QUALITY MANAGEMENT IN PROCESS PLANT MANUFACTURE.

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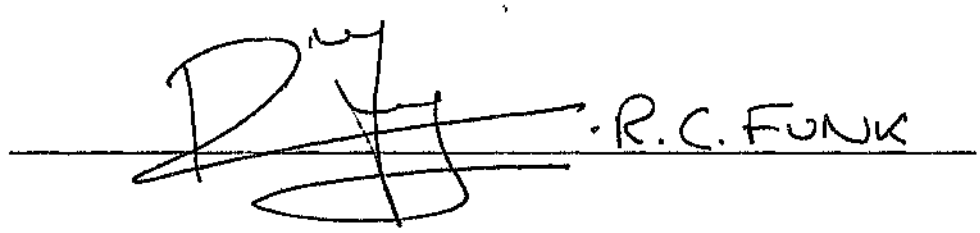
DECLARATION

This is an investigational project report and is being submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in partial fulfillment of the requirements for the degree of Master of Science in Engineering. I declare that this dissertation is my own, unaided work. It has not been submitted before for any degree or examination in any other University.



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SYNOPSIS

This investigational project is concerned with quality management in the process plant manufacturing industry. Process plant manufacture can be defined as the design, manufacture and installation of pressure vessels, pipework, heat exchangers, storage vessels, etc., for the power generation, chemical and oil processing industries, food and beverage, metals producing and mining industries. It is a sufficiently homogeneous industry in terms of manufacturing technology, supplier/purchaser relationships and manufacturing practices for similar quality assurance (Q.A.) and quality control (Q.C.) practices to be employed.

The scope and aims of the project cover the following:

a) Studying the requirements of Quality Management system standards, with particular reference to the new ISO 9000 series of standards.

b) An investigation into the present state of quality assurance in industry, with emphasis on the process plant manufacturing sector.

c) Studying the economic aspects of quality assurance, again with emphasis on the process plant manufacturing sector.

d) To obtain experience and feedback from the implementation of a formal quality management system, based on the Quality System standards, into a manufacturer of process plant equipment.

In order to achieve these aims, a general discussion on quality concepts, Quality Management standards and Quality Assurance in process plant

manufacture is followed by a detailed case study at a local manufacturer of process plant equipment. Feedback obtained from the implementation of the quality system in this company would also apply to other suppliers of process plant equipment in this country.

Most texts tend to refer to Q.C. and Q.A. of high volume manufactured items according to essentially standard spec.fications, which are usually generated by the manufacturer himself via the design department. The Q.A. approach here is very different from that applicable in process plant manufacture. In process plant manufacture, the following are different from high volume manufacture:

a) The degree of clie involvement at all stages tends to be much higher.

b) The complexity of the product tends to be much greater.

c) The uniqueness of each plant.

d) The time taken to "manufacture" the product (from design through to final commissioning tends to be very long).

e) The consequences of lack of quality, in terms of economics, safety and statutory requirements, tend to be much greater.

Some of the special features of the process plant manufacturing industry mentioned above actually determine to a very large extent the practical application of the Quality Management System standards.

The products are high value and in many cases are unique in the sense that each plant is different. They are thus "one-off" items tailor-made for that

particular client or project and therefore mass production Q.C. methods are not usually relevant.

The uniqueness of the items means that they are often manufactured to customer specifications. These detailed instructions may refer to specific quality control activities to be undertaken by the manufacturer. The quality approach to be adopted by the supplier is thus often dictated by the customer.

The items involved in the industry are also usually part of a large project or system. A failure in one item (late delivery as well as actual failure) may affect the entire project or system. There are usually safety aspects to the process plant products as well.

The economic consequences of poor quality can be enormous in the process plant industry, due to consequential costs rather than the direct cost of repair. This direct cost may be relatively small, depending on the extent of repair required and accessibility for repair. In many cases this cost would not be borne by the purchaser if it can be proven that the supplier had not met contractually agreed upon quality standards. The consequential costs, which are primarily due to lost revenue because of inoperative plant, are in general borne by the purchaser of the defective plant and tend to be very high.

The arguements presented for justifying Q.A. from an economic point of view are biased, depending on whether one is the manufacturer or client. This is because the balance between risk and expenditure is not the same for each party. The manufacturer is in a relatively low risk/high expenditure situation because he has to spend significant sums of money to maintain the Q.A. system.

The client on the other hand is in a high risk/low expenditure situation. His expenditure is relatively low because he merely assesses and generally monitors the performance of his suppliers. However, should a failure occur and the production capacity of the plant suffer or a quality problem delay the project, then the consequential costs suffered by the client can be enormous.

The costs of a Q.A. system are therefore easily justified by the client, by pointing out that an effective quality system should reduce the risks of plant failures. Furthermore, reductions in insurance premiums due to reduced risks of failure for manufacturer and supplier, also provide economic justification for a quality system.

The manufacturer is faced by a relatively high Q.A. expenditure situation and must weigh up the cost of increasing his levels of quality control against the incremental increase in quality assurance obtained and potential reductions in repair and rectification costs. The client will naturally argue that the increased costs incurred by the manufacturer are not worth considering if the extra quality control will reduce the risks of an expensive failure.

Unnecessary quality related costs and inefficient quality programmes should be avoided, however, because they must eventually be paid for. The manufacturer must realise a reasonable profit to stay in business and the cost of quality programmes must eventually be passed on to the client. It is thus in the interests of both parties to ensure that an efficient, effective quality system is operated by the manufacturer which provides the client with an adequate assurance of product quality.

With regard to methods of manufacture, "Special Processes" are usually of critical importance in this industry and failure to control special processes

is often the cause of quality problems. Particularly strong emphasis is thus placed on the Q.A. of these special processes. In the context of Q.A. these special processes refer mainly to welding, heat treatment and non-destructive testin.

Process plant equipment tends to be manufactured to detailed technical specifications which may include relevant national or international standards. (e.g. ASME codes for pressure vessel manufacture). The specifications and standards can be very specific regarding acceptable quality standards, inspection requirements and documents to be generated.

Contractual matters also influence the quality systems applicable in this industry. Manufactured items in this industry tend to be part of a larger project involving many organisations such as the clie , consulting engineers, major contractors, sub-contractors and inspection authorities. These various organisations will have contractual relationships with one another (which will include responsibilities and obligations in respect of Q.A.) and they all have some say in the quality system of the manufacturer. This is a complicating factor and tends to take away some control from the manufacturer, which is contrary to quality management principles. These principles state that the manufacturer is entirely responsible for the quality of the product. Although not satisfactory, the situation is inevitable because of the wide range of specialist skills required in the process plant industry.

Another contractual matter is that any statutory requirements must be contractually met as well. This requirement adds a further dimension to the quality policies of the manufacturer.

Finally, there is also a tradition in this industry of utilising third party inspection authorities to provide independent checks on the quality of items manufactured or installed. This manufacture - then - inspect approach tends to be less cost effective than the modern Q.A. approach of controlling design and manufacture to avoid quality problems.

All these factors were taken into account when developing and implementing the new quality system at Huppmann Fabrications, a local manufacturer of process plant equipment, in the case study section of the report. The company had been awarded a major contract by their most important customer, and was placed under great pressure to implement a formal Q.A. system. This system was to be utilised during the design, manufacture and installation of the contract.

An appropriate system was developed and implemented for the company. Experiences gained from both the workshop and site environments provided indicators for future directions the quality system at the company should take. The feedback obtained from the quality system should prove useful to other process plant manufacturers faced with the task of implementing a formal quality management system into their company.

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1. INTRODUCTION

1.1 The rise of Quality Assurance in South Africa.

In recent years there has been a trend worldwide towards more stringent customer expectations with regard to the quality of the products and services which they intend to purchase[1]. Many companies have realised that improvements in quality tend to result in an improved economic performance of the organisation. Improved quality of products or services are accompanied by increases in productivity, efficiency and market penetration.[2] The use of Quality as a major strategic weapon for a company has been highlighted by the remarkable success of the Japanese industry, which has often been attributed to their emphasis on Quality as a competitive edge.[3]

Previously acceptable levels of defects, reliability, poor workmanship etc., have become unacceptable in today's marketplace. The rise of consumerism in America during the 1960's, led by Ralph Nader and action-line columns in newspapers, resulted in a greater public interest in quality and safety of products.[4] Laws such as the Consumer Product Safety Act passed by the U.S.Congress in 1972, were aimed at preventing hazardous or defective products from reaching consumers.[4] In more affluent nations such as America or Europe, a more demanding consumer began to emerge who preferred to do without rather than pay for second best.[4]

Disasters which have incurred loss of life and equipment (such as the explosion of the chemical plant at Flixborough), as well as the rising cost of replacement plant and equipment, have resulted in the purchasers of

engineering products placing greater pressure on suppliers to provide assurance of product quality and reliability.

In South Africa, the situation is similar. Although the "average" consumer remains relatively unsophisticated and undemanding when compared with the more affluent countries, the purchasers of engineering products have become more demanding in terms of quality expectations. According to Jan de Vries of Sastech,[5] 80% of all equipment received by SASOL during the 1987/1988 period had to be returned to the fabricator or had to be repaired on site. He cites the reasons for this as being

(a) incomplete or incorrect interpretation of requirements;

(b) lack of in-house Quality Control.

Although many manufacturing industries in South Africa are making significant efforts to implement quality improvement programs,[6] clearly there are still many areas that need improvement. Since 1950, the operation of the South African Bureau of Standards (SABS) Certification Mark Scheme has required the application of "quality control" in those factories operating under this scheme. During the sixties, extensive attention was given to promoting quality control in South Africa. In 1976, the Council of the SABS was requested to investigate the need for Quality Assurance and ensure co-ordination of its application.[6] This led to the publishing in 1979 of the SABS code of practice 0157 for Quality Management Systems.

At this point, it is perhaps appropriate to clarify the use of these quality terms. "Quality Assurance" is the term given to the management system in an organisation which both ensures the quality of the final

product or service is correct, and that there is evidence of this satisfactory quality. "Quality Control" on the other hand refers to the physical actions (inspections, process monitoring) which are undertaken to help obtain this assurance.[7] The term "Quality Management" has also entered the quality terminology and can be used to describe the management system used by an organisation to control and "guarantee" his quality,[8] i.e. an organisation uses a "quality management" system to manage, amongst other things, "quality control" to provide "quality assurance." This is confusing and in this report, "quality assurance" and "quality management" will be taken as meaning the same thing i.e. the management system used to provide assurance of quality.

There has been a growing trend in South Africa, for purchasers to place increased pressures on suppliers to introduce formal quality systems, in order to provide this quality assurance.[4] The reasons are clear. Poor quality products or services are bad for a supplier's reputation and thus business in the future, as well as involving him in repair or replacement costs. The party most immediately affected by the poor quality however, is the purchaser. These consequences can conveniently be broken down into "economic", "safety" and "statutory" or "regulatory" aspects.

Under economic consequences for the purchaser one could consider the costs incurred due to the following situations:

(a) The performance of the product may be downgraded due to poor quality on receipt, or else may need repair.

(b) The product may be delivered late due to unanticipated repair work.

(c) The product may fail in service due to poor quality.

The above situations will lead to direct costs of repair as well as consequential costs resulting from non-operation (or reduced performance) of the equipment or system of which that defective product forms a part. Direct costs of repair will usually be passed on to the supplier, if he can be proven to have not met contractual requirements. The consequential costs however, will usually be borne by the customer, and these can be many times higher than the direct costs of repair.

The second consequence of poor quality, namely "safety", will be considered next. Due to sub-standard quality, a product can cause safety hazards and endanger lives. Take for example a service failure in a plant containing toxic substances. The operators (and thus purchaser) tend to bear the consequences of these failures. Financially, this may include damages paid to victims of the failure as well as more stringent (and thus expensive) subsequent controls imposed upon the purchaser.

Related to the above are the statutory requirements and product liability consequences of poor product quality. In 1965, the American Law Institute for example, issued its "Restatement of the Law of Torts" which made manufacturers liable for product defects even without proof of negligence.[4] There is thus often a need to comply with statutory safety requirements in terms of product safety and potential liability claims. A formal quality system can provide the discipline to ensure that regulations are complied with as well as providing evidence of this compliance.

Product liability can then be defended via "development risk" type arguments if "reasonable" precautions have been taken.

Quality Assurance (Q.A.) would provide this evidence and should lessen the risk of failure anyway. In fact, another advantage of having an effective Q.A. System in a company (and evidence to prove this) is that it will minimise product liability insurance premiums, which can be quite substantial [7]

It is thus understandable that suppliers are being pressurised into adopting Q.A. systems. There are however, also suppliers who wish to introduce formal quality management systems into their companies without customer pressure. They realise the strategic advantages to be gained. Improved reputation in the marketplace and minimising risks against product liability claims would be some of these benefits. A more productive company due to a more efficient conversion of resources into products would be another benefit.

1.2 Scope & Aims of Investigational Project

The aims of this investigational project can be summarised as follows:

a) To study the requirements of the Quality Management system standards, with particular reference to the new International Standards Organisation, ISO 9000 series of standards.

b) To investigate the present state of Quality Assurance in industry, with particular emphasis on the process plant manufacturing sector.

c) To study the economic aspects of Quality Assurance, again with emphasis on the process plant manufacturing sector.

d) To obtain experience and feedback from the implementation of a

formal quality management system, based on the Quality System standards, into a manufacturer of process plant equipment.

In order to achieve these aims, a general discussion on quality concepts, Quality Management standards and Quality Assurance in process plant manufacture will be followed by a detailed case study at a local manufacturer of process plant equipment. Feedback obtained from the implementation of the quality system in this company would also apply to other suppliers of process plant equipment in this country.

2. THE QUALITY OF A PRODUCT OR SERVICE

2.1 Introduction

In view of the fact that this project is concerned with Quality Assurance and Quality Control, it is appropriate at this stage to adequately define what is meant by the quality of a product or service. Numerous definitions of quality exist, which tend to view quality from different perspectives. Garvin[1,6] has developed a comprehensive framework which presents each observer's perspective.

2.2 Five Perspectives on Quality

2.2.1 The Transcendental Approach

This is the approach of philosophy, and refers to an "innate excellence" which is universally recognisable through experience. This is a vague and highly subjective approach which is not of much use in the manufacturing context.

2.2.2 The Product-Based Approach

In this approach quality differences reflect differences in the quality of attributes of products. Performance of the product is one of the attributes. Performance can be said to be the ability of the product to perform its technical function in a satisfactory manner and at an economically acceptable cost.

Product durability is another attribute and refers to the amount of usage an individual obtains from a product prior to its breakdown.

Product features are secondary attributes when compared to performance. They can be considered as the "bells and whistles" and may be personal to the individual.

2.2.3 The User-Based Approach

In this approach the user relates quality with the extent that some want or need is satisfied. This tends to be based on personal judgement and is thus subjective. As Feigenbaum states[17] "quality is what the customer says it is, not what the engineer or marketing man says it is." Sometimes the customer does not possess complete information as to the product's attributes and thus relies on indirect measures as suggested by images, advertising and brand names. Together with aesthetics, this perceived quality makes up the user based approach.

2.2.4 The Manufacturing-based Approach

The manufacturing based approach to quality is of particular relevance to this project because it considers quality from the supplier's point of view. It implies "conformance to specifications" in terms of designed specifications, the assumption being that the design satisfies the requirements of the customer as well as any applicable national construction standards.

2.2.5 The Value-based Approach

Garvin states that "Quality is increasingly apt to be discussed and perceived in relation to price." i.e. Provision of performance or conformance to requirements at an acceptable cost. This

value-based approach is becoming more prevalent according to him and implies that quality is being equated with value, or "affordable excellence."

In line with this, Chase[18] is of the opinion that "in today's global market, superior value is the preferred market share capture strategy." When product design displays close fidelity to consumer needs, in conjunction with product conformance to design specifications, "a winning synergy of product differentiation by high quality and competitive price results in superior customer-perceived value."

Garvin summarises his article by developing what he calls the "Dimensions of Quality" as follows:

a) Performance

b) Features

c) Reliability

d) Conformance

e) Durability

f) Serviceability

g) Aesthetics

h) Perceived Quality/ Image

According to Garvin, the manufacturer should always be striving to improve or add further dimensions of quality to his product or service.

2.3 A Definition of Quality

John Groocock[19] has defined quality as follows:

"The quality of a product is the degree of conformance of all the relevant features and characteristics of the product to all of the aspects of a customer's need, limited by the price and delivery he or she will accept."

This definition includes a number of perspectives mentioned above and is a useful one for the manufacturer because it includes the manufacturing approach of "conformance" as well as the user and value approaches of "need" and "price". Quality is thus "what is wanted" as well as "when it is needed" and has two aspects to it, namely accuracy or conformance, as well as timeliness. Quality Management then becomes a management system which is utilised to ensure that the customer is provided with what is wanted/needed (there is sometimes a subtle difference between the two), when it is needed.

2.4 Major Factors Influencing Quality

The five main factors which effect the quality of products can be summarised as follows:

1. Design

   The design and thus engineering specifications, together with quality specifications will affect the final quality of the product to a great extent. More specifically; the degree to which the design and related specifications, meet the needs of the customer whilst being compatible with the capability of operators, equipment and materials available.

2. Equipment

The compatibility of equipment with the design, its range of capabilities and its state of repair.

3. Material

The quality of incoming material, testing performed on material and methods of storage and packaging.

4. Scheduling

One aspect of "quality" which is particularly relevant in process plant manufacture, is that of timely delivery of products or timely commissioning and completion of projects. Scheduling within the factory as well as project planning thus clearly influences quality.

5. Human Performance

The influence of the human factor upon product quality will vary, depending on the degree of mechanisation or automation of the manufacturing process. This performance is a sum of ability and motivation. Ability in turn is affected by training, experience and the "potential" of that individual.

Individual motivation is itself an enormous topic, beyond the scope of this project. Amongst the factors influencing motivation are the general working environment and "Company Culture" within the organisation. Under this Company Culture would be included the attitude of the company towards its employees, expectations placed on employees in terms of job performance and the degree to which employee performance is rewarded.

> Under the topic of rewards, one can add that it is the value of the potential rewards and the effort required to earn those rewards, as perceived by the employee, which are of paramount importance. When rewards are given, then the perceived fairness of reward allocations also influence the motivation of the individual.[19]

The above mentioned factors would need to be carefully adressed by the Quality Management system utilised by a company, to ensure that they are not being detrimental to product quality.

3. QUALITY MANAGEMENT STANDARDS

3.1 Historical Developments

According to Rogerson[7], the introduction of "quality" as a separate discipline from design and production engineering disciplines probably arose due to advances made in the use of statistical quality control (SQC) techniques. These techniques, based on inductive statistics and informative sampling, were developed by the Americans and introduced to Japan in the 1950's.[8] SQC revolutionised quality control at the time and was applicable to manufacturers utilizing batch production or continuous production methods.

The limitations of the techniques were soon apparent to the Japanese and SQC became merely one of the tools of a new quality control approach. It was realised that all departments of a company (marketing, design, purchasing, etc.) and all the employees of the company had a contribution to make towards final product quality. This led to the development of company wide quality control which is the most important feature of Japan's Total Quality Control (TQC) today.[9]

3.2 Total Quality Control in Japan

First coined by Feigenbaum in the 1950's, Total Quality Control was seen by him to mean[7]:

"an effective system for integrating the quality development, quality maintenance and quality improvement efforts of the various groups in an organisation, so as to enable production and service at the most economic levels which allow for full customer satisfaction."

Although the approaches of Japanese TQC to include all departments in a company in the quality control system is applicable to all organisations, the actual techniques utilised are generally more applicable to batch and continual production methods. However, many of the principles and concepts of TQC are sound quality management principles applicable to any organisation, and include[4]:

i) Assigning primary responsibility for product quality to the production department rather than the Q.C. department. This puts responsibility back to those people closest to manufacturing the products.

ii) Developing a habit of improvement in all aspects of the operations of a company. A doing away with the typical American precondition that a favourable cost-benefit ratio be demonstrated prior to attempting any quality improvement projects. This has the affect of stifling quality improvement ideas. The traditional Western approach is illustrated in Figure 3.1. It maintains that there is a certain level of Quality Control which should be applied to minimise total cost. These are the "mathematics of mediocrity" as Price[2] puts it and is a doctrine of defeatism. The Japanese approach is that quality improvements are generally economically desirable and lead to reduced costs eventually.

iii) Process control rather than merely inspecting products; process capability studies, process monitoring and feedback information, leading to a reduction in unwanted variations in the manufacturing process.

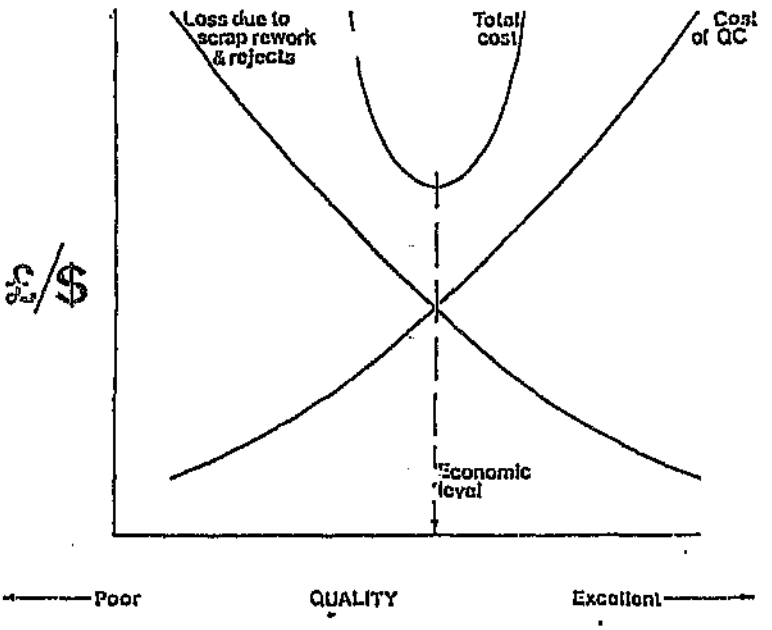


FIGURE 3.1 Quality Costs versus Quality Levels

iv) Easy to see and understand quality standards, quality performance etc. The Japanese tend to push information on quality data down levels in an organisation in order to educate the workforce and provide information necessary to analyse problems and propose solutions. The typical Western approach[10] is to feed information upwards in order to provide middle management with useful summaries. The assumption is made that these quality problems are the responsibility only of management, instead of supplying information to the people most directly involved in manufacturing the products.

v) Insistence on meeting established quality standards and giving production workers the authority to stop production processes in order to avoid producing defective products "puts teeth in the priority policy of quality first and output second."[11] Western quality departments often give in to pressure from manufacturing, passing components, sub-assemblies etc. which do not meet quality standards. This serves to undermine the entire Quality Control system.

vi) Correcting one's own errors rather than utilizing a separate re-work crew is a TQC concept which serves to complete the loop of assigning responsibility for quality to production. It provides effective feedback to the source of quality problems and allows for corrective actions to be taken.

vii) The TQC principle of performing 100% inspection where possible of products at various production stages as well as final inspection, is in contrast to the traditional Western approach of

lot-acceptance sampling using statistical methods. All statistical methods of sampling imply that a certain number of defects will be inevitable. The only method of ensuring that no defects have been produced is by 100% sampling, but the fatigue factors, time and expense of sampling large numbers usually makes 100% inspection impractical. The solution is to automate the inspection process and this has been done very successfully by many Japanese firms and is now being incorporated in Western companies as well. Toyota Motors has virtually eliminated the need for Statistical Quality Control[3] by the use of Source Inspection and "Poke-yoke" devices, as developed by Shigeo Shingo.

The idea is that defects occur because errors have been made. The ideal situation would be to catch these errors at the source before they become defects. The "Zero Quality Control" approach of Shigeo Shingo, is to utilise "poke-yoke" or error-proof devices. These perform 100% inspection and provide immediate feedback and action at the source of error, thereby preventing defects from being made. Utilizing this approach, by 1977 Matsushita achieved their first zero-monthly defects of 30,000 washing machines.[3] The ideal of zero defectives had been achieved! The 'Zero Quality Control' system is aimed at high volume production, but the principles can really be applied in any manufacturing system.

viii) TQC advocates continual quality improvements thus rejecting any notions of acceptable quality levels. In making quality improvements, the Japanese utilize structured, project-by-project improvement programmes. Typically, some sort of

committee will review proposed quality improvement projects, of which the best are selected and assigned to project teams to be worked on.[11] These proposals will tend to originate from the shop floor. All too often in Western companies, employees feel that poor quality is "in the system" and that exposure of problems could result in someone getting into trouble.[12] Schonberger[11] warns, however, that "workers and foremen can only solve about 15 percent of quality control problems. The rest must be handled by management or the engineering staff. The workforce can deal with the trivial matters, but major quality matters related to vendor relations, management policies, process and product design are outside the control of production staff."

ix) In the Japanese approach the Q.C.Department becomes a facilitator because primary responsibility for quality has been assigned to production.[4] As facilitator the Q.C.Department concentrates on the removal of defect causes, keeping track of quality accomplishments, monitoring of operations to ensure that standard procedures are followed and liaising with purchasing department to monitor supplier quality standards. The Q.C. Department also co-ordinate Q.C. training, monitors and analyses internal and external failures, and ensures that special inspections are performed which are required by customers, standards or legislation. The Q.C. Department may also carry out final sampling audits that measure the quality levels of outgoing products.

x) Housekeeping is also stressed by TQC[11] because it provides an environment which is conducive to improved work habits, quality

and care of facilities. Related to this is that of product handling whereby incoming material, work-in-progress and finished goods, are kept clean and protected.[10] Responsibility for the above rests with workers and foremen once again.

xi) Daily machine checks are performed because faulty machines are often the cause of defects. The machines are pampered through series of checks and adjustments by operators themselves,[11] in contrast with the Western worker's over-reliance on the maintenance department.

In summary then, TQC emphasises operator rather than Q.C. department responsibility as a means of obtaining the desired process control of manufacturing. The philosophy of TQC is based on logic, is directed towards simplicity and doing things right. As such, it is applicable to any organisation seeking to attain product quality excellence. The approach of TQC to involve all departments of a company is also reflected in the Quality Management standards, which shall be reviewed shortly.

A further aspect of TQC which needs to be discussed is that of Q.C. Circles. This idea was born in Japan in 1962,[3] when it was pointed out that if people on the shop floor are really the ones who generate quality, then those people should formally participate via QC circle activities. These QC circles formally mobilise small, voluntary teams in order to improve quality and productivity. There appears to be conflicting information about the success of these QC circles.

On the one hand, Shigeo Shingo[3] claims that the international acclaim for the quality of Japanese products was due more to QC circle activities than

SQC methods themselves. Schonberger[11] on the other hand states that QC circles should only be used to wring the last defects out of a production system, and that disappointment will occur if they are introduced too early into a company. Furthermore, Deming[13] states that most of the causes of poor quality belong to the "system" and are thus beyond the power of the workforce. Shigeo Shingo also warns that success of the QC circles in Japan is due to the group-orientated character of the Japanese people and that they may not be successful in the typically adversarial Western atmosphere between workers and management as well as the emphasis on individualism in the West.

In South Africa there have been attempts at introducing QC circles into companies and there are approximately 3000 circles operative at present.[6] The National Association of Productivity and Quality Circles of South Africa (NAPROQCSA) was established in 1986 to promote the QC circle concept and provide guidelines for their successful implementation.

The actual success of these Q.C. circles in South Africa remains unclear. Toyota in Durban has had great success with their QC circle programme and they suggest that teamwork comes naturally to the Zulu workers because of their group-orientated culture.[28] The success of their QC circle programme is probably also due to their inheritance of Japanese management attitudes from their parent company. The growth of Trade Unionism in South Africa, which has resulted in the present lack of solidarity between workers and management in many unionised industries, as well as the view by some Unions that QC circles are means of exploiting workers, are factors which are detrimental to the successful implementation of QC circles in this country.

In general it does appear that QC circles can work in the West, but they require good relationships to exist between management and workers, they need the development of teamwork attitudes in a company and they tend to be used in larger, mass-production type environments. Finally, they require an "enlightened" management approach.

3.3 Quality Management System Standards.

The development of quality system standards arose when it became necessary for customers to satisfy themselves that their suppliers were utilising satisfactory quality policies.[7] There was also a need to develop a management criteria framework for organisations wishing to implement formal quality systems. In order to check and approve the quality systems utilized by a number of suppliers with varying organisational structures and hence varying quality systems, the customer needed a standard against which to assess them. Hence the development of quality system standards and their bias towards the client's needs.[7]

The first "clients" who recognised the need for these methods of assessing their suppliers' competence in a quality sense, were military procurement bodies. This was due to costly delays which had occurred in several projects, when major quality problems were encountered, as exemplified in the paper by Admiral Rickover.[14] In it he details the type and extent of quality problems incurred by the US Navy in obtaining their Polaris Missile system. The 1960's thus saw the introduction of a series of quality standards for military procurement purposes.

In the U.K. this led to the introduction of civilian versions of the military standards, - BS 5179. This British standard was carefully

defined as a guide to the requirements for a quality system and was eventually superseded by BS 5750. The rise of nuclear power projects in Europe and the USA quickly resulted in the introduction of similar nuclear quality standards, ANSI N45 in America and the British BS 5882 in 1980.

The late 1970's saw the growth of formal Q.A. by many purchasers of heavy, expensive plant, which led to a proliferation of standards issued by these purchasers. This was confusing and undesirable, and resulted in the introduction of BS5750, Parts 1, 2 and 3 to cover the requirements of all purposes (except nuclear systems). The South African SABS 0157 standard is essentially identical to this standard. The Canadian standard CSA Z299 is a comprehensive one which covers general purposes as well as nuclear requirements at its Level 1.

In 1987 the International Organisation for Standardisation (ISO), which is a worldwide federation of national standards bodies, produced the ISO 9000 series on Quality Assurance. This new standard, which has subsequently been adopted by the SABS as well, is an improvement over the older standards because it is clearer in its intent and is easier to understand. It also provides improved guidelines for implementation. Although there are some differences between the new standard and the previous South African standard, they are essentially the same. A company wishing to implement a formal quality system will naturally choose the new standard because of these improvements and the added trade advantage of conforming to an international quality standard.

There have also arisen a number of industry specific standards and guidelines to implementation of quality standards (e.g. SABS Recommended Practice for the application of SABS 0157-1987 within the Pressure

Equipment Manufacturing Industry). These are based on the criteria of the general purpose standards, but offer more industry specific guidance than is possible in the general purpose standards.

The quality management system's aim is to avoid the following situations which would contribute towards quality problems.

a) not identifying a client's requirements or expectations.
b) lack of design proving
c) inadequate drawings and other work instructions
d) lack of control of purchase items and subcontracted work
e) insufficient time to achieve the required quality
f) inadequate maintenance of production machines
g) inadequate training of personnel
h) inadequate data collection and subsequent analysis
i) inadequate or incorrect use of basic statistics
j) unclear organisational responsibilities
k) not knowing the costs of quality to the company concerned.

These situations would be remedied by an effective quality management system.

The quality system standards define various management criteria for a system but not technical criteria, nor how these management criteria are to be met. This is because every organisation is different in terms of methods of working, personnel and resources. The standards define matters such as which activities need to be controlled, responsibilities, when written procedures or instructions are required, need for calibration of inspection equipment, need for systematic reporting, analysis of defects

and non-conformances, and the need for regular, systematic quality audits.[1] They may be regarded as a Total Quality Control approach because all aspects of a companies activities related to the final product or service are covered i.e. from contract review through design and manufacture, to final delivery or installation.

The management control elements which are addressed by the more rigorous standards (such as ISO 9001 of the ISO 9000 series, or SABS 0157 Part 1) can be summarised as follows:

1. Documented Quality System.

The supplier's quality system shall be documented and include the quality management objectives, policies and procedures which demonstrate compliance with that particular quality standard.

2. Organisation.

This requirement states that the organisational structure shall be documented and take into account the inter-disciplinary nature of quality assurance activities. Those performing the operation are responsible for its quality but audits of the quality system, processes and products shall be carried out by personnel with no direct responsibility for the work being performed. Someone with sufficient management position and authority must be appointed, responsible for monitoring the quality activities to ensure that the quality standard is being adhered to. Often this requirement is met by appointing a Quality Manager with only these responsibilities. This is not a requirement of the standard and would be a costly way of meeting the requirement in a small company.

3. Contract Review.

Procedures for contract review are to be established and each contract should be reviewed to ensure that requirements are adequately defined, requirements differing from the tender are resolved and that the supplier has the capability to meet contractual requirements.

4. Design Control.

Procedures to control and verify the design of the product in order to ensure that specified requirements are met, appropriate standards are taken into account and that correct design documents are produced. Checks on the adequacy of the design via formal design reviews as well as controls on design changes are also required.

5. Documents and Document Control.

Documentation is needed to define requirements, provide work instructions, record and communicate inspection results and other management or engineering decisions, in order to provide objective evidence that quality is being controlled. Document control means that documents are reviewed and approved by authorised personnel prior to issue. Amended documents shall be reviewed as well and all obsolete documents are to be removed from points of issue promptly.

6. Purchasing.

The supplier is to ensure that purchased products conform to specified requirements. The standard defines in some detail the type of information needed for purchasing documents. Where

appropriate, the supplier shall establish procedures for identifying the product during all stages of production, thus providing traceability.

7. Process Control.

Production processes are to be carried out under controlled conditions. This requires documented work instructions defining the manner of production where the absence of these would adversely affect quality, use of suitable equipment, compliance with applicable standards and quality plans. Processes and products are to be monitored during production and installation. Criteria fo workmanship are to be in a quantitive form (e.g. dimensional tolerances) or qualitive form (workmanship samples). Special processes, such as welding, require compliance with documented procedures. Processes are to be qualified and records of qualified processes, equipment and personnel maintained, as appropriate.

8. Inspection and Testing.

The standard covers requirements for receiving inspection and testing (including that of purchaser supplied products), in-process inspections and final inspection and testing, in order to verify that conformance to specified requirements have been met. Non-conforming products are to be identified and segregated. Follow-up action to the occurence of non-conformances via repair, re-work or scrapping and the institution of action to prevent further occurrences (corrective action) is to be undertaken via defined procedures. Records are to be maintained which give evidence that the product has passed inspections, with defined

acceptance criteria. In the nuclear standards, the inspection is to be carried out by someone other than those performing the activity being inspected because of the extreme assurance required in this industry.

9. Inspection, Measuring and Test Equipment.

This equipment is to be controlled, calibrated and maintained as inspection and test results have no validity if the integrity and reliability of the inspection equipment is unknown.

10. Inspection and Test Status.

The inspection and test status of products shall be identified by using a variety of methods. Records shall identify the inspection authority responsible for release of comforming product.

11. Handling, Storage, Packaging and Delivery.

The standard requires that there be documented procedures for these activities. The aim of this is to prevent damage during transportation but more importantly, to ensure that critical material is stored and used correctly to prevent deterioration.

12. Quality Records.

These shall be maintained to demonstrate achievement of the required quality and effective operation of the quality system. The period for which records are to be retained needs to be established between client and supplier or may be determined by law.

13. Training.

Procedures for identifying training needs are to be maintained and subequent training of personnel effecting quality is to be provided. Personnel performing tasks shall be qualified on the basis of appropriate education, training and experience, as required.

14. Quality Audits.

Regular, documented internal audits of the quality system are to be carried out according to defined procedures and by "qualified" auditors who have no direct responsibility for the area or function being audited. Appropriate follow-up action is to be taken and documented.

3.5 Construction Standards versus Quality Management Standards

National construction standards are commonly referred to and this is especially so in the process plant manufacturing industry. It is important to understand their relationships to Quality Management standards and their inherent limitations.

In respect of "quality", these construction standards will tend to cover the following:

1) Design - methods, allowable stresses, safety features, etc.
2) Materials - type of material allowed and permissible operating conditions (temperature and environment).
3) Quality criteria - dimensional tolerances, defect acceptance levels (especially of welded joints).
4) Inspection methods - types of inspections required, when they

should be applied and extent of inspection.

A typical example of a construction code is the ASME Boiler and Pressure Vessel code. This code includes quality management system features within the standard and "accredited users" (ASME stamp holders) have the authority to claim their products are manufactured to standard. These "accredited users" have their systems assessed and audited, just as the quality management standards require auditing.

The ASME code is thus a very comprehensive standard and a little appreciated fact is that unless the company has the required quality system elements in place, the construction is not to standard. To use part of the ASME code in isolation is a dangerous situation eg. to analyse radiograph results to ASME without the design calculations having met ASME requirements.

The National Standards are produced by a body of experts expressing consensus views based on collective experience.(7) They tend to be general documents covering a wide range of circumstances. They cannot take into account very new technology (materials, manufacturing methods, designs etc.) because there can be no general consensus on new technology. The general nature of the standards means that they do not cover the specialised nature of certain items.

It is thus not always possible to define engineering or quality requirements of a product in terms of national standards. The client or supplier must then develop their own specifications in addition to, or partly modifying, the national standards.

There are also sound engineering reasons for stating that most national standards are too stringent. This is especially so in the area of special processes. For example, the quality of welded joints is defined in terms of the defects which the currently used NDT techniques can detect. Intense studies of the correlation between weld quality (as normally defined by the standards) and the actual performance of welded fabrications have indicated that these definitions of acceptable quality are illogical when considered in terms of structural performance[22]. The standards are too conservative, implying unnecessary repairs which of course add to the cost of welded fabrication.

There is ample evidence, going as far back as Salter and Gethin's study in 1972[23], to indicate that minor workmanship defects such as porosity and solid inclusions are not the cause of structural failures (ie. failures due to overload, fatigue or fracture). Those minor defects form the majority of defects found by the various forms of NDT.[22]

Methods for evaluating the importance of defects in a quantitative way have developed, so that engineering standards can be defined in a more logical way. These methods rely on a fracture mechanics analysis to predict a defect's propensity to initiate failure.

It is beyond the scope of this investigational project to delve into fracture mechanics theory. Construction standards such as ASME XI, based on a fracture mechanics approach, have been developed. Unfortunately, due to large discrepancies in fracture toughness testing of materials and problems with accurately determining the size of defects with present NDT techniques, these new standards have remained ultra-conservative. The presence of residual stresses (due to welding for example), further

complicates the matter because it becomes very difficult to know what the applied stress at a defect is.

It seems then, that for the immediate future we must be content with the present conservative construction codes. The Quality Management system adopted by a company must therefore be able to incorporate the specific quality requirements of any construction codes or "in-house" standards utilised by the manufacturer.

4. QUALITY ASSURANCE IN PROCESS PLANT MANUFACTURE

4.1 Introduction

Process plant manufacture can be defined as the design, manufacture and installation of pressure vessels, pipework, heat exchangers, pumps, storage tanks and structural steelwork, for the power generation, chemical and oil processing industries, food and beverage, metals producing and mining industry.[7] It is a sufficiently homogeneous industry in terms of manufacturing technology, supplier/purchaser relationship and manufacturing practices for similar Q.A. and Q.C. practices to be employed. The degree of these practices may vary considerably, however, (consider the differences in levels of Q.A. that would be applicable to the construction of a nuclear power plant when compared to a dairy).

Most texts tend to refer to Q.C. and Q.A. of high volume manufactured items according to essentially standard specifications, which are usually generated by the manufacturer himself via the design department. The Q.A. approach here is very different from that applicable in process plant manufacture. In process plant manufacture, the following are different from high volume manufacture:

a) The degree of client involvement at all stages tends to be much higher.

b) The complexity of the product tends to be much greater.

c) The uniqueness of each plant.

d) The time taken to "manufacture" the product (from design

through to final commissioning tends to be very long).

e) The consequences of lack of quality, in terms of economics, safety and statutory requirements, tend to be much greater.

This latter point was touched upon previously, and will now be considered in terms of the process plant industry.

4.2 Consequences of Poor Quality

The economic consequences of poor quality an be enormous in the process plant industry due to consequential costs rather than the direct cost of repair. This direct cost may be relatively small, depending on the extent of repair required and accessibility for repair. In many cases this cost would not be borne by the purchaser if it can be proven that the supplier had not met contractually agreed upon quality standards. The consequential costs, which are primarily due to lost revenue (i.e. if a brewery is out of production for one day, there is one day's loss of production and hence, we assume, profit) are in general borne by the purchaser of the defective plant and tend to be very high.

An idea of the magnitude which these consequential costs can reach, was given by Peddie[20] in 1976 and derived from experience in obtaining and commissioning power stations in the early 1970's. At this point in time, there was great activity in the U.K. in power station construction, but it was before the imposition of formal Q.A. programmes on suppliers. He gives the following costs due to delays in commissioning:

PROJECTED CONSTRUCTION COST : 350 MILLION POUNDS

IF A 1 YEAR DELAY ON ONE 50 MILLION POUND CONTRACT OCCURS,

THEN: EXTRA INTEREST CHARGES - 40 to 45 MILLION POUNDS

ESCALATION TO OTHER CONTRACTS - 10 to 30 MILLION POUNDS

EXTRA SITE COSTS: 9 MILLION POUNDS

USE OF LESS EFFICIENT PLANT FOR 1 MORE YEAR - 30 to 110 MILLION POUNDS

This is not to say that all delays to commissioning are due to quality problems, but it does indicate how high consequential costs can be. With potential quality related costs of this magnitude, there is a very sound economic argument for purchasers of process plant equipment to impose formal quality management disciplines upon their suppliers. They wish to ensure that as far as is reasonably possible, required quality is achieved and necessary measures have been taken to prevent failures from occurring.

The safety related consequences of poor quality can be considered in terms of safety hazards caused by service failures due to inferior quality. Service failures in pressurised plant, plants containing toxic or flammable products and structural systems, are always potentially hazardous in the sense of endangering lives or the environment. It is usually the operators and thus purchaser of the engineering products who bear the consequences of failure as well as subsequently imposed more stringent (and thus expensive) controls. Again it is in the interests of the purchaser to ensure as far as

possible that these failures cannot occur and that they can be seen to have taken all "reasonable" measures to prevent them.

The need to comply with statutory requirements in respect of product safety and the potential liability of a supplier under producer liability laws was mentioned previously. In the light of this and the potential hazards of process plants, it is in the interests of both supplier and purchaser to ensure that statutory requirements are met, reasonable precautions have been taken and documented evidence of this is available. A formal Q.A. system would provide this. Suppliers also find it necessary to provide adequate Quality Assurance, in order to protect themselves in terms of their reputation and their image in the market place.

It becomes a major problem in the application of formal Q.A. and Q.C. procedures in the process plant industry, to balance the interests of supplier and purchaser, with their differing objectives and exposure to risks. Formal Q.A. system standards, such as ISO 9000, have evolved as the most efficient and "visible" method of providing the assurance of quality to the purchaser. As their value (at least to the purchaser) becomes more evident and consequences of quality failure become ever greater (due to more expensive, more complex plants and stricter legal controls), so the application of formal quality management systems will continue to increase in this sector of the engineering industry.[7]

4.3 The Economics of Q.A.

4.3.1 Introduction

The imposition of a formal quality system into a Company will involve extra costs because resources are required by the quality system. This section

of the report will concentrate on these economic aspects of Q.A., how costs can be kept to a minimum and a further discussion on the economic justification of Q.A. systems. Emphasis will be placed on these economic aspects when viewed in the light of the specialised process plant manufacturing industry. As will be seen, the nature of products (high value and unique items designed and manufactured to client and national specifications) and the traditional approach of using Third Party inspection in this industry, determines to a great extent the economics of Q.A. in process plant manufacture.

4.3.2 The General Approach to Quality Costs

The general approach to defining quality related costs, as given by British Standard BS6143 and most Q.A. literature,[23] is to distinguish between different cost categories, as illustrated in Fig 4.1. The principal areas are the costs of control and the costs of failure of control.[13] The costs of control can again be differentiated into prevention costs, i.e. the costs of any action taken to investigate, prevent or reduce defects and failures, and appraisal cost i.e. the cost of assessing the quality achieved.

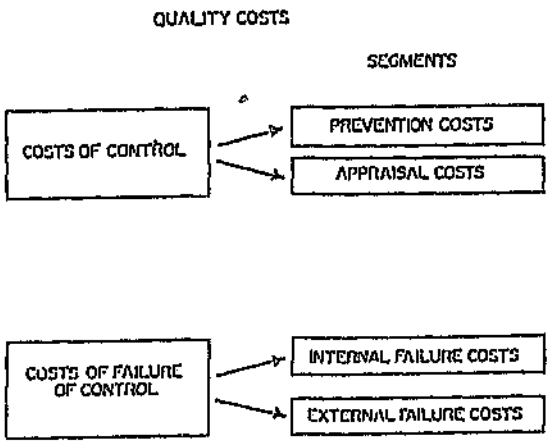


FIGURE 4.1

Costs of failure of control can be split into internal failure costs and external failure costs. Internal failure costs are those which arise within the company due to unsatisfactory quality performance, before product ownership is transferred to the customer. This includes the costs of scrap, spoilage and reworked material. External failure costs are those which arise once ownership of the product has been transferred to the customer, which include warranty and repair costs, etc. Research shows that the costs of poor quality to a manufacturing company can be dramatic. Typically, the cost of inferior quality can be between 15 and 20 percent of sales.[27] In addition, up to 25 percent of assets, 25 percent of people, 40 per cent of space and 50 per cent of inventory can be attributed to handling or coping with defective products.[27]

Generally, most of these costs have remained hidden from management because of the "iceberg" syndrome, illustrated in Figure 4.2. The clearly visible costs of poor quality such as scrap, rework and warranty costs, have not been of sufficient magnitude to attract much management attention. However, if traditional cost accounting methods were changed to account

for all other hidden quality costs, the magnitude of these costs would certainly give cause for alarm.

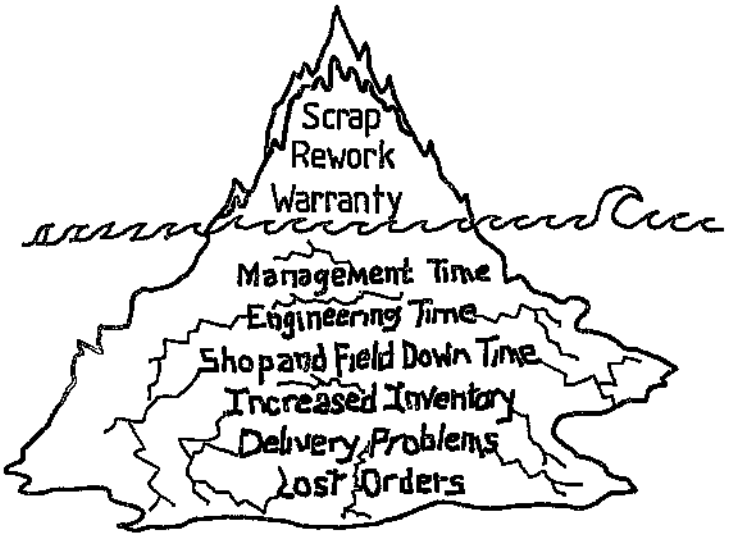


Fig 4.2. THE ICEBERG OF POOR QUALITY.

Many companies have realised this potential for reducing costs and thus increasing profitability, or else reducing prices to become more competitive. Reductions of quality costs of up to 90% have been achieved by companies that have made quality control and perhaps more importantly, quality improvement, a competitive strategy for success.[24]

4.3.3 Industry Influence upon Q.A. Economics

The general approach to quality costs, i.e. costs of control and costs of poor quality, are of most value in the manufacture of mass production or batch production items where quality costs can be averaged out over a large number of units. In process plant manufacture, however, another classification of quality related costs is more appropriate.[7]

If one regards quality costs as consisting of "money spent" and "money lost", then "money spent" can further be divided into system costs and project related costs. "Money lost" consists of repair and rectification costs as well as the consequential costs of delay and loss of revenue from the plant not operating. "Money spent" is comparable to the prevention and appraisal costs mentioned earlier, and "money lost" to the failure costs.

In this industry the products are usually unique, high value items and this 'project' approach means it is sensible to differentiate between system costs (those costs which can be considered as part of the basic cost of being in business) and project costs which can be charged directly to a project. These costs are illustrated in Table 4.1.

(a) System Costs

QA department costs (staff, production of quality manuals, internal audits, departmental overheads).
QC department costs (staff, departmental overheads).
Training.
Development (new designs, manufacturing processes, assessment of new materials).
Maintenance and calibration of inspection equipment.

(b) Project Related Costs

Auditing and surveillance by clients for specific projects.
Auditing and surveillance of suppliers for specific projects.
Inspection and test of bought-in items.
Development and qualification of manufacturing procedures for specific projects.
Development and qualification of inspection procedures for specific projects.
Qualification of operators for specific projects.
Validation inspection (including documentation requirements).
Repair and rework.
Qualification of repair and rework procedures for specific projects.
Inspection and documentation of repaired and reworked components.
Delay costs incurred by the manufacturer (penalty clauses, loss of revenue).

TABLE 4.1 Cost Categories

System costs are almost independent of the output of the company but are affected by the nature of fabrication being undertaken.[7] The range of materials utilised by the company, the degree of sub-contracting and whether or not pressure vessels are constructed, greatly influence the magnitude of these system costs. They can be thought of as "fixed" costs.

The project related costs are also very much dependent on clients' specifications, as well as contractual and statutory requirements in terms of outside inspection authorities. Although they are "variable" costs because they are directly related to the product, they are to a significant degree outside the control of the manufacturer.

For this reason, the traditional approach of trying to minimise quality related costs by balancing prevention and appraisal costs against failure costs, as illustrated in Figure 4.3, does not apply in this industry. There is however, another important reason why this approach is unacceptable. The philosophy of BS6143 illustrated in Figure 4.3 implies that there is an acceptable level of defects beyond which it is uneconomic to reduce defect levels. The prevention and appraisal costs required would exceed the subsequent reductions in failure costs.

In the process plant manufacturing industry this philosophy is unacceptable because a contractual relationship exists between supplier and client. The supplier has been contracted to supply "defect free" equipment which meets the specifications of the client and only such equipment is acceptable to the client. Furthermore, the consequences of inferior quality mentioned in Section 4.2, also mean that the BS6143 approach is unacceptable in this industry.

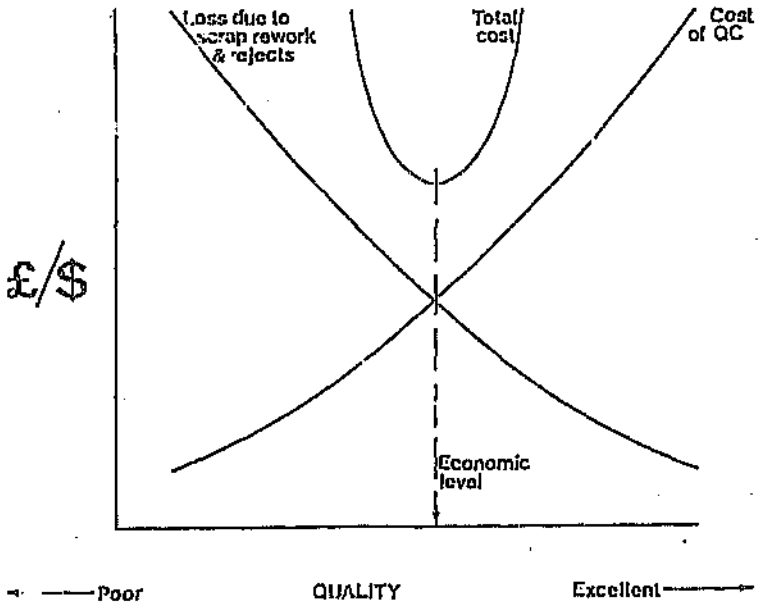


FIGURE 4.3 Quality Costs versus Quality Levels

This approach of acceptable quality levels has been rejected by the Japanese. They do not seek economic justifications for quality improvements. Instead, they regard all quality improvements as eventually being beneficial, due to a more efficient production system and improved image in this market place.[9] It is true, however, that they tend to place emphasis on "prevention" rather than "appraisal" because prevention of defects at their source is always more cost efficient than merely inspection to weed out defectives.

This Japanese approach of rejecting the notion of "Acceptable Quality Levels" has been increasingly adopted in a variety of Western industries, as part of the implementation of JIT/TQC manufacturing philosophies.[11,17]

4.3.4 Reducing Quality Costs: The Manufacturer's View

In order to attempt to reduce quality related costs in this industry, it is important to establish which quality activities account for the major portion of expenses incurred, from the manufacturer's point of view.

A detailed study of twelve process plant fabricators has revealed that these major quality activities are always the same and consist of:[9]

1) Quality engineering
2) Validation inspection
3) Qualification of special process procedures.
4) Repair and rectification.

The first activity, Quality Engineering, is taken to be all pre-manufacturing engineering and contractual matters where "quality" or "quality personnel" are involved. This would include producing quality plans, negotiating specifications, production process capability studies, etc.

A trend established in the study was that an inverse relationship exists between Quality Engineering and the total costs of quality i.e. when more effort is spent on planning and solving potential quality problems, the total quality related costs tend to be less. Again, the wisdom of "prevention is better than cure" applies.

Another major quality cost activity is validation inspection. Formal inspections by client or third party Inspection Authorities are an integral part of this industry, if only for regulatory and statutory requirements. This is especially so in the pressure vessel industry. Even the introduction of formal Quality Management systems has done little to reduce

the validation inspection activity. There is thus little that can be done about reducing these costs, with the exception that proper scheduling of inspection activities can do much to avoid unnecessary delays in production. The cost to the manufacturer of delays will be considered shortly.

The third major quality activity is that of special process procedure and operator qualifications. These special processes are of critical importance in this industry, which accounts for the emphasis placed on procedure and operator qualification. Unfortunately, these qualifications are time-consuming and thus expensive. In order to avoid excessive qualification requirements, it would be in the interest of the manufacturer to keep the number of procedures to a minimum. This could be achieved in welding for example, by standardising on plate thicknesses and design of welded joints, reducing the number of different filler materials used and avoiding a high staff turnover. Also, the manufacturer should negotiate any "special" requirements for a specific project with the client, pointing out the additional costs that would be involved.

The final major quality activity reported by the study of process plant manufacturers is that of repair and rectification costs. The costs are high, not because of the low quality standards in this industry, but rather because of the nature of the product. Poor accessibility and the high value of items means that repair work is usually expensive. This is especially so because most repair work seems to involve welding.[7] This is because it is almost impossible to produce entirely defect free welds, and the acceptance criteria for defect levels tend to be arbitrary and highly conservative.

The decision may depend on the inspector's interpretation of a particular specification. Subsequent repair work is highly disruptive to production plans and poor access often leads to re-repair[32], as illustrated in Figure 4.4 which shows the outcome of inspecting over 600 welds. After only the 6th inspection did all the welds manage to pass inspection. The costs incurred in such situations are naturally substantial.

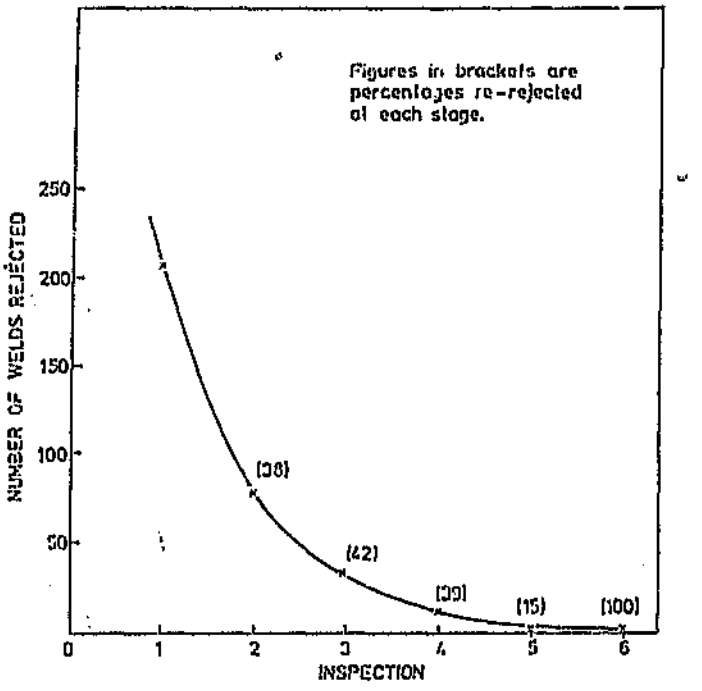


Fig. 4.4 Rejection rate of repair welds.

In order to reduce these costs, the manufacturer should aim at preventative methods such as proper Quality Engineering, making use of skilled, competent artisans and good planning. For example when constructing pipe lines, with proper planning the difficult welds can usually be performed on the floor or workbench and the final butts performed in situ can be chosen to allow good accessibility.

There is also evidence[26] that the introduction of new manufacturing technology (especially welding technology) tends to reduce quality costs. In particular, repair and rectification costs and associated delay costs are reduced because of more consistent manufacturing process quality. Dramatic quality cost reductions in the nuclear power industry have been achieved by using new manufacturing technology.[26]

A survey of process plant manufacturers[9] has shown that the costs of these four major quality activities can be classified as "low", "medium" or "high" for this industry, as indicated in Table 4.2. The aim of the manufacturer should be to have his quality costs in the "low" regions, with the reasonable assumption that he is still able to produce safe products with an acceptable level of quality. According to this survey, manufacturers operating in the "high" regions should be able to reduce their quality related costs by up to 50% .

TABLE 4.2
Costs as a percentage of value added to item

	Validation inspection	*Special process approvals*	*Repair and rectification*	*Delays*
Low	0–6%	0–1%	0–2%	0–12%
Medium	6–14%	1–2·5%	2–6%	12–30%
High	>14%	>2·5%	>6%	>30%

4.3.5 Costs due to Delays

A related cost to direct quality costs is the cost to the manufacturer of delays resulting from quality activities and quality problems. These delays are caused for example by repair and rectification, waiting for

inspection, waiting for decisions on inspections or interpretations of specifications, etc.

The costs due to delays have the following components:[7]

1) Imposition of penalty clauses.
2) Loss of interest on delayed completion payments
3) Costs and potential lost revenue of resources tied up in the delayed aspect of a project.

Calculation of actual delay costs must thus include information about interest rates, size of penalty payments, schedule of payments and capacity utilisation. Costs can be as high as 30% of contract value for, say, a 20% extension to delivery time.[7] Delay costs can thus be significant and should always be included when calculating quality related costs. The manufacturer should aim to reduce delays by reducing repair and rectifications, scheduling inspections carefully and pushing for rapid outcomes of inspections or interpretations of specifications.

4.3.6 Economic Justification of Q.A.

The arguements presented for justifying Q.A. from an economic point of view are biased, depending on whether one is the manufacturer or client. This is because the balance between risk and expenditure is not the same for each party.[7] The manufacturer is in a relatively low risk/high expenditure situation because he has to spend significant sums of money to maintain the Q.A. system.

The client on the other hand is in a high risk/low expenditure situation because he bears the risk of the consequences of failure. His expenditure is relatively low because he merely assesses and generally monitors the

performance of his suppliers. However, should a failure occur and the production capacity of the plant suffer or a quality problem delay the project, then the consequential costs suffered by the client can be enormous. One day of downtime in a large brewery producing say, 1200 Hl every brew and assuming a R1 income per bottle would result in near R4 million of lost income.

The costs of a Q.A. system are therefore easily justified by the client, by pointing out that an effective quality system should reduce the risks of plant failures. Furthermore as mentioned in Chapter 1, reductions in insurance premiums due to reduced risks of failure for manufacturer and supplier,[7] also provide economic justification for a quality system.

The manufacturer is faced by a relatively high Q.A. expenditure situation and must weigh up the cost of increasing his levels of quality control against the incremental increase in quality assurance obtained and potential reductions in costs due to repair and rectification. The client will naturally argue that the increased costs incurred by the manufacturer are not worth considering if the extra quality control will reduce the risks of an expensive failure.

Unnecessary quality related costs and inefficient quality programmes must be avoided, however, because they must eventually be paid for. The manufacturer must realise a reasonable profit to stay in business and the cost of quality programmes must eventually be passed on to the client. It is thus in the interests of both parties to ensure that an efficient, effective quality system is operated by the manufacturer which provides the client with an adequate assurance of product quality. In this way both parties benefit.

The client should thus avoid setting an excessively high level of Q.A., unless there are specific, sound reasons for doing this. More use should be made of standard items and modular design approaches in this industry. Rogerson[7] reports that process plant manufacturers with "standard" product lines have the lowest overall quality related costs because the manufacturing and quality activities become more efficient and proven designs mean that the risk to clients of failure are also reduced.

4.4 Trade-offs involved in Q.A.

If Quality Assurance is regarded as a management system designed to give maximum confidence that a given, acceptable level of quality is being achieved, with a minimum of total expenditure, then a number of aspects need to be considered.

Firstly, the management system, or "rules" encompass all of the company's activities. Secondly, it assumes that the engineering requirements of the product have been adequately defined so that Q.A. can provide the assurance that these have been met. What is "acceptable quality" is an engineering decision that must be made in conjunction with decisions regarding an appropriate level and rigour of the Q.A. system. For example, steelwork with a high degree of redundancy may only require a far less rigorous Q.A. system than, say a nuclear reactor component.

Thirdly, the cost considerations imply a number of trade-offs. These are as follows. [7]

1. The high cost of a very rigorous system and accompanying low risk of failure versus the lower cost of a less

rigorous system and thus higher risk of failure.

2. The cost of developing and introducing more advanced manufacturing processes requiring less rigorous Q.A. versus utilizing the existing, less exact manufacturing processes with a subsequently more rigorous and thus costly Q.A. system.

3. Use of a conservative design with lots of redundancy and thus a low risk of failure, which implies less rigorous Q.A., versus a more advanced, more efficient and thus economic design with little margin for error and thus requiring a more comprehensive and expensive quality system.

4.5 Special features of the Industry and their effect on Q.A.

Some of the special features of the process plant manufacturing industry actually determine to a very large extent the practical application of the quality management system standards which were discussed in a previous chapter. These features are summarised as follows:

a) High value products

b) Designed and manufactured to client specifications

c) Consequences of failure extremely high.

In order to identify the type of quality system applicable to this industry, it is also appropriate to consider the type of product, methods of manufacturing and contractual patterns of purchase and supply.

4.5.1 Type of Product.

The products are high value and in many cases are unique in the sense that each plant is different. They are thus "one-off" items tailor-made for that particular client or project and therefore mass production Q.C. methods are not usually relevant.

The uniqueness of the items means that they are often manufactured to customer specifications. These detailed instructions may refer to specific quality control activities to be undertaken by the manufacturer. The quality approach to be adopted by the supplier is thus often dictated by the customer.

The items involved in the industry are also usually part of a large project or system. A failure in one item (late delivery as well as actual failure) may affect the entire project or system. There ar usually safety aspects to the process plant products as well, which have been mentioned previously.

4.5.2 Methods of Manufacture.

"Special Processes" are usually of critical importance in this industry and failure in special process control are often the cause of quality problems[7]. Particularly strong emphasis is thus placed on the control and Q.A. of these special processes. In the context of Q.A. these special processes refer mainly to welding, heat treatment and non-destructive testing.

Process plant equipment tends to be manufactured to detailed technical specifications which may include relevant national or

international standards. (e.g. ASME codes for pressure vessel manufacture). The specifications and standards can be very specific regarding acceptable quality standards, inspection requirements and documents to be generated.

4.5.3 Contractual Matters.

Manufactured items in this industry tend to be part of a larger project involving many organisations such as the client, consulting engineers, major contractors, sub-contractors and inspection authorities. These various organisations will have contractual relationships with one another which will include responsibilities and obligations in respect of Q.A. These various organisations thus all have some say in the quality system of the manufacturer, which is a complicating factor and tends to take away some control from the manufacturer. This is contrary to quality management principles which state that the manufacturer is entirely responsible for the quality of the product. Although not satisfactory, the situation is inevitable because of the wide range of specialist skills required in the process plant industry.

Another contractual matter is that any statutory requirements must be contractually met as well. This requirement adds a further dimension to the quality policies of the manufacturer.

Finally, there is also a tradition in this industry of utilising third party inspection authorities to provide independent checks on the quality of items manufactured or installed. This manufacture - then - inspect approach tends to be less cost

effective than the modern Q.A. approach of controlling design and manufacture to avoid quality problems. Third party inspections are bound to continue, however, especially in the manufacture of pressurised plant.'7'

5. CASE STUDY - HUPPMANN FABRICATIONS

5.1 Introduction

This section of the investigational project will take the form of a case study in which a formal Quality Management program will be developed for Huppmann Fabrications (Pty) Ltd., a small company (less than 30 employees), situated in Wilbart, Germiston. It is the manufacturing arm of Hrch. Huppmann S.A., which is in turn a sister company of Hrch. Huppmann GmbH of Kitzingen, West Germany. This company specialises in the supply of brewhouse equipment and refrigeration plants to the brewing industry worldwide. Huppmann Fabrications concentrates on manufacturing brewhouse equipment for Southern Africa. Present turnover for Huppmann Fabrications is around the 3 million R.d level.

Due to the hygiene requirements of the food and beverage industry, Huppmann concentrates on the use of various grades of stainless steel in the manufacture of their products. The company can supply entire breweries on a turn-key basis or individual tanks and related process equipment, as required by the customer.

The strategy of the company is to specialise in brewhouses, which requires a high degree of specialist knowledge, rather than trying to compete in a more general tank-construction type market. The advantage of this is that the company is "focused" and can build up expertise in its field, which means a higher premium on products and less competition. In fact in South Africa, Huppmann is in a unique position in that it is the only local company in a position to manufacture a brewhouse in-house. Their major competitor, Steinecker of Freising, West Germany, only has an agency in

this country and must sub-contract their work to local manufacturers if local content is required.

The disadvantage of this extreme specialisation is that the customer base tends to be small. In Southern Africa, Huppmann has only two clients, namely South West Breweries Ltd. (SWB) and South African Breweries Ltd. (SAB). Of these, SAB is by far the larger and thus more important customer. Huppmann has received numerous enquiries from potential clients interested in micro-breweries, as per the growing trend in Europe and North America, but as yet no orders have been placed for these small plants.

In light of the above, it has been very important for Huppmann to remain sensitive to the needs of their major customer, and to adapt to these continually changing needs.

It has also become clear over the years that SAB has no intention of relying on a sole supplier of brewhouse equipment. They have financial as well as strategic reasons for this. SAB is naturally concerned that a sole supplier would not have to be competitive with pricing or could lower the standard of design and workmanship, without the customer being in a strong bargaining position. Furthermore, SAB is also concerned about placing a excessive workload on any one company. By ensuring that competition remains in the marketplace, SAB have forced suppliers to "remain on their toes" in terms of price, quality, innovation and service.

5.2 The Rise of Quality Assurance in SAB

It is not entirely clear how the need for formal Q.A. in the supply of equipment to SAB arose, but it was probably linked to the following:

(a) The completion of Koeb rg Nuclear Power Station, where Q.A. reached its zenith in South Africa, with inevitable rub-offs on other process plant industries.

(b) The current trend worldwide towards formal Q.A. and the development of international Quality Management system standards.

(c) The consistently poor quality of goods supplied to the process plant industry (bearing in mind that 80% of goods supplied to SASOL during 1987/88 were unsatisfactory, as mentioned previously).

(d) The high cost of replacement plant, which has been made worse by the weakening of the Rand against major foreign currencies.

(e) Numerous expensive failures of stainless steel process equipment, for example, due to stress corrosion cracking.

It has now become a prerequisite of SAB that before a contract is awarded, the supplier must have a formally documented and implemented Quality Management system, satisfying the requirements of SAB. In practice, however, this clause does not yet appear to be insisted upon, probably because there are not that many suppliers in the country who have implemented such a fully documented quality system.

In June 1987, with the awarding of the contract for the new brewhouse at the Ohlsson's Cape Brewery hanging in the balance, SAB conducted a visit to the Huppmann Fabrications works. They wished to see whether Huppmann had

systems in place which would assure SAB of the quality of the products Huppmann would be supplying to SAB, in the event of obtaining the contract.

Unfortunately, Huppmann had very little to show their customer with respect to Quality Assurance because no formal quality system was in place. Huppmann maintained that even though they had no formal Q.A. and Q.C. in practice, the quality of the goods they delivered in the past had been of a high standard of quality. Furthermore, Huppmann assured SAB that they would take immediate steps to implement a quality system to the requirements of SAB.

Eventually, Huppmann was awarded the contract and the pressure was then on to implement a formal quality system. An investigation into a suitable system and the implementation of such a system became the basis of this investigational project. Although it became clear that full implementation of a documented system would take a number of years of project-by-project improvement steps, the initial results of this project would provide valuable feedback to the company regarding future activities in this regard and indicate to SAB that Huppmann was serious about its Q.A. commitment.

The approach taken in this case study was to break it into distinct phases as follows:

a) Investigation phase

b) Implementation phase

c) Review and Feedback phase

The first phase was a general "data collection" phase. This involved an investigation into customer requirements regarding Quality Assurance (with emphasis on Brewhouse equipment) as well as specific process and

engineering requirements regarding Brewing equipment. The Investigation phase also included a study of past quality problems which the customers had encountered with Brewing equipment, in order that these could be avoided in future equipment supplied by Huppmann.

The Implementaion phase of the case study involved actually implementing a formal, documented quality system into the company. The results of the Investigational phase were incorporated in this phase as well as informal quality management procedures which the company was utilising at the time. The aim of the latter was to build on what was in existence already rather than introduce an entirely new sytem which would meet with great resistance within the organisation.

The final Review phase of the case study involved a critical assessment of the quality system implemented, problems encountered and future advances which could be taken by the company to improve its quality management system. This Review phase was undertaken after the completion of the Ohlssons's Cape Brewery project and includes a section dealing with the Site environment and its influence upon the quality system.

5.3 Investigation Phase

5.3.1 Customer Requirements

SAB have developed a standard, CEP 351 "Quality Assurance Requirements for Suppliers" as part of their Engineering Manual (see APPENDIX A). This specifies the Q.A. requirements of SAB, depending on the level of criticality of the equipment to be supplied. It states that before a contract is awarded, the supplier must have a formally documented and

implemented quality management system to the requirements of SAB. CEP 351 also emphasises the need for supplier "Quality plans", which contain as a minimum the sequence and methods of inspection and testing, including witness and hold points, for each stage of the work on that specific project. These quality plans will be discussed in greater detail, in the Implementaion phase of this report.

To complement CEP 351, SAB have issued CES 401 "Quality Management Systems for supplier's of Material for Equipment used in Beer Production" and CEP 360 "Classification of Material and Services into levels of Criticality" (see also Appendix A). The former is merely the SAB interpretation of SABS 0157 and the latter requires that all material and services be classified according to their respective levels of criticality utilising the following parameters,

- Consequence of failure
- Safety
- Product taint/losses (product taste influences)
- Procurement cost
- Availability

Each level of criticality is then assigned minimum quality assurance requirements. The supply of Brewhouses lies in Criticality Level 1 because they involve:

- High consequential costs of failure (repair costs and loss of production)
- Product taste/losses due to failures to meet Process requirements.
- High procurement costs
- High level of operation/maintenance personnel

- High cost of operation/maintenance (cost of raw materials and spare parts)
- New technology input (although Brewhouse technology is relatively well proven, the new Brewhouse for the Ohlssons Cape Brewery was to utilise fully stainless steel vessels for the first time i.e., no mild steel/stainless steel cladd plate to aid heat transfer, comprehensive insulation specifications and a state-of-the-art, Programmable Logic Controller (PLC) plus VDU's rather than a mimic control syste
- Generally long delays in SAB Management acceptance/agreement with various aspects of the project.
- Long lead times (for initial equipment as well as for replacement equipment if required), resulting in long delivery delays. Much of the equipment in a Huppmann supplied brewhouse is imported, which implies procurement delays unless high stock levels of spares are maintained. This is expensive however, and it may be more realistic to import major items as required. Even utilising air freight however, and assuming the foreign supplier has the required item in stock, the quickest an item could be imported into the country and passed through customs would be around four to five days. Five days of lost production in a large brewhouse operating at peak capacity can be measured in millions of Rand.

A Brewhouse is typical of process plants in that a failure in one item (late delivery as well as actual failure) may affect the entire project or system. For example, in constructing a brewhouse, a delay in delivering a tank to site due to quality problems, would delay the pipework, delaying the placing of valves and thus the instrument wiring, which would eventually delay commissioning of the plant. In the design of brewhouses,

it is not usually economically practical to have redundant parallel systems incorporated which could be activated in the event of failure of a particular piece of equipment.

Fortunately, most of the maintenance on a brewhouse can be performed relatively quickly i.e., repairs to pumps and valves, exchanging of computer hardware cards in the PLC and instruments in the field, assuming that spares are kept in stock. The exception to this would be major structural failures in vessels and to a lesser extent, pipework.

With regard to the safety aspects of a Brewhouse, the pressures reached in the pressurised steam equipment are relatively low, around 4 bar working pressure, but nevertheless they are regarded as pressure vessels and thus they have a far higher level of Q.A. required than other aspects of a brewhouse. The temperature of the product in a brewhouse does not exceed an atmospheric boiling temperature (around 103 degrees C at sea level) and thus there is little danger of burns. Steam equipment, which reaches around 180 degrees C, is insulated except for steam valves. Risks of burns are thus restricted to these areas. During Cleaning-In-Place (CIP) of the plant, there is a danger of personnel coming into contact with the hot caustic utilised during this CIP. For this reason, manholes in vessels need to incorporate proximity switches which signal the PLC or hardware interlocks, resulting in CIP valves closing automatically should a manhole be opened during CIP.

Criticality Level 1 requires that:

- The supplier be assessed to comply with CABS 0157, Part 1 or 2, or similar, as appropriate.

- Prior to contract award, suppliers submit to SAB for their review and approval, quality plans giving details of all processes employed to assure conformance to SAB requirements.
- Supplier to inform SAB of all acceptance criteria employed and documentation to be generated.
- Supplier to prepare complete data packages for SAB records. (Drawings, quality records etc.)

There are also numerous Process requirements regarding Brewhouse equipment which need to be met. These are listed in Table 5.1 and are highly specific to the brewing of beer, and some of them to SAB itself. These requirements need to incorporated at the design stage of the equipment. The major design work of a Brewhouse supplied by Huppmann tends to be done at the parent company in West Germany. For this reason it was beyond the quality system to be utilised at Huppmann Fabrications, to ensure that these Process requirements had been met. This would form part of a quality system utilised at the parent company.

The supply of brewhouses is usually done on a turn-key basis. Huppmann is thus responsible for everything in the brewhouse, excluding the civil work. The scope of supply thus includes design of mechanical, electrical, instrument and software systems, as well as manufacture, supply, installation and commissioning of all this equipment. Input from the client or their consulting engineers occurs via specifications or detailed design requirements. Huppmann in turn issues the client with their needs in terms of civil requirements as well as utility (steam, hot and cold water, electrical energy, etc.) requirements.

VESSEL/STAGE	BREWING REQUIREMENTS
MILLING	1. Complete disintegration of endosperm to make all constituents accessible to enzymatic action. 2. Husk integrity to be maintained. 3. Quantity of flour to be kept to a minimum.
MASHING	1. Oxygen pickup in mashtun to be prevented. 2. Accurate time/temperature stands required. 3. No undesirable flavours in beer due to burning of mash at heating area. 4. Stirrers should not break up malt husks.
LAUTERING	1. Sufficient clarity of wort. 2. Even sparging at correct temperature. 3. Sufficient yield of extract. 4. Adequate cleaning of false bottom.
WORT KETTLE	1. Stop all enzymic reaction. 2. Efficient and effective transfer of heat into the wort. 3. Sufficient extract of bittering and flavour compounds from hops. 4. Removal of undesirable nitrogenous and tannin material, and other volatile compounds.

TABLE 5.1 Some Brewing requirements of Brewhouse equipment.

The large variety of disciplines involved in constructing such a brewhouse means that Huppmann must sub-contract some aspects of the installation work. Huppmann Fabrications on s the in-house capability of installing the mechanical aspects of the brewhouse. Huppmann Germany can supply in-house, along with all mechanical aspects, electrical panels and PLC software. Work such as electrical and instrument installations, cable racking, grain elevators and insulation, is sub-contracted. Some aspects of the mechanical installation, such as the steam piping installation in Cape Town, were also sub-contracted due to insufficient manpower. Huppmann, being the main contractor, is contractually responsible for the quality of these sub-contractors. This meant that the Q.A. system developed for Huppmann would have to extend to include any sub-contractors utilised in a project.

5.3.2 Feedback from Existing Plants

This section of the Investigation phase involved visits to existing Huppmann plants and discussions with various SAB maintenance personnel, Process engineers and the newly formed SAB Q.A. Department. The aim of these visits was to obtain feedback about problems encountered with Huppmann process plants and what was required in future plants to avoid these problems.

It emerged that SAB were experiencing major problems at that point in time with the vessels in some of the brewhouses manufactured by Huppmann. This was due to stress corrosion cracking of the tanks which had made them structurally unsound. The author investigated this problem, with emphasis placed on determining whether the cracking was linked to quality problems

originating from Huppmann, or whether it was due to environmental factors beyond the control of Huppmann.

The investigation took place in two breweries where the problem had been encountered, Rosslyn near Pretoria and United Breweries in Bophuthatswana. Some sub-standard welding workmanship was evident, especially at United Breweries where the tanks had been manufactured in Zimbabwe at the time and imported to South Africa. The cause of cracking, however, was primarily due to insulation design details and the type of chemicals added to the vessels as part of the brewing process and the method of adding these chemicals to the vessels.

At United Breweries, water had entered the insulation of the vessels when they were being cleaned with hoses, (see Fig. 5.1) and the water had leached chloride ions out of the insulation wool. Unfortunately, the insulation was fully welded and did not have any drainage holes at the bottom. Each successive cleaning of the vessel would leach more chloride from the wool and the concentration of chloride ions became stronger and stronger. Austenitic stainless steels are very susceptible to cracking in the presence of stresses (always present in a welded, non-stress relieved storage vessel) as well as chloride ions. It was felt that the vessels in this brewhouse were beyond repair. Drainage holes had been drilled into the insulation cladding and the method of cleaning the tanks revised, but unfortunately the damage had already been done.

In Rosslyn, which is a very much larger brewhouse and thus downtime would be far more costly, the damage to the vessels was limited to a triangular region below the manholes. It was felt that this was caused by the method used by SAB to add Calcium Chloride and Sulphuric Acid to the vessels.

This was merely poured through the manhole using a bucket, and spillage of the chemicals occurred onto the internal surface of the vessel around the manhole. The high concentration of chlorides in this area then led to the stress corrosion cracking.

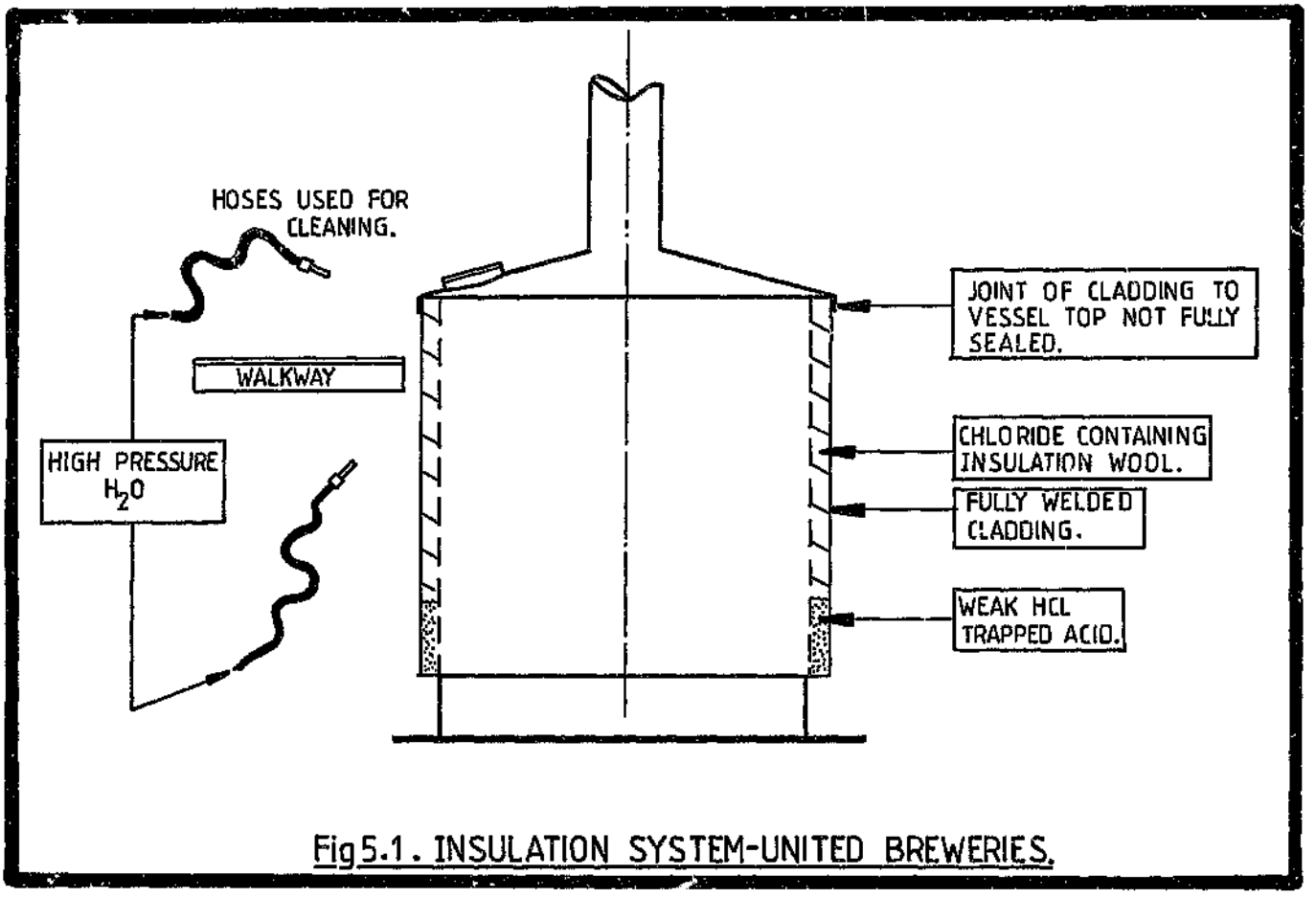


Fig 5.1. INSULATION SYSTEM-UNITED BREWERIES.

Repair procedures were suggested by Huppmann and these have subsequently been carried out by Huppmann Fabrications. It was also recommended that the method of addition of the chemicals at Rosslyn be modified by utilizing a portable chute which would add the chemicals more centrally into the vessels or by installing a dosing system which would add the chemicals directly into the tanks.

For the brewhouse in Cape Town, the method of insulating the vessels and the insulation specification issued by SAB was completely revised. After pickling and passivating the vessels, they were painted with a anti-stress corrosion lacquer, a layer of aluminium foil attached utilising a watershed effect and then chloride-free insulation wool. The cladding was to be fully sealed utilising silicone and stainless steel screws. Ample backing support to the cladding was to be provided and shrouds around all penetrations into the vessels were to be utilised, as illustrated in Fig. 5.2, In the event of leakage from the penetration, product fluid would not enter the insulation.

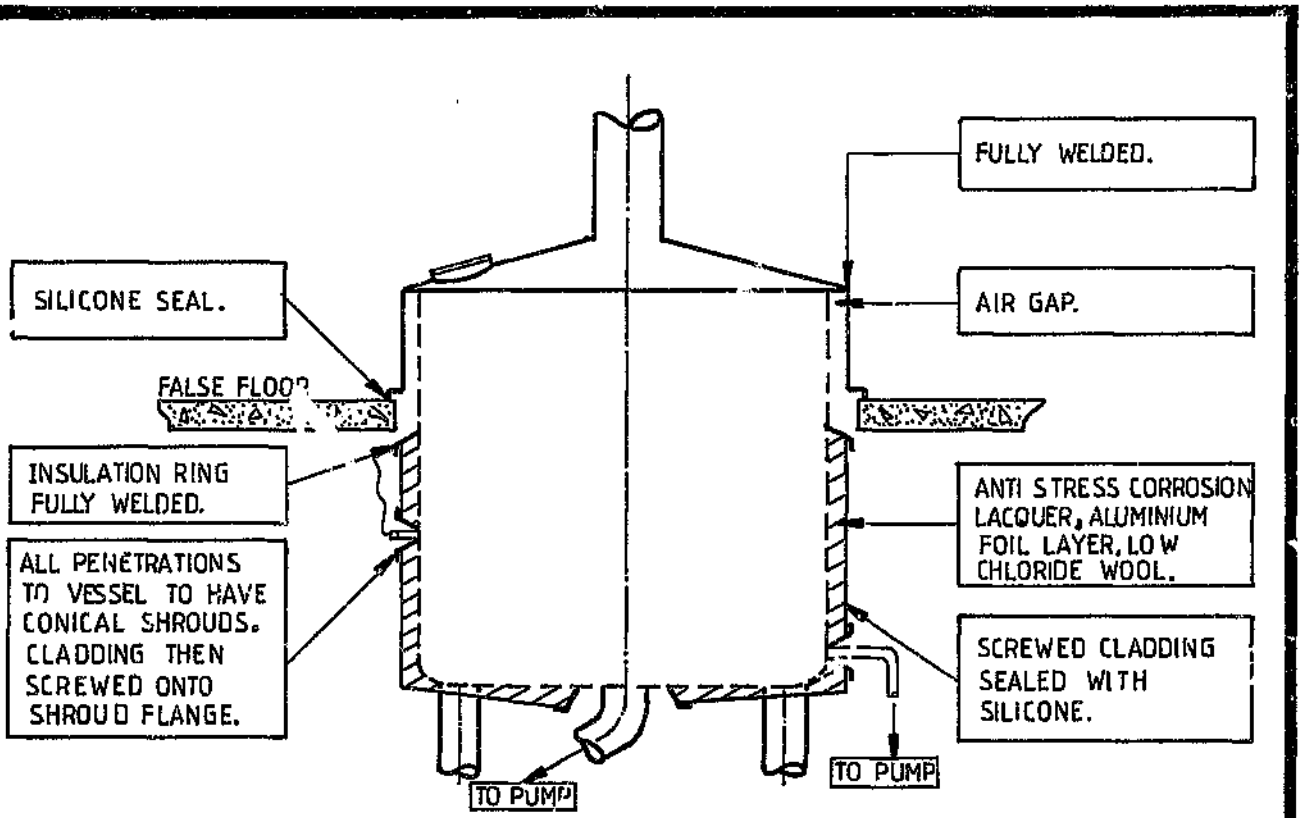


Fig 5.2. INSULATION SYSTEM – CAPE TOWN.

The addition of chemicals to the vessels was also modified. In Cape Town, a fully automated dosing system was to be utilized which would dose the chemical solutions directly into the vessels. The opening of the entry tubes into the vessels would be sufficiently far away from the sides of the vessels to prevent contamination, as illustrated in Figure 5.3.

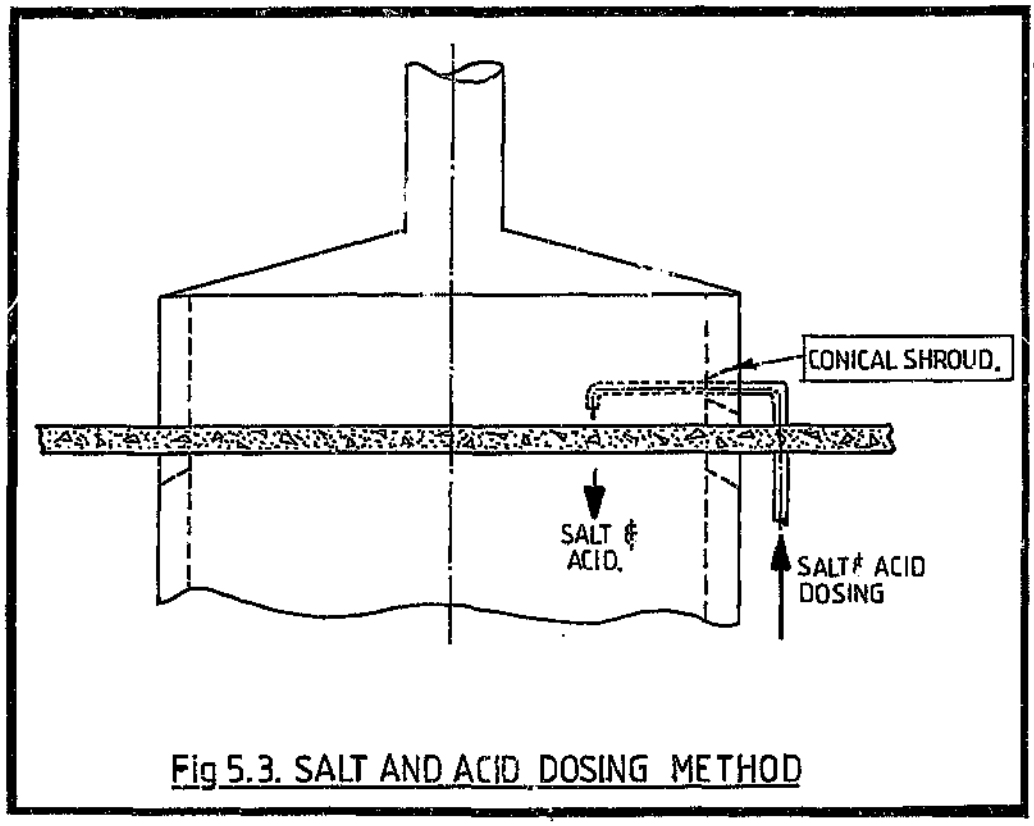


Fig 5.3. SALT AND ACID DOSING METHOD

SAB also revealed other problems which they had encountered in stainless steel process plant, not necessarily manufactured by Huppmann. These included:

i) Collapse of vessels due to insufficient support.

ii) Corrosion of stainless steel pipework due to lack of root purging during welding.

iii) Failure of a 316 grade vessel initiated at a specific length of weld. This was due to an inferior grade of filler wire used during welding of the tank.

iv) Problems with accessibility of items requiring maintenance.

v) Problems with rodents gnawing electrical and instrument cables.

vi) Corrosion of stainless steel due to carbon contamination. This can occur when stainless steel is in direct contact with mild steel, or is in the vicinity when work is being performed on mild steel. For example, when cutting with an angle grinder or when tools are used on mild steel as well as stainless steel without changing items in contact.

Experiences gained by SASOL in their process plants also gave guidance to problems experienced with fabricated stainless steel process equipment. According to de Vries,[9] 60% of all equipment received during 1987/88 was returned to the Fabricator or repaired on site. This naturally causes delays and undesirable costs. Typical problems are:

- Incorrect shell dimensions
- Incorrect nozzle size rating
- Incorrect nozzle orientation/alignment
- Incorrect welding
- Incorrect heat treatment
- Incorrect machining
- Carbon contamination

De Vries maintains that these problems are primarily due to incomplete or incorrect interpretation of requirements and a lack of in-house Quality Control. SASOL is looking into shortlisting fabricators in the future to one or maybe two fabricators per category of equipment and they are evaluating the use of standard procedures. A fabricator would submit a complete set of fabrication and testing procedures to SASTECH for approval.

This feedback of experiences gained at SAB and other process plant users provided guidelines to design improvement as well as indicating where emphasis needed to be placed by the new quality system at Huppmann.

5.4 Implementation Phase

5.4.1. Initial Steps

The first step taken in implementing the new Q.A. system at Huppmann was to obtain top management approval and support for such a venture, in order to gain the required legitimacy. A "production" meeting was called, which was attended by the Managing Director (also the Project Engineer in the case of Huppmann), the chief draughtsman, the sales representative, shop foreman, the buyer/storeman and the author.

The Managing Director explained the strategic need for introducing Quality Assurance and Quality Control into Huppmann. He emphasised that this did not mean that Huppmann had been producing inferior quality products but that there was always room for improvement. He also explained the need for Q.A from the customer's point of view.

The author was appointed as the "Quality Manager" and made responsible for the implementation of a quality system suitable to Huppmann and acceptable to the client. It was requested by the Managing Director that all personnel to be involved in the new quality system were to give the author full co-operation.

It was also emphasised that this did not mean that management was going to introduce a team of "Police" inspectors to patrol the works. Rather, the idea was to define quality responsibilities unambiguously and to ensure that personnel had the correct tools, information and management support needed to ensure that high quality work could be achieved by each

individual. The advantages for personnel were thus emphasised as well as the advantages for the organisation as a whole.

The Deming cycle (Figure 5.4) was used to illustrate this point. The cycle begins by improving quality in the company, which requires employee participation. This improved quality results in decreases of costs due to less scrap, delays etc., which in turn results in an increase in the productivity of the organisation. This would enable the company to remain competitive in the marketplace and retain or even improve its market share due to better quality products and competitive pricing due to improved productivity. The company would be able to stay in business and thus continue to provide jobs or even provide more jobs. The entire cycle is then repeated.

The on-going role of the Quality Manager's job at Huppmann would involve working continually on the manufacturing system on a project-by-project improvement basis. He was to focus on design (or design compatibility with local equipment and locally available materials), maintenance, improvement of equipment, training and supervision, and generally act as a quality facilitator rather than inspector. He would promote the removal of defect causes, monitor operations to see that standard procedures were being followed and monitor suppliers' / subcontractors' quality performances.

The results of the investigational phase of the case study were then incorporated into the Implementaion phase. This investigational phase had revealed that due to the criticality of a brewhouse in a brewery, SAB required of Huppmann Q.A. system based on the ISO 9000 series with special emphasis placed on the use of quality plans. The level of Q.A. required in Huppmann was thus dictated by the customer.

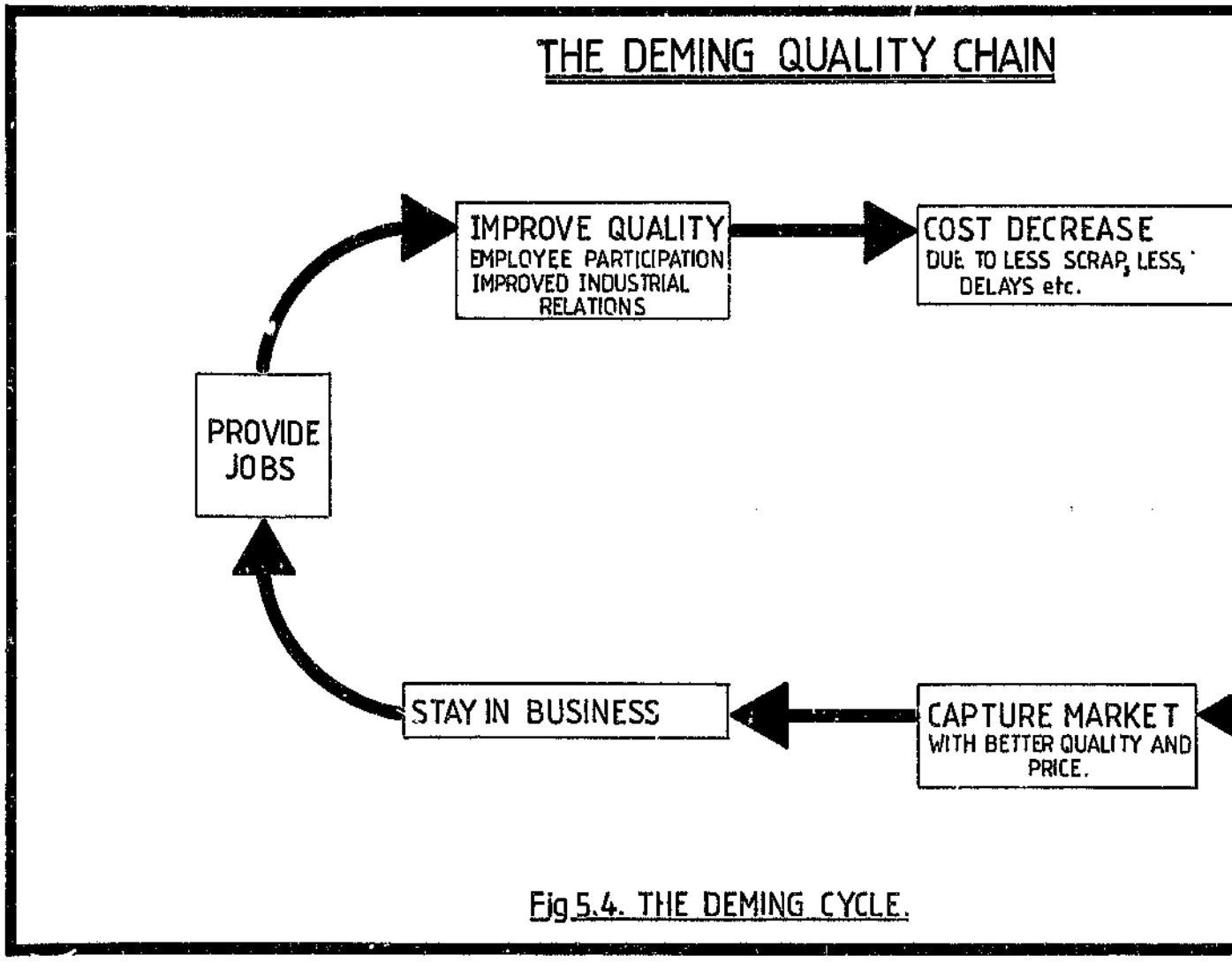


Fig 5.4. THE DEMING CYCLE.

UCTIVITY
MPROVES

To begin with, a process flowchart was constructed of the steps taken in manufacturing an item at Huppmann, from the initial customer enquiry through to delivery of the product and installation on site (see Figure 5.5). This was a useful tool because it provides an overview of the steps taken and the informal inspections utilised at the time. The aim of the quality system would be to assure the quality achieved at these various steps and to minimise delays between the steps.

5.4.2 Quality System Documentation

To formalise any existing Q.C.activities, it became necessary to add a number of inspection points into the process flowchart, at the "natural control stations." For example, in the construction of a storage tank, the following could be regarded as the main natural control stations.

a) Design
b) Material Selection
c) Material Procurement
d) Material Receipt and Inspection
e) Marking and Cutting of Plate
f) Forming of Plate
g) Fitting and Assembly
h) Welder and Procedure Qualification
i) Issue of Welding Consumables
j) Welding
k) N.D.T.
l) Dimensional Checks
m) Final Test

START

ENQUIRY TO ENGINEER FROM CLIENT

CLARIFY/INTERPRET CLIENT REQUIREMENTS

ENQUIRE TO HUPPMANN GERMANY FOR IMPORTED PORTION/ TECHNICAL SPECS./PRICES

RETURN SPECS. COST INFO.

CLARIFY LOCAL SCOPE OF WORK

PREPARE TENDER UTILISING LOCAL AND FOREIGN INFORMATION

CHECK TECHNICAL SPECS./PRICES ETC.

COMPILE TENDER/ QUOTATION

SUBMIT QUOTE/ TENDER TO CLIENT

IF TENDER/QUOTE NOT ACCEPTED

END

TENDER SUCCESSFUL

ORDER PLACED WITH HUPFMANN

ACCEPTED ORDER/ ISSUE ORDER CONFIRMATION.

DESIGN PLANT/ GERMANY/S.A.

CLARIFY CLIENT REQUIREMENTS

IF APPLICABLE SEND DRGS. TO S.A.

ISSUE G.A. TYPE DRGS. TO CLIENT FOR APPROVAL

RECEIVE CLIENT APPROVAL

CHECK IF LOCAL MANUFACTURING REQUIREMENTS ARE MET.

FEED BACK OF PROBLEMS TO DESIGN OFFICE ENGINEER

MODIFY DRGS. IF REQUIRED

CALCULATE MATERIAL REQUIREMENTS.

INFO. TO PURCHASE DEPARTMENT

ORDER MATERIAL

RECEIVE ORDERS

STORAGE OF SOME MATERIALS

ISSUE MATERIALS TO SHOP FLOOR

ISSUE DRGS. TO SHOP FLOOR

MINOR MATERIAL REQUIREMENTS ORDERED BY FOREMAN.

BUILD EQUIPMENT

FINAL INSPECTION (NOT FORMALISED)

STORAGE

DELIVERY TO SITE.

FEEDBACK OF PROBLEMS TO SITE FOREMAN FOR ACTION

COMMISSION PLANT

ERECT PLANT ON SITE

CALCULATE ANY MATERIAL REQUIREMENTS (USUALLY DONE BY SITE FORMAN)

INSPECTION OF PLANT BY CLIENT

ISSUE OF SNAG LIST

ACTION ON SNAG LISTS.

PERFORMANCE TESTS

HAND OVER

END

OF CONTRACTUAL OBLIGATIONS

~ KEY ~

- OPERATION
- DELAY
- INSPECTION
- STORAGE
- TRANSPORT

Fig5.5. PRODUCTION SYSTEM AT HUPPMANN PRIOR TO NEW Q.A. SYSTEM

Once these control stations have been identified, the following questions need to be posed (7) about the activity performed at the control station:

1. What physical action takes place to specify, measure, record or verify the engineering quality level?

2. Who is responsible for the actions defined in Question 1 above (this includes responsibility for specifying, carrying out, recording or taking action on the result of the activity?

3. How is information resulting from actions performed at the control station transmitted through the organisation to the people who need to know the results?

4. How are activities documented and recorded? Do these records give a complete, objective account of what took place?

The answers to the above questions formed a complete account of the quality system at that particular control station. When these answers for the various control stations were combined, they formed the quality system of the organisation. In order to answer these questions, however, a thorough understanding of the workings of the organisation was required.

The results of this analysis could then be arranged into an orderly matrix and the system could be checked off against the quality system standard requirements (ISO 9000 in this case). An extract from this matrix is given in Figure 5.6. Any deficiencies in the established quality system became apparent and these could be addressed.

The quality management procedures thus developed were utilised to form the Quality Manual of the organisation. This Quality Manual is essentially a

FIGURE 5.6

Natural Control Station QA Procedures	4.1	.2	.3	.4
Procedure No: Q.A.0003 Rev.1		●		
Title: Materiel Receipt and Inspection Control.				
Responsibility: Buyer or Storeman	●			
Action:				
1.) Storeman to indicate to Buyer when materiel arrives. The Buyer is then responsible for the following actions. (In the absence of the Buyer, the Storeman must resume responsibility for the following actions).	●			
2.) The responsible person is to compare the delivery note against the physical goods to ensure compatibility.				
3.) The responsible person is then to compare the original Order against the delivery note for compatibility.				
4.) The order is to be checked against the original stores requisition (see Q.A.002 for Stores Requisition Q.A. procedures).				
5.) The above checks are to be performed in terms of type, class, style, grade etc. of materiel.				
6.) If checks prove to be satisfactory, materiel to be issued to the Shop Foreman.				

T.S.O. 9001 SECTION 4 sub clauses

.5	.6	.7	.8	.9	.10	.11	.12	.13	.14	.15	.16	.17	.18	.19	.20
◐					●										
			◐		◐										
					◐										
					◐										
					◐										
					◐										
					◐										

KEY: ◐ Partial Fullfilment

● Complete Fullfilment

FIGURE 5.6 Contd.

I.S.O. 9001 . :TION 4 sub clauses

Natural Control Station QA Procedures	4.1	.2	.3	.4	.5	.6	.7	.8	.9	.10	.11	.12	.13	.14	.15	.16	.17	.18	.19	.20
Prodecure No. Q.A.003 contd. Rev. 1 Title: Materiel Receipt and Inspection Control.					●															
Responsibility: Buyer or Storeman																				
Non-conformance Action In the event that lack of compatability is detected in any of the checks performed above, then:													●	●						
1. The responsible person us to report this non-conformance to the person responsible for issuing the associated Stores Requisition.	●													●						
2. The person responsible for issuing the Stores Requisition will decide what action is required. This will either be	●													●						
(a) To return the goods to the Supplier														●						
(b) To modify the original Stores Requisition if the non-conformance is minor. This modification is to be signed and dated.														●						
(c) To obtain approval from Client prior to issuing non-conforming materiel to shop floor. Written authorisation to be obtained from the Client in this case.														●						
Records:																				
1. Responsible person to sign off Quality Plan to indicate correct materiel received.								●		●		●				●				
2. Copy of Order, Delivery Notes and Stores Requisition to be (a) maintained by Buyer								●		●		●								
(b) sent to Accounts Dept.										●										

formal description of how the various technical operations of the company, such as design, manufacture, purchasing etc. are controlled. It also includes a management organisation chart indicating the quality organisation, with job descriptions of the various key personnel. These are not, however, full job descriptions but only those parts which are relevant to the quality system. As more quality management procedures were developed, they were added to the manual.

The Quality Manual did not, however, contain detailed technical procedures, such as welding procedures or heat treatment procedures. These technical procedures are not actually a direct part of a quality management system but would be referenced where appropriate by quality plans, as will be described shortly.

For a small organisation such as Huppmann, the quality manual could contain all the details of how a particular operation was to be controlled. A large organisation would probably restrict the quality manual to defining various responsibilities for the quality control activities, and refer to separate detailed "control" procedures. This would avoid the quality manual becoming too large and complicated.

The quality manual is thus the primary quality documentaion to be produced by the company's quality system. It is to be used as a "handbook" by the company staff as well as a powerful demonstration document to outside organisations that the company is operating a formal quality system. As a formal system document, it must be controlled itself in a suitable manner. This means that it has a revision number, date of issue, record of amendments, and someone responsible for maintaining and issuing ammended

versions. At Huppmann, the Quality Manager was assigned this responsibility.

The other central documents utilised in the new quality system at Huppmann were quality plans. Each quality plan is a specific document that is devised for a particular item or project. A quality plan, as defined by SAB, is a document derived from the quality programme setting out the specific quality practices, acceptance criteria, resources and activities relevant to a particular item or project. The quality plan lists the various steps (preferably in a chronological sequence) involved in the production of that item and the various quality activities which take place at each step to verify the level of quality obtained at that step.

Quality plans differ from Huppmann's quality manual in that they are more project specific. Also, whereas the quality manual is more concerned with the management aspects of the quality system (quality management procedures), the quality plans will refer to actual technical procedures and ensure that they are relevant to the manufacturing specification.

An example of a quality plan adopted by Huppmann for a specific vessel is illustrated in Figure 5.7. and contains the following information:

a) Revision number and date - it is thus a controlled document subject to formal documentation control, as are other quality system documents.

b) Project No. - . A unique number assigned to each project. This number is then utilised on all purchasing, Q.A., and accounting data linked to that project.

c) Supplier's name. - This is included to allow for sub-contracted work as well.

d) Quality Plan No. - A unique number assigned to each quality plan. A separate quality plan will be utilised for all major items of equipment e.g. vessels, steam piping, hoppers, screw conveyors etc.

e) A sequential list of operations or steps in the manufacture, installation and commissioning of that piece of equipment.

f) Each step of manufacture is accompanied by the quality control activity to be performed, to assure the quality of that step.

g) Each quality control step is also accompanied by the acceptance criteria (either qualitative or quantitative) to be utilised when judging the acceptability of quality. This section may refer to a specific inspection procedure or specification if the acceptance criteria are complex.

h) The following column of the quality plan specifies the documentation which accompanies that Q.C. activity and which is to be consulted or generated.

i) Space is provided for the person conducting the quality check to sign and date the document. Responsibilities for performing these checks are formally asigned via the quality manual, usually to the people most closely linked to that manufacturing step. For example, when issuing a drawing to the workshop, the design

draughtsman at Huppmann will sign the quality plan to indicate that the correct revision has been issued to the shop floor. This person is then legally responsible for ensuring that the quality check has actually been performed and that the "quality" is acceptable when compared to the acceptance criteria.

j) The customer has the option of specifying the inspections and tests which are to be "hold" and "witness" points. A hold point indicates that the client wishes to inspect the product before manufacturing can proceed. A witness point indicates an inspection which the client wishes to witness. There is also the option of the customer specifying the points at which documents are to be inspected.

k) Space is also provided for a third party inspection authority in the event that this is contractually equired (For example, in the manufacture of pressure vessels). The inspection authority is able to indicate their hold, witness and inspection points and sign off the step once it has been inspected and approved e.g. a step involving radiography would only be signed off as acceptable when results of the radiographs had been approved.

l) The quality plan is to be approved by the supplier's quality management representative. He is also to indicate his hold or witness points on the quality plan, where he will sign off the quality plan activity.

m) The quality plan is also to be approved by the customer. This may involve some negotiation between the supplier and client in terms of Q.C. activity requirements, acceptance criteria, procedures, witness points, etc. Should the customer require special tests to be performed which do not form part of the "standard" Q.A. activities performed by Huppmann, then the cost of these tests can be negotiated with the client. Once the quality plan has been approved, this forms a legal, contractual document which indicates the level of Q.A. to be applied to that product.

This negotiating phase of the quality plans at the post-award/pre-manufacturing stage of a contract was a rather time consuming and thus expensive activity for Huppmann. However, as was indicated in the previous chapter on quality system economics, effort at this quality planning stage was well worth it because of the inverse relationship between quality planning and final total "cost of quality" to the company, i.e. more effort spent on quality planning tends to reduce the overall cost of quality to an organisation.

The negotiating phase of a large, multi-disciplinary project such as a brewhouse actually continues throughout the manufacturing and installation phase of the brewhouse. What is evident however, is that the engineering and quality specifications (or standards) need to be negotiated and approved by the client prior to ordering of materials, manufacture or installation. This can take the form of technical specifications issued with the tender, engineering drawings (mechanical as well as electrical), approved work and installation instructions, quality plans, site sketches etc.

EVISION															
DATE															

PROJECT NO: N509 REFERENCE NEWLANDS SUPPLIER HUPPMANN QUALITY PLAN NO: 114

DESCRIPTION: 304L SWEET WORT TANK

	1	2	3	4	5	6	7	8	9
No.	Operation	Supp. Q.C. Activity	Accep. Criteria	Doc. Reqmt.	Supp. Q.C.	Date	?	SAB Q.A.	Date
1	DESIGN	OBTAIN APPROVAL							
2	ISSUE DRAWING	CHECK REVISION	APPROVED DRAWING	DRG N°		10-2-88			
			FOR CONSTRUCTION	542142 Rev A					
3	ORDER	CHECK MATERIALS	MATERIALS SPECIFIED			10-2-88			
	MATERIALS		ON DRAWING						
4	RECEIPT OF	VERIFY CERTIFICATION	MATERIALS SPECIFIED	HEAT					
	MATERIALS		ON ORDER	CERTIFICATES					
5	MARK OUT	VISUAL DIMENSIONAL	TOLERANCES &	DRG N° 542142 REV A					
	PLATES	CHECK, CHECK MATERIAL,	MATERIALS SPECIFIED	& HEAT					
		TRANSFER HEAT NOS	ON DRAWING	CERTIFICATES					
6	CUT, FIT UP &	CHECK FIT UP	TOLERANCES ON	DRG N°					
	TACK SHELL	" "	DRAWING	542142 REVA					
	ENDS.								
7	WELD PROCEDURE	CHECK WELD SPEC	HUPPMANN	W'LD SPECS.		22-1-88			
	SPECIFICATION		PROCEDURE						

PREPARED BY:	S. FOUCHE'	22 / 1 / 88
SAB APPROVAL		11 / 02 / 88
SUPPLIER APPROVAL		22 / 1 / 88

KEY

W	SAB REP TO WITNESS INSPECTION
D	SAB REP TO CHECK DOCUMENTS
I	SAB REP TO INSPECT

QUALITY PLAN

W.P. – WITNESS OF PROCEDURE ONLY

FIGURE: 5.7.

SHEET 1 OF 2

REVISION															
DATE															

PROJECT NO: N509 REFERENCE NEWLANDS SUPPLIER HUPPMANN QUALITY PLAN NO: 114

DESCRIPTION: 304L SWEET WORT TANK.

	1	2	3	4	5	6	7	8	9
No.	Operation	Supp. Q.C. Activity	Accep. Criteria	Doc. Reqmt.	Supp. Q.C.	Date	?	SAB Q.A.	Date
8	WELD SHELL ENDS	VISUAL CHECK, WELDER TO	NO VISUAL	WELDING					
	PER PROCEDURES	SIGN WELDING SCHEDULE	DEFECTS	SCHEDULE					
9	CUT, FIT UP &	CHECK FIT UP	TOLERANCES ON	DRG N°					
	TACK LEGS &		DRAWING	542142 REV A					
	FITTINGS								
10	WELD LEGS &	VISUAL CHECK, WELDER	NO VISUAL	WELDING			W.P.		
	FITTINGS PER	TO SIGN WELDING	DEFECTS	SCHEDULE					
	PROCEDURE	SCHEDULE							
11	FINAL DIMENSIONAL	VISUAL CHECK	RELEVANT DIMENSIONS	DRG N°					
	CHECK		ON CHECK LIST	542142 REV A					
12	PICKLE, PASSIVATE	VISUAL CHECK	SAB SPEC N°				WP		
	AND PAINT.		CEP 359. REV 1						
13	PACKING &	VISUAL CHECK OF	ADEQUATE						
	TRANSPORT	PACKING	PROTECTION						

PREPARED BY:	S. FOUCHE	22 / 1 / 88
SAB APPROVAL		1 / 02 / 88
SUPPLIER APPROVAL		22 / 1 / 88.

KEY

W	SAB REP TO WITNESS INSPECTION
D	SAB REP TO CHECK DOCUMENTS
I	SAB REP TO INSPECT

WP = WITNESS OF PROCEDURE ONLY.

QUALITY PLAN

FIGURE: 5.7. contd.

SHEET 2 OF 2

The reason for this is twofold. Firstly, how else does the manufacturer know what he is supposed to make and what is acceptable, and the purchaser know what he is buying? How else is the manufacturer able to plan his purchasing of material, sub-contracting and resources required for the project, in order to avoid delays in construction and commissioning?

Secondly, the difficulty and thus cost of introducing conceptual or design changes, increases dramatically as the project proceeds, through its various stages, as illustrated in Figure 5.8. It is thus necessary that the engineering and quality specifications reflect the true requirements of the customer and that these are agreed upon as early as possible. Once agreed upon, these specifications are legally binding and cannot be changed without approval of the other party.

5.4.3. Inspection documentation and equipment

The quality system developed for Huppmann uses the quality plans as comprehensive inspection and test plans. The inspection and test plan is negotiated and approved by the customer. The quality plans reference inspection procedures where applicable, hold point, witness points and take account of sub-contractor inspection. There are actually a great number of checks which anyone performs when doing any work activity. It was necessary to develop the degree of resolution of the quality plans, in order to give the correct level of Q.A.

There is a reasonable degree in common between the quality system standards and their inspection/testing requirements. There are six aspects which need to be under some form of control (and thus defined in the quality system utilised at Huppmann).

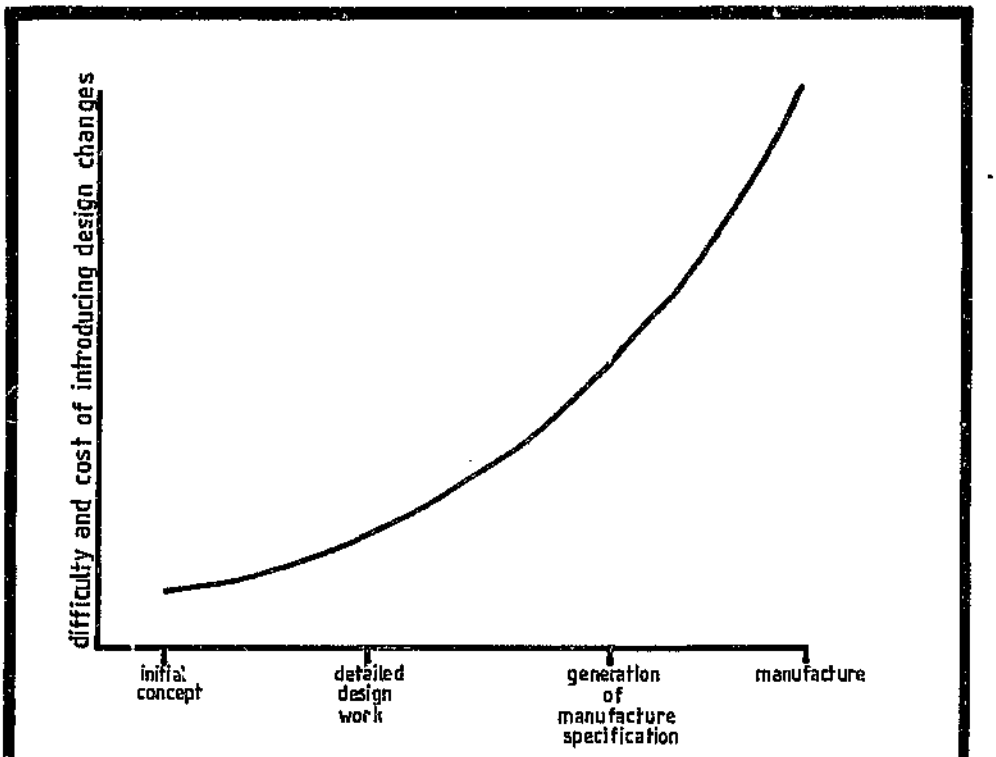


Fig 5.8. COST OF DESIGN CHANGES.

a) The inspector - his position, responsibilities and qualification.

The responsibilities of the various "inspectors" involved in the new quality system at Huppman were defined in the quality manual. These people were generally closely involved with the work being performed. This is in line with the Japanese approach of workers performing their own quality checks. For more critical equipment such as pressure vessels, independant third party inspectors supplemented internal inspectors, due to the higher levels of Q.A. required with this type of equipment.

The nuclear industry quality standards such as BS 5882 also adopt this "independent" inspector approach. This is understandable when considering the critical nature of the equipment supplied in this industry. ISO 9000 on the other hand does not insist upon the independence of the inspector, except when performing design reviews and audits of the quality system, products or processes (Section 4.1.2.2., ISO 9001, 1987).

b) Inspection procedures - their correctness, completeness and relevance.

ISO 9001 states in section 4.10.2 that the product be inspected and tested as required by quality plans or documented procedures. In other words, a quality plan can suffice and written procedures are not necessarily required.

Rogerson [7] states that all inspection and test activities should be defined by procedures (drawn up by suitably qualified personnel) and that it is advisable to provide written procedures for even the simplest inspection tasks. Although the need for assigning responsibilities for various inspections is apparent, it did not seem reasonable to develop written procedures for every simple inspection task performed at Huppmann.

For example, consider performing a dimensional check on a vessel. It is quite obvious how to perform such a check and the tolerance band on such products is such that any reasonable tape measure would suffice for the job. To develop an elaborate written

procedure for this seems unreasonable and insulting to the intelligence of the foreman responsible for such checks.

On the other hand, it was reasonable to develop a procedure which would identify which dimensions were critical to a product and required greater control. These were to be indicated by the engineer or chief draughtsman on the drawing issued to the shop floor by highlighting th·se dimensions with a flourescent yellow marker. As these dimensional checks were performed by the responsible person, they would be initialled next to the highlighted dimension to indicate that the check had been performed. The quality plan would also call for a Q.C. activity requiring dimensions to be checked, which would act as a summary that these checks had been performed.

A formal procedure was developed for dye penetrant testing at Huppmann, and this was to be performed in-house by the workshop foreman. In order to avoid total reliance on his interpretation of the test results, this was to be a witness point for the client as well, and indicated as such on the quality plans.

c. Inspection Equipment.

The calibration of inspection equipment is basic to the credibility of any inspection result. The problem is in defining to what degree inspection and test equipment needs to be calibrated and how the calibration should be traceable to a national standard.

One approach is that used by the Canadian standard CSA Z299 which divides inspection equipment into four groups:-

Group 1 - Instruments for direct measurement (eg.micrometer).

Group 2 - Accurate fixed devices (eg. gauge blocks).

Group 3 - Less accurate adjustable and fixed instruments (eg steel tapes).

Group 4 - Adjustable gauges used for the transfer of information rather than inspection (eg callipers).

Group 1 and 2 instruments should be calibrated to a recognised, authenticated standard whereas Groups 3 and 4 merely require to be periodically checked for "good working order."

In considering an inspection or testing activity it was thus necessary to consider what type of instrument was required, (if required at all as visual inspection may sometimes be appropriate) what accuracy of measurement was required (for example, the pressure gauge used for hydrostatic testing of a vessel is more critical than a humidity recorder in an electrode store) and if possible, how consistently the instrument had to perform.

Rogerson [17] warns that there are always quality system auditors who will demand that everything be calibrated, and who must be convinced with sound arguments. At Huppmann, the boiler making inspection equipment utilised (e.g. tape measures, calipers) fell into Groups 3 and 4, and thus a regular check to ensure the working conditions of this measuring equipment sufficed. On the

other hand, the pressure gauges utilised for pressure testing of vessels and pipework which fall in Group 1, needed to be controlled and calibrated. A calibration record was established for these Group 1 and 2 instruments, which indicated when, how and by whom they had last been calibrated.

d) Inspection Records -completeness, correctness and availability.

ISO 9001 requires that the supplier establishes and maintains records which give evidence that the product has passed inspections and/or tests with defined acceptance criteria. No inspection is worth anything unless the records are complete and correct.

Inspection records must include the item inspected, inspection procedure utilised (if applicable), inspection equipment utilised (usually included in the inspection procedure), inspector, date and inspection result. They should also provide evidence of follow up action, if required. Reference should also be given to linking documentation used to define acceptance criteria, such as manufacturing specifications, material standards, customer specifications etc.

An example of the type of report used by S.A.B. for non-conformance is shown in Figure 5.9. It includes a description of the non-conformance, corrective, action proposed by the contractor responsible and approval and comments by the client.

It also includes a section which indicates that the corrective action has taken place and is approved by the customer.

It was felt that the use of such defect action reports within Huppmann would cause some problems. The communication channels within Huppmann are simple and it seemed unnecessary that complex inspection reports be compiled every time a non-conformance was encountered. Furthermore they would have met with great resistance from the shop foreman who was not inclined to generate many reports and who was in any event too busy supervising manufacture.

The people involved in the quality system were instructed in the use of the quality plans, which would form the central inspection records. Signing off the Quality plan activity by the correct, responsible person indicated that the quality acceptance criteria had been met. If minor quality problems were encountered, these were to be corrected by the person responsible for generating the quality problem and signed off once acceptable.

Any major quality problems were to be reported to the Quality Manager. The Quality Manager together with the Project Engineer would then decide what corrective action was to be taken, sometimes in consultation with the client or inspection authority. If problems were encountered and they had been signed off at a preview manufacturing step, then this was to be reported to the Quality Manager because it indicated a lack of system integrity. Any non-conformance corrective action reports generated by the customer were to be completed by the Quality Manager.

THE SOUTH AFRICAN BREWERIES LIMITED

BEER DIVISION

4716

NON-CONFORMANCE CORRECTIVE ACTION REPORT

CONTRACTOR/VENDOR: HUPPMAN FABRICATION

ITEM DESCRIPTION: WORT KETTLE TOP DISHED END WITH FALSE BOTTOM

AREA	DRAWING No.	REVISION	SPECIFICATION No.	ITEM	QUANTITY
NEWLANDS 391	542 136 C				

DESCRIPTION OF NON-CONFORMANCE:

ANTI STRESS CORROSION PAINT PEELING OFF ON DONE KNUCKLES

CONTRACTOR	THE SOUTH AFRICAN BREWERIES LIMITED
BY: R. FUNK	BY: C. BNANA
TITLE: SITE CO-ORDINATOR	TITLE: SENIOR MECHANICAL TECH
DATE: 1-03-88	DATE: 25/02/88

PROPOSED CORRECTIVE ACTION WITH TIME SCALE AND PROGRAMME TO IMPLEMENT:

ANTI-STRESS CORROSION LACQUER WILL BE RE-APPLIED IN THIS AREA AT THE SAME TIME THAT THE LACQUER IS APPLIED TO THE REMAINDER OF THE VESSEL. PRIOR TO THIS WE SHALL LIASE WITH THE PAINT MANUFACTURER TO DETERMINE WHAT THE CAUSE OF THE PEELING COULD BE. THE PAINT WAS APPLIED TO CLEAN, DRY SURFACES AT THE TIME.

COMPILED BY: R. FUNK TITLE: SITE CO-ORDINATOR DATE: 7-03-88

PROPOSED CORRECTIVE ACTION APPROVED BY (With Comments if required):

PLEASE FURNISH US WITH FULL APPLICATION PROCEDURE AS PER MANUFACTURERS RECOMMENDATION.

SIGN: TITLE: SENIOR MECHANICAL TECH DATE: 07.03.88

CORRECTIVE ACTION COMPLETED.

CONTRACTOR:	S.A. BREWERIES LTD.:
TITLE: Q.A. MANAGER DATE: 1/08/88.	TITLE: DATE:

WHITE: CONTRACTOR PINK: QA/QC YELLOW: CONTRACTS GREEN: ENGINEER

N.J.P. DIN.

Figure 5.9

The recording of excessive inspection detail including very elaborate traceability requirements (eg recording which batch of electrodes was used for a particular weld) is often asked for. The assumption is that this gives a more detailed assurance of quality. This is frequently not so.[7] Merely recording data does not give assurance. Unless this detailed information is analysed and processed, for example, to give guidance in selecting welding consumables, then this expensive collection of data is wasted effort.

e) Inspection Status - Its clarity and accuracy.

It is important that an item is identifiable as either waiting to be inspected or has been inspected. The test status of products can be identified by using markings, authorised stamps, tags, labels, routing-cards, inspection records, physical location or other suitable means. Sometimes tagging is appropriate, at other times signing of a route card is more appropriate.

Identification of inspection status must be thought of in a logical sense. At Huppmann, there was a need to identify the inspection status of the material used in the tanks (by transfering the heat numbers onto the plates from the heat certificates using a roller) and the weld seams. The weld seams were identified on a drawing and the corresponding welding schedule (see section on "Special process control") indicated the status of inspection. The inspection status of the brewhouse vessels and equipment could be identified at any time by referring to the accompanying quality plan.

f) The feedback - actions initiated as a result of the inspection.

No inspection is of any use unless it provides a guide to further action. The inspection "reports" form part of a communication chain so that the responsible person (welder, design engineer, Q.A. Manager etc) can take appropriate action.

At Huppmann, quality problems caused by incorrect design and engineering specifications or quality standards that were impractical to attain, were to be directed to the Quality Manager, who would then take these up with the Project Engineer. Smaller quality problems which occurred on the shop floor could be dealt with by the shop foreman. If he was undecided about the corrective action to be taken, he could contact the Q.A. Manager or Project Engineer.

In the case of Pressure Vessels, third party inspectors were utilised at Huppmann and they would liaise closely with the Q.A. Manager. Results of inspections and N.D.T. performed by the inspection authority would be fed back to the Q.A. manager for record purpose or for action as appropriate.

5.4.4. Special Process Control

It was mentioned previously that "special processes" are the key processes in this manufacturing industry and as such, they require special attention. Included under "special processes" would be welding, heat treatment and

NDT. At Huppmann, heat treatment processes are not utilised, therefore the special processes are really limited to welding and NDT.

The only NDT performed in-house by Huppmann themselves is dye penetrant testing and a procedure was developed to formalise this. All other NDT requirements such as radiography or pressure testing of pressure vessels, was performed by third party inspection authorities. As such, it was assumed that their procedures were correct and the interpretation of the results by their personnel was also correct.

Surprisingly enough, SAB does not mention "Special Process Control" in their CEP 351 standard, "Quality Management System for Suppliers of Equipment in Beer Production". ISO 9001 on the other hand requires that "..... continuous monitoring and/or compliance with documented procedures is required to ensure that the specified requirements are met. These processes shall be qualified.....". BS5750 Part 1 is less definitive and states: "The supplier shall establish and maintain control of all special processes that form part of production or inspection. Equipment, essential processing environment and any necessary personnel qualifications shall be prescribed to the satisfaction of the Purchaser's Representative". The nuclear standards have stringent requirements for special process control, similar to ISO 9001. In general, however, all the quality system standards require measures over and above those required for "normal manufacturing".

The major attributes of all special processes are as follows:

a) A high degree of operator control and involvement

b) The complexity of the technology

c) The difficulty of doing effective process monitoring

a) Operator Control and Involvement

Operator's actions when welding are of crucial importance. The degree of automation tends to be low (unless robotic welding is performed and this is not yet feasible in this industry). Automatic welding machines are used by Huppmann in Germany to weld the tubes to tube plates in the internal boiler heat exchangers. This was not economically feasible at Huppmann South Africa because of the lower volume of heat exchangers manufactured. The skill and integrity of the welders thus needed to be qualified because operator performance is key to the success of special processes.

b) Complexity of the technology.

All special processes tend to be complex processes with many variables which control the quality of the process. Consider the variables which control the quality of a welding operation:

1. Current
2. Arc voltage
3. Travel speed
4. Electrode composition
5. Flux type or shielding gas type and flow rate
6. Electrode size
7. Welding position
8. Joint design
9. Welding sequence
10. Base metal type and thickness
11. Preheat and post-heat treatments

12. Electrode manipulation (weavers or stringer beads)
13. Electrode angle
14. Electrode-to-workpiece gap
15. Environmental conditions (dirt, grime, wind etc.)

Although a welding specification can give some rules concerning the major variables (heat input, welding position, amount of material deposited etc.), it is in practice impossible to define exactly the permitted tolerances on all the variables and develop means to control them. It is thus necessary to show in an empirical way that the welding procedure is satisfactory, but even then, the quality of the procedure will be influenced by the welder. By qualifying the procedure however, it is assumed that other welders with similar equipment and machine settings, will also achieve the quality of the tested weld.

c) The difficulty of process monitoring.

Process monitoring can only be achieved if a few critical variables can be identified and the influence of those variables on the quality of the operation is known. Furthermore, those variables need to be monitored continuously (or very frequently) and recorded whilst the operation is being performed. Near instantaneous alteration to the process variables must also be possible as a result of monitoring these critical variables.

Most special processes will fail on at least one of these points and consequently reliance must be placed on preventative measures (ensuring only qualified people conduct special processes for example) and post-operation inspections (to ensure that the special process has been carried out adequately).

The quality management steps taken by Huppmann to control special processes were:

a) Qualifying procedures to demonstrate that process procedures were satisfactory.
b) Qualifying operators to demonstrate adequate skill and experience in the process.
c) Supervision to ensure that procedures were correctly followed and only used by suitably qualified operators.
d) Post operation inspections to ensure that the special process had been adequately performed.

At Huppmann, it was agreed with the client that suitable weld procedure qualifications were to be obtained only for pressure vessels. Weld procedures for non-pressure vessels were however, to be submitted to SAB for approval. The reason for this was that there were statutory requirements concerning pressure vessels, whereas the structural integrity of normal vessels was less critical. The designers of the welding specifications (together with SAB due to their approval) were thus responsible for ensuring the suitability of the weld procedure in that context. It was important that the person drawing up the weld procedure specification be suitably qualified and experienced. An example of a welding specification developed for Huppmann is shown in Figure 5.10.

All welders were to be qualified however, to a suitable standard. In the case of the brewing pressure vessels, which are designed to A.D. Merkblatt (a German pressure vessel standard), the standard calls for welder qualification to DIN8560. This was the code used to qualify welders and an example of such a qualification is given in Figure 5.11. DIN8560 actually

calls for a written examination to be performed as well as a practical test. The test authority performing this welder qualification only gave the welder a brief verbal "examination" prior to the practical test which they felt was sufficient. This seems to undermine the DIN 8560 standard however. How can a welder be qualified to such a standard when certain requirements are omitted? It should be stated on the certificate that the practical aspect of DIN8560 had been achieved but the written test had not been performed.

In order to provide assurance that the welding specification had in fact been utilised, the welders were instructed to complete the welding schedule applicable to that piece of equipment. An example of such a welding schedule is given in Figure 5.12. It also indicates to the welder which welding procedure is to be used for each welding seam indicated on the manufacturing drawing.

The foreman was instructed to play a supervisory role on the shop floor, to ensure that the welders were actually using the correct specifications. He was to sign the quality plan once all welding was complete, to indicate that he had supervised the welding adequately.

Post welding inspections were to be performed visually by the foreman and welders after welding. The welding specification indicated defect acceptance criteria and so by signing the welding schedule and quality plans, the workshop personnel indicated that these inspections had been performed. The Quality Manager was free to indicate witness or hold points on any of this documentation or to randomly monitor the workshop to ensure that these procedures were being adhered to. As was mentioned previously, dye penetrant testing when called for was to be performed by the foreman

Huppmann
Fabrications

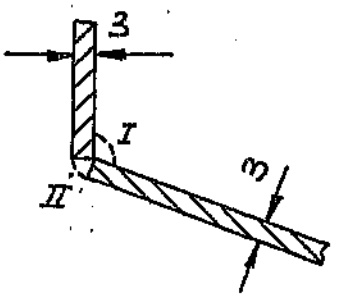
REF:

WELDING PROCEDURE SPECIFICATION

NO.: 26

CODE : N/A

MANUFACTURER : HUPPMANN FABRICATIONS

WELD PREP.	RUN SEQUENCE
N/A	

PREP. METHOD N/A

2nd SIDE PREP. N/A

PREHEAT AMBIENT (10° C)

INTERPASS TEMP. N/A

PASS NO.	WELDING PROCESS	WELD. POS.	ELECTRODE OR FILLER SIZE mm	ELECTRODE OR FILLER CODE NO.	ELECTRODE OR FILLER TRADE NAME	ELECTRODE OR FILLER POLARITY	FLUX OR GAS SHIELD	FLOW RATE ℓ/min	AMPS (A)	VOLTS (V)	TRAVEL SPEED cm/min
I	MMAW	W	2,5	E308L	AVESTA OR	+	——	——	60-90	20-24	MAN
					TRANS ARC						
II	TIG	W	1,6	E308L	TIGFIL	——	ARGON	8-10	60-80	10-12	MAN

WELD FINISH 120 GRIT

N.D.T. N/A

POST WELD HEAT TREATMENT N/A

NOTES : WELD AREA TO BE CLEAN AND FREE OF ALL FOREIGN BODIES SUCH AS OIL, GREASE, PAINT, ETC

DATE: 17-08-88

REV.: 1

MATERIAL GROUPING

GROUP: 304L to GROUP: 304L

ASME FILLER METAL CODING

PASS: A: SFA: F:

PASS: A: SFA: F:

PASS: A: SFA: F:

PASS: A: SFA: F:

SUPPORTING PQR(S)

NO.:

NO.:

NO.:

NO.:

Figure 5.10.

UNIT INSPECTION

THE UNIT INSPECTION COMPANY OF S.A. (PTY) LTD.
(GOVERNMENT APPROVED INSPECTION AUTHORITY)
REG. NO. 80/08408/07

4 SKEEN BOULEVARD,
BEDFORDVIEW 2008
TELETEX: 7-50644
TELEPHONE: 455-5640 (10 LINES)

P.O. BOX 1703
BEDFORDVIEW 2008
TELEFAX: 455-1629

ALSO AT: CAPE TOWN (021) 52-4366, DURBAN (031) 25-9462
RICHARDS BAY (0351) 4-1388, SASOLBURG (016) 6-1450

REF: 6949-1

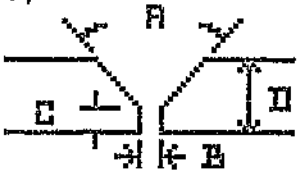
WELDER QUALIFICATION CERTIFICATE

DIN 8560-SG-R IV A f

MANUFACTURER	: HUPPMAN FABRICATIONS (PTY) LTD.		
W.P.S No.	: 1	REV.No.:	0
P.Q.R. No.	: HF-01		
WELDER'S NAME	: A. CARSON		
IDENTITY No.	: 491110 5080 010		
STAMP No.	: A		
DATE OF TEST	: 29.8.88		
PROCESS	: T.I.G. (GTAW)		
TYPE	: MANUAL		

TEST PARTICULARS			QUALIFICATION RANGE
MATERIAL SPEC	: ASTM A312 TP304	No: IV A	: ANY STEEL IN GROUPS
to		to	: R IV A OR B IV A
MATERIAL SPEC	: ASTM A312 TP304	No: IV A	:
THICKNESS	: 2 mm		: UPTO AND INCLUDING 3mm
PIPE DIAMETER	: 168.3 mm O/D		: ALL DIAMETERS
JOINT TYPE	: Single Vee Butt		: BUTT AND FILLET
POSITION	: 5G		: w,s & u (F,V & O)
WELD PROGRESSION	: VERTICAL UP		: ALL EXCEPT VERTICAL DOWN
FILLER METAL	: AVESTER ER308L		
FILLER SIZE	: 1.6 mm		
A.W.S. No.	: ER308L (DIN 8556: X2 CrNi 19/9)		
F.No./SFA.No.	: 6 / 5.9		
CURRENT	: DC		
POLARITY	: STRAIGHT		
SHIELDING GAS	: ARGON		
COMPOSITION	: 99.99%		
FLOW RATE	: 8-12 l/min.		
SAW FLUX NAME	: N/A		
REMARKS	: MAX. INTERPASS TEMP 175 deg.C (PIPE BACK PURGED)		

JOINT DETAIL



A= 70deg.
B= 3.0mm
C= 0.5mm
D= 2 mm

TEST RESULTS

VISUAL	: ACCEPTABLE	RADIOGRAPHY: ACC. REP. RT6949/001	
OTHER	: N/A		
ROOT BEND	: N/A	FACE BEND: N/A	
MACRO	: N/A	FILLETWELD FRACTURE: N/A	
OTHER	: N/A		
REMARKS	: N/A		

WE CERTIFY THAT THIS TEST HAS BEEN COMPLETED IN ACCORDANCE WITH THE REQUIREMENTS OF:

DIN 8560-SG-R IV A f.

NAME: P.KILLEEN SIGNATURE: DATE: 5.9.88

For THE UNIT INSPECTION COMPANY OF S.A. (PTY) LTD.

UNIT INSPECTION CO. No. 32 OF S.A.

Fig 5.11. WELDER CERTIFICATE

Huppmann
Fabrications

WELDING SCHEDULE

DRAWING No. A-2097 REV-2

DESCRIPTION: ASSEMBLY OF UNDERBACK ON SITE

PROJECT: O.C.B – NEWLANDS, S.A.B.

WELD SEAM	CORRESPONDING WELD PROCEDURE	CHECKED BY:	DATE
HORIZONTAL SEAM TO JOIN 1st STRAKE TO TOP	23/S	[illegible]	15/03
VERTICAL SEAM ON 1st STRAKE	21/S	[illegible]	18/03
HORIZONTAL SEAM TO JOIN 1st to 2nd STRAKE	21/S	[illegible]	18/03
VERTICAL SEAM ON 2nd STRAKE	21/S	[illegible]	21/03
HORIZONTAL SEAM TO JOIN 2nd TO 3rd STRAKE	21/S	[illegible]	21/03
VERTICAL SEAM ON 3rd STRAKE	21/S	[illegible]	23/03
HORIZONTAL SEAM: 3rd STRAKE TO BOTTOM	33/S	[illegible]	23/03
M/S LEGS TO STUBS	32/S	[illegible]	28/03

NOTE: SHOULD ANY QUERIES ARISE ABOUT THE SPECIFIED WELDING PROCEDURES, PLEASE CONTACT THE ~~DRAWING OFFICE~~ SITE OFFICE.

FIGURE 5.12

and witnessed by a customer representative. Radiography of pressure vessels was to be performed according to applicable code requirements, by an external inspection authority.

5.4.5 Incorporation of Customer Experiences

Feedback obtained in the investigational phase of the case study, regarding previous experiences with Huppmann brewing equipment, was incorporated into the new quality system at Huppmann.

For example, the problem of ensuring that the new specification regarding insulation was adequately adhered to by Huppmann was handled by incorporating the various insulation steps within the overall quality plan for that specific vessel. An extract from one of these quality plans is given in Figure 5.13. This section of the quality plan was drawn up in close liaison with the Q.A. department of SAB to ensure that it included all the inspection steps which they required.

Lack of root purging in stainless steel pipe-work was combated by including the root purging requirement into a welding specification for pipe-work. Due to the difficulty in a completed section of pipework, of actually inspecting whether root purging had been adequately performed, the welder was required to sign a welding schedule (described later in this report) indicating that this purging had been done. The site foreman, who was also in a position to monitor the welding being performed, was then required to sign off the quality plan to indicate that to the best of his knowledge, the welds had been adequately purged. The customer representative or site-engineer was free to inspect completed (and accessible) welds whenever desired

REVISION
DATE

PROJECT NO: N509/1/R/3002 REFERENCE SUPPLIER HUPPMANN QUALITY PLAN NO: 003/S

DESCRIPTION: ASSEMBLY OF LAUTER TUN ON SITE

Ref.	1 Operation	2 Supp. Q.C. Activity	3 Accep. Criteria	4 Doc. Requi.	5 Supp. Q.C.	6 Date	7	8 SAB Q.A.	9 Date
30.	PICKLE & PASSIVATE BELOW MEZZANINE	ENSURE CORRECT PROCEDURES USED. PROTECT EQUIPMENT IN VICINITY. NEUTRALIZE SPILLED CHEMICALS	AS PER CEP 359	CEP 359 REV.		14/07.			
31.	APPLY ANTI-STRESS CORROSION LACQUER BELOW MEZZANINE	CHECK ADHESION & THICKNESS ENSURE SURFACES ARE CLEAN & DRY PRIOR TO PAINTING	2 COATS, 25 µm SUNNY DRY DAY.			3/03			
32.	APPLY ALUMINIUM FOIL LAYER IN WATER SHED METHOD	CHECK ENTIRE SURFACE IS COVERED. ENSURE LACQUER IS USED FOR ADHESION. CHECK WATER SHED EFFECT.	SURFACE OF VESSEL BELOW MEZZANINE TO BE COVERED. UPPER LAYER OVER-LAPPING LOWER LAYER			5/03.			
33.	APPLY 1ST LAYER WOOL	CHECK TYPE & THICKNESS OF WOOL	LOW CHLORIDE, 50mm			8/07.			
34.	APPLY ALUMINIUM FOIL LAYER	CHECK THAT ENTIRE SURFACE IS COVERED & WATER SHED EFFECT	NO TEARS IN FOIL UPPER LAYER OVER-LAPPING LOWER LAYER			10/08			
35.	APPLY 2ND LAYER WOOL	CHECK THICKNESS OF WOOL	50mm			12/08			
36. CONTD.	APPLY CLADDING	CHECK NEATNESS, ESPECIALLY BELOW VESSEL	NEAT WORKMANSHIP						

PREPARED BY:	R. FUNK	3/02/88.	KEY
SAB APPROVAL		/ /	
SUPPLIER APPROVAL		7/02/88.	

W	SAB REP TO WITNESS INSPECTION
D	SAB REP TO CHECK DOCUMENTS
I	SAB REP TO INSPECT

PROJECT PROCEDURE MANUAL
QUALITY PLAN
CEP 357 REV. 3

FIGURE 5.13. QUALITY PLAN SHOWING INSULATION DETAILS

Failure of stainless steel equipment at welds due to inferior grade of filler wire being utilised was avoided altogether by utilising only the highest grade (316L) of stainless steel filler wire. Remaining stocks of inferior grade (e.g. 308L) wire was carefully utilised only on inferior grade (e.g.304) piping or tanks.

Corrosion of stainless steel due to carbon contamination was avoided by developing manufacturing procedures which specified that all rolls utilised in forming processes would be adequately hardened and cleaned thoroughly before use. All cutting, grinding etc. was to be done with abrasive materials dedicated to stainless steel. Cutting of mild steel was to be performed well away from any stainless steel and preferably outside the workshop altogether. These procedures were routinely monitored by the Quality Manager.

Other problems encountered, such as incorrect shell dimension or incorrect nozzle orientations were overcome by including suitable inspection steps into the quality plan. For example, an inspection of tacking a tank together, to check on the correct size prior to welding. A final inspection by the customer was also included, which consisted of dimensional and nozzle orientaion checks amongst other checks, prior to the release of vessels to site.

The quality system devised for Huppmann is thus adequately flexible to accomodate any special requirements of the customer. All that was needed was to incorporate these into the relevant quality plans or technical/manufacturing procedures. It was the resposibility of the Quality Manager to ensure that feedback from customers regarding quality problems encountered, were adequately recorded and action taken to ensure that they

would not be repeated. As such, a file was set up to store this quality feedback data and a corrective action procedure developed.

5.4.6 The Incorporation of Japanese TQC ideas

The Japanese TQC approach to quality management was discussed earlier in this investigational project. The author attempted to incorporate where possible the wisdom of the Japanese approach into the new quality system at Huppmann. The following is a discussion of the TQC concepts involved in the quality system at Huppmann.

Production Responsibility

Primary responsibility for product quality (in terms of workmanship) within Huppmann was assigned to the production personnel, with the shop foreman carrying primary responsibility for the manufacturing stages of the brewhouse equipment until it was sent to site. On site, the site foreman then resumed responsibility for the quality of the installation. Production personnel were given the authority to inspect their own work, to be supplemented by external inspectors in the case of pressure vessels.

Habit of Improvement

The Quality Manager was to act as a facilitator by initiating quality improvement projects and ensuring that these were implemented within reasonable time spans. The review and auditing requirements of the quality management standards imply that the quality system will be periodically reviewed and improved. The customer feedback mechanisms introduced into Huppmann would also

ensure that a habit of improvement was maintained within the company.

Process Control

The Quality system at Huppmann utilises formalised control over the manufacturing process at all the "natural" control stations, rather than relying on merely a final inspection of the product. This meant that errors could be detected at early stages, which is particularly important when considering the high cost of stainless steel scrap and the consequences of delays to projects. Implementing corrective action at an early stage is far easier and less costly than at a later stage.

Easy-to-see-quality

The nature of the work performed by Huppmann placed limitations on the degree to which this TQC concept could be adopted. The physical distance separating site-work and the shop floor made it difficult to ensure that the quality problems encountered on site were communicated to the shop.

Furthermore, the generally crowded, less clean and structured site environment which involves a number of disciplines (mechanical, civil, electrical etc.) makes it difficult to "see" the actual quality being achieved. In the work-shop on the other hand, the large size of the tanks manufactured, the small number in progress at any one time and the relative simplicity of them (no complicated, hidden mechanisms or electronics) made the quality "easy-to-see".

The welding aspect of the manufacturing process also placed some limitations on the "easy-to-see-quality" concept. Although if a weld has a very poor appearance, it generally is not up to standard, the converse is not necessarily true. A weld which visually appears sound may be structurally unsound due to porosity, inclusions etc., which may only be revealed by sophisticated NDT techniques.

Insistence on Compliance

In this industry, the traditional approach of Acceptable Quality Levels is not applicable because of the high costs associated with defects. Contractual relationships between Huppmann and their clients meant that compliance with specifications and quality standards was insisted upon. The assumption made was that these reflected the needs of the client and were actually attainable.

Line Stop

All personnel involved in production (not only the foreman) were given the authority to stop production if they encountered a quality problem, were unhappy with the quality obtained from a previous process or had queries about the engineering specifications or quality standards.

For example, it happened at Huppmann that during the construction of the malt hoppers for the new brewhouse, a welder complained to the foreman about a specific welding specification drawn up by the design office. It called for flush grinding of the welds. He felt that the plate used for the hoppers was very thin, and grinding the welds flush would make the hopper structually

unsound. He was reluctant to weld the hopper and then sign the welding schedule, because he did not want to be responsible for its collapse. The matter was discussed with the Project Engineer and it was decided that the vessel would be strong enough but careful grinding was required to avoid undercutting the material. The welder was thanked for his concern and assured that, as long as his welding was structurally sound and done according to specification, the vessel would be sufficiently strong.

Correcting one's own errors

This was common practice at Huppmann because the size of the operation did not allow for a separate re-work crew. Once again a problem was encountered with this TQC principle when a separate site crew was utilised. This occurred in the Ohlsson's Cape Brewery project where a combined German/locally recruit artisan team was utilised. Should a quality problem only be detected on site, then it was not feasible to send those responsible in the work-shop to repair it.

However, the entire aim of the quality system is to eliminate quality problems or certainly detect them before they are sent to site. The appearance of quality problems on site which originated in the workshop would suggest deficiencies in the quality system. It was thus of extreme importance to record any problems detected on site and incorporate these into future quality plans, in order to "tighten" the inspection net and avoid the problems being repeated.

100 Percent check

This was the method utilised at Huppmann and was in fact an essential part of the quality system. To provide the required level of Q.A., all vessels and all welds on vessels were subject to some form of control and inspection. This meant that not only pressure vessels but all the products supplied by Huppmann were to be subjected to quality control checks.

Project-by-project improvements

This was the method adopted by Huppmann to obtain quality performance improvements. Exposure of problems was encouraged and regular "production meetings" were up on a fortnightly basis. The aims of these meetings was to bring together those key people who contributed towards product quality, discuss quality problems encountered and generally to seek ways of improving the quality performance of the company. These meetings were also aimed at ironing out quality problems encount which had been caused by other "departments"or problems encou d with the implementation of the new quality system. The meetings were to serve as a forum for quality improvement projects.

One such project which developed from a production meeting concerned the welding together of the thin stainless steel plates used to manufacture a vessel. This was done by laying the plates on the floor, TIG welding them together, turning the plates over and backgrinding if necessary. The entire weld was then fused from the other side and finally ground flush.

An improvement was suggested by the shop foreman at one of these production meetings. A long, flat bar of copper was to be placed

under the weld seam prior to welding. The bar was to have a groove machined in it, which would be opposite the welding seam. Once the plates were tacked together and placed over this copper bar, the groove was plugged at one end, argon gas fed in at the other end and weights placed on the plate to form a seal. As the welding proceded, the argon in the groove was to act as a shielding gas, preventing oxidation of the material and promoting penetration. This meant that only one run was required on a weld seam. The copper would aid in absorbing the heat generated during welding and minimise distortion. The idea was approved, implemented and was successful.

Housekeeping

The emphasis placed by the Japanese on housekeeping was particularly relevant in the stainless steel environment in which Huppmann operates. These materials are sensitive to contamination and a clean environment is beneficial in avoiding this contamination. The workshop was swept entirely clean once a week and clutter in the shop was minimised by keeping most fittings in the store, where they could be drawn via a stores requisition. Stainless steel sheet offcuts were carefully stacked on one side of the shop where they could be accessed if required.

5.5 Review of the Quality System

5.5.1 Implementation Problems Encountered

This section of the report will deal with problems encountered by the author whilst implementing the quality sytem at Huppmann. These problems are analysed and solutions recommended.

Production Meetings

The first problem to be encountered during the implementation phase of the case study was that the production meetings proved to be less successful than anticipated. Only a few of the production meetings were fully attended because people were generally away on project sites elsewhere. The sales representative in particular claimed that he was too busy to attend these meetings and besides that, he knew all there was to know about quality control anyhow (he has subsequently left the company). It soon became apparent that it would be very difficult to schedule these meetings such that all the key people would be together at one time. Eventually these meetings petered out altogether when the author moved onto site during the site-work stage of the new brewhouse.

If people cannot be brought together regularly then someone must act as a central point to which quality-related information is fed and who will act promptly on such information. This should be the Quality Manager, who also needs to act as a catalyst to ensure that the drive towards quality improvement is maintained.

Management Resources

Many companies will probably find it difficult to allocate valuable management resources to this function and Huppmann was no exception. There is a danger that the company will appoint a management representative as required by the quality system standards, who will have many responsibilities besides co-ordinating the quality system effort. The implementation of the quality system can become severely delayed and in practice, it may never become implemented effectively.

Fortunately, due to a narrower product range and less communication problems, small companies will tend to have less complex quality systems. Nevertheless, faced by limited management resources to implement the system, a company faces the following options:

a) Allocating specific management time to the new quality system and possibly neglecting other areas temporarily whilst the major thrust towards implementation is required. One must then bear in mind that even once the system is established, management time must be allocated towards maintaining or improving the system and performing the various functions required by the system.

b) Employing extra management resources. This may be too expensive for a small company and implementation delays would occur whilst that person becomes familiar with the new company.

c) Enlisting external expertise in the form of a quality consultant or other expert, who will implement and document a system, then hand it over to the company to maintain. The advantage is that the expertise and experience of the consultant

would be valuable in implementing the system and the time taken would be minimised because of the intensity of implementation. It would be the sole function of that consultant whereas an in-house person would have other responsibilities and encounter a learning curve with respect to quality management system requirements. Also, sometimes an outsider sees the company more objectively and is able to solve problems because of this fresh perspective.

One disadvantage is naturally the cost of such expertise (an estimate of R10 000 was obtained from one company for documenting a quality system suitable for Huppmann). Another disadvantage is that an outsider may not be sensitive to the way in which the company operates. Resistance could also be encountered due to an outsider "prying" into the methods of operation of various personnel. The lack of legitimacy of an outsider may thus hamper the implementation of the quality system.

At Huppmann, the author was allocated responsibility for implementing the quality system and could thus be considered as a "Quality consultant". However, one important difference was that the author has had links with the company for a number of years and thus was not an "outsider" as another consultant would have been. A quality system has people at its core and thus understanding the people involved in such a system is naturally an advantage. Being a student project, the cost of this "expertise" to the company was a lot less than it would have been had a quality consultant been utilised.

Resistance of Personnel

Initial resistance was met from personnel who were involved in the new system. They regarded the formalised procedures as merely an extra work load and a waste of time. Once it became apparent that these procedures improved information flows and were in fact being done informally anyway, resistance usually began to diminish.

It must again be stated however, the need to keep documentation to a minimum in order to reduce the work load of those people involved and minimise their resistance to the quality system. There are some horror stories[7] about the mass of the paperwork generated by a Q.A. system exceeding the mass of the equipment manufactured. Careful assessment of all documentation requirements and document design for that matter, was essential. The quality management standards are a guide in this matter and tend to specify document requirements (albeit in a rather general manner) depending on the level of Q.A. required.

The customer likes to see paperwork because he mistakenly assumes this means good Q.A. The questions to ask (and to negotiate with the customer) are:

1) What information is really required to assure the quality of products adequately?

2) How can this information be obtained efficiently without delaying busy personnel unnecessarily?

At Huppmann, complete Q.A. plans were produced by the author (and eventually by the chief draughtsman) and a complete information package including drawings, welding specifications, welding schedules and quality

plans were sent to the workshop when ready. All the foreman had to do was sign and date the activities as required. Any revisions to the quality plans were issued and old ones destroyed. This did mean however that the new revision had to be re-signed for the various activities which had taken place. Fortunately, revisions to quality plans seldom occurred once they had been approved by the client.

Incomplete Quality Plans

On site, numerous revisions to quality plans occurred, due to additional installation steps being added as it became clear how the installation was to be done and what Q.C. activities would be required. It was thus impossible to draw up entire quality plans for the site-work prior to starting the installation because formal Q.A. had never been utilised by Huppmann. As the installation of the brewhouse proceeded however, the author was able to consult the various German erectors about the steps taken to install the plant and what form of quality checks they had "informally" utilised in the past.

The client was understanding in this matter and merely checked the quality plans on a regular basis as they grew, to ensure that they were satisfactory. For the next brewhouse project in Botswana, Huppann has been able to submit entire installation quality plans for approval prior to commencement of site-work, due to the experience gained in this project. This has impressed the client greatly because no other contractor working on the new brewhouse site in Botswana has been able to give SAB this degree of site Q.A.

Quality System procedures

Some problems also occurred initially with workshop personnel not adhering to manufacturing procedures. This is understandable because of the need for personnel to adapt to any new system. For example, initially welders were not given the welding specifications by the foreman and were not aware of which specification was to be utilised. On one occasion the incorrect welding method was utilised to weld a manhole into one of the malt hoppers. Too much heat input occurred and the conical top buckled severely. A large section of the top had to be cut out and carefully replaced. Upon investigation, it was revealed that the weld specification issued to the foreman by the author had not been consulted at all and the welder had performed his work unsupervised, as he thought best. It was an expensive lesson, but after this episode the welding specifications were consulted by the foreman as well as the welder concerned. Any queries from the shop floor personnel regarding welding specifications were then directed to the drawing office.

Systems tend to disorder

It is one of the natural laws of the universe that with time all systems tend to disorder. Quality systems are no exception to this as was revealed when the author returned to the head office after performing the site work aspect of this investigational project. Although the chief designer was made responsible for the quality manager's functions during the author's absence, there was a distinct "slackening" evident in the workshop, in terms of the quality system procedures. Quality plans were not always issued to the shop prior to commencement of manufacture, welding specifications were not supplied in some instances and some inspection points were only signed after the piece of equipment had left to site.

It was probably unwise to leave such a new system in the hands of someone else, but at the time there was no choice because the site aspect needed the attention of the author. It did point out the need however, for a routine surveillance of operations and regular auditing of the quality system to ensure that the correct procedures were being followed and that the quality system was functioning effectively.

Perhaps more emphasis should have been placed on "selling" the new quality system to the employees of the company. Clearly it is not an ideal system if the only means to insure its implementation is to "police" the works continually. If the employees involved in the system were sold on the idea and truly involved, then the quality system would avoid becoming merely a tedious "window dressing" exercise and "policing" the system could be avoided.

One improved method of "selling" the system could be to ensure that feedback regarding quality achievements of the company is given to employees, and illustrating how the quality system had contributed to this success. Another method could be to emphasise "quality" from the customer's point of view, by physically showing employees quality problems at customers' plants, the consequences of these problems and how the quality system was aiming at reducing the chances of these problems arising in the future. It also appeared to be important to re-establish the fortnightly production meetings, to assist in selling the quality system to employees by obtaining feedback regarding problems with the system, acting on this information and communicating quality achievements of the company, etc.

Fluctuating Q.A. levels

Another problem which occurred during the absence of the author from the head office, was that post-weld inspection methods on non-pressure vessels wer altered to suit the demands of the customer without considering the cost and time implications. SAB had increased the size of their Q.A. department and the inspector appointed for the new brewhouse in Botswana had increased the level of Q.A. required for welding. After the vessels had been welded he had requested that they be 10% radiographed and Huppmann had obliged him. Not only was it causing unnecessary expenses, but the radiographs were then judged according to ASME VIII, the American pressure vessel code of practice. Some of the welds failed this stringent test, as indicated in Figure 5.14, and had to be repaired at a further cost. When the "unsatisfactory" welds were repaired and re-radiographed, the acceptance criteria was suddenly changed to AD Merkblatt HP 5/3, (also for pressure vessels but different acceptance criteria to ASME) as indicated in Figure 5.15.

This situation is clearly unacceptable. The customer cannot be allowed to suddenly change the level of Q.A. at will and the inspection authority change acceptance specification at will either. The quality standards contractually agreed upon in the approved quality plan (see Figure 5.16) cannot be changed without negotiation between both parties.

Inspection Authorities

This example also highlights some of the problems encountered with inspection authorities. The growing commitment worldwide to formal quality systems based on quality management standards has meant the development of increased in-house expertise regarding these standards as well as the

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REG. NO. 80/08488/07

Fig. 5.14. INSPECTION REPORT

RAD

EUROMEMBER

UNIT INSPECTION

Report No. RT/2101/001/DJ

RADIOGRAPHIC INSPECTION REPORT

Issuing Office: WADEVILLE			Date of Test: 7TH SEPTEMBER 1988
Customer: HUPPMAN	Location: EDENVALE	Customer Order NO.: 7512	Unit Job No.: NDE 2101 J
Type of Work Piece: COOKER		Identification of Work Piece: ORDER NO 7512 MASH COOKER	
Service and Description of Work Piece: MATERIALS PROCESSING		Size: 3 SHOTS 10CM X 40CM	Material: STAINLESS STEEL
Welding Process: GMAW	Welding Position: DOWN HAND	Welder: BY HUPPMAN	Stress Relieved: NOT GIVEN Yes ☐ No ☐
Inspection Specification: ASME V 1980		Acceptance Specification: ASME VIII 1983	Marking and Setting Up

Basic Technique

		Container	Source	Strength	Size	Exposure	SFD
Gamma Ray	☐			C		min	
		Equipment Make and Type			Energy	Exposure	FFD
X-Ray	X				170 kV	4 mA min	700

Focal Spot Size	X-Ray Filtration	Developer	Time	Temp
4MM	Pb SCREWS	AGFA	5 MINS	20°C

Films	Screens	Density	IQI		Sensitivity
AGFA D7	Pb	1.8	10 ISO 16	Film Side ☐ Source Side X	2 %

GENERAL REPORT		
	SHOT 1	REPAIR 13 - 18CM
	SHOT 2	REPAIR 17 - 24CM + T FOR 30MM FROM XING WELD
	SHOT 3	ACCEPTABLE

Test Restriction and Comments

Continued on Sheet No. SHEET 1 OF 1

Inspecting Authority	Customer HUPPMAN	Unit Inspector/Radiographer D. JOHNSON
Signed	Signed	Supervisor/Interpreter P.K. BARBER

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REG. NO. 80/08495/07

RAD

EUROMEMBER

UNIT INSPECTION

Fig. 5.15 RE-INSPECTION REPORT

Report No. RT/2129/001/DJ

RADIOGRAPHIC INSPECTION REPORT

Issuing Office		Date of Test
VANDEVILLE		19TH SEPTEMBER 1988
Customer	**Location**	**Customer Order NO.** / **Unit Job No.**
HUPPMAN	EDENVALE	F 7512 / 2129 J
Type of Work Piece	**Identification of Work Piece**	
STAINLESS PLATE (cooker)	MASH COOKER BOTTOM	
Service and Description of Work Piece	**Size**	**Material**
GRAIN PROCESSOR	+/- 8MM	STAINLESS STEEL
Welding Process	**Welding Position**	**Welder** / **Stress Relieved**
GMAW	DOWN HAND	BY HUPPMAN / Yes [ ] No [X]
Inspection Specification	**Acceptance Specification**	**Marking and Setting Up**
AD MERKBLATT	AS MERKBLATT HP 5/3	

Basic Technique

		Container	Source	Strength	Size	Exposure	SFD
Gamma Ray	[ ]			C		min	
		Equipment Make and Type			**Energy**	**Exposure**	**FFD**
X-Ray	[X]	ANDREX			160 kV	2.2 mA min	700
		Focal Spot Size	**X-Ray Filtration**				
		4 MM	Pb				

Developer	Time	Temp
AGFA	5 MINS	20 MIN

Films	Screens	Density	IQI		Sensitivity
AGFA D7	Pb	1.8	DIN 10 ISO 16	Film Side [ ] Source Side [ ]	1.8 %

GENERAL REPORT	
	SHOT 2 R1 ACCEPTABLE
	SHOT 1 R1 ACCEPTABLE

Test Restriction and Comments	Continued on Sheet No.
2 FILMS OVER REPAIRED AREAS 10 X 40	SHEET 1 OF 1

Inspecting Authority	Customer HUPPMAN	Unit Inspector/Radiographer D. JOHNSON
Signed	Signed	Supervisor/Interpreter C. VON RUBEN pp

REVISION		1														
DATE		27/7/88														

PROJECT No. REFERENCE KGALAGADI SUPPLIER HUPPMANN QUALITY PLAN No. 14-7

DESCRIPTION. 316L DISHED BOTTOM BLANK (MASH TUN)

	1	2	3	4	5	6	7	8	9	10	11	12
No	OPERATION	SUPP. Q.C. ACTIVITY	ACCEP. CRITERIA	DOC. REQUD.	SUPP. Q.C.	DATE		SAB Q.A.	DATE		3rd party q.a.	DATE
1	DESIGN	OBTAIN APPROVAL		DRG 570506		26/7/88		H				
2	ISSUE DRG.	CHECK REVISION	APPROVED DRGS. FOR CONSTRUCTION	DRG. NO. A-2099		27/7/88			7/9/88			
3	ORDER MATERIAL	CHECK MATERIAL	MATERIAL SPECIFIED ON DRAWINGS			27/7/88			7/9/88			
4	RECEIPT OF MATERIALS	VERIFY CERTIFICATION	MATERIAL SPECIFIED ON ORDER	HEAT CERTIFICATES		27/7/88			7/9/88		✓	
5	MARK OUT PLATES AND CUT	DIMENSION CHECK	TOLERANCE ON DRAWING	DRG. NO. A-2099								
6	FIT UP AND TACK BLANKS	TRANSFER HEAT NO. CHECK. FIT UP.	DIMENSION ON WELD SPECS.	HEAT CERTIFICATES							✓	
7	WELD PROCEDURE SPECIFICATIONS	CHECK WELD SPECS	HUPPMANN PROCEDURES	WELD SPECS.		27/7/88			29/8/88		✓	
8	WELD BLANK PER PROCEDURE	DYE PENETRANT TEST (N) ON BACKGRIND WELDS TO SIGN SCHEDULE.	NO VISUAL DEFECTS	WELDING SCHEDULE.					7/9/88		✓	

PREPARED BY.	A. Nicholas	27/07/88
SAB APPROVAL		15/08/88
SUPPLIER APPROVAL		15/8/88

KEY			
W	SAB REP TO WITNESS INSPECTION	W	INSPECTOR TO WITNESS
A	ACTION	H	HOLD FOR INSPECTION
D	SAB REP TO CHECK DOCUMENTS		
I	SAB REP TO INSPECT	I	INSPECTION

Fig. 5.16. QUALITY PLAN - MAIZE COOKER

Huppmann

national construction standards. This was certainly the case with Huppmann where prior to this project, no in-house expertise regarding quality management standards and only a vague understanding of the national construction standards existed. Companies such as Huppmann tended to rely on the advice of inspection authorities regarding inspection requirements, procedure qualifications etc.

This put the inspection authority in a rather powerful position. These organisations are naturally in business to make a profit and one can assume that the more welder and procedure qualifications, radiographs, etc. undertaken, the more profit the inspection authority will make. As such their advice in some matters may not be as unbiased as one might hope. For example, the geometry of a test piece is often recommended by the inspection authority. By careful selection of the geometry of a weld procedure test, a very wide combination of actual welding geometries encountered can be covered. The converse is also true. Certain geometries are more limiting and further procedure tests would be required for geometries not covered by that procedure qualification. These procedures are expensive (around R1000 for an A-D Merkblatt procedure) and time-consuming.

A fabricator would naturally want to avoid unnecessary Q.A. costs and a high degree of understanding, of quality management and construction standards is thus desirable. This knowledge for example, may have avoided the repair costs encountered by Huppmann regarding the welds mentioned above, which failed to pass the ASME criteria.

Delays

A major problem encountered at Huppmann, and one which the author was not able to solve, were the delays caused whilst awaiting inspection or results of inspections from outside the company. Neither the customer's inspectors nor the inspection authorities were able to attend immediately to inspection hold and witness points when called for by the quality plans. Although Huppmann would try and provide sufficient warning of approaching inspection points, delays still occurred. Not only were these highly disruptive to work flows, but they also resulted in increased lead times for products and difficulties in planning completion dates. The potential consequential delays to other aspects of a project were discussed earlier in this report.

There did not appear to be an easy solution to this problem and the best approach to adopt appeared to be as follows:

a) Giving customer and inspection authority ample warning of impending witness points by estimating the progress of a particular item.

b) Requesting the inspection authority to expedite results of NDT examinations.

c) Remaining flexible in terms of workshop scheduling i.e. as soon as a delay was encountered on one job, the workshop personnel were to have other jobs awaiting which they could attend to.

d) Careful assessment of delays to other aspects of a project if the item delayed is part of a larger system and subsequent replanning of the project to try and minimise the effects of the delay.

This is clearly not an ideal situation and if these delays cannot be substantially reduced in the future then the costs encountered by Huppmann due to a less efficient production system will probably have to be passed on to the customer. This could be done for example by putting a cost to these delays, which would depend on the level of Q.A. required by the customer, and building this into the quotation for that item/project as a Q.A. system cost. It could be pointed out to the client the differing Q.A. costs, depending on the level of Q.A. required.

5.5.2 Feedback on Site Q.A.

This topic requires a separate discussion because there are many aspects of the quality management system which were influenced by the site environment. It is at the site stage of any construction project, that all the pieces of equipment are brought together to form an integrated system. The purpose of site Q.A. is to provide a level of Quality control on site so that the designers' intentions as well as the requirements of the customer are met. The objective is to ensure that the specifications of the contractor as well as the client are adhered to and to ensure that the quality of workmanship is satisfactory to the customer.

The integrity of a plant such as a brewhouse is rapidly revealed during commissioning stages and a consequence of an effective site Q.A. programme would be to contribute towards a commissioning programme which runs quickly and smoothly. The first brew done by a brewhouse is a contractual milestone date, usually with penalty clauses attached to it. Problems due to faulty workmanship and installation, besides being expensive to rectify, can cause major delays in the commissioning of a plant. The effect on the reputation of the company as well as the profitability of the project would be disastrous. Eventually the plant must perform as specified, but at what cost to the supplier, especially with contractual penalty clauses in force?

In the past, "control" had tended to be lost by Huppmann once the equipment had been manufactured and sent to site. For this reason, the site aspect of the new Q.A. system required special attention and this section of the report deals with the experiences gained by the author on site.

The Ohlsson's Cape Brewery project was the first brewhouse built by Huppmann with formal Q.A. as part of the site work activity. It is not usual for the German parent company to utilise Q.A. on site. They seem to implicitly trust their artisans to perform their work according to drawing or specification and they utilise highly experienced site foremen. They also tend to use the same subcontractors wherever they happen to build a brewhouse in the world; the subcontactors know by now what Huppmann wants from them and Huppmann knows what to expect from them.

Huppmann generally builds brewhouses on a turn-key basis. The customer (especially in less sophisticated Third World countries) will say "We need a brewhouse which produces x amount of beer" and he will supply information to Huppmann regarding their method of brewing beer. On the technical side there will be little input because it is assumed that Huppmann knows best how to build a brewhouse which will meet the requirements of the customer.

A customer such as SAB, however, wishes to have a far greater technical input and control over the final product. They utilise a combination of internal expertise in the form of brewers, engineers, technicians and draughtsmen as well as external consultants to generate a number of technical specifications.

Huppmann provides a detailed technical specification as part of the contract between themselves and their clients. This is basically a breakdown of all the various components of the brewhouse, performance figures, material specification,s etc. The technical specification, in conjunction with approved Process Flow Diagram (PFD's and various engineering drawings, form important Q.A. documents because they state what

the customer has purchased from Huppmann and how the plant is to be installed.

The role of the Q.A. representative on site (the author in this case) was to ensure that Huppmann's as well their customer's drawings, procedures and specifications were being adhered to. Another role was to clarify with the customer any aspect of the installation not covered by these specifications and drawings issued with the tender.

Site environments - their effect on Quality

There are some important differences between a site working environment and the corresponding workshop environment, which influence the quality system and have a role to play in the final quality of the product.

Firstly, site work is far less predictable and stable than the workshop. The entire manpower structure allocated to a specific project is by necessity short term, because various disciplines are required at different stages of the project. The decision whether to use locally recruited manpower and sub-contractors on site or whether to use manpower from the workshop and Johannesburg based, known sub-contractors is a difficult one with implications on product quality.

Locally recruited personnel are usually cheaper, although their hourly rate may be more, because expensive living out allowances, travelling and accommodation costs are eliminated. Their performance on site and their quality of workmanship were unknown factors however, and could only be judged once they had settled into their new jobs. A learning curve came into effect and time lost whilst adapting to a new job was undesirable in such a tightly scheduled project.

During this period, a high degree of Q.A. was of critical importance whilst the artisans adapted to the methods and procedures particular to Huppmann and SAB. Poor workmanship was sometimes evident, mistakes were made, rework had to be performed and expensive stainless steel was wasted. Once the site crew was established and accustomed to the methods of the German foreman, a fairly consistent level of workmanship occurred.

The decision to use local or workshop employees may not merely be based on economics. A small engineering company such as Huppmann Fabrications simply does not have the manpower resources to cope with such periodic, large projects. In this particular project it was not feasible to send workshop personnel on site for any great length of time because much needed output from the workshop would have suffered. The German erectors used on site are very expensive (approximately R1000 per day) and Huppmann was naturally keen to keep the time they spent on site to a minimum.

One of the major problems with opting for local artisans appears to be finding people on a short term basis who have the necessary experience, motivation and ability to perform adequately. There is also a shortage of skilled, professional artisans in South Africa. Those artisans with the necessary skills tend to have regular employment because their employers know what an asset they are.

This leads on to another problem, namely lack of company loyalty. The short-term nature of the work performed by contract personnel means that there is generally not enough time to build up any company loyalty. The adoption of Quality Assurance and Quality Control by a company is a slow process which requires a long term commitment from management as well as shop floor personnel. Short term employment and lack of company loyalty are

detrimental to the quality system and thus quality of products. The "lifetime" employment attitudes of Germany and Japan, and the high quality of their products seem to confirm this.

Artisans from the workshop, on the other hand, tended to need far less supervision than the local artisans and they were already used to some of the quality system procedures. Their productivity was also greater primarily because they wanted the job to move along rapidly so that they could return to their families.

One of the other differences between site work and the workshop environment is that of equipment resources available. There is a limit to the number and type of machines which can be taken onto a site. Clearly it is impractical to move larger machine tools. There are, however, a wide range of relatively portable machines which have a great influence on the ease with which a job is performed and thus the quality of the workmanship. Pipe cutting and pipe weld-preparation machines are good examples.

Another fundamental difference between site and workshop is the proximity of the client. On site, the client is physically close at hand and this allows for rapid feedback should quality problems occur. If the contractor or client has a query, these can be solved relatively quickly. The effect on Quality tends to be beneficial because it places more pressure on the contractor to perform a good job. On site it is more difficult to cover-up mistakes during subsequent manufacturing steps, as could be done in a workshop, because the client is continuously observing the progress made.

The assumption made, is that the client knows what he wants, and will respond rapidly when queried by the contractor. Unfortunately, this did not

often appear to be the case. Delays occurred because the client was uncertain about what he wanted and various personnel in the client company had different ideas about the same issue. This became a real problem on site because it led to conflicting instructions, re-work and confusion.

It is impractical to show every aspect of an installation such as a brewhouse on drawings, and some issues need to be resolved on site. For example, where to run cable racks or how to bracket pipes to a wall. At first, these issues were resolved verbally with the relevant client Engineer on site. The decision taken would then be translated by the Q.A. representative to the foreman or the relevant artisan. What tended to happen was that during the installation of, for example the cable racks, someone else from the client would say that the installation was unacceptable for any number of reasons, ranging from aesthetics to interfering with some other planned installation. This would then lead to re-work in that area resulting in lost time and the problem of who would pay for the re-work.

It became apparent that the only way to overcome these problematic grey areas where no approved drawings existed was to liaise closely with the client, preferably showing the various engineers on site exactly what the problem was and the proposed solution, in the form of a sketch or written description. In order to obtain rapid approval of these sketches, the contractor needs to establish who is involved in the decision-making unit (DMU) of the client, for that particular discipline. Any subsequent re-work performed in an area covered by these sketches or approved drawings would be for the account of the client and a delay due to re-work would be noted.

The effort required by the Q.A. representative to draw up these sketches and obtain approval on various issues proved well worth it. The site team was instructed not to proceed with work until clarification and approval had been obtained. It was the responsibility of the Q.A. representative to look ahead of the installation work, anticipate problem areas and push the client for rapid decisions on issues in order to avoid delays. Copies of approved sketches could then be handed to the Foreman or relevant artisan directly and would be referred to in the event of a dispute with the client.

One particular contractor on site who had not taken these measures, had to redo a major portion of their installation work free of charge. They had not obtained approval on a particular method of installation and SAB informed them that their method was unacceptable.

What must be emphasised at this point was the need for the Q.A. representative to be in a position to judge what was technically acceptable to Huppmann as well as SAB in these instances. Even though a particular aspect of the new brewhouse may have been approved by a representative from the client at the time, this is only an approval in principle. If it is proven to be technically incorrect, at the end of the day it is a Huppmann installation and although it may not reflect well on that particular person who approved it, Huppmann would probably be responsible because they "designed" and installed it. It must be borne in mind that in a turn-key type project such as this, Huppmann was responsible for virtually everything within the four walls of the brewhouse.

Whenever the author was in doubt as to what was acceptable to Huppmann in a technical sense, he would contact the Project Engineer in Johannesburg or

West Germany. Fortnightly visits on site by the Project Engineer from Huppmann in Johannesburg and periodic visits by the German design Engineer did much to clarify various technical problems which had been encountered. Close liaison with SAB Q.A. representatives on a regular basis on site also helped to ensure that their requirements were incorporated into the installation work.

Customer Requirements vs. What was Sold

Unfortunately, as was mentioned previously, not all issues are resolved at the tendering stage of a complicated, multi-disciplinary installation such as a brewhouse. Huppmann has its standard way of installing a brewhouse and a client such as SAB also has its standards, specifications and ideas about the installation method. The Q.A. discipline appears to be caught in the middle of this dilemma and seeks to marry the two harmoniously.

Most of the customer's technical specifications were included in the original contract documentation, but it became evident during the project that not much attention had been given to these by the commercial department of Huppmann, which handled the original contract. Only during the actual installation work did the financial and time implications of some of these specifications become evident.

Let us take for example the cable racking installation. The Huppmann standard method is to utilise stainless steel trunking running horizontally at two levels, one for instrument cables and the other for power cables, with a gap of approximately 300mm between the levels to avoid inductance interferences between control signals and power cables. The SAB standard, however, called for stainless steel mesh wire racking running vertically

with 600mm gap between power and control (see Figure 5.17). SAB stated that rodents were less likely to attack the cables in this type of installation.

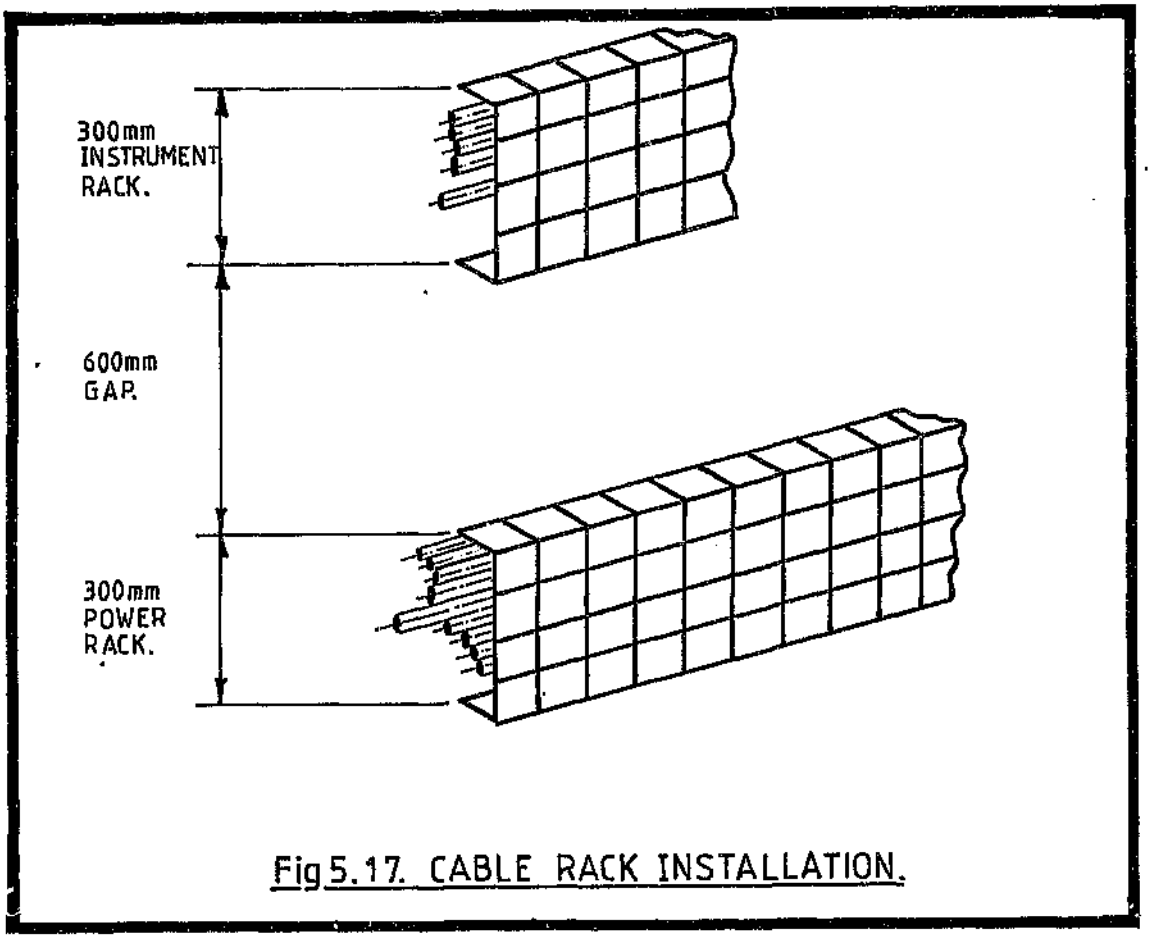


Fig 5.17. CABLE RACK INSTALLATION.

The vertical racking meant that each individual cable had to be neatly strapped to the rack at regular intervals, which made the actual cable installation more time-consuming and thus more expensive. Delays caused by waiting for a final decision on the type and orientation of racking and the greater period of time required for the cable installation work contributed greatly towards delaying the milestone First Brew date.

This example illustrates the importance of involvement of the Q.A. department as well as engineering departments at a very early stage of a

project, preferably at the tendering stage. It is of great importance to determine what the detailed requirements of the customer are and to analyse the specifications of the customer and how they differ from standard practice in order to ascertain their cost and programme implications.

During the course of the brewhouse installation there were also many options for which the client opted, which changed the original scope of work. Numerous revisions to drawings were issued incorporating these options or changes. This caused some confusion on site because of delays in obtaining revised drawings from Germany and the problem of communicating the latest information to the site team without revised drawings. It became very important to ensure that everyone was working to the latest revised drawing and if this was not available, to mark up an older drawing with the latest information.

Q.A. Documentation on site

The primary documents utilised on site to show evidence of the Q.A. activities performed on major items of equipment were Quality Plans, as utilised in the workshop. An example of a Quality Plan for the installation of a particular vessel is given in Appendix B.

The primary reference document utilised to monitor the installation of interconnecting pipework, valves and instruments was the PFD (Process Flow Diagram), a copy of which is shown in Appendix C. This does not show the actual physical arrangement of the plant, but it defines the sequences of valves and instruments, and their relative positions, i.e. the Brewhouse system. As the pipework proceeded, it was marked off on the PFD by the Q.A. representative as being correctly installed. This was updated on a daily basis and any mistakes could be rectified at an early stage.

Piping drawings which showed pipe and valve arrangements at various sections through the brewhouse as well as plan views, were also utilised to monitor the installation work. This was less satisfactory because deviations from these drawings did occur due to unforeseen obstacles on site. Deviations from the PFD were unacceptable, however, because they would jeopardise the integrity of the plant.

Supporting Q.A. documentation consisted of the various vessel drawings, heat certificates for materials, radiographs, welding specifications, welding schedules, and technical specifications from SAB and Huppmann.

Practicality of Specifications

Some of the customer specifications encountered during the brewhouse installation appeared to represent an "ideal" situation, but were impractical. For example, one specification called for a certain film thickness of powerful acid to be applied to the tanks. How does one measure such a film thickness without the use of very sophisticated equipment?

Some of the specifications appeared to have been drawn up without considering how they were to be executed (or their cost/benefit ratio, for that matter). The contractor faced the difficult situation of having agreed to abide by certain specifications, but then encountering their impracticality. It was then up to the Q.A. representative to clarify with the client the criticality of these specifications and how they were to be executed. This should have been done at a much earlier phase, in line with the previous comment of involving the Q.A. department at the tendering stage.

Scheduling vs Quality

Too much emphasis was placed by the client on scheduling rather than quality, without taking into account the inevitable clash between programme pressure and quality of workmanship. Slips in the installation programme are almost inevitable in such a multi-disciplinary, fast-track project. In Huppmann's case, civil delays alone accounted for more than five weeks' worth of delays. True, the contractor should endeavour to make up lost time if possible, but the continual emphasis by the client on meeting the original milestone dates meant that the installation became hurried, long hours were worked and quality began to suffer because short cuts were taken.

Region vs Projects

In this particular brewhouse installation, the client was divided into two camps. "Region" consisted of the Regional employees, in the form of the Brewmaster, his assistants, Regional Engineers, etc. They are the people who would eventually "own" the plant and run it. "Projects" consisted of the S.A.B. projects team, many from Head Office in Johannesburg, who were the project management team. Eventually they had to hand over the plant to Region. Huppmann was contracted to Projects and most of the design interface with the client occurred via Projects.

Region was thus not really involved in the original project conception phase, and only as the installation drew to a close did Region become more involved. Region were then not satisfied with some aspects of the installation which Projects had previously decided upon. Huppmann became drawn into the inter-company politics and it became very difficult to satisfy all parties.

The problem was that Region produced the butt lists (a list of aspects of the installation which were regarded as being unsatisfactory) at the end of the installation, which were then issued to Huppmann for corrective action. It became important at this stage for the Huppmann Q.A. representative to defend the installation work, which had been agreed upon originally with Projects and modifications required by Region were to be regarded as extras and not quality problems.

Hardware vs Software

As the installation of the brewhouse proceeded from mechanical installation, through electrical and finally software commissioning, the limitation to the use of quality plans as a means of quality control became apparent.

The quality plans were effective as a means of quality assurance during the mechanical installation, but as the installation became less and less "tangible", they became unrealistic. The extreme example is the software aspect. How does one perform quality assurance on software? This problem still needs to be resolved.

The problem may also have been that the author is a mechanical engineer and has little experience on the electrical and software side. In order to perform quality checks, the "inspector" must be in a position to be able to monitor and judge the work performed. For this reason, Huppmann sent an electrical design engineer from Germany during the electrical and instrument installation, to monitor and check the installation according to his original design. This is an ideal situation, where the original designer of a system is involved full-time on site during its installation,

and resulted in an electrical and instrument installation with high integrity.

5.6 Future Advances

A great deal of the groundwork of the new quality system has been done by the author, but the system is far from perfect. A comparison of an internal quality audit (see Appendix D) conducted by the author at the end of this investigational project to the status of Q.A. at Huppmann prior to the project indicates the degree of advances made. This quality audit is based on B55750:Part 5, but is very similar to an audit based on the new ISO/SABS series. Not all of the criteria of the quality management system standard have been met. In order to obtain the official certification from the SABS, these areas will need to addressed in the future by the quality manager.

It should become the aim of the company to obtain this official certification as the products supplied by the company are regarded by their major client as being "Criticality Level 1" items. This means the company is required to operate a quality system which complies with SABS 0157. Although the customer appears to be satisfied with the advances made at Huppmann with regard to Q.A. (especially after the successes of the Cape Town and Botswana projects), there will come a time when Huppmann will be required to show evidence of official assessment of their quality system.

Improvements to the quality system will be the ongoing responsibility of the quality manager. In order to ensure that progress rather than deterioration of the system is maintained, the case study highlighted that regular audits of the quality system would be necessary.

The quality system will tend to grow as more procedures are developed to cope with new problems encountered, and all operations of the company which have any effect on the quality of products and services, should eventually

become formalised. Procedures will also need to be developed to cope with the less tangible type of "products" supplied by Huppmann, such as PLC software.

One of the next steps to be undertaken at Huppmann should be to develop means of measuring the on-going quality performance of the company. This will indicate the effectiveness of the new quality management system, will enable management to assess and control operations, and take action when necessary.

In order to measure quality performance, Huppmann will need to establish certain meaningful "yardsticks" which over time, would indicate whether quality performance was improving or declining as well as the quality level in the company at any particular instance.

Examples of these quality measurements could include the number of non-conformance reports generated (in-house or by the customers' inspectors), the number of concessions granted, completeness of documentations, lengths of 'snag lists' generated by customers, ease and speed of commissioning as well as the more obvious workmanship measurements.

Under workmanship measurements, one could include accuracy, cleanliness, neatness and conformance to the engineering requirements. In stainless steel vessel manufacturing, the latter would consist, amongst others, (and bearing in mind typical problems experienced by SASTECH [5]) of the following;-

1. Correctness of shell dimensions.
2. Correctness of nozzle sizes and ratings.

3. Correctness of nozzle orientation.

4. Correctness of special fittings, probes etc.

5. Correctness of welding.

Of particular importance is the hygienic food and beverage environment in which Huppmann operates is the measurement of cleanliness (free of contaminants, especially carbon contamination), surface finish and ability of equipment to be easily cleaned under the latter, one would look for sharp edges, crevices and any "dead ends" in equipment which could lead to hygiene problems.

Another measure of the quality performance of the organisation would be the degree to which delivery dates are met on time, or, in the project environment, the degree to which milestone dates are achieved. This is again of particular importance in process plant manufacture where, as was indicated in Section 4.3.5, costs due to delays can be as high as 30% of contract value.[9] Besides undermining the company's reputation with its customers, consistantly late deliveries could be financially disasterous in this industry, where gross margins are often as low as 10% of contract value.

Another useful measure of performance may be to involve the customers' by asking them via questionaires or other means, how they felt Huppmann was performing from a "quality" point of view. If this was done on a regular basis, action could be taken to ensure that Huppmann was always meeting the requirements of its customers. It will also remain very important for the quality manager to keep all feedback channels from the client open. Problems encountered with products supplied by Huppmann or client problems

with the quality system itself, will always occur and solutions to these problems will need to be incorporated in the future.

The quality manager should also seek to incorporate the costs of quality, into the accounting system utilised at Huppmann. This would provide the ultimate way of measuring the quality performance of the company and the actual effectiveness of the quality management system. The implemention of such a cost accounting system was beyond the scope of this project, but could, for example, form the basis of a future student investigational project.

6. CONCLUSIONS

6.1 Conclusions Specific to The Case Study.

It is difficult to know, to what extent the attention given to quality and the new Q.A. system at Huppmann, contributed towards the success of the new brewhouses in Cape Town and more recently in Botswana. In order to do that, one would have to build an identical "control" brewhouse without formal Q.A., and then compare the outcome.

The speed at which commissioning and then full automation was achieved in Cape Town, the short snag lists issued to Huppmann and positive feedback from the client (Regional as well as Head Office) are indicators of the success of the new brewhouse and the new Q.A. system at Huppmann. The quality of recent plant supplied by Huppmann has certainly enhanced the reputation of the company in this country (see for example Figure 6.1). Perhaps this difficult to quantify strategic benefit has more than offset the cost of implementing the Q.A. system. By implementing a quality system to the satisfaction of its customers, Huppmann has ensured that it remains in a favourable position regarding future contracts and has avoided the embarressment of not being allowed to tender on contracts due to inadequate in-house Quality Assurance capabilities.

6.2 General Conclusions for the Process Plant Manufacturing Industry.

What became apparent during this investigational project was that the full implementation of a formal quality system is a lengthy process, requiring many "project by-project" improvement steps. As such, any company embarking

on such a quality system must allocate sufficient management resources to the quality system, in order to ensure successful implementation.

Care must be taken, however, to ensure that the newly adopted quality system does not merely become a "window dressing" exercise i.e. nothing really changes within the company except for the generation of copious quantities of Q.A. documentation. The quality manager needs to ensure that top management backing for the system is obtained, that the system is adequately "sold" to employees and that effective and efficient procedures are adopted. By utilising regular system audits and feedback from inside as well as outside the company, the quality manager can ensure that the quality system adapts to changing needs and does not degenerate into mere "window dressing".

The cost of implementing and running a Q.A. system will depend on the level of Q.A. opted for. In the process plant manufacturing industry, the supplier may, however, have little choice in this matter. Contractual requirements must be met, but some negotiation with the client will be required. The strategic benefits to be gained by delivering a high quality product with a high level of quality assurance and a reduction in scrap, rework and warranty costs, may more than offset this cost to the supplier. Protection against product liability claims and reductions in insurance premiums are also some of the benefits gained by a supplier operating an effective Q.A. system. As a good measure of quality performance, the accounting system of the company should consider the various costs of quality.

The quality activities which account for the major portion of expenses incurred by the manufacturer are:-

1. Quality Engineering.
2. Validation Inspection.
3. Qualification of special process procedures.
4. Repair and rectification.

More effort spent on "Quality Engineering" appears to result in reduced total costs of quality, due to less quality problems being encountered.[9] The manufacturer has little control over Validation Inspection costs, but he can minimise costs of special process procedure qualifications by keeping the number of these procedures to a minimum. Repair and rectification work often seems to involve welding work and the manufacturer needs to aim at utilising good welding equipment, competent welders, as well as careful planning of the welding operations, in order to minimise potential problems.

The nature of the quality system adopted by a company will be dictated more by the industry in which the company is operating than by the actual size of the company. Quality systems adopted by suppliers of process plant equipment tend to be customer-oriented due to the high consequential costs of quality problems, which are usually burdened onto the purchasers of process plants. This has resulted in the growing trend worldwide of customers insisting on suppliers adopting suitable, formal quality assurance systems. In order to remain competitive, all suppliers of process plant equipment who have not taken concrete steps to implement such systems, should consider doing so as a matter of urgency.

The quality management system standards that have been developed, especially the recently introduced ISO 9000 series, provide a useful management framework for organisations wishing to implement such formal systems. These have also provided clients with standards against which suppliers can be assessed.

Judging by the problems experienced by SASTECH, with 80% of fabricated stainless steel equipment requiring repair due to quality problems, there is a real need to implement effective quality management systems in this country. In order to measure the effectiveness of these quality systems, the correct quality performance "yardsticks" will need to be measured over time, and corrective action taken where necessary.

In summary, the special features of the process plant manufacturing industry influence the Q.A. approach of the manufacturer as follows:

a) Q.A. programmes tend to be customer-oriented because the customer is potentially the most adversely affected by failure costs, and because of the client input in terms of technical and quality specifications.

b) The cost of the Q.A. system to the manufacturer is likely to be high and less easy to justify on a short-term basis. However, in order to be able to compete in the market place the Q.A. system is of major stratagic importance to the manufacturer. This importance is likely to increase further in the future because of the trend towards insistence on supplier Q.A. programmes.

c) The uniqueness of most plants and the related necessary design details and manufacturing specifications, requires compatibility

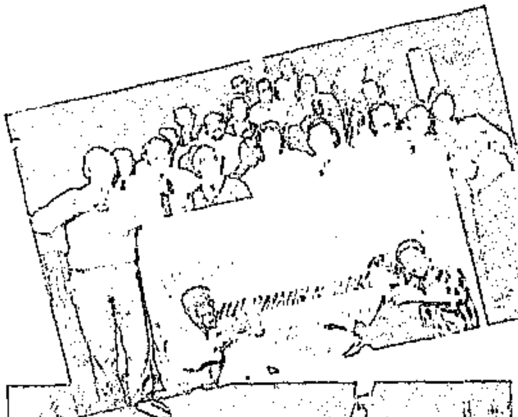
between the quality standards (or specifications) and the relevant engineering standards (or specifications).

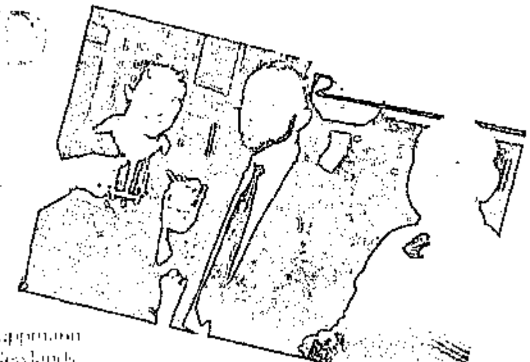
d) Complex contractual relationships, the need to satisfy statutory requirements and the traditional use of third party inspection, takes some of the control of the quality activities away from the manufacturer.

e) Control over "special processes" is critical because of the major importance which they play on the quality of the products.

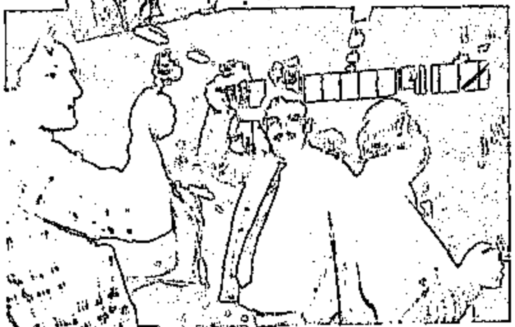
f) Varied quality demands and varied contractual relationships between different customers means that the Q.A. system must be rigorous yet flexible enough to meet these varying requirements.

RECORD [illegible]





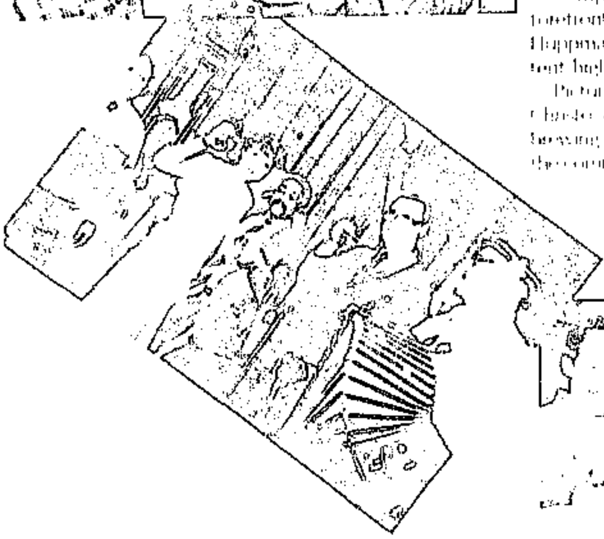
On 25 July 1988 the new Huppmann Brewhouse installed at SAB Newlands produced its first brew, conforming to all SAB quality [illegible] 9 hour [illegible] — a record time for a first brew within SAB.

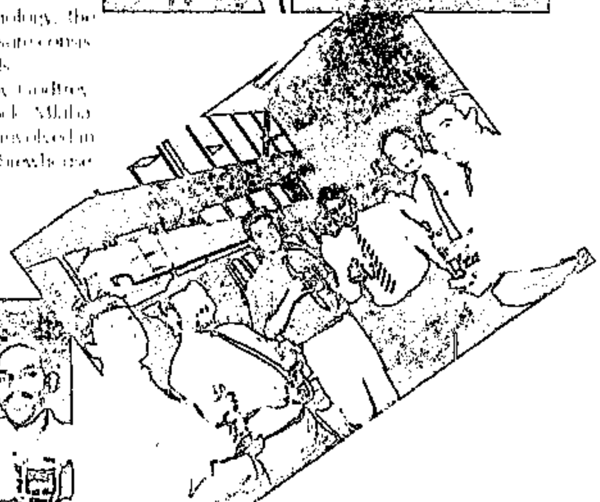


The Huppmann Brewhouse is part of the Newlands Expansion Project costing some R30m, is designed to produce a 600hl brew in three hours, giving a weekly output of 34 000hl and, together with our No. 1 Brewhouse will cope with our production needs for many years.

Computer controlled and in the very forefront of brewhouse technology, the Huppmann Brewhouse will ensure consistent high quality on all brands.

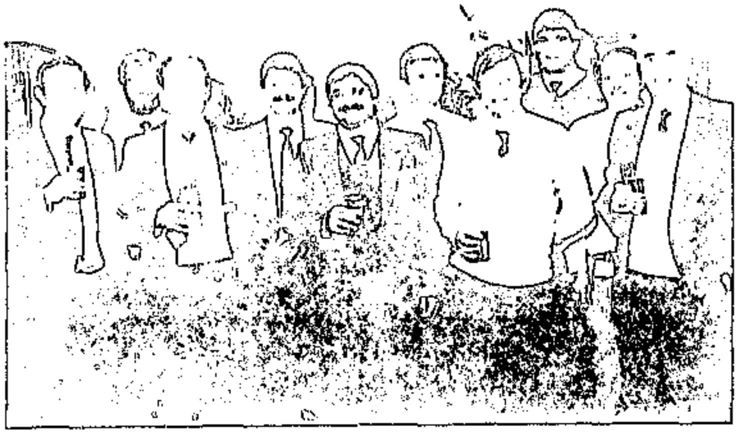
Pictured below are Timothy Godfrey, Christo de Wet and Shadrack Mtiba, brewing trainees at Newlands involved in the commissioning of the new brewhouse.





A BEER AND A JOKE

Natal's Coopers Arms enjoys a busy evening with visitors from around the country



[illegible] Graham Mackay [illegible] Norman Adam [illegible] Charles [illegible] [illegible] Mackenzie [illegible] and John [illegible]

Graham Mackay

Warren Woodfield

Sue Hamilton, Beverly Vorster (Shout Correspondent, Natal), Ben Lamprecht and Ann Daly

Fig 6.1 . ARTICLE FROM S.A.B. "SHOUT" MAGAZINE

RECORD

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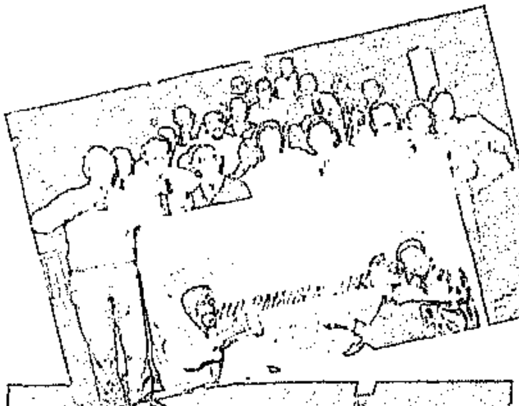
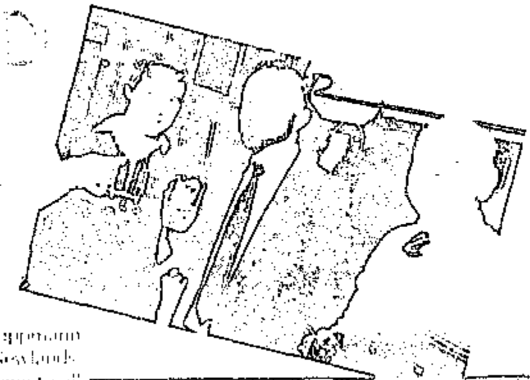


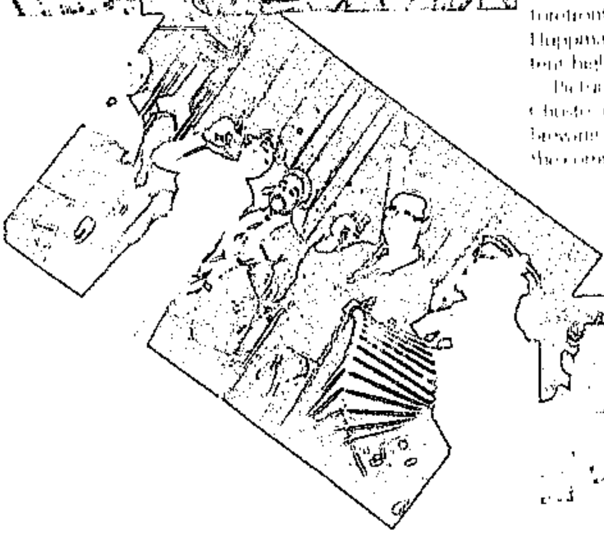


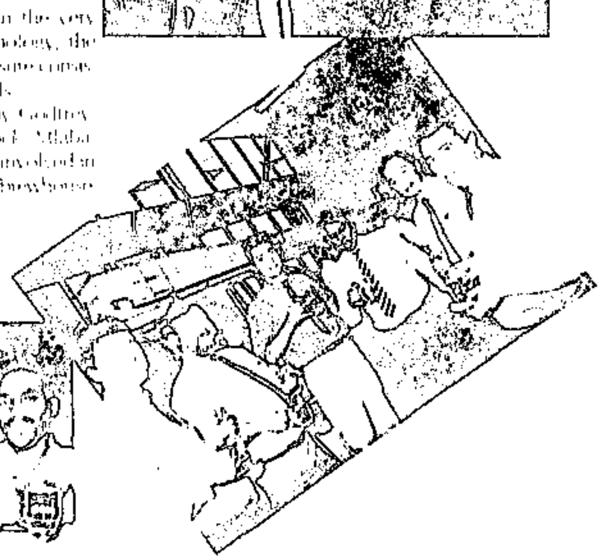
On 26 July 1988 the new Huppmann Brewhouse installed at SAB Newlands produced its first brew conforming to all SAB's first quality standard, in only 9 hours [illegible] minutes — a record time for a first brew within SAB.

The Huppmann Brewhouse is part of the Newlands Expansion Project costing some R40m and is designed to produce a [illegible] brew in three hours giving a weekly output of 34 000hl and together with our No 1 Brewhouse will cope with our production needs for many years.

Computer controlled and in the very forefront of brewhouse technology, the Huppmann Brewhouse will ensure consistent high quality on all brands.

Pictured below are Timothy Godfrey, Christo de Wet and Shadrock Mtaba, brewing trainees at Newlands involved in the commissioning of the new brewhouse.





A BEER AND A JOKE

Natal's Coopers Arms enjoys a busy evening with visitors from around the country

[illegible] Mark [illegible], Graham Mackay, Gary White, Norman Adam, Charles [illegible] [illegible] MacDonald, [illegible] and [illegible]

Graham Mackay

Wayne [illegible]

[illegible] Beverly [illegible] Correspondent "Natal" [illegible] and [illegible]

Fig 6.1 ARTICLE FROM S.A.B. "SHOUT" MAGAZINE

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APPENDIX A

SAB's Quality Assurance Requirements for Suppliers

1.0 SCOPE

1.1 This procedure shall apply to all suppliers who submit tenders to the SAB Beer Division.

2.0 APPLICABLE DOCUMENTS

SAB Quality Policy.

3.0 DEFINITIONS

Materiel

All items that are necessary for the equipment maintenance, execution, and support relating to a particular activity.

Quality Plan

A document derived from a quality programme (extended if necessary) setting out the specific quality practices, resources and activities relevant to a particular contract or project.

Quality Programme

A documented set of activities, resources and events serving to implement the quality system of an organisation.

4.0 REQUIREMENTS

4.1 It is a pre-requisite of the SAB Beer Division that before a contract/order is awarded, that the supplier has a formally documented and implemented quality management system to the requirements of SAB.

4.2 Tenderers will supply full details of their quality management system with their tender.

4.3 Also to be included in the tender:

A list of organisations, preferably South African based, who have purchased equipment or services similar to that tendered during the previous three years including:

FULL NAME OF PURCHASER

FULL ADDRESS OF PURCHASER

TELEPHONE AND TELEX NUMBERS

CONTACT, PREFERABLY THE NAME OF THE ENGINEERING EXECUTIVE OF THE PURCHASER

AGREEMENT THAT AN APPROACH TO THE ABOVE COULD BE MADE.

REVISION	DATE
A	9/83
B	9/83
C	10/83

4.4 It is an express condition of tender that tenderers and their sub-contractors shall be required to undergo a Quality Assurance Audit against the requirements of SAB by SAB or their appointed agents.

4.5 The tenderer shall provide full facilities and assistance to SAB or their appointed agents from within 24 hours of SAB's notification of intent to Audit.

4.6 The tenderer shall submit his quality plan for SAB review with his tender.

4.7 Tenderers quality plan shall contain as a minimum:

The sequence and methods of inspection and testing including witness and hold points for each stage of the Work.

e.g.

Quality Control
Detail design
Procurement
Fabrication
Construction
Erection
Installation
Commissioning

4.8 Tenderers quality plan is subject to the approval of SAB and Work may not commence without the prior written approval of the successful tenderer's quality plan by SAB.

4.9 During the life of the contract, the contractor shall provide all facilities and assistance as may be required by SAB or their appointed agents to monitor and/or audit the contractor's performance of the Work.

4.10 The contractor shall provide, for SAB's review and approval, the quality plans of his proposed sub-contractors prior to the appointment of such sub-contractors.

4.11 Quality plans may often evolve from the tender stage through the life of the contract. Each update/issue will be subject to effective documentation change control, and the content will be reviewed and approved by SAB.

ENGINEERING MANUAL	REVISION DETAIL SHEET	CES 401

THE FOLLOWING DETAILS THE CHANGES TO THIS STANDARD TO BRING IT TO REVISION:

PAGE NO.	PARA NO.	DETAIL OF CHANGES
4	Appendix B	Add: "Quality Plan, SAB, CEP 357, REV. 3"
8	2.7	Add: "acceptance criteria"
11	3.2.4	Delete: "purchasing" "production" Add: "design" "specifications for sub suppliers" "procurement" "sub supplier release" "materiel receipt, storage and control"
12	3.4.3	Add: "The responsibility for monitoring compliance to the overall Quality system and specific Quality plans should be seperated from other management responsibilities which may have an impact on materiel quality."
13	4.1.4	Add: "_ _ _ and agreed with SAB."
14	4.3.3	Add: "_ _ _ manufacture,"
21	10.6	Add: "Calibration of all such equipment must be documented and referenced against other calibrated equipment such that certification of calibration can ultimately be traced back to national standards.

N

ALL Revision Detail Sheets must be retained with the Copy of the Standard.

DATE

1.0 SCOPE

This document sets out the requirement to classify all materiel and services into their respective levels of criticality. The purpose of this classification is to ensure that the quality effort is spent in a most cost effective manner.

2.0 APPLICABLE DOCUMENTS

SABS	0157	Quality Management Systems.
SABS	0158	Code of Practice for Glossary of Terms for Quality Assurance and Quality Control.
BS	5179	Quality Management Systems.
BS	5750	Quality Systems.
BS	4778	Glossary of Terms used in Quality Assurance.

3.0 DEFINITIONS

QUALITY

The totality of features and characteristics of a product or service that bear on its ability to satisfy a given need i.e. Fitness for Purpose.

QUALITY ASSURANCE

All activities and functions concerned with the attainment of quality.

MATERIEL

Equipment, stores, supplies and spares that form the subject of a contract (this generic term is often used for large scale procurement purposes).

QUALITY PROGRAMME

A documented set of activities, resources and events serving to implement the quality system of an organisation.

QUALITY PLAN

A document derived from the quality programme (extended if necessary), setting out the specific quality practices, resources and activities relevant to a particular contract or project.

4.0 GENERAL

4.1 When considering Pareto's Principle it is vital that the main quality assurance effort is concentrated on the critical areas of materiel and services that could cause expensive/catastrophic safety, production, maintenance or product losses if they failed in operation.

Therefore, five levels of criticality are defined in terms of the following parameters:

- Consequence of failure.
- Safety.
- Product taint/losses.
- Procurement cost.
- Availability.

Based on the above, all materiel and services shall be classified in terms of one of the five criticality levels, each with its own minimum quality assurance requirements.

4.2 CRITICALITY LEVELS

The characteristics of each criticality level is as follows:

4.2.1 CRITICALITY LEVEL 1

- High consequential cost of failure.
- Failure likely to endanger human life.
- Product taint/losses.
- High procurement cost.
- High level of operation/maintenance personnel.
- High cost of operation/maintenance.
- High ergonomically or environmental affects.
- New technology input.
- Deviation from accepted SAB standards and norms.
- Long delays in Governmental/Local Authority/SAB Management acceptance/agreement.
- Long lead items.
- Long delivery delays.
- Implication of critical stock level holdings.

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4.2.2 CRITICALITY LEVEL 2

- High consequential cost of failure.
- Failure unlikely to endanger human life.
- High procurement cost.
- High cost of operation/maintenance.
- Long lead items.
- Long delivery delays.

4.2.3 CRITICALITY LEVEL 3

Only certain critical components conrtributing to:

- High procurement cost.
- High operating/maintenance cost.
- Product taint.
- Long delivery delays.

4.2.4 CRITICALITY LEVEL 4

- Low procurement cost.
- Low cost of operation/maintenance.
- Short delivery delays.
- Easily replaced.

4.2.5 CRITICALITY LEVEL 5

- Low procurement cost.
- Failure unlikely to affect operations.
- Stock items.

4.3 QUALITY ASSURANCE REQUIREMENTS

4.3.1 FEASIBILITY PHASE

During this phase SAB Management (to include all Central Departments as required; Central Lab., Personnel, T & D, Finance, Administration, Public Affairs and others)/User/Designers shall complete Annexure 1, identifying the level of importance/criticality of the various functions.

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The object of identifying criticalities in this phase is to ensure that Management/User have identified their needs sufficiently accurately to give the Designers the parameters within which they can study and cost the various options. Further, it is important to identify to the Central and Local Authorities, the total infrastructure of the brewery and to get committment from them that off-site facilities will be available on time for the various phases of development. In the event where changes to existing SAB Standards and norms relating to process or plant are envisaged, Management/User shall lay down the guidelines for any departure to the existing standards and norms that have to be evaluated in the Feasibility phase.

On the basis of the above, the Designers will engineer the options in consultation with the User within the ranges defined by Managemen., to comply with the programme of work so as to cost the various options to be presented in the Feasibility study.

The agreed level of criticality will be identified on all references made to the function/activity on all documentation including minutes of meetings, memos, reports, drawings etc.

4.3.2 SPACE REPORT PHASE

During this phase SAB Management/User/Designers shall complete both Annexures 1 and 2 which will identify the importance/criticality level of the various functions/material.

4.3.3 DETAIL DESIGN PHASE

During this phase the Designers shall code all equipment or sub-components into one of five Criticality Levels, as indicated in 4.2 by completing Annexure 3.

4.3.4 EXECUTION/COMMISSIONING PHASE

During this phase suppliers/vendors/contractors are appointed. Their QA requirements for the various Criticality Levels are as follows:

4.3.4.1 CRITICALITY LEVEL 1

- Supplier to be assessed to comply with SABS 0157, Part 1 or Part 2, or similar, as appropriate.
- Prior to contract award, Supplier to submit to SAB for their review and approval, a quality plan in accordance with CEP 357, giving detials of all processes employed to assure conformance to SAB requirements.
- Supplier to inform SAB of all acceptance criteria employed and documentation to be generated.

- Supplier to prepare complete data packages for SAB records.

4.3.4.2 CRITICALITY LEVEL 2

- Supplier to be assessed to the requirements of SABS 0157, Part 1 or Part 2, or similar, as appropriate, with the view of identifying areas of non-conformance.
- Prior to contract award, Supplier to submit to SAB, for their approval, a quality plan, in accordance with CEP 357, with particular emphasis given to areas where shortcomings in the system has been identified.
- Supplier to inform SAB of all acceptance criteria employed and documentation to be generated.
- Supplier to prepare complete data packages for SAB records.

4.3.4.3 CRITICALITY LEVEL 3

- Supplier to be assessed to the requirements of SABS 0157, Part 1 or Part 2, or similar as appropriate, with the view of identifying areas of non-conformance in relation to the critical components.
- Supplier to submit to SAB for their review and approval, a quality plan in accordance with CEP 357, paying particular attention to the stringent requirements placed on the critical components.
- Supplier to prepare data packages for critical components only for SAB records.

4.3.4.4 CRITICALITY LEVEL 4

- Supplier to be assessed on the basis of his ability to produce the materiel.
- Supplier to submit to SAB for their review and approval, a quality plan in accordance with CEP 357, detailing final inspections only.

4.3.4.5 CRITICALITY LEVEL 5

- Supplier to be assessed only on this ability to supply the desired materiel.

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1.0 GENERAL ASPECTS OF THE QUALITY MANAGEMENT SYSTEM

1.1 INTRODUCTION

Todays markets and customers have increasing expectations in terms of products and services. The objective of any good business should be to ensure that these expectations are met within acceptable availability and cost constraints. What was once acceptable is no longer so.

Any production operation needs rules and controls to meet these requirements and be cost-effective. Work in a number of countries has analysed these rules and controls and found that they have common features which can be applied to any type or size of production unit.

The techniques involved are known as Quality Assurance. It is generally accepted that the implementation of these techniques is the most effective form of production management. The application of these techniques is known as Quality Management.

The principles of Quality Management are aimed at the identification and elimination of production errors which could cause customer dissatisfaction or buying resistance. They also offer positive cost benefits. Every Rand saved by reducing design, purchasing or manufacturing errors is a Rand added to profits. An additional benefit is improved product consistency.

The requirements given in this document are an outline of the basic elements required for an effective Quality Management System. They are based on SABS 0157 - Code of Practice for Quality Management Systems. This is the local version of a number of national standards which have been published on Quality Management.

There are a number of reasons why companies introduce Quality Management Systems. Ideally the company should be convinced that the system is good management practice and that it will further the company's aims and long term prosperity through continuity of performance.

A pitfall to be avoided with the introduction of any Management System is a preoccupation with methods and procedures. These can take control of the process, so that HOW it is done becomes more important than WHAT is accomplished. The achievement of goals and objectives becomes difficult if the focus is not kept on the right area.

1.2 PURPOSE OF THIS DOCUMENT

The purpose of this interpretive document is to provide a more defined basis for suppliers in the brewing industry to develop quality assurance programmes, to ensure a more consistent outcome from assessments by SAB and SABS and to avoid multiple assessments as well as multiple inspections. To this end SAB have prepared this interpretation of the criteria of SABS 0157 to ensure a common understanding of the requirements for a quality management system necessary for the design, manufacture and erection of brewing equipment. This document should be read in conjunction with SABS 0157.

1.3 QUALITY ASSURANCE REQUIREMENTS

SABS 0157 may be imposed as a contractual requirement between purchaser and supplier to provide the purchaser with the confidence that an acceptable quality of product or service will be achieved. Too little monitoring on the part of the purchaser incurs the risk of unacceptable quality while too much monitoring and the submission of too many records can generate excessive costs. The intention is to develop an optimum contract interface in terms of cost and the assurance of quality necessary to demonstrate compliance with the contract requirements.

An effective supplier's in-house quality management system based on SABS 0157 and this interpretation document is considered to be a necessary requirement for ensuring a successful contract quality assurance programme. The supplier's quality assurance programme may have to be extended to accommodate the purchaser's special contractual quality requirements.

The degree of monitoring performed by the purchaser on the supplier will be determined by the operational requirements, safety, and sub-suppliers. The extent of records required may range from none to a full set of documents which demonstrate product integrity, depending on operational, maintenance and statutory requirements as well as the complexity of manufacture. The monitoring performed by the purchaser is part of the contract interface and is carried out to ensure that the supplier's own quality and monitoring programmes are effective.

The supplier shall determine the extent of controls he should impose on the design, manufacturing, erection and commissioning processes of an item to ensure that the specified levels of quality are achieved. An item may require a quality control plan which defines a number of in-house witness and hold points at important stages of the process and may require release by authorised persons in the supplier's organisation before proceeding to subsequent stages in the process, while another item may only require final inspection. A considered

mix of in-house surveillances and inspection activities can provide a cost-effective monitoring programme. The supplier's quality management system should have the flexibility to deal with the full range of items found in the contract works, in such a way that all activities are controlled in a cost effective manner.

The supplier's quality assurance programme should be tailored to suit the size of his organisation as well as his method of carrying out his work. For example, an elaborate programme will obviously not suit a small organisation as, for instance, there would not normally be a communication problem on interfaces between departments or sections, while in a large organisation this could be a most demanding requirement. Compliance with this interpretation which would relate to either Part I or Part II of SABS 0157 could result in a documented system anywhere between a programme of many pages and a programme of half a page, depending on the complexity of the product or product range and the size of the company.

The supplier must ensure that any sub-suppliers employed by him shall meet the quality assurance requirements of the supplier appropriate to the items or materiel supplied.

The onus is on the purchaser to establish the criteria for quality and technical requirements clearly and unambiguously by means of specifications, codes, standards, etc. The supplier is totally responsible to the purchaser for achieving the specified requirements.

All suppliers of materiel to SAB shall comply to a level of QMS indicated as required in the Criticality Levels. Only suppliers that have a SAB approved QMS shall be asked to tender.

1.4 CRITICALITY LEVELS

Depending on the level of criticality that a materiel is identified using SAB, CEP 360, REV. 0 as a guide, (see Appendix A), the necessary level or detail of the Quality Management System shall be applied and become a contractual requirement between the supplier and SAB.

DATE

2.0 DEFINITIONS

For clarity, various terms used in this document are defined.

2.1 QUALITY

The totality of features and characteristics of a product that bear on its ability to satisfy given needs or "fitness for use".

2.2 QUALITY CONTROL

The operational techniques and activities that are employed to satisfy quality requirements. Product quality control can only identify errors once they have occurred.

2.3 QUALITY ASSURANCE

All those planned and systematic actions necessary to provide adequate confidence that a product, process or service will satisfy given needs. Quality Assurance is aimed at the prevention of errors.

2.4 QUALITY POLICY

The overall quality intentions and objectives of an organisation as formally expressed by senior management.

2.5 QUALITY MANAGEMENT

The aspect of the overall management function that determines and implements the quality policy.

2.6 QUALITY SYSTEM

The organisation structure, responsibilities, procedures, activities, capabilities and resources that together aim to ensure that products, processes or services will satisfy stated or implied needs.

2.7 QUALITY PLAN

A document setting out the specific quality practices, acceptance criteria, resources and activities relevant to a particular product, process, service, contract or project. 1

2.8 QUALITY PROGRAMME

The documented implementation of a quality system.

2.9 QUALITY AUDIT / REVIEW

A systematic and independent examination to determine whether quality

REV. IN DATE

activities and results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

2.10 PROCESS CONTROL

Maintaining the performance of a process at its capability level. Process control involves a range of activities such as sampling the process product, charting its performance, determining causes of any problems and taking corrective actions.

2.11 MATERIEL

Any product or service offered by or contracted to SAB by a supplier.

3.0 SAB's INTERPRETATION OF THE CRITERIA OF SABS 0157, PARTS I & II

3.1 QUALITY POLICY

This is the primary requirement for the implementation of a quality management system.

3.1.1 Management to develop and explicitly define a corporate quality policy.

This document should contain clearly defined quality targets and provide specific guides for action for each department.

Generalised statements such as "It is the policy of this Company to market products of the highest quality" should be avoided as they do not define "fitness for use" and cannot be used as an objective.

3.1.2 It is also a management responsibility to ensure that the policy is understood, implemented and maintained at all levels and in all disciplines.

3.2 QUALITY SYSTEM

3.2.1 The suppliers' quality management system shall demonstrate his ability to achieve specified requirements in design (if applicable), manufacture, erection and associated activities related to his supply (and associated items) through planning and controlling all operations and inspection of components and completed works where necessary.

3.2.2 The quality management system shall be formally documented and describe the quality management objectives, policies, procedures and work instructions, etc., necessary for the successful implementation of the quality related activities stated in this document which have been derived from SABS 0157, Part I or Part II as applicable.

3.2.3 The documented quality management system shall relate to the particular method and characteristics of operation of the supplier concerned.

3.2.4 This is the detail of how the quality policy objective will be achieved.

Divisional/departmental heads to develop, establish and implement management systems to meet the quality policy objective.

The system should apply to all activities from the identification of customer needs through to their satisfaction.

These include:

* study of market needs
* design
* specifications for sub-suppliers
* procurement
* sub-supplier release
* materiel receipt, storage and control
* production and process engineering
* inspection and testing
* warehousing
* distribution
* sales and service

3.3 ORGANISATION

3.3.1 The supplier shall define the organisation as it relates to his quality management system. Quality is the responsibility of all personnel who contribute to, or control the design, procurement, manufacture and erection functions. The supplier shall therefore delegate to all personnel responsible for functions affecting quality, both the defined responsibility and the authority to identify and evaluate problems and to initiate, recommend and provide effective solutions.

3.3.2 The organisation structure within which the management system is to operate must be established.

3.3.3 Activities which contribute directly to the achievement of the quality policy should be identified.

3.3.4 For each activity, general and specific quality responsibilities should be defined.

3.3.5 Lines of authority and of functional communication should be defined.

3.3.6 Where different activities interface, the co-ordination area should be defined in reasonable detail.

3.4 REVIEW OF THE QUALITY SYSTEM

The supplier shall develop and implement a plan for the review of his quality management system. This review shall at least comply with the following requirements:

3.4.1 The supplier shall be responsible for periodically (internal audits / 2 times/year) determining the effectiveness of the quality management system. The effectiveness of the quality management system shall be determined by one or more of the following:

* analysis of the trends of deficiencies and corrective actions and their significance,

* review of purchaser satisfaction,

* review of quality costs.

Adjustments shall be made to the quality management system where appropriate to maintain its effectiveness.

3.4.2 Periodic reviews (external audits / 1 per year) shall be performed to verify compliance with quality manuals and documented procedures. Findings of non-compliances with established procedures which are identified shall be documented. Corrective action in respect of these findings shall be performed by the responsible personnel to the satisfaction of the quality management representative. Personnel shall not review their own areas of responsibility.

3.4.3 The responsibility for monitoring compliance to the overall Quality system and specific Quality plans should be seperate from all other management responsibilities which may have an impact on materiel quality. ⚠1

4.0 PLANNING

4.1 The supplier shall establish a procedure for conducting a sufficiently extensive and timely review of the specified requirements for the contract works. Documented planning for quality should take place as early as possible, preferably before work on the contract begins. Taking into account the scope of the contract works, the supplier shall check that,

4.1.1 the appropriate procedures and work instructions are available for design (if applicable), procurement, manufacture and erection,

4.1.2 manufacturing and erection processes and equipment are available, suitable and compatible with the contract works as designed,

4.1.3 the appropriate inspection measuring and testing equipment is available and suitable for the contract works, and

4.1.4 applicable acceptance criteria for product quality are available and agreed with SAB. 1

4.2 A quality plan shall be prepared where required by the contract, or because of the nature of the work, which shall address the quality practices and activities applicable to the contract works which are not covered by the suppliers documented quality system, e.g. identify those requirements which are unusual by reason of newness, unfamiliarity, lack of experience or absence of precedents, and shall

4.2.1 indicate how specific sub-suppliers will be monitored,

4.2.2 identify components or categories of components for which quality control plans will be prepared,

4.2.3 identify the areas or processes requiring special controls,

4.2.4 identify the records pertaining to the contract works and how they will be controlled,

4.2.5 identify the Management Representative and personnel responsible for the control of quality activities,

4.2.6 establish communication channels between the supplier and the purchaser,

4.2.7 identify the specifications, drawings, and acceptance criteria for materiel for which quality control plans are not required,

4.2.8 identify the documents which are to be submitted to the purchaser for approval, and

4.2.9 indicate the purchaser's post-award audit programme.

4.3 Quality control plans as called in 4.2.2 or as required by contract shall include as applicable:

4.3.1 the identification of the component or component category,

4.3.2 the materiel,

4.3.3 a list of the sequence of activities of manufacture, construction or erection, including inspection and tests,

4.3.4 the identification, as appropriate, of the applicable specification, drawing or procedure for each event,

4.3.5 the applicable acceptance criteria,

4.3.6 the inspections and tests the supplier has nominated for hold and witness points,

4.3.7 the inspections and tests the purchaser's representative has nominated for hold and witness points,

4.3.8 the requirements for surface treatments (e.g. painting, etc.), and

4.3.9 which inspection and test records are required to be retained by the supplier.

Subject to the inclusion of the above requirements, the format of quality control plans shall be the responsibility of the supplier. For guidance see CEP357 "Quality Plan" SAB Project Procedure Manual.

5.0 WORK INSTRUCTIONS

"Work" in the sense used is not only physical labour, but also all services or actions that are performed to meet specific requirements.

5.1 Written instructions should be developed and maintained for each work package. They should be sufficiently detailed to prescribe clearly how the work has to be performed. The aim should be to make them short and simple rather than have reams of paper written out for each activity.

5.2 Written procedures are normally separated into two categories.

5.2.1 Work Instructions

An overall outline of methods of operation within the organisation or parts of the organisation which remain relatively constant.

An instruction shows how individuals inter-relate and what their specific duties are.

Also known as Standing Instructions.

5.2.2 Job Breakdowns

Job breakdowns are working documents. They should be available to all relevant staff at all times. It breaks a particular job into basic steps which are easy to follow and easy to understand. To ensure continued effectiveness, they must be up to date at all times.

The advantages to be gained from well prepared job breakdowns are:

* Uniformity of understanding.
* Standardisation of procedures and practices.
* Continuity of performance when changes occur.
* Provide a basis for control, evaluation and review.

Each breakdown should describe:

* Why it is done.
* What is to be done.

* How it should be done.
* When it should be done.
* Who should do it.
* Special equipment, services required.
* Standards to be achieved.

6.0 RECORDS

The supplier shall ensure that:

6.1 his management system provides for the development, maintenance and retention of records which demonstrate compliance with the required quality and the effective operation of the quality system,

6.2 records are made available for evaluation by the purchaser's representative,

6.3 records include, as appropriate, explicit identification of the materiel or component, system or sub-system, nature and number of observations made, number and type of deficiencies found, quantities approved or rejected, concessions granted and the nature of rectification and corrective action taken,

6.4 sub-suppliers where appropriate develop and maintain records of their quality related activities and these records are safely retained and made available for evaluation by the supplier's and purchaser's representatives,

6.5 records are retained for an agreed period of time.

7.0 CORRECTIVE ACTION

Prompt and effective corrective action is essential to a quality management system.

7.1 A need for corrective action is indicated by:

7.1.1 Trade complaints.

7.1.2 Recurring instances of non conforming product.

7.1.3 Internal reviews or audits which highlight process weaknesses.

7.1.4 Records which demonstrate that "fitness for use" criteria have not been met.

7.2 A documented procedure which covers the following basic steps should be introduced:

7.2.1 Record all relevant data relating to the apparent defect/ deviation.

7.2.2 Carry out an investigation to establish the true cause of the defect:

7.2.3 Carry out experiments or other tests as necessary to establish the validity of the findings of the investigation.

7.2.4 Determine what must be done to prevent re-occurrence of the problem.

7.2.5 Ensure that the remedy is applied.

7.2.6 Follow up, after a time interval, to ensure that the corrective action has been absorbed into the system.

8.0 DESIGN CONTROL

8.1 The design function is the single most important factor that will ensure fitness for purpose of the equipment. The purchaser shall ensure that both the purpose of the equipment and its future environment are fully defined and all constraints, details of equipment, performance criteria, etc., are communicated to the responsible engineer.

8.2 The responsible engineer whether employed by the supplier or otherwise is responsible for the design adequacy in its totality.

9.0 DOCUMENTATION AND CHANGE CONTROL

Defective product arising from the use of outdated procedures / manuals can and should be prevented. A system to "control" the updating and changing of all important documents (that can effect product quality) is therefore essential.

Nominated individuals should be made responsible for:

9.1 Changes to all manuals.

9.2 Recording of all changes/adjustments made to major items of plant. Parameters to be "controlled" should be documented as part of the quality system.

9.3 Updating job instructions/breakdowns as required.

9.4 Maintaining records of brands and types of major consumable stores and manufacturing sundries used. Items to be "controlled" should also be documented as part of the quality system.

10.0 CONTROL OF INSPECTION, MEASURING AND TESTING EQUIPMENT

10.1 The supplier should be responsible for providing, controlling, calibrating, and maintaining inspection, measuring, and testing equipment suitable to demonstrate compliance of supplies with specified requirements. Equipment should be used in a manner which ensures that measurement uncertainty is consistent with the required measurement capability.

10.2 Calibration accuracy of this equipment should be commensurate with the required accuracy of measurement and should be traceable to national standards.

10.3 Where jigs, fixtures, templates, patterns, or other such devices are used as inspection media, they should be proven capable of verifying the acceptability of materiel prior to release for use during manufacture, and should be reproven at established periods.

10.4 The supplier should establish the extent and frequency of such proving and maintain records as evidence of control.

10.5 Design data pertaining to tools and gauges should be made available, when required by the purchaser's representative, for verification that the devices are functionally adequate.

10.6 Calibration of all such equipment must be documented and referenced aginst other calibrated equipment such that certification of calibration can ultimately be traced back to national standards. 

11.0 CONTROL OF PURCHASED MATERIEL

In principle, only materiel which is of an agreed standard should be used.

11.1 Purchase of all materiel should only be from approved suppliers and against a documented standard.

11.2 Receiving inspections to be carried out at a set frequency using documented methods.

11.3 Procedure required for the controlling of materiel which does not comply with specific technical requirements.

11.4 This documented procedure should include provision for identification, segregation and disposition of non conforming materiel.

11.5 Any repair, re-work or concessions granted on non conforming materiel should be recorded. Records should identify the materiel and the nature of the non-conformance.

11.6 Where non-conformance materiel is received, corrective action should be initiated with the supplier. Details of the action taken by the supplier should be documented.

11.7 Records should be kept of all materiel used to ensure traceability through the process.

12.0 INDICATION OF PRODUCT STATUS

At the end of each defined stage of production, product should be checked for compliance with requirements before passing on to the next stage. This ensures that product, which does not conform to specification, is identified and isolated as early as possible. It can then be corrected or repaired as cheaply as possible.

12.1 A system should be in operation at each point to give a positive indication of whetner product has-

- Not been checked/tested.
- Been checked and approved.
- Been checked and rejected.

13.0 MANUFACTURING CONTROL

General Manufacture and Construction

The supplier shall ensure that:

13.1 criteria for workmanship established by technical specifications, relevant drawings or representative samples are used during manufacture,

13.2 manufacturing and construction equipment suitable for the product being manufactured is being used and is properly maintained,

13.3 in-process inspection and testing are carried out in accordance with the quality control plans as work proceeds to ensure compliance with specified requirements, and

13.4 provision is made for inspection methods and/or work instructions to be examined on a periodic basis and updated when necessary.

13.5 personnel carrying out the production and inspection processes are qualified to do so and that such qualifications are documented, valid and available for inspection.

14.0 PURCHASER SUPPLIED MATERIEL

14.1 The supplier shall be responsible for receiving inspection of purchaser supplied materiel which shall be performed in accordance with a written instruction obtained from the purchaser.

14.2 Purchaser-supplied materiel shall be handled, stored and maintained by the supplier in accordance with the written instructions of the purchaser.

14.3 The supplier shall record and report to the purchaser any such materiel lost, damaged or otherwise found to be unsuitable as a result of the receiving inspection mentioned in clause 14.1 above.

14.4 It is the purchaser's responsibility to ensure that purchaser-supplied materiel has been inspected/tested and complies with specified requirements before despatch to the supplier.

16.0 SAMPLING PROCEDURES

16.1 Sampling must be based on sound principles (randomness, adequate sample size, etc). Incorrect sampling techniques may indicate false levels of product quality.

16.2 Sampling (and subsequent testing or analysis) must be aimed at confirming whether the necessary quality standards have been achieved. Results should be documented and evaluated periodically. Causes of defects or significant variations in the process should be analysed to form the basis of corrective action.

16.3 Sampling and inspection/analysis, because they occur after the event, can only confirm how well existing controls are working. Sampling is NOT a control mechanism in its own right.

16.4 Sampling procedures and frequencies should be documented. Where special requirements for sampling exist, these should be written up as job instructions/breakdowns.

16.5 Decision rules should be drawn up to formalise action when non conforming product is detected.

16.6 Results should be documented and evaluated periodically. Causes of defects or significant variations in the process should be analysed to form the basis of corrective action.

17.0 CONTROL OF NON CONFORMING MATERIEL

17.1 Any non conforming materiel arising from a deviation in the process should be identified and segregated from normal production.

17.2 Defective materiel should be confined to a separate holding area and should be clearly identified to prevent unauthorised use, mixing or shipment with conforming product.

17.3 Handling of non conforming materiel should be as per a documented procedure. Procedure should include details of sample sizes, decision rules, etc.

17.4 Records of non conforming materiel should be maintained. These records should detail - materiel identity, the nature and extent of the non conformance, decisions made and where the materiel was disposed of.

17.5 The occurrence of non conforming materiel should also be the basis of initiating corrective action.

18.0 INDICATION OF INSPECTION STATUS

The Supplier shall

18.1 establish and maintain a system for identifying the inspection status of the materiel and workmanship during different stages of manufacture, and

18.2 develop a system to distinguish clearly between inspected and uninspected materiel by using a suitable form of records or identification.

19.0 PROTECTION AND PRESERVATION OF PRODUCT QUALITY

19.1 The supplier shall preserve the quality of the materiel to ensure compliance with specified requirements until such time as his responsibility ceases in terms of the contract.

19.2 All materiel shall be suitably marked or labelled such that identification is possible during the appropriate stages of processing. Where called for, identification will include reference to the steel manufacturer's material certificate.

19.3 Personnel shall be trained to ensure that, as far as reasonably possible, abuse, misuse, damage or deterioration of the product is prevented.

20.0 TRAINING

Well trained staff are an essential ingredient in any defective product prevention programme. Training is one of the key elements of Quality Management.

Only trained, competent personnel should perform tasks which can have an effect on quality.

20.1 Meeting this requirement will need the following -

- Skills profile (requirements) for each job.
- Suitable training procedures.
- Periodic retraining as highlighted by internal reviews.
- Availability of trained back up staff, to cover leave, absenteeism, etc.
- Records of training given.

APPENDIX B

Quality Plan for a Typical Brewing Vessel Installation

REVISION	1										
DATE	9/2/88										

PROJECT NO: O.C.B. NEWLANDS REFERENCE SUPPLIER HUPPMANN QUALITY PLAN NO: 003/S

DESCRIPTION: ASSEMBLY OF LAUTER TUN ON SITE

No.	1 Operation	2 Supp. Q.C. Activity	3 Accep. Criteria	4 Doc. Reqmt.	5 Supp. Q.C.	6 Date	7 ?	8 SAB Q.A.	9 Date
1.	ISSUE DRAWINGS	CHECK REVISION	CORRECT REVISION	DRAWGS. NOS. 570556, 541981, 520908, 542059, 542182, 541865, 542152	RFH	3-02.			
2.	TACK TOP HALVES TOGETHER	CHECK FIT	ALLOW FOR DISTORTION DUE TO WELDING		K.J.H	5-02.			
3.	WELD TOP HALVES TOGETHER	CHECK CONFORMANCE WITH WELD SPECS.	HUPPMANN WELD SPECS.	WELDING SCHEDULE	K.J.H	8-02.			
4.	FIT UP AND TACK BOTTOM	CHECK ORIENTATION. ENSURE THAT BOTTOM IS HORIZONTAL. CHECK FIT.	ORIENTATION ON DRAWING. ALLOW FOR WELDING DISTORTION	DRWG: 570556	K.J.H	8-02.			
5.	WELD LAUTER TUN BOTTOM TOGETHER	CHECK CONFORMANCE WITH WELD SPEC. PERFORM DIE PEN. TEST	HUPPMANN WELD SPECS. NO VISUAL DEFECTS	WELDING SCHEDULE.	K.J.H RFH	10-02 11-02			
6.	ASSEMBLE SUPPORT STRUCTURE	CHECK ORIENTATION		DRWG: 570556	RFH	12-02			

PREPARED BY:	R.C. FUNK	31/02/88	KEY
SAB APPROVAL		/ /	
SUPPLIER APPROVAL			

W	SAB REP TO WITNESS INSPECTION
D	SAB REP TO CHECK DOCUMENTS
I	SAB REP TO INSPECT

APPENDIX B. - Q.PLAN FOR TYPICAL BREWING VESSEL INSTALL.

PROJECT PROCEDURE MANUAL

QUALITY PLAN

CEP 357 REV. 3

REVISION												
DATE												

PROJECT NO: NEWLANDS REFERENCE SUPPLIER HUPPMANN QUALITY PLAN NO: 003/5

DESCRIPTION: ASSEMBLY OF LAUTER TUN. ON SITE.

	1	2	3	4	5	6	7	8	9
No.	Operation	Supp. Q.C. Activity	Accep. Criteria	Doc. Reqmt.	Supp. Q.C.	Date	?	SAB Q.A.	Date
7.	LIFT TOP INTO MEZZANINE	ENSURE ADEQUATE SUPPORT. ENSURE THAT LIFTING GEAR DOES NOT DAMAGE SURFACE	SUFFICIENT SUPPORT			12-02			
8.	LIFT BOTTOM & SUPPORT INTO MEZZANINE	ENSURE ADEQUATE SUPPORT. ENSURE ADEQUATE CAPACITY OF LIFTING GEAR.	SUPPORTS UNDER MAIN MEZZANINE CROSS BEAMS.			12-02			
9.	FIT UP LEGS TO BOTTOM	CHECK FIT. CHECK HEIGHT OF VESSEL	HEIGHT ON DRWG. NO. 570556.	DRWG. No: 570556.		20-02			
10.	BOLT LEGS TO BOTTOM	CHECK SIZE OF BOLTS	M22			12-02			
11.	FIT UP AND TACK SHELL	CHECK CIRCUMFERENCE OF BOTTOM AND TOP	FIT REQUIRED BY WELDING SPECS.			16-02			
12.	FIT UP AND TACK SHELL TO BOTTOM	CHECK FIT UP				16-02			
13.	WELD SHELL AND SHELL TO BOTTOM	CHECK CONFORMANCE WITH WELD SPECS.	HUPPMANN WELD SPECS.	WELDING SCHEDULE		16-02			

PREPARED BY:	R.C. FUNK	3/02/188.
SAB APPROVAL		/ /
SUPPLIER APPROVAL		

KEY

W	SAB REP TO WITNESS INSPECTION
D	SAB REP TO CHECK DOCUMENTS
I	SAB REP TO INSPECT

PROJECT PROCEDURE MANUAL

QUALITY PLAN

QEP 357 REV. 3

DIVISION												
DATE												

PROJECT NO: NEWLANDS REFERENCE SUPPLIER HUPPMANN QUALITY PLAN NO: 003/S

DESCRIPTION: ASSEMBLY OF LAUTER TUN ON SITE.

No.	1 Operation	2 Supp. Q.C. Activity	3 Accep. Criteria	4 Doc. Reqmt.	5 Supp. Q.C.	6 Date	7	8 SAB Q.A.	9 Date
14.	FIT UP AND TACK TOP TO SHELL	CHECK FIT	FIT REQUIRED BY WELDING SPECS.		R.C. Funk	25/02			
15.	WELD TOP TO SHELL	CHECK CONFORMANCE WITH WELD SPECS.	HUPPMANN WELD SPECS.	WELDING SCHEDULE	R.C. Funk	2/03			
16.	FIT SPENT GRAINS CASE	CHECK FIT.	DRWG: 570556	DRWG: 570556	[illegible]	16/02			
17.	FIT UP AND TACK LAUTERING PIPES	CHECK FIT AND ORIENTATION.	AS INDICATED ON DRWG: 541981	DRWG: 541981	R.C. Funk	4/03			
18.	WELD LAUTERING PIPES.	CHECK CONFORMANCE WITH WELD SPECS.	HUPPMANN WELD SPECS.	WELDING SCHEDULE	R.C. Funk	4/03			
19	FIT LAUTER TUN PEDESTAL	CHECK VERTICAL ALIGNMENT	ACCURATE TO WITHIN 91mm in 1m		Fr. Pfister	26/04			
20	PULL IN SHAFT & PUSH GEARBOX INTO APPROX. POSITION	CHECK APPROX HEIGHT OF GEARBOX	HEIGHT DETERMINED BY SHAFT LENGTH		Fr. Pfister	29/04			

PREPARED BY:	R.C. FUNK.	3/02/88.	KEY
SAB APPROVAL		/ /	
SUPPLIER APPROVAL			

W	SAB REP TO WITNESS INSPECTION
D	SAB REP TO CHECK DOCUMENTS
I	SAB REP TO INSPECT

PROJECT PROCEDURE MANUAL

QUALITY PLAN

CEP 357 REV. 3

REVISION												
DATE												

PROJECT NO: N509/1/R/8002 REFERENCE SUPPLIER HUFFMANN QUALITY PLAN NO: 003/5

DESCRIPTION: ASSEMBLY OF LATTERTUN ON SITE

	1	2	3	4	5	6	7	8	9
No.	Operation	Supp. Q.C. Activity	Accep. Criteria	Doc. Reqmt.	Supp. Q.C.	Date	?	SAB Q.A.	Date
21.	ADJUST GEARBOX LEVEL & INSERT SHAFT.	CHECK ALIGNMENT OF GEARBOX AND SHAFT	SHAFT MUST BE FREE TO TURN BY HAND AND MUST SLIP IN EASILY		Fr. Pfister	2/04			
22.	MOUNT RAKE HEAD ONTO SHAFT.	CHECK HEIGHT OF HEAD. INSERT SIGNS TO PREVENT SLIPPING OF HEAD.	DETERMINED BY DRAWING No: 570556. TOLERANCE: ± 1mm.		Fr. Pfister	2/05			
23.	ATTACH RAKE ARMS. HEAT SHAFT TO ADJUST HORIZONTAL LEVEL AS REQUIRED.	ATTACH OPPOSITE SIDES SIMULTANEOUSLY. CHECK HORIZONTAL LEVEL OF ARM.	ARM TO BE LEVEL WITH TOLERANCE OF ± 1mm.		Fr. Pfister	4/05			
24.	MOUNT SPENT GRAINS PLATS.	ENSURE THAT SHAFTS AND GEARBOXES ARE ALIGNED.	SHAFTS MUST ROTATE FREELY BY HAND.		Fr. Pfister	10/05.			

PREPARED BY:	R.C. FUNK	3/02/88	
SAB APPROVAL		/ /	
SUPPLIER APPROVAL		3/02/88.	

KEY

W	SAB REP TO WITNESS INSPECTION
D	SAB REP TO CHECK DOCUMENTS
I	SAB REP TO INSPECT

PROJECT PROCEDURE MANUAL

QUALITY PLAN

REVISION												
DATE												

PROJECT NO: N509/YK/3002 REFERENCE SUPPLIER HUPPMANN QUALITY PLAN NO: 003/5

DESCRIPTION: ASSEMBLY OF LAUTERTUN ON SITE

	1	2	3	4	5	6	7	8	9
No.	Operation	Supp. Q.C. Activity	Accep. Criteria	Doc. Reqmt.	Supp. Q.C.	Date	?	SAB Q.A.	Date
25.	INSERT FALSE BOTTOM	CHECK SEQUENCE. CHECK WHETHER FLAT.	CORRECT SEQUENCE ALL FEET SHOULD TOUCH BOTTOM		Fr. Plate	12-05			
26.	ATTACH KNIVES & TACK INTO POSITION	CHECK HEIGHT OF KNIVES.	15mm ± 91mm.		Fr. Plate	19-05			
27.	WELD INSULATION SHROUDS FLANGES & RINGS TO VESSEL	ENSURE SHROUD FLANGES ARE 100mm AWAY FROM VESSEL	FULLY WELDED SHROUDS & FLANGES.						
28	PICKLE & PASSIVATE ABOVE MEZZANINE	ENSURE CORRECT PROCEDURES USED PROTECT EQUIPMENT IN VICINITY.	AS PER CEP 369. PLASTIC OVER VALVES etc.			25-06.			
29.	APPLY ANTI-STRESS CORROSION LACQUER	CHECK ADHESION & THICKNESS. APPLY LACQUER A.S.A.P AFTER PICKLING & PASSIVATING	20μ., 25μm.			28-06			

PREPARED BY:	P.C. FUNK	3/02/88	KEY
SAB APPROVAL		J /	
SUPPLIER APPROVAL			

W	SAB REP TO WITNESS INSPECTION
D	SAB REP TO CHECK DOCUMENTS
I	SAB REP TO INSPECT

PROJECT PROCEDURE MANUAL

QUALITY PLAN

CEP 357 REV. 3 Page 5 of 6

REVISION												
DATE												

PROJECT NO: 1559/1/1/3002 REFERENCE SUPPLIER Huppmann QUALITY PLAN NO: 003/5

DESCRIPTION: ASSEMBLY OF LAUTER TUN ON SITE.

	1	2	3	4	5	6	7	8	9
No.	Operation	Supp. Q.C. Activity	Accep. Criteria	Inc. Reqmt.	Supp. Q.C.	Date	?	SAB Q.A.	Date
36 CONTD	APPLY CLADDING	CHECK SEALING OF ALL JOINTS & SEALING OF CLADDING TO INSULATION SHROUD FLANGES	JOINTS TO BE SEALED WITH SILICONE RUBBER CLADDING TO SIT ON TOP OF SHROUD FLANGES			26/1.			
		CHECK CONNECTION OF CLADDING TO SHROUD FLANGES	CLADDING TO BE SCREWED ONTO FLANGES						
		CHECK MATERIAL	304 S/STEEL						
37.	GLASS BEAD BLAST ABOVE MEZZANINE.	CHECK WHETHER VESSEL SEALED ENSURE THAT ALL COMPONENTS ABOVE MEZZANE ARE PROTECTED. CHECK UNIFORMITY	NO GLASS BEADS TO ENTER VESSEL NO PATCHES		AFTER BLOCKING FOR 2nd TIME.	17/09			
38	APPLY OIL TO TANKS	CHECK TYPE OF OIL	MEDICAL LIQUID PARAFFIN.			12/09			
	FINAL INSPECTION	OVERALL CHECK	CLIENT SATISFACTION			18/09.	I		

PREPARED BY:	P. FUNK.	3 / 02 / 88.	KLY
SAB APPROVAL		J /	
SUPPLIER APPROVAL		3/02/88.	

W SAB REP TO WITNESS INSPECTION

D SAB REP TO CHECK DOCUMENTS

I SAB REP TO INSPECT

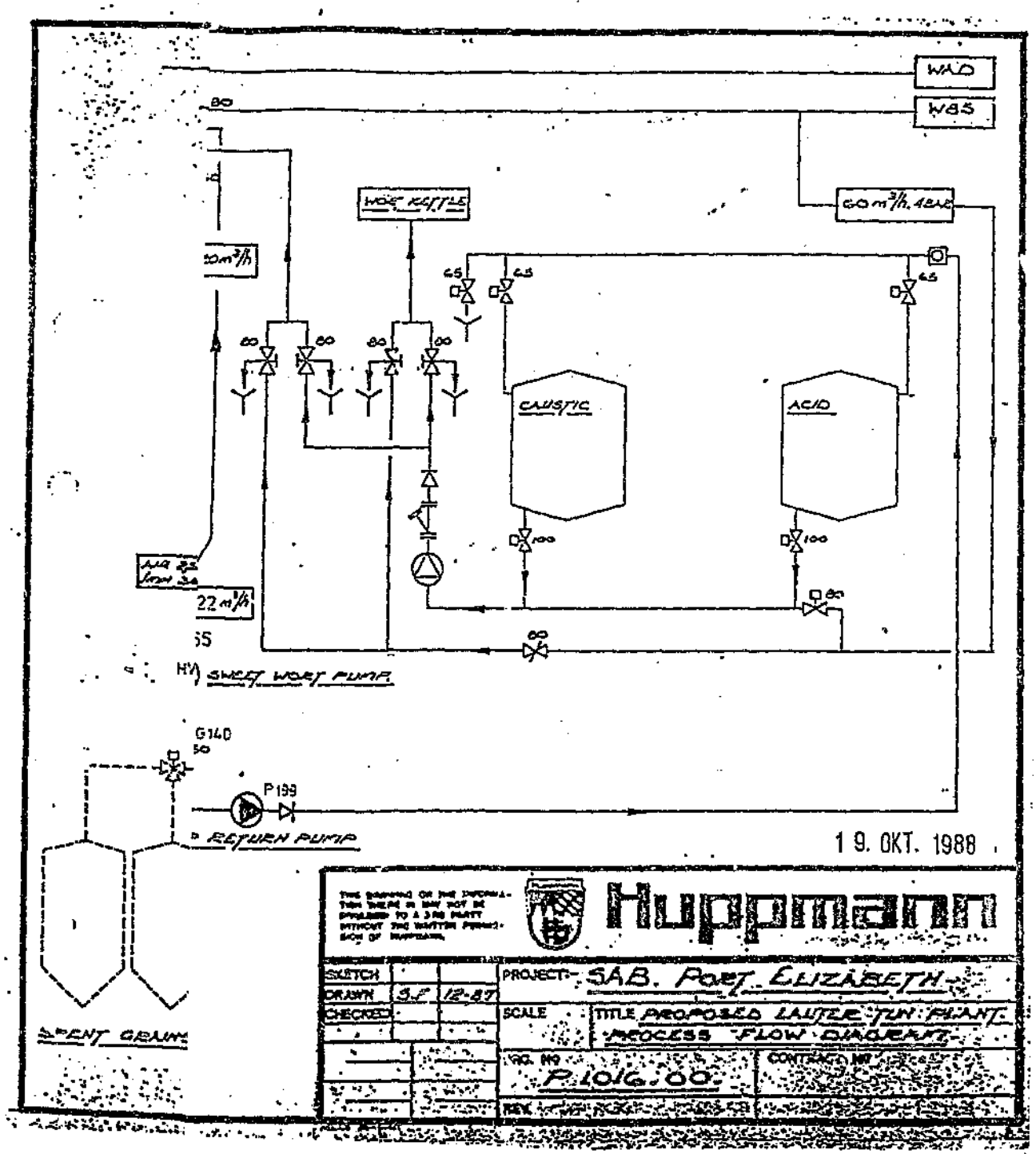
PROJECT PROCEDURE MANUAL

QUALITY PLAN

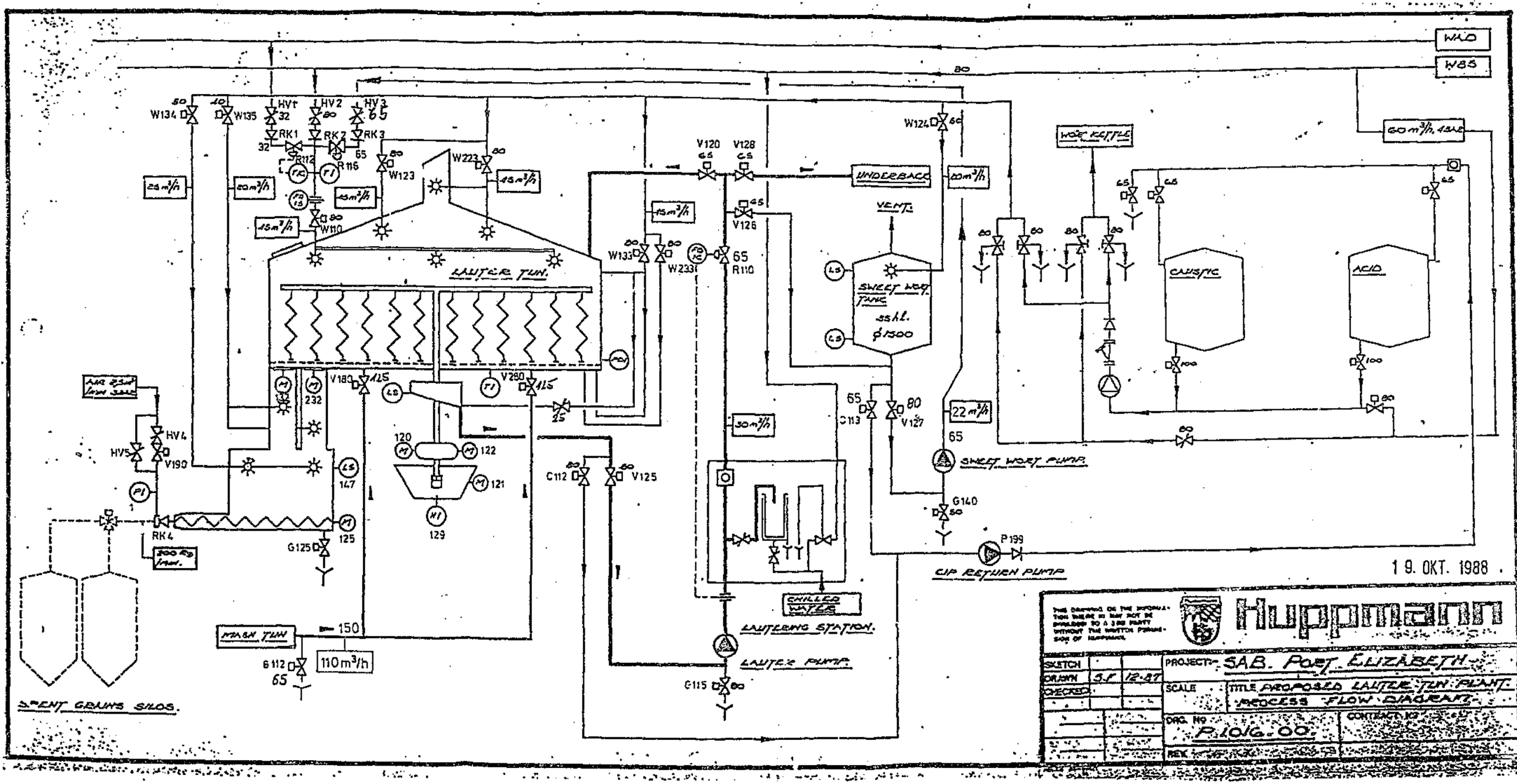
CEP 357 REV. 3

APPENDIX C

Process Flow Diagram of a Typical Brewhouse Installation



APPENDIX C: P.F.D. OF A TYPICAL BREWHOUSE INSTALLATION (PARTIAL)



APPENDIX C:

P.F.D. OF A TYPICAL BREWHOUSE INSTALLATION (PARTIAL)

APPENDIX D

Quality System Audits

APPENDIX D

QUALITY AUDIT

FOR: HUPPMANN FABRICATIONS & BOTTQUIP FABRICATIONS

BY: R.C. FUNK POSITION: Q.A. MANAGER

SIGNED: [signature] DATE: 2/09/87

This audit is performed using BS 5750: Part 1: 1981, Appendix A. These questions are intended only to serve as indicators & reminders of important points to bear in mind and this does not serve as a complete audit of the system. Answers to questions are Yes, No, N/A (Not Applicable) or ? (Uncertain).

	STATUS	COMMENTS
A.1 Quality system		
(a) Has the supplier documented his system for inspection?	No	
(b) Do the supplier's plans for inspection provide for all specified requirements to be met?	No	Except for pressure vessels
(c) Are the supplier's arrangements for inspection to be performed outside his premises acceptable?	No	Usually N/A
(d) Are the supplier's inspection records capable of providing objective evidence that the specified requirements have been met?	No	Except possibly for pressure vessels → Data Books
A.2 Organization		
(a) Has a representative responsible for inspection been appointed?	Yes	R.C. Funk at present
(b) Has the representative the necessary authority, responsibility and ability to perform his functions effectively?	Yes	Top management support
(c) Are the responsibilities for inspection clear and comprehensive?	No	Systematic Inspections not performed presently
A.3 Review of the quality system		
(a) Does the supplier's management carry out periodic reviews?	N/A	New system
(b) Do these reviews make use of the findings of internal audits?	N/A	New system
(c) Does the supplier have a documented procedure for the audit of the system?	No	
(d) Are the procedures systematically conducted and do they provide objective evidence of the effectiveness of the inspection system?	No	
(e) Is corrective action taken when the inspection system is found to be deficient and is such action effective?	N/A	New system
(f) Are records of audits maintained as part of the supplier's records as required by 4.4.2 of BS 5750 : Part 2 : 1979?	Yes	This is the first record

	STATUS	COMMENTS
A.4 Documentation		
A.4.1 *Inspection and test procedures*		
(a) Does the supplier have appropriate documented inspection procedures for, as a minimum, those inspection stages where inspection is performed to demonstrate conformance to specified requirements?	No	Procedures do not exist at present except: Pressure Vessels
(b) Are such inspection procedures clear, current and complete?	No	" " " "
(c) Do they include criteria for acceptance or rejection and identify the inspection equipment to be used?	No	
A.4.2 *Records*		
(a) Are there records of essential inspection and test activities?	No	Except pressure vessels
(b) Do the records contain all essential data?	Yes	When they exist
(c) In instances of rejection, do records show resulting action?	N/A	No records yet
(d) Are there satisfactory arrangements for storage and retrieval of records?	Yes	Filing cabriet in Drawing office
A.4.3 *Technical data and changes*		
(a) Does the supplier have procedures that ensure that only the latest applicable technical data are used for inspection purposes?	No	
(b) Is there an acceptable system for controlling changes to technical data or instructions arising therefrom?	No	
A.5 Inspection equipment		
(a) Does the supplier have a documented measurement and calibration system and does it meet the requirements of BS 5781 : Part 1?	N/A; ?	? Need to check
(b) Are necessary gauges, testing and measuring equipment available and used? NOTE. For further typical questions reference should be made to appendix A of BS 5781 : Part 2 : 1981.	N/A; ?	" "
A.6 Inspection of purchased materiel or services		
A.6.1 *Purchasing*		
(a) Does the system assure that material and services supplied by sub-contractors meet contract requirements?	No	
(b) Does the system provide for the selection of sub-contractors on the basis of their quality capability?	No	
(c) Does the supplier review his sub-contractors' performance at intervals consistent with the complexity and quality of the product?	No	
(d) Do supplier records provide evidence that the supplier's controls, and those of his sub-contractors, are adequate to assure the quality of purchased materiel and services?	No	Only need certificates for certain materials.
A.6.2 *Purchasing data*		
(a) Do the supplier's purchasing documents clearly describe requirements?	?	Need to check
(b) Are requirements for any necessary tests and inspection of raw materials specified in purchasing documents?	N/A; ?	

	STATUS	COMMENTS
A.6.3 *Receiving inspection*		
(a) Does the supplier inspect incoming materiel to the extent necessary upon receipt?	No	
(b) Does the supplier adjust the extent of receiving inspection on the basis of objective data?	No	
(c) Does the supplier assure that materiel conforms to the applicable physical, chemical and other technical requirements, using laboratory analyses as necessary?	Yes	N/A in most cases
(d) Is tested, approved materiel identified and carefully segregated from that not tested or approved?	No	
(e) Does the supplier have effective controls for preventing the use of non-conforming incoming materiel?	No	No control at present
(f) Are there adequate procedures for providing sub-contractors with appropriate data regarding unsatisfactory quality?	?	Unsatisfactory goods would usually be returned.
(g) Has the supplier adequate controls for assuring correction of sub-contracted non-conforming materiel?	?	Unclear as to present procedure
(h) Does the supplier's system provide for the immediate recall and replacement of materiel released for production prior to completion of receiving inspection and subsequently found to be non-conforming?	N/A	
A.6.4 *Verification of purchased materiel*		
(a) Do sub-contracts afford the Purchaser's Representative the right to verify conformance at source when required by the contract?	Yes	If required this could be arranged
(b) Are copies of documents necessary for such verification made available to the Purchaser's Representative in good time?	N/A	
A.7 In-process inspection		
(a) Is inspection performed during manufacture on all characteristics which cannot be inspected at a later stage?	No	Not formally
(b) Are the inspection procedures carried out, test devices used, records kept, etc., suitable?	?	No records kept except Pressure Vessels
(c) Do the operations performed by the supplier meet any special process requirements specified in the contract?	Yes	If required
(d) Does the supplier periodically monitor these operations to ensure their continuing compliance with requirements?	No	
A.8 Workmanship		
(a) Has the supplier established satisfactory standards of workmanship?	No	Some standards for Hypronom Fab
(b) Do these provide an objective basis for decisions on acceptability of materiel?	?; N/A	Standards are lacking
(c) Are only qualified personnel used for work requiring special skills or training?	Yes	Some welders are coded
A.9 Corrective action		
(a) Does the system provide for prompt detection of inferior quality and for correction of its assignable causes?	No	
(b) Is adequate action taken to correct the causes of defects in materiel, facilities and functions, e.g. design, purchasing, testing?	No	

	STATUS	COMMENTS
(c) Are analyses made to identify trends towards material non-conformance?	No	No statistical analysis is done
(d) Is corrective action taken to arrest unfavourable trends before non-conformances occur?	No	
(e) Does corrective action extend to sub-contractor materiel?	no	
(f) Is corrective action taken in response to user data?	No	Some redesigning may occur
(g) Are data analysis and materiel examination conducted on scrap or re-work to determine extent and causes of defects?	No	
(h) Is the effectiveness of corrective action reviewed and subsequently monitored?	No	
A.10 Purchaser supplied materiel (a) Does the supplier examine 'supplied materiel' upon receipt for damage, quantity, completeness and type?	N/A	
(b) Are there precautions and inspections during storage against damage and deterioration and to check on storage life limitations?	N/A	
(c) Is all 'supplied materiel' properly identified and protected from unauthorized use or improper disposal?	N/A	
(d) Have procedures been established for notification to the purchaser of any loss, damage, malfunction or deterioration of 'supplied materiel'?	N/A	
A.11 Completed item inspection and test (a) Are completed items given a final inspection and test to establish overall quality?	Yes	Can be improved; especially Bottling
(b) Does the final testing meet the requirements of the relevant specification?	Yes	When used eg. Pressure Vessels
(c) Are inspection and test problems or deficiencies promptly reported to the appropriate authority?	Yes	(Pressure vessels)
(d) Is there re-inspection and re-test of all items that are re-worked, repaired or modified after initial and product testing?	Yes	(Pressure vessels)
A.12 Sampling procedures (a) Are recognized standards on sampling being utilized or are supplier-designed sampling plans available for review by the Purchaser's Representative?	N/A	Volumes are probably too low.
(b) Do supplier-developed sampling plans provide valid confidence and quality levels?	N/A	" "
(c) Does the supplier enforce all of the conditions required for the application of the sampling plans used?	N/A	" "
(d) Are proper records maintained of sampling procedures and results?	N/A	" "
(e) Is there a clear identification of characteristics to which sampling is applied?	N/A	" "
A.13 Control of non-conforming materiel (a) Does the supplier have an effective system for controlling non-conforming materiel?	No	
(b) Does the supplier properly identify, segregate and dispose of non-conforming materiel?	No	
(c) Are the procedures for repair and re-work of non-conforming materiel documented and acceptable?	No	Not documented
(d) Is relevant scrap and re-work data maintained and available for review?	No	No data maintained

	STATUS	COMMENTS
(e) Do repair and re-work activities comply wit documented procedures?	N/A	
(f) Are holding areas adequate for the segregation and storage of non-conforming materiel?	No	
(g) Has the supplier nominated personnel with authority to be responsible for review and sentence of non-conforming materi ?	No	
A.14 Alternative inspection procedures and equipment (a) Is the supplier's proposal to use alternative inspection procedures and equipment backed by valid evidence?	N/A	
(b) Do supplier proposals provide information on how the continuing suitability of alternatives will be maintained?	N/A	
A.15 Indication of inspection status (a) Does the supplier employ an effective system for indicating the inspection status of materiel?	No	No system exists
(b) Is th inspection status of materiel readily apparent?	No	
(c) Is batch or lot identity maintained throughout the manufacturing process where necessary?	Yes	Heat No. with pressure vessels
A.16 Protection and preservation of product quality (a) Does the system provide for the identification, as necessary, of the materiel from the time of receipt until the supplier's responsibility ceases?	Yes	Probably
(b) Are adequate work and inspection instructions prepared and implemented for the handling, storage and delivery of materiel?	No	Possibly N/A
(c) Are handling, storage and delivery procedures and methods monitored as part of the quality system review?	No	
A.16.1 *Material handling* (a) Has the supplier instructions or procedures, where necessary, to control handling and transport operations?	N/A	
(b) Are special crates, boxes, containers, trucks or other transportation vehicles provided for handling materiel?	Yes	
(c) Are handling devices periodically inspected for cleanliness and suitability for use?	Yes	
(d) Is materiel suitably protected when passing through or held in areas that may contain harmful contaminants?	N/A	Need to check that s/steel is not mixed with mild steel.
A.16.2 *Storage* (a) Are there procedures and regular schedules for the inspection of products in storage and are these procedures adequate to prevent deterioration or damage?	No	Except for annual "clean-up". Possibly adequate
(b) Is there a procedure to assure that items that can corrode or otherwise deteriorate during manufacture or interim storage are properly cleaned and preserved?	N/A	Generally N/A
(c) Are all required critical environments maintained during storage?	Yes	welding rods have an oven

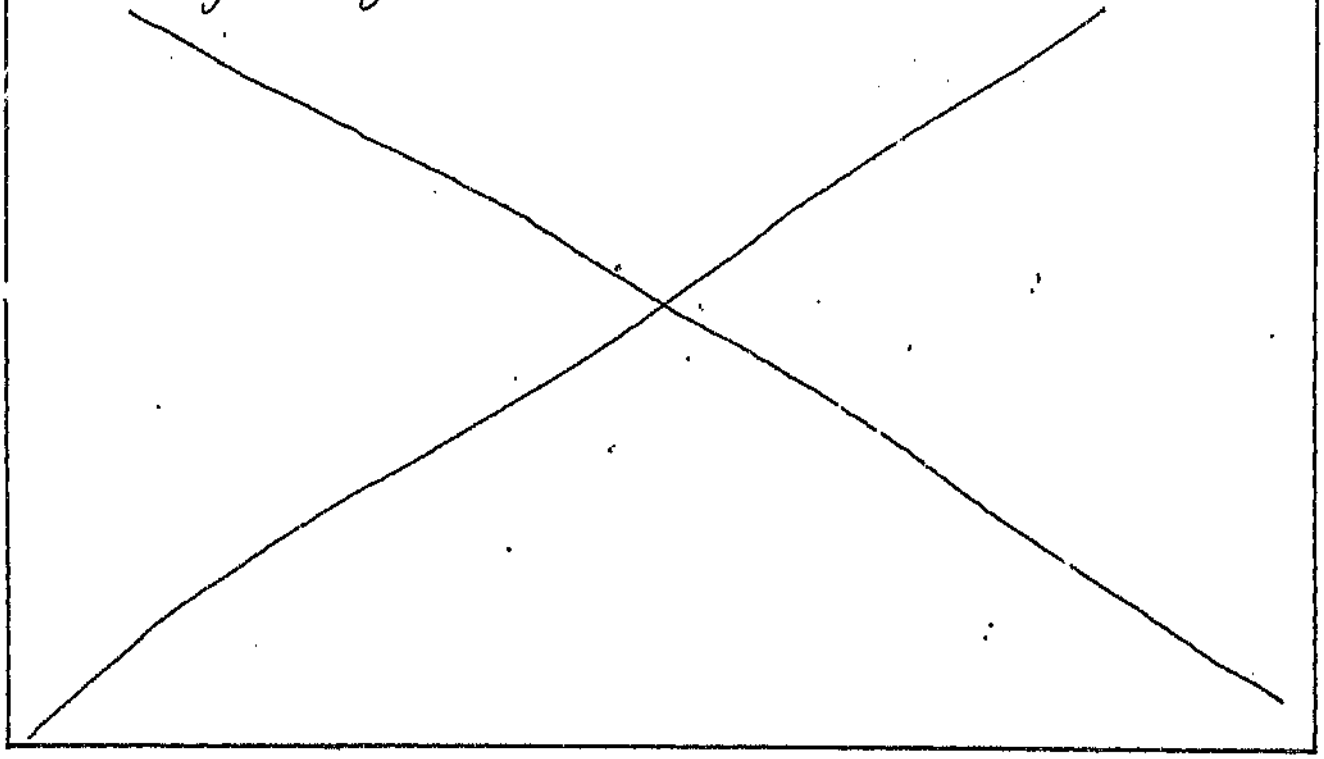
	STATUS	COMMENTS
A.16.3 *Delivery* (a) Is all material to be stored or shipped properly identified and labelled?	Yes	
(b) Are all shipments prepared and transported in conformance to specified requirements and applicable carrier regulations?	Yes	
A.17 Training (a) Are arrangements for personnel training satisfactory?	No	
(b) Are training records maintained?	No.	

STATISTICS

1) No. of Questions answered "Yes" = 19
2) No. of Questions answered "No" = 45
3) No. of Questions answered "N/A" = 23
4) No. of Questions answered " ? " = 6

COMMENTS

-- Prior to implementing new Quality System, clearly, many areas require attention.



QUALITY AUDIT

FOR: HUPPMANN FABRICATIONS & BOTTQUIP FABRICATIONS

BY: R.C. FUNK POSITION: Q.A. MANAGER.

SIGNED: DATE: 1/11/88.

This audit is performed using BS 5750: Part 5: 1981, Appendix A. These questions are intended only to serve as indicators & reminders of important points to bear in mind and this does not serve as a complete audit of the system. Answers to questions are Yes, No, N/A (Not Applicable) or ? (Uncertain).

	STATUS	COMMENTS
A.1 Quality system (a) Has the supplier documented his system for inspection?	Yes/No	Not fully completed
(b) Do the supplier's plans for inspection provide for all specified requirements to be met?	Yes	Via detailed Quality Plans
(c) Are the supplier's arrangements for inspection to be performed outside his premises acceptable?	Yes.	Q.A. applied to Subcontractors & Site Work
(d) Are the supplier's inspection records capable of providing objective evidence that the specified requirements have been met?	Yes.	3rd party inspection reports in the case of pressure vessels. Q. Plans for other equipment.
A.2 Organization (a) Has a representative responsible for inspection been appointed?	Yes.	Q.A. Manager - Qualified Engineer.
(b) Has the representative the necessary authority, responsibility and ability to perform his functions effectively?	Yes.	Experience of implementing Q.A. systems Top Management Support. Qualified Engineer
(c) Are the responsibilities for inspection clear and comprehensive?	Yes.	Responsibilities for quality have been delegated to personnel.
A.3 Review of the quality system (a) Does the supplier's management carry out periodic reviews?	Yes.	Every six months.
(b) Do these reviews make use of the findings of internal audits?	Yes.	
(c) Does the supplier have a documented procedure for the audit of the system?	No.	
(d) Are the procedures systematically conducted and do they provide objective evidence of the effectiveness of the inspection system?	?	
(e) Is corrective action taken when the inspection system is found to be deficient and is such action effective?	Yes	For example, when weld procedures were not being consulted.
(f) Are records of audits maintained as part of the supplier's records as required by 4.4.2 of BS 5750 : Part 2 : 1979?	Yes	

	STATUS	COMMENTS
A.4 Documentation A.4.1 *Inspection and test procedures* (a) Does the supplier have appropriate documented inspection procedures for, as a minimum, those inspection stages where inspection is performed to demonstrate conformance to specified requirements?	Yes/No.	Simple inspections eg. dimensional checks, are not procedure documented. Inspection procedure for Dye Penetrant Testing is documented, as well as Incoming Materiel Control
(b) Are such inspection procedures clear, current and complete?	Yes	
(c) Do they include criteria for acceptance or rejection and identify the inspection equipment to be used?	Yes	
A.4.2 *Records* (a) Are there records of essential inspection and test activities?	Yes.	Quality plans, welding schedules and 3rd party inspection reports.
(b) Do the records contain all essential data?	Yes	Date, who inspected, outcome, action etc
(c) In instances of rejection, do records show resulting action?	Yes/No.	Only major non-conformance action is documented
(d) Are there satisfactory arrangements for storage and retrieval of records?	Yes	One central filing cabinet
A.4.3 *Technical data and changes* (a) Does the supplier have procedures that ensure that only the latest applicable technical data are used for inspection purposes?	Yes	Not documented however,
(b) Is there an acceptable system for controlling changes to technical data or instructions arising therefrom?	Yes	Revisions to drawings etc. issued. Old drawings destroyed.
A.5 Inspection equipment (a) Does the supplier have a documented measurement and calibration system and does it meet the requirements of BS 5781 : Part 1?	No./Yes	Not documented. Critical inspection equipment is calibrated however
(b) Are necessary gauges, testing and measuring equipment available and used? NOTE. For further typical questions reference should be made to appendix A of BS 5781 : Part 2 : 1981.	Yes	
A.6 Inspection of purchased materiel or services A.6.1 *Purchasing* (a) Does the system assure that materials and services supplied by sub-contractors meet contract requirements?	Yes	Via Quality plans for sub-contractors and incoming materiel inspection procedure.
(b) Does the system provide for the selection of sub-contractors on the basis of their quality capability?	Yes.	Records of quality performances of sub-contractors are kept.
(c) Does the supplier review his sub-contractors' performance at intervals consistent with the complexity and quality of the product?	Yes.	Hold and witness points indicated on their Q. Plans
(d) Do supplier records provide evidence that the supplier's controls, and those of his sub-contractors, are adequate to assure the quality of purchased materiel and services?	Yes.	Quality plans and feedback from customer provide evidence
A.6.2 *Purchasing data* (a) Do the supplier's purchasing documents clearly describe requirements?	Yes/No.	Sometimes a bit vague. Could be improved.
(b) Are requirements for any necessary tests and inspection of raw materials specified in purchasing documents?	Yes.	Via attached and negotiated Quality Plans.

	STATUS	COMMENTS
A.6.3 *Receiving inspection* (a) Does the supplier inspect incoming materiel to the extent necessary upon receipt?	Yes.	Some slight mishaps still occur however.
(b) Does the supplier adjust the extent of receiving inspection on the basis of objective data?	No/N/A.	Insufficient data at present
(c) Does the supplier assure that materiel conforms to the applicable physical, chemical and other technical requirements, using laboratory analyses as necessary?	Yes/N/A.	e.g. check heat certificates.
(d) Is tested, approved materiel identified and carefully segregated from that not tested or approved?	Yes.	
(e) Does the supplier have effective controls for preventing the use of non-conforming incoming materiel?	Yes	Appears to be satisfactory
(f) Are there adequate procedures for providing sub-contractors with appropriate data regarding unsatisfactory quality?	Yes.	Via non-conformance reports or personal attention of Quality Manager
(g) Has the supplier adequate controls for assuring correction of sub-contracted non-conforming materiel?	Yes.	Quality standards are insisted upon. Deviations may be negotiated with client
(h) Does the supplier's system provide for the immediate recall and replacement of materiel released for production prior to completion of receiving inspection and subsequently found to be non-conforming?	Yes	
A.6.4 *Verification of purchased materiel* (a) Do sub-contracts afford the Purchaser's Representative the right to verify conformance at source when required by the contract?	Yes.	Client representative is free to inspect any sub-contracted work at any stage
(b) Are copies of documents necessary for such verification made available to the Purchaser's Representative in good time?	Yes.	Quality plans of sub-contractors are approved by client, prior to issue.
A.7 In-process inspection (a) Is inspection performed during manufacture on all characteristics which cannot be inspected at a later stage?	Yes.	Detailed Quality Plan activities.
(b) Are the inspection procedures carried out, test devices used, records kept, etc., suitable?	Yes	Customer is satisfied with records.
(c) Do the operations performed by the supplier meet any special process requirements specified in the contract?	Yes.	Special process requirements are detailed in Quality Plans.
(d) Does the supplier periodically monitor these operations to ensure their continuing compliance with requirements?	Yes.	Quality Manager is closely involved in e.g. welding control.
A.8 Workmanship (a) Has the supplier established satisfactory standards of workmanship?	Yes/No.	Some workmanship standards are difficult to quantify e.g. neatness.
(b) Do these provide an objective basis for decisions on acceptability of materiel?	Yes.	When they exist.
(c) Are only qualified personnel used for work requiring special skills or training?	Yes.	Welders are qualified by coding. Boilermakers are very experienced.
A.9 Corrective action Does the system provide for prompt detection of inferior quality and for correction of its assignable causes?	Yes.	Numerous inspections. Little delay in communication due to small size of company.
(b) Is adequate action taken to correct the causes of defects in materiel, facilities and functions, e.g. design, purchasing, testing?	Yes.	In conjunction with Huppermann Germany if necessary.

	STATUS	COMMENTS
(c) Are analyses made to identify trends towards material non-conformance?	N/A.	Low volume → SQC. not applicable
(d) Is corrective action taken to arrest unfavourable trends before non-conformances occur?	Yes.	
(e) Does corrective action extend to sub-contractor materiel?	Yes	
(f) Is corrective action taken in response to user data?	Yes	Feedback from customer used in new design.
(g) Are data analysis and materiel examination conducted on scrap or re-work to determine extent and causes of defects?	Yes.	By foreman or Q.A. manager.
(h) Is the effectiveness of corrective action reviewed and subsequently monitored?	No.	Assumed to be functioning
A.10 Purchaser supplied material (a) Does the supplier examine 'supplied materiel' upon receipt for damage, quantity, completeness and type?	Yes.	Materiel receipt procedure.
(b) Are there precautions and inspections during storage against damage and deterioration and to check on storage life limitations?	No/N/A.	Stainless steel does not corrode.
(c) Is all 'supplied materiel' properly identified and protected from unauthorized use or improper disposal?	Yes.	Heat numbers are transferred onto sheets.
(d) Have procedures been established for notification to the purchaser of any loss, damage, malfunction or deterioration of 'supplied materiel'?	No.	But purchaser would be notified
A.11 Completed item inspection and test (a) Are completed items given a final inspection and test to establish overall quality?	Yes.	Final inspection called for on all Quality plans. Pressure test for pressurised equipment.
(b) Does the final testing meet the requirements of the relevant specification?	Yes	
(c) Are inspection and test problems or deficiencies promptly reported to the appropriate authority?	Yes	Prompt feedback loops
(d) Is there re-inspection and re-test of all items that are re-worked, repaired or modified after initial and product testing?	Yes.	
A.12 Sampling procedures (a) Are recognized standards on sampling being utilized or are supplier-designed sampling plans available for review by the Purchaser's Representative?	N/A	Volume too low
(b) Do supplier-developed sampling plans provide valid confidence and quality levels?	N/A	" " "
(c) Does the supplier enforce all of the conditions required for the application of the sampling plans used?	N/A	
(d) Are proper records maintained of sampling procedures and results?	N/A	
(e) Is there a clear identification of characteristics to which sampling is applied?	N/A	
A.13 Control of non-conforming materiel (a) Does the supplier have an effective system for controlling non-conforming materiel?	Yes/No.	Could be improved. Small non-conformants are repaired informally.
(b) Does the supplier properly identify, segregate and dispose of non-conforming materiel?	Yes.	
(c) Are the procedures for repair and re-work of non-conforming materiel documented and acceptable?	Yes	Approved by client as required.
(d) Is relevant scrap and re-work data maintained and available for review?	No.	Informal repairs mean that records are not really generated

	STATUS	COMMENTS
(e) Do repair and re-work activities comply with documented procedures?	Yes	When documented procedures exist.
(f) Are holding areas adequate for the segregation and storage of non-conforming materiel?	?	
(g) Has the supplier nominated personnel with authority to be responsible for review and sentence of non-conforming materiel?	Yes.	Quality manager
A.14 Alternative inspection procedures and equipment (a) Is the supplier's proposal to use alternative inspection procedures and equipment backed by valid evidence?	Yes/?	If required; unclear
(b) Do supplier proposals provide information on how the continuing suitability of alternatives will be maintained?	?	
A.15 Indication of inspection status (a) Does the supplier employ an effective system for indicating the inspection status of materiel?	Yes.	Quality plan indicates inspection status. Low volume means no I.D. problems
(b) Is the inspection status of materiel readily apparent?	Yes.	Q. Plans / low volume.
(c) Is batch or lot identity maintained throughout the manufacturing process where necessary?	Yes.	Heat Numbers transferred.
A.16 Protection and preservation of product quality (a) Does the system provide for the identification, as necessary, of the materiel from the time of receipt until the supplier's responsibility ceases?	Yes.	Low volume & heat numbers. All pressure vessels are stamped and numbered.
(b) Are adequate work and inspection instructions prepared and implemented for the handling, storage and delivery of materiel?	Yes/No	Some damage to equipment does occur during transport to site.
(c) Are handling, storage and delivery procedures and methods monitored as part of the quality system review?	No.	Easy to implement however.
A.16.1 *Materiel handling* (a) Has the supplier instructions or procedures, where necessary, to control handling and transport operations?	No/N/A	Assumed that personnel know how to handle products.
(b) Are special crates, boxes, containers, trucks or other transportation vehicles provided for handling materiel?	Yes	Cranes, supports, padding etc.
(c) Are handling devices periodically inspected for cleanliness and suitability for use?	Yes	By foreman.
(d) Is materiel suitably protected when passing through or held in areas that may contain harmful contaminants?	Yes.	After installation, vessels are pickled and passivated.
A.16.2 *Storage* (a) Are there procedures and regular schedules for the inspection of products in storage and are these procedures adequate to prevent deterioration or damage?	N/A	
(b) Is there a procedure to assure that items that can corrode or otherwise deteriorate during manufacture or interim storage are properly cleaned and preserved?	Yes	Welding consumables are carefully stored, in heat boxes if required.
(c) Are all required critical environments maintained during storage?	Yes.	Heat boxes for welding electrodes.

	STATUS	COMMENTS
A.16.3 *Delivery* (a) Is all materiel to be stored or shipped properly identified and labelled?	Yes.	
(b) Are all shipments prepared and transported in conformance to specified requirements and applicable carrier regulations?	Yes	
A.17 Training (a) Are arrangements for personnel training satisfactory?	No	No formal personnel training occurs.
(b) Are training records maintained?	No/N/A	

STATISTICS

1) No. of Questions answered "Yes" = 69.
2) No. of Questions answered "No" = 12
3) No. of Questions answered "N/A" = 9½
4) No. of Questions answered " ? " = 3½.

COMMENTS

ACTION REQUIRED

- Documented audit procedure required.
- System in general to be documented → Quality Manual.
- Inspection procedures need to be reviewed
- Non-conformance records/actions need to be reviewed for suitability.
- Inspection equipment/calibration needs to be reviewed.
- Improve purchasing documentation w.r.t. requirements to be met by sub-contractors
- Check whether inspection of incoming materiel is sufficient
- Try to develop more engineering and quality specifications and standards.
- Check for effectiveness of corrective actions
- Check on storage methods for stainless steel. Avoid all contact with mild steel to avoid contamination.
- Investigate methods of transporting vessels etc. to try and eliminate damage caused during transport.

In general, quality system much improved compared to 2/09/87 audit.