ABSTRACT
Crosby explains the benefits of determining from the operators on the shop floor "what the problem really is" (1979). Taking the time and effort to listen to the people doing the job can lead to valuable insights. Under the sub-heading of 'Error-Cause Removal', Crosby highlights a number of difficulties relating to communication between the shop-floor operators and management. The phrase, 'Quality is Free' (Crosby, 1979), refers to the costs which can be saved on quality improvement whilst covering the costs of making the improvements.

This paper seeks to illustrate some of the issues which emerged from a longitudinal study in a manufacturing environment. Key findings have been selected to illustrate the changes made throughout the study and the main conclusions of the research. These include: evidence of a growing awareness of the importance of the "customer", internal as well as external (Schonberger, 1990); the study showed that changes made had improved the overall performance and quality of the case company; the major learning outcome was that it is not enough to concentrate on either human resource issues or processes: both are interrelated and should be dealt with concurrently.

1.0 Introduction
In 'Quality is Free', Crosby (1979) explains the benefits of determining from the operators on the shop floor "what the problem really is". By listening to those doing the job he not only gains an insight into the extent, importance and knock-on effects of the problem area, but possible alternative solutions begin to form in his mind. Under the sub-heading of 'Error-Cause Removal', Crosby highlights a number of difficulties relating to communication between the shop-floor operators and management. A key point is made that after operators bring the problem to management’s attention they are also expected to provide the solution - which, in most cases, is beyond their training as well as their sphere of authority. The errors and problems which occur in processes impact on organisational profitability. Deming illustrated in a simple diagram (Deming, 1982) that by addressing issues such as rework and mistakes, market share improves and scope for employment and expansion exists. Feigenbaum (1956, 1961), played a fundamental role in articulating the concepts of quality costs and provided a framework which allowed management to begin to understand the importance of quality-related cost issues.

A current major change initiative in the UK's upstream Oil and Gas industry is the CRINE Initiative (Cost Reduction in the New Era, UKOOA, 1994) this involves improvements on a large scale and incorporates quality-related activities. The methodologies, successes and failures in quality costs have been discussed in a range of settings (see Grimm, 1987; Campanella, 1989) and it is commonly quoted that quality costs amount to as much as 10-25% of turnover (Dale and Plunkett, 1992). Templates are available for data capture and analysis (Dale and Plunkett, 1995). However, in order to get to the 'gold in the mine' of Juran (1951), it is important to realise that there are many underlying quality issues relating to the management of people and this can provide insights into areas which require attention. This paper seeks to illustrate some of the issues which emerged from a longitudinal study in a manufacturing organisation. The research methodology employed combined a number of...
approaches: structured interviews and semi-structured interviews were used within participative and non-participative observation techniques.

2.0 The Case Study Organisation
The Company (referred to as Company A), which is the case subject of this paper, is part of a major multi-national and employs over 80 people on the site. Approximately one-third of the employees fell into a general category of Management or Administration: this included all of the senior management team e.g. the General Manager, Technical Manager, Production Manager and Quality Manager. During the study, this number of employees varied between 70 plus and approximately 90 staff. Most of the employees, in this male-dominated works, were categorised as Operators: there were a number of different stages in the overall manufacturing process and most of the jobs tended to be specialised within sections of the works.

Location
Company A is located in an area which has a long association with brick manufacture and ceramic material production. Although it is a supplier of consumables (refractories) to the steel industry and exports world-wide, the ceramic pieces are referred to as ‘bricks’ by the operators. The products are an essential item in casting steel as well as the transfer of molten metal and are an integral part of the steel making process. The products are relatively sophisticated with different designs, shapes and attributes depending on the users’ requirements. Manufacturing requires a combination of old and new technologies. However despite changes in process technology - with the inclusion of computers at the design and control stages, the organisation can be described as a 'traditional industry' which has, in this case, developed from the brick making industry.

Personnel
The management team of Company A introduced a TQM initiative which focused on key aspects of the organisation as well as the manufacturing process. This was a continuation of their goals in quality which followed on from registration to ISO 9002. This continuous improvement programme included the successful recruitment of managers, and trainee managers. At the human resource level, involvement in the Investors in People (IiP) programmes was undertaken to improve the education and training of the whole workforce. The managers and middle managers hold, for the particular industry, high levels of educational qualifications. Substantial investments in equipment and machinery were also made which subsequently led to improvements in productivity and the quality of the output. The Quality Assurance Manager’s role in the company was far reaching and extended from overseeing the quality system to introducing the Total Quality Management (TQM) activities and philosophies. The scope of his job included working with people, individually or in groups, and introducing techniques to achieve organisational objectives. The objectives of the Quality Cost programme included the determination of high cost problems, identifying cost reduction targets and the determination of performance measures. Generally speaking, the QA Manager had to balance key aspects in the collection of quality costs data, such as determining the relevance of the data for collection, assessing the ease of collection and determining actions for improvement of the processes. Identifying poor-quality cost issues in the company at the outset of the study was not, in itself, a problem. The real problem was determining the process relationships between stages, knock-on effects, and cause and effect situations: for example, with a failure rate amounting to 25%, there was a need to manufacture 134 units to ship 100.

3.0 Quality Costs
A great number of articles on quality costs and quality cost related issues have been published. These range from when Juran (1951), coined the phrase “gold in the mine” which could be determined or evaluated by asking the question “What present costs would disappear if all defects disappeared?”, through to practical approaches such as the work of
Alford (1979, parts I-III), and the voluminous body of work presented by Dale at UMIST; and on to key issues such as the approach taken in relation to quality costs and accountancy. Important literature has emerged from a number of sources. Perhaps the best source of reference material come from the ‘Guide for Managing Supplier Quality Costs, edited by Winchell (1986); plus the ‘Principles of Quality Costs, second edition’ (1990) edited by Campanella; and ‘Quality Costs: Ideas and Applications’ volumes 1 and 2 (1987, 1989), edited by Grimm and Campanella respectively. Most of this published material relates to the experiences in the USA and this is typical despite publications now emerging from many countries. The willingness to use company names and real examples typify USA publications. For example, when Garvin produced ‘Quality on the Line’ (1983) it raised awareness not only in the US but world-wide in relation to quality and quality costs. In the UK the best source of reference material comes from Dale and Plunkett (1992,1995) on Quality Costing.

The definition and understanding of the term Quality Costs can be confusing. Juran in ‘Juran on Leadership for Quality’ (1989) uses the term ‘Cost of poor quality (COPQ)’ which is defined as “Those costs which would disappear if all products and processes were perfect - no deficiencies.” He states that “The very term ‘quality costs’ is confusing whereas the term ‘cost of poor quality’ is clear.” This confusion is fuelled by key American authors and the different approach to defining what they mean: Harrington, (1987) refers to quality costs as “poor-quality cost”, whilst Gryna (1978, 1988) tends to refer to it as the “cost of poor quality”. Generally speaking, the cost of quality and quality costs are used synonymously. There are different approaches and there does not appear to be one agreed format. This is perhaps most apparent through the definitions used by British Standards. BS4778 Part 2 (1991) defines Quality Cost as: “the expenditure incurred by the producer, by the user and by the community associated with product or service quality.” Quality Related Cost is defined as: “the expenditure incurred in defect prevention and appraisal activities plus the losses due to internal and external failure”. A similar definition to this has been incorporated into BS6143 Part 1 (1991), the Process Cost Model. This states that quality related cost is defined as: “costs in such categories as prevention cost, appraisal cost, internal cost and external failure costs”. For the purpose of this study, the definition chosen comes from BS6143, Part 2 (1991):“cost in ensuring and assuring quality as well as loss incurred when quality is not achieved.”

4.0 Methodology

This longitudinal study with Company A was carried out over a three year period. The researcher set out to investigate issues in the organisation which would be explanatory as well as exploratory (see Yin, 1993 and 1994). The overall aim of the study was to determine the nature of quality-cost related problems in the organisation and involved asking the same questions in different time periods (see Wall and Williams, 1970). The research methodology employed combined a number of approaches: structured interviews and semi-structured interviews were used within participative and non-participative observation. Progress in quality-related matters was monitored. Interview surveys with personnel were used to identify problems, changes which could be made, and improvements in the organisation as well as the manufacturing processes. The sample frame was to include all, or as many as possible, of the total on-site workforce to get their views and opinions. It was not possible to include the whole workforce because of holidays, sickness, business and, a small number who did not wish to take part. Carrying out the research in this manner is highly intensive and costly in terms of the researcher’s time. However, it also means that a high response rate can be expected (see Fowler Jr., 1993).

4.1 Participant Observation

At the outset of the research it was very important to understand the organisation. The objective was to see what people were doing, and why. It was important to realise that the researcher may have a very different view of the social interactions observed within the work groups (see Harvey, 1990). Initially, meetings and discussions with individuals within the management team were held, and site visits to view the processes took place. This period was very useful as it enabled the researcher to build a relationship with the managers.
involved and help facilitate access and field relations (see Hammersley and Atkinson, 1983). Circumstances precluded a ‘complete participant’ role, for example, as an operator on the shop floor for a short period of time. Therefore, the research role selected was as a ‘participant-as-observer’. Adopting this role allows the data to be gathered in a way that the researcher was not covert. The researcher could make it clear that research was the prime interest and he would be free to observe and build relationships (see Burgess, 1984). An active role in gathering data involved carrying out surveys of the total workforce to determine changes over time. Attendance at Company A was intermittent, and therefore non-participative observation techniques were incorporated into the research design. The main activities involving participative observation are outlined below:

Company Visits
The key manager for contact on the research was the Quality Assurance Manager and it was of vital importance that a good relationship was established between the researcher and the QA Manager. The visits to the company always included a meeting with the QA Manager to discuss changes, improvements and areas of difficulty. Questions were asked by the researcher and very often solutions generated by the manager from these questions.

Meetings
The researcher, through the QA manager, was invited to sit in on technical meetings and discussions with the management team in order to identify where their problems lay. This was not an open invitation, but more a series of individual invitations.

Factory visits
The factory visits were extremely important as changes in the workplace could be observed by walking through the process. Significant changes occurred over time in housekeeping, the amount of rework on the shop floor and the volume of incomplete orders awaiting dispatch. Other significant aspects included the condition of machinery and equipment. These visits also gave the researcher an opportunity to spend time in discussion with the workforce at different production stages, enabling the researcher to build a rapport with the operators.

Presentations
As the research progressed and analysis was carried out, presentations of the findings were made to the senior management team. The management team was at liberty to ask for explanation of the findings and the researcher was able to comment about the context and give indications of what these findings might mean. Other presentations were made regarding the role and the content of quality costs and how these might impact on Company A. The objective of this was to stimulate thought and conversation about the ways that quality costs could be reported on a regular basis to the senior management team.

Input to skills needs
From the research the gaps in skills emerged. These were included in the reports produced by the researcher and discussed with the senior managers. The findings were also used to aid skills needs assessment prior to starting the IIP programme. Thus, some of the fundamental work had been done for this phase of company development.

Problem solving
During the course of the visits and discussions it became evident that problem identification and problem solving skills in the management team could be improved. The researcher was able to give some indication of what could be done in the way of addressing issues before they became problems. A decision was made by the senior management to appoint a member of staff to the position of problem solver.

4.2 Non-Participant Observation
The nature of the research meant that the researcher could only spend a limited period of time each week in the organisation. A form of non-participation observation was employed and involved identifying areas which would indicate some improvement or change. One of the main metrics was the monitoring of production figures from an output sheet produced by the first line managers and the Quality Manager. Coupled with this, the weekly waste and scrap reports were viewed as a way of indicating improvements in the level of output. The Quality Control labs and the Quality Manager produced these.
Rework
Rework was a major problem area as the design complexity meant that very small batches were made to satisfy a customer's order if breakages or poor product quality had initially been produced.

Team meetings
An interesting aspect of the changes the organisation was going through was the progress made by the teams as they met to discuss problems in the organisation and findings from these meetings were fed back to the researcher. This was done intermittently.

Company records
Access to company records, although limited, provided some useful data, e.g. the attendance and sickness records of the workforce over selected time periods. This could, potentially, be used to show improvements in morale as the situation changed.

4.3 The Surveys
The first survey involved approximately 90% of total on-site staff. The objectives of the survey were:

i) To determine how effective the organisation’s Quality Improvement Programme had been in raising awareness and helping to improve product quality.

ii) To identify areas requiring improvement as well as problem areas that the management team should be aware of and concerned with.

iii) To provide information which would help with the proposed Quality Cost Programme by identifying key areas where resources could be effectively applied.

The staff were categorised into three distinct groups: Operators, Engineers/Electricians and Management/Administration. The interviews were held with individuals in private. Confidentiality was assured and it was explained that steps would be taken to remove elements which might indicate the respondent’s identity (see Patton, 1990; Oppenheim, 1992; Berg, 1998). The structured questionnaire was used as a guide for the key questions which were asked of each category of the staff. Answers were written down by the interviewer and notes taken when the respondent wished to add more than the question asked. The interviews lasted between 35-40 minutes and recordings were not made. The decision not to record the interviews was made after the pilot following discussions with senior managers. It was of great importance to put the interviewees at ease (see Hart, 1991) and, in some cases, to explain objectively what the questions meant and their purpose. The interviews began with a brief explanation of what the interview was about.

The main themes for the interviews had been determined from literature on quality-related costs, observation within the company, and unstructured interviews with senior managers. These themes evolved over time during the initial stage and were discussed with key individual in Company A. Five main themes emerged:

- Quality (involving products and processes)
- Communication
- Equipment (availability, accessibility, standards etc.)
- Health and Safety
- Training

In addition to these, personnel were asked to identify up to three Problems which impacted on their jobs, up to three Likes related to their work, up to three Dislikes about their jobs, and up to three areas where they would like to see Changes effected.

The interviews were repeated two years later, again involving almost all the on-site staff. As major changes had taken place within the personnel structure of the organisation, the staff were categorised into two distinct groups - Operators and Management/Administration. The objectives of the second round of interviews built on the first phase with two extra considerations:

i) The Management/Administration group were also asked to identify ‘On-site’ strengths. This could be used as a further pointer for company development.

ii) Data collection which would allow a contrast to be made with the earlier survey.

As well as involving staff in the research, the overall manufacturing process was broken down into key stages or sub-processes in order to collect data and determine where problems were occurring, the standard of output from each stage was recorded, new resources issues...
were identified, and the knock-on effects from problems in the sub-processes were recognised.

5.0 Results
A number of major organisational changes occurred during the period of the study. For example, Continuous Improvement Through People (CITP) teams were set up to deal with problem areas; investment was made in plant and equipment; training needs, identified in phase 1 of the study, were assessed and actioned; and the engineering/maintenance function was outsourced. Phase 1 yielded a total of 64 interviews: 30 with Operators; 9 with Engineers/Electricians; and 25 with the Management/Administration groups. The restructuring of the staff in the organisation resulted in two groups within the Company. Phase 2 resulted in 72 interviews being held: 44 with Operators (including two tradesmen); and 28 with the Management/Administration group.

A number of the key findings from the study are presented beginning with an outline of the process problems and examples of changes which took place.

5.1 Processes and Quality
The management literature in recent years has focused on processes and redesigning the way people work to take advantage of new technology, removing duplication in the systems and improve throughput. The initial publication from Hammer and Champy (1993) deal with reengineering organisations does not only apply to large companies and lessons were learned within Company A by examining the overall system and identifying process stages. Process flows were examined by the QA Manager and the researcher to determine the routes through the factory as well attempting to identify bottle-necks and reduce the complexity of the system (see Manganelli and Klein, 1994). The Process Cost Model (BS6143, part 1, 1991) provided a useful guide to identifying inputs and outputs to the sub-processes, but the language used by the researcher and QA Manager tended to be in line with the Prevention, Appraisal and Failure (PAF) Model (BS6143, part 2, 1990). The process model can be complex and difficult to communicate without a solid grounding in its application and, depending on circumstances, the elements of PAF model can be easier to use (see Keogh et al, 1996).

The overall process comprised of a number of sub-processes. These amounted to between 10 to 14 - depending on product requirements. At almost all of these sub-processes there was scope for rework and badly damaged product was scrapped. Some of the scrap from certain stages could be recycled and recycled material could be reused in the mix - the proportions varied depending on a number of factors. For example, the mixing stage was complex and this sub-process became the subject of a Taguchi experiment involving extensive laboratory trials and rigorous monitoring by design engineers and Quality Control staff. Around 25 variables were identified, including temperature, humidity and process times. The researcher relied on informal interviews to be kept up to date on progress.

Figure 1 is a simplified model of the manufacturing process. Examination of the sub-processes highlighted problem areas. For example, say the acceptable output from stage 1 was 95% or 0.95; stage 2 achieves 0.98; and stage 3 produces 0.9 acceptable output. Then, by the end of stage 3, only 84% of acceptable product has been produced. Added to this was the problem that faulty items could have value added at later stages until rejection. To combat this, a monitoring methodology was developed by the researcher, with input from the QA Manager, to record and identify potential problems before they occurred i.e. prevention rather than failure. Although benefits would have accrued in weeks - which could have led to permanent change - the methodology was not adopted by the front-line managers and administrators. Reasons given included being ‘too busy with present work’ and ‘not enough time’. However, despite these difficulties major quality improvements were achieved during the study period which resulted in higher rates of acceptable output and the development of a ‘fast-track’ process for urgent orders.
5.2 Outcomes from the Interview Surveys

Quality
- More than 75% of all respondents thought product quality was ‘Good’ compared with 53% in the first survey.
- 70% of the Operators had noticed improvements in materials/product - particularly within the last year (between interviews).
- 71% of the Operators group and 68% of the Management/Admin. group felt that Quality Training Programmes had helped improve quality.
- To aid further improvements in product quality, 28 Operators made suggestions which included improvements in materials and the mixing sub-process, training, and maintenance.

Communication
- Almost all of the staff, in both groups, read the waste charts and notices which had been explained to staff and more widely used since phase 1 of the study.
- Almost all respondents felt that ‘team briefings’ - introduced after suggestions from staff during the first round of interviews - were a good idea.
- 83% of all respondents thought they were working either ‘well’ or ‘very well’.
- The benefits of team briefing to most respondents was that they were being kept informed of events in, and which affected, the company.
- 82% of the Operators felt that communications had improved within the last year - this contrasted somewhat with the Management/Admin. group. Twenty-one out of the 28 (75%) in the Management/Admin. group felt that communications could be rated ‘Fair’ or ‘Poor’.
- 68% of all respondents made at least one suggestion for improving communications.

Equipment/Resources
- Half of the Operators said there had been improvements in equipment/machinery within the last year i.e. relating to performance/reliability.
- A high proportion of the Operators, who felt that engineering had not improved, gave reasons which indicated that the Contractors’ skills and knowledge base were lacking.
- A large number of Operators made suggestions for improvements relating to needs for other equipment or utilisation of existing equipment.
- Twenty-three (82%) of the Management/Admin. respondents identified at least one problem with the area(s) in the works that they had most contact with. By and large, the problems identified impacted on the external customer.
- A fairly high proportion of managers’ time was spent on works problems they did not expect. For example, after removing extreme values (50% or above), the average time spent by the Management/Admin. group still worked out at 13% of their working week.

Health and Safety
- It was evident from the replies that staff felt ‘safety training’ could still be improved.
- Safety Standards were viewed as being a bit better, with 57% stating that these were ‘Good’ or ‘Excellent’.

Training
The average training time for each group, Operators (35) and Management/Admin. staff taking part (19), was three and a half days.

Thirty-seven out of the 55 not involved in the CITP programme wished to take part.

In the main (69%) of the respondents expected positive improvements on Quality through the CITPs and their projects.

**Problems/Likes/Dislikes/Changes**

The ‘Problems’, included Communications and Attitudes. ‘Likes’, included comments on liking the job, workmates and the variety and interest. Under ‘Dislikes’, the shift system operation, dust, attitudes and barriers between departments were identified as significant.

Related to this, ‘Changes’ suggested included better communications and attitudes.

On-site strengths identified by the Management/Admin. group indicated that staff were aware of commitment, the abilities of individuals, and the need for change. Throughout the interviews it was evident that, in the main, staff were very aware that things had changed in the company. However, a number of comments were made which indicate that some individuals were unhappy about certain aspects which require attention such as attitudes, and conflict between departments.

### 6.0 Conclusions and Learning Outcomes

Involving human resources in quality costs is of strategic importance. Training and education are vital in order to impart understanding of problem areas in which the workforce can effect improvement (see e.g. Belasco, 1990; Petrick, and Furr, 1995; Coulson, 1996). It was evident over the three year period of the study that many staff members wished to improve themselves and their contribution to Company A through education and training. Through the findings from the initial survey the management began to change the conditions which would allow individuals to contribute more to problem solving as well as grow through personal development (see Argyris, 1996). The methodology described in this paper, to get below the statistics produced by the managers and accountants, is one way that the human resources of an organisation can be aided in their involvement in the improvement process.

Throughout the study, a growing awareness of the importance of the “customer”, internally as well externally was evident (Schonberger, 1990) and the company’s management team was also coming to terms with this. Greater emphasis was being placed on customer satisfaction and more effort was expended on broad quality concepts which included a greater emphasis on employee participation - as one would expect from a TQM initiative.

The aim of a quality cost improvement programme is to shift the costs from the failure category to prevention and reduce overall costs. The British Standard guides, BS 6143, make it clear that to be successful in business requires financial planning and control. Although, BS6143 has been put under scrutiny and constructively criticised for a number of reasons including the difficulties with its implementation (Plunkett and Dale, 1988; Porter and Rayner, 1992), it does make users aware that “failures, however caused, reduce profits”.

This study showed that the changes made had improved overall performance and quality. Perhaps the major learning outcome is that it is not enough to concentrate on either human resource issues or processes: both are interrelated and should be dealt with concurrently. It is vital that the processes are understood, that the causal relationships between activities are identified and that staff are made aware of the importance of their input. As a basis for quality improvement, a quality cost system can play a significant role and can become an important tool to be used in the management of the organisation (Campanella, 1990). However, this should be balanced by listening to the workforce, encouraging participation and working proactively towards solutions (see Wilkinson, 1994).

### References


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