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Indian Standard

GUIDE ON RELIABILITY OF ELECTRONIC AND ELECTRICAL ITEMS

PART 2 RELIABILITY AND MAINTAINABILITY MANAGEMENT

(First Revision)

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Indian Standard

GUIDE ON RELIABILITY OF ELECTRONIC AND ELECTRICAL ITEMS

PART 2 RELIABILITY AND MAINTAINABILITY MANAGEMENT

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0. FOREWORD

0.1 This Indian Standard (Part 2) (First Revision) was adopted by the Indian Standards Institution on 28 June 1984, after the draft finalized by the Reliability of Electronic and Electrical Components and Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard (Part 2) provides management guidelines for establishing reliability and maintainability programmes applicable in varying degrees to the complete life cycle of electrotechnical products. The scope and impact of selected comprehensive group of reliability and maintainability activities are given in this standard, while procedures for accomplishing these activities are contained in the Indian Standards given in Appendix A. This standard is intended to serve as an overall standard that links the various standards on technical aspects of reliability and maintainability.

0.2.1 The reliability and maintainability procedures covered in the guidelines are applicable to large organizations as well as small companies. They are also applicable to producers and users of large systems and small components.

0.2.2 Taking into consideration the current emphasis on the need for economic resource conservation, the standard provides management guidelines for the selection of reliability and maintainability activities for electrotechnical products based on life cycle concept. Activities are performed in the most appropriate phase of product life and decision criteria take into account impact on all phases of product life.

0.3 This standard (Part 2) was first issued in 1975 and this revision has been undertaken to bring it in line with the latest developments taking place in this field.

0.4 This standard is based on and technically equivalent to IEC Document 56 (Central Office) 86 Draft—Guidelines for Reliability and Maintainability Management issued by the International Electrotechnical Commission (IEC).

1. SCOPE

1.1 This standard (Part 2) provides management guidelines for the selection of reliability and maintainability activities appropriate to each of five definable phases of product life : concept and definition, design and development, manufacturing and installation, operation and maintenance, and disposal.

1.2 This standard is applicable to electrotechnical products and is an overall standard to be applied by management in establishing a reliability and maintainability programme appropriate to the product and its end use.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions and explanation of terms given in IS : 1885 (Part 39)-1979* shall apply.

3. LIFE CYCLE CONCEPT

3.1 The reliability and maintainability activities to be implemented for each phase of product life cycle shall be selected within the context of the total life cycle of the product. Decisions made at any point in time have an impact on product reliability and maintainability and cost at that time and in subsequent phases of the product life.

There are five definable phases in the product life cycle as follows:

a) *Concept and Definition Phases* — when the need for the product is decided and its basic requirements subsequently defined, usually in the form of a product specification, agreed to between customer and contractor.

b) *Design and Development Phase* — wherein the product hardware and software are created to perform the functions described in the product specification. This phase may conclude with the assembly of a prototype product and its test, either under laboratory-simulated conditions or in actual-field trial conditions or with the formulation of detailed manufacturing specifications and instructions for operation and maintenance.

*Electrotechnical vocabulary: Part 39 Reliability of electronic and electrical items (*first revision*).

c) *Manufacturing and Installation Phase* — during which the design is placed into production. In the case of large, complex products, the installation of the product on a particular site may be regarded as an extension of the manufacturing process. This phase may conclude with product acceptance testing before it is turned over to the customer.

d) *Operation and Maintenance Phase* — when the product is operated for the period of its useful life. During this phase, essential preventive and corrective maintenance actions are taken and product performance is monitered. The useful life of a product ends when its operation becomes uneconomic because of increasing repair costs or other factors, or the product becomes technically obsolete.

e) *Disposal Phase* — when the product reaches the end of its useful life, or the requirement no longer exists for the product, it is being disposed.

4. RELIABILITY AND MAINTAINABILITY PROGRAMME

4.1 To assemble an effective reliability and maintainability programme during the product life cycle phases requires not only a knowledge of reliability and maintainability principles, but an understanding of the product itself and its technology and the various cost factors. More effective results can be achieved if reliability and maintainability activities are integrated into all other activities connected with the product rather than managed separately.

4.2 In establishing a reliability and maintainability programme the management shall take into consideration the following criteria:

a) The level of reliability and maintainability required for the product,

b) The phase of the product in its life cycle,

c) Assignment of responsibility for each reliability and maintainability task,

d) The technology proposed for the product and past history of similar products, and

e) Programme constraints (such as scheduling and funding) and technical constraints (such as size, weight and programming language).

4.2.1 Using these criteria, the management may select appropriate reliability and maintainability activities from those described in **5** to establish an effective reliability and maintainability programme.

4.3 The basic classes of reliability and maintainability activities and areas of involvement indicating their principal associations with the life cycle phase of a product are tested in Table 1. An effective reliability and maintainability programme can be assembled by selecting the appropriate activities to suit specific needs and circumstances of product requirements.

4.3.1 The tasks called for in the reliability and maintainability programme shall be implemented by applying the procedures of relevant Indian Standards referred to in Appendix A.

5. RELIABILITY AND MAINTAINABILITY ACTIVITIES

5.0 The basic classes of reliability and maintainability activities and area of involvement from which a reliability and maintainability programme can be prepared are described in **5.1** to **5.12.**

5.1 Establishment of Reliability and Maintainability Plan and Objectives— A 'reliability and maintainability plan' should be established the during concept and definition phase to provide for an integrated series of tasks necessary to achieve reliability and maintainability objectives. The 'reliability and maintainability plan' selects the appropriate tasks required from the list of reliability and maintainability activities, assigns responsibility for each task, and provides a preliminary schedule for implementation.

The 'reliability and maintainability plan' should establish objectives in quantitative and qualitative terms and state criteria and conditions for their verification.

The reliability and maintainability plan should include the following minimum details:

a) An organization structure and management responsibilities for the reliability and maintainability activities associated with the product,

b) Quantitative and qualitative reliability and maintainability objectives,

c) Schedule for reliability and maintainability tasks implementation,

d) Criteria for reliability and maintainability assessment and product verification,

e) Parts control and standardization,

f) Design reviews,

g) Documentation, and

h) Training and support programmes.

5.2 Definition and Analysis of Operating Conditions — Operating conditions should be defined during the concept and definition phase and

TABLE 1 PRINCIPAL ASSOCIATION OF RELIABILITY AND MAINTAINABILITY ACTIVITIES WITH LIFE CYCLE PHASES

(*Clause* 4.3)

CLAUSE REFERENCE	LIFE CYCLE PHASES RELIABILITY AND MAINTAINABILITY ACTIVITY	CONCEPT AND DEFINITION	DESIGN AND DEVELOPMENT	MANUFACTURING AND INSTALLATION	OPERATION AND MAINTENANCE	DISPOSAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)
5.1	Establishment of reliability and Maintainability plan and objectives	×				×
5.2	Definition and analysis of operating conditions	×				
5.3	Evaluation of product reliability and maintainability base	×				
5.4	Establishment of maintenance policy and analysis of requirements	×	×		×	
5.5	Establishment of product design guidelines		×		×	
5.6	Evaluation of contractual reliability and maintainability requirements and interface	×	×	×	×	
5.7	Selection of reliability and maintainability analysis		×			
5.8	Evaluation of risk and cost	×	×			×
5.9	Provision of design reviews		×			
5.10	Verification and compliance		×	×		
5.11	Documentation and data		×	×	×	×
5.12	Training and support programmes		×	×	×	

updated during the design and development phase. These conditions have an influence on all the elements of operation and maintenance, and directly affect reliability and maintainability.

It is necessary to analyse the product environment in terms of following conditions:

a) Modes of operation,

b) Duty cycle and processing speed,

c) Operating and maintenance environment,

d) Transportation and installation conditions, and

e) Requirements for operating and maintenance personnel.

5.3 Evaluation of Product Reliability and Maintainability Base — Evaluation of product reliability and maintainability base forms part of an overall evaluation of product base. The purpose of the evaluation is to define the starting point for new design work and to assess the impact of reliability and maintainability features on the selection of technology, design configuration, and product performance capability to meet market requirements. There shall be an evaluation of cost and risk involved in bridging the gap from the existing product base to the new generation product.

Typical considerations for the evaluation of product base should include the following aspects:

a) New product functional requirements,

b) Market potential for new generation product,

c) Technological obsolescence of existing product,

d) Life cycle cost, and

e) Effort associated with new product development *versus* modification of existing product to meet new market demand.

5.4 Establishment of Maintenance Policy and Analysis of Requirements — The maintenance policy should be established early in the concept and definition phase. Reliability and maintainability task involvement includes the following:

a) Analysis of product maintainability and diagnostic features,

b) Levels for maintenance in product support and the repair policy of each,

c) Skill level of maintenance personnel, and

d) Test facilities at each level of maintenance.

The maintenance policy shall be appropriate to the service requirements associated with product operating conditions. In the design and

development phase, when more detailed design information becomes available, an analysis should be carried out of maintenance requirements so that appropriate reliability and maintainability features can be designed into the product.

5.5 Establishment of Product Design Guidelines — The reliability and maintainability programme should consider the basic standards applicable to the design, development, manufacture, and operation of the product, because these have an impact on the cost. The applicable standards include the following :

a) Customer and contractor standards such as those for manufacturing and design practices, part stress criteria and parts application, preferred part lists, approval of non-standard parts, maintenance test points, and design guidelines for maintainability features; and

b) Industry and government standards and regulations, such as those governing various aspects of safety, electromagnetic emission levels, pollution control lists and power consumption.

5.6 Evaluation of Contractual Reliability and Maintainability Requirements and Interface — The reliability and maintainability contractual requirements shall be reviewed and evaluated in terms of ability of product to comply with the specifications and standards called up.

Contractual reliability and maintainability contractual requirements shall also be evaluated in the light of their interface with other requirements, such as, safety, quality, field support and performance. Interaction among various programmes within the contractual requirements is needed so that a concerted effort can be made to provide a standard product in a cost-effective manner on schedule.

5.7 Selection of Reliability and Maintainability Analysis — The reliability and maintainability analysis to be performed shall be selected to assist in assuring that the product will be capable of meeting end-item application. Typical reliability and maintainability analysis that could be selected include the following:

a) Reliability and maintainability allocation and apportionment,

b) Thermal and electrical stress analysis and through part,

c) Parts application,

d) Reliability and maintainability predictions, and

e) Failure modes, effects and criticality analysis.

The reliability and maintainability plan shall establish a preliminary schedule for these analyses that takes into account the timing of major programme milestones and the costs of performing the analyses.

5.8 Evaluation of Risk and Cost — Cost is a significant element of each product development programme. An economic evaluation allows management to assess the risks and benefits over the system life cycle resulting from decisions made during the design and development phase. The decision-making process should consider the impact on:

a) Facilities, workload, and schedule;

b) Reliability and maintainability, operation, and safety;

c) Maintenance, logistic support and future requirements;

d) Cost of design, development and manufacture; and

e) Cost of ownership (operation, maintenance and energy).

The evaluation shall assess the risk of using new technology for achieving product objectives including reliability and maintainability, given the constraints of schedule, budget and technical specifications.

5.9 Provision of Design Reviews — Design reviews performed at specified intervals throughout the design and development phase as part of the product development programme enhance reliability and maintainability. The purpose of the design reviews is as under:

a) Assess the design options available,

b) Identify areas of design study toward product reliability and maintainability improvement,

c) Provide experience feedback to design authority, and

d) Document the design decision process.

5.10 Verification and Compliance — Reliability and maintainability verification tasks are normally carried out during the design and development phase to verify the adequacy of the design, during manufacturing to verify the conformance and producibility of the design, and during installation to verify product service performance. For large and complex systems the reliability and maintainability verification activities are often conducted in early operation phase to assess compliance of system service objectives.

5.10.1 Verification tasks include both analytical approach and testing taking into consideration the product performance history and the associated hardware and software failure characteristics of the product where applicable. Reliability growth phenomenon of newly developed products should be recognized and appropriate steps taken for reliability growth monitoring and verification. For each verification task a plan should be prepared that identifies the aim, intent, and expected results of the verification task. The plan should provide a schedule and assign responsibility for task performance. It should provide for distribution of results of the verification task, and, if possible, the action to be taken if the results

are not in line with expectations. Verification of results could serve as evidence for product reliability and maintainability compliance.

5.11 Documentation and Data — The extent of documentation and data requirements shall depend on the contract data requirements and data management objectives.

5.11.1 The reliability and maintainability programme should institute a system of events and reporting of results that ensures visibility of key events. Typical key events to be monitored should include the following:

a) Establishment of reliability and maintainability objectives.

b) Apportionment of reliability and maintainability requirements,

c) Testing,

d) Failure and fault occurrences,

e) Maintenance actions,

f) Part list development,

g) Analysis of data, and

h) Corrective action taken and results.

5.11.2 The events reporting system should provide for traceability of data and documentation of conditions under which the data were collected, the assumptions made, and the constraints on application of data. The reporting system should capture the minimum data necessary to achieve the objective; the output of the reporting system should be structured to the needs of recipients and distributed for appropriate action.

5.12 Training and Support Programmes — Training requirements shall be planned early in the reliability and maintainability programme. Training and support programmes should tie in with product development planning, maintenance policy and the operational strategy of the product.

5.12.1 Personnel shall be trained to operate, maintain and support the product. The training and support programmes should consider the type and level of training needed by the service personnel, the complexity of the product, the operation requirements, the maintenance and logistics support policy, the time and resources available, and facilities and tools needed.

5.12.2 The reliability and maintainability activities should complement other support functions such as given below:

a) Occupational and product safety;

b) Testing, manufacturing and life;

c) Quality control/assurance;

d) Inspection/measurements;

e) Calibration services;

f) Standardization;

g) Supplier/vendor/subcontractor activities;

h) Installation and field services; and

j) Spares provisioning.

APPENDIX A

(*Clauses* 0.2 *and* 4.3.1)

REFERRED INDIAN STANDARDS ON RELIABILITY

Cl Ref	*Reliability and Maintainability Activities*	*Applicable Standard*	
5.1	Establishment of reliability and maintainability plan and objectives	Electrotechnical vocabulary: Part 39 Reliability of electronic and electrical items (*first revision*)	IS : 1885 (Part 39) 1979
		Mathematical guide to the terms and definitions for reliability of electronic equipment and components (or parts) used therein.	IS : 7690-1975
		Guide on maintainability of equipments: Part 3 Maintainability programme.	IS : 9692 (Part 3)-1981
		Overall ability concept	*Under preparation*

Cl Ref	*Reliability and Maintainability Activities*	*Applicable Standard*	
5.4	Establishment of maintenance policy and analysis of requirements	Guide on maintainability of equipment: Part 1 Introduction to maintainability	IS : 9692 (Part 1)-1980
		Guide on maintainability of equipment: Part 2 Maintainability requirements in specifications and contracts	IS : 9692 (Part 2)-1980
		Guide on the maintainability of equipment: Part 5 Maintainability studies during the design phase	*Under preparation*
5.6	Establishment of contractual reliability and maintainability requirements and interface	Guide on reliability of electronic and electrical items: Part 6 Inclusion of reliability clauses into specifications for components (or parts) (*first revision*)	IS : 7354 (Part 6)-1983
		Guide on maintainability of equipment: Part 2 Maintainability requirements in specifications and contracts	IS : 9692 (Part 2)-1980
		Guide for the inclusion of reliability requirements into specifications for electronic equipment	*Under preparation*
5.7	Selection of reliability and maintainability analyses	Guide on maintainability of equipment: Part 5 Maintainability studies during the design phase	*Under preparation*
		Presentation of reliability, maintainability and availability predictions	IS : 10139-1982

Cl Ref	*Reliability and Maintainability Activities*	*Applicable Standard*	
		Analysis techniques for system reliability: Part 2 Procedure for failure mode and effects analysis (EMEA) and failure mode, effects and criticality analysis (EMECA)	*Under preparation*
5.9	Provision of design reviews	Reliability and maintainability design reviews	*Under preparation*
5.10	Verification and compliance	Guide for equipment reliability testing: Part 1 Principles and procedures	IS : 8161 (Part 1)-1976
		Guide for equipment reliability testing: Part 2 Design of test cycles	*Under preparation*
		Guide for equipment reliability testing: Part 4 Procedure for determining point estimates and confidence limits from equipment reliability determination tests	*Under preparation*
		Guide for equipment reliability testing: Part 3 Preferred test conditions for equipment reliability testing	*Under preparation*
		Guide for equipment reliability testing: Part 5 Compliance test plans for success ratio	IS : 8161 (Part 5)-1981
		Guide for equipment reliability testing: Part 6 Tests for validity of a constant failure rate assumption	IS : 8161 (Part 6)-1983

Cl Ref	*Reliability and Maintainability Activities*	*Applicable Standard*	
		Guide for equipment reliability testing: Part 7 Compliance test plans for failure rate and mean time between failures assuming constant failure rate	IS : 8161 (Part 7)-1977
		Guide on maintainability of equipment: Part 6 Maintainability verification	IS : 9692 (Part 6)-1983
5.11	Documentation and data	Guide on reliability of electronic and electrical items: Part 4 Collection of reliability availability and maintainability data from field performance	IS : 7354 (Part 4)-1974
		Guide on maintainability of equipment: Part 7 Collection, analysis and presentation of data related to maintainability	IS : 9692 (Part 7)-1984
		Guide on reliability of electronic and electrical items: Part 3 Presentation of reliability data on electronic and electrical components (or parts) (*first revision*)	IS : 7354 (Part 3)-1984

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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