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DEVELOPMENT OF STANDARDISATION AND QUALITY CONTROL.

DP/SRL/82/003

SRI LANKA

Technical Report: Foundry Technology

Prepared for the Government of Sri Lanka
by the United Nations Industrial Development Organisation,
acting as executing agency for the United Nations Development Programme

Based on the work of D.Worth, Adviser in Foundry Technology.

United Nations Industrial Development Organisation
Vienna

4011

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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INTRODUCTION

A. General

In recognition of the importance of standardisation and quality assurance as necessary adjuncts to the economic development of the country, the Bureau of Ceylon Standards was established by Act of Parliament, No.38 of 1964. This Act was later repealed and replaced by the Sri Lanka Standards Institution Act, No.6 of 1984.

In 1982 the Government of Sri Lanka concluded an agreement with the United Nations Development Programme to execute a large scale Project, DP/SRL/82/002 - Development of Standardisation and Quality Control, designed to aid the S.L.S.I. in the implementation of the Act by expanding its quality assurance and standardisation activities for both local and imported goods. The execution of the Project was to be assisted by the United Nations Industrial Development Organisation, and it commenced in November,1982. As a consequence of the increase in the quantity of imported goods and a large increase in the volume of the work of the S.L.S.I. the Project Document was revised in 1984 to:

" (i) Incorporate two new activities, namely Laboratory Accreditation and Import Inspection;

(ii) Strengthen certain activities covered by the present Project namely; Export Inspection, Signing of Twinning Agreements with Foreign Standards Organisations, and the setting up of a Consultancy Unit."

B. Objectives, Activities and Outputs

Project Objectives

The immediate objectives of the Project are to

" Upgrade the capability of the S.L.S.I. to:

(i) prepare and implement national standards;

(ii) inspect and certify the quality of the products for local consumption and export;

(iii) establish a scheme of laboratory accreditation;

(iv) carry out consultancy services at factory level in order to promote quality control and company standardisation procedures;

(v) provide facilities for the testing and calibration of precision instruments."

Project Outputs

The specific outputs are stated as:

(i) Increased capabilities (of the S.L.S.I.) in the preparation and implementation of national standards;

(ii) New Quality Control and testing laboratories (at the S.L.S.I.);

(iii) Scheme for accreditation of laboratories;

(iv) Consultancy Unit of Quality Control and Company Standardisation;

(v) Twinning Agreements.

Project Activities

The above objectives and outputs are to be achieved by the following activities:

(i) International training of S.L.S.I. staff in the preparation and implementation of scientific and engineering standards;

(ii) Establishing a laboratory complex;

(iii) Setting up a Consultancy Unit to assist industry in the areas of Quality Control and Company Standardisation;

(iv) Assist in the operation of quality inspection and certification marking scheme;

(v) Establishing and operating a national scheme of laboratory accreditation;

(vi) Recommending appropriate measures for improving production and quality control practices in foundries;

(vii) Improving the activities of the S.L.S.I. in the areas of organoleptic testing of marine products;

(viii) Reorganisation of the Statistical Unit of the S.L.S.I.;

(ix) Signing of twinning agreements with National Standards Organisations.

Adviser's Terms of Reference

This Adviser was recruited in June,1985, for a period of 3 months specifically for Activity No. (vi) above, with the following terms of reference:

(i) to study the technical background of the Sri Lanka ferrous and non-ferrous foundry industry and recommend appropriate measures for improving the technologies and quality control practices of these foundries;

(ii) to advise the foundry industry and the S.L.S.I. on the training requirements of their staff;

(iii) to assist the staff of the S.L.S.I. to identify areas for standardisation, methods of testing, equipment and other relevant materials within the area of foundry technology.

C. Achievements

The Adviser feels that he has been able to achieve success in all three requirements of his terms of reference. The details of the achievements are discussed in the body of the report.

I. TECHNICAL BACKGROUND OF THE SRI LANKA FOUNDRY INDUSTRY.

Terms of Reference.

See Annex I - Job Description.

"To study the technical background of the Sri Lanka ferrous and non-ferrous foundry industry and recommend appropriate measures for improving the technologies and quality control procedures of the foundries."

A. Study of Foundries.

General

All industry in Sri Lanka, including foundries, is divided between public and private ownership and, with only one or two exceptions, all foundries are in direct competition with each other, making the same [illegible] for the same customers. The exceptions to this are the Sri Lanka Steel Corporation, which appears to have the only steel foundry in the island, small specialised units such as bell foundries, and those foundries casting for their own machine shops which produce finished goods such as rice hullers or pumps.

All foundries however, whether State owned or private, suffer from the same problems.

Activities.

It is difficult to estimate how many foundries exist in Sri Lanka; only about 25 are "registered" but there are obviously many more than this. There are numerous small establishments in many unexpected places, making items like drawer knobs, decorative fittings, window brackets, and within 3 or 4 kilometres of the Project Secretariat there are two highly specialised bell foundries. A rough estimate would be that there are at least 100 foundries. Obviously not all of these could be visited so, after some initial visits to some large and small foundries, it was decided to concentrate on certain organisations producing castings which are fundamental to the basic industries of the country, namely tea, rubber, coconut, coffee and rice, together with light engineering industry such as the manufacture of sewing machines, fans, valves, pumps and platform scales used for weighing the tea produced on the plantations. On this basis a work plan for the duration of the Adviser's visit was established. See Annex II.

In all, [illegible] foundries were visited, several more than once, varying in size from [illegible] to [illegible] employees, some privately owned and some State owned, and all producing both ferrous and non-ferrous castings. The Sri Lanka Steel Corporation was included.

As visiting foundries only would provide a one sided view of the industry, customers of the foundries were also consulted, i.e. the Sri Lanka Cement Corporation, sewing machine manufacturers and tea plantation owners. A considerable number of the foundries, particularly in the private sector, had their own machine shop and these could legitimately be considered as being customers.

The Adviser was fortunate in being able to obtain access to all levels in the industry, from Managing Directors, General Managers of State Corporations and large private companies, owners of smaller companies, through senior production management, junior management and supervisors to the moulders, core makers and furnace men. On three occasions, the Adviser was invited by Companies to participate in large meetings of executives and supervisors, with the General Manager as Chairman. An example of the notes submitted to the Company after such a meeting by the Adviser are attached in Annex III.

To fulfil the Adviser's committments to recommend appropriate measures for improving the techniques and quality control in foundries, a Seminar was held to which representatives of industry, education and training establishments, castings purchasers and other interested bodies were invited. Altogether 108 invitations were sent out and 62 attended. The meeting was chaired by Dr. N.R. de Silva, Director General of the S.L.S.I. A copy of the paper presented is given in Annex IV. Additionally, several comprehensive reports were prepared for submission to individual foundries. A copy of one such report is attached as Annex V.

<u>Observations</u>

Without deep probing into the industry, it became immediately obvious that:

a) Quality Control as understood in developed countries does not exist in any foundry visited.

b) The basic concepts of quality control are not understood.

c) The standard of foundry competence at all levels is exceedingly low.

d) Costs have been cut to such levels that scrap has been increased.

e) A considerable number of foundries are overstaffed.

f) There is too much capacity for the amount of work available.

g) The bigger the foundry, the worse trouble they are in.

h) The foundries are facing a challenge from imported castings, and particularly from "dumping".

i) Electricity charges are thought to be too high for the industry to be economical.

j) Foundries have been caught out by the change to a Government more liberal in allowing imports at reduced duty levels.

Obviously, all of these comments do not apply to all foundries, but they all apply to some foundries, and some apply to all foundries.

a) Quality Control

In a small ferrous or non-ferrous foundry in a developed country, one would expect to find at the least, one individual whose sole occupation would be the maintenance and improvement of quality. This may be an inspector, without whose sanction a casting cannot leave the foundry, or a laboratory assistant providing routine chemical analysis and sand test results for the foundry manager. In both cases the foundry manager would be expected to take action based on the information supplied to him by these people.

In larger organisations it would be usual to find either a laboratory or quality control department under the control of a Quality Manager or Chief Metallurgist. It would be the responsibility of this person to take the necessary action to control the metal and sand quality. Any decisions he made would be based on consideration of the type of casting being made, its weight and section thickness, and the specification to be met. His decision on the acceptability of metal quality would be final. Additionally, there would probably be a Chief Inspector whose decision on acceptance or rejection of castings for casting defects such as blowholes, slag, and dimensional accuracy would likewise be final.

In the interests of the organisation it is essential that these two high level members of staff should be capable of working in harmony with the top production staff such as the Works Manager or Foundry Manager. They are expected to work as a team for the benefit of the company, and any individual who does not fit in is soon replaced.

In very large organisations having say, a machine shop, heat treatment plant, galvanising plant or even a paint shop, then the quality of items leaving these sections would also be the responsibility of the Quality Manager and the Chief Inspector. Naturally, the greater the spread of work then the larger would be the quality and inspection staff. This may even extend to line inspectors who take random samples anywhere for checking, or patrol metallurgists moving from furnace to furnace taking temperature readings of the metal, or from sand plant to sand plant.

In a cast iron foundry using cupolas or induction furnaces, then it would be quite common to take analysis samples for carbon and silicon every hour, manganese, phosphorus and sulphur twice a day, and wedge tests from every tap. With a direct reading spectrograph then all five elements would be analysed every half hour, also with wedge tests on every tap.

Another essential of quality control is the maintenance of adequate records for such items as metal charges and analysis, sand testing and temperature readings. During production, analysis and sand test results are exhibited on a board in the foundry so that everyone concerned can see what is happening. Statistical plots are quite often used to predict trends.

Above all, accurate scrap records both in terms of weight and cause are always maintained. These records are usually in the form of scrap record sheets (see Annex VI) and by exhibiting them in consecutive order under each other it is possible to see which scrap causes predominate. It then becomes possible, by cross reference to the analysis and temperature records etc.,to attack these causes at the source, whether at the furnace, sand control or moulding etc.

No organisation visited in Sri Lanka had a Quality Control department as described, or even any single individual whose sole job was the control and improvement of quality. Similarly, no organisation appeared to have an inspection department with the responsibility of assessing quality, whether visual or dimensional. The Sri Lanka Steel Corporation has a large, central laboratory for metallography and sand testing etc., but this seems to be more research rather than production, oriented. The stage laboratory is only equipped with the bare minimum for the rapid determination of carbon and silicon in steel, and the quality of operation of this equipment leaves a lot to be desired.

Hence, the acceptance or scrapping of a casting is in the hands of those who have made it, and this leads to the passing to the customer, or the machine shops, of items of very doubtful quality. Very few foundries keep any records of scrap and its causes and those that do have very simple divisions such as,broken,bad metal, or technical which, in fact, means that they do not know the cause. Records are only kept in general for the purpose of costing and in the simplest of forms, such as the amount of metal melted and the weight of castings produced. As, in a lot of cases, there are no scales for weighing the metal melted, then the whole procedure is based on guesswork and is of dubious value.

The concept of keeping accurate records of the causes and weight of scrap, the amount of metal poured away as unsuitable, etc., and then using these records as a tool for increasing efficiency and yield is totally alien. Also, the taking of tests during production and using the results of these tests to maintain standards during a melt was only seen in one foundry. This foundry was using the simplest of wedge testing, but under the circumstances, this can be regarded as putting it ahead of its competitors.

The most distressing aspect was to see one large foundry, well equipped with mechanical aids to production, in which the laboratory seemed to be regarded as unnecessary and was only used for recording history, that is, analysing samples of metal cast two or three days earlier. No routine sand testing was carried out, or in fact any other kind of routine test. Needless to say, this attitude to the laboratory was symptomatic of the whole staff attitudes to quality and consequently, quality was very low. It is fundamental to all quality control that the correct attitudes are maintained at all times, and particularly by the supervisory and management staff.

b) Quality Concepts

There was absolutely no realisation that quality control is a "total concept" and a joint responsibility, not only of all departments in a company, but all sections in a department, and all individuals in a section.

If a coremaking section persistently produces poor quality cores then the castings will also be of poor quality. It would not matter if the mould was superb and the metal quality exactly to specification, the casting will still be bad. If a moulder is allowed to cut a running system to his own design, then every one will be different and every casting will be different; and especially if the metal quality is not correct then the rest of the production time is wasted. For example, if the cupola control in an iron foundry is non-existent and the carbon content of the iron varies from day to day, then the iron's fluidity, shrinkage, solid contraction, chilling tendency, mould penetration ability and casting temperature all vary. The result of this is misruns, hot tears, porosity, hard spots, chilled iron, rough castings, blowholes, or slag and dirt inclusions may appear. So a running and feeding system which is satisfactory on one day may be unsatisfactory on the following day. Unfortunately the method of attempted correction is usually to alter the running system, in other words, to attack the symptom rather than the cause. (It is like taking an aspirin for a headache which is caused by eye strain and the proper treatment is spectacles.)

Until control of the basic factors in Sri Lankan foundries is achieved that is metal control, sand control, control of running and feeding systems, and scrap control then there can be no improvement in quality in any foundry. To attempt to correct any individual casting in the existing state of affairs simply adds to the confusion.

Before control of any factor can be achieved however, there must be a realisation that supervision is not control. Control requires that everyone works to orders, the supervisor ensures that those orders are carried out 100% accurately, that no changes are made without instructions and that those changes and their results are recorded, observed, analysed and the results of this analysis used.

On the basis of these observations there is no quality control in any of the foundries visited.

c) Foundry Competence

It is sad to relate that the level of foundry competence of the majority of production staff is very low. There are some older foundry managers who were trained under British foundrymen prior to independence, but, unfortunately the majority of these have now retired. As the facilities for the training of professional foundrymen are virtually non-existent then it is difficult to envisage any rapid improvement. On more than one occasion, the Adviser was told that it was difficult enough to get any kind of young engineer into the foundry, and those that did take jobs in the foundry did so because they could not get jobs in any other section of engineering. There are naturally exceptions to these sweeping statements and there are one or two good foundry engineers who have spent considerable periods abroad working in overseas foundries. The presence of these people is marked by the better quality and productivity from the foundries they run.

However, foundrywork today is no longer an art but a science and to meet today's demands for quality then scientific principles must be used. For instance, unless an engineer can apply the principles of streamlined flow to a running system he cannot produce a smooth flow of metal into a mould; unless he realises the importance of grain size, shape and distribution of the sand he uses, then he will not be able to produce castings free from blowholes or dirt etc., certainly not to the quality demanded today.

But not only must he have theoretical competence. He must also have practical competence so that he can recognise bad practice, and he must be capable of replacing the obsolete methods at present in use with those necessary for today's demands.

In every foundry visited a proportion of the moulds were being made by hammering patterns into the floor, a practice that in developed countries is reserved for making moulding box parts, core irons or other rough pieces needed for use in the foundry. In very few foundries were " tea pot spout" ladles being used to prevent slag from entering the moulds (in one foundry one such ladle was standing in a corner but it was not used). Almost all foundries left the preparation of the moulding sand in the hands of the moulders and, either did not have sand mills, or even worse, if they did have them they did not use them. Knowledge of the principles of cupola operation and control were completely non-existent and the melting is usually left wholly in the hands of the cupola operator. The one exception to this was the State Hardware Corporation where the operation of the mains frequency induction furnace was exemplary: this, apparently, has been forced on the company by the cost of electricity, but the management were pleased to inform the Adviser that the induction furnace metal was Rs.1500/- per ton cheaper than their cupola metal.

d) Cost Cutting

Unfortunately the inadequate levels of technical competence have led to the management functions of both large and small foundries being taken over by accountants, economists or other professions more concerned with money than with quality. The result has been that costs have been cut to such levels that they are directly responsible for increases in scrap, reduction in quality such as surface finish, and increases in costs in other departments such as fettling and machine shops.

As an example, the clay additions to the sand in every foundry visited had been cut to such an extent that the moulding sands were almost too weak to hold together. To enable them to be used, the moulders use liberal quantities of water, creating what is known in foundry terminology as a "moisture bond". Because the sand is weak then moulding is more difficult, it takes longer, and more patching is required so productivity inevitably drops. Unfortunately on drying out, either by the heat of the metal or by evaporation on standing, the bond disappears, the mould becomes weak and the flow of metal rapidly erodes the surface, pieces of the mould drop off under their own weight and metal penetration into the mould face increases. The result is an increase in scrap levels due to sand inclusions, rough and mis-shapen castings.

On the other hand, if the sand is not given the opportunity to dry out fully because either the moisture is very high, or the mould is cast quickly, then there is a proliferation of blowholes, misruns, and, in extreme cases, the possibility of a mould explosion due to the breakdown of the water into hydrogen and oxygen by the molten metal.

All of these defects cost money by the need to remake the scrapped castings, by increased fettling costs, by slow turning or milling and excessive tool wear in the machine shop, and these, together with the low productivity already mentioned, mean that the reduction of clay proves to be a very expensive economy.

Only one example has been quoted in detail but other similar examples are:

- (i) Reduction or elimination of coal dust in facing sand
- (ii) Elimination of pig iron in cupola charge
- (iii) Reduction in coke in the cupola bed
- (iv) Reduction in coke in the cupola charge
- (v) Use of soft coral or dolomite instead of good quality limestone
- (vi) Use of poor quality patterns and core boxes
- (vii) Use of poor quality moulding boxes without pins or bushes

All of the foundries visited have adopted at least some of these economies to such an extent that the visible saving is far less than the increase in costs caused, i.e. they have now become false economies.

In such cases there is no alternative but to increase the relevant expenditure. One foundry on the suggestion of the Adviser, increased the coal dust additions in its facing sand. The results in terms of improvement in surface finish were spectacular and the saving in costs in grinding and fettling labour and materials were far in excess of the cost of the coal dust. This foundry is now adopting action in other areas with the expectation of similar improvements.

The topic of cost cutting and false economies was discussed in more detail in the paper presented to the industry seminar. (see Annex IV)

e) Overstaffing

This problem is restricted to the large foundries and especially to those in the public sector.

There would appear to be two main causes:

(i) an attitude, still prevalent, that State industry is to be considered a social service as much as a production unit;

(ii) the use of labour intensive methods rather than the use of machines because of the cost of the machines and the expense of running them.

In the smaller, privately owned foundries the first point does not apply and the average productivity in these units is five to six times higher than it is in the large State foundries: extremes are 273 employees producing 16 tons of castings per week as against 40 employees producing 15 tons per week.

However, the second cause is prevalent in every foundry visited except one. In six of those visited moulding machines had been installed, but in one only were they in use; one other was making an attempt but it was very half hearted and obviously being obstructed at every turn by the foundry work force.

The commonest reasons for not using these machines were:

(i) the electricity to run the compressor is too expensive

(ii) the workers do not want to use them

(iii) we cannot afford the patterns

(iv) we do not have a good enough patternmaker

(v) we do not have enough moulding boxes.

Whatever the reasons for the non-use of these machines, it seems strange that managements are not pressing the production staff for a return on the considerable investment made in the plant; this particularly applies in the case of the State foundry with 273 employees, which has a fully mechanised system comprising moulding machines, pattern shop, sand preparation plant, overhead sand delivery system, roller conveyors for casting, shake-out, laboratory, a mains frequency induction furnace, hot blast shell cooled cupolas capable of melting 200 tons per day, but no suitable moulding boxes. The capital expenditure must have been millions of dollars but production is about 16 tons of castings per week. This foundry could produce 160 tons per week with the same labour using the machines.

f) Foundry Capacity

The Sri Lanka foundry industry has been hit, like its counterparts in other countries, by the loss of traditional markets. For instance, cast iron drain pipes and gutterings have been replaced by plastics as have water pipe fittings, cast iron baths, conduit fittings and many similar items; drain covers, inspection covers and other easily removable heavy pieces are being stolen and sold as scrap, so are being replaced by concrete covers; soil pipes, water pipes, spun pipes for the oil industry, are now being made either in plastics or in Spheroidal Graphite iron which is not produced in Sri Lanka; cast bearings are being replaced by nylon or other synthetic materials, etc. etc. As so many foundries depended on these items as bread and butter lines, then they are suffering badly.

Most of the foundries visited are casting only once a week; one is casting three times a week. The reasons for this are that mould production is very slow and that such casting is adequate to fulfil the orders available, despite the high scrap levels. Of course, in the cases of those foundries who produce castings for their own use, such as pump parts, then the demand for castings is purely dependent on the demand for the finished product. Owners of such foundries have said that there is a drop in demand for their finished products because of the opening up of the market to imported competitive goods and that, despite looking for alternate work on the jobbing market there is none available. However, inventiveness is apparent in some cases and new finished product lines are being designed and experimented with. The Adviser has been asked not to divulge what these items are, to prevent ideas from being stolen. Other foundries are diversifying into totally different fields away from the foundry industry, and cutting their losses by supplying existing customers and not looking for other work. They admit that very shortly their foundries will probably close. This naturally will mean a little more work for those foundries still in existence, but not enough to alter the overall state of the market.

When it is considered that the State Hardware Corporation has enough capacity, both in moulding and melting, to supply all the small castings presently being made by all the small firms, then if this foundry could be put right it would eliminate all competition. If all the sewing machine treadle frames that are now cast in all the smaller foundries, were cast in one big foundry, then it could lead to a tremendous increase in productivity and consistency of product. As it is, with them being cast in small numbers in many different places, the production and pattern costs are inevitably high.

In the larger foundries producing the heavier castings, should any one reduce its high scrap levels to a more economic level, and there is no reason why it should not be as low as 5% average, then the others will suffer. The present reason given by a tea dealer for spreading the work was that it was to ensure that they did get some good castings. If all the work was in the hands of one foundry with their present capabilities, then the tea, rubber and cement industries would halt unless castings were imported. The Sri Lanka Cement Corporation is already contemplating importing their castings because of the inability of the local foundries to meet their quality criteria. This will lead also to a further reduction in demand.

Any one foundry which can improve its quality and productivity to the average level of a foundry in a developed country would effectively close all opposition.

g) Foundry Size

For many reasons the quality and productivity seem to vary inversely with the size of the organisation. Foundries with 40 employees are, in some cases, producing more than foundries with 150 employees.

One of the reasons is that these foundries are privately owned, and the owner works on the shop floor amongst his men so supervision is continuous. The owner is concerned with making money so pattern, mould and casting quality is good, scrap is low, equipment is maintained in good working condition, discipline is good, no slackness of any kind is allowed and no waste is tolerated. As an example, one small foundry melting cast iron is buying scrap cylinder blocks from the Sri Lanka Transport Board and re-melting them. But before re-melting one man breaks up the blocks, removes all the high tensile nuts, bolts and studs, valve springs, the alloyed iron crankshafts, and anything else with a saleable valve either for re-use or as higher priced alloyed scrap. The value of the scrap sold pays for the employment of this man with a considerable profit. There is the additional bonus of eliminating alloy contamination, particularly chromium, from the iron, with reduced scrap from chilled iron and better machinability.

The larger foundries, without the same personal interest, find it difficult to adopt this kind of attitude.

Of course, the larger foundries are expected by their customers to make larger castings but unfortunately, by the technology adopted by them, these are really beyond their capability. Eight out of ten scrap rollers for rubber sheet rolling is a realistic estimate and as each weighs about 1 tonne then this is bound to be uneconomic. Even those castings passed as acceptable are only accepted by industry under sufferance. For instance, an imported kiln nose end takes $4\frac{1}{2}$ hours to change. A local casting needs 2 to 3 days of grinding, drilling and chipping to make it fit and then it only lasts half as long as the imported one.

It is the larger type of casting which requires good technologists and craftsmen, good quality control, good raw materials and good equipment. All the large organisations appear to be losing money - one company lost Rs.30 million in 1984/85 and Rs.13 million in 1983/84 - and it must be asked "How much of this is due to their inability to make good castings?" However the effect is that these organisations cannot make the quality castings needed because of the obsolete methods used and they also claim that their losses are so great that there is no finance available to modernise. Closure of some of these seems inevitable.

h) Dumping

The industry is also under attack from other countries. There is considerable evidence of finished goods being imported at ridiculously low prices which will not even cover the cost of shipping. Some of these items are of poor quality, but sell because of their price, but there are others which are of good quality and are being sold at prices which cannot in any way be profitable.

As an example, a good local cast iron foot valve for fitting to the hose of a water pump was on sale in shops at Rs.95/- (U.S.dollars 3.50) which by any standards is low. A valve is now obtainable in the local market of almost as good quality, which when landed at Colombo Port costs Rs.12/- (U.S.dollars 0.45). After an import duty of 60% it appears in the shops at about Rs.30/- (U.S.dollars 1.10). The local item is now no longer being made because it cannot compete in price. No foundry can compete with this kind of competition. There is no point in solely imposing import quality inspection because, although some items would fail, a large proportion would be acceptable. Also, the production of an export quality certificate from the country of origin would obviously present no problems.

This problem must be dealt with quickly and it can only be done at Government level by the imposition of stiff anti-dumping tariffs together with import inspection. If not, the foundry industry will, like the cotton spinning and weaving industry in Europe which was attacked the same way, disappear. Then the prices of the imports rise rapidly and steeply.

i) Electricity Charges

One factor which has emerged as an apparent negative influence to progress in general and quality and productivity in particular, is the cost of electricity. Most foundry managers encountered were of the opinion that it was cheaper to use labour intensive methods rather than to mechanise. All foundries are geared to the conservation of electricity rather than its consumption, even to the extent of not using equipment already installed; foundries with pneumatic moulding machines standing idle claimed that it was too expensive to run the compressor to operate them. In other cases, sand mills were not used and in one extreme case, even the lights were turned off. There was little or no interest expressed in any recommendation which involved the introduction or use of any electrically powered equipment.

The source of the irritation is not the unit cost, which at Rs.1.50 (U.S.dollars 0.05) is low by world standards, but the structure of the tariff system. This is probably unique in being a deterrent to the use of electricity instead of being designed to encourage people to use more to increase electricity revenue. For tariff see Annex VII.

It is based on a "Contract Demand". If an organisation has an installed electrical capacity which will result in a demand at any one time for more than 50 KVA, it becomes subject to a contract with the Electricity Board for a fixed charge of Rs.100/- (U.S.dollars 3.60 approx.) per month per KVA for the maximum anticipated demand. This is in addition to the unit charge. The demand is monitored and, if at any time, the contract figure is exceeded for a period of more than 15 minutes, the Electricity Board revises the contract to a level above the over demand. This revision is not subject to appeal and the new rate is applicable for a minimum period of 12 months. This means that once an organisation comes within the scope of these charges it has a minimum fixed cost per month of Rs.5000/- (about U.S.dollars 180) whether it uses any power or not.

This may not be a lot by developed country levels but in Sri Lanka it represents a month's pay for four foundry workers such as moulders or coremakers. As an example, to use a 50 horse power compressor for moulding machines at a local power factor of 0.6 means a demand of about 65 KVA, so the compressor will cost, in fixed demand alone, Rs.6500/- which is roughly the equivalent of five persons wages. The cost of the units used must also be taken into account and this could raise the labour intensive equivalent to possibly 10 to 12 men.

So it is easy to understand the attitudes of foundries who avoid electrification. Whether the quality of the product and the productivity achieved are compatible with this attitude is very doubtful. This argument is extended in the paper presented to the seminar. (see Annex IV)

j) Import Duties and Change of Government

The industrial policy of the preceding Government with its imposition of import restrictions dictated by the shortage of foreign exchange, gave an impetus to the local manufacture of all types of goods. In many industries the quality of such products was below that of previously imported items to which the consumer had hitherto been accustomed, and this was one of the factors which led to the formation of the original Bureau of Ceylon Standards.

Unfortunately a change in Government policy, allowing unrestricted imports of all kinds, has dealt the Sri Lanka foundry industry a very severe blow. The change of policy has allowed the import of unfairly priced "dumped" finished goods as described in section (h), as well as the import of good quality goods at "fair prices" which are either better than, or competitive with, the local product, and this has upset the industrial complacency which had become prevalent. The industry is in fact still "protected" in that all its raw material supplies are rated at only 5% duty, and all its competitive products, including plastic items used instead of castings such as pipes and baths, are rated at 60%.

The prices of raw materials on the open market are the same for any country, the difference being in the shipping costs, so it would be expected that the difference in duty rates between raw materials and finished goods would compensate for the cost of shipping raw materials such as pig iron, coke, non-ferrous ingots, etc. Unfortunately, by Sri Lanka wage and salary levels, the prices of these imported raw materials seem astronomical and industry in general seems to have been unable to adjust its thinking. Hence it persists in trying to exist without buying pig iron, non-ferrous ingots and other basic materials, and buying the minimum of essentials such as bentonite clay, coal dust and other similar items, claiming that they are too expensive. The result is that product quality is very poor, obsolete methods are retained, productivity is low and markets are being lost to import competition.

3. Comments on the Foundry Study

State of the Industry

Certain facts are absolutely clear. They are that

(i) the foundry industry in Sri Lanka is of very poor standard;

(ii) quality is not good and productivity is exceptionally low;

(iii) no foundry is exercising quality control;

(iv) very few foundries have the equipment so to do;

(v) equipment for improving productivity is standing idle;

(vi) managements have taken expenditure cutting to such an extent that it has become counter productive;

(vii) there are very few technical personnel available to improve the situation.

Future of the Industry

There are not many options open as to what may happen to the industry. Only one thing is certain and that is that it cannot remain as it is. It must either advance or regress. There is too much capacity available for the amount of work locally available and, certainly at present, the quality of product would not sell abroad so there is no immediate export market. Hence, closures appear inevitable.

Cast Iron Foundries

The total melting capacity for cast iron in Colombo alone is well over 2000 tonnes per week which will produce about 1200 tonnes of finished castings. A rough estimate of existing production would be of the order of 300 tonnes only.

It would only need one or two foundries to become efficient for the rest of the industry to suffer a severe blow. The State Hardware Corporation already has the facilities to do this, but in the past it has been treated as a social service, has become so overstaffed and inefficient, and its excellent equipment been so allowed to deteriorate that it has lost money heavily. It now has no funds even to buy new moulding boxes, but if a capital injection could be found, together with a good practical foundryman who was given a free hand to regenerate the plant, then it could very rapidly become extremely profitable. The equipment is available for good quality control.

There is also one foundry in the private sector which is now producing what the Adviser considers to be the best grey iron castings in Sri Lanka. This foundry has recently had a change at top management level and now has a young and good team, who are both productivity and quality conscious.

Non Ferrous Foundries

In general the non-ferrous foundry industry is in an even worse condition than the ferrous. The Adviser has seen no evidence of any foundry importing ingot material and all the production is by remelting scrap. This scrap is bought on the open market as "brass scrap", under the mistaken impression that an experienced foundryman can tell the difference between the different alloys by looking at them. As there are very few experienced personnel available, and it is an impossible task in any case, then quality control is totally out of the question. Copper alloy castings which should have contained 10% tin, were analysed at the S.L.S.I. as 5% tin and 12% zinc.

There is no knowledge of the different melting processes required for different alloys so shrinkage, porosity, gas holes, inclusions and every other possible defect are present. By developed country standards, the scrap rate would be 90 to 100%, but because of the necessity to obtain castings, probably 50% are accepted, but with reluctance. More and more non-ferrous castings are being imported, particularly in the form of die castings where dimensional accuracy is far better than the sand cast product available locally.

General

There are very few foundries which have the equipment necessary to produce castings to any standard, but, more importantly, there are even fewer foundries with the equipment to test whether their product conforms to such standards. In those foundries which possess the equipment it is rarely used and, in many cases, so covered with dust that it obviously has not been used for some considerable time.

Additionally, there are very few foundry customers with the facilities for testing the castings they buy. As delivery is uncertain at the best of times, then if the outward appearance of a casting is satisfactory it is generally acceptable. The scrap is usually discovered subsequently, either in the machine shop or when the casting fails prematurely in service and considerable amounts of money may have been spent on it.

The S.L.S.I. is now being called on more often to carry out tests on castings, but there is a limit to what can be done to the actual casting (as explained in Section IIIA of this report). Tests such as ultrasonic inspection, hardness or radiography can be carried out, but chemical analysis and strength tests cannot be done without destroying the casting. Obviously, examinations can be carried out on castings which have failed prematurely in service, but this is only of value if the results can be applied to the improvement of future production. All the indications are that this would be done in very few cases.

II. TRAINING REQUIREMENTS.

Terms of Reference.

See Annex I - Job Description.

"To advise the foundry industry and the Sri Lanka Standards Institution on the training requirements of their staff."

A. Training for the Foundry Industry.

Areas for Training.

The three main groups for whom training is essential are;

a) the Junior Management, i.e. at the level of Foundry Engineer,

b) foremen,

c) artisans of all types, moulders, coremakers, furnacemen.

a) Junior Management. The usual recruitment for these posts is directly from new University graduates in Engineering. There are very few who stay long in these posts as the working conditions in any foundry are not salubrious so there appears to be a constant turn-over of young staff. They are further deterred from making the foundry their career by the fact that their engineering training has left them unprepared for what they will be expected to do. The amount of foundry technology included in the engineering courses appears to be confined to some slight study of general principles in subjects like Workshop Technology. There are no specialised foundry curricula for young men who wish to become Foundry Engineers, even in Production Engineering courses. Consequently, when they start their professional career they are completely out of their depth. Some of the larger organisations do have engineering apprenticeship schemes where these young graduates are given practical training in the works after graduation, but a period of perhaps two weeks seems about the average time they spend in the foundry.

As they can be of very little technical assistance to the foundry except as a means of supervision and transmitters of orders from the foundry manager, their only opportunity to learn is by watching the craftsmen. As the level of craft skill is very low, then they have little chance of obtaining information or instruction of correct foundry methods. They certainly can be of no assistance in ascertaining the causes of, and preventing, foundry scrap, or in improving quality and productivity.

Those young engineers who find that they like foundrywork and wish to make it their career, have a very difficult time in trying to obtain further training or information. There appear to be no post-graduate specialist courses in foundry technology, and the supply of suitable books in libraries is very limited.

b) Foremen. It was impossible to establish on what basis a man is made a foreman and, in fact, it does not appear to be a very common post in the Sri Lanka foundry industry. Certainly, the appointment or promotion does not appear to be on craft skills, as the few foremen met seemed to be no better than the workmen they supervised, and there would appear to be no training for the job of foundry foreman as such.

c) Artisans. The level of craft skills in every department is very low and especially among patternmakers and moulders. A lot of this may be caused by the attitudes of management to costs, so that only the cheapest of materials is available for them to use. Poor wood and nails are the common materials for patternmaking, instead of knot free timber, glue and screws. Moulding sands are of too low clay content to be mouldable all of which tends to engender a "laissez faire" attitude.

The majority of moulders, whether regarded as skilled or otherwise, do not appear to have received any formal training. In a large number of foundries, unskilled labourers from the local street or village are taken into the foundry, taught roughly how to make one specific casting and this they do until the order is finished. They are then either retrenched, or retrained to make another casting. Some "moulders" have been making the same casting by hand for five years.

Some large organisations such as the Government Factory No.9, do have apprentice training schemes where young men have a good opportunity of learning the trade. After their training, these young men naturally expect to obtain a good wage as a skilled craftsman, but the present economic situation of the foundry industry, together with the attitudes of management about money, preclude this. Most of the trained men appear to take jobs in the Middle East so Sri Lanka is acting as a training ground for these countries at the expense of its own industry.

There is a desperate need for highly skilled moulders, patternmakers, coremakers and furnacemen, but, additionally, companies must recognise the value of these men and prevent them from emigrating by making it more worthwhile for them to stay in Sri Lanka. The present methods of recruitment can only hasten the death of the industry.

Training Facilities.

a) Junior Management. Facilities are available at the University of Moratuwa for a considerable increase in the foundry content of Graduate courses. Additionally, practical faclities are available at the training foundry of the Industrial Development Board at Ratmalana, less than 5 kms. from the University.

b) Foremen. The Adviser visited the newly opened Foremen's Training Institute at Narahenpita to ascertain if any of its facilities would be of use in the foundry industry. Unfortunately, none of the workshops offer any suitable facilities for any of the foundry trades.

Regretfully, the Director and his Assistant failed to keep the appointment so the Adviser was unable to discuss with them what the future of the Institute could hold for foundries. It was also not possible to discuss what training in general supervisory techniques and man management was available.

c) Artisans. The Industrial Development Board Training Foundry is well supplied with equipment provided by a previous I.L.O.Project and the chief instructor seems to have practical ablility. Unfortunately the type of training given at present is the perpetuation of the old fashioned methods in use in local foundries. The equipment supplied by I.L.O. is not used, the laboratory seems to be permanently locked and unused, and even locally supplied items such as moulding boxes are rusting away.

This centre has great potential as a training centre but the methods and practices it teaches must be brought up to date before it can be of any great benefit to Sri Lanka.

Future Training.

a) Professional. The Adviser had discussions with Professor C.L.K. Tennakoon, the Dean of Engineering at the University of Moratuwa, on the foundry content of Engineering courses. He agreed to give serious consideration to the representations made to him, when the University carries out its annual review of courses. If possible, a foundry technology optional subject will be introduced into the Mechanical Engineering courses and possibly this would also be made an integral part of the degree courses in Production Engineering and Materials Engineering.

Professor Tennakoon also agreed to introduce short courses of one week or two weeks duration for professional foundry personnel, on highly specialised foundry topics to assist industry in its development.

The Adviser submitted to the Dean some suggestions of topics for short courses (see Annex VIII) and the depth of coverage required for the subjects to be of value to industry. At the Seminar for Top Management, the announcement of these short courses seemed to be greeted with approval.

b) Foremen. As no facilities exist at present for any kind of foreman training, then the Institute of Management in Wijerama Mawatha, Colombo, should be used for at least basic training in costing and man management.

c) Craft. The facilities of the Industrial Development Board must be utilised more and its methods brought up to date. Apprenticeship training through the National Apprenticeship Board could then be expanded. Additionally, the Board's foundry could also be used by industry for practical training for their Foundry Engineers. Four weeks at the training foundry would enable them to become fairly conversant with what can and cannot be done with a set of moulder's tools, without loss of face among their own labour force.

The equipment provided by I.L.O. could also be utilised in their training by letting them carry out small investigations into the effects of various sand mixes, changes in cupola operational procedure, and the advantages of using moulding machines, etc. etc.

Specific facilities for the training of the most specialised of all foundry trades i.e. patternmaking, appear to be almost non-existent. However there is no reason why the facilities of Technical Colleges such as Ratmalana, which have workshops for carpentry and joinery, and machine shops, could not be utilised. Tradesmen and apprentices could then be properly trained in both metal and wood patternmaking. The quality of patterns in use throughout the industry is appalling and training is essential.

Apparently an I.L.O. team visited Sri Lanka earlier this year to look into training in Governmental engineering organisations, and it is possible that the foundry sections of industry were included in this study.

Unfortunately, although the report has been submitted to the Government, the SIDFA in Colombo advises that the I.L.O. Representative has informed him that the document is still "confidential".

B. Training for the Sri Lanka Standards Institution.

Training Courses.

It was decided that rather than simply look into the training requirements of the officers of the S.L.S.I. there was no reason why some training should not be carried out by the Adviser. Accordingly, a very concentrated short course of 8 (which became 9) sessions was given on the subjects of foundry processes and the defects which arise from these; 12 officers attended. The course was concluded with a visit to a local foundry, arranged for a time when both moulding and casting were in progress.

The aim of the course was not to make foundrymen out of the officers but to enable them to be more knowledgeable about the whole subject of castings, and to know what to look for when visiting foundries and inspecting castings. The course syllabus is attached as Annex IX.

An 82 page set of notes was produced for the trainees and the originals for these notes have been left at the S.L.S.I. It is possible that the Institution may find a market for some, or all, of the sections, as so little information, particularly in melting procedures, is available in the country.

Subsequent to the foundry course, a very rapid training in the principles of the polishing of metallurgical samples for microscope examination was given to 3 of the officers of the materials testing section.

Both types of training given by the Adviser will not be sufficient to produce staff adequately qualified to cope with experienced foundrymen or who could be relied upon to give an accurate interpretation of a metallographic structure, but it will make their work a little easier and more understandable.

More information on foundry work can only be obtained by the S.L.S.I. officers by them actually spending some time in a foundry, preferably working, and, if possible, this should be in a country with similar problems to Sri Lanka i.e. with very little local raw materials.

For the interpretation of micro-structures, there is no alternative than that the S.L.S.I. requires a fully qualified metallurgist, which at present it does not seem to have.

Library.

The Adviser visited the S.L.S.I. library to examine the contents of the foundry section. Where a staff require so much technical information then a good library is essential. Therefore, a list of suggested textbooks has been drawn up and is given in Annex K.

The Adviser also visited the local Representative of the British Council in Colombo to ascertain whether the S.L.S.I. staff could become members of the Council Library. The Representative was very helpful and is examining the possibility of the S.L.S.I. itself becoming a Library member, with the staff having reference facilities. He also stated that the S.L.S.I. could qualify for a grant from the British Council for British books, which could be as much as 25000 every three years. The Director General of the S.L.S.I. has, therefore, submitted the necessary request to be included in the Council's "Book Presentation Programme", and after inspection of the S.L.S.I. library etc. it has been accepted.

III. AREAS FOR STANDARDISATION.

Terms of Reference.

See Annex I - Job Description.

"To assist the staff of the S.L.S.I. to identify areas for standardisation, methods of testing, equipment and other relevant materials within the areas of foundry technology."

A. Types of Standard Needed for Castings.

Factors influencing Castings Standards.

A totally different approach from that used in most other industries is required for the foundry industry. Whereas for food items it is possible to specify the level of contaminants, or the percentage composition, such as the amount of fruit in a jar of jam; or for electrical items it is possible to give tolerances on resistors, breakdown voltage for capacitors; or for typewriter ribbons it is possible to specify its length, thickness and breaking strength, i.e. product specification, such specifications involving destructive testing cannot be used for castings.

Castings are very expensive to produce and a batch of castings (sic) may be only a single casting. So destructive testing in such a situation would just not be possible.On the other hand, some batches in mass production foundries may run into thousands and, if the castings are small and relatively inexpensive, then statistical sampling policies with destructive testing may possibly be allowable. But a standard specification must be able to cover all the situations.

Additionally there are metallurgical problems which preclude strength testing of castings. All castings, whether irons, steels, copper alloys, aluminium alloys are "section sensitive". That is, the metallurgical structure in any individual casting varies from place to place in the same casting depending on the section thickness in those places. The thinner the casting section, the faster is the rate of cooling and this alters the properties so that generally, thicker sections are softer and of lower strength than the thinner sections. In extreme cases with iron castings, the section may be so thin as to produce a "chilled" structure right through the section or on edges or corners. This chilled structure may have a Brinell Hardness Number of 450 compared with the rest of the casting at about 200 B.H.N. and such a hardness value makes the casting virtually unmachinable.

Some castings, such as plain carbon steels or high manganese steels containing 10 to 14 % manganese, need to be annealed or normalised to destroy the "as-cast" structure. Similarly, castings made by casting into metal moulds, such as spun cast iron pipes, must also be annealed to remove the chill.

In consequence of these factors, standards for castings are drawn up on the basis of measuring the properties of the material poured into a mould using separately cast test bars poured at the same time as the relevant castings. Naturally the dimensions of these separately cast test bars must be related to the section thickness of the castings being made and so, in particularly sensitive cases such as grey cast iron, the dimensions of the test bar "as-cast" and after machining are quoted. The number of test bars required for a particular batch of castings may be determined by statistical **methods**, either on the basis of the total weight or on the number of castings, or both, in the batch. Annex XI shows the test bar specifications and statistical requirements for the Sri Lanka Grey Iron Standard No.178:1972 to illustrate these points.

Cast material specifications may, or may not, contain chemical analysis requirements. For instance, the Grey Iron specification referred to above contains sections which state:

4.1 The composition of the iron as cast shall be left to the discretion of the manufacturer, but minimum and/or maximum limits for phosphorus and/or sulphur may be specified by agreement between the purchaser and the manufacturer.

4.2 In the case of special castings the detailed chemical composition shall be as agreed to between the purchaser and the manufacturer.

Similar clauses are to be found in the Grey Iron Standards of the British, Indian, American and South African Standards Organisations.

In contrast to this, however, in the cases of copper or aluminium alloy castings, in addition to the mechanical properties chemical analyses are quoted and some are given in great detail. For example B.S.1400, "Copper Alloy Ingots and Castings", for Leaded Bronze LB 2, quotes limits for ten elements even though the basic alloy has only three constituents 10% tin, 10% lead, 80% copper. Of the other seven elements, aluminium at 0.15% maximum, manganese at 0.01% maximum and silicon at 0.02% maximum are subject to compulsory analysis because of their deleterious effects on the properties of the alloy.

Nevertheless, even when considering analysis the effects of section and segregation on solidification have to be taken into account. For instance, the centre of a 70% copper, 30% zinc, brass casting is always richer in zinc in the centre of the casting than at the surface. Hence it is usual practice to cast a separate analysis block which is either chill cast to prevent segregation, or drilled completely through and the drillings mixed and averaged. This type of situation is usually covered in either a Standard for a Method of Analysis or a Code of Practice.

Tests of actual castings are usually confined to:

(i) Visual examination for obvious defects like shrinkage, blowholes, slag etc.

(ii) Internal examination by X-ray, γ ray or ultrasonic methods.

(iii) Crack detection by dye penetrants or magnetic methods.

(iv) Actual property determination in the case of cast irons by determination of resonant frequency.

(v) Property determination by eddy current comparison methods.

Tests (ii) and (iii) are usually confined to large castings with the customer having the right to accept or reject on the available evidence; tests (iv) and (v) are applied to mass produced critical parts such as brake drums, axle hubs, crankshafts etc. for motor vehicles, generally referred to as "life or death components".

The practice employed is to carry out the sonic or eddy current test on a range of castings, obtain the relevant readings and then test these castings to destruction. In this way the associated test results are obtained for castings which suit the performance requirements. The properties of such castings are usually established by joint agreements between foundry and customer.

The only other specification which may be applied to castings relates to permissible dimensional tolerances of different materials and components. The basic reference on which other standards are based is ISO - TC3. Limits and Fits. International Standard No. 8062, Castings - System of Dimensional Tolerances.

Standards Needed

Hence to conform to international standards practice for castings, the S.L.S.I. need only be concerned with dimensional tolerances, material specifications, and methods of test and analysis. In view of the limited number of alloys being made at present in the country, it is only necessary to consider the following;

(i) Copper alloys castings:i.e. brasses, bronzes and gunmetals.

(ii) Aluminium alloys castings: heat treatable and non-heat treatable.

(iii) Cast steels: plain carbon, low alloy, and high manganese (10-14% Mn.)

(iv) Castings: Dimensional Tolerance.

(A standard for Grey Iron Castings already exists, No.178:1972.)

The following Codes of Practice would be an asset;

(a) Standard Methods of Analysis for Cast Iron - carbon, silicon, manganese, phosphorus, nickel, chromium, magnesium, sulphur, titanium, aluminium.

(b) Standard Methods of Analysis for Copper Alloys - tin, zinc, lead, aluminium, iron, nickel, manganese, antimony, arsenic, silicon, bismuth, phosphorus.

(c) Standard Methods of Analysis for Aluminium Alloys - magnesium, iron, silicon, manganese, nickel, zinc, lead, tin, titanium.

(d) Standard Methods of Analysis for Steels - carbon, manganese, sulphur, silicon, phosphorus, nickel, chromium, tungsten, molybdenum, copper, niobium, titanium.

General Conditions.

All standards for castings invariably include general clauses to cover aspects of production which are not measurable i.e. standards of grinding and finishing, general appearance of the castings, repair of castings, weldability, machinability etc.

For instance, the Sri Lanka Standard for Grey Iron includes:

5.2) The castings shall be sound, clean and free from distortion and injurious defects. They shall be well dressed and fettled.....
They shall be machinable by the normal methods for the grade specified.

5.3) No welding or repairs shall be carried out without the prior permission of the purchaser. Welding referred to here includes burning in or fusion welding in accordance with the common foundry practice."

All standards which may be subsequently prepared by the S.L.S.I. for castings should contain similar clauses.

3. Standards for Methods of Test for Cast Metals.

Standard Tests.

The usual mechanical tests carried out on cast materials are for tensile strength and ductility, hardness, impact resistance and, in the case of grey cast iron, transverse load resistance. Additional to this, chemical analysis is invariably required and for some alloys, particularly cast steels, evidence of a satisfactory micro-structure could be asked for. As outlined in Section IIIa "Type of Standard Needed for Castings", these tests are carried out on separately cast test bars.

Tensile and Transverse Tests.

Because different types of alloy require differences in test conditions for tensile and transverse tests, eg. differences in strain rate, the use of machined or unmachined test bars, or different sizes of test bars, then it is common practice for the standards for cast metals to include the specific test details in each relevant material standard. These will even include full details of the method of manufacture for the test bars to ensure that reproduceability of the test is maintained. So, to conform to international practice, any standards produced for materials for castings should also include this information. As an example, the standard requirement for aluminium alloy castings is shown in Annex XII.

Hardness and Impact Tests.

Hardness tests may be carried out on either the test bars, on the separately cast blocks for analysis, or on the casting itself. As long as the surface has been ground to produce an area free from moulding sand, surface oxidation or any other condition which may produce a spurious result, then this will be adequate. A range of Hardness values is always specified in the material standard and if the material meets the other specifications then it invariably meets the hardness requirements.

Impact test pieces are usually machined from extra tensile test pieces cast specifically for the purpose.

Both types of test ie. Hardness and Impact, have already been internationally standardised and Sri Lanka has issued its own specifications as follows:

Sri Lanka Standard No. 112, Vickers Hardness Test;
Sri Lanka Standard No. 145, Rockwell Hardness Test;
Sri Lanka Standard No. 146, Brinell Hardness Test;

Sri Lanka Standard No. 354, Izod Impact Test;
Sri Lanka Standard No. 355, Charpy Impact Test.
So no further work is required in this field.

Chemical Analysis.

This has already been discussed in Section IIIA "Areas for Standardisation" and recommendations made for the issuance of Codes of Practice to cover the analysis of cast irons, steels, copper and aluminium alloys.

Micro-structures.

This is a highly specialised area of metallurgy and there are only a few standards which contain specific requirements. Probably the most notable is that for the degree of graphite nodularity in standards for Spheroidal Graphite Cast Irons. As this is not produced in Sri Lanka, and is unlikely to be for some considerable time, then no action is needed at present by the S.L.S.I.

C. Equipment for Testing Cast Materials.

Equipment Available.

The S.L.S.I. is well equipped for the majority of tests usually specified for castings. The deficiencies had already been identified prior to the arrival of the Adviser, and the equipment ordered. The Adviser found some errors due to lack of specialised knowledge in certain fields and these have been rectified; the major error occurring in the specification for equipment for the determination of carbon in irons and steels.

Additionally, there were some shortages of basic tools and equipment although the major items had been ordered. For example, although an Izod/Charpy impact machine is available, the special milling cutters needed for the production of specimens had not been procured.

The only possible weakness is the capacity of the machine used for tensile testing. At 25000 Kg. maximum load it may be slightly too small in the future if the foundry industry achieves the capability of making the higher strength steel castings, or if industry requires tests on any high strength steel products. It is, however, adequate for present production and larger equipment is available at the Universities and at the Steel Corporation.

The S.L.S.I. possesses hardness testers, an Izod/Charpy impact machine, a tensile test machine, an X-ray machine, an eddy current tester, and a workshop for the preparation of test pieces.

For the analytical aspects of its work, the S.L.S.I. has good chemical analysis facilities. In the metallographic section a good microscope is available, although there are deficiencies in the specimen preparation facilities. Unfortunately, the specimen polishing wheel has been usurped for other purposes and is now no longer fit for metallographic work. There is a shortage of good quality hand files which are essential in the initial stages of specimen preparation.

In view of the established facilities it has only been necessary for the Adviser to ensure that all the ancillary equipment for the main equipment was available.

Equipment Requisitioned.

Prior to the arrival of the Adviser, a range of hardness testers and an ultrasonic flaw detector had been requisitioned. The Adviser has added to the list of probes for the ultrasonic machine to enable transmission as well as reflection testing to be carried out. When this equipment arrives, the S.L.S.I. should be well equipped for the mechanical and metallographic testing of castings and cast materials.

The Adviser has recommended that various additions be made to the metallographic equipment, including the replacement of the polishing wheel, and requisitions have been submitted to UNIDO.

In the chemical section, a Strohlein determinator for carbon in irons and steels has been requisitioned, together with the necessary furnace tubes, combustion boats, standard samples etc. for approximately one year's needs.

Equipment Deficiencies.

The Adviser is of the opinion that for the determination of copper and lead in copper alloys, an electrolytic bench would be an advantage. Discussions with the Head of the Laboratories has indicated that the control panel for this can be produced within the S.L.S.I. and that the principal expenditure would be for a pair of rotating platinum electrodes with a stirrer.

When all of this equipment has been received, then the S.L.S.I. should be able to cope with all the tests necessary for cast metals.

D. Other Items Relevant to Foundries.

It is possible that in the future, the foundry industry may require standards for some of its raw materials, such as ferro-alloys, linseed oil, sodium bentonite, limestone etc. This would involve the S.L.S.I. in a complete new field of activity and would perhaps require an extension of the laboratory facilities.

The majority of the testing required would be in the form of chemical analysis as deliberate contamination, particularly of linseed oil and sodium bentonite with inferior quality materials is quite common in many developing countries. There are however, some naturally occurring critical factors which may make a material unsuitable for foundry use. A good example is limestone where the presence of as little as 1% silica can render it only 50% efficient as a fluxing agent when used for melting and /or refining cast irons and steels.

The preparation of such standards would be of use to the foundry industry as, at present, the level of technical knowledge is not high and these standards would be a guide as to what to specify in making purchases of these materials.

It is unlikely that the preparation of standards for foundry sand would be effective as so many different factors are involved, depending on the metal or alloy being cast. Sands required for small, lightweight castings are different from those for large, heavy castings. Casting temperatures vary from approximately 680° C. for large aluminium castings to 1600° C. for steel castings, so the range of refractoriness required would be extremely large.

However, it is possible that standards for some or all of the following would be helpful to the industry in the future: ferro-silicon, ferro-manganese, foundry coke, graphite for carburising purposes, linseed oil, sodium bentonite, limestone, dolomite.

IV. CONCLUSIONS.

A. Foundry Industry.

1) Quality control, with all its concepts as understood in developed countries, does not exist in Sri Lanka. Organisations which have the facilities for quality control either do not use them at all or use them improperly. Most foundries have no facilities.

2) The foundry methodology in use throughout the country is obsolete and has been discarded everywhere else in the world that the Adviser has visited as a Consultant.

3) There is an excess of foundry capacity in relation to the amount of work available and it is only the use of slow, labour intensive methods, coupled with high rejects, that enables most foundries to stay in business. Improvements in quality control and better productivity will both reduce the amount of work available and some foundries will have to close.

4) There is a great reluctance to change existing methods despite assurances to the contrary. It seems to be easier to produce reasons why something cannot be done rather than to think positively that something must be done.

5) The level of technical competence in the industry is very low at all levels. Education and training are desperately needed in manual skills, management and costing methods, quality control and the scientific principles of foundrywork.

6) All the foundries belonging to the larger organisations, both public and private, are grossly over-staffed because of the methods used.

7) There is a definite danger to the industry from the "dumping" of cheap items with a high cast content at below cost price.

8) The form of the electricity tariff is not understood in industry and even if it were, it would still be a considerable deterrent to the use of electrically powered machinery.

9) There are no practically competent organisations or individuals to whom industry can turn for technical assistance. There are not even representatives from the large foundry materials suppliers; these people may be concerned with selling their products but, in general,

they are good practical foundrymen of wide experience and are usually willing to help their customers.

10) There is encouragement in the attitudes of those of the young engineers who wish to stay in the industry and make the foundry their career. They are prepared to work hard, are not afraid of getting dirty and they are willing to learn.

3. Sri Lanka Standards Institution.

11) When all the equipment which has been requisitioned has been brought into operation, the S.L.S.I. should be able to cope with the inspection of any cast materials or castings. Facilities will exist for chemical, metallurgical, mechanical and visual examination.

12) Although there are some officers employed by the S.L.S.I. who have some foundry knowledge, there is only one person who appears to have practical experience, and this is not adequate.

13) There is a need for a metallurgist to be employed in the materials testing section who is capable of interpreting metallographic structures.

14) The Institution will obviously operate in a more cohesive manner when all the sections are united in the new laboratory buildings.

15) It was gratifying to note the enthusiasm for the job shown by every individual who was encountered.

7. RECOMMENDATIONS.

A. Foundry Industry.

When drawing up these recommendations the following points had to be taken into account:

a) As distinct from applying to any single organisation, the recommendations must be relevant to a whole industry covering large and small, public and private, and ferrous and non-ferrous foundries. They must be based on national considerations and not towards the improvement of any individual company.

b) They must be directed to helping the industry to help itself.

Bearing these in mind, the following recommendations are made.

Training.

1) If any sustained improvement in the industry is to be made, then the standards of foundry education and training must be raised considerably. Foundry technology should be introduced into Mechanical Engineering degree courses, at least as an optional subject, and it should be a compulsory subject in Production Engineering and Materials Engineering courses. These courses should contain a large proportion of practical work, not necessarily with the objective of producing moulding ability, but directed towards knowledge of the necessary properties of moulding sands, the founding properties of different alloys, and the scientific processes involved in metal melting, all of which are lacking in the young engineers presently employed in the industry. The University of Moratuwa would appear to possess the necessary facilities to do this.

2) Short courses on specific foundry topics, such as cupola operation, non-ferrous melting, properties of moulding sands, should also be run at the University of Moratuwa. These would be directed specifically towards engineers employed in the foundry industry at all levels. It is just as essential for senior management as well as the production staff to know the fundamentals of the processes under their aegis. Only then can they effectively assess the efficiency and economics of each department.

3) The facilities of the training foundry of the Industrial Development Board at Ratmalana should be utilised for practical training of engineers already in employment in foundries. The training, however, should be in modern methods of production and not the perpetuation of the obsolete methods at present in use in industry. The presently unused equipment

supplied by a previous I.L.O.Project should be brought into use for this.

The use of these facilities for this purpose would enable employed engineers to receive some training in private, i.e. without loss of face or prestige by being seen by the employees under their supervision.

4) The training given at the Industrial Development Board Training Foundry to apprentices from the National Apprenticeship Board should be modernised to produce craftsmen more able to make the types of castings required by present day industry. More use must be made of plated patterns, moulded runners, pinned and bushed boxes and milled sand. Training must also be given in the use of moulding machines. Training to mould small castings in the floor must be stopped.

5) To overcome the need for skilled patternmakers able to make both wood and metal patterns and plated patterns for machine moulding, a course of training should be started. This should be at one of the Technical Colleges, such as Maradana or Ratmalana, where facilities for the necessary drawing office training, machine and hand woodwork and metalwork are available. Like the other training suggested, this should be in modern methods, using milling machines for a very high accuracy, and even nails should be eliminated in favour of screws and glue.

6) Although the Foremens Training Institute at Narahenpita does not have the facilities for practical training for skill upgrading for foremen, it should, at least, be asked to provide courses in foremanship itself, covering such items as man management, basic principles of costing, and the other aspects of officework which today's foremen are expected to perform.

7) The appointment of a full-time Adviser in Foundry Technology by UNIDO is recommended. The Adviser would be expected to provide technical assistance to any foundry which requested it. To this end, the appointment should be for a minimum of one year, but two years would be preferable, as the changes in industry will, of necessity, be slow because of the capital investment which will be required.

The Adviser would, additionally, be expected to assist in the implementation of Recommendations 1 to 6. Hence the qualifications of the individual appointed should be based on long, practical, foundry experience in a developed country, and academic qualifications should be of secondary importance. It is unlikely that a candidate from a developing country would have the necessary long and broad practical experience at the level required.

Government Action.

8) As remarked in the body of the Report, one of the major deterrents to industrial progress in Sri Lanka is the system of charging for electricity. The Government should immediately review the principles underlying the present tariff system, and produce a new system which will encourage electrification.

There will be little value in the extensive hydro-electric power developments at present under way if, by the time the power comes on stream, the engineering industry is not in a position to use it. This may be due to, either the present reluctance of the industry to install electrically driven equipment or, that the engineering industry, due to its failure to meet its competition, has collapsed. Evidence of this failure is already apparent in the massive financial losses being sustained at present by the major engineering companies.

9) The second negative factor influencing industrial progress is the "dumping" of cheap items with a high cast component at prices below cost. Import inspection and anti-dumping tariffs are necessary, and should be introduced by the Government immediately. If no action is taken, then the foundry industry will suffer badly and, when it has collapsed, the market prices of the imports will rise considerably.

10) The Government should set an example to the rest of the industry by the introduction of a technical overhaul of the State foundries. In particular, the State Hardware Corporation has the facilities for the production of at least 100 tons per day. The expensive German equipment for the sand conveyor system, the hot blast cupola, the moulding machines, have all been neglected and should be re-furbished. The labour force should be reduced in the first place by at least 60%, from 273 employees to no more than 110, and the savings on wages should be used to pay a good foundry manager (imported if necessary), and to buy good quality raw materials. This foundry has the capacity and equipment to produce excellent quality at low cost, given the right practical know-how.

3. Sri Lanka Standards Institution.

11) There is a need for a graduate in Metallurgy in the Materials Testing Laboratory. The person should specifically be capable of interpreting metallographic structures and relating them to the production method. Naturally a foundry background would be preferable in view of the type of work intended to be done by the section. A graduate in Materials Science is unlikely to have the necessary qualifications, unless he/she has been extensively employed in the field of metallography since graduation.

12) To facilitate the Institution's work in the area of casting inspection it would be advisable if at least one, but preferably two, of the staff receive more training in foundry work. A period of practical training in a foundry is regarded as necessary, so that they are more familiar with foundry processes and, more particularly, the defects occasioned by those processes. A period of three months in each case is suggested, one person should be sent East, say to Japan, and the other West to a country like Argentina or Mexico, which have similar raw material problems to Sri Lanka.

13) The S.L.S.I. should prepare standards for the following:

a) Copper Alloys - Ingots and Castings.

b) Aluminium Alloys - Ingots and Castings.

c) Steel Castings.

The standards should be prepared according to international conventions and should include details of the pattern etc. for the test bars specified.

14) The S.L.S.I. should prepare Codes of Practice for the following:

a) Standard Methods of Analysis for Copper Alloys - tin, zinc, lead, aluminium, iron, nickel, manganese, antimony, arsenic, silicon, bismuth, phosphorus.

b) Standard Methods of Analysis for Aluminium Alloys - iron, zinc, magnesium, silicon, manganese, nickel, lead, tin, titanium.

c) Standard Methods of Analysis for Cast Irons - carbon, silicon, sulphur, phosphorus, manganese, nickel, chromium, magnesium, titanium, aluminium.

d) Standard Methods of Analysis for Steel Castings - carbon, manganese, silicon, phosphorus, nickel, chromium, tungsten, molybdenum, copper, niobium, titanium.

22/10/1984

ANNEX I.

UNITED NATIONS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

Project in Sri Lanka

JOB DESCRIPTION

DP/SRL/82/003/Rev.1/11-03/323.K

Post title	Adviser on Foundry Technology
Duration	3 months
Date required	March 1985
Duty station	Colombo, Sri Lanka
Purpose of project	To upgrade the capabilities of the Sri Lanka Standards Institution in the implementation of standards and introduce industrywise quality control practices and facilities for local and export products.
Duties	The Adviser will be attached to the Sri Lanka Standandards Institution and will work in close co-operation with the other organizations and Institutions concerned with quality control activities of foundry technology.

Specifically, the Adviser will be expected to:

i) study the technological background of the Sri Lankan ferrous and non-ferrous foundry industry and recommend appropriate measures for improving the technologies and quality control practices of these foundries;

ii) advise the foundry industry and the Sri Lanka Standards Institution on the training requirements of their staff;

iii) assist the staff of the Sri Lanka Standards Institution to identify areas for standardization, methods of testing, equipment and other relevant materials within the area of foundry technology.

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

V.81-33106

Qualifications

University degree or equivalent in Metallurgy, Industrial Chemistry or Materials Science with extensive work experience in a medium or large-scale foundry.

Language

English

Background information

The Sri Lanka Standards Institution (SLSI) came into being in 1965, with the passig of Bureau of Ceylon Standards Act Nº 38 of 1964. The Bureau presently consists of four major Technical Divisions, namely, Scientific Standardization, Engineering Standardization, Implementation, Certification Marking and Export Inspection Services. These divisions are under Asst. Directors, who report to an Executive Director. In addition to the major Technical Divisions, services are provided by a Library, a Training Unit and a Printing and Publication Section.

The Scientific and Engineering Standardization Divisions are responsible for the preparation of Standards Specifications and codes of practice. Presently, they also deal with ISO and IEC work, namely, study of ISO and IEC Draft Standards at the voting stage and participation in ISO Technical Committee Work.

The preparation of Standard Specifications are grouped under 6 Divisional Committees, namely:

1. Electrical Engineering;
2. Mechanical Engineering;
3. Civil Engineering;
4. Agricultural and Food Products;
5. Chemicals; and
6. Textiles

SLSI has so far finalized 600 standards and 150 subjects are under standardization currently.

Among these are products standards as well as codes of practice concerning the environment and the health and safety of the workers. Some of these codes of practice are intended to be useful guidelines for the formulation of regulations by various Government Departments and Authorities for practices and procedures an trades coming under their jurisdiction.

Under the recently enacted Consumer Protection Law, around 340 consumer commodities have been declared as essential to the life of the community and have to conform to the standards prescribed by the SLSI through regular sampling from the market as well as from production, testing in the SLSI Laboratories and follow up action with the manufacturers.

Only two standards have so far been declared as Compulsory Standards under the SLSI Act as the procedure outlined under the SLSI Act for legal enforcement of Compulsory Standards is cumbersome and costly.

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The Laboratory Division of the SLSI functions under the Assistant Director assisted by 2 Senior Testing Officers. 11 Testing Officers at graduate level and 11 Technical Assistants. The Laboratory has been organised to handle engineering testing, which includes Electrical and Electronic; Physical and Mechanical, and Scientific Testing which includes textiles, food and chemicals and microbiology. A workshop has also been set up to facilitate the fabrication of equipment required for testing work.

The Sri Lanka Standards Institution (SLSI) headquarters and laboratory are presently accommodated in temporary premises comprising of around 23,000 sq.ft. of space of which 8,000 sq.ft. is occupied by the Laboratory, 2,000 sq.ft. by the library, 4,000 sq.ft. by the Implementation and Training Division and 9,000 sq.ft. by the Administration, Standardization and Printing Division. The Laboratory carries a modest range of equipment necessary for its testing and quality control work.

In the above background the present organization and infrastructure of the SLSI for the development of standards, guidance and quality control services to industry, training of industrial personnel, testing and quality certification of local products both for the rapidly expanding local market and foreign markets, is hardly adequate to carry out these gigantic tasks effectively,

It is prohibitively expensive for a small country to meet the costs of strengthening the present technical services and infrastructure, in order to effectively carry out the above tasks. The Government is therefore, soliciting the assistance of the UNDP and UNIDO to augment and develop the institutional arrangements required for providing the technical services in the current industrial background to pursue a planned national programme for building up a viable standards organization. In view of the paucity of local technical experts to devote their time and services to SLSI it is desirable to enlist the services of international experts to assist in the programme formulation, equipment selection, training of local personnel and preparation of operating manuals for implementing the SLSI's programme.

Activities / Week No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Survey of SLSI and Laboratory	—	—												
Visits to Foundries	—	—	—	—										
Discussions with Foundry Customers			—	—										
Preparation of Equipment Lists			—	—	—									
Meetings with Senior Foundry Executives					—	—								
Meetings with Senior Government Representatives					—	—								
Instructions of SLSI Staff in Foundry Processes						—	—	—						
Instructions of SLSI Staff in Foundry Control							—	—	—					
Instructions of SLSI Staff in Foundry Testing								—	—	—				
Preparation of Individual Foundry Reports							—	—	—	—	—			
Short Course for Senior Foundry Management										—	—			
Final Report											—	—		

[illegible] II.

MEETING AT COLOMBO COMMERCIAL CO. LTD.

TUESDAY 9th JULY 1985, at 2.30 p.m.

PRESENT:	Mr. Amarasinghe	-	General Manager,
	Mr. Akbar	-	Foundry Consultant,
	Mr. Mendis	-	Research & Design Engineer,
	Mr. Worth	-	UNIDO,

and other members of foundry middle management.

Mr. Amarasinghe asked Mr. Worth to comment on his observations made during his visit to the foundry on 21st June and his discussions with Mr. Mendis on 4th July.

Mr. Worth commented on the following:

1). The necessity for strict control of cupola charging and operation, segregation of scrap to remove steel scrap, aluminium scrap and any obviously alloyed scrap, particularly that which may contain chromium.

The charge should be weighed and the coke charge controlled by volume. Mr. Worth explained that it is the height of the coke bed above the tuyeres which is important and as the size of the coke pieces will control the packing of the coke in the bed, then it is easier to control the bed height this way. Additionally it eliminates the variable due to the valuable moisture content of the coke especially during the monsoon seasons.

2). The practice of making green sand moulds and leaving them standing open for 2 or 3 days before casting. In this time the moulds dry out, the sand loses its properties and washes away when the metal runs over it. This gives the castings a bad finish and additionally the sand may appear inside the casting when it is machined, so wasting expensive machine shop time and damaging tools.

3). The use of expensive and imported Mansfield red sand. Admittedly this is an excellent sand but there are adequate local replacements. No other foundry so far visited by Mr. Worth finds the need to do this. In any case the moulding practice renders it a waste of money.

4). The practice of moulding the bottom half of the mould in the floor rather than using two box moulding. This makes it more difficult to get facing sand coverage of the pattern, damages the pattern by hammering it into the floor, makes box location difficult leading to off-set castings. The practice of using angle iron at the corners of the moulds makes them vulnerable to damage by kicking or tripping. There is very little or no venting of the bottom half of the mould so increasing the tendency to blow holes.

5). There are no facilities for mixing core sand. At present it is done by hand on a wooden board by a coremaker. This is wasteful in time and expensive in oil as the mixing is not good. With a good paddle mixer the oil content could possibly be cut by as much as 50% and the mixer would soon pay for itself.

6). There are no routine scrap inspection reports. After every cast a report should be made on a record sheet not only of the amount of scrap but also the cause of the scrapping every individual casting rejected. The reports should be visible in consecutive order, say pinned underneath each other on a board so that the regular causes of scrap can be identified. Only when the causes are known can action be taken to prevent recurrence.

A suggested layout such a form has been given to Mr. Mendis, and he is starting the operation of such a system.

7). Productivity is very low. A labour force of 80 men working 45 hours per week at standard time plus 4 hours overtime for casting at time and a half is a very expensive way of casting about I5-20 tons of melted metal. An estimate of labour costs is about Rs.2500/= per ton of good casting. This is very high for medium size jobbing work being produced on a regular basis. By comparison a local "mini-foundry" is selling a set of 7 castings for sewing machines, intricate castings of good quality and finish, for Rs.360/=. The set weighs 46lbs so the selling cost per ton is about Rs.I7500/= and as the foundry is private then it is obviously profitable at this figure.

Mr. Worth concluded by saying that only when consistency of operation is achieved can the levels of control be established. e.g. if the carbon content of the iron from the cupola varies from say

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3.2% to 3.8%, i.e. a range of 0.6% in one melt, then the first thing to do is to tighten up the controls to bring this range down to a maximum of 0.2% e.g. to 3.2 ± 0.1%. Only then would it be possible to control the level of the carbon e g. raise it to 3.4 ± 0.1%.

Mr. Akbar then stated that the main problem appeared to be (a) chilled castings (b) blowholes.

Mr. Worth commented that the cause of chilled castings was solely that of using iron of unsuitable composition for the section thickness being cast. The usual causes are low Carbon content or low silicon content or high Chromium content, or high Sulphur content or any combination of all four.

Chilled castings can only be eliminated by:

a). Strict control of cupola operation so that consistent levels of Carbon. Silicon and Sulphur are obtained and the levels adjusted to those necessary for the castings being made;

b). removal from the charge of all Chromium bearing material, even if only Chromium plating and the segregation of all scrap produced from Chromium alloyed castings made in the foundry. A Chromium content of 0.1% usually needs 0.6% to 0.8% Silicon to overcome its chilling effects;

c). setting up a system of either wedge testing or chill testing of the iron <u>before</u> it is poured into the mould. If the iron is shown to be unsuitable then some modification can be made to the composition by ladle additions or it can be used in a different casting from the one for which it was originally intended and for which it is more suitable.

The details of wedge tests are given in the Foseco handbook, a copy of which is apparently available in the foundry office, and a photostat copy is attached to this report.

Mr. Mendis remarked about some castings which were to be made in 1% Cr iron being given to another foundry because of the difficulty of obtaining the required Cr content. Mr. Worth commented that Ferro - Chromium ladle additions should be bagged or enclosed in some way and

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thrown into the ladle after there was liquid metal in the bottom of the ladle: tapping is then continued on top of this. Putting the Ferro - Chrome in the bottom of a dry, hot ladle simply causes loss of Cr by oxidation : this loss may be as high as 25% of the addition.

If chilled castings are a problem in the foundry then the right decision has been taken when it was decided to have these I% Cr castings made elsewhere.

Passing onto the topic of blowholes, Mr. Worth remarked that the prime causes are excessive gas produced in the mould, bad venting of the mould, and metal of too low a temperature which freezes too quickly and traps gas bubbles before they can escape through the vents.

Greater attention to moulding practice, using boxes instead of the foundry floor, better cupola control, and the checking of the metal temperature would go a long way to eliminating this defect automatically. When these factors are under control then attention can be given to individual castings which still give trouble. Mr. Mendis is already investigating the cost of buying an optical pyrometer to measure the metal temperature.

(It should be pointed out that fluidity of grey cast iron depends not only on temperature but also on composition. The lower the levels of Carbon, Silicon and Phosphorus then the lower is the fluidity and the greater the tendency to blowholes, Shrinkage porosity and chill).

During the meeting Mr. Amarasinghe, General Manager gave instructions (a) that control of cupola charging, segregation of scrap and consistency of blowing must be introduced immediately;
(b) a paddle mixer be built for core sand mixing;
(c) a scrap identification system should start immediately;
(d) moulding boxes should be made to eliminate the use of the foundry floor and reduce mismatched castings;
(e) all Chromium bearing scrap arising in the foundry must be segregated; this includes scrap castings, runners and risers;
(f) to prevent dried out green sand moulds then they should be planned to be made as late as possible before the cast. They should be

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closed uncored immediately with the runners covered and just before casting they should be reopened, blown out, cored and closed again. Cores must be placed as late as possible to prevent moisture pick up by the cores from the mould;

(g) that wedge or chill testing should start.

All of these items are basically just good practice which can be introduced without a lot of capital expenditure (apart from the motor for the paddle mixer).

The question of a laboratory for chemical analysis and sand control was briefly mentioned as a possibility for the future when and if money is available for capital expenditure. Mr. Worth mentioned that sand test equipment is available at the laboratories of the Steel Corporation.

THE SRI LANKA FOUNDRY INDUSTRY - PRESENT AND FUTURE.

I will start by explaining why I am here and what I have been doing for the past three months. I am employed by the United Nations Industrial Development Organisation (UNIDO) as a Foundry Adviser and I have been working at the Sri Lanka Standards Institution. One of my terms of reference was: "to study the technological background of the ferrous and non-ferrous foundry industry in Sri Lanka, and recommend appropriate measures for improving the technologies and quality control practices of these foundries."

The Director General, Dr. N.R.de Silva, and the Deputy Director General, Mr. R. Jayawardena, thought that one way towards achieving this would be to call this meeting and generally comment on what I have seen, heard and felt about the foundry industry here, and I concurred. It ought to be more satisfactory than producing another report, which may simply be filed away somewhere with the interested parties never knowing what was in it.

Of course, some of you have been astute enough to take advantage of my visit here, have given me open access to your foundries and asked me to help with specific problems, and for this, I thank you. You may not have liked some of my comments, but I have tried to be fair, honest,constructive, and conservative with your money!

What I shall now say represents my own opinion, does not represent any opinions or attitudes held by UNIDO, UNDP, SLSI, or any other person or organisation. Naturally, it is based on only three months here, but you will see from the introductory statement that I lived in Sri Lanka for 3½ years from 1971 to 1974, so I am not totally an "instant expert" as some visitors to developing countries become after three days. Also, I have worked in foundries, both large and small, for many years, so my comments are based on practical experience.

Since I arrived at the beginning of June, I have seen some good foundries, some not so bad, and some awful. Similarly, I have met some very good foundrymen, some fairly good, and unfortunately, some very poor. There are several generalities which strike me, among which are:

a) the bigger the foundry, the more trouble it is in.
b) the lack of quality control and the lack of understanding of what quality control in a foundry really means.
c) the technically backward state of the industry.
d) the lack of internal cost controls.
e) the lack of training programmes available for all levels and hence, the inadequate levels of junior management and shop floor control.

a) Foundry Size.

In my opinion, in Sri Lanka at present, there are too many foundries chasing too little work. So much of the traditional market of foundries has disappeared, not only in Sri Lanka but throughout the world, causing excess capacity. Many examples come to mind - the replacement of conduit and conduit fittings, water pipe and water pipe fittings by plastics, drain covers by concrete, cast iron bearings by polymer self-lubricating bearings, gutterings by extrusions and/or plastics, cast iron baths by plastic, and many items which were originally sand cast are now die cast, made in weldments or as forgings.

The smaller foundries, producing for their own use, such items as parts for rice hullers, hand operated rubber rollers,electric motors, fan components etc., and those producing jobbing work, for example, diesel engine liners, sewing machine frames, brake blocks etc., are possibly more fully occupied than the large foundries. They limit their production to items within their capabilities, and, in general, if the casting looks right, or can be made to look right and will do the job without someone demanding that it has a tensile strength of ,say 15 tons per square inch minimum, it is acceptable. I have also found in these foundries, an attitude of inventiveness and diversification, and a willingness to look for, and create, other markets, which for obvious reasons I will not divulge.

Unfortunately, this does not apply to the large organisations producing the larger castings and, in particular, to those producing rubber and tea machinery. If they will forgive me for saying so, my opinion is that they are trying to make items beyond their present methods, and I will explain this in detail when I talk about quality control. Suffice it to say that it is internationally recognised that the most difficult castings to make are brake drums, and the second most difficult are cast iron rolls. To try to make rolls with sand of quality which varies from day to day depending on the whim of the moulder, uncontrolled mould drying, metal which varies in quality from cast to cast, and with moulders and patterns, to say the least, of dubious quality, is simply asking for trouble.

The smaller foundries should not feel too self-congratulatory about this, because their methods are exactly the same; it is simply that the kind of work they make allows them to get away with it. If any one of the larger foundries can get its quality and productivity right, then the small foundries could lose their jobbing work and also be in trouble.

But, to return to the larger foundries. Because of their theoretical capacity, and one of them has in my view, a melting capability of at least 200 tons per day, they are expected by their customers to make the bigger castings. The situation is now that the customers find their expectations are not being realised, and the foundries are frustrated with their problems, so neither side is happy.

So why cannot both the large and small foundries produce castings equal in quality and price to those which can be imported, despite the protective tariff of 60% which applies? There are two reasons;

a) lack of quality control - not only knowing how to control quality, but what to control, and

b) productivity which, in some cases, is so low as to be beyond belief - in one foundry I calculated it at 37 kg/employee/week!

b) Quality Control

There is a misapprehension that supervision is control. Unfortunately it is not. Supervision literally means "watching over" and may only involve seeing that men are working. Control means that personnel do exactly as they are told every time, that changes are only made one at a time and under instruction, that the changes are recorded, and the results of the changes recorded and used for future production. Also of course, it means that exact instructions must be given and, following on from this, there must be controllers who are technically capable of giving these instructions. To date, I have not discovered a foundry with a Quality Controller as such.

Quality control is a "total concept" i.e. it is not satisfactory to control only one factor in production, but it is essential to control all factors and to the same limits every time.

Let us, for instance, consider blowholes. I have listed in Fig.1 seventeen different possible causes and there may be more. Who is the genius who is going to look at a blowhole and state with accuracy which of these causes is to blame? If he says the sand was too weak, how does he know? If he says the metal was cold, again how does he know? And, logically, if you cannot pinpoint the cause of the blowholes, how can you start to eliminate them? Without control, the cause of the blowholes may be cold metal today, it may be wet sand tomorrow, and something else again the following day. Another example; let us consider what happens if the carbon content of cast iron is low. Fig.2 gives some of the effects. And all of this can happen because at 10.30 am the wind was Force 7 instead of Force 3, and from the West instead of the South!

Fig.1. POSSIBLE CAUSES OF BLOWHOLES.

a) too much moisture in the sand
b) too much coal dust in the sand
c) uneven moisture content of the mould due to bad mixing
d) low sand permeability due to too much clay
e) low sand permeability due to wrong grain size,shape and distribution
f) underbaked cores
g) too much oil in the core sand
h) bad, or blocked, mould venting
i) bad, or blocked, core venting
j) excessive use of moisture when sleeking and repairing mould faces
k) wet ladles
l) wet furnace tapping spout
m) low pouring temperature
n) pouring too quickly
o) wrong metal analysis resulting in low fluidity
p) formation of excessive manganese sulphide in cast irons
q) contamination from dissolved gases on melting, eg. hydrogen in bronzes, nitrogen in cast iron.

Fig.2. EFFECTS OF LOW CARBON CONTENT

Property Change	Defects Caused
Low Fluidity	Blowholes. Slag inclusions. Misruns, cold laps. Excess metal discarded.
High Liquid to Solid Shrinkage	Shrinks, draws, porosity. More feed metal needed.
High Solid Contraction	Hot tears, twisted and deformed castings. Castings undersize.
High Chill Tendency	Higher casting hardness Chilled edge. White iron castings Hard spots. Difficult to machine or Unmachinable castings.

Fig.3. EFFECTS OF LOW COKE BED.

1) Low metal temperature	blowholes,slag,misruns,shrinkage
2) Low carbon pick-up	shrinkage,hot tears, chill,slag
3) High Silicon losses	shrinkage, chill, slag inclusion hot tears.
4) High Manganese losses	brittle castings, slag, blowholes
5) Thick viscous slag	slag inclusions
6) Low melting rate	

You may think this is a ridiculous statement, but consider it in detail. The commonest cause of low carbon content from the cupola is that the coke bed is too low. When the cupola is first lit, it is started with a wood fire and coke charged on to this when the wood is well alight. When the coke is alight, the wood ash is raked out through the breast door and more coke added. Finally, when the bed is well alight, and just before charging the metal, say two bags of coke are added so that a constant amount of coke is used in the bed each day. This seems to indicate control, but unfortunately a strong wind from the West today, will give a different rate of bed burn-in from yesterday when the wind was light and from the South. So today's bed has burnt away more by the induced draught, and is now low. The final stage which was lacking in the bed preparation was to measure bed height, i.e. the actual size of the bed. A constant bed height above the tuyeres (usually about 1 meter to 1m.30 cms) every time the cupola is charged initially, is essential to obtain the same metal analyses every day. It is exactly like trying to cook a meal on a big fire, a medium fire or a small fire. It may be over cooked and burnt, just right, or undercooked and cold. Other factors could be the coke size, small coke packs more easily than large coke, or, perhaps, charging was delayed for some reason, so the bed burnt for a longer time before it was made up. Whatever the reason, if the bed height is not controlled initially, then metal control is lost before the melt starts.

The overall effects of a low coke bed are given in Fig.3. If you look at these points, it seems to me that the cost of an extra bag of coke could be well worth it. Save 100kg. of cold metal and you save Rs.1000/-; save a 1 ton casting from slag or blowholes or shrinkage defects and you can pay for a lot of extra coke.

What I have tried to illustrate is that in a foundry every individual operation interlocks with another to influence the quality of the final product. If the cupola coke bed varies, so the metal analysis varies, and a running and feeding system which was satisfactory yesterday may not be satisfactory today. In other words, it is of no use to try to put one individual casting right by varying the running and feeding system, the type of sand, or any other localised action, unless the basics i.e. the metal, the sand, the cores etc. are all under control.

Some of these controls cost very little, eg. to measure the bed height requires only a long piece of chain; metal quality can be empirically tested by wedge tests or chill tests using cores or cast iron chill moulds; the standard text book on cupolas, the American Foundrymen's Society Cupola Handbook, costs about 25 dollars.

Obviously, sand testing and laboratory apparatus for analysis is more expensive. Equipment for testing green strength, moisture and permeability which are the minimum tests, would cost about 2000 dollars for the cheapest, but none the less effective equipment. For better methods of carbon and silicon control, than wedge testing, there are relatively new pieces of equipment for determination of carbon content based on cooling curves and a fast chart-type recorder, and for silicon based on the thermo-electric properties of the iron. These would cost about 4000 dollars but can be used on the foundry floor before the metal is cast.

Finally of course, there is the provision of a laboratory, and certainly for the larger foundries I would consider it a necessity. It is, however, distressing to have visited foundries where laboratories exist and to find that they are virtually unused, or used for recording history, such as the analysis of metal cast two days before. In foundries producing high quality castings overseas, the norm is carbon and silicon every hour, phosphorus, manganese and sulphur twice a day, and it is not uncommon to find this in association with wedge tests from every tap. All results are recorded both permanently and on a board next to the cupola for everyone to see. Trends in analysis can then be observed and action taken before the situation deteriorates too far. It is even more effective if the results are presented graphically. Figs. 4 and 5 illustrate two different methods of presentation. Fig.4 shows plots of the average value of every five consecutive samples and the range of those values. The upper curve shows the level of control i.e. 3.2% carbon and the lower the extent of the control i.e. ±0.1% or a range of 0.2%. The control target is therefore 3.2% ± 0.1% carbon. Fig. 5 shows a different method of plotting the same type of information, and in this case represents a target of 3.0% ± 0.1%.

This is the standard of quality control which a foundry must achieve if it intends to produce consistent castings, and only when consistency of this level is achieved can it produce to given specifications. This level cannot be achieved overnight, because until all the foundry's own scrap has been recycled two or three times, does that scrap itself begin to come within the control limits.

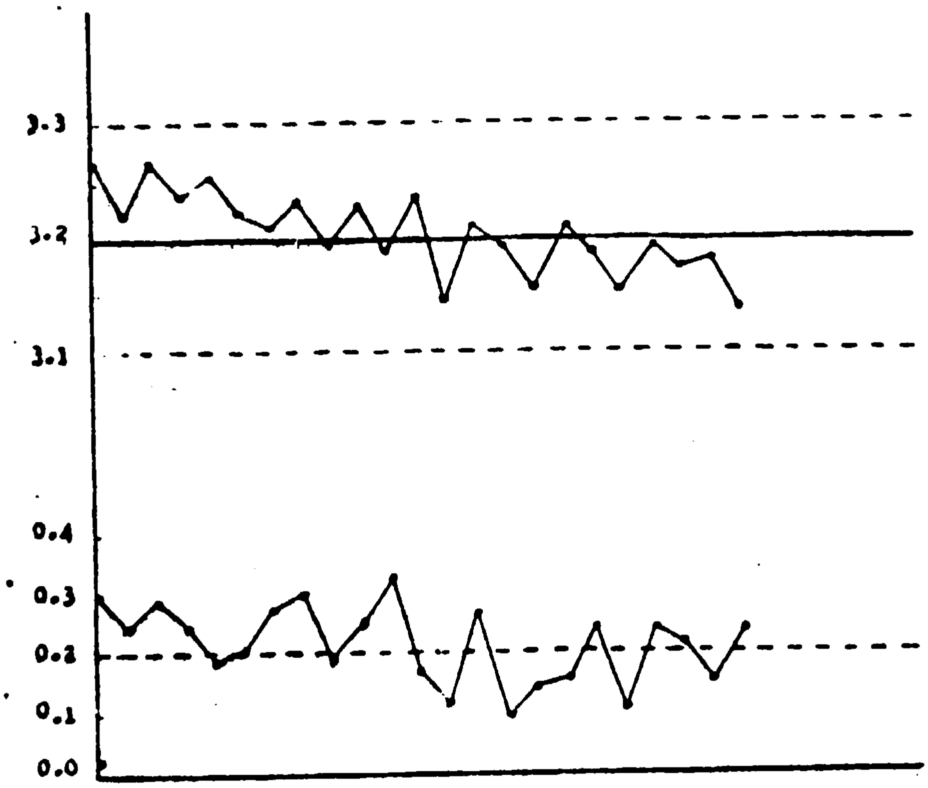


Fig.4. PRESENTATION OF ANALYSIS RESULTS. I.

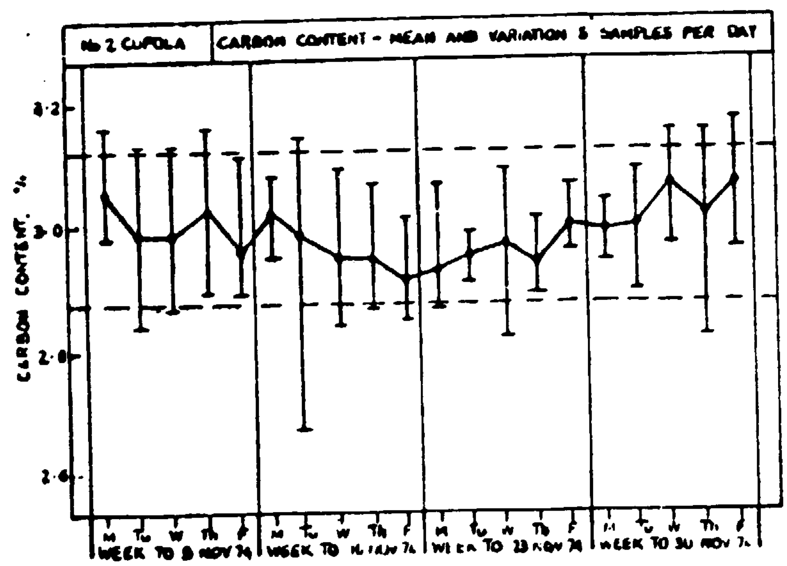


Fig.5. PRESENTATION OF ANALYSIS RESULTS. II.

Productivity

The second reason I gave for the failure of Sri Lankan foundries to meet its challenges is productivity, which I shall define simply as kg. of castings per employee per week. By employee, I mean all those connected with the production of the finished casting; patternmaker, moulder, furnaceman, fettler, office staff, even the tea maker to the foundry engineer, because they all have to be paid for out of the price of the casting. Based on the figures given to me for iron castings production and labour, the figure appears to vary from 37 kg. to 250 kg., and by standards in other countries these are very low indeed. I spent some time on a consultancy in a foundry in Egypt where the figure was approximately 1000 kg. per employee per week; (160 tonnes for 160 employees) they were making the same type of work and using exactly the same make and size melting equipment as the foundry in Sri Lanka returning the figure of 37 kg. but I was called in because they were unhappy about their scrap levels and productivity!

The last commercial organisation in which I worked as an employee (I was Chief Metallurgist and Quality Manager) was a mixed jobbing and mass production foundry. Casting size was from about 100 gms. to 20 tons, we used 250,000 cores per week, melted a minimum of 250 tons per day and despatched about 750 tons of iron castings per week. This was with a labour force of just under 300, so the productivity was about 2500 kg.

I know that you will say that such productivity is not possible in this country because there is not so much work available. Agreed - but this is the type of competition which you must meet if your markets are attacked by import competition.

And here I will acknowledge that there is a serious problem facing your industry, and that problem is the "dumping" of cheap, imported finished products containing a large proportion of cast components, at prices obviously below cost. Some of these products are poor, some are good quality, but both are causing considerable damage to the local foundry industry. This sort of unfair competition can only be dealt with at Government level, by "anti-dumping" tariffs coupled with an import inspection scheme.

But this sort of action will not bring down the price of Sri Lanka castings or improve their quality to make them competitive with "fair"competition.

So we must ask "Why is productivity so low?". I see three reasons i) obsolete methods, ii) high scrap, iii) overmanning, and, in general, the high scrap and overmanning are consequences of the obsolete methods.

During my three months here, I have said on so many occasions, "You are trying to make 1985 castings by 1935 methods." I never expected in this day and age to see castings still being moulded in the floor; about the only things usually made in this way now are moulding box parts and core irons. I have been given many reasons for the use of obsolete methods, of which, the commonest is cost. The usually quoted items are electricity, interest on loans for development equipment, and the cost of raw materials.

Electricity Costs.

I agree that the Contract Demand system does seem to be a considerable deterrent to the installation of electrically powered equipment. But even taking this into account, the cost of electricity here, by world standards, is low; it just seems high in comparison with what you have been accustomed to paying, and industry is receiving special treatment. The various rates applicable in Sri Lanka are given in Fig.5. So many times I have been told that industry needs to have a preferential tariff. It has! Think what your electricity bills might be if you were on the hotels tariff.

		Industry	General	Hotels
At 440/220 volts	Contract Rs/KVA	Rs.100.00	Rs.125.00	Rs. 150.00
	Unit cost	Rs. 1.45	Rs. 1.60	Rs. 1.60
At 11KV or 33KV.	Contract Rs/KVA	Rs. 90.00	Rs.115.00	Rs. 140.00
	Unit cost	Rs. 1.25	Rs. 1.50	Rs. 1.50

Fig. 5. Electricity Tariffs.

Interest Rates.

I have also been given the premise that because of high interest rates on loans, and depreciation allowances on machinery only over four years, that it is cheaper to stay with a labour intensive system of operation than to buy machinery to replace the labour. It is claimed that it is cheaper to take a labourer off the street, teach him to make one particular type of mould and let him make anything from 20 to 40 moulds per day, than to buy a pair of moulding machines, a sand mill, some good boxes and make a minimum of 40 moulds per hour. I do not claim to be familiar with wage rates in Sri Lanka but I believe that Rs.1500/- per month is about usual for an unskilled moulder. But when the scrap produced is taken into consideration, I do find such statements a little hard to believe, even if interest rates are 23 to 26%. I think the problem is, again, one of too much capacity and too little work.

In one day, a pair of moulding machines could make what now takes two weeks by hand. So what is to be done with the rest of the machine's operational time? If they stand idle then they are not paying for themselves. Also, if you only need to run the machines for one day per two weeks then what do you do with the labour on the other eleven working days?

I have worked in plants with jolt squeeze pin lift machines and jolt squeeze pattern draw machines producing 120 moulds per hour per pair of machines, using four men per machine. If one foundry here was to operate a pair of machines with some good boxes, an overhead sand system, mould conveyors (rollers will do) to take the moulds to the metal, a good melting unit and good patterns, it could take over the small castings industry.

There is one such foundry already in existence in Colombo. Unfortunately, it has been neglected and run down, it is grossly overstaffed for its production, but if it was put right, and it can be, then the rest of the small casting industry could be put out of business.

Raw Material Costs.

I know that you have very little foundry raw material in Sri Lanka - no pig iron,no coal or coke, no ferro-alloys, no non-ferrous alloys, so the majority of your raw materials must be imported. But the price for pig iron on the open market is the same for Sri Lanka as it is for Korea, China, Germany or the U.K.; the difference is the shipping cost. Now to offset this, the import duty on almost all foundry raw materials is only 5% (with one notable exception - linseed oil - which for a reason I have not been able to establish is 60%).The duty on raw castings is 60% of the c.i.f. Surely, despite the shipping costs on the raw material, an import duty on the competition of this level must make the balance in favour of Sri Lanka.

In fact, I have been through the Government Gazette of November,1984, which lists all the rates of duty payable and the foundry industry can only be regarded as " protected". Typical examples of rates of duty are given in Fig.6.

I think that the major part of the excessive cost of your raw materials is false economy. By this I mean saving money by reducing the cost of production, but increasing the overall cost by reducing quality and making more scrap.It is a situation where you must spend to save money, and one which the non-technical side of management must be made to see. I have seen large grey iron castings being machined at one fifth of the accepted speed because of the sand on the surface, and the internal hard spots caused so much cutting tool damage. It may have saved Rs.100/- on coal dust, but I wonder how many hours extra machining time it cost?

False Economies.

I shall now detail some of the false economies, together with the ways they increase the cost of production, rather than save money.

a) Coal dust in facing sand: Elsewhere this is usually at a level of 4% to 8% and it is used to produce a better surface finish; without it (or, what is even more expensive, too little, say 2%) the finish is rough and fettling and grinding costs are raised.

b) Bentonite (or other clay) in facing sand: In almost every foundry I have visited the level of clay has been reduced to the bare minimum; I have had foundry engineers talking about ordering 5 bags of bentonite when what they needed was 5 tons. When the properties of moisture, green compression strength and permeability are not measured, then the sand is literally in the hands of the moulder. He determines, by squeezing a handful, whether he thinks it will do. If the clay content is low, he obtains his mouldability by increasing the water content (see Fig.7). He might add some clay if there is any available, but usually just adds water. The result is blowholes.

When the sand dries, either by the mould being left standing open for three or four days, or by casting, the moisture bond disappears and the sand loses its strength. So, when the mould is cast, the erosion of the metal washes away the weak surfaces of the running system and the casting, pieces of the mould drop off, or break off, and enter the casting, and metal penetration into the mould surface is increased.

So with a low clay sand you cannot win! You either get blowholes, or rough castings with loose particles of sand in the casting, and probably both.

If you had a sand mill you could make the small quantity of clay work more for you and reduce the scrap. A heavy muller will give a better distribution of the clay around the sand grains, more strength and less need for water (see Fig.8). 5% Bentonite sand mulled for about 5 minutes will give roughly the same properties (but better permeability) as a 7% Bentonite sand mixed by hand and shovel.

c) Lack of pig iron and steel scrap in cupola charge: When cupola iron is melted, silicon and manganese are lost, phosphorus is virtually unchanged but sulphur increases. The increased sulphur increases the demand for manganese according to the ratio (%S x 1.7) + 0.3% = %Mn. Increased manganese leads to increased blowholes caused by manganese sulphide. This slag is particularly difficult to separate. If extra manganese is not added then the iron is exceedingly brittle and hard. So when iron is remelted and remelted, more and more sulphur accumulates, the silicon drops and the manganese drops; so more limestone is needed, more ferro-silicon and ferro-manganese are needed, materials like proprietary desulphurising blocks are added and the result is more and more scrap, caused by sl[illegible]

0%	Bentonite, phosphor copper, kaolin.
5%	Magnesite, limestone, coal, coke, fuel oils, refractory bricks, pig iron, ferro alloys, scrap iron and steel, copper master alloys, aluminium, lead, zinc, tin, ingot moulds, ladles, moulding boxes, moulding machines, mills, mixers, laboratory equipment and testers, machine tools.
45%	Tea machinery other than CTC and LTP. PVC tubes.
50%	PVC pipe fittings, AC motors, copper castings and forgings.
60%	Linseed oil, graphite, steel grinding balls, coffee mills, rice hullers and grinders, sewing machine stands, cast iron tubes and pipes, cookers, iron and steel castings in the raw state, centrifugal pumps under 7.5cm inlet or outlet (or Rs.1000/-), other pumps.
75%	Base metal bells, fan motors.
100%	Coconut scrapers, dolomite.

Fig.6. Rates of Duty Payable.

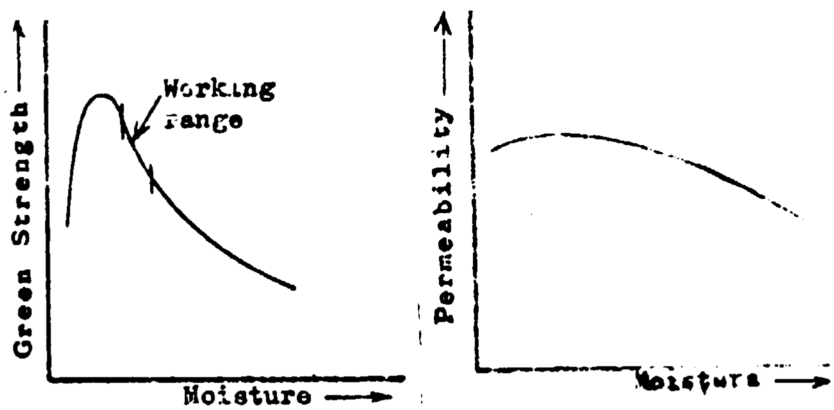


Fig.7.

PROPERTIES OF SAND/CLAY/WATER MIXTURES

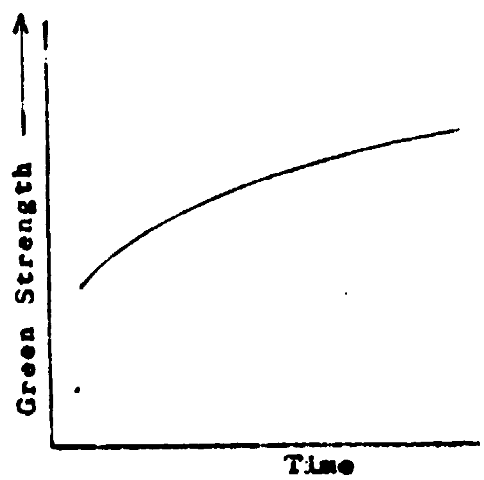


Fig.8.

EFFECT OF MILLING TIME ON PROPERTIES

The only way to reduce sulphur in the cupola is to dilute it with low sulphur charged material, that is, pig iron and/or steel scrap.

Taking into account the phosphorus, silicon and manganese contents of the pig iron, its addition will reduce the phosphorus, reduce or eliminate the addition of ferro-silicon, ferro-manganese and the so-called desulphurising blocks, reduce the limestone, and incidentally the "kish" graphite in the pig iron will reduce the tendency for chilled edges and reduce the shrinkage. The overall effect of these factors is that scrap will also come down.

d) Poor quality patterns and core boxes: If a pattern or core box is damaged by rammers then the damage marks appear on the mould or core and must be repaired on every mould or core. Is not a few hours patternmakers time better than all the mould or core patching time?

If a pattern is nailed together with vertical nailing, the nailed joints pull apart, sand gets into the joint so that when the pattern is drawn the mould is damaged. Then the moulder happily spends a long time repairing the mould because, after all, it is much less tiring to patch than to ram. All that time spent for the price of a few screws and some glue.

Does not a pattern draw much more easily if it is given a good coat of paint, if the cracks in the wood are filled, if the corners are nicely rounded and filleted? I have not quite decided if the moulders do not care about mis-using the patterns because of the poor state to begin with, or whether the pat ternmakers do not care because of the damage that the moulders will inflict on the patterns. Whatever the reason, you cannot make good castings economically with poor pattern equipment. Time spent on mould repair is lost production time.

I could go on with more and more similar observations eg. lack of use of tea-pot ladles, lack of charge weighing facilities, lack of patterns for runner systems so moulders must hand cut them, lack of use of sieves for facing sand, not blowing out moulds before closing, making copper alloy castings from unknown scrap, hand moulded pouring basins, moulding in the floor instead of boxes leading to blowholes,offsets, loose sand, swollen castings, bad dimensions, poor or no maintenance.

What I am saying is that a lot of the problems of quality and productivity are self-induced. Cost cutting has become a mania without regard to the consequences.

The time has come in a lot of cases when expenditure must increase to reduce costs. I will also allow that all of what I have said earlier does not apply to every foundry, but all of it does apply to some foundries, and some of it applies to all foundries.

As I said earlier, high levels of scrap and/or overmanning are products of the methods used. Foundries which have improved their methods by using metal patterns, pinned and bushed boxes, plated patterns with attached runners, and good maintenance, are producing better quality castings at lower scrap than those who have not.

d) Internal Controls

I have seen very little evidence of internal controls, either quality or cost. In some cases I have seen evidence of cost recording, or production recording, but as I have indicated previously, recording is not control. Records are only a tool and control involves using them to improve the existing situation; without adequate records and their use, very expensive waste can go completely un-noticed.

For instance, how many of you record the amount of cupola cold metal that is poured away at the beginning of, and during, a melt? I have seen hundreds of kgs. dumped on the floor, and at Rs.1000/- per 100 kg. (your figures, not mine) this is very expensive dumping. If this amount was recorded and costed every heat, then very quickly it would become obvious that drastic action needs to be taken. If a little bit more care and attention in the cupola bed preparation was given, and another bag of coke added, saving Rs.3000/- for 300 kgs. of cold metal, then surely it is worth it?

Likewise, I have seen little evidence of strict scrap control. I have seen foundries where the amount of metal or castings scrapped is recorded, but nowhere have I seen any systematic use of these records. In fact, on one occasion on being asked to advise on how to improve one particular casting where only one acceptable piece had been made out of six, an argument developed among the foundry staff and supervisors as to what was wrong with the five that were scrapped. If you do not know what is wrong, how can you put it right? I would state that every time you cast you need a scrap inspection sheet. I have included as Fig.9 the type of chart recommended by the British Cast Iron Research Association. A similar type (Fig.10) can be used for scrap from the machine shop. These should be pinned on a notice board one under another so that it immediately becomes obvious if certain types of scrap were common on one day, and if one type of scrap is persistently recurring every day. Because of the lack of good records, I have found it very difficult to obtain any accurate figures for scrap and yield i.e. good castings from the foundry as a percentage of the weight of charged material. I have been given figures, but they were so ridiculous that they were unbelievable. One person gave me a yield figure of 90%, but as he also told me he was using 20% coal dust in his facing sand, then obviously he either did not know, or did not want to tell me.

Daily Scrap Record Sheet

(Knock-out, Shotblast and Dressing Shop)

Date ------------------

Job number or description of casting	Moulding unit, Type of mould, etc.	Number of mould cavities poured	Type of Defect														Remarks	Total number scrapped	Total good castings
			Misrun	Dirt	Drawn or sunk	Dropped mould	Scab	Blown	Core fault	Swollen	Crushed	Cross-joint	Chilled or hardened	**Broken-in**	**Other** faults				
TOTALS FOR EACH DEFECT																			

Fig.9

Daily Scrap Record Sheet

(*Machine shop*)

Date ....

Job number or description of casting	Number of castings machined	Reason for rejection											Remarks	Total number scrapped	Total number passed
		Internal porosity	Cracked	Hard spots and edges	Pinholes	Entrapped dirt	Open grain	Blowholes	Dimension fault	Machining error	Other faults				
TOTALS FOR EACH DEFECT															

Fig.10

The results from the scrap record sheets should be summarised on a graph in the foundry, situated where everyone can see it, together with comments about action taken, as shown in Fig. 11.

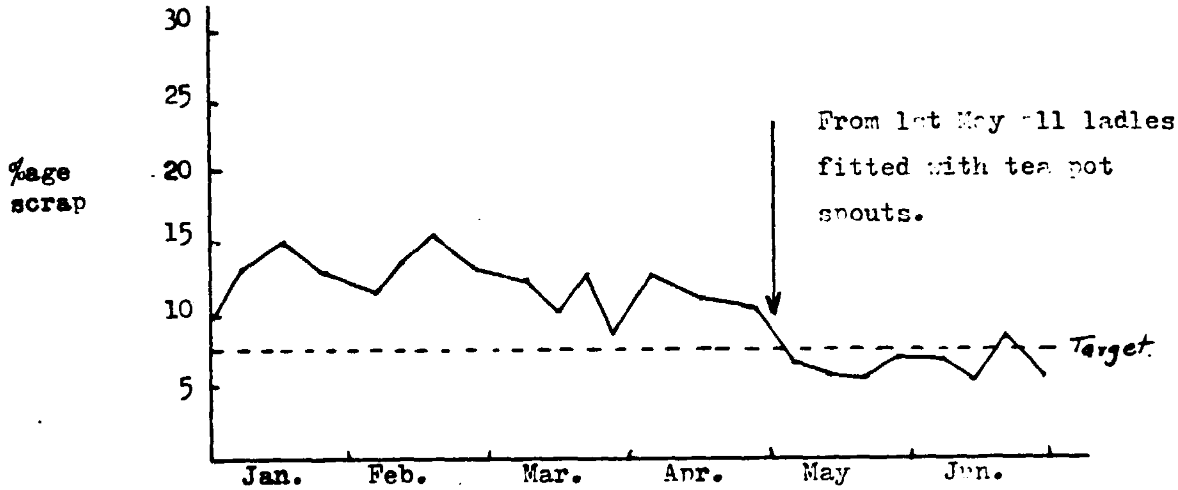


Fig. 11. DAILY SCRAP RECORD SHEET.

Unless a very tight control is exercised over such records it is not possible to find out where waste is occurring.

As another example of lack of internal control, suppose a heavy casting, about 1 tonne in weight, is moved from the foundry to the machine shop. This will involve hoisting it on to a truck of some kind in the foundry transporting it and unloading it in the machine shop. This takes time,labour and fuel. At the machine shop, it is found to be unfettled and has to go back to the foundry. This will involve the casting being moved three times instead of once, and this all costs money. I know it seems ridiculous that something like this could happen, but I have seen it for myself.

In the foundry it is so easy to lose costs to other departments, in the above case, costs were probably accepted as transportation. How much machine shop scrap is ever charged back to the foundry, extra fettling costs because of "flash" and rough castings, increased machine shop time because of chill and hard spots etc. etc. It is essential to know where the waste arises before you can stop it.

e) Training

But, of course, all of these processes will fail without adequate staff to operate them. If a foundry engineer is lacking in knowledge of the basic principles involved in foundrywork, such as how to operate a cupola, the effect of sand grain size, shape and distribution, principles of feeding etc., then he cannot be blamed for not knowing. Management can be blamed for employing him in that capacity, the training institutions he has attended can be blamed for not providing him with the necessary knowledge. The engineer can only be blamed if he makes no attempt to improve his knowledge. The engineer can also be blamed, of course, if he does have the knowledge, but is too idle to use it, or too status-conscious to leave his office. I have been pleased to see, however, a younger generation coming up who are keen to learn, are not afraid of getting dirty, being innovative, and hard work does not bother them. I ask management to recognise, in the case of the youngsters, that everyone makes mistakes, and if they are wrong occasionally, but only occasionally. then please allow them the credit for trying.

But this is not enough. Formal training is needed and needed badly, and it is needed at all levels. At the beginning of this paper I said that quality control needs people who are technically capable of giving the necessary control instructions. I hope that the universities and other technical training institutions can find their way to increase the foundry content of their courses both in quantity and depth. Also, if they could run regular foundry short courses, which cover in some detail certain aspects of foundry work such as running, gating and feeding, or cupola operation or the melting of non-ferrous alloys, it would be invaluable. After all, the foundry is the basis of the engineering industry, and if the foundry industry collapses, then there may not be any need for any engineering graduates at all. Of course, it needs the co-operation of industry to run these short courses, because if you do not release your personnel to attend, then the courses will not happen and, naturally, your staff will remain static in knowledge and performance.

The Future

There are not many options open as to what may happen to the industry: only one thing is certain, and that is that it cannot remain as it is. It must either advance or regress and, regrettable as it may be, I think that some closures are inevitable. As I have said repeatedly, there is far too much capacity for the business available. If one organisation can improve

its quality

and productivity, and there are many who could do so, then it would take work away from other foundries. As there is already insufficient work for the jobbing foundries then life will become more difficult. Some of the smaller foundries have apparently seen the writing on the wall and are already diversifying their foundry and finished products, and going into activities other than castings.

Also, unless action against the dumping of finished products is taken, and taken rapidly, then the industry is likely to suffer heavily. It was such "dumping" which closed down the whole of the cotton spinning and weaving industry in Europe; and then, when the local industry was dead, prices went up rapidly.

So far I have not mentioned your customers. You do not need me to tell you what they think of your products. Their biggest complaints are;

a) castings failing in service too quickly and too often
b) internal porosity
c) lack of dimensional accuracy
d) bad surface finish

and these are universally applied whatever the material of the casting.

I have been quoted one case where a local casting takes 3 to 4 days of grinding, drilling and filing to be fitted, against the time for fitting an imported piece of $4\frac{1}{2}$ hours. Additionally, the local casting only lasts half as long as the imported one so needs changing twice as often. In such a situation, 60% duty is no deterrent. Unless the local products are improved, you can expect no sympathy from your customers. After all, you are in business to make money and so are they. If you are making them uncompetitive or increasing their losses, they will look for altern tive sources of supply and there are plenty of foundries throughout the world ready, willing and able to provide that supply.

I will exclude from my remarks here the smaller foundries making castings for their own final products such as pumps, grinders, hullers etc. Their competition is from the finished product and as far as I can see, they are making a determined effort to meet the situation.

I am sorry that my forecast for the future is so full of doom and gloom and that I have not been particularly kind to you and your industry.

Please appreciate that I am a foundryman, and proud of it. I think there is no greater professional pleasure to be gained than to see a beautiful casting and to say "I helped to make that." So the comments I have made are not meant to be derogatory, but to give you my impressions with the hope that they may be of assistance.

Thank you for listening to me so patiently and thank you also for the tremendous co-operation I have received from everyone in the industry during my stay here. It has helped to make my task much easier and my visit so much pleasanter.

D.Worth.
UNIDO Foundry Adviser.
Colombo, Sri Lanka.
22nd August, 1985.

VISITS TO BROWN AND CO. LTD. (FOUNDRY AND ENGINEERING DIVISION)

DATES: Wednesday, 17th July, 1985 and Saturday, 27th July, 1985.

PRESENT:

Mr. M.P.S.Wijesinghe	Chief Engineer.
Mr. Prasad Silva	Works Manager
Mr. Illangaratne	Foundry Manager
Mr. D.Worth	UNIDO Foundry Adviser

During the visits Mr. Worth was able to watch moulding and core making practices, cupola operation and machine shop work. His attention was drawn particularly to the number of rejects of large rubber rollers, the presence of slag in large numbers of castings, shrinkage defects in copper alloy liners and the general presence of blowholes.

All of these defects can, in the writer's opinion, be put right by improved supervision and control, an application of basic foundry principles and, in some cases, a revision of the methods being used.

The general impression received was that castings were being made in ways easiest for the moulders rather than for Brown and Co. Ltd., for example, there is a lavish use of water on mould faces to achieve a good looking finish but it results in steam blowholes; there is a readiness to use poor quality patterns so that time is spent on mould patching rather than ramming, which is much harder work. It must not be inferred in any way that this is deliberate policy on the part of the moulders - naturally any workman will seek to find the easiest way to do a job - but they need to be made more aware of the consequences of their actions. In general, the foundry creates an impression of struggling to catch up with today, trying to make 1985 castings by 1925 methods.

One of the fundamentals of quality control is that control is not established unless and until it covers all applicable factors, hence no attempt to control the quality of any individual casting, such as rubber rollers, will be 100% successful until control of all operations is obtained. For example, the fluidity of cast iron, its shrinkage, hardness, casting temperature, penetration into mould surfaces, separation of slag, etc. etc. all depend on the analysis of the iron. So, unless the analysis is consistent then a running and feeding system which is satisfactory on one day will not be satisfactory on some subsequent day. Likewise, unless the moisture and clay content of the moulding sand are controlled by means other than squeezing a handful and guesswork, then naturally the appearance and quantity of blowholes will be spasmodic and irregular and surface finish will be poor.

Only when control is established can the level of control be fixed, e.g. only when the Carbon in the iron from the cupola is controlled to a range of ±0.1% can it be determined whether the Carbon should be 3.2 ± 0.1% or 3.5 ± 0.1%. At present, nobody has any knowledge of what the Carbon content of any cast is.

It should be stressed here that supervision is not control; supervision literally means "watching over" the work force, control means ensuring that they do the same thing every time and changes are only made under the direction of the controller. If a moulder is allowed to cut a running system to his own ideas of size and shape or position, then the running system will be different every time and must be regarded as out of control and consistent castings cannot be expected.

Some of the factors which need attention are attached on separate sheets, together with notes on cupola operation which cover both practice and the relevant theoretical principles.

CUPOLA EQUIPMENT

Tuyere covers do not fit. Covers should be fitted with blue glass so that melting and slag conditions in the furnace can be observed. Cover bolts are damaged so that covers cannot be adequately tightened. There is only one set of covers which is moved from cupola to cupola.

Massive air leaks at tuyeres and windbelt giving uneven air distribution up cupola stack. Air wasted is power wasted by increasing loading on fan. One fan bearing sounds rough; the other is new; it is preferable to change bearings in pairs.

CUPOLA CHARGE

Scrap: sections are too large for cupola diameter, and will cause "bridging". (See page 32 of notes - Size of Charge Material). Sections are universally too thick. Better results will be obtained if some lighter scrap mixed in. Good clean scrap used. Too many charges placed too close together on charging platform making separation into individual charges difficult and giving uneven charge weights. (See page 31 - Effect of Charge weight.)

Coral is used for fluxing instead of limestone. Quality is very soft and of very small size. Pieces are blown up out of stack instead of forming slag. Would be more economical to use a greater weight of a better quality and so reduce the excessive quantity of BRIX blocks being used. BRIX will desulphurise the metal slightly but its basic action is on slag fluidity and even the makers only recommend 1kg. per 1000kg. of metal charged. Reaction can be reversed ie.fluidity decreased if too much BRIX is used.

Coke is of good condition but bed preparation is bad. All wood ash should be raked out at the breast plate and blown out through tap-hole and the bed thoroughly consolidated before the breast door is closed. The cupola bed should then be made up to a specific height (usually about 1 metre) above the tuyeres and the height measured.(See page 21 - Coke Bed Height.)
It is not adequate to charge in a fixed quantity, say three sacks, as the actual amount required is never the same from day to day: it depends on how long the bed has been lit, the rate of combustion of the coke, and this can even be affected by the strength and direction of the wind (!) and the way in which the coke pieces of different sizes will pack together. (See page 23 - Determination of Cupola bed height.Although these notes seem formidable, the procedure is simple and most cupola operators can tell visually when metal temperature is increasing or decreasing.) The subsequent operating conditions to maintain the bed height can then be determined. (See pages 24 and 25.)

Limestone <u>must</u> be added to the coke bed interspersed with the coke to flux the ash of the coke burnt in the bed.

The bed can be measured with either a "dipstick" steel rod or, more easily, with a chain marked in some way so that when the end of the chain, when lowered through the changing door, just touches the charge, the mark is at the charging door sill.

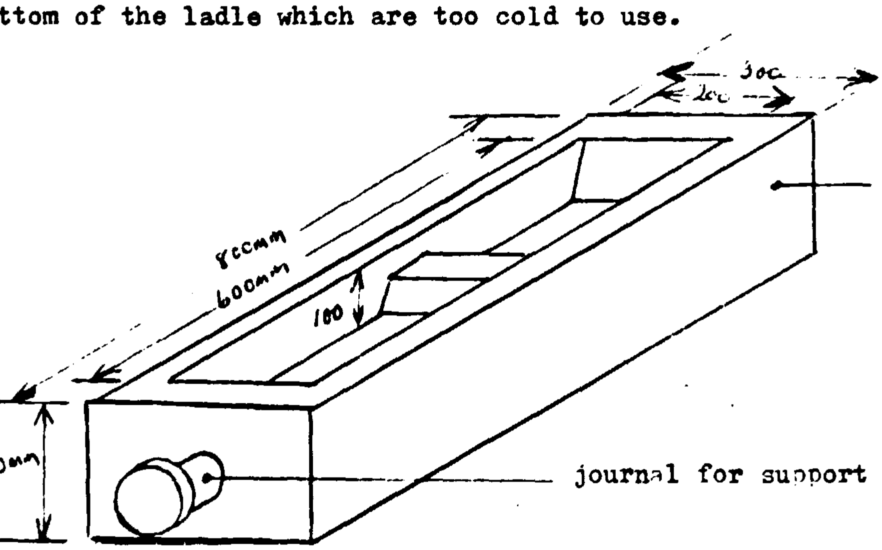
CUPOLA OPERATION

The clay bots in the taphole would be easier to remove if dipped in coal dust or graphite before use. A bigger cupola operator's platform is needed so that operators can clean the tuyeres without standing on steel drums. The cupola should be kept full up to the charging door at all times with constant poking to prevent bridging. The slag condition indicates over-blowing for the coke bed height but it is difficult to assess with the shortage of limestone in the charge. A slightly larger slag hole would make slag tapping easier and give a better opportunity for watching its condition.

GENERAL

Immediate attention must be given to bed preparation. At an estimated cost of say Rs.10,000/- per ton of metal at the cupola spout (an average of figures quoted around Sri Lankan foundries and including labour, fettling etc.) then every 100kg. poured away cold at the beginning of the heat is Rs.1000/-. It is estimated that on Saturday, 27th July, 400 kg. was poured away. That Rs.4000/- will easily pay for a lot of cupola operating improvements - and presumably this happens every melt.

It would be an improvement if some pig moulds were cast in the foundry and the cold metal run into these instead of on to the sand floor. When this metal is remelted all this intermixed sand needs to be fluxed - a further increase in cost. The moulds would also be useful for small quantities in the bottom of the ladle which are too cold to use.



Melting of 100% scrap iron charges is not to be recommended. Each time the iron goes through the cupola the Sulphur content increases from the Sulphur in the coke even if using BRIX blocks. The only method of reducing the Sulphur content is by dilution with low S charge material ie. pig iron and/or steel scrap which are both about .03%S. If bought iron scrap has been cast in Sri Lanka then it is probably higher in Sulphur than scrapped imported castings. The Sulphur in the iron can be combined with Manganese to reduce its deleterious effects but the increase in managanese sulphide poses other problems with slagging and blowholes. Minimum Manganese should be (%S x 1.7) + 0.3%. The question of using pig iron raises financial considerations on which the author cannot comment as he is unaware of existing costs.

ASSESSMENT OF METAL QUALITY

This can be done quite easily in an empirical way by wedge testing. Chill testing is not recommended as this is suitable only for iron being cast into thin sections. The wedge test does not replace analysis but it will give an indication of the level of control and the suitability of the iron for the casting. It must be borne in mind that the wedge must be big enough to be representative of the sections being cast and show a "chill value". A completely grey or white wedge gives no information except "too soft" or "too hard". Details are given in the Foseco Handbook in the Works Manager's office and a summary sheet is attached to this report.

RECOMMENDATIONS. CUPOLA.

1. Control the bed preparation
2. Close all tuyere and windbelt leaks.
3. Put blue glass into tuyere covers.
4. Use better limestone and eliminate BRIX.
5. Control metal charge size.
6. Improve charge separation.
7. Enlarge operations platform.
8. Enlarge slag hole.
9. Make pig moulds.
10. Institute wedge testing.

MOULDING, COREMAKING AND PATTERNS.

In general moulding standards appear to be poor but this may be a misleading impression caused by the condition of the patterns and the methods adopted. Moulding in the floor is almost extinct in developed countries except for the roughest of work and items like core irons. Boxes are used wherever possible to ensure accurate location and casting dimensions. If floor moulding must be used then top box location by bits of steel bar against the box lugs is bad. Pins through the holes into the floor must be used. Box "slog" of up to 6mm was observed. Pins with "constant direction rotation" can reduce this to less than 1mm. Better still, use boxes for both top and bottom. Boxes can be made by the universal section method, either by casting or fabrication, and bolted together for different sizes. The majority of work being made in the floor can be made on the jolt rollover machine which is standing idle, giving a better finish, greater accuracy, less labour and greater output.

Moulds are not blown out before closing so consequently any dirt, paper, nails, sand and other rubbish which has fallen into the bottom, stays there and appears in the casting.

There was no evidence of any facing sand preparation or any evidence of coal dust to improve surface finish. For the heavy sections being cast, at least 6% coal dust in the facing sand is usually considered the minimum. It is generally necessary to light the coal gas being driven out at the vents but it does not seem necessary at Brown's! The moulding sand is weak and bonded only by water. At no time was there any evidence of screening of the sand for mould facing. Excessive moisture is being used to sleek the moulds. Where blacking is being used, it is used too lavishly (excess moisture again!) and is not adequately finished. Large, easily removable lumps are conspicuous on the mould surfaces. Only hand polishing is used and this cannot reach the bottom of cooling fins on certain castings.

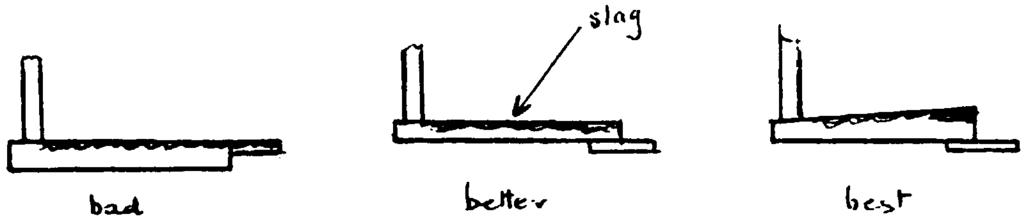
Patterns are in very bad condition. Almost every pattern inspected had undercuts and most of these derive from the original pattern making; paint on the patterns was badly worn or non-existent; patterns had cracks into which sand could penetrate; all of these lead to broken mould faces on drawing the pattern and excessive patching time repairing the mould. Excessive rapping is used to loosen patterns because of their poor condition so dimensional accuracy is lost.

Core placing is poor - in one mould two adjoining cores had a gap between them of about 5-6mm instead of being face to face.

Core boxes are also in a very bad condition with core faces damaged by impact from coremakers rammers. They are coated with old sticky sand so that cores will not strip. Most joints are undercut. Paintwork is in a bad condition. Probably the worst feature observed was Aluminium core box inserts or loose pieces which still had a rough sand cast finish - the only fettling they had had was a rub over with a piece of emery cloth.

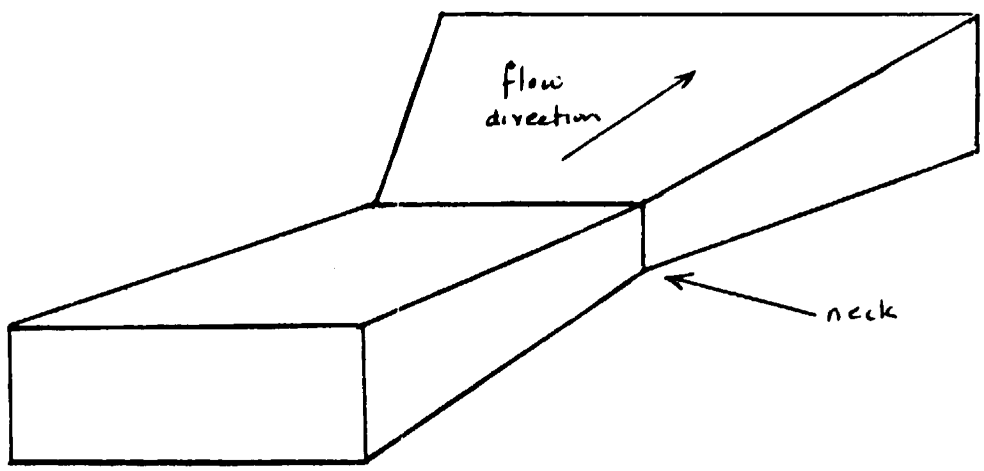
One must query whether the moulders do not care how they mis-use the patterns because of their condition to start with, or whether the pattern makers are careless because they know the rough treatment the patterns will get from the moulders.

In some cases moulders were cutting running systems by eye with a trowel, with runner bars in the bottom and ingates off the top of the runner. Runner bars must be in the top box and the ingates in the bottom.



Runners and ingates should be moulded round patterns and using facing sand. All metal entering a mould goes through the running system so the sand used for it must be the best possible and not the backing sand as happens when a moulder cuts away the mould face. The poor backing sand erodes very easily because of its poor strength under the metal flow, even if coated with blacking.

Fundamental gating principles are not observed,ie. the cross sectional area of the downgate must be greater (by about 10%) than the area of the runner bar which, likewise, must be greater again by about 10% than the total cross sectional area of the ingates at the narrowest section. This ensures that the system will fill, produce laminar floor to reduce erosion, and act as a slag trap. To prevent a jet of iron under pressure spurting into the mould,ingates can be tapered outwards (see sketch). The neck will assist in knocking off the ingate, reduce the chances of "breaking in" and reduce fettling costs.



RECOMMENDATIONS

1. Stop moulding in the floor.
2. Provide a good milled facing sand.
3. Use about 6% coal dust on facings.
4. Stop cutting runners.
5. Start an immediate pattern and core box overhaul.
6. Follow basic gating principles.
7. Blow out every mould before closing.
8. Provide a good mixer for core sand.
9. Increase the clay content considerably of all the moulding sands to reduce the amount of moisture being used to bond the sand.
10. Sieve the facing sand on to the patterns.

METAL POURING

A well made tea pot spout ladle was seen in a corner of the foundry but a straight ladle was being used for casting. All the ladles should be of tea pot form.

Ladles should be well pre-heated before use and not warmed up with metal at Rs.1000/- per 100kg. Even an oil fired burner would be cheaper than this!

GENERAL

Strong, determined action is needed to put this foundry on a profitable course, but it can be done. None of the suggestions made need cost a lot of money, apart from a sand mill and a sand mixer. Extra time on pattern making would probably pay for itself in productivity by reducing mould repair time. Coal dust should reduce fettling costs etc. A laboratory for metal analysis and sand control would probably pay big dividends in the future, provided it was used as a control tool and not just to record what has happened ie. completing the analysis two days after the metal is cast.

Daily Scrap Record Sheet

Date ------------

Job No. of casting	No. of moulds cast	Type of Defect: Misrun	Dirt	Draw	Dropped	Scab	Blown	Core fault	Swollen	Crushed	Cross-joint	Cracked	Broken-in			Remarks	Number Scrapped	Number good
TOTALS FOR EACH DEFECT																		

C.E.B. TARIFF — EFFECTIVE FROM 1985.03.01

	General Purpose	*Industrial*	*Hotel*	*Industrial (Time of Day)*	*Hotels (Time of Day)*
Supply at 400/230V. Contract Demand less than 50kVA					
Unit Charge (Rs./Unit)	1.70 +	1.55 +	1.70 +	—	—
Fixed Charge (upto 10 KVA. (Rs.)	20.00 OR	20.00 OR	20.00 OR	—	—
Fixed Charge (above 10 KVA. (Rs.)	100.00	100.00	100.00	—	—
Supply at 400/230V Contract Demand 50 KVA and above					
Demand Charge (Rs./kVA.)	125.00 +	100.00 +	150.00 +	50.00 +	50.00 +
Unit Charge (Rs./Unit)	1.60 +	1.45 +	1.60 +	1.35 (Off Peak) + 1.90 (Peak 6 pm. to 9 pm.) +	1.35 (Off Peak) + 1.90 (Peak 6 pm. to 9 pm.) +
Fixed Charge (Rs.)	200.00	200.00	200.00	200.00	200.00
H.T. Supply at 11kV, 33 kV and 132 kV					
Demand Charge (Rs./kVA.)	115.00 +	90.00 +	140.00 +	45.00 +	45.00 +
Unit Charge (Rs./Unit)	1.50 +	1.25 +	1.50 +	1.20 (Off Peak) + 1.75 (Peak 6 pm. to 9 pm.) +	1.20 (Off Peak) + 1.75 (Peak 6 pm. to 9 pm.) +
Fixed Charge (Rs.)	200.00	200.00	200.00	200.00	200.00

NOTE : The Fuel Adjustment Charge is applicable to all General Purpose, Industrial and Hotel consumers.

For a 12 months period from 1985-03-01, the Fuel Adjustment Charge is zero percent.

ANNEX VIII.

Project Secretariat:
SRI LANKA STANDARDS INSTITUTION
618 2/1 GALLE ROAD
COLOMBO 3
SRI LANKA.

TEL: 580462

PROJECT ON DEVELOPMENT OF STANDARDIZATION & QUALITY CONTROL

UNITED NATIONS

එක්සත් ජාතීන්

1st August, 1985.

Professor C.L.K. Tennakoon,
Dean of Engineering,
University of Moratuwa,
COLOMBO.

Dear Professor Tennakoon,

Thank you very much for giving up so much of your valuable time on Tuesday 30th July to discuss foundry problems with me.

We discussed the possibility of your running short courses on foundry Technology of may be one or two weeks duration and you asked me for suggestions of topics which may be usefully included. I have attached on separate sheets some of my ideas for your consideration. I have also attached a set of notes which I have drawn up cupola operation and some sand topics and these may give you some idea of the levels of coverage which I think is necessary to help the foundry industry.

I have also attached a list of organisations which may be interested in sending some of their staff members as course participants.

I do hope you can do something on these lines and I am sure that it will be invaluable to the foundry industry. Also when you review your full - time courses I'm sure that the Sri Lanka foundry industry would be grateful for an increase in both depth and content of the foundry coverage of your courses. After all if the foundry industry in this country were to collapse then the engineering industry in general would also suffer terribly and possibly jobs for engineering graduates would become even scarcer!

I look forward to the possibility of seeing you again before I leave Sri Lanka in September.

Yours sincerely,

Derek Worth.
UNIDO Foundry Adviser.

c.c. Dr. N.R. de Silva.

-/Wr.

A) MOULDING SAND:

1) Properties of Sands for foundry use: Purity; grain size, shape and distribution; natural and synthetic sands; clay contents; alkali content.
2) Effect of these properties on characteristics of moulding and core sands: green strength, dry strength, permeability, shatter strength, moisture demand.
3) Use of coal dust, graphite, blackings etc. for improvement of casting surface finish.
4) Sands mixtures and properties for grey iron, steel, copper and Aluminium alloy castings.
5) Causes and prevention of defects due to moulding sands. Sand inclusions, poor finish, blow holes, scabbing etc.

B) MELTING OF CUPOLA CAST IRON -

1) Basics of cupola construction.
2) Cupola operation: critical importance of coke bed height; critical sizes of charge pieces, metal, coke and limestone; inter-relationship between air input, coke charge and metal charge weight and the use of these for operational control. Cupola net diagrams.
3) Melting losses and gains and their control; Carbon, Sulphur, Silicon, Manganese and Phosphorus.
4) Control testing: wedge tests, chill tests, relation to casting section thickness, fluidity spirals.
5) Causes and prevention of defects due to poor quality metal, slag, blowholes, chill, shrinkage, misruns etc.

C) PROPERTIES OF GREY CAST IRON

1) Effect of Carbon and Silicon contents on properties, tensile strength, hardness, fluidity, shrinkage.
2) Effect of cooling rate and section thickness on properties.
3) Effect of impurities such as Chromium on chilling, Aluminium on pin hole formation, Sulphur on brittleness, Phosphorus on pressure tightness.

D) RUNNING AND FEEDING OF CASTINGS

1) Liquid shrinkage; Liquid to Solid shrinkage, its variation from alloy to alloy, values of volume shrinkage for common alloys, Need for feeding to replace shrinkage.
2) Solid shrinkage, pattern makers contraction, different values for common alloys.

3) Calculation of size of feeder heads needed to replace shrinkage. Placing of feeder heads to control directional solidification. Placing of ingates to assist control of directional solidification.

4) Interrelation ship of sizes of different parts of running system to promote streamline flow to reduce erosion. Use of running system as a slag trap. Reasons for different systems for irons, steels, copper alloys, light alloys.

5) Design and function of pouring basins. Use of core sand and facing sand for basins. Use of top quality sand for running systems. Necessity for use of patterns for running systems to control Uniformity.

6) Causes and prevention of defects due to bad running systems, bad placing of feeders etc.

E) MELTING OF NON-FERROUS ALLOYS - types of furnace; crucible, reverberatory, rotary. Necessity for oxidation/reduction techniques. Degassing. Special techniques for some non-ferrous alloys.

Defects specific to certain non-ferrous alloys.

F) i). MELTING OF STEEL - arc furnaces. Single and double slag processes. Effects on moulds of higher casting temperatures. Defects specific to steel castings.

ii). Structure of steel castings. Feeding and shrinkage problems. Need for annealing of castings.

COMPANIES POSSIBLY INTERESTED IN FOUNDRY TECHNOLOGY SHORT COURSES.

1) Steel Corporation.
2) State Hardware Corporation.
3) Colombo Commercial Co. Ltd.
4) Cement Corporation.
5) Samuel Sons & Co. Ltd.
6) Brown and Company Ltd.
7) Walkers.
8) Jinadasa Industries Matara.
9) Jinasena Industries. Ja - Ela.
10) Industrial Development Board. Foundry, Ratmalana.
11) Sri Lanka Standards Institution.
12) USHA Sewing machines. Ratmalana.
13) Sri Lanka Dockyard Foundry.
14) Government Railway Foundry.
15) Foreman Training Institute. Narahenpita.

There are various other foundries out of Colombo, at Galle and Kandy which I don't have details of.

SHORT FOUNDRY TRAINING COURSE FOR STAFF OF SRI LANKA STANDARDS INSTITUTE.

COURSE DURATION: 4 Weeks.

DAY AND TIME: Mondays and Tuesdays 2 p.m. to 4 p.m.

COMMENCING: 22nd July 1985.

I). Basic parts of a mould - terminology e.g. box, core, core print, downgate, feeder, ingate, runner bar, pouring basin, joint line, facing sand, backing sand etc. Machine moulding, Defects due to moulds, cores and moulding method.

2). Types of moulds and cores; green sand, dry sand, loam sand, core sand, CO2 sand, air setting sands, Properties of clays, Synthetic and natural sands.

3). Properties of sands that need to be tested and reasons for testing. Grain size, shape and distribution, Alkali content, clay content, green strength, dry strength, permeability, moisture content, shatter strength.

Use of coal dust, graphite, blacking and other mould coatings for surface finish improvement.
Defects due to bad sand, moulds and cores.

4). Melting of Cast Iron, Cupola melting, charge make-up, weighing, bed height. Changes in melting, Carbon and Sulphur pick-up, Silicon and Manganese losses. Function of slag. Charge make-up and calculation.

Defects due to metal quality, analysis, temperature and cleanliness.

5). Melting of Cast Iron - Induction furnaces - basic principle of operation. Linings for furnaces. Advantages and disadvantages over cupola melting.

6). Structure of Grey Cast Iron - Effect of cooling rate on structure and properties - relation of cooling rate to section thickness of castings. Simple foundry tests, wedge tests, chills, fluidity spirals.

7). Melting of non-ferrous alloys - types of furnace; crucible, reverberatory, rotary, Necessity for oxidation/reduction techniques. Degassing. Special techniques for some non-ferrous alloys.

Defects specific to certain non-ferrous alloys.

8). Melting of steel - are and induction furnaces. Single and double slag processes. Effects on moulds of higher casting temperatures. Defects specific to steel castings.

9). Structure of steel castings. Feeding and shrinkage problems. Need for annealing of castings.

ANNEX X.

SUGGESTED LIST OF BOOKS FOR ADDITION TO S.L.S.I. LIBRARY.

A. Published in U.S.A.

(i)	Analysis of Casting Defects.	American Foundrymans Society, Des Plains, Illinois.
(ii)	Foundry Sand Handbook.	American Foundrymans Society, Des Plains, Illinois.
(iii)	Cupola Handbook.	American Foundrymans Society, Des Plains, Illinois.
(iv)	Principles of Metal Casting.	Heine, Loper and Rosenthal.
(v)	Foundry Engineering.	Taylor, Flemings and Wulff.
(vi)	Engineered Castings.	Cook, G.J.
(vii)	Principles of Metallographic Laboratory Practice.	Kehl.
(viii)	Steel Castings Handbook.	Steel Founders Society of America.

B. Published in U.K.

(i)	Clay Bonded Foundry Sands.	Parkes. Applied Science Publications Ltd., Barking, Essex.
(ii)	Foundry Metallography.	Bailey, A.R. Metallurgical Services Laboratories, London.
(iii)	Foundry Metallurgy.	Bailey, A.R.
(iv)	Foseco Foundrymans Handbook.	Pergamon Press, Oxford.
(v)	Foundry Practice.	Salmon and Simons. Pitman.
(vi)	Typical Micro-structures of Cast Metals.	Institute of British Foundrymen.
(vii)	Atlas of Casting Defects.	Institute of British Foundrymen.
(viii)	Practical Microscopical Metallography.	Greaves and Wrighton.
(ix)	Engineering Data on Cast Irons.	British Cast Iron Research Assocn.
(x)	Foundry Broadsheets - Full set.	British Cast Iron Research Assocn.
(xi)	Guide to Safe Working Practices in Foundries.	Council of Ironfoundry Association.

1. SCOPE This standard covers the requirements for grey iron castings where the carbon component present as graphite is mainly in the lamellar form.

2. GRADES There shall be seven grades of grey iron castings namely Grades 10,15, 20, 25, 30, 35 and 40.

The grade numbers are based on minimum tensile strength in kgf/mm^2 of 30 mm diameter cast test bar.

3. MATERIAL The castings shall be cast from metal melted or refined in any suitable metallurgical plant.

4. CHEMICAL COMPOSITION (4.1) The composition of the iron as cast shall be left to the discretion of the manufacturer, but minimum and/or maximum limits for Phosphorus and/or Sulphur may be specified by agreement between the purchaser and the manufacturer.

(4.2) In the case of special castings, the detailed chemical composition shall be as agreed to between the purchaser and the manufacturer.

5. WORKMANSHIP AND FINISH (5.1) The shape, dimensions and mass of iron castings shall conform to drawings or patterns, and the permissible tolerance shall be determined between the purchaser and manufacturer.

5.2) The castings shall be sound, clean and free from distortion and injurious defects. They shall be well dressed or fettled and shall be free from chill and other indications of free carbides except as specified by the purchaser. They shall be machinable by the normal methods for the grade of iron specified.

5.3) No welding or repairs shall be carried out without the prior permission of the purchaser. Welding referred to here includes burning or fusion welding in accordance with the common foundry practice. The method of weld repair and subsequent stress relieving shall be as agreed to between the purchaser and the manufacturer.

6. PROVISION OF TEST BARS (6.1) The test bars shall be cast separately. They shall be poured at the same time and from the same ladle of metal as the castings they represent. A sufficient number of test bars to meet the requirements under Clauses 9 and 11 shall be provided.

6.2) When castings are moulded in loam or dry sand, the test bars representing the castings shall be cast in dry sand. When castings are moulded in green sand, the test bars representing castings shall be cast in green sand or in dry sand. If the castings are produced in any other mould material, the material to be used for the mould for the test bars shall be as agreed to between the purchaser and the manufacturer.

EXTRACT FROM SRI LANKA

STANDARD CE 178 : 1972

GREY IRON CASTINGS

TABLE 1 - Mechanical test requirements of grey iron castings

Grade	Sectional thickness of castings	Diameter of test bar as cast	Tensile strength min	Transverse test			*Brinell Hardness
				Breaking load min	Corresponding transverse rupture stress	Deflection min	
	mm	mm	kgf/mm^2	kgf	kgf/mm^2	mm	HB
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
10	4 to 50	30	10	700	-	3.5	201
15	4 to 8	13	19	180	41.7	2.0	
	Over 8 upto 15	20	17	400	38.2	2.5	149 to 197
	Over 15 upto 30	30	15	800	34.0	4.0	
	Over 30 upto 50	45	13	1 700	28.5	6.0	
20	4 to 8	13	24	200	46.4	2.0	
	Over 8 upto 15	20	22	450	43.0	3.0	179 to 22[illegible]
	Over 15 upto 30	30	20	900	38.2	4.5	
	Over 30 upto 50	45	17	2 000	33.5	6.5	
25	4 to 8	13	28	220	51.0	2.0	
	Over 8 upto 15	20	26	500	47.8	3.0	197 to 24[illegible]
	Over 15 upto 30	30	25	1 000	42.4	5.0	
	Over 30 upto 50	45	22	2 300	38.6	7.0	
30	8 to 15	20	31	550	52.5	3.5	
	Over 15 upto 30	30	30	1 100	46.7	5.5	207 to 241
	Over 30 upto 50	45	27	2 600	43.6	7.5	
35	15 to 30	30	35	1 350	57.3	5.5	
	Over 30 upto 50	45	32	3 300	55.3	7.5	207 to 241
40	15 to 30	30	40	1 500	63.7	5.5	
	Over 30 upto 50	45	37	3 700	62.7	7.5	241 to 320

*Brinell hardness test is optional for all grades of castings.

For Grades 10 and 15 tensile, transverse and hardness tests are optional.

A.3 DIMENSIONS OF CAST TEST BAR

A.3.1 The test bar shall be cast as a cylindrical bar. The diameter of the test bar shall be governed by the thickness of the castings as given in Table 3.

TABLE 3 - Dimensions of cast test bars

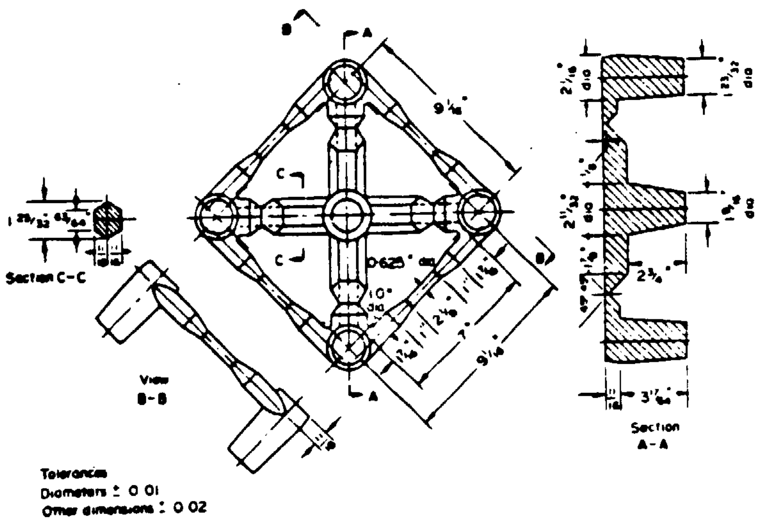
Thickness of castings mm	Diameter of test bar mm
Over 4 upto 8	13
Over 8 upto 15	20
Over 15 upto 30	30
Over 30	45

Casting tolerance on diameter of test bar shall be $^{+2}_{-0}$ mm.

Number of tests

Mass of individual castings	Test requirements
Upto 12.5 kg	One test for each 500 kg of castings or part thereof.
Over 12.5 kg and upto 50 kg	One test for every 1 tonne of castings or part thereof.
Over 50 kg and upto 500 kg	One test for every 2 tonnes of castings or part thereof.
Over 500 kg and upto 1 tonne	One test for every 3 tonnes of castings or part thereof.
Over 1 tonne	One test for every 4 tonnes of castings or part thereof, or one test for every casting weighing 4 tonnes or more.

STANDARD TEST BAR FOR ALUMINIUM ALLOYS SAND CAST

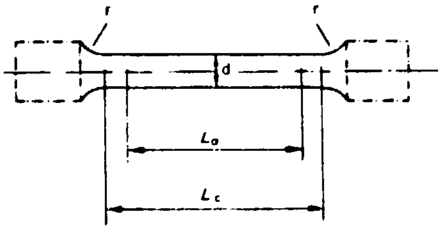


Tensile test sample

9 1/16 in.	230.18 mm	2 1/16 in.	52.38 mm	1 in.	25.40 mm
7 in.	177.80 mm	1 7/8 in.	47.62 mm	63/64 in.	25.00 mm
3 11/32 in.	84.95 mm	1 25/32 in.	45.25 mm	11/16 in.	17.46 mm
2 3/4 in.	69.85 mm	1 23/32 in.	43.65 mm	0.625 in.	15.88 mm
2 11/32 in.	59.55 mm	1 9/16 in.	39.69 mm	1/8 in.	3.17 mm
2 1/8 in.	53.97 mm	1 7/16 in.	36.51 mm		

Tensile Test Piece

The ends to be shaped to fit the axial loading shackles of the testing machine.



Cross-sectional area A_o	Diameter D	Gauge length L_o	Minimum parallel length P	Minimum radius at shoulder R
mm^2	mm	mm	mm	mm
150	13.82	69	76	26

ANNEX XIII.

LIST OF ORGANISATIONS VISITED.

1) Colombo Commercial Company Limited, Colombo. (Twice)
2) Jinasena Industries Limited, Ja Ela.
3) Walker, Sons and Company, Limited, Mutwal, Colombo.
4) Sri Lanka Steel Corporation.
5) Sri Lanka State Hardware Corporation.
6) Usha Industries Limited, Ratmalana.
7) Jayanta Metal Industries, Malabe.
8) Brown and Company, Limited, Colombo. (Three times.)
9) Dharmadasa Industries, Limited, Malabe.
10) Samuel Sons and Company Limited, Colombo. (Twice)
11) Industrial Development Board, Ratmalana. (Twice)
12) Piyasena Jinadasa, Matara.
13) British Council, re Library membership.
14) Sri Lanka Electricity Board, re tariffs.
15) University of Moratuwa, re training courses. (Twice)
16) British High Commission, re import tariffs.
17) Foremens Training Institute, Marahennita.

ANNEX XIV.

LIST OF INDIVIDUALS WITH WHOM ADDITIONAL DISCUSSIONS WERE HELD.

1)	General Manager,	Sri Lanka Steel Corporation.
2)	Managing Director,	Sri Lanka State Hardware Corporation.
3)	Chief Engineer,	Brown and Company.
4)	Mr. Nihal Jinasena,	Owner, Jinasena Industries.
5)	Mr. D. D. Dayaratne,	Owner, Jayanta Metals.
6)	Mr. Dilharr Jinadasa,	Owner, Piyasena Jinadasa.
7)	Mr. T.B.R. de Silva,	Tea Estate Owner.
8)	Mr. D.J.M. Blackler,	Executive, John Keell's, Tea Brokers.
9)	Mr. A. Dharmadasa,	Owner, Dharmadasa Industries.
10)	General Manager,	Samuel, Sons and Company Limited.
11)	Managing Director,	Brown's Group of Companies.
12)	General Manager,	Sri Lanka Cement Corporation.

XII. ADDENDUM - FINAL VISIT TO BROWN AND COMPANY.

After the completion of the body of this report, the Adviser was asked to pay another visit to Brown and Company for discussions with the Managing Director and to see the action taken on the Report to the Company (see Annex V).

It is exceedingly pleasing to record that every recommendation in this report either has been, or is being, implemented. The Managing Director is very pleased, costs have gone down, productivity and quality have gone up, and, as a result, a completely new attitude has arisen in the foundry.

Similarly, it is a pleasure to state that as a consequence of the Adviser's Report to Samuel Sons and Company, drastic action has been taken. Their General Manager is also highly pleased with the improvement in quality and productivity and the reduced costs.

Naturally, the Adviser feels gratified at these results and wishes to commend all those who have worked hard to help their respective Companies.