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Draft Indian Standard

Guide to Terotechnology
Part 1: Introduction to Terotechnology
(First Revision)

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FOREWORD

This Indian Standard (part 1) was adopted by the Bureau of Indian Standards, after the draft finalized by the Management and Productivity Sectional Committee had been approval by the management and System Division Council.

In any organization it is necessary to identify and then choose between the investment option 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 technology should assist in the object of getting the best value for money from that investment and thus justify it.

A multidisciplinary study, research or industrial practices combining the core branches of management, finance, design & engineering, operation & maintenance, life assessment & disposal applied to physical assets in pursuit of desired economic life. Terotechnology is a combination of management, financial, engineering, building and other practices applied to physical assets in pursuit of economic life cycle costs. It is concerned with the specification and design for reliability and maintainability of physical assets such as plant, machinery, equipment, buildings and structures. Terotechnology is concerned with the specification and design for reliability and maintainability of physical assets such as rotary & static), instruments & control equipment etc. The application of terotechnology takes into account the economic methods / processes of supply chain including transit, asset installation & commissioning, operation & maintenance, modification, disposal of assets 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 project. It 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.

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 will 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.

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 1): 1992 ‘Guide to terotechnology (the economic management of assets): Part 1 Introduction to terotechnology’.

In addition to this part, this standard has the following two parts which are referred in the text:

Part 2 Introduction to the techniques and applications
Part 3 Guide to the available techniques (*Under preparation*)

Indian Standard
GUIDE TO TEROTECHNOLOGY
PART 1 INTRODUCTION TO TEROTECHNOLOGY

SECTION 1 GENERAL

1. SCOPE

This standard (Part 1) gives a general introduction to the concepts of terotechnology. This standard describes how the principles and use of terotechnology can assist the decision-making processes, the benefits which can be obtained from its adoption and the overall resources required for efficient implementation.

2. REFERENCE

The standard contains provision which, through reference in this text, constitutes, provision of this standard. At the time of publication, the edition indicated was 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
9990:1998	Glossary of terms in terotechnology *(first revision)*

3. DEFINITIONS

For the purposes of this standard the definitions given in IS 9990 shall apply:

SECTION 2 CONCEPT

4. OBJECTIVES

4.1. Primary Objective

4.1.1. Terotechnology is aimed at achieving the best possible value for money for a user from the procurement and subsequent employment of a physical asset. This may range from a complex building or engineering plant to a domestic appliance. Terotechnology can be applied with advantage by organizations of any complexity or even individuals.

4.1.2. A user would employ the principles of terotechnology in the selection of the asset and then in the subsequent management of it. A supplier, on the other hand, applies the principles in the design, manufacture and support for his product. This can achieve improved customer satisfaction generally. It may also act as a valuable incentive to potential customer, especially if they, as prospective users, are selecting their assets on the basis of terotechnology principles.

4.1.3. There is a close interrelationship between a supplier’s product and the user’s asset. A compatibility of approach should therefore be feasible and practicable.

4.1.4. An organization often acts both as a user and as a supplier. It acts as a user in respect to its acquisitions of assets with which it produces its own output products, in supplying these products, which might be either further assets, materials or a service, to its customers the organization is clearly acting as a supplier. It is essential that the organization gives till consideration to the acquisition and management

of its own assets, using terotechnological principles. It is equally important that it gives due consideration to its products and how these will best satisfy the terotechnological needs and aspirations of its customers. This is valid even when the customers for the products are the general public or individual members of it. In such cases the organization should make every effort to ascertain the terotechnological needs of its customers by market research and (or any other appropriate means and then to meet these needs as far as possible.

4.2. Lowest Asset Costs Over Life Cycle

4.2.1. Terotechnology is applied to the assessment of the total costs involved with the asset over its full life cycle up to and including its disposal. This will include the cost of financing as well as the initial capital costs and subsequent revenue or running costs. These will be related to a defined level of performance and the expected life cycle. This latter may be determined by the perceived market for the product rather than the practicable life of the asset itself.

4.3. Approach

4.3.1. In most cases the life cycle cost assessment will be influenced by the relationship between the producer of the product and the customer who acquires it. The customer or client, who orders a product specifically designed to satisfy his particular requirements will usually have a close liaison with designer and producer. He will therefore have a direct interest in the cost of ownership of the asset he will be acquiring and consequently in the life cycle costing implications of the different solutions which may satisfy his requirements. However, even a bespoke product may incorporate sub-assemblies, equipment or articles which are standard items and from which choices may be made.

4.3.2. On the other hand, the manufacturer of a mass-produced item may have no direct personal involvement with the eventual purchaser. In order to establish the best market for his product he may therefore have to rely on techniques such as market research to identify the life cycle costs and reliability which will ensure satisfactory value for money. There will also be variations between those two extremes.

4.3.3. Nevertheless, in all cases there should be a need to identify the options which may be available in the procurement of the asset so that the most economic solution may be chosen which best fits the user's requirement. This solution will largely depend on a price/cost equation or a cost benefit analysis.

4.3.4. The full terotechnology cycle begins at the investment appraisal stage and ends with the disposal of the asset, but the application of terotechnology can be made at any stage in the life of a physical asset and continue for some or all of the remaining life cycle periods until disposal or replacement.

4.3.5. Maximum benefit will be obtained from applying the complete principles of terotechnology. However, many aspects of terotechnology are already being very successfully practiced by many organizations under different names. The following list, which is not exhaustive, may help managers to identify those parts of terotechnology with which they are already familiar:

a) Asset management (including physical asset management) Reliability Management/ ALA/RBI/RCM
b) Resource management;
c) Cost of ownership.
d) Total commitment for life;
e) Womb to tomb costing;
f) Cradle to grave management;
g) Design for life costing;

h) Life long care

4.3.6. Terotechnology is concerned with helping to optimize life cycle costs. In a case where the life cycle is short, the trade-off between initial and upkeep costs might point towards buying an asset with the lowest purchase price. This approach would obviously be undesirable where there was the possibility of retaining, for example, a plant for a longer period than originally intended. Such a policy would almost certainly result in unreliability and high unkeep costs, but the opposite does not necessarily follow.

5. PRINCIPLES

5.1. Scope

5.1.1. Terotechnology is essentially concerned with the following:

a) Selection and provision of permanent (that is, not consumable) physical resources used in the production of goods and services;
b) Caring for those resources effectively and efficiently;
c) Coordinating them to help achieve overall minimum costs over their life cycle; and
d) Feeding back information to improve them.

5.1.2. The successful application of terotechnology depends upon ability to-balance factors which are uniquely important for a particular situation. It requires an understanding of management and accounting sciences and a general knowledge of engineering associated with the technological expertize appropriate to a particular industry.

5.1.3. In more specific terms, the application of terotechnology brings together the whole or parts of a number of techniques and disciplines. The blend and depth required of each will depend on the particular circumstances in which terotechnology is being applied. These techniques and disciplines include the following:

a) Investment appraisal;
b) Operational research;
c) Replacement analysis;
d) Marketing/ SCM/ Transportation/ Sub-contracts management
e) Purchasing;
f) Accounting; & Finance
g) Design for reliability and maintainability; RID
h) Preparation of specifications;
i) Installation;
j) Commissioning including Acceptance Testing
k) Maintenance procedures and technology SMPs/ Reliability, Availability Maintainability (RAM),
l) Information systems in environment of CMMS/ERP
m) Programming; and
n) Technical communications.

5.1.4. The life cycle and performance of a total asset will be affected by the individual life cycles and performance of its constituent parts.

5.2. Participation of the Whole Organization

5.2.1. It will be seen from the outline of the scope of terotechnology given in 4.1 that it is essential that the whole of an organization is involved preferably through a dedicated terotechnology (TT) group

5.2.2. Terotechnology is essentially a multi-disciplinary contribution to optimizing life cycle costs and the experience and skills of a number of specialists are required for its implementation. The basic principles of terotechnology can be applied within an enterprise without changing organizational structures (except where these are defective in themselves) and there is no need to create a new breed of specialist (a terotechnologist). Save in exceptional circumstances, the range of skills and breadth of knowledge and experience necessary for its full implementation is unlikely to be acquired by any one individual.

5.2.3. Although terotechnology can be easily understood and applied by line management, engineers, accountants and others, in their daily working lives, the subject can be applied successfully at company level only with the active participation and understanding of senior management.

5.3. Interprofessional Cooperation

5.3.1. The application of terotechnology demands that all those involved have abroad recognition of their own contribution together with that of their colleagues in other disciplines and its success is dependent upon effective communication between all parties. It requires an understanding of management and accounting and knowledge of the technology associated with the particular industry or asset. The following are two examples which may help to illustrate this principle:

a) The designer of a product should take into account the feasibility of producing his design and its cost to the consumer in operation and maintenance.
b) When assessing the proposed design of a product the management will require feedback data on the price the market may be prepared to pay for the product and the cost of producing it.

5.3.2. However, it should be remembered that these are only two examples of a wide range of interrelationships and each member of the team should endeavour to prepare his own list of the ways in which his role should interact with the whole team. This is discussed in more detail in Section 3.

5.4. Interdepartmental Cooperation

5.4.1. It is common practice for senior management of an organization to require individual departments to optimize their individual activities. Unfortunately, if this is taken as the primary objective of departments it can result in a less than optimum performance of the organization as a whole. This arises from the inevitable interaction of decisions between departments. Examples of this are not hard to find. If a purchasing department acquires the cheapest possible asset it is likely that the operating and/or maintenance costs will tend to be higher. Similarly, inadequate maintenance, to reduce maintenance costs, invariably results in penalties in the cost of operation and/or a shorter working life of the asset.

5.4.2. Consequent upon the above, the primary objective of all departments working under the principles of terotechnology, is that their individual decisions are made on the basis of achieving the best balance of cost and performance for the organization as a whole.

5.5. Collection and Analysis of Data

5.5.1. To action the optimization objectives described in 4.2 to 4.4, it will be clear that each individual department will require suitable quantitative data from all other interacting departments. These data need

to be those required for the department to optimize its own decisions in the overall interest of the organization as a whole.

5.5.2. It is essential that there are communication channels between departments (see 4.3). It should be emphasized that part of the communications through these channels needs to be the data needed by other departments to carry out their own optimization exercises, on an organization-wide basis.

5.5.3. Furthermore, this can, and frequently does, require a department to collect data not required for its own purposes but necessary for proper use by other departments.

5.5.4. This collection, analysis and dissemination of data does not necessarily remain within the organization but can and should extend to the suppliers of the assets used by the organization. Only in this way, can the supplier organization refine its designs in the overall interests of its customer organizations.

5.5.5. Data may be required for central decision making. These may be central data or they maybe departmental data, but they should be collected in a form which satisfies both the central and the departmental needs.

5.5.6. Experience to date has shown that in many organizations there is an advantage in appointing a terotechnology group throughout the organization. This group should be appointed by and be responsible to, the Board of Management. Ideally, it should be independent of any particular department, but in any case, needs to be free to cut across departmental boundaries.

5.6. Minimum Activities Necessary for Implementing Terotechnology

5.6.1. The minimum activities necessary for the implementation of terotechnology are the following:

a) Decide what production and cost targets are to be met;
b) Decide what physical assets are needed and how to use them to achieve the targets over a specified period, taking into account their forecast cost of ownership and use;
c) Specify the performance of the assets to be acquired;
d) Acquire, install and commission those assets;
e) Care for them;
f) Monitor their use; and
g) Replace and improve the assets and improve their care, using information from them to help minimize total life cycle costs.

6. BENEFITS FROM INTRODUCING TEROTECHNOLOGY

The benefits which may be gained by the use of terotechnology maybe broadly described as:
a) Improved control by the client or senior management in the making of vital decisions; leading to;
b) Better investment decisions arising from:
1) Improved information regarding costs and performance requirements; as related to particular patterns of expenditure and design choice.

NOTE — Performance includes such things as:
i. Reliability;
ii. Durability and life expectancy/requirement;
iii. Quality control;

iv. Safety, including statutory liability and product liability;

2) Improved client identification of requirements and development of a brief for the asset acquisition;
3) Information regarding the cost consequences of the options under consideration;
4) Better investment analysis of cost options available; leading to; and

c) Better value for money from the final product and /or an improved market for the product.

Other benefits may include:

a) Increased profitability through a reduction in the total cost of ownership;
b) Improved control of the product and the production process;
c) As a result of common orientation on cost and performance from the perspective of the organization as whole, together with a more frequent contact, an expectation that there will be greater understanding between client or senior management and other functions on how to achieve common goals; and
d) The cross-fertilization of good ideas and data across traditional boundaries.

For convenience, the benefits that can be derived from the use of terotechnology are summarized in Annex A

7. COSTS OF IMPLEMENTING TEROTECHNOLOGY

7.1. One of the principal obstacles to the implementation of terotechnology has been the lack of data. Data are an essential input for implementing terotechnology, and this may include detailed cost, performance [see Note to 6,1(b)] and marketing information.

7.2. The main costs associated with terotechnology data are:

a) Cost of collecting additional data, not already collected for management purposes;
b) Cost of making existing data compatible with the needs of terotechnology;
c) Cost of any additional analysis and
d) Cost of supplying feedback information or of processing feedback received.

7.3. However, with the improvements in information technology now taking place there is a vast increase in data availability and the cost of collecting and processing data is reducing dramatically as time goes on. Solutions to some of the other problems involving the implementation of terotechnology are dealt with in Section 3.

SECTION 3 INTRODUCING TEROTECHNOLOGY TO AN ORGANIZATION

8. GENERALS

8.1. Terotechnology requires no new techniques or disciplines. It is essentially a new way of examining, and grouping some familiar activities and involves a bringing-together of well-tried methods in a new way which can be used to improve management of physical assets in accordance with the objectives of an enterprise.

8.2. Terotechnology is a combination of management and technology and can be applied by both users and manufacturers in industry, building and commerce. Its basic principles can be applied at company

level and also by management, engineers, accountant and other specialists in their day-to-day working lives.

8.3. No matter what a company or undertaking designs, constructs, manufactures, processes or purchases, terotechnology has a vital effect upon efficiency, profits and market share.

9. MANAGEMENT PARTICIPATION

9.1. For management, terotechnology is one of a number of concepts which can contribute to the overall efficiency of an enterprise. Like others, it can be classed as common sense or 'simple when you know how', but requires careful, thought and planning to realize the potential benefits of its application.

9.2. The principal function of the chief executive in any organization is to examine investment options and to make choices between them. He needs to consider the availability or cost of raising funds and the various opportunity costs and make judgments on the best courses of action that are available. He needs to remember that the best economic solution may need to be used. He may be faced with conflicting advice from various advisers and a decision has to be made.

9.3. Senior managers have to consider and evaluate all the various available options in acquisition, operation, maintenance and disposal of all assets. All the financial answers need to be converted to a common base and any government or customer incentives or disincentives evaluated. The results of all of the findings of senior managers have to be in a simple and consistent format to enable the options to be evaluated in the light of the organization's overall policy and strategy to come to a decision on the best course of action to follow. More details of this are given in Part 2 of this standard.

9.4. The role of the senior manager in an organization seeking to apply terotechnology is fivefold as follows:

a) To encourage departmental managers to work together, and provide each other with all the information that each requires;
b) To foster friendly environment between rival departments and to encourage ideas on economies to come from the shop floor (possibly by incentive schemes);
c) To coordinate the departmental managers to arrive at a number of possible options (all prepared using the same ground rules to allow correct comparisons to be made);
d) To decide on which option to adopt (see 4.1); and
e) To ensure that the departmental managers implement the decision which is made.

10. ORGANIZATIONAL FRAMEWORK

10.1. The introduction of terotechnology into an organization does not require any significant changes in the organization's-functional and departmental framework. There will still be a need for the individual specialized activities; all that will be changed will be the basis of the primary objectives of the individual departments. A group, Terotechnology Team (TT),may be formed .

10.2. The principal change will be in the extent and content of interdepartmental communications, and also in the relationship between the organization and the suppliers of its principal assets, whether these be buildings, plant or both. These changes extends to suppliers of balance of plant equipment, auxiliaries, and any assets including static or rotary equipment and control systems.

10.3. With the changes in internal and external communications there will inevitably be some modification to individual responsibilities and there need to be some changes in individuals' attitudes to their responsibilities. These changes should be towards a more collective corporate attitude and away from narrow departmental or professional allegiances.

11. INCORPORATION OF TEROTECHNOLOGY INTO ACTIVITIES

11.1. Modification of and Additions to Existing Activities in the Organization

11.1.1. Terotechnology involves understanding and Collaboration between functions to be effective. An organization will be said to be practicing terotechnology when it is consciously managing the cost of owning its assets. The concepts of 'cost of ownership' involves the appreciation of trade-offs between acquisition costs and running costs. It is easy to understand, but not necessarily easy to apply.

11.1.2. The application of terotechnology requires senior management to have a thorough understanding of each specialist's role. This also means that specialists need to have a broad recognition of their own contribution plus that of their colleagues in other disciplines. If senior management has to make decisions on the purchase: f new plant with little or no information on past performance and operating costs, this can lead to wasted resources, high costs, higher downtime and lost orders. The till terotechnology cycle begins at the investment appraisal stage and ends with the disposal of the asset, but the circle can be entered at any point. For example, a company may decide to improve maintenance and reduce downtime on existing plant; although the trade-off between initial capital costs and subsequent costs cannot be taken into account, the company's decision will have a very real effect on the cost of ownership. The fact that terotechnology cannot be applied from the beginning of the life cycle of a piece of plant should not deter a company from attempting to sustain/improve reliability, or to improve or design out maintenance or to implement RID (reliability in design), process reengineering/ process design

11.1.3. Experience to date has shown that in many organizations there is an advantage in appointing a senior person to oversee adoption of the principles of terotechnology throughout the organization. This person should be appointed by and be responsible to, the Board of Management. Preferably he should be independent of any particular department, thus being capable of cutting across departmental boundaries without bias.

11.2. Modification to Customer/Supplier Relationship

11.2.1. Many of the problems which arise at a late stage in the life of physical assets stem from inadequate specification of requirements and poor communication between customer and supplier. It is important to distinguish between specification for function and specification of reliability, maintainability and continuity of optimum performance of the assets in question. The related KPIs should get a place in specifications sheet and also in the vendor evaluation factors, besides price.

11.2.2. Terotechnology is not concerned with the first (for example, the process), but it does include the latter. This is a fundamental distinction which helps to illustrate the relationship between terotechnology and other management techniques.

11.2.3. Only the user is able to specify the overall requirement but the supplier can and should have responsibility for much of the detail. Equipment suppliers make an important contribution to the efficiency of industry because they determine the reliability i.e continuing. fitness for purpose; of the assets they supply and management in this area has a particular responsibility to ensure that the customer takes

delivery of plant which meets his requirements, both in terms of technical parameters and predicted life cycle costs.

11.2.4. In certain industries, there has developed an understanding that the customer/supplier relationship has a very real effect on the efficiency and prosperity of all concerned. In such cases there is a deeper appreciation of each other's role and requirements than would be the case with purely formal and procedural relationships.

11.2.5. Not only are the customer and supplier better able to plan their respective operations, but the early and crucial stages in the life of a plant develop more smoothly and logically than would otherwise be the case. Benefits resulting from a closer customer/supplier relationship are as follows:

1. Planning made easier and with a better chance of success;
2. Easier transition from specification to production;
3. Production schedules more readily met; and
4. Increased company effectiveness and greater chance of meeting market requirements.

11.2.6. This situation may not come about if the customer does not know how to specify exactly what he wants, and the supplier does not feel it is his responsibility to ask for a precise specification or there may be complete ignorance of the fact that there is a communication gap. Equipment is sometimes bought and modified by the customer who, perhaps because of fear of disclosing commercial secrets, does not inform the supplier, with the result that more plant of the same type will be designed and built with the same shortcomings.

11.3. Terotechnology in Different Project Phases in a User Organization

11.3.1. *Concept and Investment Appraisal Phase*

11.3.1.1. Initially the organization will have to establish its own objectives and a plant to meet these, broken down into a series of individual projects. The steps in the process are as follows:

a) Identify each project including the total market demand for the product or service and the national target share of this demand to be met by the organization. Both of these aspects need to be determined against a time scale.
b) Identify the scenario against which these market predictions are being made.
c) Identify and agree the probable ranges of variations in this scenario and both the probabilities of such variations and the consequences on the national output and time sensitivities on the project objectives.
d) Identify any performance requirements such as availability or reliability equipment, product output and any product quality targets and the consequences (include penalties) of not meeting these requirements.

The second part of this phase involves the identification and selection of a specific asset in plant proposal. The steps are as follows:

a) Identify the technically feasible way of meeting the project targets, within any restraints, financial or otherwise.
b) Estimate outline costs of alternatives (life time costs)
c) Estimate cost variations within the identified ranges of scenarios.
d) Select best option or options for further detailed study after taking into account the assessed probabilities and risks.

e) Refine assessments to reduce best options to a single proposal and communicate this in full detail.

11.3.2. *Acquisition Phase*

11.3.2.1. In this phase the first task is to specify the assets needed for the project. The steps include the following:

a) Obtain inputs from all parts of the organization regarding the assets needed and the probable future resource needs during the project lifetime.
b) Identify and evaluate potential trade-offs, for example, automation versus manpower, inherent reliability versus maintenance.
~~Either specify assessed optimum of trade-offs or demand information in tenders on which to determine the optimum.~~
c) Specification to include New Technology, monitoring sensors, O&M parameters, safety precautions/ notes, reliability & maintenance strategies to be followed documentation include supplier acceptance testing data, O&M manuals for each part of whole package
d) Fully specify requirements in all particulars including contract documentation, manuals and support during the life cycle of the asset
e) Finally issue the enquiry specification to all viable tenders.

11.3.2.2. When tenders have been received, these will have to be assessed and compared. The essential elements of the assessment to be included are as follows:

a) Ensure all specification requirements, including data, have been met.
b) Identify shortcomings or alternatives and estimate the consequential penalties to the user organization.
c) Identify options offered, then determine and select best option for the user.
d) Identify further penalties shortcomings (not necessary outside-specification) and evaluate a reasonable notional penalty based upon risk and consequence estimates.
e) Identify guarantees being offered.

11.3.2.3. Competitive tenders should be compared and tenders then selected for all the contracts for the various assets in the total project. Before proceeding it will of course be necessary to check that the tendered data does not invalidate the chosen asset plan or the original market plan proposals. Finally, contracts are let or orders placed for the assets needed.

11.3.3. *Commissioning Stage*

During the commissioning stage of the assets further detailed examination needs to be given to all the options regarding policies, strategies and the support resources needed for operation and maintenance of the assets. At this stage, the detailed examination/ checks needed are: parts/ assembly inspection reports, transit and local storage manadate, sub-contracting agencies quality checks of activities, mechanical electrical, instruments and control unified tasks.The objective is to identify the optimum position viewed overall with respect to the project targets. Further refinement should be made of estimates of resources needed for operation and maintenance during the asset life cycle particularly in the light of any variations within the scenario ranges agreed, from time to time, by senior management.

11.3.4. *Useful Life Phase*

11.3.4.1. During the useful life phase, in which operation and maintenance are the primary activities, the policies and strategies, initially forecast during the commissioning stage, will be reviewed and modified in the light of experience and circumstances, As time progresses, reviews need to be held *inter alia* to clearly define the project targets, particularly regarding the duration of the life cycle and the associated costs in respect of disposal of the assets and/or their replacement if this is appropriate. Monitoring of O & M KPIs regularly is vital. These will help in review of assets health, business KPIs besides O&M KPIs and finally LCC.

Routinely, the performance of the asset and associated costs should be reviewed and be improved if this is possible.

11.3.4.2. A major feature of this phase will however be the collection and analysis of data not only for use in the operation and maintenance of the current assets but also for use by the user's planning and project staff in future projects. To this should be added such data which, when fed back to the manufacturers or suppliers, enables them to improve their performance in serving the terotechnological needs of future users.

11.3.5. *Disposal Phase*

This terminal phase of the life cycle will have to be optimized as part of the life cycle management. The optimization of assets, when a sense of deteriorating performance is felt based on O&M stage KPIs, is to be to be completed by SMEs following techniques of Reliability Analysis, RUL, ALA initiatives that are strictly carried out based on LCC.Therefore, the data and costs associated with this phase should be considered for use in the studies of future projects.

11.4. Effect on Supplier Organizations

11.4.1. In so far as supplier will normally also be a user of assets acquired from another supplier, he will have an interest in terotechnology applied to his own assets. But his consideration should also extend to the assets he is supplying to his customers. To do this he needs to consider in his own operations the terotechnology needs of his customers, as users, by viewing matters from their points of view.

11.4.2. In particular his designs for assets to be supplied to a customer should make the user's terotechnology needs the priority consideration. Having done so, it will be equally essential that the supplier markets his product with due emphasis on how the customer's terotechnology needs have been considered and catered for. This aspect goes beyond the design of the product and extends to both contractual conditions (guarantees, etc) and support for the service phase. This latter could include both spares and specialist advisory services.

12. MODIFICATIONS TO INDIVIDUAL FUNCTIONAL ACTIVITIES

12.1. Management

12.1.1. The decisions made by management is outcome of the information which is made available to them. At management level the primary function of terotechnology is as an information and control system and as an aid to communication and appraisal. Information feedback from all functions within the organization will enable better evaluation of the performance of physical assets and so improve corporate planning and forecasting.

12.1.2. Management style is important in the application of terotechnology and a policy which encourages communication and information exchange will facilitate this. The acquisition, processing and transmission of relevant data is a fundamental requisite for the full practice of terotechnology and although this may sometimes call for sophisticated data systems based on computers, this should not automatically be assumed to be the case. The type of information required should be specified first, and then the methods of recording it. Care needs to be taken to ensure that cost of gathering and evaluating the information does not outweigh its usefulness.

12.2. Accountants

The accountant should have the responsibility to:

a) Develop effective communication with colleagues in design, manufacturing, maintenance and marketing to assist the flow of information on all aspects of cost, particularly to enable a proper examination of the relationship between the initial purchase cost of an asset and the total life cycle cost;
b) Insist that departmental managers feed him cost data in a form that can be used in wider decision processes of life cycle costing, including optimization of policies;
c) Make available cost and performance information to assist in making investment proposals, which in turn will lead to improved investment appraisals and better investment decisions.

12.3. Designers and Project Engineers

The designer and project engineer should have the responsibility to:

a) Ensure the availability of feedback information from users on such items as:
1) Cost of installation and commissioning;
2) Reliability;
3) Maintainability;
4) Functional performance including numbers and types of failure or malfunction; and
5) Consequences of failure and use of failure modes, effects and criticality analysis.
b) Enable the whole life cycle costs including manufacture, transit/ transportation, installation, commissioning, operation, overhaul, repair and disposal to be considered at the design and development stage;
c) Become fully aware of the cost implications of their design decisions;
d) Facilitate the preparation and presentation of technical manuals and brochures on the product; and including safety cautionary notes, instruments and health parameters alert/ trip values, performance parameters as per desired applications, latest technology if any used/ sensors etc.
e) Show, if required, the need for specialist personnel and their required skills, and identify how these can be employed. Decide on how this need can be satisfied by the time these skills are required and consider recruitment or training.

12.4. Purchasing Executives

The purchasing executive should have the responsibility to strengthen communication bridges with the suppliers:

a) Internally using structured process of procurement using ERP/ CMMS. This involves better communication between tech & non-tech stakeholder of assets within organization.

1) Identifying for any new acquisition the full requirements of the user groups in the organization; and
2) Providing to those involved in determining acquisitions the information necessary to assist in making correct purchasing decisions and help to ensure that initial cost is not used as the sole criterion.

b) Externally by:
1) Fully communicating the requirements of the user groups to suppliers; and
2) Making available to suppliers' adequate data on the relevant aspects of the required life cycle performance of physical assets being considered for acquisition, including initial cost, installation and commissioning, performance, maintenance overheads include spares and consumables, reliability and maintainability and thereby assisting in preparing an adequate specification of the assets being acquired.

12.5. Production Managers and Engineers

12.5.1. The production manager and engineer should have the responsibility to:
a) Provide information on reliability, maintainability, safety, costs and failure or malfunction, etc, of plant and equipment in use;
b) Provide the relevant information enabling clear and complete specifications of requirements to be prepared when consideration is being given to the purchase of new or replacement assets;
c) Make available relevant data when considering production programmed and how they would be affected by maintenance schedules;
d) Receive and act on feedback of information from the users of the product on failures, reliability, maintainability and safety; and
e) Assist in the preparation of valid estimates of delivery time and price when responding to a prospective purchaser's enquiry.

12.5.2. The better information and cooperation resulting from the use of terotechnology will often result in an overall improvement in costs and efficiency.

12.6. Maintenance Managers and Plant Engineers

The maintenance manager and plant engineer should have the responsibility to:
a) Encourage the provision of proper maintenance strategies established following plant wide relaibility-based approach such as RCM, RBI, FMECA etc.
b) Provide a fault recording and analyzing system as part of a maintenance strategy, giving information on spares requirements, reliability, maintainability, maintenance including staructured RCA/RCFA process costs, safety, etc;
c) Make available information on the total costs of maintenance including both direct and indirect costs, which would assist in assessing the right time for equipment replacement;
d) Provide the means of checking that forecast reliability, Availability and maintainability figures are achieved in practice; Establish asset-wise maintenance strategies, like PM, PdM/CBM, RTF etc.
e) Evaluate condition-based maintenance techniques as part of terotechnology to optimize maintenance costs and improve plant availability; and
f) Highlight to top management how poor or inadequate maintenance can result in poor delivery performance, and consequently dissatisfied customers and lost markets.

g) Asset excellence through right maintenance strategies brings Business Excellence

12.7. Marketing Executives

The marketing executive should have the responsibility to:

a) Provide information to enable the competitive features of the product to be presented to the prospective purchaser and particularly the trade-off between initial cost and total life cycle costs;

b) Consider such factors as delivery, performance, price quality, reliability, maintainability, aftersales service, spares availability, the quality of technical manuals, etc, and whether:

1) he is fully equipped to respond to the customer's requirements;

2) he has information to assist in detailed comparisons with rival products; and

c) Establish feedback from customers on product performance

d) Be spokesperson of the organization producing reliable products based on terotechnology and related assessment covering entire life cycle considering both user and supplier's terotechnology needs.

12.8. Effect on Training

To achieve the maximum benefits from terotechnology it will be necessary to introduce the concept into the staff training of the organization. This should lead, in turn, to a level of training sufficient to allow each participant to understand his own contribution and the contribution to be expected or required from all other members of the organization. The greater appreciation by individuals of the work and contributions of others should lead to smoother relationships within the organization, less friction and disturbances and a greater identification of each individual with the corporate entity of the organization. A formal training need identification is needed covering all functions and covering stages of life of assets.

13. COMMON PROBLEMS AND SUGGEESTED SOLUTIONS IN IMPLEMENTATION OF TEROTECHNOLGY

13.1. General

13.1.1. Organization considering the introduction of terotechnology may initially face a number of difficulties. Some of the common problem are identified and some solutions to them suggested in 13.2 to 13.5.

13.1.2. The problems discussed may be divided into four broad categories:

a) Conceptual /awareness;

b) Technical and economic;

c) Management organization; and

d) Personnel management

13.2. Conceptual /awareness

13.2.1. A reluctance to accept the concept of terotechnology is often a problem within an organization for a variety of reasons. In order to deal with the problem the following are suggested solutions:

a) Where the problem lack of understanding of the term terotechnology a solution may be found in the definition itself and further scope of its field is given in 4.3.5.

b) Where there is doubt regarding the benefits in adoption of terotechnology , sensitivity analysis may be undertaken. it is often surprising how valuable such an introductory exercise can be and what it leads to.

c) Where there are no specific reasons for the problem other than the natural reluctance to accept change, a trial in one trade-off situation can often be convincing as It will demonstrate how the use of terotechnology leads to more informed decision making.

13.2.2. Whilst the concept of terotechnology may be acceptable in an organization there may be opposition to the implementation of terotechnology in the organization because the costs are thought to be prohibitively high.
However, much of the data required in the application of terotechnology can be derived from data which should already be collected for normal management purposes and the analysis of the data can use the existing facilities. The solution to the problem therefore is to convince the objectors that the additional cost based on LCC will be minimal. as the organization will perform efficiently post adoption of terotechnol;ogy.
13.2.3. The application of terotechnology calls for multi-disciplinary cooperation. however, there are differences in academics and industrial various functions in nurturing cooperation. This problem is gradually disappearing because of the following:
a) Terotechnology, often under the guise of other names, is accepted by the professions and is now being taught by many technical colleges, polytechnics, etc. In-house training can also be effective in further eliminating the problem.
b) In many organizations today it is recognized that liaison and cooperation between the different professions is essential for the efficient running of the business and this is what needed in implementation of terotechnology.

13.3. Technical and Economic Problems

13.3.1. The most common problem in this area is that there is an apparent non-availability of data in a form suitable for use in terotechnology. This problem is less serious today than in earlier times it should gradually disappear for two reasons:
a) Recent explosive developments in information technology and matured ERP software within organization allow the derivation of data suitable for terotechnological purposes. Data quality is a challenge even today and right training will reduce this anomaly.
b) Efficient management now recognizes the need for quality data to allow the preparation of programmed, control budgets and the monitoring of performance. It is not difficult for such data to be collected in a form which will also allow them to be used for terotechnology. The wider availability of personal computers in offices of all sizes makes this collection of data possible. In some cases, the required data can be derived from hypotheses and/or published information.

13.3.2. Another problem which has discouraged the use of terotechnology is the belief that there are no suitable techniques for the processing of data.

This is not the case. The normal techniques used for investment appraisal can be used, including statistical analysis and discounted cash flow techniques. The skill lies in applying these techniques to terotechnological problems and interpreting the results. Equally, there are techniques available through proven Reliability & Maintenance software in every stage of asset's life

13.3.3. A problem to be faced in the application of terotechnology is how to deal with uncertainties about the future. finance, investment, life of physical assets.
In order to deal with uncertainties, assumptions about the future have to be made. Every form of investment analysis is based on such assumptions. In terotechnology these may include the likely life of

the product, the rate of inflation, the discount rate to be used, and tax incentives. These aspects are dealt with in some detail in Parts 2 and 3 of this standard. There are well-tried techniques available for choosing the best Reliability analysis, Life assessment, Risk assessment etc. scientific proven techniques are used to deal with uncertain future for physical assets in value adding chain of the enterprise. assumptions. In case of doubt it will be wise to apply sensitivity analysis to establish the degree of accuracy required of the data and the extent to which any assumption will affect the solution.

13.3.4. Certain external constraints may affect the solution to a terotechnology problem and a sub-optional solution may have to be adopted in preference to the ideal solution (In this context, external constraints are constraints imposed by the organization's policies and may include the cost of initial financing, the imposition of cost limits or a requirement to accept the lowest tender). bypassing at times engineering evaluation/ techno-economic evaluation of vendors.

The great merit of terotechnology is that it identifies the benefits that may be gained. These may produce powerful arguments for revising the constraints imposed and certainly allow more informed decisions to be taken.

13.3.5. When compared with the life of the production run, the duration of the promotional advertising of a product may be relatively short. If the degree of success is appraised at the end of the advertising period the full benefits of terotechnology may be underestimated.

Since it obviously takes time for clients and customers to assess the benefits of total life costs, the full benefits will normally only materialize in the Longer term. This aspect should be borne in mind in setting up the promotional programme; in subsequent promotions results can be quoted.

13.4. Management Organization

13.4.1. Terotechnology requires inputs from a number of different disciplines which may be located in different functional divisions within an organization. This may create a problem. Normally the problem does not apply to small organizations or to larger organizations which are split up into small groupings by region or type of operation. Nonetheless, in many cases some overall guidance may be essential. The problem has to be solved by identifying and eliminating the root cause, such as the following:

a) In some cases, different departments or different disciplines in an organization find it difficult to cooperate for the common good due to the fact that the departments are considered to be separate accounting units, each of which has to show a profit. In such cases it should be made clear that each department should consider all the options open to it and take into account the effect these will have on other departments. Someone should then be appointed to consider all the options and to recommend to the senior manager the solution most beneficial to the organization as a whole.
b) Departments may not recognize that some of their data have the potential of serving the needs of other departments. Everybody needs to be made aware that information is available in the various departments. In order to make this information useful to other departments it will be necessary to open up and maintain interdepartmental channels of communication but its encouraging to note that many large corporate today with the established ERP/ CMMS platform (like SAP), the departmental information storage and ownership are minimized to a large extent.

13.5. Personnel Management

13.5.1. The introduction of terotechnology has a significant impact on human resource management. Senior and middle managers in particular need to develop to appropriate levels their knowledge of
a) Multi-disciplinary skills;
b) interaction between functions
c) Language and jargon used in each interacting discipline in the terotechnology concept.
In addition, departmental isolation and loyalties have to be redirected to secure the wider aims of terotechnology.
d) Dept managers slowly need to be HR manager to develop their own dept colleagues as they are aware of the need of training in department.

However, this objective should not prevail to the extent that specialist skills become too dilute, resulting in a staff knowing a little about everything but nothing in depth.

13.5.2. For most organizations staff represent their most valuable resource and organizations which fail to recognize this, and do not strive constantly to enhance their quality, rarely prosper.

The introduction of terotechnology demands re-education and restraining of personnel throughout the organization and career development along terotechnology lines needs to form an integral part of the personnel management policy.

Awareness programs specialist knowledge and staff need to be encouraged to absorb all the technological changes within their own specialisation. The career development strategy of the organization should be to overlay management training and multi-disciplinary awareness on in-depth specialist knowledge. Senior management needs to be trained in the necessary corporate decision-making skills.

Top management will need to delegate specialist tasks and require constituent branches of the organization to present progress reports, financial information, etc, using the techniques in Part 3 of this standard, in such a form that corporate decisions can easily be made, justified and explained. The acquisition of staff can be treated to some extent like the acquisition of other assets. A similar life cycle/cost approach can be taken and career management and progression are in many respects similar to the processes outlined for maintenance and improvement of other assets.

13.5.3. In certain circumstances specialists may fear the implications of revealing their special skills to colleagues outside their own discipline. multi-skilling is to be rewarded in the organization to get relief from this fear, undesired for terotechnology. These fears may concern possible loss of status if not loss of employment altogether. Management generally must ensure that they recognize when or where such concerns are arising and take such steps as are necessary to counter them. These fears may concern possible misapplication and consequent loss of status.

Acknowledgement and due recognition of both specialist skills and cooperative efforts should help in this respect as well as appropriately structured training which explains and promotes the value of interdisciplinary cooperation. The formation of interdisciplinary teams to tackle selected tasks rather than the maintenance of single disciplinary line managements throughout the organization may also assist in allaying fears and demonstrating the value of interdisciplinary contacts to staff at an early stage.

Monetary incentives for specialist skills may be appropriate and a sharing in the increased profitability or savings maybe the best method of applying incentive for cooperative efforts. However, a sense of person appreciation may be even more important.

14. APPLICATION OF PROCEDURES AND TECHNIQUES

14.1. General

The application of terotechnology demands that all those involved have a broad recognition of their own contribution together with that of their colleagues in other disciplines and its success is dependent upon effective communications between all parties. It requires an understanding of management and accounting and a knowledge of the engineering associated with the particular industry or asset.

The full terotechnology cycle begins. at the investment appraisal stage and ends with the disposal of the asset, but the application of terotechnology can be made at any stage in the life of a physical asset and continue for some or all of the remaining life cycle periods until disposal or replacement.

14.2. Procedures and Technique

The procedures and techniques available for the implementation of terotechnology are many and varied. Some examples of these techniques in relation to life cycle cost functions are given in Table 1. or full details of these techniques and their application see Parts 2 and 3 of this standard.

14.3. Terotechnology Checklists

Terotechnology checklists have been prepared for use by various functions within organizations. As an example, the checklist aimed at managers in user organizations is included as Annex B. The full set of checklists is reproduced in Part 3 of this standard

Table 1 Some Examples of Relationships Between Life Cycle Functions and Relevant Technique
(Clause 14.2)

Sl no.	**Life Cycle Functions**		**System Specification**	**Plant Design**	**Plan I manufacture**	**Commission, Install**	**Plant Operation**	**Maintenance**	**Replacement**
	Performance	Task	Define parameters for technical performance	Balance performance against time and cost	Evaluate prototype performance		Assess performance to specification and reliability		Asses future performance need
		Techniques	Performance evaluation	Environ-mental planning	Tribology; corrosion				
	Quality	Task		Carry out value engineering	Set quality I limits	Commission and test to	Check quality to specificat	Asses influence of	Determine future

				study		quality limits	ion	maintenance on quality	quality need
		Techniques	Marketing factors	Probability theory; sensitivity analysis	Quality assurance. \"value engineering		Quality assurance, sampling	Corrosion, tribology, sampling	
	Reliability	Task	Specify realistic limits	Assess failure probabilities		Test reliability	Set maintenance schedule	Maintain to schedule and assess reliability	Determine future reliability
		Techniques	Marketing forecasts	Value engineering, simulation	value engineering	Forecasting		Preventive maintenance, probability analysis	
	Downtime	Task	Collect data from previous plant records	Assess maintenance need in light of specification	Snags carried forward	Snags carried forward	Establish actual downtime		Evaluate progressive future downtime
	Control	Task	Evaluate project, set control parameters and reporting	Control design. schedule, time and **cost**	Control manufacture schedule. time, cost and quality	Pre-planning implemented control schedule and cost	Control cost and progress	Control maintenance cycle and cost	Collate life cycle cost for appraisal
		Techniques	Project appraisal	Network analysis		Network analysis	Linear programming	Network analysis	Project evaluation
	cost	Task	Calculate whole life cycle cost	Allocate design costs	Allocate manufacture cost, set price	Allocate installation cost	Assess cost of operation and downtime	Assess cost of maintenance	Asses and evaluate economics
		Techniques	Life cycle costing, investment appraisal,	Finance, cost accounting, management accounting	Cost and management accounting	Programme evaluation and	Cost and management accounti	Marginal costing	Cost forecasting. Discou

			sensitivity analysis			review techniq ue(cost)	ng		nted cash flow, investm ent apprais al, Cost-Benefit Analysi s
	Schedu ling	Task	Request schedule as part of quotation	Produce manufacture and installation schedules	Set work flow based on schedule	Install based on schedul e	Set work flow for producti on	Set maintena nce schedule	Schedu le replace ment phase
		Techniq ues	Planning	Resource scheduling	Work study'. Resource scheduling materials handling	Work study, resource scheduli ng, material s handlin g	Work study. resource materials handling linear program ming	Work study, resource scheduli ng, materials handling	
	Time	Task	Set design plan	Utilize feedback to reduce design time	Work study Production process	Value of long-term commis sioning	Investiga te economic runs	Evaluate maintena nce load	Determ ine econom ic life
		Techniq ues	Marketing factors	Critical path analysis	Critical path analysis		Critical path analysis		
	Feasibi lity	Task	Carry out feasibility study to set specificatio n	Use feasibility study data	Test operation feasibility				Assess project feasibil ity
		Techniq ues	Probability theory	Probability theory	Modelling, synthesis	Simulati on			Cost-Benefit Analysi s
	Record s	Task	Specify records to be kept (up to delivery)	Determine future records needed	Maintain process and manufactur e records	Keep commis sioning log	Keep producti on. downtim e. cost records	Keep maintena nce records	Collage records

		Techniques	Information systems, information theory	System analysis	Automatic data processing	Network analysis	Automatic data processing	Automatic data processing	
	Feedback	Task	Keep specification up-to-date	Modify design in light of feedback	Feedback design	Feedback to design and sales	Feedback to purchasing and design	Feedback to previous stages	Feedback to all previous stages
		Techniques	Information theory	Behavior science					

ANNEX A
(Clause 6)

SUMMARY OF THE BENEFITS FROM USING TEROTECHNOLOGY

A-1 The use of terotechnology can provide benefits in the following areas:

a) *Profit:*
1) Reduction in total cost of ownership of physical asset and hence increased profitability;
2) Demonstrable balance between long- and short-term profit goals; and
3) Identifies future penalties associated with expedient short-term actions.

b) *Communications and Control:*
1) Improved understanding between senior management and other business functions (on topic of asset management) using common language of total cost of ownership;
2) Cross-fertilization of good ideas and data across traditional functional boundaries;
3) Greater scope for delegation of asset management tasks to junior staff leaving time for more important decision making. Emphasis on more coherent inputs from below (less risk, time saving);
4) Provides common goals and language for all functions within the business;
5) Encourages a multi-disciplinary approach to management which develops healthy attitudes in respect of:

I. Inter-functional relationships;
II. Short *versus* long term effects;
1) Provides a rational approach to asset management which will allow senior managers to make decisions on the basis of a lower volume of more meaningful information.

c) *Management Development:*
1) Disciplines junior management to develop appropriate balance between immediate goals and future penalties or benefits; and
2) Encourages a multi-disciplinary approach, helping to reduce the negative effects of inter-functional tension.

d) *Profitability:*
1) Reduction of the total costs of physical assets and hence increased profitability; and
2) Achievement of an appropriate balance between long- and short-term goals.

A-2 The use of terotechnology can have the following beneficial result:
a) Improved profitability, with appropriate balance between short- and long-term goals;
b) Improved communications and sense of common purpose between company functions enabling greater delegation of asset management tasks, encouraging junior management to develop healthy attitudes;
c) Reduction in time spent on asset management by senior managers, whilst, demonstrably improving control and asset management activities; and
d) Lower development and production costs through:
1) Limited performance improvement objectives
2) Elimination of non-essential functions;
3) Design simplicity;
4) Greater use of design inheritance;
5) Greater use of standard and commercial products;
6) Use of high-volume production parts; and
7) Designing to facilitate multiple source competition.

e) Improved reliability through:
1) Greater use of proven design;
2) Greater attention to non-random failures;
3) Simplified design;
4) Improved quality control;
5) More efficient development and test procedures;
6) More representative and stringent environmental tests; and
7) Timely elimination of software errors.
f) Improved maintainability through:
1) More design attention to maintainability;
2) Improved test equipment and procedures;
3) Improved accessibility;
4) Improved reliability of test equipment;
5) Greater support equipment standardization;
6) Use of standard components in support equipment; and
7) Built-in self-test capabilities.
g) Improved support operations through:
1) Reduced proliferation of sub-systems;
2) Reduced proliferation of parts;
3) Reduced maintenance skill and manpower
4) Use of common support equipment
5) Reduced special training;
6) Reduced logistics pipeline time; and
7) Reduced scheduled maintenance requirements

ANNEX B
(Clause 14.3)
EXAMPLE OF A TEROTECHNOLOGY CHECKLIST

B-O GENERAL
This checklist is intended to help organizations in the application of terotechnology. Tick those items on the check list for which yes is appropriate or mark those to which, perhaps for organizational reasons, only a negative answer can be given; in this way one should be able to highlight areas where improvements could be made.

B-1 TEROTECHNOLOGY CHECKLIST FOR OVERALL MANAGEMENT OF A USER ORGAN1ZATION

B-1.1 General
a) Ensure that there is effective two-way communication between the organization and suppliers of plant, machinery, equipment, buildings, structures or other physical assets.
b) Check that this includes quantitative information on the following:
1) Functional utility;
2) Health and safety in all phases, including disposal;
3) Reliability;
4) Maintainability;
5) Types (and man-hour costs) of malfunction or failure;
6) Man-hour costs of maintenance (including overhaul and repair); and
7) Environmental compatibility.
c) Ensure that there is an efficient system for monitoring, recording and analyzing the performance and life cycle costs of the physical assets used by the organization.
d) Are the following being considered:
1) Condition monitoring?
2) Trends in quality and quantity of the output or service obtained from the unit in question? And
3) Trends in the costs of use and maintenance?
e) Encourage those responsible for purchasing to:
1) Maintain interest in the physical assets of the organization;
2) Make a positive contribution to decisions affecting the acquisition; and
3) Take full account of life cycle criteria when recommending or selecting a supplier of bought-in components or assemblies.
f) Check that manuals and other support literature:
1) Are acceptable to those in the organization who install, operate and maintain the units in their care; and
2) Permit the preparation of life cycle plans, including financial provisioning

B-1.2 When Making Decisions on Acquisition of a New Physical Asset
a) Ensure that the investment appraisal:
1) is based on a life cycle plan;
2) has taken account of, and displays, the balance between initial cost and total life cycle costs;
3) compares the estimated life cycle costs and performance of the proposed acquisition with those of refurbishing and recommissioning units already in service; and

4) recognizes the full implications of quality assurance.

b) Before making or confirming the decision to acquire a new asset consult the concerned persons responsible for:

1) Finance;
2) Marketing;
3) Production;
4) Maintenance;
5) Quality; and
6) Safety.

c) Ensure that the statement of your requirements:

1) is unambiguous; and
2) covers all relevant aspects of life cycle performance

d) Check that it will permit intending suppliers to:

1) prepare without delay a specification for comment or agreement; or
2) submit proposals for modifications which they consider will make the asset feasible or more acceptable on grounds of performance or costs.

e) Ensure that proposals for modification are communicated to and acted upon without delay by those who will be responsible for installing, operating and maintaining the unit.

f) Ensure that the proposals for modifications made by the organization are kept to the necessary minimum and can be justified.

g) Check that the effects on cost and delivery of modifications to the asset in question are fully communicated.

h) Ensure that decisions on proposals for modifications are communicated without delay to the potential supplier.

i) Review terms of warranties offered by intending suppliers when placing the order. Assess their potential value and take this into account in economic assessments.

j) Ensure that the purchasing specification has been agreed by all those who were consulted on acquisition of the unit in question.

k) Ensure that the purchasing specification includes adequate data on all aspects of life cycle performance.

l) Ask for confirmation of warranties, price and delivery.

m) Use the life cycle plan to monitor and record progress and costs starting from the time when acquisition was first considered.

n) Inform all concerned that changes in the purchasing specification after the order is placed will be prevented.

o) Ensure that there is a formal procedure for dealing with proposals for modifications which may result from:

1) problems in design and manufacture or construction; and
2) unavoidable changes in requirements.

B-1.3 After Delivery

a) Check that those who will be responsible for operating and maintaining the unit are satisfied with:

1) Its testing;
2) Its installation;
3) Availability of documents /manuals for operation and maintenance;
4) Its performance; and
5) Their relationship with the supplier.

b) Ensure that all legal, regulatory and commercial formalities are completed correctly (for example, those relating to safety and warranties).

c) Review how promises, estimates or forecasts of:

1) Functional performance;
2) Spares;
3) Reliability;
4) Maintainability; and
5) costs;

have been substantiated or modified between placing the order and acceptance of the unit.

d) Consult with those in the organization who are responsible for Finance, Marketing, Production, Maintenance, Purchasing and Quality on how this review will affect the organizations' future plans.

ANNEX A

COMMITTEE COMPOSITION
Management and Productivity, MSD 04

Organization(s)	*Representative(s)*
International Management Institute, Nagpur	Dr. B. A. Metri
International Management Institute, Nagpur	Prof Rajeev Aggarwal *(Chairman)*
Indian School of Business, Hyderabad	Prof. Chandan Chowdhary
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), Mumbai	Shri Satyendra Singh
Indian Institute of Materials Management, New Delhi	Shri V. K. Jain
International Institution of Technology and Management, New Delhi	Shri V. K. Gupta
Indian Institute of Management, Mumbai	Prof. Milind Akarte Prof. Ravindra Gokhle Prof. Ruchita Gupta
Indian School of Business, Hyderabad	Prof. Pratap Sunder *(Alt.)*
Microsoft Corporation India Pvt. Ltd., New Delhi	Shri Samik Roy Shri Dhiraj Gyani *(Alt.)*
National Productivity Council, New Delhi	Shri N. K. Chanji Shri Kumud Jacob Lugun
Ordnance Factory Board, Kolkata	Dr. Onkar. S. Mondhe, IOFS (PM) Dr. H. S. Negi (*Alt.*)
Paramount Dataware Pvt. Ltd., Chennai	Ms. Manjula Subramanian Shri Govind Srinivasan *(Alt.)*
Perstorp India	Shri Divakaran P. Kaiprath
Siemens Ltd., Mumbai	Shri S. Venkatesh Shri Manoj Belgaonkar (*Alt.*)
IIM Shillong	Dr. Naliniprava Tripathy
In personal capacity, New Delhi	Prof. Ved Prakash
In personal capacity, (*187,* (*RPS*) *DDA Flats, Sheikh Sarai Phase-I, New Delhi 110007*)	Ms. Renu Sharma
In personal capacity, (*Osimo Tower, Mahagum Moderne, Sector 78, Noida – 201301*)	Shri Anupam Kaul
In personal capacity, (*Sector B/5, Rohini, New Delhi)*	Shri Jagdish Prasad
BIS Directorate General	Mr. Anuj Swarup Bhatnagar , Scientist 'F' and Head (MSD) [Representing Director General (*Ex-officio*)]

Member Secretary

Shri Ashish V Urewar,
Scientist 'C' (Management and Systems), BIS