IEC 60300-3-11

Edition 2.0 2009-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Dependability management –
Part 3-11: Application guide – Reliability centred maintenance

Gestion de la sûreté de fonctionnement –
Partie 3-11: Guide d'application – Maintenance basée sur la fiabilité

IEC 60300-3-11:2009

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:
Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,…). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:
Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 60300-3-11

Edition 2.0 2009-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Dependability management –
Part 3-11: Application guide – Reliability centred maintenance

Gestion de la sûreté de fonctionnement –
Partie 3-11: Guide d'application – Maintenance basée sur la fiabilité

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX X

ICS 03.100.40; 03.120.01

ISBN 978-2-88910-098-9

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

DEPENDABILITY MANAGEMENT –

Part 3-11: Application guide – Reliability centred maintenance

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60300-3-11 has been prepared by IEC technical committee 56: Dependability.

This second edition cancels and replaces the first edition, published in 1999, and constitutes a technical revision.

The previous edition was based on ATA[1]-MGS-3; whereas this edition applies to all industries and defines a revised RCM algorithm and approach to the analysis process.

1 The Air Transport Association of America.

The text of this standard is based on the following documents:

FDIS	RVD
56/1312/FDIS	56/1320/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

A list of all parts in the IEC 60300 series, under the general title *Dependability management* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be:

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Reliability centred maintenance (RCM) is a method to identify and select failure management policies to efficiently and effectively achieve the required safety, availability and economy of operation. Failure management policies can include maintenance activities, operational changes, design modifications or other actions in order to mitigate the consequences of failure.

RCM was initially developed for the commercial aviation industry in the late 1960s, resulting in the publication of ATA-MGS-3 [1][2]. RCM is now a proven and accepted methodology used in a wide range of industries.

RCM provides a decision process to identify applicable and effective preventive maintenance requirements, or management actions, for equipment in accordance with the safety, operational and economic consequences of identifiable failures, and the degradation mechanism responsible for those failures. The end result of working through the process is a judgement as to the necessity of performing a maintenance task, design change or other alternatives to effect improvements.

The basic steps of an RCM programme are as follows:

a) initiation and planning;
b) functional failure analysis;
c) task selection;
d) implementation;
e) continuous improvement.

All tasks are based on safety in respect of personnel and environment, and on operational or economic concerns. However, it should be noted that the criteria considered will depend on the nature of the product and its application. For example, a production process will be required to be economically viable, and may be sensitive to strict environmental considerations, whereas an item of defence equipment should be operationally successful, but may have less stringent safety, economic and environmental criteria.

Maximum benefit can be obtained from an RCM analysis if it is conducted at the design stage, so that feedback from the analysis can influence design. However, RCM is also worthwhile during the operation and maintenance phase to improve existing maintenance tasks, make necessary modifications or other alternatives.

Successful application of RCM requires a good understanding of the equipment and structure, as well as the operational environment, operating context and the associated systems, together with the possible failures and their consequences. Greatest benefit can be achieved through targeting of the analysis to where failures would have serious safety, environmental, economic or operational effects.

2 Figures in square brackets refer to the bibliography.

DEPENDABILITY MANAGEMENT –

Part 3-11: Application guide – Reliability centred maintenance

1 Scope

This part of IEC 60300 provides guidelines for the development of failure management policies for equipment and structures using reliability centred maintenance (RCM) analysis techniques.

This part serves as an application guide and is an extension of IEC 60300-3-10, IEC 60300-3-12 and IEC 60300-3-14. Maintenance activities recommended in all three standards, which relate to preventive maintenance, may be implemented using this standard.

The RCM method can be applied to items such as ground vehicles, ships, power plants, aircraft, and other systems which are made up of equipment and structure, e.g. a building, airframe or ship's hull. Typically, equipment comprises a number of electrical, mechanical, instrumentation or control systems and subsystems which can be further broken down into progressively smaller groupings, as required.

This standard is restricted to the application of RCM techniques and does not include aspects of maintenance support, which are covered by the above-mentioned standards or other dependability and safety standards.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-191:1990, *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 60300-3-2, *Dependability management – Part 3-2: Application guide – Collection of dependability data from the field*

IEC 60300-3-10, *Dependability management – Part 3-10: Application guide – Maintainability*

IEC 60300-3-12, *Dependability management – Part 3-12: Application guide – Integrated logistic support*

IEC 60300-3-14, *Dependability management – Part 3-14: Application guide – Maintenance and maintenance support*

IEC 60812, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*

3 Terms, definitions and abbreviations

For the purposes of this document, the terms and definitions of IEC 60050-191 apply, together with the following.

3.1 Definitions

3.1.1
age exploration
systematic evaluation of an item based on analysis of collected information from in-service experience to determine the optimum maintenance task interval

NOTE The evaluation assesses the item's resistance to a deterioration process with respect to increasing age or usage.

3.1.2
criticality
severity of effect of a deviation from the specified function of an item, with respect to specified evaluation criteria

NOTE 1 The extent of effects considered may be limited to the item itself, to the system of which it is a part, or range beyond the system boundary.

NOTE 2 The deviation may be a fault, a failure, a degradation, an excess temperature, an excess pressure, etc.

NOTE 3 In some applications, the evaluation of criticality may include other factors such as the probability of occurrence of the deviation, or the probability of detection.

3.1.3
damage-tolerant
capable of sustaining damage and continuing to function as required, possibly at reduced loading or capacity

3.1.4
failure (of an item)
loss of ability to perform as required

3.1.5
failure effect
consequence of a failure mode on the operation, function or status of the item

3.1.6
failure management policy
maintenance activities, operational changes, design modifications or other actions in order to mitigate the consequences of failure

3.1.7
function
intended purpose of an item as described by a required standard of performance

3.1.8
failure mode
manner in which failure occurs

NOTE A failure mode may be defined by the function lost or the state transition that occurred.

3.1.9
failure-finding task
scheduled inspection or specific test used to determine whether a specific hidden failure has occurred

3.1.10
functional failure
reduction in function performance below desired level

3.1.11
hidden failure mode
failure mode whose effects do not become apparent to the operator under normal circumstances

3.1.12
indenture level
level of subdivision of an item from the point of view of a maintenance action

NOTE 1 Examples of indenture levels could be a subsystem, a circuit board, a component.

NOTE 2 The indenture level depends on the complexity of the item's construction, the accessibility to subitems, skill level of maintenance personnel, test equipment facilities, safety considerations, etc.

[IEV 191-07-05:1990]

3.1.13
inspection
identification and evaluation of the actual condition against a specification

3.1.14
maintenance action
maintenance task
sequence of elementary maintenance activities carried out for a given purpose

NOTE Examples include diagnosis, localization, function check-out, or combinations thereof.

3.1.15 tem

part, component, device, subsystem, functional unit, equipment or system that can be individually considered

NOTE 1 An item may consist of hardware, software or both, and may also, in particular cases, include people. Elements of a system may be natural or man-made material objects, as well as modes of thinking and the results thereof (e.g. forms of organization, mathematical methods and programming languages).

NOTE 2 In French the term "entité" is preferred to the term "dispositif" due to its more general meaning. The term "dispositif' is also the common equivalent for the English term "device".

NOTE 3 In French the term "individu" is used mainly in statistics.

NOTE 4 A group of items, e.g. a population of items or a sample, may itself be considered as an item.

NOTE 5 A software item may be a source code,an object code, a job control code, control data, or a collection of these.

3.1.16
maintenance concept
interrelationship between the maintenance echelons, the indenture levels and the levels of maintenance to be applied for the maintenance of an item

3.1.17
maintenance echelon
position in an organization where specified levels of maintenance are to be carried out on an item

NOTE 1 Examples of maintenance echelons are: field, repair shop, and manufacturer.

NOTE 2 The maintenance echelon is characterized by the level of skill of the personnel, the facilities available, the location, etc.

[IEV 191-07-04:1990]

3.1.18
maintenance policy
general approach to the provision of maintenance and maintenance support based on the objectives and policies of owners, users and customers

3.1.19
maintenance programme
list of all the maintenance tasks developed for a system for a given operating context and maintenance concept

3.1.20
operating context
circumstances in which an item is expected to operate

3.1.21
potential failure
identifiable condition that indicates that a functional failure is either about to occur or is in the process of occurring

3.1.22
potential failure – functional failure (P-F) interval
interval between the point at which a potential failure becomes detectable and the point at which it degrades into a functional failure

3.1.23
reliability centred maintenance
method to identify and select failure management policies to efficiently and effectively achieve the required safety, availability and economy of operation.

3.1.24
safe life
age before which no failures are expected to occur

3.1.25
system
set of interrelated or interacting elements

[ISO 9000, 3.2.1][2]

NOTE 1 In the context of dependability, a system will have:

a) a defined purpose expressed in terms of required functions;

b) stated conditions of operation/use;

c) defined boundaries.

NOTE 2 The structure of a system may be hierarchical.

3.1.26
useful life
time interval to a given instant when a limited state is reached

NOTE 1 Limited state may be a function of failure intensity, maintenance support requirement, physical condition, age, obsolesence, etc.

NOTE 2 The time interval may start at first use, at a subsequent instant, i.e. remaining useful life.

3.2 Abbreviations

FMEA Failure mode and effects analysis

FMECA Failure mode, effects and criticality analysis

ILS Integrated logistic support

HUMS Health usage management systems

LORA Level of repair analysis

NDI Non-destructive inspection

RCM Reliability centred maintenance

4 Overview

4.1 General

The RCM process is fully described in this standard and provides information on each of the following elements:

a) RCM initiation and planning;

b) functional failure analysis;

c) task selection;

d) implementation;

e) on-going improvement.

Figure 1 shows the overall RCM process divided into five steps. It can be seen from this figure that RCM provides a comprehensive programme that addresses not just the analysis process but also the preliminary and follow-on activities necessary to ensure that the RCM effort achieves the desired results. The RCM process can be applied to all types of systems. Annex D provides guidance on how the process should be interpreted for structures for which the failure mechanisms and resultant tasks are more narrowly defined.

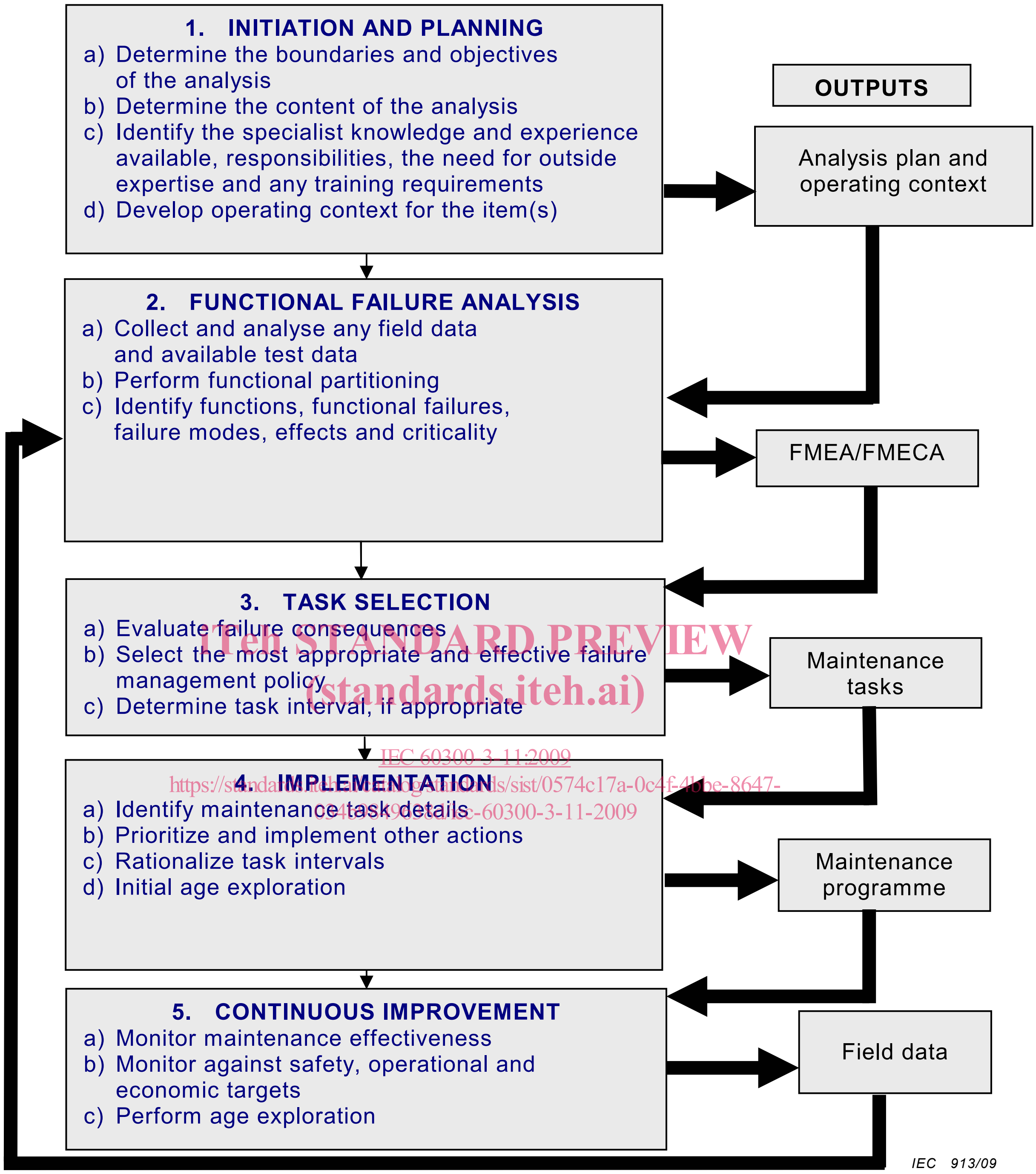
1. INITIATION AND PLANNING
a) Determine the boundaries and objectives of the analysis
b) Determine the content of the analysis
c) Identify the specialist knowledge and experience available, responsibilities, the need for outside expertise and any training requirements
d) Develop operating context for the item(s)
OUTPUTS
Analysis plan and operating context
2. FUNCTIONAL FAILURE ANALYSIS
a) Collect and analyse any field data and available test data
b) Perform functional partitioning
c) Identify functions, functional failures, failure modes, effects and criticality
FMEA/FMECA
3. TASK SELECTION
a) Evaluate failure consequences
b) Select the most appropriate and effective failure management policy
c) Determine task interval, if appropriate
Maintenance tasks
4. IMPLEMENTATION
a) Identify maintenance task details
b) Prioritize and implement other actions
c) Rationalize task intervals
d) Initial age exploration
Maintenance programme
5. CONTINUOUS IMPROVEMENT
a) Monitor maintenance effectiveness
b) Monitor against safety, operational and economic targets
c) Perform age exploration
Field data
IEC 913/09

Figure 1 – Overview of the RCM process

4.2 Objectives

As part of a maintenance policy, the objectives of an effective preventive maintenance programme are as follows:

a) to maintain the function of an item at the required dependability performance level within the given operating context;

b) to obtain the information necessary for design improvement or addition of redundancy for those items whose reliability proves inadequate;

c) to accomplish these goals at a minimum total LCC, including maintenance costs and the costs of residual failures;

d) to obtain the information necessary for the ongoing maintenance programme which improves upon the initial programme, and its revisions, by systematically assessing the effectiveness of previously defined maintenance tasks. Monitoring the condition of specific safety, critical or costly components plays an important role in the development of a programme.

These objectives recognize that maintenance programmes, as such, cannot correct design deficiencies in the safety and reliability levels of the equipment and structures. The maintenance programme can only minimize deterioration and restore the item to its design levels. If the reliability intrinsic levels are found to be unsatisfactory, design modification, operational changes or procedural changes (such as training programmes) may be necessary to achieve the desired performance.

RCM improves maintenance effectiveness and provides a mechanism for managing maintenance with a high degree of control and awareness. Potential benefits can be summarized as follows:

1) system dependability can be increased by using more appropriate maintenance activities;
2) overall costs can be reduced by more efficient planned maintenance effort;
3) a fully documented audit trail is produced;
4) a process to review and revise the failure management policies in the future can be implemented with relatively minimum effort;
5) maintenance managers have a management tool which enhances control and direction;
6) maintenance organization obtains an improved understanding of its objectives and purpose and the reasons for which it is performing the scheduled maintenance tasks.

The maintenance programme is a list of all the maintenance tasks developed for a system for a given operating context and maintenance concept, including those arising from the RCM process. Maintenance programmes are generally composed of an initial programme and an on-going, "dynamic" programme. Figure 2 shows the principal factors which need to be considered in the development stage, that is before operation, and those which are used to update the programme, based on operational experience, once the product is in service.

The initial maintenance programme, which is often a collaborative effort between the supplier and the user, is defined prior to operation and may include tasks based on the RCM methodology. The on-going maintenance programme, which is a development of the initial programme, is initiated as soon as possible by the user once operation begins, and is based on actual degradation or failure data, changes in operating context, advances in technology, materials, maintenance techniques and tools. The on-going programme is maintained using RCM methodologies. The initial maintenance programme is updated to reflect changes made to the programme during operation.

An initial RCM programme may be initiated when the product is in service, in order to renew and improve on an existing maintenance programme, based on experience or manufacturer's recommendations, but without the benefit of a standard approach such as RCM.