IEC 60706-5

Edition 2.0 2007-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Maintainability of equipment –
Part 5: Testability and diagnostic testing

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Maintenabilité de matériel –
Partie 5: Testabilité et tests pour diagnostic

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX XB

ICS 03.120.01; 03.120.30; 21.020

ISBN 2-8318-9295-3

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MAINTAINABILITY OF EQUIPMENT –

Part 5: Testability and diagnostic testing

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International Standard IEC 60706-5 has been prepared by IEC technical committee 56: Dependability.

This second edition cancels and replaces the first edition published in 1994. This second edition constitutes a technical revision. It expands and provides more detail on the techniques and systems broadly outlined in the first edition.

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

FDIS	Report on voting
56/1211/FDIS	56/1231/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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 60706 series, under the general title *Maintainability of equipment*, 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

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INTRODUCTION

Testability is an important feature in the operation and maintenance of a system or equipment and has a significant effect on its availability and maintainability. Diagnostic testing may be carried out manually or with test equipment which may contain various levels of automation. Optimum design for testability requires close cooperation between design, operation and maintenance organizations. This standard is intended to highlight the various aspects of testability and diagnostic testing and to assist in their timely coordination.

In this standard, items to be considered in respect of their testability design may be systems, equipment or functional units which are the objects of a contract, and will be referred to as "products". Each product has to perform its required functions which should be verified during the development and production phases and should be retained over the whole life cycle. For a product to retain its functionality, the functional status of each sub-function should be known at any time while the product is in its operating condition. If a failure occurs, action should be taken to ensure that the fault is recognized and the faulty item localized. This requirement placed on the testability of a product might appear to be quite simple, but if it is not considered at the start of product development, subsequent realization will result in increased work and significantly increased cost. If all requirements are available at the start of development, the development engineer can specify the functional characteristic "testability" without much additional effort and therefore achieve considerable cost savings e.g. by minimizing the number of test steps for verifying the development results. Experience has shown that the extra cost and effort in the development phase can be recovered for example in the production phase since available test equipment can be used. Reliable fault recognition and low in-service maintenance costs increase the market value of a testable product considerably.

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As the technologies which are applied in the products covered by this standard are wide-ranging, this document has been written in a neutral manner with regard to technologies and techniques. This standard therefore only provides an assessment basis for making calculations and the basic approach for achieving the required testability of a product. The technical realization of fault recognition and fault localization in the product is the task of the product development engineer and has to be achieved according to the state of the art at the time when the product is being developed. It is therefore not of great importance whether the required test task is realized in hardware or software form, but it is essential that all functions are checked via test paths and that the characteristic values established for testability correspond to the specified target values. If there are deviations from the target values, action should be taken to ensure that the target values are met. These actions should take place at an early stage of development before freezing the design.

MAINTAINABILITY OF EQUIPMENT –

Part 5: Testability and diagnostic testing

1 Scope

The purpose of this part of IEC 60706 is to

- provide guidance for the early consideration of testability aspects in design and development;
- assist in determining effective test procedures as an integral part of operation and maintenance.

This International Standard can be applied to all types of products which may include commercial off-the-shelf (COTS) items. In this respect, it does not matter whether the product belongs to mechanical, hydraulic, electrical or some other technology. In addition, this International Standard applies to the development of any products, with the aim of designing the product characteristics so that they are verifiable (testable).

The objective of this International standard is to ensure that prerequisites relating to the testability of products are defined in the preliminary phases of development, laid down by the customer, implemented, documented and verified during development.

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This International Standard also provides methods to implement and assess testability as an integral part of the product design. It recommends that the product testability documentation should be continually updated over the product's life cycle.

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2 Normative references

The following 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, *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 60706-2, *Maintainability of equipment – Part 2: Maintainability requirements and studies during the design and development phase*

IEC 60706-3, *Maintainability of equipment – Part 3: Verification and collection, analysis and presentation of data*

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

3 Terms, definitions and acronyms

3.1 Terms and definitions

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

3.1.1
built-in test
BIT
integrated capability of a test item enabling automatic fault recognition and fault localization

3.1.2
built-in test equipment
BITE
hardware and/or software assigned to the built-in test

3.1.3
commercial off-the-shelf
COTS
designates items readily available commercially

3.1.4
criticality
significance attached to a malfunction

NOTE Criticality is expressed in grades: the higher the grade, the more severe the consequences to be expected from the malfunction.

3.1.5
depth of test
specification of the level to which the unit or sub-unit is to be identified

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3.1.6
design level
level to which the design elements (functional and/or physical units), when they already exist, are assigned within the product breakdown structure

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NOTE In some cases “design level” is known as “indenture level”.

3.1.7
diagnosis correctness
proportion of faults of an item that can be correctly diagnosed under given conditions

3.1.8
diagnostic testing
test procedure carried out in order to make a diagnosis

3.1.9
false alarm
indication of failure which, after carrying out failure finding activities, is not found

3.1.10
false alarm rate
the percentage of false alarms in the total number of failure indications

3.1.11
fault recognition time
period of time between the instant of failure and fault recognition

3.1.12
fault simulation
inclusion of faults by non-destructive interventions in the hardware units and/or, where necessary, simulation via software in order to verify the diagnostic capability

3.1.13
function
performance required of the item

NOTE A function is always associated if realised with an item of a given level in the product breakdown structure.

3.1.14
functional model
conceptual representation of an item describing the interrelationship and dependencies between its stimuli and measurement (response) terminals

NOTE The functional model, which arises during the development of a product, is in principle a block diagram showing the functions of the product and supplemented to include the test paths envisaged by the developer.

3.1.15
functional test
testing of all the specified functions of hardware units to prove their functional capability

3.1.16
hardware unit
design element which represents functions and/or sub-functions in the form of hardware, possibly including software components

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3.1.17
line replaceable unit
LRU
replaceable hardware or software unit which can be replaced directly on the equipment by the user or by a maintenance support facility

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3.1.18
maintenance concept
interrelationship between the design levels and the levels of maintenance to be applied for the maintenance of an item

3.1.19
maintenance policy
general approach to the provision of maintenance and maintenance support based on the objectives and policies of owners, users and customers

3.1.20
monitoring
automatic supervision of the functions required for the operation in a selected operational mode; operation should not be affected by this

3.1.21
operational context
circumstances in which an item is expected to operate

3.1.22
parameter
physical quantity that specifies a function

3.1.23
product
specified deliverable goods or service

NOTE 1 In the context of dependability, a product may be simple (e.g. a device, a software algorithm) or complex e.g. a system or an integrated network comprising of hardware, software, human elements, support facilities and activities).

NOTE 2 Product has its own life cycle phases.

NOTE 3 Product has the same definition as item.

3.1.24
product breakdown structure
hierarchical tree visualizing the physical composition of a product by assemblies of units and sub-units

3.1.25
shop replaceable unit
SRU
replaceable hardware or software unit which can be replaced by the user depot/workshop or by the maintenance support facility at the same level or in the company's workshops

3.1.26
signal
variation of a physical quantity used to represent data

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NOTE A signal is represented by one or several parameters.

3.1.27
specification
detailed definition of the functions of an item for a given level of the product breakdown structure

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NOTE Specifications should be derived from the systems requirements and be verifiable.

3.1.28
statement of work
SoW
document which defines goods and services to be provided.

NOTE The statement of work is prepared or accepted by the customer and defines the work for which a contract is to be placed and which is to be provided by the contractor. It therefore forms the main technical document according to which the bidders present their offers, the contractor performs the work and the customer accepts the goods and services provided.

3.1.29
stimulus
input signal with defined parameters for the purpose of triggering functions

3.1.30
sub-function
sub-division of a function (see also function, 3.1.13)

3.1.31
terminal
generic term for the physical access points to the signals of a test item. Examples of physical implementations or relevant terms for synonymous expressions are

– pin

– connector
– plug/plug-type connector
– test point
– interface
– port

NOTE A terminal is generally identified by a unique identifier.

3.1.32
test concept
description of the results of the system testability requirements analysis and stipulation of the method of how the requirements are to be met

3.1.33
test coverage
ratio of the number of faulty functions actually capable of diagnosis by the given test instruction to the total number of functions

3.1.34
test equipment
tools (hardware and/or software) required for conducting tests

NOTE Due to the technology involved, these are divided into internal (BITE) and external test equipment.

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3.1.35
test instruction
document describing how the tests required in the test specification are to be implemented

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3.1.36
test path
description of the assignment of hardware units to their terminals, taking the associated test steps into account

NOTE In addition, the test path defines the (functional) relationship between the stimulus and the response.

3.1.37
test sequence
series of test steps

3.1.38
test specification
document in which test sequences, parameters and functions are specified

3.1.39
test step
smallest unit in a test conducted on a hardware unit

3.1.40
test task
sum of all the tests necessary to meet the specifications of fault recognition and localization

3.1.41
testability
design characteristic which determines the degree to which an item can be functionally tested under stated conditions

3.2 Acronyms

ATE	automatic test equipment
ATS	automatic testing system
BIT	built-in test
BITE	built-in test equipment
COTS	commercial off-the-shelf
DP	data processing
FL	fault localization
FM	functional monitoring
FME(C)A	failure mode, effects, (and criticality) analysis
FR	fault recognition
FT	functional test
FTA	fault tree analysis
HWE	hardware unit
LCC	life cycle cost
LORA	level of repair analysis
LRU	line replaceable unit
PCB	printed circuit board
SoW	statement of work
SRU	shop replaceable unit
SF	sub-function
TS	technical specification

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4 Description of testability and diagnostic testing

4.1 General

The efficient and cost effective operation and maintenance of products is aided by ensuring that testability is considered during design and also during all the phases of the life cycle. Applicable diagnostic testing methods are then incorporated into the product as a component of the maintenance concept. Implementation of testability and diagnostic testing is accomplished throughout the life cycle of a product.

Life cycle cost (LCC) is an increasingly important aspect in evaluating the quality of any design. In addition to the immediate acquisition cost, many customers demand control of the costs associated with day to day operation, maintenance and logistic support. These costs are primarily influenced by the product's reliability, maintainability and maintenance support characteristics. In this context, the application of diagnostic testing techniques can be a significant contributory factor in the reduction of certain cost elements in the LCC. Constraints resulting from LCC optimization efforts should therefore be taken into account whenever diagnostic testing requirements are established.

This International Standard is intended to be applicable to all phases of the life cycle, i.e. from the time when the need for a product is identified through the design and development phase, to the manufacturing and installation phase and finally to the operation and maintenance phase as follows (see also Figure 1).

a) **Design and development phase**
From the concept down to the realization of a product, the requirements placed on a