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***भारतीय मानक***

***Indian Standard***

***टेरोटेक्नोलॉजी के लिए मार्गदर्शिका***

***भाग* 2 *तकनीकों और अनुप्रयोगों का परिचय***

*(* पहला पुनरीक्षण *)*

**Guide to Terotechnology**

**Part 2 Introduction to Techniques and Applications**

*( First Revision )*

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FOREWORD

This Indian Standard (Part 2) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Management and Productivity Sectional Committee had been approved by the Management and Systems Division Council.

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.

Terotechnology is a multi-disciplinary study or research or industrial practices combining the core branches of management, finance, design and engineering, operation and maintenance, life assessment and disposal applied to physical assets in pursuit of desired economic life cycle. It is concerned with the specification and design for reliability and maintainability of physical assets such as plant machinery (rotary and static), instruments and control equipment, buildings, etc. The application of terotechnology concept takes into account the economic methods/processes of supply chain including transit, asset installation and commissioning, operation and maintenance, modification and replacement. Business decisions on asset’s acceptance or rejection at any stage of life cycle are influenced by information on design, commissioning, performance and costs throughout the life cycle of a project.

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 consumer item, the needed reliable design and performance (as perceived by customers) will get a boost by the adoption of terotechnology and thus improving market security for the producer.

Terotechnology was developed in the context of larger organizations, with the objective of making them more efficient and competitive. Throughout this standard the applicability to a larger organization is used as a basis as this with represent the more complex situations. However, the objective of maximizing value for money spent and the principles involved in achieving this, are equally applicable to small organizations. Small organizations face problems as much as those faced by the larger; more complex organizations. Their problems may be simpler but the principles of problem solving remain the same.

The small organization can, therefore, benefit from this guidance by selecting those parts of the decision-making process that can help them.

The key ingredients of success in the application of terotechnology are enthusiasm and cooperation throughout a well-structured organization with impetus maintained by enthusiastic senior managers. Discipline too, is important to efficient application and managers need to specify the degree of analysis which backs different levels of decision-making in various phases of assets the organization is operating. In order to arrive at the right key performance indicators of the business processes, it is essential that adequate and quality data are available within the enterprise to support the required confidence level limits that are possible to attain after adoption of terotechnology.

Regardless of the success (or failure) achieved in the management of an asset, the experience can provide valuable feedback which is fundamental requirement of terotechnology. This feedback is gathered by monitoring decisions, actions, consequences and the lifetime performance of the asset and can be used to improve confidence in new decisions.

The cyclic nature of terotechnology demands that decisions about asset management are reviewed in the light of increasing experience and knowledge. Throughout an asset’s life, the relevant data need to be collected and analysed in order to guide current and future decisions.

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(*Continued from second cover*)

This structured and analytical approach amalgamated with latest philosophies of plant management especially acquisition management, operation and maintenance management, latest scientific disposal management based on life assessment, etc results in better decision-making throughout the organization, thereby providing opportunities to improve profitability, efficiency, cost-effectiveness, sustainability and overall organizational reputation. Proven strategies are given here in brief in the various places in the text considering their appropriateness in life cycle phases.

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

This standard is largely based on BS 3843 (Part 2) : 1992, ‘Guide to terotechnology — Part 2: Introduction to the techniques and applications.

The composition of the Committee responsible for formulation of the standard is given in Annex A.

*Indian Standard*

GUIDE TO TEROTECHNOLOGY

**PART 2 INTRODUCTION TO TECHNIQUES AND APPLICATIONS**

*( First Revision )*

1. **SCOPE**

This standard (Part 2) provides introductory guidance to managers on the techniques used in applying terotechnology (the techniques themselves are described in Part 3 of this standard). It outlines the techniques and describes how, generally, they are incorporated into decision-making processes. It also illustrates how individual and departmental interests and considerations interact with others and emphasizes the importance of communication throughout the enterprise.

1. **REFERENCES**

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below:

|  |  |
| --- | --- |
| *IS No.* | *Title* |
| IS 9990 : 1998 | Glossary of terms in terotechnology (*first revision*) |
| IS 15363 | Guide to terotechnology: |
| (Part 1) : 2024 | Introduction to terotechnology (*first revision*) |
| (Part 3) : 2004 | Guide to available techniques (*under preparation*) |

1. **DEFINITIONS**

For the purpose of this standard the definitions given in IS 9990 shall apply, together with the following.

* 1. **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.

**3.2 Organization** — In the context of terotechnology, this means 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.

**3.3 Spare** — A replica or equipment component purchased to replace the original component supplied a part of the asset.

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

1. **PRINCIPLES OF TEROTECHNOLOGY**

**4.1** Investment in capital plant, buildings and equipment is fraught with uncertainties and risks which make the assessment of lifetime economics difficult. Terotechnology provides techniques within a structured approach which help an organization both to evaluate an investment and having invested, to protect and service it economically throughout its working life, terotechnology’s first and paramount prerequisite is communication. Because its techniques are interactive it is vital that departmental interests do not become isolated. Instead, there needs to be continuing dialogue between all the functional departments in the organization and line managers need to understand the weight of every argument, for it is their responsibility to decide on the level of risk that is acceptable to the organization.

**4.2** Clearly the most financially desirable venture is worthless if based on unachievable technology and equally the cleverest invention is useless, if it is beyond the financial reach of the market. As a general rule, however, ventures are rarely as clear cut and careful, comprehensive analysis are required in evaluating all the factors that contribute to decisions. When investing in a domestic appliance, for example, a wise buyer seeks the best buy to meet his or her particular needs. In reaching a decision, such factors as cost, capacity, appearance, potential time saving running and servicing costs, maintenance and insurance are examined. Decisions are often conditioned by advice from other users of similar products. Performance reviews throughout (and particularly at the end of) the appliance’s life reveal whether the forecasts made at the time of purchase have been realized. This review provides valuable input to new decisions, firstly on whether or not to replace the appliance and secondly, on the selection of a replacement.

**4.3** This selection process marks the beginning of a new life cycle.

**4.4** These thought processes represent the application of terotechnology in the simplest, and probably most effective form. The principal activities are best summarized as follows:

1. Initial investment appraisal using the ‘best data currently available; and
2. Investment in the acquisition of the asset.

Then, when the asset has been acquired and its useful life progresses, the user develops:

1. Operational experience; and
2. A maintenance history.

Finally, experience during these four activities is used in:

1. Feedback of information into considerations of improvements to the asset or in its use; and
2. Disposal and replacement decisions.

**4.5** Mass production cannot meet the individual’s specific needs. Instead, a wise manufacturer will include market research as a key element in applying terotechnology in respect of his products; on the results of such exercizes he will ensure that desirable features are developed and undesirable ones dropped or designed out. Dissatisfied customers are more likely to air their views and prompt, positive reaction by designers to the most common complaints should render the product more competitive and marketable. Negative attitudes to customer input, have the opposite effect and many suppliers adopting a take it or leave it sales policy have found that customers have taken the latter choice. Often such suppliers have failed to survive.

* 1. An organization contemplating a multi-million-rupee capital project, perhaps to build a factory to produce domestic appliances, applies identical principles in its decision-making. However, because the financial risks are very much greater, a structured, formal approach to lifetime costs and decision-making is required. Unfortunately, far too frequently, economic appraisals and cost-benefit analysis are carried out merely to support an acquisition decision already made. Thereafter the asset is often managed by instinct and in ignorance of the industrial efficiency and product structured, scientific approach which these standard advocates. Terotechnology offers such a structured approach and this standard introduces the primary techniques available.
  2. Part 1 of this standard describes the consequential benefits and costs of introducing terotechnology. Benefits to be gained by an organization through introducing terotechnology are listed in **5** of IS 15363 (Part 1). This standard describes how those benefits can be achieved and -emphasizes the need for regular, structured communication between different specialism. Tables used to illustrate this structure and to list the thought processes and techniques that support decision-making. All of the tables in this part have a similar layout and they summarize those matters, which can influence the major decision phases of the asset life cycle. These phases are concept and investment decision, acquisition, useful life (comprising operation and maintenance as the principal activities) and disposal. The four columns of the Tables list the following:

1. Primary analysis, listing the particular factors that need to be analyzed as contributions to each major decision;
2. Consideration, providing an aide memoire of the matters that typically impinge on the factors of the primary analysis;
3. Techniques and procedures, outlining the methods by which the considerations can be measured objectively (and where necessary optimized) in reaching judgments on the primary analyses factors; and
4. Interacting interests, indicating those departments or activities within the organization which might input information to, or gain benefit from, the aspects of terotechnology listed in (a), (b) and (C).
5. **GENERAL CONSIDERATION**
   1. **Organizational Strategies**
      1. An organization may wish to -embark on a new project for a number of reasons. These include the following:
6. Expand the organization’s share of a market for a given product;
7. Fill a gap-perceived in the market, that is a new or updated product;
8. Meet customers’ requests;
9. Conform to a statutory requirement;
10. Support other activities being undertaken by the organization; and
11. Replace another project coming to an end.
    * 1. In cases **5.1.1(a)** to **(e)** the circumstances will directly determine the product and in most cases, the output as well. Options will exist with respect to the assets with which to carry out the specified objectives. There will also be an interaction between the detailed design of the product and the assets needed to execute this design. This increases the number of potential options that will have to be considered.
      2. In the last case **5.1.1(f)**, the board may direct an objective that may not be specific in terms of the product but may be simply in terms of turnover or profit. This will increase the number of options open to the manager of the new project.
      3. In all cases the organization is likely to be faced with a number of options, one of which might be not to proceed with a new project at all. By employing terotechnology techniques, a best choice of option can be selected and decisions in respect of the assets made throughout the life cycle in the interest of achieving the most economic life cycle costs.
      4. It is clear that, in pursuit of the terotechnology objective, the cost and benefit implications of all aspects of the asset’s life need to be considered. Where costs and benefits are distributed in time throughout the life cycle, analytical techniques such as discounted cash flow are used to sensibly compare incomes and/or notional expenditures at different dates. However, in addition other aspects which may not have a notional cost and/or benefit implication need to be taken into account; in some of these a notional cost implication might be appropriately used. in other cases, alternative approaches may have to be taken. The principal areas to be considered are outlined in **5.2** to **5.7**.
      5. Techniques based upon the principles of discounted cash flow are also used in comparing the costs and benefits arising from different forecast scenarios which identify the factors that maximize the benefits to the enterprise of equal importance are factors which could negate these benefits and these key areas of risk need to be identified and the risk minimized wherever possible. In essence, an attempt should be made to identify those uncertainty factors -which have the greatest influence on the likely return (sensitivity analysis) and, if necessary, to concentrate resources on investigating those factors in more detail. This is particularly relevant to the most common source of risk which arises from uncertainty in the data used in the economic assessments.
      6. There should be a corporate input to decisions to invest in capital projects so that the impact of existing policies on forecast scenarios (and possibly the converse) can be properly examined. The organization needs to ensure that the investment does not affect the nature and objectives of the business in an uncontrolled way because this could result in uncontrolled risk.
      7. Inevitably any new project will result in change which can affect both the organization and those outside it, such change may involve factors which are subject to external constraints and these have to be considered and their influence included in the investment appraisal.
    1. **Community** 
       1. The social and environmental acceptability of changes are increasingly prominent considerations for organizations contemplating new investment or developing existing facilities. These aspects can impact with equal severity whether the proposal is to extend a dwelling house or to build a major production facility. People awareness of such developments quite properly increases with improved living standards and wider educational aspirations. As knowledge grows, so increasingly more stringent international, national and local controls are applied to protect the environment. In addition to these legal constraints, developers also need to consider individual local acceptability as well as the specialist views of pressure groups. What may be regarded as a prosperity-generating asset by one section of the community can equally be considered a dangerous, toxic monstrosity by another.
       2. Because of these differences of view, there is a risk of future growing public unacceptability which might limit the operation of the asset. For example, increased legislative requirements in regard to, say,’ effluents, noise and even demolition and disposal processes could significantly affect lifetime cost equations.
       3. In planning changes the owner and/or user needs to assess the risk to the investment or the organization’s overall image and the associated effect on profitability.
    2. **Nature of the Business**

Developers should also consider the risk that investment proposals pose for the organization’s existing business. Here, concern centres on whether or not the proposed investment is concomitant with, or fundamentally different from, the organization’s traditional business. For example, a proposed new project may produce goods or services repugnant to existing customers on political or ethical grounds or which may be seen to compete with products of customers who purchase the traditional products or services of the organization. This could be reflected in market resistance to the existing products and the consequent reduction in profitability having to be made good by income from the new investment. The corporate study might conclude that this effect would be so severe that the proposed investment would adversely affect the organization and thereby select other suitable alternative(s).

* 1. **Commitments/Involvement**

The third area of risk is that of corporate confidence in the ability to maintain the quality of existing and new products with increased diversity and that commitment to and involvement of customers old and new will be unaffected. Further, the commitment/involvement of employees has to be considered because they, too, will have opinions about environmental and ethical aspects which may so affect their reactions to internal changes that low morale would reflect in poor quality. Proper consultation with employees at every stage is desirable if their support for change is to be forthcoming.

* 1. **Markets**

On the more tangible aspects of the business, the investment appraisal needs to examine the market for the asset’s products. There has to be high confidence that a significant and continuing market exists and that foreseeable output booms and slumps can be accommodated without undue risks to production costs, delivery schedules, stockholding costs, product quality or asset viability. It is also important to recognize that products themselves, particularly in the high technology field, can rapidly become outdated. This imposes the need to examine the adaptability of production facilities, the market life of products and the impact on the asset of the introduction of new products, -possibly by competitions. Future opportunities should be critically assured for product innovation, design development, rationalization, improved quality and unit cost and price reductions.

* 1. **Production**

Input by production specialists to the corporate analysis includes the effect of the investment (particularly where asset refurbishment is concerned) on unit costs that will be achieved as the result of increased output from more efficient equipment, providing there is a market. Though this cheaper product allows the marketing section increased input to terotechnology by way of wider analysis in opportunities, it presents alternatives and new risks and therefore calls for an increased order to maximize profit (or minimize loss) whether through changed volume of sales or altered selling prices, or reduced production, selling or administrative costs. The longer the term of the investment, the greater will be the uncertainty and risk attaching to these key data elements. The greater the perceived risk, the greater the depth of investigation that should be undertaken. The need to examine various combinations of ‘what if?’ questions gives rise to the need for sensitivity analysis to guide decisions adequately. Production specialists would also assess, for example, the efficiency with which the operation of the asset could be managed, seeking to minimize money tied up in queuing and work in progress and the ways in which new processes will be integrated into established areas. These aspects also influence the cost equations.

* 1. **Resources**
     1. The organization needs to examine financial and human resources. In material terms it has to be able to finance the investment and decide on sources of capital. Where external finance is sought, lenders or shareholders will wish to understand the risk they are accepting and all the foregoing corporate considerations should be included in the formal investment proposal. With increases in technology, skilled human resources become significant organizational assets. Due consideration should, therefore be given to the value and availability of skills of the personnel employed in the organization.
     2. Decisions on how acquisition, installation, operation and maintenance of the asset are to be managed are generally a matter of the organization’s policy and related to its size and experience in that activity rather than directly to terotechnology considerations. Operation has traditionally been resourced in-house, but maintenance and other aspects can often be managed more economically by specialist consultants and other professionals.

1. **MANAGEMENT AND TECHNIQUES THROUGH THE PROJECT LIFE CYCLE** 
   1. **General, Economic Appraisals** 
      1. Throughout the life cycle of a project, opportunities for alternative ways forward will arise almost constantly and management will be faced with decisions between such alternatives. Unless there is an overriding consideration, such as, a statutory constraint, the decisions made should always be, such as, to achieve the best economic solution. An economic solution needs to be viewed in terms of the full residual life of the project and, where relevant, the objectives set for it. These may, of course, differ from those originally set when the project was initiated due to developments in the organization. Thus, each time a decision has to be made, a new appraisal should be carried out into the differences expected throughout the residual life of the project, in terms of costs and benefits. In the earliest phases of the project, these appraisals may have to be made in absolute terms as well as in terms of differences between alternative options to ensure that the project remains viable in terms of the set objectives. Similarly, at later stages, during the useful life of the asset, an appraisal in absolute terms maybe appropriate to ensure that continuation of the project remains viable.

**6.1.2** In the case of both comparative appraisals and absolute appraisals, where the comparison is against financial objectives laid down for the project, similar techniques are employed.

**6.1.3** The fundamentally important aspect of any project whose life extends at. All over a period of time is the need to compare on some valid basis the cash flows which arise at different points in time. A sum of money, A, spent today has a different value from a similar sum to be spent in x years’ time. This arises because a sum smaller than A can be invested today such that, with interest, it could produce a sum A in x years’ time to meet the required expenditure. The actual sum to be invested today to achieve A in x years is termed the ‘present worth’ of A in x years and will depend upon both x and the expected rate of interest. Thus, the value of A invested in x years’ time can be considered as having been discounted to a smaller (present) value. The general term for this principle of evaluation is discounted cash flow (DCF) and is common to the techniques recommended for use in economic appraisals.

**6.1.4** Other traditional methods of evaluation are the following:

1. Rate of return; and
2. Payback. Since these do not adequately take into account all the factors relevant to an evaluation, they are not dealt with in this standard.

**6.1.5** Another source of difficulty in comparing cash flows at different future points in time arises from changing price levels, both general and specific. However, in many cases relative values, when viewed over the lifetime of a project, may be assumed to be reasonably constant. In practical terms the selling prices of products can be expected to remain in roughly the same ratio to the prices of labour and materials, all changing proportionately -to the changes in value of the currency. Owing to the impossibility of predicting future inflation, it is normal to assume a constancy of value in economic assessments, that is to assume no inflation at all will take place and the relative cash values of materials and services as well as selling cycle of the project. Assessments made on this basis are normally termed as being on a constant price basis, for example, all values in terms of January 20XX prices.

**6.1.6** Where, however, a particular service, labour need or material is expected to change in price in real terms, that is its price is expected to rise faster or slower than the general price level, this should be taken into account. In such circumstances, when using constant prices, one should nevertheless calculate the variations in terms of the expected rates of relative change in real value and not in terms of price. A similar consideration may have to be made regarding the rate of interest to be used in discounting future cash flows. if comparative assessments are carried out in constant price terms the rate of interest to be used in discounting future cash flows should also reflect changes in value rather than prices. When comparative assessments are carried out in constant price terms the rate to be used in discounting future cash flows should not necessarily be taken as the current rate of interest which contains an element to compensate for the current inflation rate.

**6.1.7** The above considerations are common to all economic appraisals and assessments. In consideration of the total costs and benefits of a project over its life, especially those arising before commitment to the project is made, several approaches may be used in presenting, in a summarized form, the overall results of the appraisal.

**6.1.8** While the underlying principle of discounting is the same, sometimes the circumstances of a project make one of its variants preferable to another.

**6.1.9** Table 1 lists the various methods of making economic appraisals, which may be required in any phase of the life cycle, and shows the variants of the discounted cash flow approach.

* 1. **Concept/Investment Decision Phase** 
     1. As discussed in **5.1**, an organization’s incentive to initiate a new project may arise from any one of a number of reasons. According to the circumstances the product of the project may or may not be known from the start. If the product is not so specified, a number of possible product options may be offered for consideration and, in most cases, there will be further option on product output.

**Table 1 General Economic Appraisals**

(*Clause* 6.1.9, *Table* 2 *and Table* 3)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SI No.** | **Primary Analysis** | **Consideration** | **Techniques** | **Notes** |
| (1) | (2) | (3) | (4) | (5) |
|  | Forecasts of capital expenditure | Need to identify transactions in terms of time and value | As given in Table 2 to Table 6 |  |
|  | Economic appraisals | Comparison of optional courses of action or judgement of viability against objectives | 1. Discount cash flow: 2. Net present value 3. Internal rate of return 4. Annuity 5. Rate of return 6. Payback 7. Cost-benefit analysis | 1  2  3  4  5  6  7 |
| NOTES  **1** All forms of DCF take into account the time value of money, but different forms are more appropriate for particular situations.  **2** This, the commonest form of DCF, is suitable where constant rates of interest apply throughout the life of the project.  **3** This variant of DCF takes account of varying rates of interest applicable throughout the life of the project.  **4** This variant is only relevant when there is need to finance a project on an even basis throughout its life and is normally only appropriate to government (especially local Government) projects. Strictly it is based on-calculations of net present value or internal rate of return (*see* Notes 2 and 3).  **5** This takes no account of the time value of money, nor of the interest benefit of depreciation.  **6** While this approach recognizes the time value of money, it fails to recognize adequately the situation in the more distant future.  **7** This is used in cases where the costs or benefits cannot easily be quantified in monetary terms. | | | | |

* + 1. Alternative production methods and the assets needed for these widen the choice still further. Before the possible production methods and the assets to achieve these can be considered the product design SI1OUId be developed to an advanced stage. This should be carried out with the terotechnological needs of the customer in mind.
    2. The establishment of these choices into a series of proposed projects, each with a given output of product, produced by a given method from a defined asset, in the first step in the conceptual process. In all circumstances the number of such options will have to be reduced to manageable proportions. Some may be eliminated because of serious deficiencies in terms of the factors discussed in **5**. Thereafter, the number should be reduced to those offering the best economic prospects by conducting and repeating investment appraisals on each remaining option, using progressively refined inputs and eliminating those which fail to meet the organization’s specified objectives or are less attractive from a life cycle cost benefit point of view. On the final short-list of options an investment appraisal should be carried out in as much detail as possible and using the best input data available. The exercises should also identify areas of risk and the implications that these may have on the costs and benefits of the proposed projects. These studies-should be pursued until an optimum choice is clearly established and the probable full consequences for the organization can be appreciated. At this point the final decisions can be made on the option to be chosen and whether to proceed; this is the final investment decision.

**6.2.4** The items to be considered in the investment appraisal and the techniques that might be employed are given in Table 2.

**6.2.5** The benefits of capital projects, in certain cases, are not measurable in terms of cash or profit. This does not mean that terotechnology is inappropriate to such projects. On the contrary, its application is simply a matter of defining the benefit in different terms. Rates of treating patients, processing documents or passing examinations for example may be perfectly valid parameters on which decisions can be founded.

* 1. **Acquisition Phase**
     1. In the acquisition phase of a capital asset, many contractual routes are open to the user organization, particularly where mechanical plant is concerned. For example, an organization may wish to consider hiring or leasing rather than buying. Terotechnology can be applied to this decision as to all others in order to determine, say, the net effective cost of hiring compared with buying the asset or some of its components. It often transpires that hiring or leasing is more costly than buying but the elements of risk accruing to the hirer may be very considerably reduced in comparison with buying. Leasing may also reduce the peak financial borrowing required for the project and this may be of significant value to the organization.
     2. At the acquisition stage, the organization seeks to turn investment plans and decisions into reality in the form of buildings and plant, completed to time and cost schedules, ready to begin productive operation.
     3. Table 3 lists relevant considerations, shows the appropriate techniques and lists the various functional specialities which interact at each stage of analysis. It shows how the management of the acquisition process involves the overall planning, control and coordination of a project aimed at achieving the concept objective by completion on time, within the defined cost parameters of the investment appraisal/decision and to defined quality standards. Success depends on the ability to:

1. Plan and programme all the resources and activities required to complete the project;
2. Commit everyone involved to the project’s objectives particularly those relating to programme and cost;
3. Design the plant, structure, or buildings comprising the asset;
4. Make appropriate arrangements for the supply, delivery and setting to work of the asset;
5. Construct and/or install the asset;
6. Commission and run-in the asset;
7. Monitor and control progress and take remedial action where appropriate to achieve the programme; and
8. Finance the project and ensure that costs are contained within the planned budget.
   * 1. Whether these functions are performed directly by the buyer or consultants on his behalf, the considerations, techniques and interactions listed in Table 3 are equally applicable. The scale of the project and its attendant risks naturally given the depth of analysis of each aspect, but even quite modest projects benefit from the disciplined approach outlined in Table 3.
     2. Though acquisition decisions may be delegated throughout the management organization, they cannot be made until the corporate decisions to invest has been reached and promulgated, providing clear financial objectives together with the ethical, social and environmental parameters which have to be accommodated.
     3. These decisions are influenced by the analyses and considerations listed in Table 3. The degree to which they are applied requires discretion and depends upon the gravity of the decision. For example, the purchase of an additional typewriter would require only minimal analysis whereas a new factory project would attract the most rigorous examination at the highest level. Table 3 shows that an early decision is required on whether the asset is to be hired or bought and despite the objective view provided by a cost-benefit analysis, other considerations might be more powerful. For example, cash availability could be the prime determinant, in which case hiring might be the only course open to the enterprise. Here, the input by the finance department is a key element and prompt communication of its advice reduces abortive effort elsewhere in the organization.
     4. Analysis of lifetime benefits and costs calls for methods that reduce the variable money values occurring throughout an asset’s life to a common monetary level in order to facilitate proper comparisons. This is achieved by the methods described in **6.1**. Because many of the inputs are themselves estimates, they have to be tested using statistical techniques and by comparison with past recorded experience of similar assets. Techniques like regression analysis together with sensitivity and probability tests are necessary to establish levels of confidence conducive to sound management decision making and the reduction of risk in the acquisition to acceptable levels.
     5. These analyses of costs and benefits continue into the early stages of specification and design of the purchased asset because they aid the selection of alternative designs and layouts that can equally well achieve the technical objectives. Before considering the detailed requirements for the asset, the design of the product needs to be developed in sufficient depth so that the total requirements for the asset in terms of output, quality and possible production methods can be identified.

**Table 2 The Concept/Investment Decision Phase**

(*Clause* 6.2.4, *Table* 1, *Table* 3 *and Table* 6)

| **Sl No.** | **Primary Analysis** | **Consideration** | **Techniques** | **Interacting Interests** |
| --- | --- | --- | --- | --- |
| (1) | (2) | (3) | (4) | (5) |
|  | Objectives set by board | Product output turnover or profit project life organizations purpose and policy resources available |  | Organization’s  business plan |
|  | Identification of options | Products and output product designs and production methods outline of assets required | Market research | Marketing |
|  | Identification of common bases of judgement | Basic scenario assumptions scenario variations and ranges price level changes |  | Planning |
| Interest and discount rates taxation/grants accounting methods | *See* Table 1 | Finance |
| Items not measurable in cash terms method of presentation of selection/ recommendation |  | Legal and/or statutory obligation |
|  | Select shortlist of viable options | Roughly estimate life cycle costs and returns of options in Sl No.(ii) select short-list of best projects for further study | *See* Table 3 to Table 6 |  |
|  | Detailed study and evaluation of short-listed options | Refine product designs life of project cost of finance | Product design | Design sales programme contracts |
| Time to come on stream Probable capital cost | *See* Table 3 | Finance |
| Project design appraisal | Project design appraisal | Operations, maintenance marketing |
| Product proceeds cash flow expectations forecasts of outputs from Table 3 to Table 6 implications for other activities of the organization report on each option | Procurement cost engineering |
|  | Factors to be included:   1. Risk and uncertainty | Effects of scenario variations within ranges identified in Sl No.(iii) uncertainties in data range and distribution of uncertainties | Probability analysis risk analysis | Cost engineering |
| 1. Effects on budgets | Annual expenditures annual revenues effects on other activities contingent costs for uncertainties |  | Contracts, finance |
| Interest during construction use of facilities | Quality surveyor project staff, maintenance |
|  | Selection of best option | Comparison with objectives cash flow predictions report of appraisals and recommendations approval to proceed |  | Board |

**Table 3 The Acquisition**

(*Clauses* 6.3.3, 6.3.4 *and* 6.3.6, 6.3.15, *Table* 1, *Table* 2 and *Table* 6)

| **Sl No.** | **Primary Analysis** | **Consideration** | **Techniques** | **Interacting Interests** |
| --- | --- | --- | --- | --- |
| (1) | (2) | (3) | (4) | (5) |
|  | Choice of hire, lease or use of existing internal sources | Cash availability uncertainty and risk obsolescence of components reliability of sources |  | Finance |
| Suitability of available components strategic spares availability and requirements | Design, operations maintenance, reliability finance contracts |
| Effect on taxation/grants, etc responsibility for maintenance costs compare costs of alternatives | *See* Table 1 | Design, sales, quality assurance |
|  | Prepare specification of asset requirements: | Complete product design | Product design audit | Design, sales, quality assurance |
|  | 1. Technical requirements | Consider alternative asset/component types to achieve product design objectives establish any policy needs of the organization affecting design |  |  |
|  | Output capacity required highlight safety |  | Marketing safety, operations |
|  | Identify special requirements regarding: compatibility with other assets replication aspects |  | Operations maintenance |
|  | Number and size of production streams | Drawings | Operations |
|  | Economic configurations | Queueing theory | Work study |
|  | Optimization of alternatives and orientations | Value analysis | Inspectorate |
|  | Statutory requirements | Allowance for statutory inspections control of waste | Inspectorates |
|  | Standards (company and national) spares provisions time to come on stream |  |  |
|  | Reliability or maintainability demonstrations | Reliability/ maintainability analysis | Operations maintenance |
|  | Asset life | Plant history files |  |
|  | Special materials to be used or prohibited |  | Design |
|  | Supply sources | Vendor assessments | Contracts, legal |
|  | Efficiency aspects | Performance analysis | Design, operations |
|  | Suitability for special grades of operations/maintenance personnel | Ergonomics | Maintenance, personnel, operations |
|  | Environmental requirements to be met communications | Environmental planning | National and/ or local government |
|  |  | Flow chart |  |
|  | 1. Contractual requirements | Form of contract for asset Penalties for non-fulfilment of contract conditions and programme guarantees |  | Contracts project staff |
|  |  | Payment schedule and cost variations |  |  |
|  | Assess tenders or offers to supply asset: |  |  |  |
|  | 1. Technical/ contract | Review against factors identified in Sl No.(ii) | See (ii) design appraisal | See (ii) |
|  | 1. Additional factors | Estimate likely capacity decline with time Review constructability |  |  |
|  |  | Review supply programme | Construction analysis modelling | Project staff |
|  |  | Determine optimum spares holdings needed |  | Operations, maintenance, stores |
|  |  | Likely asset availability life expectancy of various likely operating regimes effects on public accountability and relationships areas of uncertainty status of proposed designs |  |  |
|  | Select supplier | Review assessment under Sl No.(iii) review expected life cycle costs and incomes against those authorized at end of investment decision phase identify best offer and report if needed, seek approval of selection place order or contract |  | All departments |
|  | Design and manufacture asset | Design submission procedure design freeze |  | Programming |
|  |  | Design and development programme | Drawings | Project management |
|  |  | Consultation and communication programme |  |  |
|  |  | Quality assurance | Quality programme | Quality assurance |
|  |  | Work tests | Quality assurance methods |  |
|  |  |  | Test procedures | Project management |
|  |  | Progress and stage payments | Budgets | Finance |
|  | Erect/build and install | Procurement/construction programme | Network analysis bar charts progress assessment |  |
|  |  | Interface management and access |  |  |
|  |  | Terminal points |  |  |
|  |  | Effects on existing operations |  |  |
|  |  | Quality assurance and stage inspections | Quality programme | Quality assurance |
|  |  | Surveillance |  |  |
|  |  | Safety of people and plant | Safety consultation Structural safety limits | Safety |
|  |  |  | Allowance for statutory inspections | Inspectorates |
|  |  | Handling and storage | Technical manuals | Stores |
|  |  | Time and cost | Expected cost to completion | Supplier |
|  |  | Security |  | Supplier |
|  | Commissioning | Commissioning programme design limits, fits, tolerances documentation | Network analysis quality programme drawings, technical manuals, commissioning procedures | Supplier quality assurance project management, operations |
|  |  | Train operations and maintenance staff | Training schedule | Personnel |
|  |  | Precommissioning checks during installation |  |  |
|  |  | Test and run up plant, etc |  |  |
|  |  | Load/output tests to ensure contractual conditions met |  | Supplier, operations |
|  |  | Extended production run |  | Operations |
|  |  | Time to come on stream | Performance guarantees | Design, contracts |
|  |  | Re-test economic equations before setting initial sales price of product | Contracts *see* Table 1 and Table 2 | Finance, sales, cost engineering |

* + 1. In the asset design stage, the value engineering technique can be applied to problems ranging in magnitude from plant layout to rationalization of the smallest components, whilst a scale model of the asset (where appropriate) aids the design’s development. In addition, network analysis, of manufacturing, delivery and construction programmed may be necessary.
    2. The second major input to design and specification of the asset is the feedback of data relating to actual performance of similar assets, coupled with lifetime estimated data used in the earlier cost and benefit statements. Mathematical modelling can be used to optimize different aspects of operational life, such as, reliability, availability and maintainability. Differing possible operating regimes can also be tested using these models. Again, operational research techniques, such as regression analysis and probability analysis provide the means of comparing alternative courses of action.
    3. The acquisition’s social and environmental aspects often demand outside liaison with Governmental and other public bodies, and consequently systems need to be established to seek the necessary consents and to make financial and design provisions to meet all legal requirements relating to both the local community and to national statutes. This could include the need to cover against product liability claims.
    4. Aspects of acquisition have two main facets, procurement and financial control. Procurement strategy is concerned with the selection of the tenderers, the conditions of contract and purchase, the price required by the tenderers and the eventual selection of a supplier. Guidance on technical matters front designers and on financial aspects from the finance department are required in order to contract for exact needs. Financial control involves the development of cash flow programmed to align with the procurement processes of manufacture, construction, installation and commissioning and will need to consider the consequential interest on money tied up in these processes during procurement. Again, for consistency, the discounted cash flow technique is used and escalation and inflation are-handled as separate elements in the budget for the acquisition phase of the project.
    5. At the hardware stage of the acquisition, beginning with manufacture, the major elements of capital expenditure begin. The project management is generally pre-occupied with two main factors: time and cost.
    6. Timely completion of the acquisition is vital for two reasons:

1. No income can be generated by the asset until it is installed and commissioned; and
2. Many elements of capital cost can be time dependent and therefore delayed acquisition means increased capital cost as well as delayed income generation.
   * 1. Consequently great care is necessary on the part of the organization, agents, suppliers and installers to ensure that realistic, optimized programmed are prepared, agreed and followed. The techniques most commonly used for all but the simplest programming are network analyses, of which critical path analysis and programme evaluation review technique are perhaps the most widely used. However, the choice of techniques depends on the particular application, organizational preferences, whether analysis is manual or computerized and the capacity of particular computer software packages amongst many other considerations. Simple programmed which contain no significant interdependencies and have few parallel activities can be directly drawn in bar chart form. As shown in Table 3, network analysis can be used to programme all aspects of the acquisition and provide overall and departmental objectives. Used in connection with computing systems, the techniques can be applied hierarchically to provide a computer aided management system for each level in the organization acquiring the asset. Such systems analyse the networks to produce working documents, such as, bar charts, resource requirements and schedules which all assist in both target setting and the control of acquisition time.
     2. The need for cost control is self-evident; if it is not enforced the very basis of the asset’s lifetime cost effectiveness can be put at risk. Cost control, like time control, required a programme of cash flows which derives primarily from, but might also influence the logic of, the time control programme itself. Normally the cumulative expenditure programme (or budget) for a capital acquisition is presented in the form of a money versus time curve (known as an ‘S’ curve). Regular comparisons of actual cumulative expenditure (manually or through a computer aided management system) with this budget curve, read in conjunction with similar time control comparisons, serve as management guides to the acquisition project’s status.
   1. **Useful Life Phase, Operational Aspects**
      1. Table 4 lists various processes that underlie the monitoring and control of the operational life of an asset. Here, effort is concentrated on the optimization of the asset’s performance in order that the enterprise can fully exploit the planned return on its investment. Table 4 shows, for example, that production plans depend on the forward survey of demand by marketing specialists and that this forecast distils into, and its accuracy is checked by, the plant loading schedule required to meet current firm orders for the product, The production plans are conditioned by inputs from specialists including operational research, work study and cost control in deriving the most economic plant loadings consistent with the optimum deployment of labour, materials and other key resources including energy.
      2. Well designed systems for the collection of operational performance data are imperative both for the short-term appraisal of plant health and for longer term use in the organization’s global application of terotechnology. The former provides vital inputs to maintenance decisions, whilst the latter may be a key element in future investment or replacement decisions, systems can vary between simple daily log sheets that might be compiled by an operator to record output and the sophisticated computer controlled continuous data logging and plant surveillance schemes now typical in modern process plant designs. Condition monitoring techniques, wherever required, and applications have developed so rapidly that they can be utilized during an asset’s life. Similarly, owners might change maintenance techniques in the light of experience to optimize costs, performance, reliability and other considerations. The long-term interests of terotechnology are best served by feeding back such -applications and the data need to be judged against possible costs in terms of reduced competitiveness.
      3. The production of goods and services, through the operation of the asset, is the organization’s prime objective. Consequently, those responsible for its operation interact with all other parts of the management organization and all should seek to service the operation of the asset. In order to ensure that the asset is well served, the operating department should carefully monitor operation and ensure that appropriate data are collected and disseminated throughout the management organization. Information needs vary and effective feedback can only be achieved if it matches the needs of individual user departments. For example, operational data appropriate to the ‘marketing department may be valueless to the maintenance department and vice versa. However, for effective terotechnological performance the needs of both have to be met.
      4. The department responsible for the operation of the asset is involved in decision making throughout the asset’s lifetime. The management services techniques, including operational research, work study, programming, planning, scheduling and cost accounting and control, all have a role to play in guiding these decisions and in providing input and feedback to other departments.
      5. Whilst output achievements are precise in nature, forecasts are less definitive. When the forecast is made before the asset is acquired, it can contain very significant uncertainties and similar problems beset forecasts projecting the distant periods of an asset’s life. The more uncertain the input data, the more predictive the forecast and the more predictive the forecast the greater the risk to the enterprise. Consequently, medium and long-term forecasting requires the application of mathematical modelling techniques to assess not only quantitative matters like output and market size but also the related, more intangible, qualitative aspects of probability and sensitivity which really indicate the degree of risk in acting on the forecast. Similarly, the mathematical approach to stock” control through optimizing buffer storage and lead time, prompt reordering, improved transportation and distribution by means of linear programming and better service by means of the use of queuing can have significant effect on the amount of capital tied up in stock.
      6. The work study techniques of work measurement and method study are used to optimize the employment of labour and the utilization of the asset and their results are also invaluable in production planning and control.
      7. Quality assurance procedures for the asset’s products can reflect on the asset itself. “For example, increasing reject rates might indicate a declining quality. of the asset showing the need for intensified maintenance or earlier replacement. Alternatively, for example, there may be operator failures which would signal to the personnel function a possible need for retraining. Terotechnology covers these aspects in order to bring significant benefits to the organization.
   2. **Useful Life Phase, Maintenance Aspects**
      1. The maintenance of assets has significant cost implications which are inseparable from the operation of the asset. Even if the asset is temporarily out of use, time, weather and general environment together cause continuing deterioration and consequently maintenance costs continue until a disposal decision is reached. Traditionally, maintenance managers have based their strategy on what is known as the bathtub curve effect. This hypothesis suggests that maintenance costs per plant item are high during its early life due to running in problems, they reduce significantly in midlife but rapidly increase as the item’s life expires. Terotechnology offers the opportunity to reduce the cost impact of the curve through the following:
3. Improved design resulting from operational and maintenance feedback;
4. Design input from reliability analysis;
5. Quality assurance programmed;
6. Value engineering; and
7. Improved functional specifications.
   * 1. Most of these have traditionally been regarded as unrelated to the maintenance department. The primary benefits of the application of terotechnology have been higher reliability, resulting in reduced maintenance costs and better designs optimizing early costs as a proportion of the lifetime maintenance cost. Optimizing the disposal or replacement dates of components or the entire asset can also reduce the life end cost peak.
     2. The application of terotechnology to the maintenance function itself provides valuable guidance on strategy decisions where, for example, the selection of the maintenance aspects can be made in an objective (rather than intuitive) way, here, due consideration can be given to the impact of various aspects on the following:
8. Labour resource requirements;
9. Spares inventory costs;
10. Breakdown probability and risk; and
11. Availability for production.

The maintenance aspects can then be updated accordingly.

* + 1. The considerations particularly applicable to the maintenance function are given in Table 5.
    2. The maintenance function’s prime objective is to keep the asset in good, safe, efficient condition by maintaining it at the correct frequencies in the appropriate order and within budgetary provisions consistent with the financial objectives of the organization. This would lead to feedback information ensuring the application of terotechnology throughout the organization.
    3. Table 5 emphasizes the close relationship between operational and maintenance aspects of asset management. It appears self-evident that an asset which is heavily worked will require more intensive maintenance care than its lightly loaded counterpart but this is not always the case. Often the decline in condition of an asset relates to ‘exposure to weather or other particular environmental factors. Also, in the case of mechanical plant, for example, heavy continuous load can be less deleterious than intermittent light load. Again, therefore, terotechnology demands a disciplined approach to maintenance decision-making.
    4. Operational research techniques (*see* **6.4.1**) are used to examine the maintenance needs of different operating aspects and to forecast replacement dates for major parts of the asset, thus providing a basis for likely lifetime maintenance costs which can be used for budgetary control. Similar techniques can be applied to examine reliability and availability, optimize maintenance frequency and guide decisions on the maintenance strategy most appropriate to the particular conditions.
    5. The resources needed to execute the maintenance strategy also have to be programmed and scheduled. Network analysis techniques, with computer processing, provide the means for doing this work, whilst quantitative inputs derived from the application of work study techniques allow the programme to be modified according to manpower availability. Similarly, stock control, cost control, tribology and other technical aspects can be built into the maintenance management model and supplementary computer programmed used to produce the necessary maintenance documents. Typically, bar chart programmes, labour resource charts, cash flow programmed, parts and materials orders and schedules, and detailed work instructions are produced.
  1. **Disposal Phase** 
     1. Disposal is invariably a consequence of outdated technology and demands new investment appraisal and decisions.
     2. Disposal is invariably a consequence of outdated technology and demands new investment appraisal and decisions.
     3. Disposal is often a maintenance decision based upon the unacceptable maintenance cost of an item/asset which is life-expired. In such cases, the replacement cost may be offset to a degree by its scrap value.
     4. Disposal decisions are guided largely by the outcome of the reliability and availability analysis which condition the operational and maintenance aspects of asset management. In addition, continuing cost-effective utilization, product demand and the considerations profitability have to be considered because the decision may go beyond more disposals to complete or part replacement.
     5. In the case of replacement of all or a significant part of the asset, the terotechnology cycle should begin again with a fresh investment appraisal.

The considerations which apply in the disposal phase are given in Table 6

**Table 4 Useful Life Phase, Operational Aspects**

(*Clause* 6.4.1 *Table* 1, *Table* 2 *and Table* 6)

| **Sl No.** | **Primary Analysis** | **Consideration** | **Techniques** | **Interacting Interests** |
| --- | --- | --- | --- | --- |
| (1) | (2) | (3) | (4) | (5) |
|  | Production management | Profitability in context of original project appraisal |  | Finance sales, marketing |
|  |  | Future demand of product |  | operations |
|  |  | Output forecasts and achievements, documentation | Order processing |  |
|  |  | Documentation | Technical manuals including: Operating instructions system drawings flow charts control limits loadings |  |
|  |  | Availability |  |  |
|  |  | Reliability |  |  |
|  |  | Down-time costs |  | Cost accountants |
|  |  | Maintenance frequency, etc |  | Maintenance |
|  |  | Maintainability | Plant history tiles |  |
|  |  | Statutory inspections | Operator maintenance |  |
|  |  | Obsolescence |  |  |
|  |  | Disposal and replacement of components | Life assessment | Maintenance |
|  |  | Safety | Operator instruction |  |
|  | Output performance | Production capability | Material needs | Purchasing |
|  |  | Plant loading | Work study |  |
|  |  | Operating regime | Stock control |  |
|  |  | Plant performance | Control limits | Design |
|  |  | Production efficiency | Data logging |  |
|  |  | Output quality |  |  |
|  |  | Reject rate |  |  |
|  |  | Waste |  |  |
|  |  | Statutory restraints |  | Statutory bodies |
|  |  | Environmental factors |  |  |
|  | Resource optimization |  | Operational research production planning |  |
|  |  | Manpower | Recruitment and employee training | Personnel, trade unions, labour relations |
|  |  | Energy materials | Energy management | Engineering |
|  |  |  | Quality assurance methods, | Purchasing, quality |
|  |  |  | Marketing programme | Assurance, marketing |
|  |  | Cash |  | Finance |
|  | Feedback to new projects |  | Data logging | Design |
|  |  |  | Reports | Operations |
|  |  |  | Plant history files |  |

**Table 5 Useful Life Phase, Maintenance Aspects**

(*Clauses* 6.5.4, 6.5.6, *Table* 1, *Table* 2 *and Table* 6)

| **Sl No.** | **Primary Analysis** | **Consideration** | **Techniques** | **Interacting Interests** |
| --- | --- | --- | --- | --- |
| (1) | (2) | (3) | (4) | (5) |
|  | Maintenance | Documentation | Quality records | Quality assurance |
|  |  |  | Plant inventory | Supplier |
|  |  |  | Technical manuals/drawings giving: spares lists maintenance instructions structural safety limits workshop overhaul instructions work instructions | Project management |
|  |  |  | Reports of work done |  |
|  |  | Maintenance requirements | Statutory inspection maintenance scheduling resource allocation |  |
|  |  | Maintenance-strategy: Preventive condition monitoring corrective breakdown contracts expertize available from suppliers/consultants |  |  |
|  |  | Strategy reviews | Probability analysis reliability analysis |  |
|  |  | Maintenance/repair guarantees | Design appraisal technical diagnosis and analysis failure investigations fault analysis (FTA and FMECA) Tribology |  |
|  |  | Spares turnover and stock-holding | Stock control | Stores, purchasing |
|  |  | Working methods | Work study | Specialists |
|  |  | Resource acquisitions: |  |  |
|  |  | Workshops and tools |  |  |
|  |  | Manpower | Recruitment | Personnel |
|  |  |  | Training schedule | Maintenance, suppliers |
|  |  | Maintenance costs |  | Finance |
|  |  | Down-time costs |  | Finance |
|  |  | Labour productivity |  | Operations |
|  | Life cycle of asset | Operational feedback on:  Availability process efficiency product quality | Maintenance history | Operations |
|  |  | Asset history plant modifications design aspects |  | Design, supplier design |
|  |  | Unit replacements | Repair/replacement optimization | Planning |
|  |  | Major reliability and maintenance capital/ revenue schemes |  | Planning, operations,  finance |
|  |  | Life extension/reduction |  | Operations,  finance |
|  |  | Obsolescence/disposal maintenance programme |  | Operations,  finance |
| Fault tree analysis and fault modes and effects and criticality analysis. | | | | |

**Table 6 Disposal Phase**

(*Clause* 6.6.5, *Table* 1 *and Table* 2)

| **Sl No.** | **Primary Analysis** | **Consideration** | **Techniques** | **Interacting Interests** |
| --- | --- | --- | --- | --- |
| (1) | (2) | (3) | (4) | (5) |
|  | Economics of disposal | Consideration of project | *See* Table 2 | Marketing operations |
|  |  | Continuation of demand for product | *See* Table 2 |  |
|  |  | Obsolescence of product of asset | *See* Table 3 | Sales, operations |
|  |  | Repair replacement optimization net cost of disposal | *See* Table5 | Operations, maintenance |
|  | Suitability for further use | Maintenance policy survey of condition | *See* Table 5 | Maintenance |
|  |  | Change of use |  | Operations |
|  |  | Residual value |  | Contracts |
|  |  | Resale value |  |  |
|  |  | Scrap value |  |  |
|  |  | Special hazards: Structural chemical and dangerous materials buried wastes electrical | *See* Table 3 | Safety statutory controls inspectorates local Government |
|  |  | Documentation | *See* Table 3 and Table 4 |  |

**ANNEX A**

(*Foreword*)

**COMMITTEE COMPOSITION**

Management and Productivity, MSD 04

|  |  |  |
| --- | --- | --- |
| *Organization* |  | *Representative(s)* |
| International Management Institute, Nagpur |  | Prof Rajeev Aggarwal **(*Chairperson*)** |
| Asper School of Business/ISB |  | Prof Kiran Pedada |
| Centre for reliability and Diagnostics, Mumbai |  | Dr Tarapada Pyne |
| Cubic Turnkey Private Limited |  | Shri Tejas Sura |
| Directorate General, Factory Advice and Labour Institutes (DGFASLI) |  | Shri Satyendra Singh |
| IIM Shillong |  | Dr Naliniprava Tripathy |
|  |  |  |
| Indian Institute of Management, Mumbai |  | Prof Ruchita Gupta  Prof Milind Akarte (*Alternate*) |
| Indian Institute of Materials Management, New Delhi |  | Shri V. K. Jain |
| Indian School of Business, Hyderabad |  | Prof Chandan Chowdhary  Prof Pratap Sunder (*Alternate*) |
|  |  |  |
|  |  |  |
|  |  |  |
| Microsoft Corporation India Pvt Ltd, New Delhi |  | Shri Samik Roy  Shri Dhiraj Gyani (*Alternate*) |
| National Productivity Council, New Delhi |  | Shri Shri N. K. Chanji  Shri Kumud Jacob Lugun (*Alternate*) |
| Ordnance Factory Board, Kolkata |  | Dr Onkar. S. Mondhe, IOFS (PM)  Dr H. S. Negi (*Alternate*) |
| Siemens Ltd, Maharashtra |  | Shri S. Venkatesh  Shri Manoj Belgaonkar (*Alternate*) |
| In Personal Capacity, New Delhi |  | Shri Divakaran P. Kaiprath |
|  |  |  |
| In Personal Capacity, New Delhi |  | Prof Ved Prakash |
| In Personal Capacity [*(RPS) DDA Flats, Sheikh Sarai Phase-I, New Delhi - 110007*] |  | Ms Renu Sharma |
|  |  |  |
| In Personal Capacity (*320 Pocket B/5 Sector 8 Rohini New Delhi - 10085*) |  | Shri Jagdish Prasad |
| BIS Directorate General |  | Shri Anuj Swarup Bhatnagar, Scientist ‘G’ and Head (Management and Systems) [Representing Director General (*Ex-officio*)] |
| *Member Secretary*  Shri Ashish V. Urewar  Scientist ‘C’/Deputy Director  (Management and Systems), BIS | | |