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Design and supply of 3000 litre fully automatic autoclave for the pharmaceutical industry

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In general these reports were an effective tool for maintaining a communication link between the contractor and client. This is essential as in practise this link very often falls away and the client and contractor carry on with their own priorities and only get together near the end of the project. At that stage it is then too late to implement any major design alterations.

Also, through having to draw up these reports, the contractor automatically kept abreast with the status of the project.

In practise, however, it should also be ensured that reporting and holding of meetings do not occur more frequently than required as this then has a reverse effect of generating unnecessary paperwork and wasting valuable project time. Thus the project engineer should ensure that meetings are held at a frequency relative to the status of the project and depending on whether any important matters have to be discussed.

10.4.2 Cost consciousness in the design stage

According to Harrison[6], one of the factors with considerable influence over the eventual cost of a project is the basic project scope and design. This determines the eventual cost of the project and all the other control practices described above then ensure good performance.

Emphasis of cost control has been on the construction and procurement phases of a project, with emphasis on labour productivity and management efficiency. However attention to cost control should commence in the early stages of the project life.

The actual distribution of cost between the phases of a project vary from project to project and from industry to industry. However the principal phases of a project and the approximate percentage of project cost incurred in each phase should be:

(i)	Project evolution and primary design	:	2%
(ii)	Design engineering	:	13%
(iii)	Purchased materials and equipment	:	55%
(iv)	Construction	:	25%
(v)	Installation and handover	:	5%

The key decision making phases of a project are the project evolution and design engineering phase. The seemingly high 15% of the overall cost expended during these phases basically determines the cost of the following stages. Controls in the last three stages are then more concerned with performance than with decision making.

Thus emphasis should be given to cost minimisation and control in the early stages of a project as this then sets the way for an optimum and minimal final project cost.

With this project, the contractor placed more emphasis on cost control during the design stage of the project as opposed to the construction and procurement stage, as he had in the past. This in turn then set the eventual cost of the project and the final cost distribution for this project as shown in Figure 10.1.

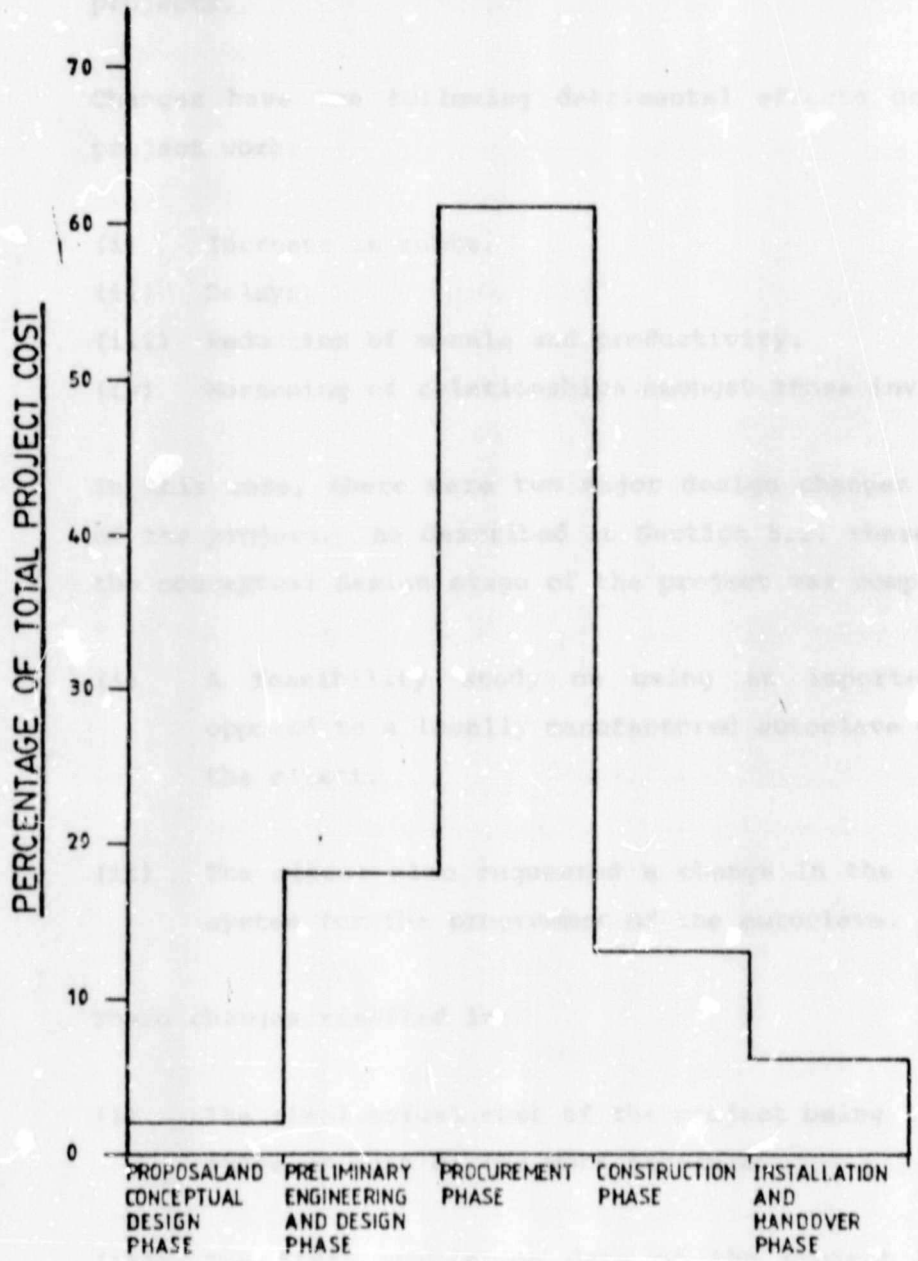


Figure 10.1. Distribution of project costs between phases as recommended by Harrison[6].

10.4.3 Control of changes to project

In accordance with Kerzner[7], the most common causes of cost escalation, low labour productivity and delays are changes to projects.

Changes have the following detrimental effects on performance in project work:

(i) Increase in costs.
(ii) Delays.
(iii) Reduction of morale and productivity.
(iv) Worsening of relationships amongst those involved.

In this case, there were two major design changes during the life of the project. As described in Section 5.2, these occurred after the conceptual design stage of the project was completed.

(i) A feasibility study on using an imported autoclave as opposed to a locally manufactured autoclave was requested by the client.

(ii) The client also requested a change in the computer control system for the programmes of the autoclave.

These changes resulted in:

(i) The final actual cost of the project being 15% more than the budgeted cost of the work scheduled.

(ii) The final completion date of the project being 50% later than the estimated completion date.

These increases in costs and delays in time would have been avoided had the changes been requested and set during the specification and quotation phase of the project.

10.4.4 Productivity

Labour productivity has a significant influence on the efficiency of a project with respect to cost and completion time. Thus, during the duration of this project we concentrated on the motivation of our task force.

In this project the following motivational factors were always taken into account:

(i) Correct wages being paid.

(ii) Suitable and safe working conditions being maintained.

(iii) Direct involvement between the engineers and the workers being established.

(iv) A direct feedback of progress being relayed to the workers as the work progressed.

(v) Recommendations by the workers of improvements to the design and construction phase of the project being encouraged and considered by management. Where these recommendations were viable, they were implemented with the full knowledge of the workers involved.

In accordance with Bennigson[4], management should constantly be on the alert to correct any factor leading to low productivity as low productivity not only reduces labour efficiency but its effects may also be multiplied for the life of the project.

With this project it was found that the major factor influencing labour productivity was the team's basic attitude to work.

It was found to be essential to maintain the interest of the task force and sub-contractors involved with this project at an acceptable level throughout the project's life. At the beginning of the project this interest was generally high and started declining as the project progressed. Towards the end of the project, when interest was being focused on the next job, this interest tended to reach an unacceptable low level.

As productivity was directly effected by this flagging interest, it was the project engineer's responsibility to ensure that the project team's interest and performance was maintained at an acceptable level by:

(i) Eliminating industrial relations problems as described above, this involved the identification and subsequent solution of problems related to:

- Correct earnings.
- Suitable working conditions.
- Satisfactory fringe benefits.
- Accurate job descriptions with lines of responsibility being properly defined.

(ii) Ensuring that management was at all times competent, in order to maintain the respect of the workforce. If this respect is lost for any reason whatsoever, low productivity almost inevitably follows.

It was found that the workers generally lost confidence in management if:

- Drawings and relevant information were unavailable when required.

- Different versions of the same instructions were being used by different people.

- There were frequent changes to instructions.

- There were delays due to delivery of materials and equipment.

- There were frequent alterations to the work already completed.

- There was poor site management.

(iii) Planning manpower requirements effectively and efficiently

With this project it was found that there was a limit to the number of men that could effectively be used on a job at any one time to obtain the most efficient output. If a job was overloaded with people, it had the effect of reducing productivity and increasing the project cost rather than shortening the project time.

Also, it was found that, with very few exceptions, overtime work should have been avoided as this was expensive labour and the work gains obtained were relatively minimal.

10.4.5 Human behaviour

Benningson[4] indicates that some of the main factors involved in achieving effective human relations are:

(i) The accurate specification of the authority of everyone involved.

(ii) The ability of the project engineer to handle non technical requirements and an effective managerial role.

(iii) The elimination of interpersonnel problems.

(iv) The development of an effective team and the elimination of the formation of separate groups.

(v) The effective resolution of conflicts.

As discussed in Section 4.2, during the life of this project the only major human behaviour problem arose between the supplier of the computer and the manufacturer of the autoclave.

This problem was due to a lack of communication between the various groups and due to the fact that the control of the computer supplier was initially the client's responsibility and not the contractor's.

This problem was then rectified by:

(i) Defining and specifying each sub-contractor's responsibilities. The Contractor achieved this by drawing up job descriptions for each sub-contractor detailing the extent of the sub-contractor's commitment.

(ii) Establishing communication channels between the sub-contractor's. The contractor achieved this by defining each sub-contractor's position within the organisational structure of the project team and indicating each sub-contractor's responsibilities to the contractor and to his fellow sub-contractors. Only where necessary direct links were formed between sub-contractors with the contractor presiding over such a link in an advisory capacity.

(iii) Placing all the sub-contractors under the control of the contractor. The contractor was then the sole link to the client. This then eliminated instructions being given to the sub-contractors by both the client and contractor.

11 INSTALLATION, COMMISSIONING AND HANDOVER

11.1 Installation

After satisfactory inspection and preliminary commissioning of the autoclave at Albert Moore's works, the autoclave was delivered to Adcock Ingram's site using a flat bed truck.

At the site it was:

- Offloaded with the use of a crane.
- Moved into position.
- Aligned and levelled.
- Connected to services and other vessels supplied by the contractor

11.2 Commissioning

After installation, the autoclave was commissioned by the client and contractor. This commissioning lasted for ten working days during which time the following problems were corrected:

(i) All leaking pipes were replaced.

(ii) All faults on the safety operation of the doors were rectified.

(iii) The computer programme was adjusted to suit the client's requirements.

(iv) All faulty instrumentation was replaced or repaired.

(v) All faulty thermocouples were replaced.

11.3 Handover

After the autoclave was operated several times to the satisfaction of all concerned, it was officially handed over to the client.

At this stage, as a safeguard against any unforeseen problems the client retained 10% of the total value of the order for three months. The contractor in turn, retained an equivalent 10% from his suppliers for three months after commissioning.

One month after satisfactory commissioning, the contractor supplied the client with an operation manual in triplicate. This manual included:

- Operation instructions.
- Equipment details.
- Maintenance details.
- Spares recommendations.
- All approved engineering drawings.
- All inspection certificates.

12 RESULTS AND DISCUSSIONS

12.1 Overspending

The final expenditure figure for this project was 15% over the estimated cost. Although this does not seem excessive, the estimated cost had a 10% contingency factor built into it for any unforeseen factors.

This overspending can be attributed to the following:

(i) Changes in the initial specifications.
(ii) Costly design changes in the computer control system.
(iii) Uniqueness of this type of equipment resulting in unforeseen design and manufacturing requirements.

However, due to the relatively small size of the project and the control systems that were implemented, the overrun on the budget was contained to a realistic level.

The system of controls which were implemented were as follows:

(i) To monitor costs, the cost of the actual work performed at each stage of the project was compared every two weeks to the estimated budget cost for that period. Where large variances in cost occurred, reasons were sought for these overexpenditures and measures were then taken to rectify the situation.

(ii) To monitor progress, an effective system of presenting regular project reports and holding periodic meetings between the client and contractor was devised.

This resulted in the client obtaining a sterilization plant which was of high quality, at realistic price and within an acceptable time period. The contractor in turn had the opportunity of realizing a realistic but not excessive profit while designing a sterilization plant with basically new concepts in the pharmaceutical industry.

12.2 Late Delivery

The delivery time of the autoclave was 8 weeks overdue. This represented a delay of 45%. Although this did not hamper the production requirements of the client, it was not acceptable as it resulted in increased costs and a consequent lower profit for the contractors. Also the time spent on this project could have been utilised on other work.

The late delivery can be attributed to:

(i) Design and specification changes by the client.

(ii) Lack of communication between the various suppliers of equipment in the early stages of the project.

(iii) Late deliveries of certain equipment supplied by sub-contractors. Although penalty clauses for late deliveries were incorporated in all major orders to sub-contractors, these did not have the desired effect of ensuring equipment arriving on time as the maximum liability to the suppliers did not exceed ten percent.

12.3 Controls

The systems of cost and project controls that were implemented on this project were basic and simple but sufficed to ensure that:

(i) The quality of equipment supplied was of a standard equal to that of similar imported items.

(ii) The equipment met the clients requirements.

(iii) The costs were contained to a realistic level.

(iv) A realistic profit was realized by the contractor.

(v) Manpower motivation and consequently productivity was of a satisfactory standard.

(vi) The client obtained a plant that was in excellent working condition and had all the necessary back-up and maintenance systems for its future operation.

13 CONCLUSION

13.1 Size of Project

The conclusions drawn up below, generally refer to a small sized project. A small sized project can be defined as a project which:

(i) Has relatively simple design parameters.

(ii) Can be handled by a task force of up to twenty people.

(iii) Is of relatively low cost. As a rough guideline this refers to projects with a total estimated cost of less than five million rand where cost of equipment is about 60% of the total cost. These costs are relevant at the date of this report.

(iv) Requires not more than two years for completion.

13.2 Initial Decisions

As projects are generally a once off practice and are very seldom repeated, it is essential at the start of any project for the client, who is initiating the project, to study in detail and to familiarise himself with all the systems and designs that are available on the market place.

According to Kerzner[7], in the initial decision making stage, it is essential for the client to:

- Analyse all the data available on such a project.
- Compare all the alternatives available in the market place.
- Predict and evaluate the outcomes with each alternative.
- Estimate the costs of each alternative.
- Study the past record of each alternative.
- Select an alternative which is most suited to the environment and local conditions.
- Draw up objectives and proceed with the selection of a project team.

This is an essential and important step in any project, as bad and incorrect decisions taken at the start of any project, no matter what size, will affect a project throughout its life.

In this case, the client, who initiated the project, took the following approach:

- An enquiry was drawn up listing all the basic requirements based on the client's past experience with sterilisation plants.

- Two contractors were then approached to submit quotations on this enquiry. However, the requirements and specifications listed in this enquiry were insufficient for the contractors to submit realistic quotations. At this stage the client should have paid more attention to the compiling of this enquiry. Alternative methods of sterilisation should have been looked into and overseas companies who had tackled similar plants should have been approached for advice.

- Quotations were then submitted to the client by the contractors.

- The client's selection of contractors was then based mainly on price. This is incorrect as at this stage other aspects such as the contractor's past experience and "track record" should have been taken into account.

- Once the contractor was awarded the contract, he selected his team and proceeded alone with the project. This again was incorrect as with a project of this nature, which involved new technology, both the client and contractor should have worked together on the initial specification stage of the project until the aims of the project were defined and the objectives drawn up.

13.3 Handling of Project

Whenever the need arises within a company for a new project to be executed, management within the company is faced with the choice of either handling the project inhouse or appointing an independent contract company to take charge of the project.

Generally the decision on how to handle the project is taken as follows:

(i) A project can be handled inhouse where:

- It is of an unspecialised nature.
- It is an extension of existing technology with which the project team are fully familiar and experienced.
- A separate and independent team is available to conduct the work without being interrupted by the daily operation requirements of the plant.
- Sufficient priority is given to the project by management to ensure that it is completed on time and within an acceptable budget.

(ii) With this project, Adcock Ingram made the correct decision and approached an independent contract company to handle the work, as:

- Adcock Ingram themselves did not have sufficient staff available to appoint an independent project team.
- They were not fully familiar or experienced with the new sterilisation process required, whereas the contractors had had past experience in this field.
- The project was sufficiently divorced from the daily operation of the plant and thus the contractors could proceed uninterrupted with their work.

13.4 Type of Contract

The following two basic types of contract can be drawn up between a client and a contractor.

(i) Fixed price contract.

This type of contract is recommended where all design aspects of a project are clearly defined and the scope of the project is accurately set.

The reasons for selecting this type of contract are:

- The client is aware of his final cost commitment.
- The client can select the most competitive bid from the various contractors.
- The contractor is motivated to complete the project as scheduled.
- The contractor has a high concern for efficiently controlling costs.

Any deviations, however, to design or scope usually result in expensive changes and costly time delays. It is therefore essential with this type of contract to ensure that from the outset all the requirements, design basis and scope are clearly defined and accepted by both the client and contractor.

(ii) Cost plus contract.

This contract should be implemented for a project with new technology where considerable research and development is initially required and where design parameters are not clearly specified.

The reasons for selecting this type of contract are:

- Work on the project can begin as soon as the contractor is selected.
- The conceptual design and development stage of the project is carried out by both the client and the contractor. The client is then involved in the selection of materials and equipment and is thus ensured of suitable quality.
- If the client is dissatisfied with performance, he can at any time during the project discharge the contractor. This however only occurs in extreme cases of contractor inefficiency.
- The contractor is insured against any costly design or scope changes to the project.

It is recommended however that the client exercise effective cost control measures to ensure that the final cost of the project is economically justifiable.

Other types of contracts can also be drawn up which incorporate a mix of the two types mentioned above. However, it is essential for the correct type of contract to be selected which:

- Safeguards the client.
- Allows flexibility for design and scope changes.
- Is appropriate for that particular project.
- Controls unnecessary expenditures.
- Allows for a realistic but not excessive profit to the contractor.

13.5 Organizational Structures

Once a contract for a project is awarded, responsibility should be properly allocated and clear lines of authority, communication and control must be defined. Proper job descriptions for all the staff involved in the project will avoid any unnecessary conflicts and misunderstandings.

13.6 Planning Systems

The two most common techniques used for project planning are bar charts and network analysis.

13.6.1 Bar charts

This method of planning was utilised during this project and proved to be successful.

Bar charts are recommended where:

- The project is sufficiently small and simple for it to be divided up accurately into its various activities. These activities with their associated manpower requirements are then easily defined and understood from the pictorial picture formed by the bar charts.

- The activities are limited in number, as with this project where they were limited to nineteen.

- Frequent changes and updating of the project are not anticipated.

13.6.2 Network analysis

Common names for this type of analysis are Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT).

This type of analysis should be used on projects where:

- The projects are large and complex. These are projects which due to size and expense are too complex for a single project manager to co-ordinate efficiently. With such projects, the various activities are treated as seperate project packages with each package being co-ordinated by its own project manager. The subsequent overall co-ordination of these project managers can then efficiently be executed by a single responsible person.

- A large number of activities, in excess of two hundred, are involved.

- It is essential to highlight those activities which are critical to the overall time of the project and to indicate the available spare time on the other activities.

- It is essential to highlight the interrelationships between those activities which are not clearly understood or defined.

An advantage with this type of analysis is that all the information is easily computerised and the project team is thus supplied with a readily available source of information.

13.7 Performance Measurements

It is essential to ensure that, as a project proceeds through its design phase, various stages are identified which will assist in the project estimate becoming more refined and which will decrease the level of uncertainty in the project as more information becomes available.

For this situation to occur in time and for a project with similar characteristics as the one in this report, the following stages should be aimed for:

- At about 15% of the project life, the design work should be 20% complete, 80% of the equipment should be specified, the area layouts should be 70% complete and 50% of the orders should be placed.

- At about 25% of the project life, the design work should be 40% complete, all the equipment should be specified, the area layouts should be completed and 70% of the orders should be placed.

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