1. Up-grading of Scrap Processing

First Phase: Scrap Processing Team:

For securing a steady supply of processed scrap for the melting shop it is recommended to set up a team fully engaged in segregation and processing of scrap. This team can be organized of 10 people:

ONE - Team Leader

TWO - Torch Cutters

TWO - Mobile Crane serving Workers

ONE - Specialist selecting and collecting reusable components

TWO - Workers engaged in removing aluminium castings, and other non-ferrous metals and alloyed iron and steel components.

TWO - Workers preparing aluminium castings to be used in the deoxidation process of steelmaking.

Layout of Scrap Processing

Scrap processing can be done at different places simultaneously.

Light Scrap Processing: Mobile bailing machine should process the piled light scrap both in the craned and open area. Bales from the latter will be transported in containers by mobile crane to charge preparation area close to the melting shop.

Medium and Heavy Scrap Processing: Segregation and processing are carried out by torch cutters, and the processed scrap is also transported to the melting shop by mobile crane.

Containers that might contain oil or gas or other chemicals are advised to be separated and dismantled prior to cutting or mixing with the charge.

Additionally one more Alligator Shearing Machine is required for cutting medium size steel scrap of flat characteristics.

Classification of scrap can be performed by

- Visual inspection
- Spark testing
- Hardness testing
- Carbon and Sulphur analysis in the up-graded Gas-

-Volumetric Laboratory and later in Spectrometer Laboratory.

- Using permanent magnet in the selection of ferrous and non-ferrous metals.

Phase two:

In the second phase a scrap Processing Plant separated from the Ethiopian Iron and Steel Foundry will handle all the activities of scrap processing.

2. Modification of Steelmelting Practice and Teeming of Pencil Ingots

Charging method:

The two charging buckets filled with only processed scrap should be used again.

After the completion of repairing the weighing bridge the charge will be measured by weight exactly basically important for load calculation.

The introduction of a revised "Melting Log" for being able to keep steelmaking under control is recommended /see Annexure G/.

Charge Composition

Only processed steel scrap and cast iron carbonizing material can be the compounds of the charge.

Baled Scrap. Light mixed scrap is baled to the size of 600 x 400 x 400 mm

Medium and Heavy Scrap: prepared by torch cutters, alligator shears; in the size of max. 500 x 300 x 300 mm

Cast Iron: This carbon carrying material should be broken in the size of not more than 300 x 300 x 300 mm.

The charge composition together with other important data such as electricity consumption, quantity of alloying elements, etc. are registered in the Electric Arc Furnace Melting Log /see Annexure G/.

Charge Calculation

The total weight of metallic charge equals with the weight of ingots to be produced, sprue and runners and the heat loss i.e.:

Weight of charge	=	Weight of ingots	+	Weight of sprue and runners	+	Heat loss

Weight of Ingots: with one melt altogether 56 pieces of pencil ingots of 85 kg each are teemed making, total of 4760 kg.

Weight of Sprue and Runners: is estimated to be approximately 100 kg with one teeming.

Heat loss: in the course of steelmaking appr. 8 per cent heat loss can be calculated making a total figure of 420 kg.

When calculating the charge the basic principle should be to have about 0.2 to 0.3 per cent higher carbon content in the scrap to be melted comparing to that of the final composition.

This can be gained by adding cost iron which has a carbon content of 3 to 4 per cent comparing to 0.10 to 0.30 per cent carbon content of steel scrap.

Charging

The charging by the use of buckets should be done as quickly as possible, otherwise the furnace cools down and its re-heating to operating temperature needs energy input.

The furnace roof and the electrode clampings should be cleaned off the dust as soon as charging has been completed.

Normally with one bucket the total weight of charge cannot be put into the electric arc furnace. The second one with balance weight will go in when the first quantity has been semi-melted.

Melting of Steel

In the course of steelmaking the value of electric power consumption is related to the tapping of transformer and reactor. Not more than the real need should go into the furnace, therefore, from the start of melting the scrap up-to tapping the position of transformer, reactor, and the length of arc should be in accordance with the demand /see Annexure K/.

For 10-15 minutes only 60 per cent of total transformer capacity should be introduced reducing the heavy direct heat effect of arc onto the roof.

It si recommended to use burnt lime of lumpy-type for slag forming.

Probe taking die should be introduced by which liquied steel samples can be taken for analyzing carbon, manganase, silicon, sulphur, and phosphorous, and other alloys if required.

During oxidation, for purifying purposes appr. 0.2 to 0.30% carbon should be removed; this is the reason why iron castings of hight carbon content must be added to the charge.

Slag should be removed after ten minutes of oxidation by the use of slag removing tool. By the use of tilting for slag removing the total slag cannot be removed and liquid steel may also leave the furnace.

Carbonizing: When the speed of oxidation of carbon is too high more carbon has been removed than necessary. In this case the carbon pick-up can be done by the following ways:

- Adding crushed electrodes: when applying this method slag has to be removed then grained electrodes are thrown onto the surface of liquid steel.'

- Deepering of electrodes into liquid steel: the power is switched off and the electrodes are deepened into the steel. This method is rather expensive and instead of doing this proper quantity of iron castings should be mixed with steel scrap.

In order to ensure very effective deoxidation it is reccommended to remove oxidized slag then form a new slag and add Silicomanganese and Ferrosilicon into the furnace; and finally pieces of Aluminium castings into the ladle when tapping steel.

Ferrosilicon and aluminium are separately added because their different activity to the oxygen. The aluminium is a stronger oxygen eater therefore it is charged after ferrosilicon has completed its reaction.

Tapping of Steel: In order to improve surface quality of pencil ingots it is advised to fulfil the following preparations when tapping:

- Temperature of steel should be 1580 ^{o}C. Purchasing a launce-type temperature measuring device is necessary.
- To preheat the ladle to 600-700 ^{o}C.
  A ladle preheating unit is easy to set-up with the use of local resources.

Teeming of Pencil Ingots

Between tapping and teeming liquid steel is to be rested for at least 5 minutes to homogenise the liquid steel. Mechanical cleaning if required and lime /black wash coating after each teeming would improve the lifetime of moulds and result smoother surface to pencil ingots which is finally the surface of rolled products.

3. Extending the lifetime of Refractory Linings and Graphite Electrodes

Furnace roof: The lifetime of the roof can be extended if:

- Dust accumulated on outside surface of roof is removed by compressed air after each melt; hence cooling ability will improve.
- Burnt lime is lumpy-type. If this slag-forming material is dusty a good part of it will reach the roof, inside the furnace, reacts with silica bricks forming calciumsilicate of low melting point, therefore, the lifetime of the roof will be shortened.
- Electrode cooling rings will be replaced and will cool refractories around graphite electrodes, extending their lifetime.

Bottom and wall: will last longer if they are repaired after each melt.

Ladle: The ladle can be used for a longer period if the following recommendations fulfilled:

- To preheat the ladle to 600-700 $^{\circ}C$ before each tapping.
- Repairing should be carried out carefully.
- Higher tapping temperature will eliminate accretion formation.

Graphite Electrodes: Electrode consumption can be reduced in the following ways:

- Electrode cooling ring should be replaced. By their use the heat effect of the flame coming out of the furnace through the three holes of the roof is considerably reduced and the electrodes outside the furnace will not be burning.

- Electrodes should not be used for carburizing the liquid steel.

4. To improve the Running Practice and Maintenance of the Electric Arc Furnace

One of the most important things to do with the electric arc furnace is to give adjustments to the control system of electrode moving mechanism. Instruments for this purpose did neither exist in the steel foundry nor at EELPA-Ethiopian Electric Power Authority.It is the furnace supplier who should be approached for adjusting instruments.

Furnace roof should seated after charging. Transformer and reactor tapping have to be according to steelmelting requirements /see Annexure K/.

Basing on daily, weekly, monthly, and yearly schedules a preventive maintenance system should be worked out /see Annexure L, M/. The existing maintenance shop has to be modernized, its manpower demand is:

ONE - Electrical Engineer
TWO - Technicians
THREE - Skilled Workers
TWO - Unskilled Workers

Main activities of this group will be:
- checking and repairing of instruments e.g. Voltage, current, kVA and kWh indicatihg and registering instruments,
- maintenance of protection relays and circuits,
- controlling the function of temperature measuring instruments and thermocouples,

- checking and repairing the circuit brakers and high tension parts,
- checking and maintaining electric motors of cranes and other equipment.

C/ Manpower Training Requirements

Both production techniques to be up-graded and further developments demand adequately trained personnel at all levels. The local staff might get further assistance from different sources:

1. Assistance from external experts

a/ Chief Technical Advisor, specialized in rolling mill operations, engineering and management, duration: 12 months

b/ Expert in Electric Arc Furnace steel making, duration: 6 months.

c/ Expert in metal scrap input control segregation and processing, duration: 2 months.

d/ Expert in Metallurgical Laboratory and quality control, duration: 2 months.

e/ Short term consultants in special areas /mechanical/electrical, maintenance, production of nails, roll pass design, etc. Total duration: 6 man-months.

f/ Plant workers trained by plant personnel to be trained abroad as well as other expatriate experts to be deputed as experts on fields above /see Paragraphs a, b, c, d, e/.

2. Training of EISF personnel abroad

Since there exist limited number of trained manpower at EISF, it is not practical to send all of them abroad. Hence the following arrangement is suggested:

a/ Training at ZISCO STEEL, Zimbabwe concerning rolling mill operations.

b/ Training of Ethiopian metallurgists in Hungary where conditions are similar to that of the EISF.

c/ Under the umbrella of UNIDO, Workshop Programme on core metallurgical industries are held each year. Engineers might attend this event.

3. Utilization of Ethiopian resources

The Ethiopian Standard Institute, the Faculty of Natural Sciences at the Addis Abeba University, and the Ministry of Mines Minerals and Energy all have potential resources to participate in training programmes for the Ethiopian Iron and Steel Foundry personnel.

D/ Quality Control

Establishment of a Full-Scale Metallurgical Laboratory.

1. Up-grading of the existing Gasvolumetric Laboratory. Phase One.

With the involvement of funds UNIDO has launched the condition of existing gasvolumetric laboratory can be improved in order to be capable carrying out basic control analyzes for scrap segregation, steel making, and rolled products.

The Gasvolumetric Laboratory remains in the existing building. Moreover the presence availibility of instruments and chemicals additionals will be needed as follows:

- New analytical balance has to be purchased and placed on a rigid /concrete/ table with shock absorbing basing. For producing steel ships one table-type drilling machine will be installed.

In order to fulfil the present and future demand the following items will have to be purchased and stored with present chemicals:

Standard steel chips 500 g/bottle
Sublimated iodine 250 g
Chromic acid/Cr/VI/oxide 1000 g
Carbon tetra-chloride 5 litres

Equipment and accessories:

ONE - equipment for C and S analysis,

ONE - oxygen bottle /high purity oxygen/ with stand and pressure reducer.

ONE-cupboard with safety locking and fire-proof walls for chemicals /some of them are poisonous and dangerous/.

ONE-table to hold the gasvolumetric analysing system with under self /2.2 x 0.8 m/.

ONE-table welded from steel profiles and plates with under self to hold samples, tools, glass-wares serving the analysis process, to prepare solutions and store these provisionally /2.0 x 4.0 m/.

ONE-cupboard with standard locking for spare parts of the furnace, porcellain boats and spare parts of the analysing system /glass ware, hoses, plugs, etc./

ONE-double sink with two water taps.

ONE-electric resistant heater

ONE-glass container for porcellain boats with dessicating.

ONE-laboratory balance /0-120 g/.

ONE- barometer applicable to local barometric pressure with is approx. 570 Hgmm.

Area of Gasvolumetric laboratory is: 4.5 x 3.0 m

Electrical facilities:

- three sockets /220 V A.C., 4 A/ for illumination the balance and equipment
- one socket /220 V A.C. 16 A/ grounded for furnace
- illumination: 400 lux

Forms of diary of carbon analysis in the laboratory should be introduced to certificate results /see in Annexure T/.

List of chemicals stored in the laboratory /see Annexure N/.
Arrangement of facilities /see Annexure P/.

Some of the listed items could be purchased immediately with the utilization of funds available at UNIDO /see Annexure B/.

2. Commission of the Spectrometer

Phase Two.

Allocated in the office building until the laboratory complex is commissioned this unit will carry out very quick and reliable chemical controls for all routine exercises in the plant.

The spectrometer laboratory and the probe preparing unit will be arranged close to each other but in separate rooms, see Annexure Q.

Facilities needed for the Spectrometer Laboratory are specified herewith.

ONE - ESA 4 type sequential spectrometer
ONE - Analytical balance
ONE - Rigid table with shock absorbing basement
ONE - Argon bottle /Argon 97% + hydrogen 3% with high purity /with pressure reducer.
ONE - Blower to keep the room temperature between the desired limits.
ONE - Stereo microscope /binocular/
ONE - Table for keeping samples and tools serving the spectrometer as well as the microscope.
ONE - Cupboard for spare parts of the spectrometer and keeping documents.
ONE - Writing table.
ONE - Bootself
ONE - Water tap with sink.

Electrical connection facilities

ONE - socket /220 V A.C., 5 kVA, 25 A with earthing connection/ for spectrometer with protecting braker.
ONE - voltage stabilizer /220 V. A.C.5 kVA output/
FOUR - sockets /220 V. A.C., 4 A each/.

Probe preparing workshop

Facilities of probe prepairing unit Annexure R.

ONE-rapid cutter for prepairing testpieces for spectrometer

ONE-grinder/polisher machine to prepare samples for spectrometer

ONE-laboratory furnace /max. temperature: 1200 °C/ for heat treatment of samples

ONE-drilling machine /table type/ with hard metal tools /dia. 4 mm/ for preparing chips for gas volumetric analysis /see also at gasvolumetric laboratory/

ONE-wooden workshop table

ONE-workshop vice

ONE-set tools to operate and maintain laboratory equipments

ONE-cupboard to store spare parts, accessories and supply

ONE-water tap with sink

Electric connection facilities:

ONE-socket /220 V A.C. 1 kVA with earth connection/ according to the cutter's manuel

ONE-socket /220 V A.C. k VA with earth connection according to the manual of grindes/polisher machines

ONE-socket /220 V A.C. 1 kVA with earth connection/ according to the manual of drilling machine

ONE-socket /220 V A.C. 16 A with earth connection/ according to the manual of furnace

THREE-sockets 220 V A.C. 4 a for other purposes

Illumination: 1000 lux

Since the Spectrometer is in the storehouse its commissioning could be carried out very quickly.

3. Erection of a New Chemical Lab.ratory comprising both Gas-volumetric and Spectrometer as well as Mechanical Testing units,

Phase Three.

Close to the office building the area is sufficient for the erection of a Laboratory complex comprising every unit above viz.:

Spectrometer Laboratory /shifted from phase two/
Gasvolumetric Laboratory /shifted from phase one/
Tensile Testing Lab. Mechanical Testing.
Probe Preparing Workshop.

/Annexure V./

Herewith is the manning of the full-scale metallurgical Laboratory:

ONE - ENGINEER
TWO - Technicians
ONE - Mechanical worker
ONE - Unskilled worker.

Facilities of spectrometer and gas volumetric laboratories as well as probe preparing unit integrated into the full--scale metallurgical laboratory have been partly listed under Phase one and Phase two.

Facilities required for Tensile Testing Laboratory are given herewith:

ONE - tensile testing machine as shock absorbing basement; minimum loading capacity 100 kN.

ONE - hardness tester machine on concrete slab basement with HB and HV measuring capabilities.

ONE - portable hardness tester /Poldi/ with twenty master rods.

ONE-large rigid table made of wood to store samples, tools, spare parts

ONE-large workshop vice attached to the table

ONE-large cupboard for spare parts, accessories, books and documentation of laboratory work

ONE-table

For electric connection:

ONE-socket /220 V A.C. 16 A/ in accordance to the manual of tensile testing machine

FOUR-sockets /220 V A.C. 4 A/ for hardness tester and other purposes

Froms of certification of laboratory results see in Annexures S, T, V.

Complementary equipment and materials to be purchased for Full-scale Metallurgical Laboratory and their prices

Gasvolumetric Laboratory:

ONE-cupboard, fireproof with safety locking	280 ETB
ONE-barometer /scaling from 500 Hgmm/	85 ETB
ONE-double sink with two water taps	250 ETB
chemicals:	
- 250 g of sublimated iodine	20 ETB
- 1000 g of chromium /VI/ oxide	20 ETB
- 5 litres of carbon tetra-chloride	35 ETB
- 500 g/bottle of standard steel chips with C-content 0.05; 0.10; 0.20; 0.30; 0.40; 0.50; 0.60 W %	120 ETB
	810 ETB

Spectrometer laboratory:

ONE-analytical balance /LE-1050/	2950 ETB
ONE-rigid table for balances	200 ETB
ONE-argon bottle with fixing and reducer	300 ETB
ONE-blo er /window-built/	150 ETB
ONE-stereo microscope /binocular/	1400 ETB
ONE-cupboard for spare parts, etc.	300 ETL
ONE-bookshelf	300 ETB
ONE-water top with sink	200 ETB
	5800 ETB

Probe preparing workshop:

ONE-rapid cutter machine /Metasecan/	10 472 ETB
ONE-drilling machine to make chips	2 000 ETB
ONE-laboratory furnace	2 500 ETB
ONE-wooden workhop table	300 ETB
ONE-workshop vice	40 ETB
ONE-set of tools	200 ETB
ONE-cupboard	300 ETB
ONE-water tap with sink	200 ETB
	16 012 ETB

Tensile testing laboratory

ONE-tensile testing machine Annexure Z /200 kN, EV 20/	44 000 ETB
ONE-hardness testing machine HB and HV	4 000 ETB
TWENTY-Master rods for POLDI hardness tester	300 ETB
ONE - Rigid wooden table for samples, tools, etc.	500 ETB
ONE - Workshop vice	78 ETB
ONE - Cupboard for storing spare parts	300 ETB

Building budget for full scale Laboratory 40 000 ETB

Total cost of the full-scale Metallurgical Laboratory 111 800 ETB

Location of Laboratory complex and some reasons for selecting certain instruments:

the building of laboratory was located to the office building consulting with the local technical staff;

in case setting up the laboratory to the production as close as possible dynamic effects /shocks/ from the scrap handling and rolling which are harmful for the laboratory work and testing equipment;

the purpose off application of selected /recommended/ main material equipment:

Tensile testing machine: to check and certificate mechanical properties of steel bars, wires and other products of the steel plant. This is a basic instrument in quality control of produced and imported steel grades.

The recommended loading capacity of 200 kN is high enough to test samples with as rolled surface from the most frequent diameter categories of bars.

Hardness testing machines /HB and HV/ are useful for

- quick estimation of tensile strength of steel products on the basis of well-known correlation between hardness and tensile strength;
- controlling the hardness of samples of steel melting process as well as samples from the scrap-yard on the basis of correlation between C-content and hardness of steels in quenched state
- controlling hardness of wire products in different steps of drawing as well as nail production /e.g. quality of heading of nails/
- helping reconstruction of tools and producing heat-treated spare parts for producing facilities /e.g. heading and sharpening of nails, etc./.

Stereo microscope /binocular/

It is necessary for evaluation of surface condition and quality samples of steel bars, cold drawn wires, nails, worn tools and machine parts, etc.

ANNEXURE A

WORKING PROGRAMME

1 Arriving to the site - Ethiopian Iron and Steel
Foundry
Mr. Ferenc Zsigovics, Expert in Electric Arc Furnace steel making, team leader,
4th February 1985
Mr. Laszlo Palinkas, Expert in Electric Arc Furnace handling and electrical maintenance
11th February 1985
Mr. Antal Dacskai, Expert in metallurgical laboratory equipment/operation and quality control
25th February 1985

2 Scope of services

To provide day to day practical advices and on-job training through direct participation in the production process covering the following areas

- scrap segregation and processing
- laboratory operation
- steel melting process and teeming of ingots

3 Appointments with relevant Authorities and Institutes

- Ministry of Mines and Minerals
- Ethiopian Standard Institute
- UNIDO Office, Addis Ababa
- National Metal Works Corporation
- Ethiopian Electric and Light Power Authority
- Ministry of Industries

4 Expiry of assignment

- late April and/or early May

ANNEXURE B

Specification of laboratory/quality control equipment and chemicals for the modernization of existing laboratory

	Estimated Price /USD/
ONE-Hardness tester Type: Diatestor	2200.-
ONE-STEREO Binocular Microscope	750.-
ONE-Analitical Balanc Type: LB-1050	1400.-
ONE-Barometer	55.-
TWENTY-Master Rods for Poldi hardness tester	150.-
EIGHT BOTTLES-Standard Steel Chips 500 g per bottle with carbon contents of 0,1 to 0,8 percent	60.-
ONE BOTTLE-Cast Iron Chips	10.-
250 g Sublimated iodine	10.-
1000 g chromic ocid $/Cr_2O_7/$	12.-
5000 ml Carbon tetrachloride	18.-
USD:	4665.-

Ex works Europen suppler

ANNEXURE C

ON - JOB TRAINNING

A comprehens·̣ e trainning programme can secure trained manpower for the smooth running of a production line.

However, as far as on-job training is concerned during the expert's assignments a special course was implemented.

Moreover the day to day practical advices and on-job consultations through direct participation in the production processes, classroom training also helped the better understanding of the neccessity of up-grading production techniques.

Altogether 10 engineers attended this trainning programme.

The Following subjects were discussed in the classroom programme

Scrap Processing
Electric Arc Furnace Steelmaking
Furnace Operation
Quality Control /Metallurgical Laboratory/

/For detailed programme see Annexure D and E/

ANNEXURE D

Detailed Programme of Training

1. Scrap Processing
   - a/ Source and type of scrap
   - b/ Segregation of - cast iron
     - non-ferrous metals
     - alloyed iron and steel
     - non metallic components
     - dangerous items and materials
     - reusable items
   - c/ Processing techniques namely, Bailing, torch cutting, alligator shearing, and breaking.
   - d/ Chemical laboratory involvement in segregation.

2. ELECTRIC ARC FURNACE STEELMAKING
   - a/ Charge preparation and calculation.
   - b/ Steelmaking in Electric Arc Furnace.
   - c/ Refractory linings.
   - d/ Teeming of ingots.

ANNEXURE E

3. ELECTRIC ARC FURNACE IN OPERATION

a/ High tension units i.e. transformer, reactor, protection devices.

b/ Low tension parts busbars, flexible cables, graphite electrodes.

c/ Control system,
measuring of voltage and current; moving of electrodes; hydraulic system.

d/ Power consumption during steel making.

4. QUALITY CONTROL

a/ Importance of metallurgical laboratory

b/ Traditional ways of carbon analysis and temperature control.

c/ Carbon and sulfur analysis in the existing laboratory.

d/ Factors influencing the quality of ingots.

e/ Full-scale metallurgical laboratory spectrometer and gas volumetric analysis.

ANNEXURE F

TIMING OF CLASSROOM TRAINING

Date	Lecturer	Subjects
March 5, 1985	A.BACSKAI	1/ a, b
March 7	F.ZSIGOVICS	2/ a
March 8	A.BACSKAI	4/ a
March 11	A.BACSKAI	1/ c, d
March 12	L.PALINKAS	3/ a
March 13	A.BACSKAI	4/ b, c
March 15	F.ZSIGOVICS	2/ b
March 21	L.PALINKAS	3/ b
March 28	F.ZSIGOVICS	2/ c
April 5	L.PALINKAS	3/ c, d
April 15	F.ZSIGOVICS	2/ d
April 18	A.BACSKAI	4/ d
April 26	A.BACSKAI	4/ e

ANNEXURE G

ELECTRIC ARC FURNACE MELTING LOG

Date Starting Time	Melt No. Finisching Time	Ladle No.	Shift No. Duration of Melt:
Steel Category: Mild	Medium	Hard	

SCRAP CHARGE:

Steel Scrap .... Kg

Cast Iron for

Carburing .... Kg

Total .... Kg

ALLOYS:

Ferrosilicon /FeSi/ ... Kg

Siliconmangenese /SiMn/ ... Kg

SLAG FORMING MATERIALS:

Limestone /Ca_2CO_3/ .... Kg

Burnt Lime /CaO/ .... Kg

OXIDIZING MATERIAL

Mill Scale .... Kg

Chemical Composition of Alloys:

Fesi:		SiMn	
Si = 75 %		C	= 2 %
Al = 2 %		Si	= 16 to 20 %
Fe = 23 "		Mn	= 65 to 75 %
		Pmax	= 0,03
		Smax	= 0,03

ELECTRIC ENERGY METER READING

	Meter 1 /KWH/	Meter 2 /KWH
Start of Melting		
After Tapping		
Consumption		
Total Consumption		KWH

CHEMICAL ANALYSIS:	
%	C, S, Si, Mn, P
First Probe	
Second Probe	
Final Composition	

BREAK-DOWN TIME:

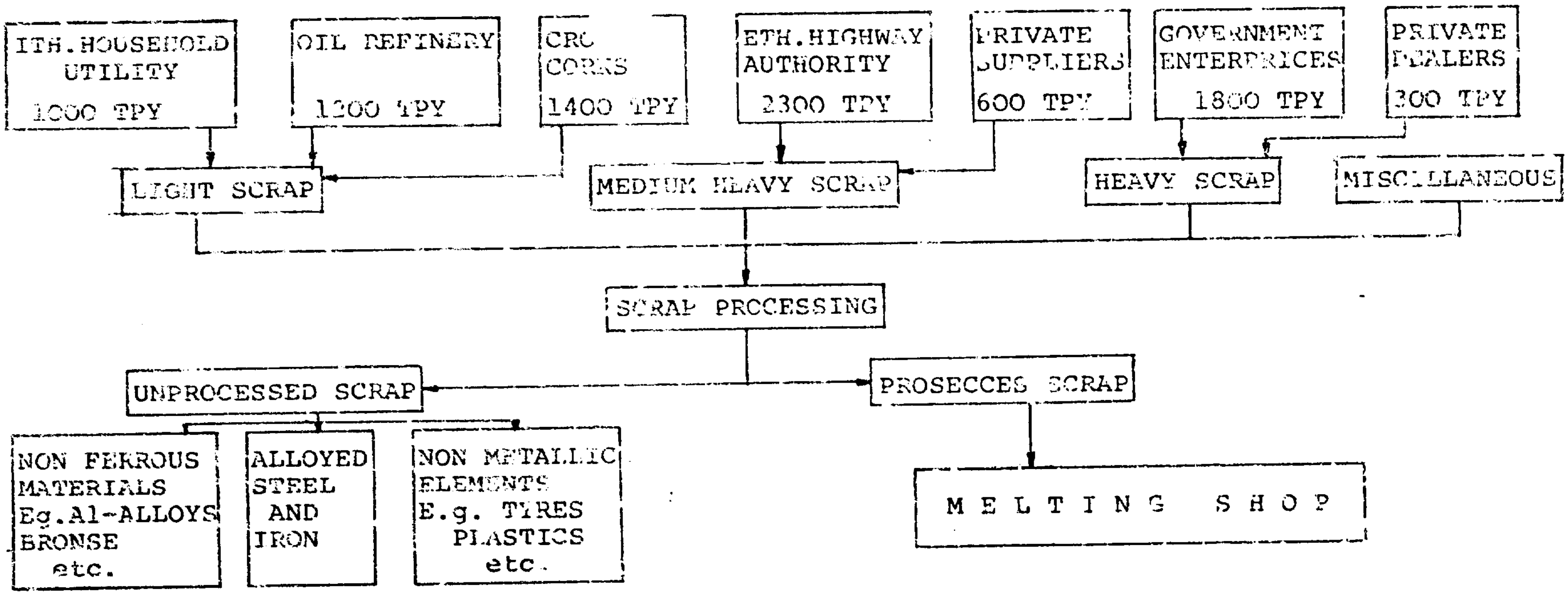
Reasons	Duration /Min/
Electrode Extension	
Roof Change	
Repair of Wall	

Shift Foreman

Production Head

ANNEXURE H

SCRAP FLOW DIAGRAMME



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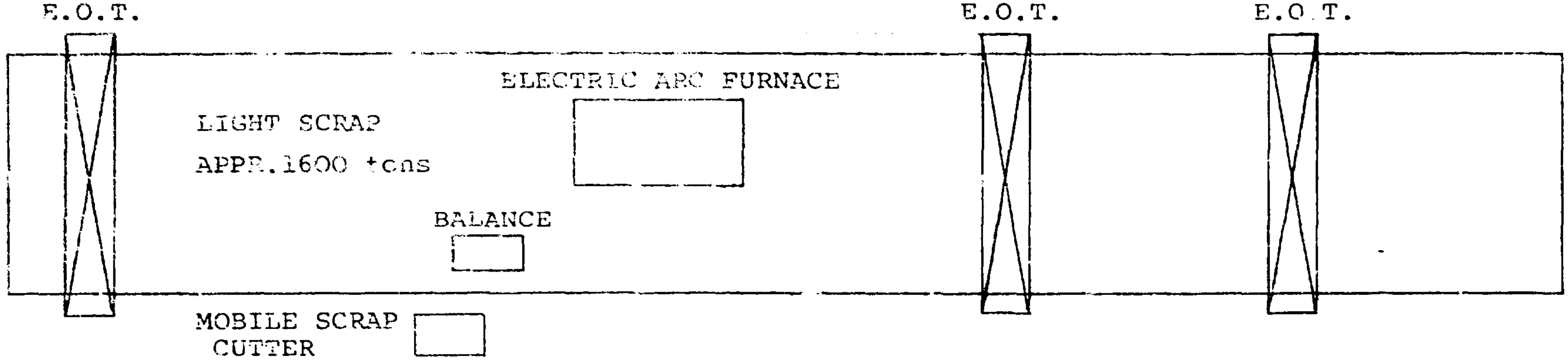
ANNEXURE I.

CHARACTERISTIC OF SCRAP AND LAYOUT OF EXISTING SCRAP PROCESSING



MEDIUM HEAVY SCRAP

MEDIUM HEAVY SCRAP

SCRAP PROCESSING:

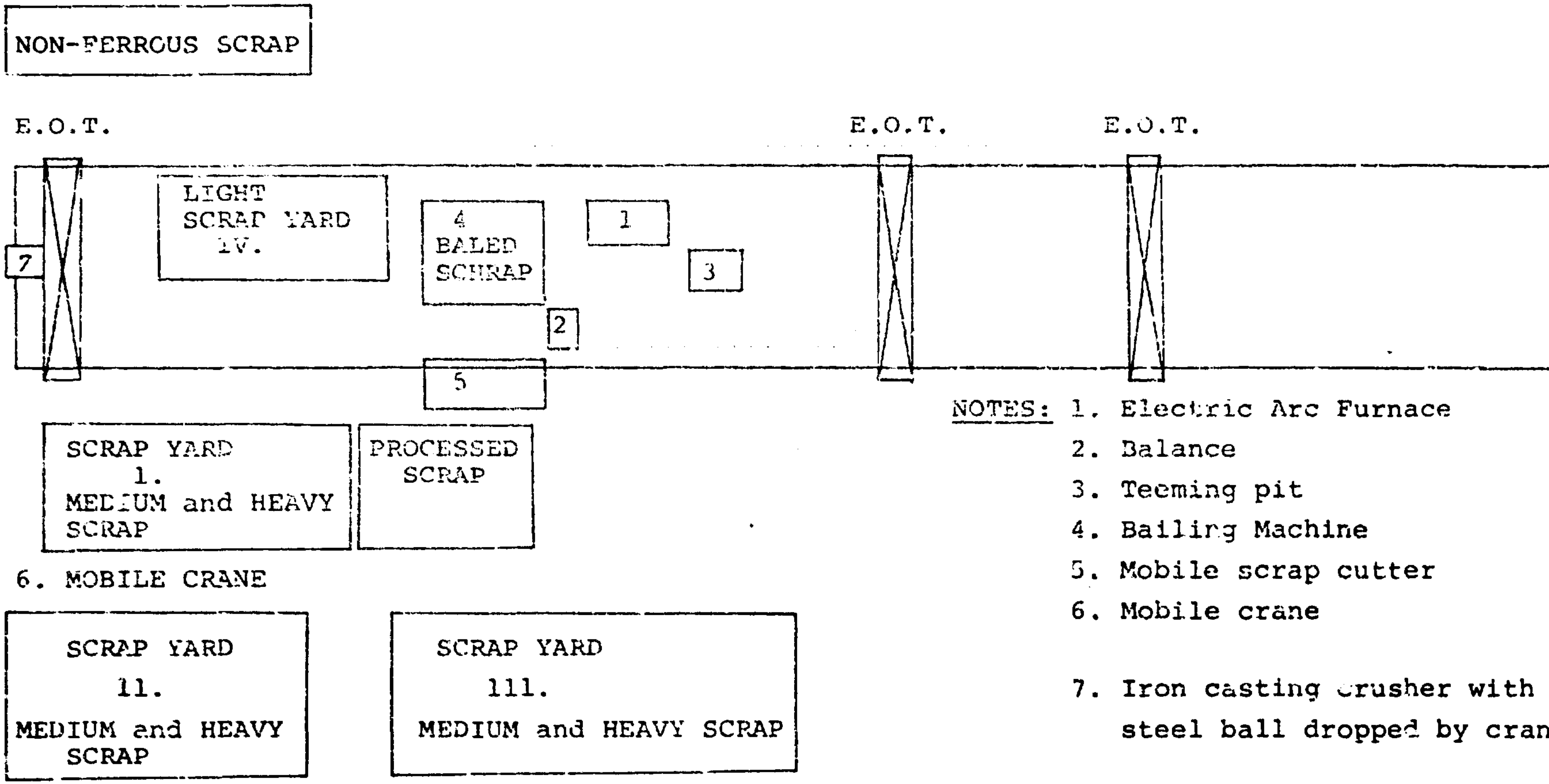
- TORCH CUTTING
- SCRAP CUTTING /SHEARING MACH/
- MOBILE CRANE INVOLVEMENT

MEDIUM, HEAVY AND LIGHT SCRAP

WEIGHT OF SCRAP APPROXIMATELY:

LIGHT SCRAP	:	1800 tons
MEDIUM SCHRAP	:	700 tons
HEAVY SCRAP	:	600 tons
TOTAL	:	3100 tons
NON-FERROUS	:	150 tons

PROPOSED LAYOUT OF SCRAP PROCESSING



NOTES:
1. Electric Arc Furnace
2. Balance
3. Teeming pit
4. Bailing Machine
5. Mobile scrap cutter
6. Mobile crane
7. Iron casting crusher with steel ball dropped by crane.

ANNEXURE K

POWER TAPPING DURING STEELMAKING

1. MELT - IN: - Commencement of melting: for 10 minutes

60 % of full power is lot-in
Reactor: in full; position 1
Transformer: position 4
Length of Arc: shortest; position 8

- Electrodes are well-in the scrap
Reactor: in full; position 1
Transformer: in full; position 6
Length of Arc: medium; position 4

2. OXIDATION: The total charge is liquid, oxidation starts
Reactor: switched off; position 4
Transformer: medium; position 3
Length of Arc: shortest; position 8

3. DEOXIDATION: The Temperature is raised a litle.
Reactor: switched off; position 4
Transformer: position 4
Length of Arc: shortest; position 8

4. BEFORE TAPPING: For 5 minutes temperature is increased before tapping
Reactor: switched of; position 4
Transformer: position 6
Length of Arc: shortest; position 8

ANNEXURE L

Preventive Maintenance to the Electric Arc Furnace

1. Daily Task:

To check:
- temperature of cooling water
- condition of electrode clamps
- oil temperature in transformer and reactor
- condition of pumps and safety tank
- moving speed of electrodes
- condition of instruments and flexible cables
- whether there is air in the oil-water emulsion system.

2. Weekly Control of:

- Furnace tilting and roof lifting and swinging mechanism.
- Cleanless of electric board and connection points e.g. push bottoms, instruments.
- Instruments and if they do not work properly change them.
- Flexible cable connections and insulating materials.
- High tension isolator moving parts.
- Condition of greasing and lubricating.

3. Monthly Check-up of:

- Grounding system
- Protection system
- Current relays
- Temperature measuring and V, A, KW, KWh metering instruments
- Condition of oil emulsion and clean the tank if the substance of emulsion is not acceptable.

ANNEXURE L ctd.

4. <u>Yearly Maintenance means:</u>

- Desmantling of all moving parts; change items if neccessary.
- Laboratory testing of the oil in the transformer and reactor, and recondition it if its insulating character is found less than required.
- Once a year the circuit braker is undergoing a complete checking.

ANNEXURE M

Instruments and Equipment the Proposed Mainitenance Shop is furnished with

Measuring Device-to control protection relays

- Voltage Stabiliser - Voltage: 220 V;
  Current: 20 A minimum /AC/
- Toroid Transformer - Voltage: 3x380 V/3x0-220 V
  without taps
- Instruments to measure - V, A, W, VAr with
  Laboratory accuracy of
  at least 1 %
- Current Generator - from 0 to 20 A /AC/
- Voltage Supplier - to control the
  /pt-R+Rh-Pt
  Ni-Cr-Ni thermocouples
- Resistance Measuring Bridge
  /Wheatstone or Thomson bridge/
- Resistance wires of different types ie.
  Manganium, tantal etc.
- Tachometer to check the rotation of electric
  motore
- 3-Phase Measuring Instrument
- Direct Current, DC, Supplier
  Raging Current from OE 550 A
  Voltage from 0 to 24 V
  It can be used for Battery charging as well
- Isolation Tester /Megger type/ Voltage ranges:
  500 V, 1 kV; 2 kV
- Isolation Resistance Measuring Instrument
- Grounding Resistance Measuring Instrument
- Portable Instrument
- Standtools of many use.

ANNEXURE N

CHEMICALS AVAILABLE AT THE PLANT

CHEMICALS	CONCENTRATION	QUANTITY
PHOSPHORIC ACID, H_3PO_4	85 %	2000 gr
HYDROCHLORIDE, HCl	NIL	2500 gr
POT. SSIUM HYDROXIDE, KOH	85 %	7000 gr
AMMONIUMPERSULPHURICUM $(NH_4)_2S_2O_8$	93 %	2000 gr
SODIUM CHLORIDE, NaCl	NIL	500 gr
SODIUM CARBONATE, Na_2CO_3	NIL	4000 gr
TIN POWDER, Sn	99 %	8000 gr
SODIUM ARSENICOSUM, $NaASO_2$	95 %	500 gr
METILORANGE		300 gr
METILBULE		150 gr
SODIUM HYDROXIDE, Crystal, NaOh		4000 gr
SODIUM HIDROXIDE, Liquid, NaOh		6000 gr
POTASSIUM IODIDE, KJ		2000 gr
POTASSIUM IODATE, KJO_3		500 gr
STARCH		300 gr
POTASSIUM DICHROMATE $K_2Cr_2O_7$		500 gr
MERCURY, Hg		
SULPHURIC ACID, H_2SO_4	96 %	6000 gr
SILICON		50 gr
GREASING AGENT		20 gr
OXYGEN In tank		AVAILABLE:

ANNEXURE O

FACILITIES AVAILABLE

ONE - Balance measuring from 0 to 125 gr.

ONE - Analitical Balance

ONE - Combustion furnace with

TWO - Spare Thermometer, from 0 to 1500 °C

THIRTY - Spare silite rods.size Ø 8 x 180 m.m
Electrical resistance 4,2 ohm

ONE THOUSAND AND EIGHT HUNDRED - Poscelaim cambustion boats

TWENTY-TWO-Procelain Combustion tubes.size 26x20x600 m.m

ONE-GLASSWARE Assembly for volumetric Carbon analysis

SPARES - For another two assemblies and Glassware Spares.

ONE - Glassware Assembly for Surfur analysis

SPARES - For another ONE Assembly and Glassware Spares

ONE - Glass container with desicoating salt for keeping dry combustion Boats

GRADUATED CYLINDERS, FUNNELS, TITRATING GLASSES

ONE - BAROMETER /Mercury is missing/

ONE - Thermometer from 18 to 50 °C

ONE POLDI-type from hardness tester

ONE - Plastic container for distilled water, capacity 20 littres

ONE - Plastic Container for distilled water capacity 10 lit.

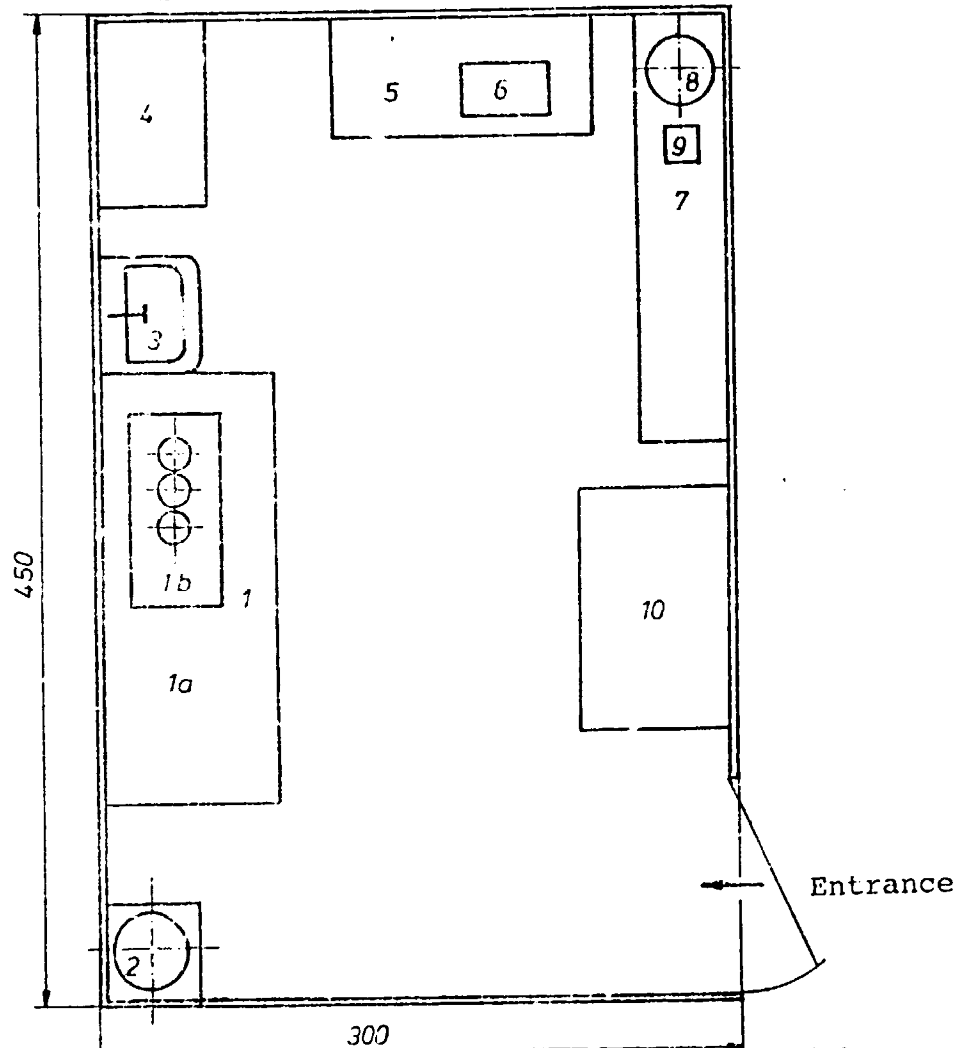
ONE - Oxygen bottle

ONE - Pressure with built-in Flow meter.

ANNEXURE P

GASVOLUMETRIC LABORATORY: EXISTING

PHASE ONE



1 Table to hold gasvolumetric analysing system /with under self/

1a Tube furnace to burn sample chips

1b C, S analysing system /BICASA/

2 Oxigen bottle in fixing stand

3 Water tap with porcellain sink

4 Cupboard to store chemicals

5 Table to hold analytical balance and samplex

6 Analitycal balance

7 Table with welded structure with under self to hold samples /as brought in/ and glasswares on the under self

8 Glass container

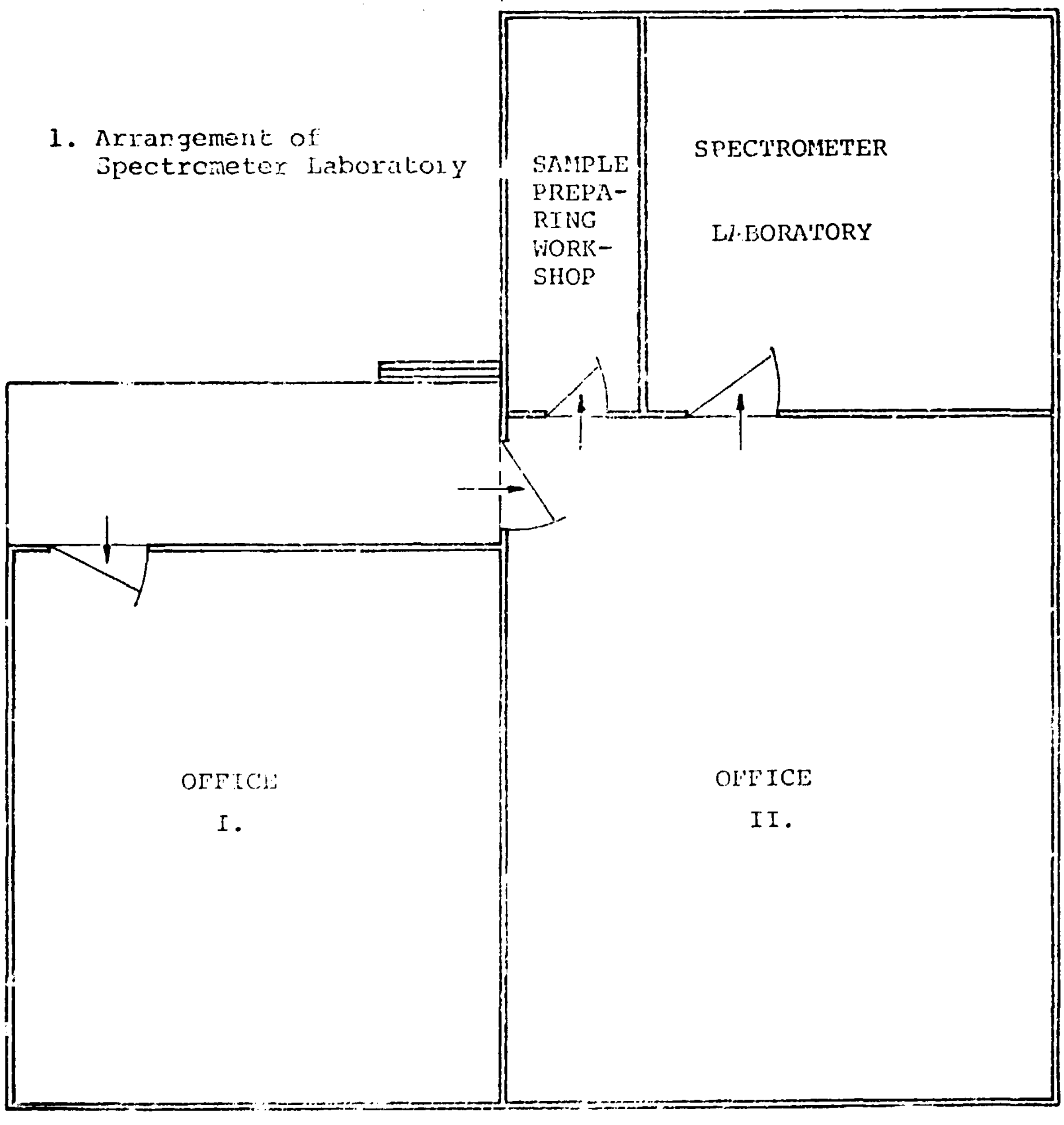
9 Laboratory balance /0-125 g/

10 Writing-table

ANNEXURE Q/1

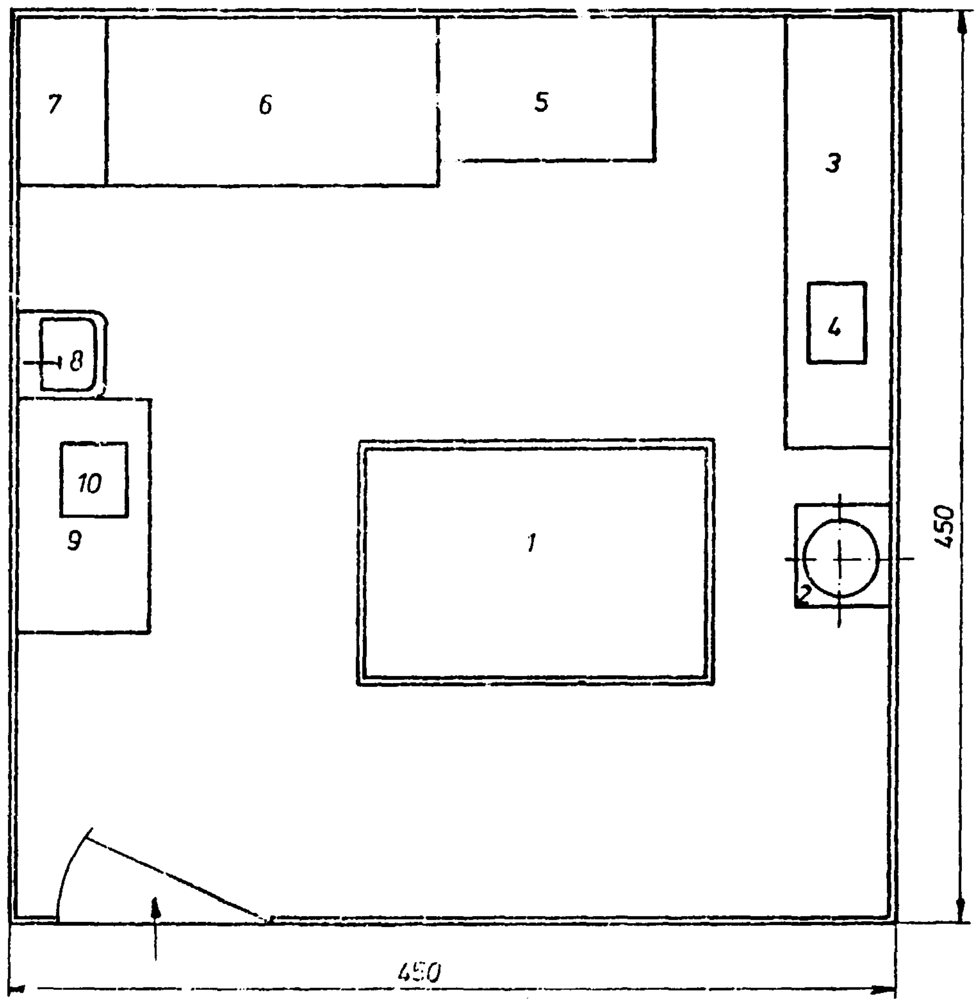
SPECTROMETER LABORATORY,
PHASE TWO

1. Arrangement of Spectrometer Laboratory



ANNEXURE Q/2

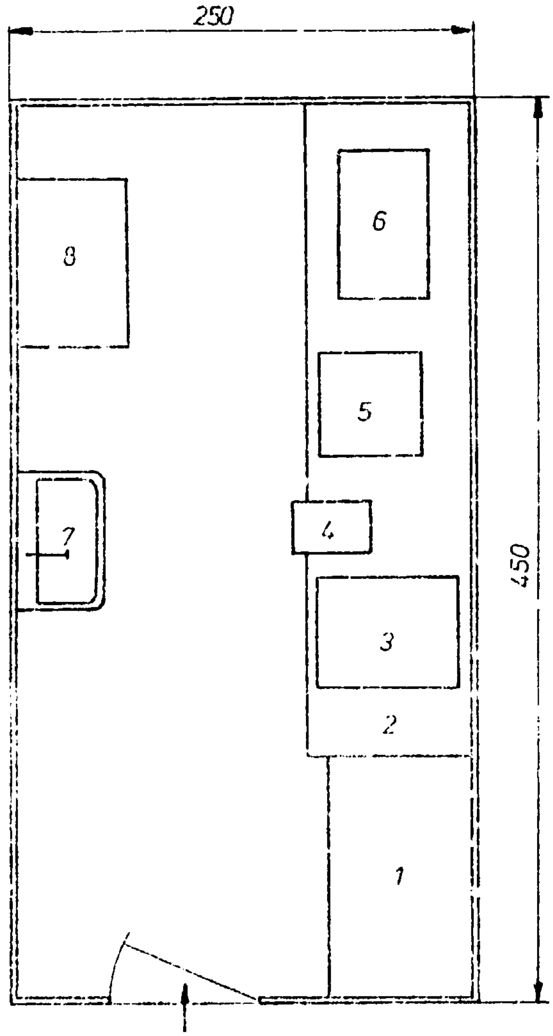
SPECTROMETER LABORATORY,
PHASE TWO
Arrangement of Equipment



1. ESA 4 Sequential spectrometer
2. Argon-bottle with fixing
3. Table for samples, tools etc /2,0x0,5 m/
4. Binocular microscope
5. Cupboard for spare parts, documentation
6. Writing-table
7. Book shelf
8. Water tap with sink
9. Rigid table /concrete/
10. Analytical balance

ANNEXURE R

SPECTROMETER LABORATORY, PHASE TWO
SAMPLE PREPARING WORKSHOP



1 Cupboard for accessories
2 Worskshop table /3,0x0,8 m/
3 Drilling machine
4 Workshop vice
5 Laboratory furnace
6 Pilisher/grinder machine
7 Water tap with sink
8 High Speed cutter

AKAKI
Steel Works

ANNEXURE S

CERTIFICATE FOR SPECTROMETRIC AND
GAS VOLUMETRIC ANALYSISES

Marking of samples	Chemical composition /weight %/										Registration Number
	C	Mn	Si	P	S	Cr	Ni	Cu	Mo	Al	

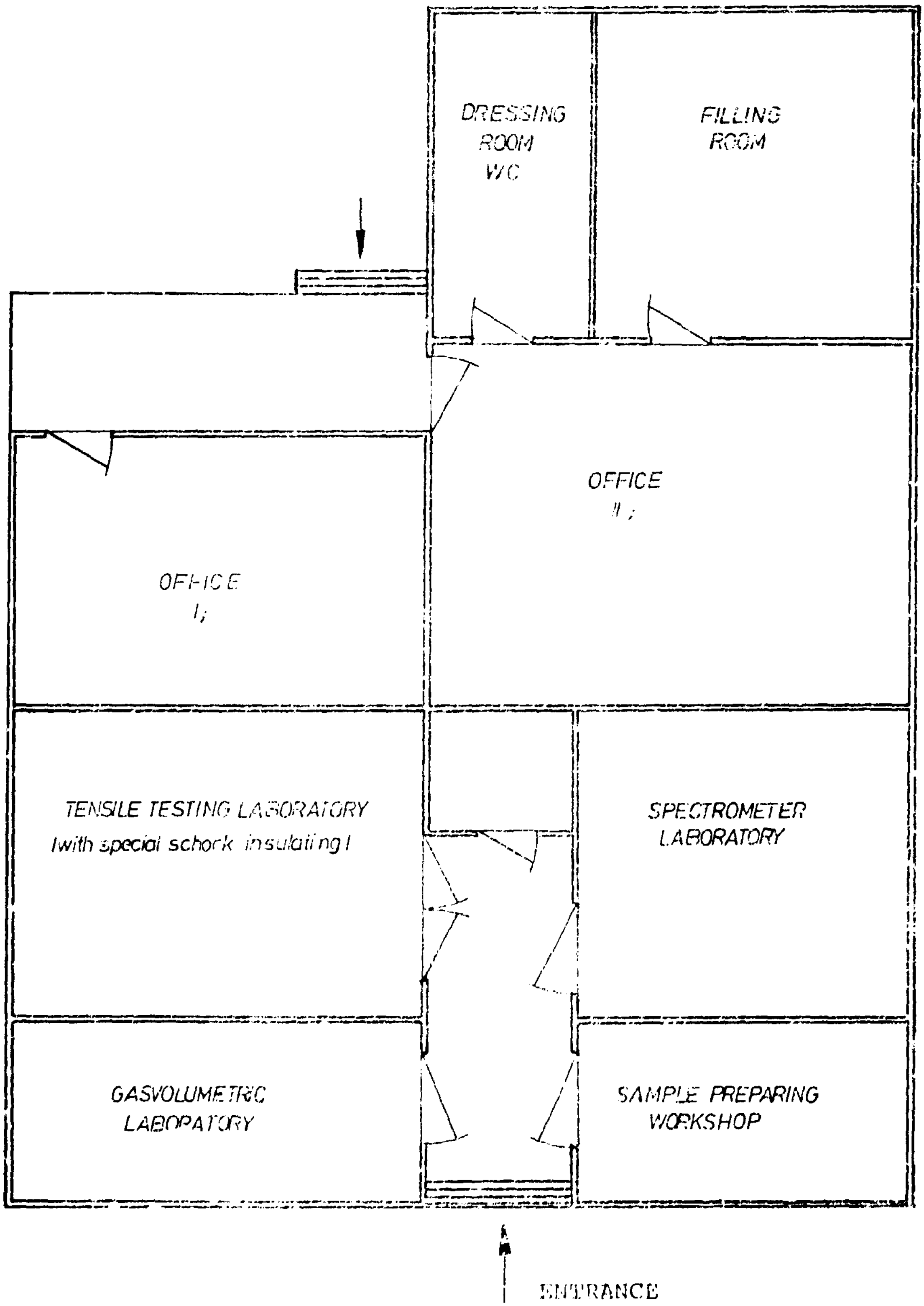
Notes: ....

Date: ....

Signature: ....

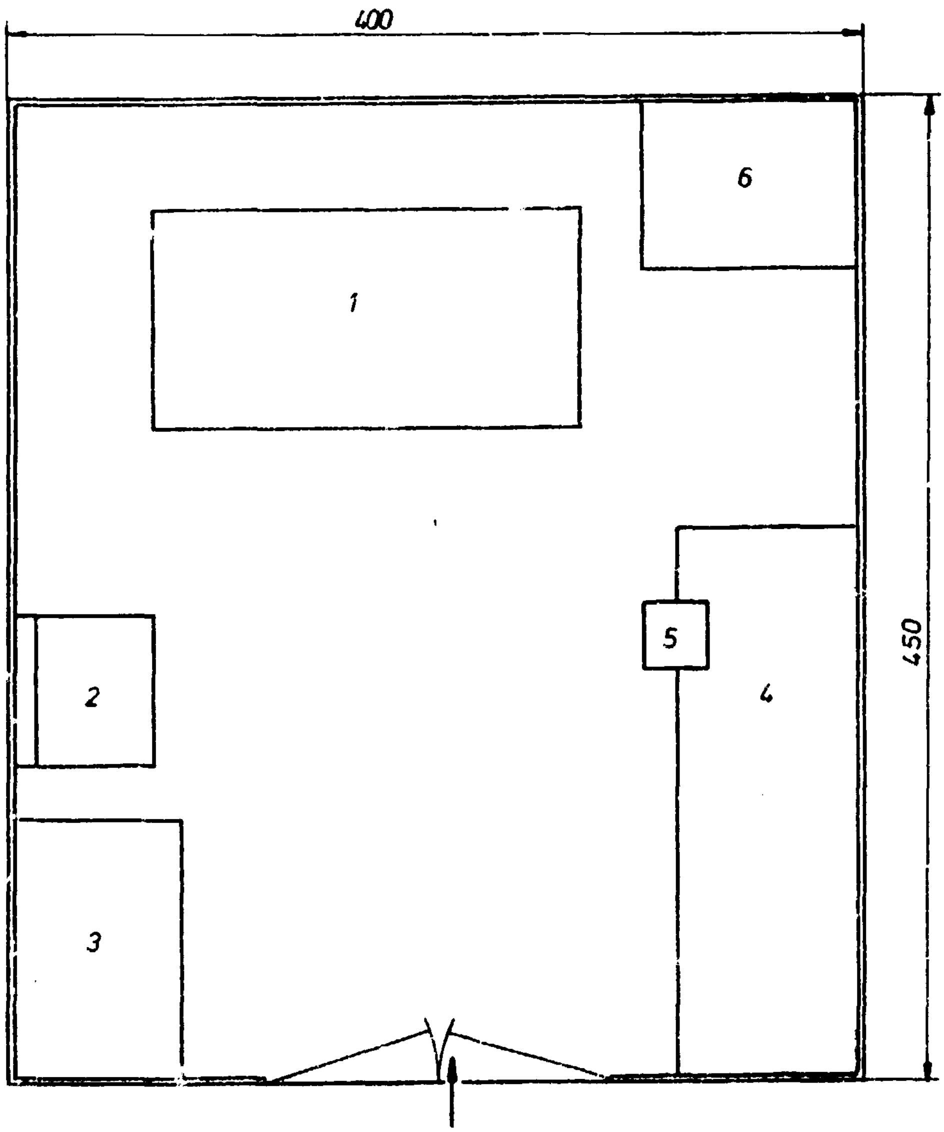
ANNEXURE Q/2

NEW LABORATORY COMPLEX, PHASE THREE



ANNEXURE Q/2

NEW LABORATORY COMPLEX, PHASE THREE



1 Tensile testing machine

2 Hardness testing machine

3 Writing table

4 Workshop table

5 Workshop vice

6 Cupboard

DIARY

ANNEXURE T

of carbon analysis /volumetric/

Registration Number	Marking on the samples	Quantity of chips	Reading scale on the burette	Barometric pressure	Temperature in the burette	Multiplying factor	C content	Notes
		g		Hgmm			%	

ANNEXURE U

Certification of Tensile Test

Material: ....

Registration Number	Marketing of testpieces	Dimension of the testpieces								Loading at yielding	Maximal loading	Yield strength	Tensile strength	Elongation	Reduction in area
		before testing				after testing									
		diameter thickness	width	cross section	measuring length	diameter thickness	width	cross section	measuring length						
		mm	mm	mm^2	mm	mm	mm	mm^2	mm	N	N	N/mm^2	N/mm^2	%	%

Notes:

Datum: ....

Signature of
Testing personel: ....
Supervisor: ....

ANNEXURE V

People were met

1. National counterpart Personnel-Ethiopian Iron and Steel Foundry

Mr.B.Abdissa, Plant General Manager
Mr.W.Tadesse, Technical Head
Mr.D.Wondimu, Maintenance Head
Mr.G.M.Getachen, Production Head
Mr.T.Daniel, Rolling Mill Engineer
Mr.E.Errenso, Melting Department Head
Mr.A.Tefera, Administration Head

2. Institutes, Organisations

5 February 1985 - Mr.S.Gebreab, Deputy General Manager
National Metal Works Corporation

5 February 1985 - Mr.K.J.Mahalingan, UNIDO Metal Processing Export, Addis Ababa

13 March 1985 - Dr.Nigussie Retta, Head of Chemistry Department
University of Addis Ababa,
Faculty of Natural Science

16 March 1985 - Mr.M.Megao, Laboratory Head
Mr.A.Aseffa, Geological Survey Head
Ministry of Mines Minerals and Energy

22 March 1985 - Mr.J.Afewerk, Technical Head
Ethiopian Standard Institute

26 March 1985 - Mr.Vencatachellum, UNIDO Senior Industrial Adviser Addis Ababa

11 April 1985	- Mr.C.Chibsa, Chief Engineer, Division of Electrical Workshop Ethiopian Electric Power Authority
29 April 1985	- Mr.Vencatachellum, UNIDO, Senior Industrial Adviser
29 April 1985	- Mr.Assefa, Director of Planning, National Metal Works Corporation

I. Velev/rg
2 February 1984

ATTACHMENT II

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
SUBSTANTIVE TERMS OF REFERENCE

Project No.: SI/ETH/84/801

Project Title: Technical Assistance in Electric Arc Furnace Steelmaking

A. General Background Information:

The Ethiopian Iron and Steel Foundry is one of six factories in the Addis Ababa region under the jurisdiction and control of the National Metal Works Corporation. Started in 1961, the factory is located 20 km from Addis Ababa, produces steel nails, plain and ribbed reinforcement bars and steel wire netting. On 2-shift basis, about 12,000 TPY of reinforcement bars /6-32 mm dia/ and 4,000 TPY of nails are being produced within a total workforce of 450 including supervisors.

The molten steel is bottom-poured through a central trumpet into 14 pencil ingot moulds. The pencil ingots /85-90 kg/ are then reheated and rolled in a cross-country merchant mill into rounds to be used either as reinforcements or for further processing into nails and wire coils.

The steel scrap is purchased from various sources in the country and is heterogenous in character. No proper facilties exist for its classification, segregation, control and preparation. Likewise, no proper facilities exist for the quick chemical analysis and control of the steelmaking process in the electric furnace. Visual inspection of the fractured sur faces of broken samples is the only method employed do determine the carbon content, which method is crude and unsatisfactory.

The Government has recognized the above acute needs of up-gradation, and, as a first step, has earmarked funds for a spectrometer. Further, a full-scale metallurgical laboratory is planned to be established.

B. Aim of the Project

/i/ To improve the existing scrap handling practice, and specifically, the entry, quality control, procurement, segregation, chemical composition and preparation;

/ii/ to improve the steel melting practice, and particularly, the quality control;

/iii/ to establish a proper metallurgical laboratory with appropriate equipment and facilities for quick chemical analysis.

C. Scope of Contracting Services

The contract work will consist of field mission of a team of three highly experienced engineers, namely:

- Expert in electric arc furnace steelmaking - Team Leader - overall operation, mechanical and electrical maintenance, scrap qualification, collection and preparation;
- Expert in furnace operation and electrical maintenance;
- Expert in metallurgical laboratory equipment/operation,

of the duration of three months each, to provide day-to-day practical advice and on-the-job training through direct participation in the production process. As a result of their work, in co-operation with the national counterpart personnel, both the level of productivity, and especially, the quality of steel would be noticeably improved.

The experts, and particularly the Team Leader, and the expert on metallurgical laboratory equipment/operation will be expected to advise the counterparts on proper specification, layout, manning and other pertinent problems to establish a full-scale laboratory.

The experts will alsobe expected to set out their findings and recommendations in a Final Technical Report, to be submitted to UNIDO on behalf of the subcontractor.

D. Required Inputs

a./ The three experts, as described above, should be fielded at the earliest possible time. The total input of the subcontractor's field work will thus be 9 man-months.

b./ The subcontractor will render to his experts all relevant backstopping as appropriate. Manuals, technological instructions and other working production-technical documentation, which is to be applied through the everyday on-the-jog training, is included in the contract price, to be later presented to the project.

c./ The subcontractor is expected to include in the Final Report the basic design of the metallurgical laboratory with a preliminary calculation of costs.

E. Sequence of Work to be carried out

Prior to their departure to the duty station, the subcontractor's team should be briefed, either in Vienna, or at the subcontractor's Headquarters, whichever is more convenient, by relavant UNIDO representatives.

The following time schedule is envisaged:

Activity	Dates
1. Award/conclusion of contract	A
2. Briefing of Subcontractor's team	A + 15 days
3. Fielding of experts	A + 20 days
4. Intermediate report	A + 30 days
5. Termination of field work	A + 110 days
6. Submission of Draft Final Report /DFR/	A + 140 days
7. UNIDO's and Government's comments on DFR received by subcontractor	A + 160 days
8. Submission of Final report	A + 175 days

F. Reports

a./ Intermediate report, containing the experts' initial findigs, and recommendations, and the specification of supplementary laboratory/ quality control equipment, for US$ 8,000, to be purchased through the project, should be prepared in three copies, in English, according to paragraph E.4 above.

b./ Draft Final Report should be provided in three copies, in English, according to paragraph E.6 above.

c./ Final Report should be submitted in eight copies, in English, according to paragraph E.8 above.