

Guide to

Terotechnology —

(the economic management of assets) —

**Part 3: Guide to the available
techniques**

Committees responsible for this British Standard

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- British Council of Maintenance Associations
- British Institute of Management (Asset Management Group)
- Chartered Institute of Management Accountants
- Chartered Institution of Building Services Engineers
- Consumer Policy Committee of BSI
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- Electricity Supply Industry in England and Wales
- Institute of Marine Engineers
- Institute of Materials Management
- Institute of Purchasing and Supply
- Institute of Scientific and Technical Communicators
- Institution of Electrical Engineers
- Institution of Incorporated Executive Engineers
- Institution of Mechanical Engineers
- Institution of Plant Engineers
- Ministry of Defence
- Royal Institution of Chartered Surveyors

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Foreword

This Part of BS 3843 has been prepared under the direction of the Quality, Management and Statistics Standards Policy Committee.

In any organization it is necessary to identify and then choose between the investment options open to it and to make decisions on how best to invest the capital available. Once a decision has been made to make an investment in some form of physical asset or project, then the application of terotechnology should assist in the object of getting the best value for money from that investment and thus justify it.

In 1970 the then Department of Industry formed a Committee for Terotechnology which reported in 1973 to the Secretary of State. Soon after that the National Terotechnology Centre was born in 1975. In 1974 the Department of the Environment formed a Committee for Building Terotechnology which reported in 1977 under the title of "Terotechnology in Buildings".

In 1974 BSI published a revision to BS 3811 in which the official definition of "terotechnology" appeared. In 1984 BS 3811 was revised and extended to be of greater use to those practising terotechnology.

The Quality, Management and Statistics Standards Policy Committee which is responsible for BS 3811 has decided that the time is now right to produce a series of guides to terotechnology to assist industry, commerce and public services.

This series of guides sets out in detail all the activities that should be carried out to ensure that the organization which uses terotechnology can compete successfully and, at the same time, achieve consumer satisfaction.

Three Parts of this standard have been published, and further Parts are envisaged in order to give greater emphasis to certain aspects of terotechnology and to take account of new developments. The first three Parts may be summarized as follows:

Part 1: Introduction to terotechnology. This Part gives guidance on the formulation of a brief to senior management within an organization, to highlight the benefits to be gained from using terotechnology, together with the overall resources required for its efficient implementation. It is also an introduction to the concept of terotechnology for those members of an organization who are required to perform their duties within this concept.

Part 2: Introduction to the techniques and applications. This Part gives guidance on how and where organizations should apply terotechnology. It shows what should be considered and when, what techniques are available, and how to deploy and coordinate them.

Part 3: Guide to the available techniques. This Part gives guidance on the specific techniques and is divided into sections, one for each of the techniques considered. It also includes checklists as an aid to the verification that all functions within an organization are being carried out within the principles of terotechnology.

Throughout this standard use of the pronouns he, him and his is intended to be non-gender specific.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 60, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1.1 Scope

Part 2 of this standard identified which techniques of terotechnology were appropriate in the various phases and stages of the life cycle of a project. This Part gives more detailed guidance to those who are directed to implement terotechnology practices in their work. Many techniques are, in practice, applicable at several different stages but this Part is arranged to avoid repetition of guidance.

This Part is divided into three sections. After the introductory section, section 2 gives guidance for each of the techniques identified in Part 2. For convenience these are preceded by a summary of the relevant techniques against the listing of phases and activities in the project's life cycle, derived from Part 2. Each guidance note gives, where necessary, appropriate references to published documents in which the technique is explained in detail. In many cases a full description of a technique may be the subject of a separate complete standard or a chapter in a textbook. Repetition, even in abridged form, would render this standard too long and, in the light of probable developments, difficult to keep up to date. This Part gives directions to suitable sources of the requisite details.

The third section of this Part consists of a series of checklists. Each of these is intended for the use by persons responsible for a specific function in an organization. These checklists are intended to be used by the various functionaries to identify their own role in working to terotechnology principles and to enable them to check that organizational arrangements and procedures exist for the necessary information flows and consultations to take place. These checklists were developed from those originally promulgated in the earliest days of terotechnology but have been modified and extended in the light of experience.

As explained in Parts 1 and 2, many organizations can act both as user and supplier. Furthermore, it is clear that one person's product can become another's asset. To avoid confusion, this Part, in common with Part 2, is written from the viewpoint of a user organization seeking and then using an asset to produce its own product. The need for a supplier to give maximum consideration to his customers' terotechnology needs in designing his products, as well as his own similar needs in acquiring and using his own assets has already been stressed in Parts 1 and 2. This inevitably leads to advantages to both parties if they adopt terotechnology principles.

NOTE The titles of the standards publications referred to in this standard are listed on page 60.

1.2 Definitions

For the purposes of this Part of BS 3843 the definitions given in BS 3811 apply, together with the following.

1.2.1

terotechnology

a combination of management, financial, engineering, building and other practices applied to physical assets in pursuit of economic life cycle costs

NOTE 1 Terotechnology is concerned with the specification and design for reliability and maintainability of physical assets such as plant, machinery, equipment, buildings and structures. The application of terotechnology also takes into account the processes of installation, commissioning, operation, maintenance, modification and replacement. Decisions are influenced by feedback of information on design, performance and costs, throughout the life cycle of a project.

NOTE 2 Terotechnology applies equally to both assets and products because the product of one organization often becomes the asset of another. Even if the product is a simple consumer item its design and customer appeal will benefit from terotechnology and this will reflect in improved market security for the producer.

1.2.2

asset

a physical item such as a building, plant or machinery which is acquired by a user and then employed by him in the pursuance of his business, trade or profession

1.2.3

board

superior management level of the organization, ultimately responsible for deciding upon and authorizing any new project, specifying the objectives and policies to be followed in assessing options

1.2.4

component

an element of the asset which can be acquired separately

**1.2.5
feed**

material to be processed by the asset to form the product

NOTE In certain cases, e.g. a social benefit office, this input might be in the form of data rather than physical material.

**1.2.6
organization**

the totality of the enterprise which is to undertake a proposed new or additional project

NOTE This may be a large industrial company, a public service or in the extreme an individual.

**1.2.7
output**

a quantitative and qualitative measure of the product which is to be supplied from the project

**1.2.8
product**

the output of the relevant assets when employed by the user, including physical items of any complexity (ranging from raw material to a complete system), services as defined in BS 3811, or more general services (e.g. banking, welfare, transport)

NOTE The product of one organization can often become the asset of another.

**1.2.9
project**

a discrete activity ordered by the board to allow an organization to supply a given output of the product, and the acquisition and use of an asset required to achieve this; deemed to start with the instruction from the board for a given objective to be met and extending until the asset is disposed of

**1.2.10
spare**

a replica or equivalent component purchased to replace the original component supplied as part of the asset

NOTE Replacement is normally expected to be required due to failure in its widest sense.

**1.2.11
technique**

an identifiable mathematical or logical procedure or procedures or a subject area which is or has been studied analytically by experts

**1.2.12
vendor rating**

assessment of a supplier's ability to fulfil promises of performance, quality, cost and delivery

NOTE In most cases this is made by the intending purchaser's Quality department or engineer, using past experience and other relevant information.

Section 2. Guidance to the techniques

2.1 The life cycle of a project

Within the context of this standard a project is deemed to commence with the establishment of an organizational objective that calls for the acquisition of an asset with which to produce a product. The project is only deemed to finish when the asset has been disposed of. The total intervening period represents the asset's and the project's life cycle.

For any life cycle there will be four distinct phases. Chronologically the first is the Concept/Investment Decision phase in which the objective is translated into the identification and, in some cases, the choice of a product and thence the asset required to produce it. In the second, the Acquisition phase, the asset is acquired and put to work. The third phase is the Useful Life phase which is sometimes termed the Operation and Maintenance phase. Finally when the asset is no longer required to produce, or capable of producing, the product, it has to be disposed of. This activity can involve further costs against the project but may also attract savings. Thus the Disposal phase will involve further activities which should be organized to achieve the best terotechnological advantages for the organization. These four phases will be applicable to all projects, but may overlap to some extent.

Within each phase the activities may be divided into a number of separate stages. These are shown in Table 1 in approximate chronological order. For a particular project the order of these stages may be changed by the particular circumstances; their relative importance and formality can also be markedly different from project to project.

2.2 Life cycle breakdown of techniques

Part 2 of this standard discusses the application of techniques in the terotechnological management of a project during the four phases identified in 2.1, with the activities in the Useful Life phase split between the production and maintenance areas. Table 2 summarizes which techniques are applicable in which phase and to which activities.

Because terotechnology is concerned with the economic management of a project, economic appraisal of alternative possible courses of action arises whenever such alternatives are encountered. In practice, these can arise in any phase and any stage, and thus the basic techniques used in such economic analyses are applicable throughout the project. Consequent[ly], these are identified separately and ahead of those listed under the various phases.

2.3 Layout of guidance sheets for the techniques

Each of the techniques identified in Table 2 is provided with a guidance sheet to follow in 2.4. The layout of each sheet is based on the format shown in Table 3. Whilst some techniques will be well known such that little guidance is needed, others are relatively new or are still being developed. Because of this, guidance to known sources of details of such techniques is more appropriate in this standard than an attempt to give a comprehensive account of the details. Furthermore some techniques require extensive guidance to the extent that a full description would require a complete and separate standard or a complete chapter of a textbook.

Whenever possible references are made to other British Standards which may themselves make reference to further explanatory documents. If an International Standard exists, but there is no equivalent British Standard, this is used as a second choice of reference. For the more commonly used techniques reference is made to a suitable standard textbook.

Each guidance sheet is numbered and cross-referenced against the relevant phase(s) and stage(s) listed in Table 2.

Table 1 — Phases and stages of a project

Phases	Stages	Short titles
Concept/Investment Decision	Identification of objectives Identification of possible project proposals Initial research of options, leading to estimated cash flows and risk assessments Identification of restraints on organization, leading to judgement criteria Selection of option(s) to be pursued	Options Evaluation Criteria Selection
Acquisition	User lists his requirements in an enquiry specification User identifies potential suppliers Suppliers consider enquiry, identify outline designs for offer and response Suppliers' offers and supporting data submitted in tenders User considers tenders and selects a supplier after negotiating mutually attractive contract terms Selected supplier carries out or selects detailed design and plans programme Acquisition of materials Manufacture and testing (including Quality Assurance) Delivery Construction/erection/installation Commissioning including testing and proving Recruitment and training of user's staff	Enquiry Tender list Offer Tenders Appraisal Design and development Material Manufacture Delivery Erection Commissioning Training
Useful life (Operation, Maintenance)	Overlapping and coincident stages: — Production and operation — Maintenance, including modifications — Collect data for optimization of this project and/or for use in future project selections — Periodic reviews of project until a final review leads to decision to terminate this project	 Operation Maintenance Data Review and termination
Disposal	Identification of methods in light of constraints Evaluate options and select best Effect disposal	Disposal options Disposal appraisal Disposal action

Table 2 — Life cycle breakdown of techniques

Phases and stages	Name of technique	Technique number
0. General. Economic appraisals	Discounted Cash Flow	1
	Net Present Value	2
	Internal Rate of Return	3
	Annuity	4
	Rate of Return	5
	Payback	6
	Cost-benefit Analysis	7
1. Concept/Investment Decision phase		
a) Identification of options	Market research	8
b) Detailed study and evaluation of options	Product design review/audit	9
	Project design appraisal	10
c) Risk and uncertainty	Probability analysis	11
	Risk analysis	12
2. Acquisition phase		
a) Technical requirements for specification	Product design review/audit	9
	Drawings	13
	Queueing theory	14
	Value Analysis	15
	Reliability/maintainability analysis	16
	Plant history files	17
	Vendor assessment	18
	Performance analysis	19
	Ergonomics	20
	Environmental planning	21
	Flow charts	22
	Control of waste	23
b) Assessment of tenders	Project design appraisal	10
	Construction analysis	24
	Modelling	25
c) Manufacture	Design schedules	26
	Drawings	13
	Quality programme	27
	Quality Assurance methods	28
	Test procedures	29
	Financial analysis and budgets	30
d) Erect/install	Network analysis	31
	Bar charts	32
	Progress assessment	33
	Safety consultation	34
	Technical manuals	35
	Expected cost to completion	36
	Handling and storage	37
	Structural safety limits	38

Table 2 — Life cycle breakdown of techniques

Phases and stages	Name of technique	Technique number
e) Commissioning	Network analysis	31
	Quality programme	27
	Drawings	13
	Technical manuals	35
	Commissioning procedures	39
	Training schedule	40
	Performance guarantees	41
3. Useful Life phase. Operational aspects		
a) Production management	Order processing	42
	Technical manuals	35
	Plant history files	17
	Allowance for statutory inspections	43
	Operator maintenance	44
	Life assessment	45
	Operator instructions	46
b) Output performance	Material needs	47
	Work study	48
	Stock control	49
	Data logging	50
	Control limits	51
c) Resource optimization	Operational Research	52
	Production planning and control	53
	Recruitment	54
	Employee training	55
	Energy management	56
	Quality Assurance methods	28
	Marketing programme	57
d) Feedback to new projects	Data logging	50
	Reports	58
	Plant history files	17
4. Useful Life phase. Maintenance aspects		
a) Maintenance management	Quality records	59
	Asset inventory	60
	Technical manuals	35
	Drawings	13
	Work instructions	61
	Reports of work done	62
	Allowance for statutory inspections	43
	Maintenance scheduling	63
	Resource allocation and planning	64
	Reliability/maintainability analysis	16
	Design appraisal (project)	10
	Technical diagnosis and analysis	65
	Failure investigations	66
	Fault analysis	67
	Tribology	68
	Stock control	49
	Work study	48
	Recruitment	54
	Employee training	55

Table 2 — Life cycle breakdown of techniques

Phases and stages	Name of technique	Technique number
b) Health of asset	Maintenance history and analysis	69
	Repair/replacement optimization	70
5. Disposal phase	Risk analysis	12
	Plant history files	17
	Flow charts	22
	Construction analysis	24
	Safety consultation	34
	Technical manuals	35

Table 3 — Layout and explanation of guidance sheets for the techniques

Guidance sheet sections and subsections	Purpose
1. Technique	To give the title of the technique and any alternative title(s).
2. Basic principles of technique	To give the purposes of the technique in general terms.
3. Usage in terotechnology	To indicate when and where the technique is used in terotechnology, including in which phases of a project.
4. Details of technique and applications	To cover how the technique is carried out (usually in general terms) and how it is applied in circumstances given in section 3 of the guidance sheet. The full intent of this section is normally covered in the subsections detailed below. However, in some cases an introductory paragraph has been included to aid readability of the section.
Subsections:	
4a. References	To give references to more detailed descriptions of the technique.
4b. Related techniques	To indicate other techniques used in applying the technique in question. This subsection has been omitted if the technique is in effect a basic technique.
4c. Further information	To give additional, detailed information on the technique. This subsection has been omitted where the technique is adequately covered in the references given in 4a.
4d. Examples	To give examples of situations where the technique is applicable. This subsection has been omitted where the technique is adequately covered in the references given in 4a.

2.4 Guidance sheets for the techniques

NOTE Guidance sheets for techniques 1 to 70 are given in 2.4.1 to 2.4.70, respectively.

2.4.1 Technique 1 (see Table 2, phase 0)

1. Technique

DISCOUNTED CASH FLOW (DCF)

2. Basic principles of technique

A sum of money available in the present will, by investing it at a fixed interest rate, grow to a larger sum, measured in money terms, in future years. From this it follows that a sum of money accruing in the future is equivalent to a smaller sum of money in present-day terms. Thus, when a payment of £X has to be made in the future, a sum of £Y, which is smaller than £X, can be invested today at an interest rate of r which will yield the sum of £X at the future point in time at which it is required for payment. The sum £Y is termed the “present worth” of the sum £X and it is obtained by discounting £X at a discount rate r .

Because of this time value of money, it is not possible to compare directly sums of money accruing at different times in the future. To make such a comparison possible it is necessary to convert these sums to their equivalents at a common point in time, by discounting. The process involved in discounting is in fact the inverse of compounding. In order to assess two different investment proposals, each involving a number of cash flows at different points in the future, the proposals can only be compared after all cash flows have been discounted to a common base date at a common discount rate which is appropriate to the circumstances and agreed by all parties involved. The common base date does not necessarily have to be the present time, but could be some date in the future, such as the start date for the proposed project.

The discounting of cash flows is more than just a technique. It is a principle that is involved in all modern methods of investment appraisal. Unfortunately the term “Discounted Cash Flow” is also used to denote a specific method of investment appraisal in which the discount rate is calculated which, operating over the life of a project, gives a zero net present worth of all the cash flows associated with the project. To avoid confusion the alternative name “Internal Rate of Return” for this investment appraisal method is preferred. (See Technique 3.) The DCF principle is also used in Technique 2 (Net Present Value) and Technique 4 (Annuity).

3. *Usage in terotechnology*

The DCF technique/principle is used in all economic appraisals in which expenditures and incomes occur at different points in time. It is especially used in the Concept/Investment Decision phase where investment in an asset at the start of a project has to be viewed in conjunction with or in comparison with the operational costs and revenue or savings arising throughout the commissioned life of the asset concerned. When applying DCF, the cash flows taken into account should always be with due allowance of the timing of tax payments and tax allowances.

4. *Details of technique and applications*

4a. *References*

- Merrett, A.J. and Sykes, A. *The finance and analysis of capital projects*. Longman, 1963.
Bierman, H. and Smidt, S. *The capital budgeting decision*. Macmillan. 1971
Bromwich, M. *Capital appraisals*. Pelican. 1979
Carsberg, B. *Analysis for investment decisions*. Haymarket Publishing, 1974.

2.4.2 **Technique 2** (see Table 2 phase 0)

1. *Technique*

NET PRESENT VALUE

2. *Basic principles of technique*

This technique is used to evaluate the relative merits of alternative proposals for investment in assets to meet a given objective. Essentially the technique is only applied to projects which have a financial return and are economically viable. To enable comparison of widely different assets, results are usually expressed in terms of net cost per unit of capacity or output where options can be measured in this way.

In this technique, the commonest form of DCF, discounting is carried out at a predetermined discount rate. It is therefore particularly suitable where constant rates of interest are applicable or are expected throughout the life of the project.

3. *Usage in terotechnology*

The technique is first used in the conceptual phase of a new project to determine which of alternative asset acquisitions should be studied in greater depth.

During the lifetime of an existing asset the technique may also be used to compare alternative options such as extending planned life of an existing asset or scrapping and replacing it.

4. *Details of technique and applications*

4a. *References*

- Merrett, A.J. and Sykes, A. *The finance and analysis of capital projects*. Longman, 1963.

4b. *Related techniques*

In the use of this technique all costs and returns are expressed in terms of their “present worth” values at a base date which is usually chosen to be the proposed commissioning date of the proposed asset. (See Technique 1, Discounted Cash Flow.)

4c. *Further information*

The Net Present Value of a proposed project is the calculated value, in present worth terms at the base date, of the expected income from the sale of output over the lifetime, less the acquisition costs and operating costs over the lifetime (including disposal).

2.4.3 **Technique 3** (see Table 2 phase 0)

1. *Technique*

INTERNAL RATE OF RETURN

2. *Basic principles of technique*

This method is essentially the same as that described in technique 1 as the special case of the term "Discounted Cash Flow". The calculated Internal Rate of Return (IRR) is also known as the Discounted Cash Flow Rate of Return (DCFRR).

This technique finds the discount rate (the IRR) at which the Net Present Value (NPV) is zero. The IRR method only compares rates of interest whereas the NPV method allows comparison of sums of money and for this reason the NPV method is often preferred to the IRR method.

3. *Usage in terotechnology*

This technique can be used in all economic appraisals in all phases.

4. *Details of technique and applications*

4a. *References*

Scott, R. Evaluating innovation, *Professional Engineering*. 1989.

Merrett, A.J. and Sykes, A. *The finance and analysis of capital projects*. Longman, 1963.

4b. *Related techniques*

Discounted Cash Flow: Technique 1.

2.4.4 **Technique 4** (see Table 2 phase 0)

1. *Technique*

ANNUITY

(ANNUAL CAPITAL CHARGE)

2. *Basic principles of technique*

This technique offers an alternative way of presenting the value of net expenditure over a period. In essence, it presents expenditure in terms of a fixed nominal sum that would have to be paid each year over the period which has the same value as the (annually variable) expenditure expected.

3. *Usage in terotechnology*

In terotechnology, the technique is used to present life cycle costs, covering purchasing, operating and maintaining the asset as a single nominal annual sum over the life cycle period. (In some cases the costs of disposal would also be included.) In this form it can be used to compare the life cycle costs of alternative proposals with differing life cycles, more readily than by the use of present worth presentation of the same costs. Comparisons of costs with expected returns, especially when these are expected to be reasonably constant, are also easier to make using this technique.

This variant arises when there is a need to finance a project on an even basis throughout the life of the project and is thus normally more appropriate to governmental (especially local governmental) projects. Strictly, it is based on calculations of net present worth.

4. *Details of technique and applications*

4a. *References*

Merrett, A.J. and Sykes, A. *The finance and analysis of capital projects*. Longman, 1963.

4b. *Related techniques*

Net Present Value: Technique 2.

Discounted Cash Flow: Technique 1.

Internal Rate of Return: Technique 3.

4c. *Further information*

The relationship between Annuity (A) and Total Present Value [$C(P)$] is given by the equation:

$$A = C(P) \times c / (1 - (1 + c)^{-P})$$

where P is the period in years and c is the calculation rate of interest.

2.4.5 Technique 5 (see Table 2 phase 0)

1. *Technique*

RATE OF RETURN (RR)

RETURN ON INVESTMENT (ROI)

2. *Basic principles of technique*

The terms above are two of the commonest forms used for the book (or accountants') rate of return and are defined as the ratio of profit (net of accounting depreciation) to the capital.

3. *Usage in terotechnology*

This method is not appropriate to economic appraisals but is one that is used in publishing accounts for a project. It particularly fails to allow for the incidence of capital outlays and incomes. Whilst it can be useful for comparing established processes, it is unsuitable for innovations.

4. *Details of technique and applications*

4a. *References*

Merrett, A.J. and Sykes, A. *The finance and analysis of capital projects*. Longman, 1963.

Scott, R. Evaluating innovation. *Professional Engineering*. 1989.

2.4.6 Technique 6 (see Table 2 phase 0)

1. *Technique*

PAYBACK

2. *Basic principles of technique*

This is one of the most commonly used methods of investment appraisal used in the United Kingdom. It is based upon the assessment of the number of years before the cash flows from income from the project equal its capital cost.

In practice such calculations may be carried out in terms of incomes gross of tax or net of tax and the method employed should be clearly identified.

Acceptable projects are those whose payback periods are less than some predetermined time and within this constraint projects with the shortest payback periods are selected.

This method has certain disadvantages. It takes no account of cash flows after the payback point has been reached and it ignores the time distribution of the cash flows (i.e. no discounting).

NOTE Some organizations use present worth equivalents of the cash flows in their application of the technique. This variant is also referred to as the "payback method" although strictly speaking this is not correct.

3. *Usage in terotechnology*

This method of comparing options may be suitable for short term projects. It also has a place, usually in conjunction with DCF based techniques, when cash rationing is necessary.

4. *Details of technique and applications*

4a. *References*

Merrett, A.J. and Sykes, A. *The finance and analysis of capital projects*. Longman, 1963.

2.4.7 Technique 7 (see Table 2 phase 0)1. *Technique*

COST-BENEFIT ANALYSIS

2. *Basic principles of technique*

Techniques 1 to 6 are applicable when the output from a project, or its income, is capable of being measured or assessed in tangible cash terms. Many social projects, however, are not capable of having their outputs identified in such terms. In such cases and in others where a substantial part of the benefits cannot be assessed in terms of cash, these techniques cannot be used.

Nevertheless, economic appraisal of alternative courses of action should be carried out. Instead of profitabilities being calculated it is necessary to calculate a suitable Cost-Benefit index for each alternative. An index such as “the cost per patient treated” may be appropriate in, say, a hospital scheme.

3. *Usage in terotechnology*

This technique, using the principles of DCF, should be used to compare schemes whenever appropriate, as described above. The inability to identify scheme benefits in cash terms should not be used as an excuse for not carrying out economic appraisals of alternatives.

4. *Details of technique and applications*4a. *References*

Scott, R. Evaluating innovation. *Professional Engineering*. 1989.

Mishan, E.J. *Cost benefit analysis*. 3rd ed. George Allen and Unwin, 1982.

2.4.8 Technique 8 [see Table 2 phase 1 a)]1. *Technique*

MARKET RESEARCH

2. *Basic principles of technique*

Market research is a general term describing various techniques employed by, or on behalf of, a supplier or prospective supplier in respect of a product or proposed product. These techniques are aimed at obtaining a reasonably accurate estimate of one or more of the following objectives.

- a) The potential size of the market in terms of number of units of the product required and the time scale involved.
- b) The supplier's likely share of that market.
- c) The probable effect on the market of the unit price of the product.
- d) The features and characteristics of the product/proposed product deemed especially important by potential customers.

3. *Usage in terotechnology*

In terotechnology, market research is principally of value in the Concept/Investment Decision phase, firstly to determine the capacity of the proposed asset and then in terms of limits to inputs into the economic assessment of the proposed project. During the Operation and Maintenance phase, further market research estimations can be used to refine studies on whether an asset should be refurbished or replaced.

4. *Details of technique and applications*4a. *References*

Livingstone, J.M. *A management guide to market research*. Macmillan. 1976.

4c. *Further information*

The individual market research techniques to be used will depend upon the product involved but might include one or more of the following.

- a) Formal or informal questionnaires either issued to the general public or to specially targeted potential customers.
- b) Review of existing products and sales.
- c) Review of customers' inputs or queries raised by potential customers.
- d) Analysis of officially collected statistics (by government or a trade association).

2.4.9 Technique 9 [see Table 2 phases 1 b) and 2 a)]1. *Technique*

(PRODUCT) DESIGN REVIEW/DESIGN AUDIT

2. *Basic principles of technique*

During development of a product design, it is essential that the work is monitored and controlled to ensure that the emerging design will satisfy the requirements and be within the constraints of the design brief. This brief will have incorporated in it the relevant requirements directed by the board of the organization for the project.

To ensure that these requirements are met, a formal review procedure is desirable with the design being scrutinized at specific review points. The recommended stages are:

- a) at completion of the design concept;
- b) on completion of the detailed design drawings; and
- c) on completion of prototype testing.

3. *Usage in terotechnology*

This technique is used in the early stages of the Concept/Investment Decision phase.

4. *Details of technique and applications*4a. *References*

BS 5750, *Quality systems — Part 0 Principal concepts and applications — Part 1 Specification for design/development, production, installation and servicing.*

BS 7000, *Guide to managing product design.*

PD 6470, *The management of design for economic production. Standardization philosophy aimed at improving the performance of the electrical and mechanical manufacturing sectors.*

4c. *Further information*

Whilst a general view on the asset required for producing the product may be obtained at stage a) (see Section 2 above), a full specification of the asset may not be possible until the detailed design is complete, i.e. stage b). Thus there is a direct interplay between the design of the product and the asset required for the project, and also on the costs of production. These are important factors in the Concept/Investment Decision phase of the project. For comparison between options, the results of the first stage design review may be sufficient to eliminate some of these and the cost of further design work on these can be avoided. In many cases development to point b) will be necessary for the final investment appraisal on which final authorization is sought for the project to proceed.

2.4.10 Technique 10 [see Table 2 phases 1 b), 2 b) and 4 a)]1. *Technique*

(PROJECT) DESIGN APPRAISAL

2. *Basic principles of technique*

This is an appraisal of the proposed asset and its usage to furnish the proposed product. The implications of the asset design on reliability/availability and thus output and on operation and maintenance costs should also be assessed.

3. *Usage in terotechnology*

This technique is principally used in the Concept/Investment Decision and Acquisition phases.

4. *Details of technique and applications*4a. *References*

BS 7000, *Guide to managing product design.*

BS 7373, *Guide to the preparation of specifications.*

PD 6470, *The management of design for economic production. Standardization philosophy aimed at improving the performance of the electrical and mechanical manufacturing sections.*

4c. *Further information*

This technique is initially used in the Concept/Investment Decision phase, and is applied to the first draft outline design of the asset. At this stage the appraisal is used to refine the specification for the asset, in terms of numbers and capacities of components. In the later stages of the Concept/Investment Decision phase, design appraisal is used to identify, as accurately as possible, all the significant cost and performance implications of the options being considered and especially the preferred option when this is identified.

The technique is also used in the early stages of the Acquisition phase to identify and quantify, whenever possible, differences between offers for the supply of the specified asset. Once a supplier has been selected, and especially during the commissioning stage, detailed design appraisal has to be carried out to identify the needs for trained personnel, for production, maintenance and product support and for other resources such as repair material and spares.

During the life of the asset, the technique may also be used when replacement of a major component of the asset is being contemplated and significantly different options are available.

2.4.11 Technique 11 [see Table 2 phases 1 c)]

1. *Technique*

PROBABILITY ANALYSIS

2. *Basic principles of technique*

In any study or comparative study, the effects on the end result of the various parameters used in the calculations are established. When an input parameter has to be estimated it can often be of distinct value to establish the effect on the end result of variations of the parameter over its likely range and to calculate the likely result by weighting each result by the assessed probability of the corresponding input having the value to be experienced in practice.

3. *Usage in terotechnology*

In the Concept/Investment Decision phase, the use of probability analysis on the inputs to the economic appraisal of a prospective project may give a better estimate of likely viability than by using mean/median or best guess values for the input parameter. Such an analysis could also highlight certain risks inherent in the proposal. In the Acquisition phase the technique, similarly applied, can help in the selection between prospective suppliers of the asset.

4. *Details of technique and applications*

4a. *References*

Moore, P.C. and Thomas, H. *The anatomy of decisions*. Penguin, 1976.

2.4.12 Technique 12 (see Table 2 phases 1 c) and 5)

1. *Technique*

RISK ANALYSIS

2. *Basic principles of technique*

This technique is used in two separate areas, namely that of analysis of the risk in committing funds to a project and, secondly, that relating to the risks in respect of safety.

Risk analysis may be applied to the commitment of funds to a project and the likelihood that those funds may be lost. It may be measured against a base where it is known that the committed funds are secure. In financial terms this base is often government "gilts".

Once the risk has been assessed this may be translated into the return expected from the investment; the greater the risk the higher the return demanded. This is then often used in determining the discount rate used; again, the greater the risk the higher the percentage used.

3. *Usage in terotechnology*

In terotechnology risk analysis relates to the identification and analysis of those risks which either threaten the assets themselves, their performance and costs or the earning capacity of the organization in terms of its output of products or services.

Risk analysis of hazards to employees, customers or the general public should be included in the assessment, and consequences of such risks in either financial terms or in terms of constraint or embargo on a proposed course of action, as appropriate, should be taken into account.

4. Details of technique and applications

4a. References

Hamilton, G. *This is risk management*. Chartwell Bratt, 1988.

Sprent, P. *Taking risks: the science of uncertainty*. Penguin, 1988.

Cooper, D.F. and Chapman, C.B. *Risk analysis for large projects: models, methods and cases*. Wiley, 1987.

Health and Safety Executive, *Quantified risk assessment: its input to decision making*. HMSO, 1989.

Dixon, R. *Investment appraisal, a guide for managers*. Charteres Institute of Management. Kogan, 1988.

2.4.13 Technique 13 [see Table 2 phases 2 a), 2 c), 2 e) and 4 a)]

1. Technique

DRAWINGS

2. Basic principles of technique

Drawings are an essential part of all technical communications between parties involved in a project. These communications take place within the supplier's organization, within the user's organization and also between the supplier and the user. Whilst few drawings can convey ideas without a supplementary text, they will often convey ideas more clearly and permit explanation of an idea with a minimum of accompanying text.

In most technical disciplines there are conventions and rules which are applied to drawings and these should always be followed to avoid confusion or misunderstanding.

3. Usage in terotechnology

Communication between parties and therefore use of drawings associated with these communications takes place in all phases of a project.

In the Concept/Investment Decision phase these drawings are principally used within the user organization during the formulation of the project. In the Acquisition phase, the principal drawings are produced by the supplier and submitted to the user. Initially these will relate to the offer being made. In the case of a large unique project these will progress from those giving outline designs to drawings in more developed detail. Towards the end of the Acquisition phase, drawings should be submitted to the user which show the asset in some detail in the form in which it is actually being supplied. At this time the supplier should also supply such drawings as are necessary for training of and use by the operators and those needed to assist in the maintenance of the asset. Special drawings needed for the erection of the asset and/or dismantling and disposal of the asset at the end of its life should also be provided. Drawings necessary for training of and use by operators, and drawings needed for the erection and/or dismantling of the asset should be included in the technical manual (see Technique 35).

4. Details of technique and applications

4a. References

BS 1192, *Construction drawing practice*.

BS 3939, *Guide for graphical symbols for electrical power, telecommunications and electronics diagrams*.

BS 4884, *Technical manuals*.

BS 4899, *Guide to user's requirements for technical manuals (based on the principles of BS 4884)*.

BS 5070, *Engineering diagram drawing practice*.

4b. Related techniques

Technical manuals: Technique 35.

2.4.14 Technique 14 [see Table 2 phase 2 a)]

1. Technique

QUEUEING THEORY

2. Basic principles of technique

This technique relates to the use of mathematical models and theorems in the analysis of systems of finite capacity in which service is to be provided under conditions of varying supply and demand.

Queueing is an activity with which everybody is familiar and it applies to machines, money and materials, as well as people. Queueing theory is based on statistical principles and is frequently used to solve management orientated problems. In general, it has applications to those types of problem where a varying demand has to be accommodated by a discrete number of service units, be they people, vehicles, pay-out tills or ticket machines.

In the maintenance field the sizing of work forces is a particular area where queueing theory can be of benefit.

3. Usage in terotechnology

In terotechnology this technique is first used in the design of the asset and how it is to be operated. This is particularly appropriate in those cases where the product is produced in a series of stages and also where a stage involves batch processing. The analysis can also be applied to the flow of feed materials.

The method is also applicable in the management of maintenance of the asset, both in terms of task allocation and in the supply of spares and material.

4. Details of technique and applications

4a. References

Cooper, R.B. *Introduction to queueing theory*. Edward Arnold, 1981.

Kemble Bennett, G. and Melloy, B.J. Applying queueing theory helps minimize waiting time and costs of available resources. *Industrial Engineering*. 1984, **16** 7).

Burley, T.A. and O'Sullivan, G. *Work out operational research*. Macmillan, 1986.

Hall, R.W. Expected performance of a queueing system with ancillary activities. *Journal of Operational Research Society*. 1989, **40** 8).

Gibson, E.J. (ed), *Developments in building maintenance*. Applied Science Publishers. 1979.

2.4.15 Technique 15 [see Table 2 phase 2 a)]

1. Technique

VALUE ANALYSIS

2. Basic principles of technique

The concept of "value" varies depending on whether it is applied by the producer of a product or the eventual owner or user. In both cases it may be measured by the extent the product contributes to the profit of the producer or of the owner although in the latter case profit may be hard to evaluate if the product is used for some form of social service, e.g. health or education.

Value may be measured by assessing the various elements contributed by the product. These may be:

- a) physical condition;
- b) functional efficiency;
- c) compliance with statutory requirements;
- d) energy efficiency;
- e) degree of utilization.

Each of these may be measured and a value placed on it. These values may then be weighted depending on the contribution each makes to the value of the whole product to give an overall value.

3. Usage in terotechnology

In terotechnology this technique should first be applied to the design of the product or service envisaged for the project and then to the assets with which these are to be produced.

4. Details of technique and applications

4a. References

DIN 69910 Wertanalyse (Value analysis)

Miles, L.D. *Techniques of value analysis and engineering*. McGraw Hill, 1972.

American Society of Tool and Manufacturing Engineers, *Value analysis in manufacturing*. Prentice-Hall, 1967.

2.4.16 Technique 16 [see Table 2 phases 2 a) and 4 a)]1. *Technique*

RELIABILITY/MAINTAINABILITY ANALYSIS

2. *Basic principles of technique*

Reliability and maintainability are important performance functions for any new or proposed asset. In combination with the associated maintenance support facilities provided for an asset, these functions will be the principal contributors towards the availability of the asset and thus its potential for output and ultimately profit. The terms reliability and maintainability are both defined in BS 3811.

Future reliability values are generally expressed in terms of probabilities of success or failure and the distribution functions of such probabilities.

3. *Usage in terotechnology*

At the design stage for any new asset, the asset design should be studied from both a reliability and maintainability point of view as essential steps in the assessment of the likely availability of the asset in service. Such studies and their subsequent analysis should be carried out in such a way that the prospects for optimizing and refining the designs to give improved availability performances and minimizing both downtime and maintenance costs can be carried out. These studies are therefore key elements in the assessments of life time costs and ultimately in the viability of the project and its profitability. Accessibility is an important facet of maintainability which is, unfortunately, too often overlooked.

4. *Details of technique and applications*4a. *References*

Reliability and maintainability and their characteristics are a complete field of study. An introduction to these can be derived from the following references:

BS 4778, *Quality vocabulary — Part 3 Availability, reliability and maintainability terms — Section 3.1 Guide to concepts and related definitions — Section 3.2 Glossary of international terms.*

BS 5760, *Reliability of systems, equipment and components.*

IEC 300, *Reliability and maintainability management.*

IEC 605, *Equipment reliability testing.*

IEC 706, *Guide on maintainability of equipment.*

4b. *Related Techniques*

Plant history files: Technique 17.

Performance analysis: Technique 19.

2.4.17 Technique 17 (see Table 2 phases 2 a), 3 a), 3 d) and 5)1. *Technique*

PLANT HISTORY FILES

(ASSET HISTORY FILES)

(LIFETIME RECORDS)

2. *Basic principles of technique*

Although particularly relevant to plant and equipment, history files are also relevant to, and should be kept for, other assets such as buildings and structures.

The elements to be recorded in history files should include the following:

- a) operations with particular reference to operation in abnormal conditions;
- b) failures and details of rectification;
- c) other maintenance including preventative maintenance;
- d) inspections/examinations and records of findings;
- e) tests carried out and results;
- f) modifications carried out;
- g) modifications proposed but not carried out.