

NEW ZEALAND METAL CASTING INDUSTRY

CODE OF PRACTICE FOR THE
SUPPLY AND PURCHASE OF
CASTINGS

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Casting Technology New Zealand Incorporated.

A voice for the metal casting industry

Casting Technology New Zealand exists to promote the Metal Casting Industry

Through

- championing development of **World Class Foundries** using **Technology, Marketing** and recognised **Best Practice**
- **Marketing** the productive capabilities of members
- organising **Technical, Business and Networking Activities** at branch level and through National and Australasian **Foundry Conferences**
- encouraging active participation in quality **Training** at every level
- creating **Publications** useful to the industry including a dynamic **Website**
- forming **Partnerships with Government** that strengthen the prosperity of the industry
- keeping abreast of proposed **Legislation** that will affect the industry, clarifying **Current Issues** and **Representing** the metal casting industry's position to government.
- recognition of the **Professional Foundryman**
- encouraging operational activities that respect the **Personal Wellbeing** of members, their staff and the general public.

An elected executive, representative of the various sectors of the metal casting industry, govern the Association and a Wellington-based secretariat co-ordinates the Association's day-to-day activities.

Membership is open to all persons with metal casting interests. Firms not directly engaged in the casting of metal, but which have some link with the industry and wish to support the Association's objectives, such as patternmakers, heat treatment services and suppliers, are also eligible for membership.

For further details contact:
The Executive Assistant
Casting Technology New Zealand
P.O. Box 1925, Wellington

Tel: (04) 496 6555 Fax: (04) 496 6550
Email: lboland@businessnz.org.nz
Website: www.castingtechnologynz.org

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Introduction

THE AIM OF THIS BOOK is to provide a guide to good practice for the purchase of castings; to assist designers and specifiers, buyers, and users of castings on the factory floor, by outlining some of the more important considerations necessary for effective comparatively trouble-free procurement. It is not intended as a work of technical reference, although of necessity some technical information has been included.

Castings procurement is in many ways one of the most difficult of all industrial purchasing activities. This code of practice is intended to assist industry achieve the quality, structural integrity and competitive pricing expected from the metal casting industry.

Contractual matters, such as disputes regarding the requirements or intent of this code of practice, between the purchaser and supplier, are not dealt with as such details should be covered in the tender or contract documents.

This code of practice is intended to ensure that castings manufactured in accordance with its requirements are fit for their intended use.

Unfortunately many "mysteries" remain. There is still suspicion on both sides brought about by intense competition, under-investment and poor representation on the part of the foundries. The desperate struggle to survive has inflicted much damage on the industry and there is still a tendency for users to believe that the purchase of castings necessarily involves the purchase of scrap or trouble of some kind. All too often buyers, or those to whom they are responsible, insist that if they have to buy "rubbish" it should be bought as cheaply as possible.

It is not intended to argue this point - simply to show that buyers of castings have a much greater control over their destiny than they imagine. The mastery of a few basic facts may help them avoid much frustration and save their companies a great deal of money, inconvenience and/or loss of business.

It is important that users should be aware of the range of casting production processes available, the relative costs of both tooling and castings and the various parameters which affect the buying decision. References to standards in the text refer to New Zealand Standards (see Appendix xxx.). Where no relevant New Zealand Standard exists, buyers and foundry companies should agree which international or industry standard should be used.

1. FOUNDRY PROCESSES

1.1 FACTORS AFFECTING THE CHOICE OF PROCESS

Some of the most important factors affecting the choice of process, though not necessarily in order of importance, are as follows:

- the quantity of castings required;
- stability of the design;
- the material specification;
- surface finish required;
- tolerances to be achieved;
- complexity;
- the economics of machining versus casting costs;
- financial constraints on equipment costs;
- delivery requirements.

Often more than one process is possible, and in some circumstances geography or accessibility to a supplier's foundry may be considered important. Usually the economics are fairly straightforward and it is possible to devise a simple formula to assist the ultimate decision using such data as the cost of equipment, the unit cost of castings multiplied by the volume and making due allowance for any special factors.

1.2 GENERAL DESCRIPTION OF BASIC PROCESSES

Sandcasting This is the oldest and most versatile of all the foundry processes. Within what is really a group of processes there are a number of terms in regular use these include:-

- Greensand moulding
- Hard sand moulding
- CO² moulding
- Loose moulding
- Machine moulding
- Oil sand cores
- Shell (resin bonded sand) cores
- CO² cores
- Furane (air setting) cores

Although some foundries still have skilled moulders capable of using loose patterns, the tendency these days is for the foundry to insist on using plated patterns, i.e. split patterns (two halves) moulded on boards or metal plates.

The moulding box is usually a metal frame (although wood is used for some processes and types of castings). The moulding box is placed over one of the pair of pattern plates and filled with sand which is compacted round the pattern to produce a cavity representing one half of the casting. Compaction is achieved by either ramming, jolting and or "squeezing" the mould. A second mould of the other half is produced in like manner and the two moulding boxes brought together to form the complete mould.

An important feature of plated patterns is the runner system through which molten metal passes from the downgate. Runner systems and risers must be designed carefully to ensure correct metal flow to all parts of the mould cavity and to avoid shrinkage cavities developing in the casting during the process of metal solidification.

If the casting has hollow sections a core consisting of hardened sand (baked or chemically hardened) is used. Cores are located in cavities formed by projections on the pattern equipment known as core prints. Sometimes extra support for the core is provided by chaplets which fuse with the molten metal when the casting is poured.

In recent years high pressure moulding techniques have been introduced. These have greatly improved the standards of accuracy and finish which can be achieved with certain types of castings. Normally, high volume is necessary to take advantage of these techniques.

Shell moulding Resin-bonded silica sand is "dumped" to a heated pattern plate, the heat producing a "biscuit" of fairly uniform thickness. Ejector pins enable the mould to be released from the pattern and the entire cycle is completed in seconds. The two halves of the mould, suitably cored, are glued and clamped together prior to the pouring in of the metal. Shells may be stored for long periods if desired. Because of the pattern costs, the method is best suited to volume production. It is then possible to take advantage of the close tolerances obtainable and designers should seek the advice of the foundry to ensure that all the benefits of the process are achieved.

Investment casting (lost wax) This is a complete departure from the sandcasting process in that wax impressions of the shape required are produced in a metal die. These wax "patterns" are assembled on a "tree" and invested with a ceramic slurry. The "tree" is then immersed in a fluidised bed of refractory particles to form the first layer of the ceramic shell. The mould is allowed to dry and the process repeated with coarser material until sufficient thickness has been built up to withstand the impact of hot metal.

The wax is then melted out for subsequent recovery and the moulds pre-tested prior to casting. Most materials can be cast by this process but the economics indicate that fairly high volume is necessary and the shape and complexity of the castings should be such that savings are made by eliminating expensive machining. Unless advantage can be taken of these features, it is unlikely that the lost wax process will compare favourably with other processes. Accuracy of castings is totally dependent on the accuracy of the die and extremely fine tolerances can be achieved with an exceptionally wide range of materials.

Table 1: Typical Tolerances Of Various Foundry Processes

Process	100mm to 600mm	Additional Tolerances across Joints
Sand moulding (hand)	± 0.8mm to 2.4mm	-0 to 0.8mm
Sand moulding (machine)	± 0.8mm to 1.2mm	-0 to 0.8mm
Shell moulding	± 0.4mm to 0.8mm	-0 to 0.8mm
Gravity diecasting	± 0.25mm to 0.38mm	-0 to 0.25mm
Investment casting	± 0.127mm	(normally restricted to small castings)

Diecasting There are three main types, normally used for zinc or light alloy castings:

- Gravity diecasting:
- Low pressure diecasting
- Pressure diecasting

All three processes can be used to provide extremely accurate castings and often a good deal of freedom to the designer. Die costs are considerably higher than tooling or patterns for other casting processes.

Normally gravity diecasting is used because it is more accurate than shell moulding. It is preferred almost exclusively to shell moulding for light alloy components.

Pressure diecasting is a high volume production technique suitable for small zinc, light alloy and low melting point castings. Great care must be taken with the design to avoid porosity to which this process is prone.

Where pressure tightness is essential, the buyer can arrange for vacuum impregnation. Sometimes the foundry is prepared to make arrangements with a suitable sub-contractor but, depending on circumstances, the user may prefer to deal directly with a local specialist company.

Centrifugal casting This method is ideally suited to the casting of tubes but the outer shape may be modified by the use of special techniques. Normally, metal moulds are used and molten metal is poured into the rotating mould. Centrifugal force improves both homogeneity and accuracy.

Table 2: A summary of the main advantages and disadvantages of foundry processes.

Advantages	Disadvantages
Sandcastings □ □ Most items can be cast by this method. Pattern costs are relatively low. The method is adaptable to large or small quantities □	There are practical limits to complexity of design. Machining is often required to achieve the finished product. Dimensional accuracy cannot be rigidly controlled although good standards are possible with high class pattern equipment.
Shellmoulding □ □ Closer tolerances than with sand moulding. Improved surface finish. Greater design latitude. Better and more consistent quality.	Equipment costs are relatively high. Castings tend to be more expensive but the extra cost can be more than offset by elimination of some machining
Investment casting □ □ Extreme accuracy and flexibility of design. Useful for casting alloys that are difficult to machine. Exceptionally fine finish. Suitable for large or small quantities	Limitation of size of castings. Casting costs make it important to take full advantage of the process to eliminate all machining operations '
Ceramic mould (Shaw process) Excellent surface finish. Consistent quality.	Castings tend to be expensive. Used for relatively low volume. Dimensional accuracy broadly similar to sandcasting, depending on standards of pattern equipment used.
Gravity diecasting (permanent mould) Good dimensional accuracy. Consistent quality. Relatively inexpensive castings. Suitable for fairly complex casting in light alloys	Relatively high cost of equipment. Commonly used for light alloy castings. Other materials can be cast using the permanent mould process but few foundries produce metals other than light alloy
Pressure Diecasting □ □ Low cost of casting. Good surface finish. Considerable design flexibility. High degree of accuracy. As with other processes inserts can be cast in if needed to enhance design capability	Suitable for relatively low melting point 871°C (1600°F) and high volume. Limit on size of casting. Most suitable for small castings up to a few kg. Equipment costs are high. Some risk of porosity. Good design is essential
Vprocess Superb finish. Good dimensional accuracy. Freedom from gas hole defects. Under ideal conditions can be highly competitive	Not suitable for jobbing work. Requires plated pattern equipment. Close synchronisation of mould and metal readiness is essential in the foundry
Centrifugal Castings Improved homogeneity and accuracy in special circumstances	Limitations on shape of castings. Normally restricted to the production of tubes or similar

2. MELTING PROCESSES

2.1 CUPOLA FURNACE

The Cupola used to be the most economical method of bulk melting cast iron, however it has been largely superseded in recent times with Electric Induction melting. Environmental concerns and the costs involved in controlling emissions will likely see the Cupola's extinction in New Zealand with only one or two foundries still operating this type of furnace.

2.2 ELECTRIC INDUCTION FURNACES

Coreless Induction furnaces can be designed in varying frequencies however in New Zealand the vast majority are Medium Frequency (250-1500Hz) furnaces. These units are batch furnaces which start well on cold charge and so can be emptied and drained after each melt. This leads to great flexibility in the melting programme, permitting a wide variety of specifications to be melted. However, such a multigrade melting programme demands the most rigorous metallurgical control and documentation. The Medium Frequency coreless system can also be used for batch-melting almost any alloy from steel and cast irons through the full range of exotic alloys and non-ferrous metals.

Channel Induction Furnaces are used for either melting or holding molten alloys of constant composition. It is necessary to maintain liquid metal in the furnace channel at all times. The furnace can melt cold materials charged into the liquid bath, or can mix and superheat pre-melted metal. They are suited to continuous production rather than batch operations.

2.3 ELECTRIC ARC FURNACES

Arc Furnaces are used mainly for steel melting. They will often only be found in the larger foundries and in steel works where steel making takes place. It is important to know that some specialist high impact steels are normally best prepared by using the refining processes available to the Arc furnace.

2.4 CRUCIBLE FURNACES

These furnaces are distinguished from other furnace types by their use of a pre-formed and often removable crucible, a lining that holds the molten alloy. The crucible may also transfer the molten metal to the mould for casting. Crucibles furnaces come in a variety of types often designated by the power sources used including Oil fired, gas fired, electric induction and electric resistance. Mainly used for melting non ferrous alloys the crucible furnace can be found in hobby shops and large professional foundries.

3. CASTING DESIGN

For all types of castings close tolerances should be specified only where necessary. Avoid heavy sections wherever possible. Recognise that changes of section promote stresses during cooling and will affect overall tolerances.

3.1 DESIGN CONSIDERATIONS

With varying degrees of difficulty, almost any shape can be cast. If one ignores cost and quality, the range of foundry processes permits tremendous flexibility and complexity of design. This is both an advantage and a disadvantage to the casting user, because it is so easy to produce a casting design which cannot be cast completely free of defects.

Successful castings buying begins with good design coupled with a wide choice of foundry processes. Companies using large quantities of castings would do well to employ a competent castings engineer and smaller companies should encourage their foundry suppliers or prospective suppliers to make design suggestions to improve quality and reliability and reduce cost. Impartial advice maybe obtained from consultancy services.

Best casting results are achieved when engineering advice is sought at the earliest possible stages of the design. Companies adopting this principle will be well rewarded for a little extra care and expense before putting a new design into production. Equally, cost reduction and/or quality and delivery improvement may result from minor changes in existing design. Frequently, minor changes which do not affect function can be introduced to reduce costs.

Buyers should encourage foundries, perhaps through contact between respective quality engineers, to suggest small changes which eliminate hazards or facilitate production.

It is not within the scope of this guide to attempt anything other than a fairly simple approach to the problem of design. It is a broad-ranging subject and it has been dealt with in depth in text books for those whose primary responsibility is in the technical field.

The buyer may however, benefit from the knowledge of a few simple rules:

1. As a general rule rounded surfaces and generous radii produce superior castings.
2. Extensive flat surfaces are extremely difficult to cast accurately. Strengthening ribs are often desirable.
3. Rapid changes of section should be avoided wherever possible.
4. Care should be taken with material selection and the correct grade of material used for any metal thickness.
5. The shape of the casting should be such as to avoid shrinkage cavities.
6. Ideally it should be possible to draw the pattern from the mould without the use of loose pieces. In some low volume jobs, however, loose pieces may be the cheapest way of achieving the desired shape.
7. Although cored holes and apertures often reduce machining costs, it is virtually impossible to avoid core flash where the cast and cored surfaces meet. Cores should be balanced and properly supported, preferably at both ends and, if possible, at the sides.
8. Wherever possible, bosses should be designed to lie along the mould joint line.
9. Spoked wheels are best produced if spokes are curved - not in line across the diameter. This reduces cooling and mechanical stresses.
10. Cores can sometimes be used to avoid changes of section. A solid casting is not always the preferred design.
11. Adding thickness or weight to a casting does not necessarily increase strength or give more reliable quality.
12. One of the most difficult castings to produce free of defects and to reliable quality standards is a solid casting, e.g. a "brick."

13. Except where volume permits, the use of expensive coring-up jigs and designs involving the placing of cores into invisible coreprints should be avoided.

3.2 DESIGN FEATURES OF VARIOUS TYPES OF CASTINGS

Sand castings There is a wide choice of ferrous and non-ferrous materials. Considerable complexity is possible and size is limited only by melting capacity. Section thickness depends on the material used but 3mm should be regarded as the absolute minimum, with 8mm the desirable minimum for most popular grades of cast iron. The tolerances are from $\pm 1.5\text{mm}$ to $\pm 6.5\text{mm}$ for iron castings over 750mm.

The figures for aluminium alloys and copper alloys are similar to grey iron but it is impossible to generalise because of the wide range of alloys available.

The minimum sections thickness for steel is 6.smm. Tolerances depend on physical shape, precise metallurgy, size of castings and class of pattern equipment to be used.

Where doubt exists, the buyer is strongly recommended to take very seriously the advice of the founder in deciding the practical limits for any given design.

Shell moulded castings There is a wide range of ferrous and non-ferrous materials. Complexity is restricted by factors such as cycle times and the need for easy withdrawal of the mould from the pattern. The process is mainly suitable for small parts weighing only a few pounds. Larger, heavier parts can be produced by using sand or shot backing of shell but this is an expensive process. Accuracy is reasonably good. Tolerance is 0.125mm per 25mm generally, and there is a variation of a further 0.25mm across the joint line. Under some conditions, section thicknesses may be slightly less than for sandcastings.

Diecastings (permanent moulds) There is a limited choice of materials - normally restricted to zinc and certain light alloys. Iron and bronze can be cast in permanent moulds if simple shapes are used. Low melting point alloys provide considerable design flexibility and permit great complexity. High production rates can be achieved with pressure diecastings but porosity can be a problem. Tolerances vary from 0.04mm per 25mm for low melting point alloys to 0.10mm per 25mm for cast iron or bronze. Minimum wall thickness of as little as 2.5mm is possible in some light alloys.

4. PATTERN EQUIPMENT

4.1 IMPORTANCE OF GOOD PATTERN EQUIPMENT

With the possible exception of those companies involved in high volume production who are accustomed to a huge investment in tooling, there is a general reluctance to spend money on pattern equipment.

Castings buyers, perhaps under pressure from higher management, frequently seek ways of avoiding or reducing this initial cost, choosing cheap wooden patterns where metal is essential or poorly constructed cheap wooden patterns instead of the strongly built laminated type. Sometimes buyers opt for part cost patterns. This is not normally recommended and generally speaking full ownership of patterns is much to be preferred.

As a general rule economising on patterns is most unwise. That is not to say the buyer should not seek to negotiate attractive prices for patterns but that he should avoid the temptation to downgrade the pattern equipment in the interests of lowering the initial cost. Good pattern equipment constructed to a high standard consistent with the demand for castings and the accuracy required, and well maintained, is essential for quality castings at minimum cost. So the buyer should avoid pattern equipment bargains they do not exist.

The practice of having patterns constructed by a pattern maker without due consultation with the foundry is another hazard to avoid. The foundry may add a small mark-up to any patterns they purchase outside their own organisation but in the final analysis it is cheaper to place the full responsibility with the foundry and insist that they provide the pattern equipment.

In pursuing this course the buyer may feel at risk should the need arise to transfer equipment from one foundry to another. If the choice of foundry is correct in the first instance this need will seldom arise. But supposing it is essential to have this kind of flexibility, if the patterns are well made it is a simple and fairly inexpensive process to re-mount patterns onto new boards or pattern plates to suit the new foundry.

4.2 CLASSES OF PATTERN EQUIPMENT

There are many types of pattern equipment:

- cheap wood patterns for prototypes, possibly loose moulded (i.e, unplated);
- hardwood patterns mounted on boards for regular low volume or small batch quantity production;
- resin pattern equipment for medium volume production where reasonable wearing properties are important. Resin has the added advantage that it is shrink-free and therefore ideally suited for the reproduction of wooden patterns if their condition is suitable;
- metal patterns produced in cast iron or cast aluminium according to the foundry or process used. Brass or bronze patterns are seldom used these days. Pattern dimensions are made to "contraction rule" not "standard" rule. Different casting alloys have different contraction rates which can prevent one pattern being used to cast different alloys;
- dies for lost wax castings which are often single impression and machined from the solid. It is possible to use master patterns (replicas of the casting to be produced) to facilitate the manufacture of lost wax dies but advice from the founder should be sought in each individual case;
- dies for pressure and gravity diecasting are almost always machined from the solid. These are generally very complex and expensive types of equipment involving moving cores etc and a high degree of skill in both the design and manufacture;
- shell cores which are sometimes used where dimensional accuracy is important. Shell coreboxes maybe used for producing cores for castings made from wooden patterns. More usually shell cores are used with sand or shell moulded castings where metal patterns are in use. The method of producing shell cores relies on heated coreboxes and a sand/resin mixture being introduced into the cavity of the desired shape.

The advantage and disadvantages of the different classes of pattern equipment are summarised in Table 3

4.3 OWNERSHIP OF PATTERNS AND DIES

The main points to consider are as follows:

- full ownership gives the buyer the right to withdraw equipment and transfer to another foundry;
- full ownership of dies (especially pressure dies) give the same right of transfer but there may be technical problems moving equipment to another foundry;
- normally die foundries offer only part cost of tooling, thus retaining an interest in the equipment;
- with part ownership of patterns or when patterns are amortised, the buyer should ensure that the pattern cost element in the unit cost is deducted when the agreed quantity has been called off;
- where the foundry agrees to provide patterns at no cost to the buyer, the unit cost should be adjusted when initial pattern costs and interest charges have been paid off.

Table 3: Advantages and Disadvantages of different classes of pattern equipment.

Advantages	Disadvantages
<p><i>Cheap wood loose patterns</i></p> <p>Relatively cheap to produce. Can be used to produce resin patterns. Easily modified</p>	<p>Not suitable for production batches unless converted into resin before becoming worn. Tend to become inaccurate and to produce poor surface finish</p>
<p><i>Hardwood patterns</i></p> <p>Relatively inexpensive if required for small batch production. Can be used as masters for resin patterns. Fairly easily modified but expensive if multiple impressions are involved</p>	<p>Fair wearing properties. With care will remain reasonably accurate over fairly long periods. Not suitable for high volume production</p>
<p><i>Resin patterns</i></p> <p>Relatively inexpensive to produce. Good wearing properties. Easily modified. Suitable for medium quantity batch production</p>	<p>Tolerances only as for wooden equipment. Not suitable for really high volume production. Use limited to sand castings</p>
<p><i>Metal patterns</i></p> <p>Excellent wearing properties. High standards of accuracy and stability. Suitable for high volume production and shell moulding (normally cast iron or Aluminium)</p>	<p>Extremely costly. Difficult to modify. Equipment less readily adaptable for movement from one foundry to another</p>

5. PURCHASING POLICY

5.1 SELECTING THE FOUNDRY

There are many ways of selecting foundry suppliers. Frequently this is a random process - names taken from a buyers guide, from the visitors book, or from visiting cards, advertising material, magazines and recommendations from other buyers and engineering staff.

A more scientific approach is recommended. Buyers should seek more reliable information about sources of supply and try to match foundry capacity to their purchasing needs.

This can be achieved by issuing a questionnaire to prospective suppliers. However reluctant foundries may be to answer these questions, the buyer should insist this is done as a prerequisite to consideration for future business.

Replies should be studied with great care because they will considerably reduce the scope for error and provide the guidelines for future purchasing policy. For example, the buyer will know precisely whether the supplier can produce the grade of material required in sufficient quantity. It will be possible to judge how important or otherwise the business it is intended to place would be to any given supplier. Attitudes to quality can be assessed from the percentage of total personnel directly involved in quality control. The buyer should recognise that a foundry's strong emphasis on quality control indicates they are probably producing very high grade castings. Their price structure will reflect this whether or not castings to exceptionally high standards are required. A word of warning, however. The buyer must not, for example, assume that ballast weights can be produced by any foundry. The casting of ballast weights is a speciality of relatively few foundries.

If it is intended to buy heavily cored castings look first for the supplier who is accustomed to this type of work. Discuss overall capacity to avoid disappointment after the order is placed. Delivery failures can often be caused by insufficient core making capacity.

Brand names

Generally speaking there is no magic in material brand names. Buyers would do well to use New Zealand Standard (see Appendix ****.) or other international specifications and make buying decisions on the realities of the situation- the price, and the quality/inspection standards required for any given set of chemical and mechanical properties.

From the answers to the questionnaire the buyer may deduce whether or not transport will be a problem and the prospects which may exist for further development of business with the supplier. But perhaps the most important point, when all other conditions have been satisfied, is to look at the foundry's current pattern of production. Is it principally high volume, small castings, or simply jobbing? what are their standard box sizes? Box size can have a dramatic effect on prices and quality of castings. If possible, when designing castings, keep in mind the moulding box size to maximise the number of patterns on a plate. This could reduce cost significantly. Always allow sufficient space around the castings for core-prints (the projections needed to provide adequate support for the core). Consult the founder if in doubt on this point.

5.2 THE FOUNDRY AS AN EXTENSION OF THE BUYER'S MANUFACTURING CAPABILITY

After the careful selection of source(s) of supply there is an overwhelming onus on both the buyer and the seller to regard their relationship as that of partners. This does not preclude tough negotiation or making concessions- the best results are achieved when there is some give and take. If a conflict situation exists between buyer and seller there is little hope of successful business being transacted.

The buyer should seek to build up a harmonious relationship with the source of supply, so that it is possible when necessary to say some very hard words or to refuse a price increase.

The buyer should visit his supplier's foundry and become known to as many people as possible at all levels with a view to furthering the relationship. In short, the foundry should be regarded as if it were another department with both parties exchanging information in their mutual interest.

If, as is suggested, the buyer tries to build close relationships with the foundry, it is important to use relatively few suppliers and not be tempted into fragmenting one's spending and sending enquiries to virtually every foundry that solicits business.

There maybe marginal cost savings from new sources and the buyer would be foolish not remember that changing circumstances materially affect purchasing decisions. But there are hidden costs in changing sources and there are hazards. If the existing supplier is a good one the costs of expediting and of monitoring will be less than with a new supplier. It is preferable to negotiate hard and increase bargaining strength by concentrating these cost on a few rather than many sources.

From the point of view of the supplier, selling costs are at a minimum whenever the expenditure is large and the buyer should seek all the benefits possible from the use of few suppliers. Among the most important benefits are regular monitoring visits from the foundry (as part of the deal) and price advantages over those customers who purchase from a large number of foundries.

Having carefully selected a short range of suppliers the buyer would be wise to establish a supplier "league" table and to advise each supplier of his position and the reason for it; also all suppliers should be aware that promotion in league table depends on performance.

Penalty Clauses

Where the buyer's company is forced to accept "penalty" clauses or is dependent on prompt delivery, there is an alternative to expensive visits and/or lengthy telephone calls. Firstly, obtain the supplier's agreement that delivery is part of the contract- that is, in return for a certain consideration (price), the supplier undertakes to supply good quality castings at the agreed date (within the supplier's lead time). Negotiate on the basis that the full price should only apply to those orders where all the conditions of the contract are met. It is suggested that a small percentage (say 2%) is withheld. Award points on the basis of 100 for delivery exactly on time. For late deliveries deduct lead time multiplied by number of weeks' delay. Thus if the lead time is eight weeks and delivery is two weeks late, points for delivery are $100 - (2 \times 8) = 84$. Because early delivery is also expensive the same formula maybe applied to early delivery and the same number of penalty points deducted.

By way of balancing the situation, special delivery co-operation can be rewarded in the same way. If the supplier improves on a lead time of eight weeks by two weeks at the request of the buyer, award 16 bonus points. At the end of each month calculate points lost and bonus points awarded. If the supplier has achieved a 9% delivery performance, a delivery "bonus" of 1% would be applicable. If only 85%, 0.5% is payable and so on.

The advantage of this type of arrangement is that the top management at the foundry have a convenient means of measuring their delivery performance. The availability of statistics such as these will have the effect of focusing attention on the importance of reliable deliveries and the cost of failure to both buyer and seller.

Some attempt should also be made to establish the cost of quality problems. In all probability, the cost of a rejection over a very broad spectrum of castings procurement is as much as five times the original price. Thus, if a batch of castings costing \$1 each has a reject rate of 5%, the true cost of that batch is 5 at \$5 each plus 95 at \$1 each, a total of \$120 or \$1.20 each, a massive increase of 20%.

The actual cost of quality failures is a matter for argument: the undeniable fact is that these costs are significant and emphasise the need for close collaboration and better understanding between buyer and supplier.

5.3 FOUNDRY COSTS

Because of the many types of foundry, the range of metals cast and the extremely wide range of circumstances, it is impossible to offer any precise guidance on the subject. There are, however, a few salient points which may be helpful. Irrespective of the type of foundry, costs will break down into three main categories- materials, direct labour and expenses. Materials may be further sub-divided into raw materials - pig iron (or ingot), scrap and alloying constituents and process materials -coke, sand, moulding materials, bonding agents, shot, paint etc.

Increasing mechanisation and automation have made some impact on the foundry industry but labour remains a large percentage of costs. Expenses are extremely variable depending on the facilities of the foundry and the precise method of costing.

While accepting that there is no magic formula which can be universally applied to foundry costs, it is still possible for the buyer, by the application of some simple arithmetic and a few intelligent assumptions, to develop some idea of the pattern of costs for any given foundry or particular cast component.

For example, the cost of pig iron (or ingots) and alloying constituents is published information and most buyers will be aware of the level of scrap prices. It is usually possible to obtain some indication of the percentage ratio of pig iron, scrap etc. in a typical (furnace) charge. Thus having established an approximate cost per tonne of foundry output, based if necessary on the average cost per kg of a range of castings purchased, it is possible to arrive at a rough idea of the range of costs of the various materials, expressed as a percentage of total costs.

Some idea of labour costs as a percentage of total cost can be calculated using average cost per tonne of output related to the numbers of direct and indirect personnel and assumed levies of remuneration.

By multiplying the number of impressions on a pattern plate by the unit price for the casting, it is possible to estimate the return per box expected by the foundry. Care must be taken to differentiate between cored and uncored work, grade of material, moulding method and box size when making use of these figures.

Assuming castings represent a sufficiently large area of expenditure, the buyer would be well advised occasionally at least, to analyse casting prices by foundry process, grade of metal, size/weight, cored or uncored, moulding box size and moulding machine used. This is useful in comparing sources of supply and, related to quality statistics, provides a helpful guide to policy- making and a useful tool in the negotiating process.

5.4 COST REDUCTION AND MUTUAL PROSPERITY

This is the essence of good castings buying. There is no point in buying castings cheaply if the supplier goes out of business. Already there has been a tremendous reduction in the number of foundries in New Zealand and the industry is still in decline. There are many reasons-environmental controls, the need for more investment, the traditional attitudes of foundrymen and buyers, overseas competition from lower wage countries, etc. If buyers wish to continue purchasing castings in New Zealand and retain this important basic industry there must be more professionalism, less secrecy and more honesty as regards capability on the part of the foundry and a general recognition that mutual prosperity is essential. As is now becoming obvious in the world economy this mutual dependence must be recognised.

Some thoughts on this subject which may influence buying policy are as follows:

Action by foundries:

- Increasing specialisation
- Refusal of unsuitable/uneconomic work
- Mergers into larger groups to rationalise production

- Development of own machining facilities
- Improved technical liaison
- Assistance with preferred material specifications
- Improved production control arrangements

Action by buyers:

- Design to use supplier box sizes
- Encourage foundries to provide a design advisory service
- Better designs
- More consultation
- Careful choice of process
- Closer quality monitoring and feed back

Action by both:

- Use of optimum batch quantities
- Closer co-operation between buyer and seller
- Better planning
- More reliable deliveries to achieve lower investment in stocks
- Long term customer commitments to encourage investment on special plant
- Capacity planning - advance notice from buyer
- Steady load to optimise manufacturing costs
- Co-operation between buyer and seller to deal with monopoly suppliers with regard to scrap prices, availability etc... and with representatives of government departments concerning licensing, regulations etc.
- Optimisation of computer use for costing, production planning and all administration

5.5 MACHINED DRAWINGS

A comparatively small number of New Zealand foundries have a machine shop, although it is usual for steel foundries and die foundries to have this facility.

Putting aside possible constraints and assuming the buyer has complete freedom of action, consideration should be given to the purchase of machined castings if:

- there is a high hazard and repairs may be needed;
- the material has unusual properties requiring specialised machining techniques;
- castings have to be subjected to inter-operational testing or cleaning using specialised equipment;
- there is insufficient capacity at customer's own works;
- transport costs of raw castings are prohibitive;
- castings are being purchased from overseas.

Usually the decision is fairly straightforward but perhaps too few New Zealand foundries have set out to attract large volume orders for machined castings. The result has been that overseas foundries have made a strong impact. Local foundries have come to realise that to capture the business from overseas or distant customers a large volume machining capability is essential.

Foundries often have a local sub-contract machinist for small quantity work.

It may be true to say that a good deal of the failure of New Zealand foundries in recent years has been due to a reluctance to supply fully machined castings. This reluctance and the lack of specialisation have been exploited by foreign competitors.

5.6 SUPPLIER SERVICES

Earlier (see Section 5.2) the need for buyer and seller to establish long term relationships, involving mutual trust, some give and take, and the encouragement of the idea of partnership, was mentioned. The need to avoid fragmenting expenditure on castings was also stressed.

Progressive foundries are always willing to provide advice on casting design to reduce cost and improve quality. The buyer has the right to expect this kind of assistance but in return the founder will wish to have the opportunity of recovering the cost of this service in the volume of sales.

Supplier services can only be optimised when a genuine effort is being made by the buyer to concentrate the spending on a limited number of sources and there is a reasonable payments situation.

Services to be sought by the buyer include:

- practical advice on casting design, choice of material and foundry process. In view of impending product liability legislation, the buyer should carefully examine the supplier's recommendations and officially endorse them. They should then be embedded in the purchase specification. Otherwise the foundry may not be willing to advise;
- regular monitoring of quality on customer's premises;
- regular commercial contact-early warning of impending difficulties, raw material price movements likely to affect casting prices, etc.;
- constant updating of lead times and genuine help with urgent delivery requirements.

The buyer must always ensure that the choice of foundry is such as to permit complete objectivity when advice or help is being sought.

It is sometimes considered that objective advice is only possible when the foundry has a broad capability offering a range of processes and materials. This is not necessarily the case and it is in these matters that the buyer must exercise judgement. Fair play coupled with a competitive atmosphere and tough negotiation will bring to the fore those who have the ability to meet the quality and price criteria. The less competent will seek easier conquests if lines of communication between buyer and seller are seen to be permanently open.

5.7 BUYING FROM OVERSEAS

Some larger companies have already established considerable businesses outside New Zealand and clearly all castings buyers will at some stage be tempted to purchase overseas. This will bring a new set of problems. They are not insurmountable but a few helpful hints may not be out of place. Firstly, bear in mind that the overseas supplier will insist on strict observance of the contract. The buyer must be precise in specifying exactly what is required and the terms under which it is to be supplied. Be quite sure of the position with regard to rejects and how long after delivery credit for defective castings will be available. Define responsibility for transport of rejects. Reach agreement as to whether reject castings may be scrapped and if so who will inspect.

If there is an obvious hazard in the design of the castings it may be wise to insist on non-destructive testing or to purchase castings in the fully machined condition.

It is assumed that in comparing quotations shipping and other known costs will have been considered. But, before placing business overseas consider very carefully the cost of monitoring. Telephone conversations when another language is involved can be lengthy and frustrating and often completely abortive. On a somewhat pessimistic note, it must always be remembered that when something has gone wrong it is comparatively easy for the supplier to excuse his failure or to avoid the problem simply by saying that he does not understand.

Importing castings into New Zealand is not difficult because shipping or air freight agents will always be on hand with helpful advice. Generally speaking they are efficient and reliable because it is their livelihood and they only prosper from satisfied customers.

If in doubt consult other buyers known to be importing castings - indeed ask the supplier to give you names of other customers and contacts. Buyers are nearly always helpful to other members of the fraternity and it is good buying practice to take advantage of any information that is freely available.

6. CONDITIONS OF PURCHASE

In the absence of a formal Conditions of sale the following example of a General Conditions of Sale may form the basis of a suitable document.

All quotations made are subject to confirmation or amendment prior to acceptance of order. Any order accepted by the company shall be subject to the following conditions.

6.1 DEFINITIONS

Wheresoever the words "company", "us", "our", "customer", or "purchaser", "they" are used in these general conditions, "customer", "purchaser" and "they" shall be deemed to mean the person, firm or company for whom this company is executing the work subject to this quotation, and "company", "us", and "our" shall mean (NAME OF SUPPLYING COMPANY).

6.2 PAYMENT

If the period for payment is not stipulated overleaf, then it is deemed to be payable no later than the 20th of the month following despatch and without deduction whatsoever.

If payment is not met by the due date the company reserves the right to charge the customer all reasonable legal and court costs (including solicitor to client costs) incurred in recovering or attempting to recover the unpaid balance.

6.3 DELAYS

Delivery is subject to the goods or materials being available when your order is accepted. No responsibility is taken for delay(s) in execution of orders caused by events beyond our control. In any such event the delivery date shall be extended until the operation of the causes preventing such delivery has ceased or the contract may at the company's discretion be terminated.

6.4 QUALITY GOODS OR MATERIALS

The company will replace free of charge any faulty goods or materials if promptly reported and return to us within one (1) month of the date of delivery, but our liability is, in all respects, limited to replacement only and we shall not be responsible for any loss or damage whatsoever however otherwise arising.

Except as provided above we give no warranty or undertaking of any sort whatsoever as to the fitness of our goods or materials for any particular purpose (whether such purpose was disclosed to us or not), nor as to the merchantable quality of our goods or materials, nor as the conformity of such goods or materials either with the description under which they are sold or with any sample shown to the purchaser, and all conditions or warranties whether express or implied by common law, statute or otherwise are hereby expressly excluded.

6.5 ACCEPTANCE OF QUOTATION

The prices and schedule quoted are subject to re-quotation if not accepted within 30 days from the date of this quotation. All prices are quoted on the condition that the quantity of work quoted for will be carried out; this company has the right to review such prices if such quality of work is not executed.

6.6 RISE AND FALL

All prices quoted herein are based on rates of labour, materials, freight, insurance, custom tariff, primage, foreign exchange and all other operating costs ruling at date of quotation. Any variation in the above rates, either up or down, shall be to the purchaser's account.

6.7 PATENTS AND PATENT RIGHTS

The purchaser warrants that:

- the goods or materials to be furnished on any order accepted by this company do not infringe any patent and other intellectual property; and
- they will defend any suit that may arise in respect thereto; and
- they will save the company harmless and indemnified from any loss which may be incurred by the assertion of any patent rights and respect to the goods or materials furnished hereunder.

6.8 TOOLING

All dies and tools, designed and/or manufactured by us and paid for by the purchaser, shall remain in the exclusive custody of this company at all times notwithstanding completion or termination of the contact but the company will not, without the consent of the purchaser, use the same other than for orders accepted from the purchaser. If an outright charge for dies and tools is not made, the company has the right to use the same as it pleases.

This company will retain and make all such dies and tools available for the production for a period not exceeding two years from the date of the last delivery provided always that such dies and tools are suitable for further production.

Alterations to dies and tools to meet the requirements of the purchaser, replacements or renewals shall be paid for by the purchaser.

6.9 INSURANCE

While tooling, dies, production inserts and the like are held by this company the same are at the risk of the purchaser and insurance cover is his responsibility. No action with respect to insurance will be taken by the company unless it is especially requested to do so, and the cost of insurance will be to the purchaser's account.

This company shall not have the risk of or be liable for any losses or damages in transit. Insurance is not effected by us on any goods or materials forwarded from our premises unless we are instructed to insure at the expense of the purchaser.

6.10 QUANTITIES OF GOODS AND MATERIALS.

We have the right to deliver against the order of the purchaser a tolerance of 10 per cent, in the total quantities of goods or materials

6.11 TERMINATION

Should a writ of attachment or a distress warrant be issued against the purchaser or should the purchaser execute a Deed of Assignment for the benefit of his creditors, or where the purchaser is a company should it have an official manager or a receiver appointed, or should it be wound up either

voluntarily or by order of the court, we have the right, at our absolute discretion to terminate any contract, arising out of our acceptance of order, without incurring any liabilities at law or in equity and without prejudice to our right to recover amount due or to become due by the purchaser and to stop any goods or materials in transit and to repossess any goods or materials already delivered to us.

The company has the right at its discretion to suspend and/or terminate any contract arising out of its acceptance or order should the purchaser fail to carry out any of these terms and conditions (time for payment being of the essence). If we incur additional costs or expenses as a result of such suspension or cancellation without prejudice to any other rights of recovery such costs and expenses shall be reimbursed to us by the purchaser.

6.12 RETENTION OF TITLE

Unless and until the conditions of this contract are fulfilled by the purchaser and goods supplied hereunder shall remain at all times the sole and exclusive property of the company and the purchaser shall have no estate or interest therein other than the right to retain possession of them as bailee and the right to sell them as agent for the company in the usual course of the purchaser's business. Where goods are sold, the purchaser shall account in trust for and on behalf of the company until payment is made to the company or the conditions of this contract are fulfilled.

The purchaser shall store and keep the goods separate from other goods stored by the customer and in such away that the goods shall be readily identified as the company's goods.

6.13 DESIGNS

In the event of the company submitting any designs for goods or materials to the purchaser, such designs shall be deemed to be strictly recommendations and/or suggestions. Before the company shall commence to manufacture any goods or materials which it has designed, the purchaser must approve the said design(s). Such approval shall be deemed to be an adoption by the purchaser of the said design as its own. The purchaser shall indemnify the company against any liability, loss, claim or proceedings arising out of any insufficiencies, failure or any other matter or thing whatsoever in respect of the said design.

6.14 PRECEDENCE

Contracts and orders are accepted only upon and subject to our general conditions and special conditions (if any) as herein contained and such conditions are to have a full force and effect as if incorporated into the purchaser's order or acceptance. In the event of us commencing to carry out work covered by this quotation, any qualifications of our conditions in an order of acceptance shall be deemed to be and shall be void and of no effect unless our Conditions are expressly excluded by us in writing.

7. THE ENQUIRY

It has already been stated that the buyer is best served by the concentration of expenditure on a few rather than many sources. Using all available information, the buyer should send enquiries only to those foundries with whom he is prepared to do business in the event of their submitting the most attractive quotation (i.e. the best offer in terms of price, quality or delivery or any combination of these and other factors which may influence the purchasing decision). The practice of inviting quotations from poorly equipped low cost producers, whose ability to meet the required standard is in doubt, setting their prices against those of other sources known to observe higher standards and using this information as a negotiating ploy, only leads to disaster.

The buyer must also beware the foundry which, as a short-term expedient, is prepared to undercut all competition. Such foundries, in the final analysis, discard unattractive items, usually at times inconvenient to the buyer, and what appeared a worthwhile saving can become a significant loss. With these caveats it is now necessary to deal with the enquiry in detail. In order to attract the best quotations the information given to potential sources must be comprehensive and should include the following details:

- pattern number (where appropriate);
- drawing number;
- description;
- material specification, NZS or equivalent;
- annual requirement (if known); otherwise estimate;
- batch quantities required and commencing date;
- pattern equipment/tooling-if existing give details; if new pattern/tool required ask for prices and details; state if for prototype or production use;
- actual or estimated casting weight;
- special features required, e.g. finish; cleaning; heat treatment; non-destructive tests;
- service conditions required, e.g. abrasion; corrosion; temperature.
- supply of chemical, mechanical, NDT, microstructure, heat treatment or dimensional test certificates
- involvement of third party inspection
- visits from buyer representatives

The drawing accompanying the enquiry should where possible show the standard material specifications or mechanical properties desired, e.g. tensile; hardness; dimensional tolerances; max/min temperature characteristics; pressure tightness (if important); machining data; location of part numbers, trade marks; gauging points (if applicable); surface finish requirements; internal integrity requirements.

It is recommended that the enquiry should call for prices ex works and delivered.

Always ask for separate prices for castings and pattern equipment (tooling). Drawings used for enquiries should be marked "for enquiry purposes only".

Quotation Details

Having given potential suppliers comprehensive details of the requirement, insist that quotations are not simply pieces of paper giving rise to more questions than answers.

For example, if the requirement is for intricate castings, the quotation should specify those features which cannot be achieved in the "as cast" condition.

Preferably, quotations should be accompanied by a marked drawing showing the precise form of supply and identifying any special machining allowances.

All ambiguities regarding price, quality, material specification, delivery, non-destructive testing, terms of payment etc, should be eliminated before any quotation is considered.

8. THE ORDER

Although the order is an important legal document it is surprising how frequently only the minimum information is given to set in motion a complex chain of events. Often a satisfactory outcome is only achieved by extensive use of the telephone and time-consuming visits to and from the supplier. Sooner or later these costs have to be recovered and the inefficiency paid for in a variety of ways.

Most buyers are familiar with the stories of 100 tins of paint becoming 100 tons as a result of a small typographical error. Fewer maybe aware that SG Iron has been wrongly interpreted as Soft Grey Iron with disastrous results. These are extreme and unlikely examples of the consequences of carelessness; nevertheless, they forcibly illustrate the point that accuracy is important and ambiguity should be avoided.

A great deal of information on castings specifications is available and designers and buyers are advised to ascertain the appropriate New Zealand Standard specification for the grade of material they require (see Appendix *****). This is preferable to supplier brand names or alloy reference numbers and may well be cheaper.

Most of the preliminary work necessary for successful castings procurement has already been dealt with and it is assumed that all that remains is to finalise the arrangements with the chosen supplier. The ideal procedure for the purchase of new items may therefore be as follows:

1. Ensure that both the design and production engineering departments are satisfied that all technical points have been cleared and that the production drawing has been amended to show the agreements reached on such points as:
 - machining allowances;
 - machining data;
 - position of cast part number or foundry marks.
2. Make a final check on supplier's conditions of sale.
3. Prepare the purchase order giving:
 - the full material specification;
 - casting pattern or drawing number;
 - total number of castings required (if applicable);
 - date for delivery of samples;
 - batch quantities;
 - rate of delivery (or schedule);
 - quoted (or negotiated) price;
 - quotation date and reference (or details of price agreement);
 - details of pattern equipment to be supplied by or to the supplier;
 - price of pattern equipment (if applicable);
 - details of test certificates required;
 - details of non-destructive testing required;
 - definition of responsibility for marking out samples;
 - details of any special requirements of service conditions (even if also on drawing);
 - terms of payment (settlement discounts or as applicable).

Take care to enclose a certified copy of the drawing for production purposes and ensure that there is a reference to this enclosure on the order.

9. DELIVERY RELIABILITY

9.1 EXPEDITING - INFLUENCING PURCHASING POLICY

The need for excessive expediting activity is a reflection on purchasing policy in that it is probably due to one or several of the following reasons:

- bad choice of supplier;
- poor payments;
- incorrect pricing;
- inadequate lead times;
- unsuitable pattern equipment;
- unrealistic scheduling;
- inadequate transport facilities.

Supplier selection is a key factor and the buyer is recommended to visit each and every foundry with whom business is intended. He should look for good production control facilities and method used.

At the practical level the buyer should try to assess the work rate in the foundry and be sure to look in the fettling shop for a satisfactory flow of castings into the despatch bay. He should examine castings waiting despatch and compare these with his own requirements of shape, size and finish.

Unless the buyer is satisfied on all these points he should not be tempted by price advantages. Suppliers with inadequate management resources, skill and experience in the production of the required type of castings will invariably fail on delivery due to poor administration or the production of excessive scrap.

Poor payment is the surest way to encourage unreliable delivery performance. Priority will always be given to work which is rewarded with payment on the due date. If extended credit is needed during difficult times, the buyer should think carefully about the cost of this credit if it is intended to bludgeon the supplier into submission. Supposing this is achieved, the cost, if known, would probably exceed the value of the credit obtained.

Incorrect pricing, whether due to unfair competition, tough negotiation or simple error, will almost certainly lead to delivery failure, for obvious reasons.

If lead times are inadequate, delivery reliability will only be achieved at enormous cost. Castings users would do well to concentrate their attention within their own organisation to reduce the incidence of urgent requirements to the absolute minimum.

If the pattern equipment is inadequate-insufficient number of impressions, poor state of repair or not of the type required by the foundry- the result is likely to be unreliable deliveries coupled with bad quality and unfavourable prices.

A frequent cause of delivery failure can be traced to transport problems. Not all foundries have their own transport, but in any event attempts will always be made to optimise transport costs - castings are liable to be delayed whilst a suitable load is collected together for a particular destination. Transport arrangements seldom feature strongly in negotiations with the foundry, but should be carefully considered whenever delivery reliability is being analysed.

9.2 SUPPLIER CO-OPERATION TO BE EXPECTED

Suppliers should be expected to co-operate with buyers to achieve best possible results. Depending on the size of the account it may be reasonable that they should allocate one member of staff solely to progress that account and to liaise by regular personal visits. Excellent results are often achieved in this way if buying policy tends to concentrate expenditure.

At least the foundry should acknowledge all orders and comment on the delivery schedule. Similarly, buyers have a right to expect reliable delivery promises to be made against all schedules. Failure to comment on delivery prospects implies the supplier's agreement to meeting the requirement set out in the order. Unfortunately, very few foundries take customers' delivery requirements seriously unless they happen to fit their own circumstances or the buyer's progress activity demands that attention is given. The buyer should therefore make a point of the importance of delivery in the negotiating stage whether this be before placing individual orders or renewing/reviewing annual contracts. Capacity planning in terms of the number of boxes available on a daily, weekly or monthly basis will often avoid many delivery failures. If the buyer has a sizeable account, it is reasonable that the supplier should be prepared to co-operate by allocating the buyer a certain capacity and a degree of flexibility. This in turn requires fair play on the part of the buyer and many companies enjoy the advantages of mutual co-operation in this respect.

9.3 SCHEDULING - NOTICE OF REQUIREMENTS

Unrealistic scheduling-whether quantities are too small, too large or too frequent, having regard to the pattern equipment in use - inevitably means delivery performance will be less reliable than if care is taken to match the equipment to requirements at time intervals which are realistic in terms of the foundry capability.

Agreements made between buyer and seller with regard to lead times for schedule changes should be honoured by both parties. The buyer should, if possible, avoid rapid changes in schedule. It is a valid and common complaint on the part of foundries that buyers over schedule their requirements until excessive stock accumulates and then there is a sudden and dramatic drop in volume or even the complete cancellation of a schedule. Suppliers of castings have no right to expect to live in a perfect world, but equally buyers, or more likely their production managements, should recognise that it is impossible for foundries to plan order out of chaos and however desirable it may be that the customer is always right, it is sometimes unrealistic to expect this to be translated into practical results.

9.4 VISITS TO AND FROM SUPPLIERS

Reference has already been made to visits to and from suppliers. From the buyer's point of view, visits to the foundry ensure that he is known to the appropriate personnel and this is important to success with delivery arrangements. Buyers should strive to create the conditions under which suppliers will be willing to send production control or sales personnel to monitor customers' delivery requirements at regular intervals. As regards visits to the foundry, the buyer would do well to retain the element of surprise. It is not unknown for suppliers of castings to postpone action which should have been taken very much earlier until on or near the routine visit date.

Delivery reliability is only achieved by good purchasing policy and constant vigilance coupled with intelligent planning and sensible demands upon the capacity available. It is seldom achieved by bullying tactics even though there is sometimes evidence to suggest that the sins of the larger users are more readily overlooked than those of users who make only modest demand on foundry capacity.

10. QUALITY ASSURANCE

The ISO 9000 series has been adopted in New Zealand as an internationally recognised quality standard.

The attainment of one or more third party certified internationally recognised quality management systems goes a long way to establishing a good purchaser/supplier relationship.

Close liaison between purchasing and quality assurance personnel is essential for successful castings buying. Both should have an involvement with the supplier and it is important that there are good communications between the two departments.

Visits to and from the foundry should be encouraged and, by means of a formal or informal system audits, depending on the circumstances of the buying company, quality approval should be sought before new suppliers are introduced.

This is not to say that every foundry should be expected to have highly sophisticated inspection equipment or an army of white coated inspectors but that quality assurance arrangements at the foundry should be satisfactory for the type of work they are required to produce.

The technology of quality assurance has progressed over the years and a brief reference to some of the techniques and terminology in the following list may be helpful.

Hardness. *Brinell hardness.* A comparative measurement of hardness obtained by pressing a steel ball of known diameter into the surface of a material under a standard pressure and measuring the diameter of the impression. The higher the number, the greater the Brinell Hardness (BHN) (see also Rockwell Hardness). *Rockwell Hardness* Similar to Brinell Hardness in that hardness of the material is determined by indenting with a steel ball or diamond cone under specific loads. There are three scales, A, B and C, utilising respectively, diamond cone 60kg load, steel ball 100kg load and diamond cone 150kg load.

Cast Analysis Test pieces cast from the same heat as the casting used to obtain the chemical analysis of the casting. Results obtained may vary in different parts of the castings and must therefore be carefully interpreted. *Spectrochemical Analysis* A means of examining suitable machined test pieces and verifying the existence of known elements in correct proportions.

Mechanical Properties. *Charpy Impact Test, Ultimate Tensile Stress, 0.2% Proof Stress, % Elongation,* are performed from a specially prepared bar either cast onto the casting or cast separate from the same heat. It is important that the bar is metallurgically treated with the casting through casting manufacture to ensure its properties properly represent those of the casting it relates to.

Non Destructive Surface Inspection. *Dye Penetrant Test* A fairly inexpensive non-destructive method of examining castings for surface defects. Castings are dipped into, brushed or sprayed with a fluorescent dye. The surface is wiped dry and viewed under ultra violet light. Faults are readily discernible. *Magnetic Particle Inspection* Suitable for use only on ferrous magnetic materials. A powdered magnetic material is applied to a magnetised surface. Cracks are readily identified by the accumulation of iron powder at the flux leakage resulting from the crack. Detection can be facilitated by pre-painting the area white or using iron powder coated with fluorescent material. *Visual Inspection* A simple inexpensive procedure for eliminating castings possessing obvious faults.

Gauging Enables castings to be checked on critical dimensions on a production basis.

Pressure Test Apertures are sealed off and the casting filled with water or oil. Pre-determined pressure is built up and maintained while the casting is examined for leaks.

Proof Machining Limited machining operations designed to expose faults at an early stage.

Radiography X-Ray and Gamma Ray examinations are similar except that Gamma Ray procedures permit several exposures of different parts of the casting at any time. The Gamma Ray process is, however, much slower and the resultant film less readily interpreted than the single shot X-Ray process. X-Rays are normally used for thin sections and Gamma Rays for heavier sections. Radiography is extremely costly and should only be used for high integrity castings.

Ultrasonic Test Internal defects can be identified by transmitting high frequency through the material. Defects are identified by the reflections of the transmitted signal which are generated when a defect is encountered. The reflected signals are reproduced on an oscilloscope which enables the operator to establish the precise position of the defect.

Microstructure. The metallurgical condition of the casting is analysed under the metallurgical microscope and the microstructure reported on. Perhaps for Graphite shape in the case of a Grey or SG iron, grain size of a steel, proportion of β phase in a Manganese bronze or to confirm effective Heat Treatment of an Austenitic Manganese steel.

Test Certificates. The analysis or other test results of those methods described above are often presented to the buyer in the form of a certificate. This certificate may be verified under the foundries own quality system or may be endorsed by ISO guide 25 laboratory quality system accreditation.

11. PITFALLS

11.1 BRAND NAMES

Generally speaking there is no magic in a brand name. The purpose is almost invariably to establish brand loyalty. Wherever possible, castings buyers are advised to use New Zealand or international standard specifications.

11.2 CASTING WEIGHT DISCREPANCIES

Whilst the castings buyer will find it useful and illuminating to convert castings prices into prices per kg it is a mistake to purchase on this basis.

In the event of an agreement between buyer and seller to adjust prices up or down depending upon actual versus estimated weight, the buyer must ensure that, if the weight of the casting shows an increase, the price is increased only by the metal content- labour and other costs remain unaltered.

It is advisable to agree in the enquiry stage the precise details of any price adjustment clause. By this means accurate comparisons may be made between various suppliers' quotations (see also Section 5.3: Foundry Costs).

11.3 PATTERN EQUIPMENT CONDITION

This is a very neglected area resulting in quality and delivery failure and often increased cost. Suppliers should be encouraged to examine and report on patternequipment condition at the end of each production run or at regular intervals of time.

Foundries are often guilty of returning pattern equipment to stores on completion of an order or production run without even a cursory examination. On the other hand, pattern equipment will become the focus of attention when urgent delivery is required, or when castings have been rejected or a price increase challenged.

Prevention is always better than cure and buyers are advised to budget annually for repairs and to insist that foundries provide the necessary information

11.4 POOR PROCESS SELECTION

The foundry industry today offers a wide choice of processes. Basic information has already been given on this subject and care must be exercised if optimum results are to be achieved.

If in doubt consult the foundry offering a range of processes or seek independent advice. Poor process selection is responsible for many of the problems which castings' users experience. Not only is it possible to develop high cost situations resulting from quality failures but choosing the wrong process can involve unnecessarily high cost by achieving standards which are not required.

Fitness for the purpose must be uppermost in the mind of the buyer when making this often difficult choice.

12. Summary of Helpful Hints

The following is a summary of helpful hints, many of which have already been mentioned under other headings. No apology is made for the repetition because, in the main, the importance of these points justifies it.

1. Always give potential suppliers casting weights if known.
2. View with suspicion all quotations submitted by the founder solely on a price per kg basis or any prices which appear to have been calculated in this way.
3. Insist on the supplier stating estimated weights on all quotations.
4. For the purpose of comparing suppliers, types of casting and differing metal specifications, and for statistical reasons, it is sometimes helpful to calculate the price per kg from actual or estimated weights but do not expect dissimilar castings in shape, weight or size to convert to a constant price per kg.
5. If changing sources, tell the new supplier of any quality problems. Do not transfer your quality problem with the pattern equipment.
6. Encourage suppliers to suggest design modifications to improve quality and to discuss their problems openly.
7. Always use the best pattern equipment you can afford relative to castings demand.
8. Seek to reduce costs by maximising the number of impressions per mould.
9. Encourage suppliers to report on pattern equipment at the end of each run. ,
10. Establish responsibility for routine pattern repairs.
11. Obtain estimates annually for pattern repairs/renewals to facilitate preparation of budgets.
12. Involve the supplier in your problems and advise any machining changes or introduction of new machine tools.
13. Insist on routine monitoring visits from suppliers according to the volume of business transacted.
14. Do not over specify.
15. Do not use vague specifications.
16. Do not expect good, consistent quality from cheap equipment or at unrealistic unit cost.
17. Look for positive, enthusiastic management attitudes among your suppliers and try to cultivate long term relationships.
18. Get to know who to contact for what purpose and encourage technical personnel to contact their opposite numbers at the foundry.

Appendix: New Zealand Standards

NZS/BS 1400:1985

Specification for copper alloy ingots and copper alloy and high conductivity copper castings

Specifies requirements for the chemical compositions, mechanical properties and other characteristics for (a) copper alloy ingots intended to be remelted for the production of castings and (b) copper alloy and high conductivity copper castings.

NZS/AS 1830:1976

Grey Iron castings

Sets out the requirements for the manufacture and testing of flake graphite grey iron castings produced in sand or ceramic moulds. It covers six grades for general engineering purposes, primarily to tensile strength requirements, classified as the 'T' series, and four grades for applications where hardness, microstructure and machinability are the prime requirements, classified in the 'H' series. Appendix A provides advice and recommendations on the information to be supplied by the purchaser at the time of enquiry and/or order, and other appendices include information on typical distribution and size of graphite flakes, and approximate variations of strength.

NZS/AS 1831:1985

Iron castings - spheroidal or nodular graphite cast iron

Specifies requirements for 6 grades of spheroidal or nodular graphite castings (also known as 'SG iron' and 'ductile' castings) in terms of mechanical properties, microstructure and freedom from defects. Appendices provide purchasing guidelines and information on graphite distribution.

NZS/AS 1832:1976

Malleable iron castings

Sets out the requirements for the manufacture and test-ing of two grades of whiteheart malleable iron castings, three grades of blackheart malleable iron castings, and five grades of pearlitic malleable iron castings, to specified mechanical properties. Appendix A provides advice and recommendations on the information to be supplied by the purchaser at the time of enquiry and/or order.

NZS/AS 1833:1976

Austenitic iron castings

Sets out the requirements for the manufacture and testing of nine grades of flake graphite austenitic iron cast-ings, to specific chemical composition and mechanical properties. Appendix A provides advice and recommendations on the information to be supplied by the purchaser at the time of enquiry and/or order, and other appendices give information on physical and mechanical properties,

applications of the castings, typical test bars, and designation of the microstructure of graphite in cast iron.

NZS/AS 1874:1969

Aluminium and aluminium alloys - ingots and castings

Specifies requirements for aluminium ingots and aluminium alloys, ingots and castings

NZS/AS 2074:1982

Steel castings

Specifies requirements for carbon, low alloy and high alloy steel castings for pressure and general engineering purposes. Includes appendices setting out purchasing guidelines and indicating suitable grades for specific applications.

Copies of New Zealand Standards may be obtained from:

Standards Association of New Zealand, Private Bag,
Wellington