

Reliability stress screening —

Part 1: Repairable assemblies manufactured in lots

The European Standard EN 61163-1:2006 has the status of a
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ICS 31.020

National foreword

This British Standard is the UK implementation of EN 61163-1:2006. It is identical to IEC 61163-1:2006. It supersedes BS 5760-16-1:1996 which is withdrawn.

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Part 1: Repairable assemblies manufactured in lots
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Déverminage sous contraintes
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(CEI 61163-1:2006)

Zuverlässigkeitsvorbehandlung
durch Beanspruchung
Teil 1: Instandsetzbare Baugruppen,
losweise gefertigt
(IEC 61163-1:2006)

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CENELEC

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Foreword

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CONTENTS

INTRODUCTION.....	6
1 Scope	9
2 Normative references	9
3 Terms and definitions	11
4 Symbols	13
5 General description	13
5.1 The reliability stress screening principle	13
5.2 Failure categories.....	15
5.3 Time of occurrence of failures	16
6 Planning.....	16
6.1 Stress conditioning	16
6.2 Evaluation of the failure-free period T_M	18
6.3 Time graphs for determination of the failure-free period.....	20
7 Pilot-production screening	25
7.1 General.....	25
7.2 Collection of information	25
7.3 Evaluation of information	25
7.4 Re-evaluating the failure-free period T_M	26
8 Mature production screening.....	27
8.1 General.....	27
8.2 Collection of information	27
8.3 Evaluation of information	27
8.4 Dealing with discrepancies.....	27
8.5 Eliminating reliability stress screening.....	29
Annex A (informative) Stress conditions – General information	30
Annex B (informative) Stress conditions – Temperature	33
Annex C (informative) Stress conditions – Vibration and bump.....	37
Annex D (informative) Stress conditions – Humidity	43
Annex E (informative) Stress conditions – Operational stress.....	46
Annex F (informative) Voltage stress.....	48
Annex G (informative) Highly accelerated stress screening	49
Annex H (informative) Bimodal distributions – Weibull plotting and analysis	50
Annex I (informative) Evaluation of the failure-free period and the average screening duration.....	56
Annex J (informative) Worked example.....	66
Annex ZA (normative) Normative references to international publications with their corresponding European publications.....	81
Bibliography	80

Figure 1 – Conceptual difference between reliability screening and growth.....	7
Figure 2 – Typical flow for the design and modifications of reliability stress screening processes for repairable assemblies	8
Figure 3 – Typical flow of hardware assemblies from the component manufacturer to the end user	10
Figure 4 – Reliability stress screening of repairable assemblies	14
Figure 5 – Dependency of categories of failures	16
Figure 6 – Elements of stress conditioning	16
Figure 7 – Assembly showing screening duration.....	18
Figure 8 – Time graphs for the determination of the failure free period	21
Figure 9 – Example of an experimentally determined Weibull curve that is levelling off at p % failures	26
Figure H.1 – The S-curve for a bimodal Weibull distribution mixed by $F(t) = 1 - e^{-\left(\frac{t}{30}\right)^{1,5}}$ and $F_2(t) = 1 - e^{-\left(\frac{t}{60000}\right)}$ in the proportions 15 % and 85 %, respectively	51
Figure H.2 – Estimation of p , β_1 and η_1 for the purpose of reliability screening optimization	52
Figure H.3 – The c.d.f. curves for bimodal exponential distribution	54
Figure H.4 – The hazard rate function for bimodal exponential distribution	55
Figure I.1 – The basic system	56
Figure I.2 – An assembly surviving the screening period T_M with n_{RE} remaining weak components	58
Figure I.3 – Possible states when a component fails during the stress screening.....	58
Figure I.4 – Assembly states after failure and repair	58
Figure I.5 – Time graph for evaluation of the failure-free screening period.....	60
Figures I.6a and I.6b – Average screening duration versus the normalized failure-free period $\frac{T_M}{m_{F1}} - p_C = 0,0005$ and $p_C = 0,001$	62
Figures I.6c and I.6d – Average screening duration versus the normalized failure-free period $\frac{T_M}{m_{F1}} - p_C = 0,002$ and $p_C = 0,005$	63
Figures I.6e and I.6f – Average screening duration versus the normalized failure-free period $\frac{T_M}{m_{F1}} - p_C = 0,015$ and $p_C = 0,02$	64
Figures I.6g and I.6h – Average screening duration versus the normalized failure-free period $\frac{T_M}{m_{F1}} - p_C = 0,03$ and $p_C = 0,04$	65
Figure J.1 – Derivation of the failure-free period T_M	69
Figure J.2 – Derivation of the average screening duration.....	71
Figure J.3 – Weibull plot of the observed and predicted failure pattern for the pilot production PBAs	74

Figure J.4 – Weibull plot of relevant failures and predicted S-curve for the pilot production screening	76
Figure J.5 – Time graph (corrected) for determination of the failure-free period	77
Figure J.6 – Time graph (corrected) for evaluation of the screening duration	78
Table A.1 – Stress types – Indication of cost of application	31
Table J.1 – Relation between sensitivity of flaws and stresses	68
Table J.2 – Observed failure ranks and times to first failure for the pilot production	72
Table J.3 – Revised rank values	75

INTRODUCTION

Quality control and good design are prerequisites for reliability. However, in cases where an assembly has an unacceptably low reliability in the early failure period, a reliability screening process may be necessary.

An unacceptably low reliability level can be different from one customer to another, or can be based on general market requirements.

Reliability stress screening (RSS) and reliability growth programmes both aim at improvements in the reliability found by the user. However, the two methods are different in principle:

- a reliability growth programme is a development activity, the purpose of which is to improve the inherent reliability performance of the assemblies by effecting changes to the design (see IEC 61014 and IEC 61164);
- the purpose of reliability stress screening is to detect and remove flaws; it is part of the production process, and should not be relied upon to reveal inadequacies in design.

Furthermore, the two methods affect the reliability performance differently. This is illustrated in Figure 1. In principle, a reliability screening programme "cuts away" the early failure period (or part thereof), while a reliability growth programme reduces the overall failure rate level. A reliability growth programme may affect the need for a reliability screening programme if the flaws are of such a nature that they can be prevented from being present at all.

The user of this standard should be aware that reliability stress screening does not improve the intrinsic reliability of the assemblies under consideration and, where possible, should be made unnecessary by reliability growth programmes and/or quality control.

In this standard the term "Item" is used when it is not necessary to distinguish between components, assemblies and system(s).

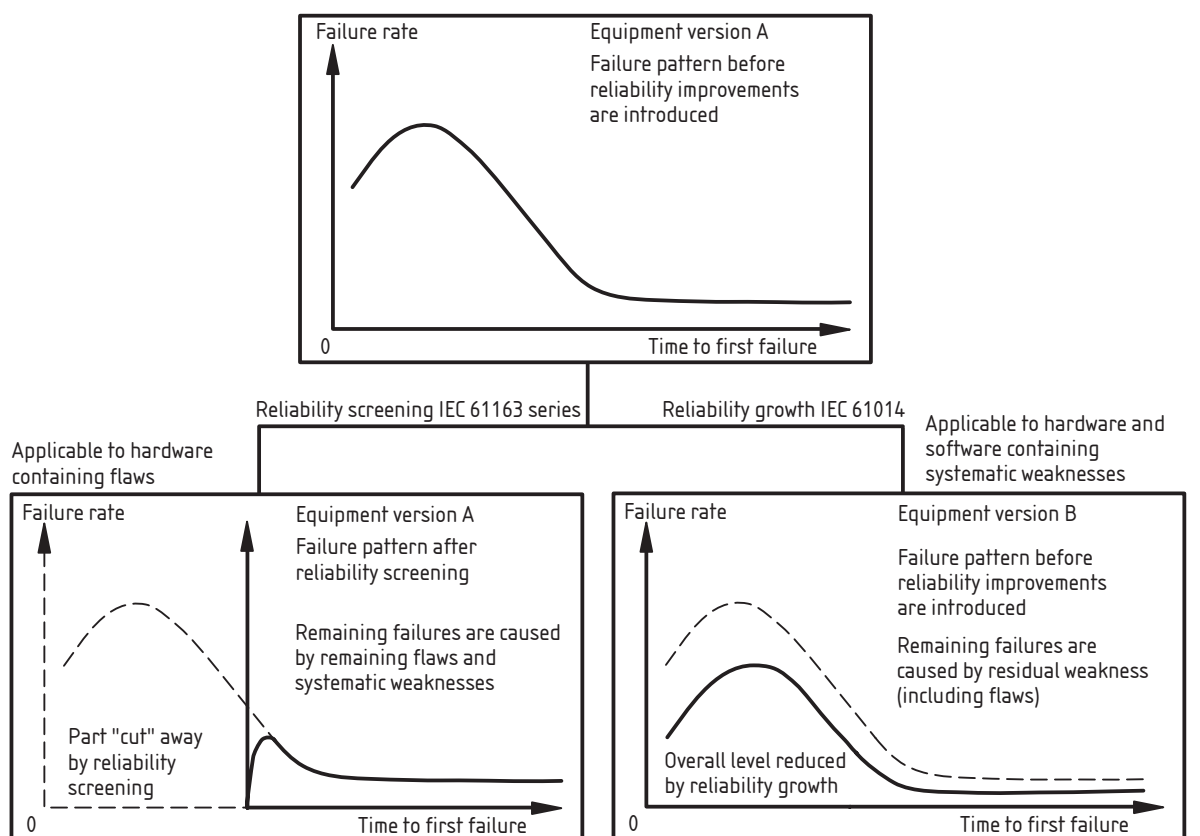
The specific purpose of carrying out a reliability screening process is to detect and remove flaws in hardware assemblies before they reach the customer, or are assembled into higher-level products. This means that, in principle, every hardware assembly under consideration should be included when a reliability screening process is introduced into a production process.

Reliability screening may cover hardware assemblies of different types and at different levels of the manufacturing process. This standard covers composite items – assemblies which are intended to be repaired. Once the allowable fraction of weak assemblies has been specified, the methods in this standard lead to the most economical screening process for assemblies that are manufactured in lots. This is because not all types of assemblies need to be subjected to a reliability screening process. Only the types of assemblies likely to contain flaws should be included. Furthermore, the extent (stress conditions, duration, etc.) to which these selected assembly types will be subjected to screening needs to be minimized.

In reliability stress screening the flaws are precipitated into failures by exposure of the assemblies to a suitable stress, for example environmental stress, operational stress, or a combination of these. Reliability stress screening is often called environmental stress screening (ESS).

If rogue components are known about and proved to originate in the component manufacturing process, it is much more effective to use screening e.g. burn-in of the rogue components in question instead of the assembly. However screening a component cannot remove flaws introduced in the assembly process (e.g. soldering, handling (ESD) etc.).

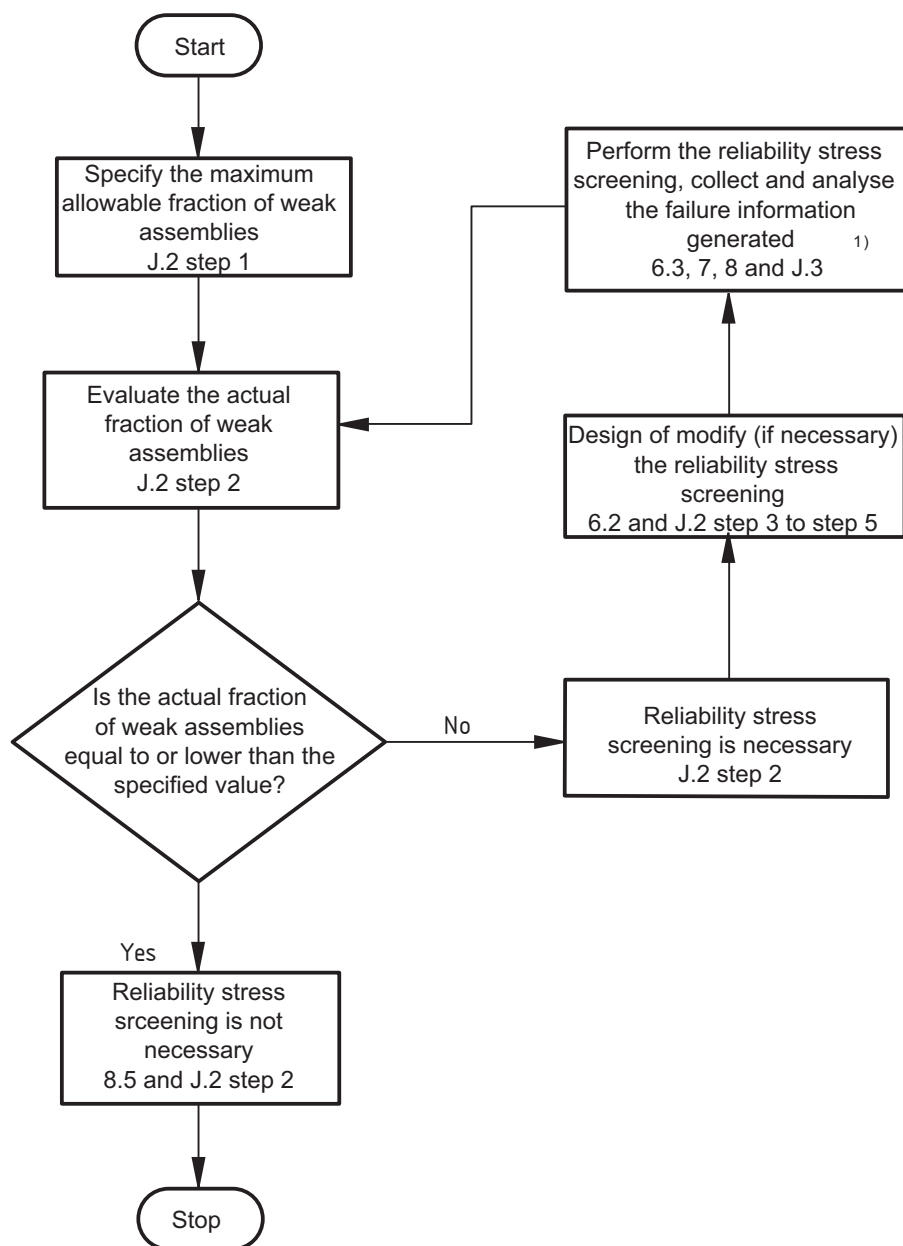
The typical steps in a reliability stress screening process are illustrated in Figure 2.



IEC 1026/06

NOTE This standard addresses reliability screening only. For reliability growth see IEC 61014 and IEC 61164.

Figure 1 – Conceptual difference between reliability screening and growth



IEC 1027/06

¹⁾ The result of the analysis of the failure causes may be used in a reliability growth and quality control programme.

Figure 2 – Typical flow for the design and modifications of reliability stress screening processes for repairable assemblies

RELIABILITY STRESS SCREENING –

Part 1: Repairable assemblies manufactured in lots

1 Scope

This part of IEC 61163 describes particular methods to apply and optimize reliability stress screening processes for lots of repairable hardware assemblies, in cases where the assemblies have an unacceptably low reliability in the early failure period, and when other methods, such as reliability growth programmes and quality control techniques, are not applicable. The reasons for using reliability stress screening may be time constraints and/or the very nature of the deficiencies that the reliability stress screening is designed to catch.

The processes apply to any stage of a series production of repairable assemblies (see Figure 3). The methods for setting up a process can be used during production planning, during pilot-production, as well as during well-established running production.

A prerequisite for the application of the methods is that a certain level of flaws remaining in the outgoing assembly can be specified.

The processes described are general processes for reliability stress screening in cases where no specific process is described in a product standard. They are also intended for use by IEC committees in connection with preparation of product standards. A reliability stress screening process can form part of an overall reliability programme (see IEC 60300-2).

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): *International Electrotechnical Vocabulary (IEV) – Chapter 191: Dependability and quality of service*

IEC 60068-2-2: *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6: *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14: *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-29: *Environmental testing – Part 2-29: Tests – Test Eb and guidance: Bump*

IEC 60068-2-30: *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-64: *Environmental testing – Part 2-64: Test methods – Test Fh: Vibration, broad-band random (digital control) and guidance*

IEC 60068-2-78: *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

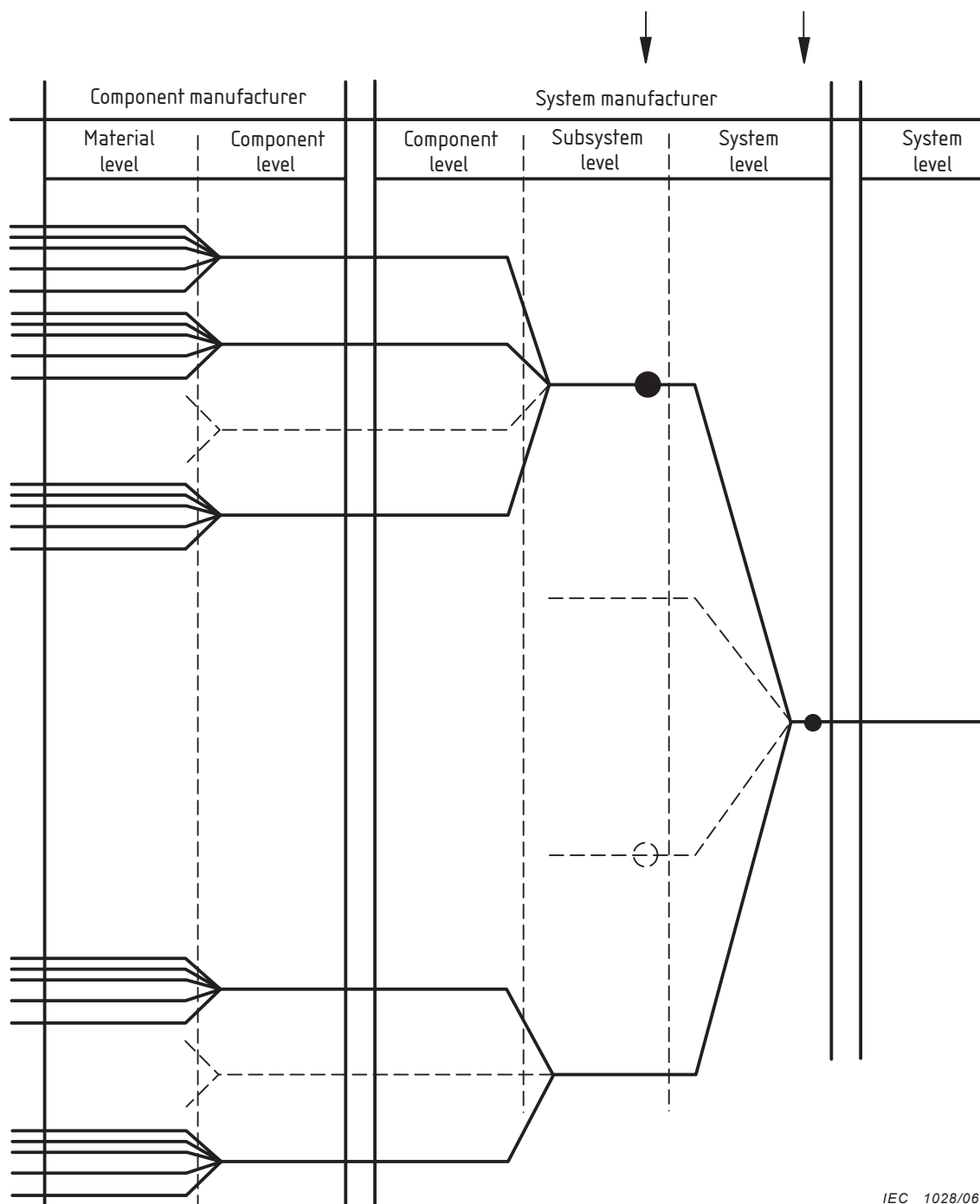
IEC 60300-2: *Dependability management – Part 2: Guidelines for dependability management*

IEC 61165: *Application of Markov techniques*

IEC 61649, *Goodness-of-fit tests, confidence intervals and lower confidence limits for Weibull distributed data*

ISO 2041, *Vibration and shock – Vocabulary*

Possible applications of reliability stress screening process for repairable items as indicated by the arrows below.



IEC 1028/06

NOTE Screening may be made on subsystems (left black circle and open circle) or on system level (right black circle).

Figure 3 – Typical flow of hardware assemblies from the component manufacturer to the end user

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE 1 Unless otherwise stated, general reliability terms used in this standard conform to IEC 60050(191).

NOTE 2 Terms of particular importance for reliability stress screening of repairable assemblies are quoted with the IEC 60050(191) reference number stated in square brackets. Where certain notes do not apply, the term "modified" has been used. All comments on an IEC term, relevant to reliability stress screening, are stated as "additional notes".

NOTE 3 Other terms defined in this clause are specific to reliability stress screening.

3.1

reliability improvement

process undertaken with the deliberate intention of improving the reliability performance by eliminating causes of systematic failures and/or by reducing the probability of occurrence of other failures

[IEV 191-17-05]

ADDITIONAL NOTE Reliability stress screening reduces the probability of occurrence of other failures. The systematic failures are principally catered for by a reliability growth programme, but some may appear during reliability screening.

3.2

reliability screening

process of detection of flaws and removal or repair of weak assemblies for the purpose of reaching rapidly the reliability level expected during the useful life

NOTE 1 IEV 191-17-02 defines the term "burn-in". This term, however, is used by many manufacturers to describe a so-called "soak test", which is only one of many possible ways of screening. Furthermore, "burn-in" may include ageing, the purpose of which is to stabilize parameters, and in many cases where no failures occur.

NOTE 2 IEV 191-14-09 defines the term "screening test". This term, however, is defined too broadly to be applicable in the present context, because it encompasses screening for any type of non-conformities. Furthermore, reliability screening is a process, not a test.

3.3

reliability stress screening

reliability screening process using environmental and/or operational stresses as means of detecting flaws by precipitating them as detectable failures

NOTE Reliability stress screening is designed with the intention of precipitating flaws into detectable failures. An ageing process designed with the intention of stabilizing parameters is not a reliability screening process, and therefore, lies outside the scope of this standard.

3.4

item

any 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.

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 number of items, for example a population of items or a sample, may itself be considered as an item.

[IEV 191-01-01]

ADDITIONAL NOTE 1 In this standard the term "item" is used when there is no need to distinguish between components, assemblies and system(s)

ADDITIONAL NOTE 2 In the context of reliability screening, only the hardware part of an item is relevant. Current examples are electronic components, assemblies, equipment, and hardware parts of systems.

3.5

assembly

any composite item which is intended to be repaired

3.6

weak assembly

assembly which has a high probability of failing early in life, due to a flaw

3.7

component

any single item which is not intended to be repaired

3.8

component class

group of components characterized by having one or more of the following features in common

- technology;
- type;
- manufacturer;
- batch

3.9

rogue component class

component class, which is likely to contain components with inherent and/or induced flaws

NOTE The lifetime distribution of a rogue component class can, for the purpose of reliability stress screening, be approximated with a bimodal distribution. This means that the individual component may be either weak or strong.

3.10

relevant failure

failure that should be included in interpreting test, or operational results, or in calculating the value of a reliability performance measure

NOTE The criteria for inclusion should be stated.

[IEV 191-04-13]

ADDITIONAL NOTE The criterion for inclusion here is that the failure is caused by either an induced or an inherent flaw.

3.11

weakness

any imperfection (known or unknown) in an assembly, capable of causing one or more weakness failures

NOTE Each type of weakness is assumed to be statistically independent of all other such types.

3.12

weakness failure

failure due to weakness in the assembly itself when subjected to stress within the stated capability of the assembly

NOTE A weakness may be either inherent or induced.

[IEV 191-04-06, modified]

3.13

flaw

weakness in hardware which gives rise to early weakness failures

NOTE A flaw is localized to a component, or to an interaction between components, with characteristics close to the margins of the design requirements.

3.14

inherent flaw

flaw in an assembly related to its technology and manufacturing process

3.15

induced flaw

flaw in an assembly related to assembling, testing, handling, or other manipulation of the assembly after it has been manufactured

NOTE The induction may take place at the component manufacturer's plant, during transportation or at the system manufacturer's plant.

3.16

early failure period

that early period, if any, in the life of an item, beginning at a given instant of time and during which the instantaneous failure intensity for a repaired item, or the instantaneous failure rate for a non-repaired item, is considerably higher than that of the subsequent period

[IEV 191-10-07, modified]

ADDITIONAL NOTE The early failure period is the period where the weak assemblies fail.

4 Symbols

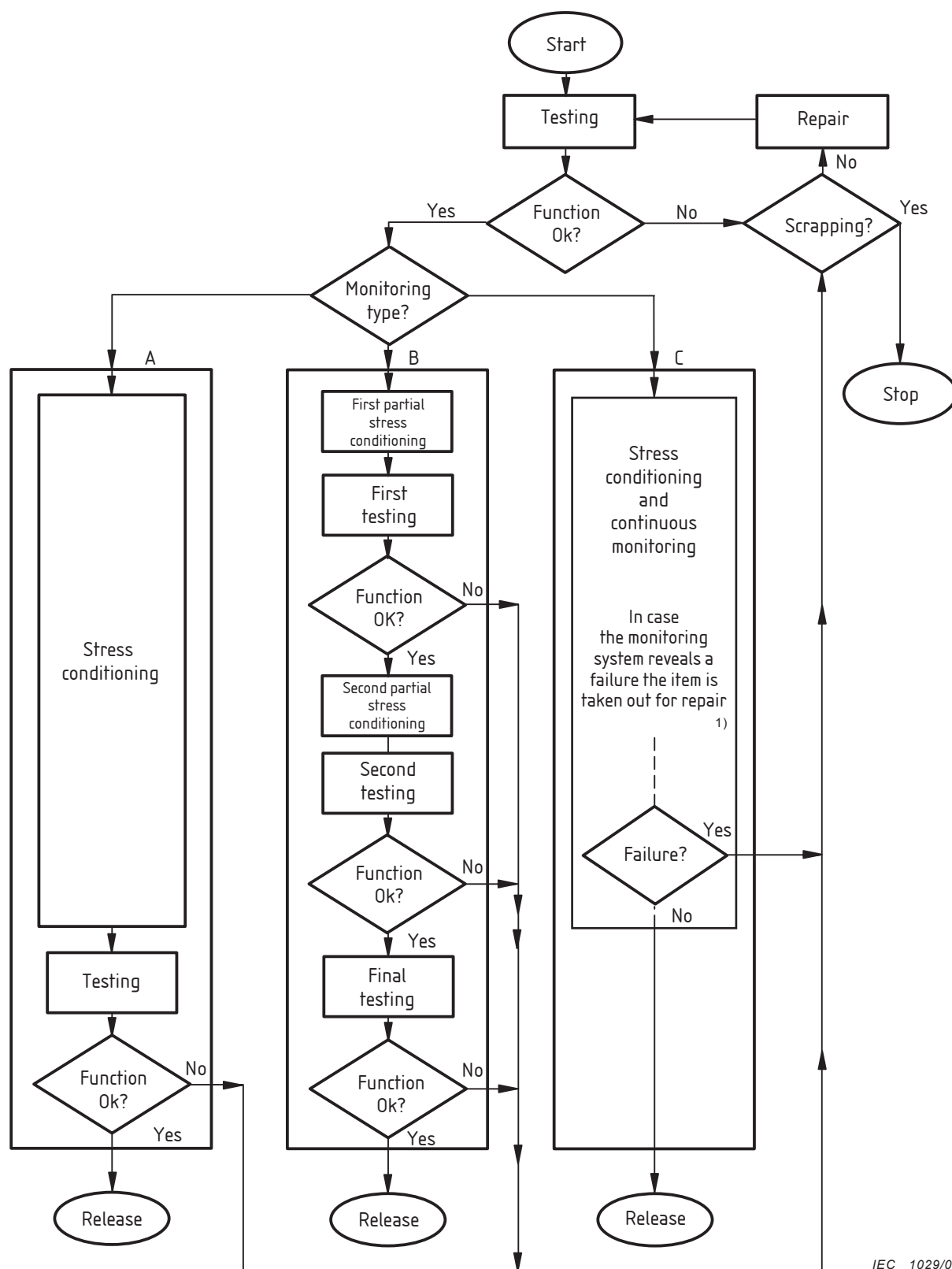
For the purposes of this standard, the following symbols apply.

m_{F1}	the mean time to failure for the weak components in the rogue component classes lumped together
m_{Fs}	the mean time to first failure for the weak assemblies among the assemblies under consideration
N	the sum of the numbers of components in the rogue component classes
p_B	the acceptable fraction of weak assemblies remaining after reliability stress screening
p_C	the fraction of weak components in the rogue component classes lumped together
p_s	the fraction of weak assemblies before reliability stress screening
T_B	average duration of reliability screening per assembly
T_M	the failure-free period an assembly has to survive before submission to the next production step or to the customer

5 General description

5.1 The reliability stress screening principle

The general principle of reliability stress screening is shown on the flow diagram in Figure 4. According to this principle, an assembly shall survive a so-called "failure-free period", T_M , before it is released to the next step of production, or to the customer. Other screening principles may be possible, but are not covered by this standard.



1) Sometimes it may not be practical to remove and repair the failed assemblies before the end of the period T_M (see 6.1.3).

Figure 4 – Reliability stress screening of repairable assemblies

The flow diagram shows three alternatives in connection with stress conditioning:

- alternative A shows two function checks, one before and one after the stress conditioning;
- alternative B shows performance monitoring at discrete points in time with time intervals, preferably selected according to a logarithmic scale, so that the closest monitoring takes place at the beginning of the stress conditioning;
- alternative C shows continuous monitoring during the entire stress conditioning. This alternative is preferable, especially for complex products, because of:
 - time and cost saving;
 - detection of intermittent failures and of failures present only during the action of the stress;
 - avoidance of stressing after a failure.

Performance monitoring is of particular importance during pilot-production reliability stress screening. During reliability stress screening of mature production the performance monitoring under stress conditioning may be deleted, according to the circumstances. However, the two function checks, one before and one after the stress conditioning period, can never be omitted. It is essential that assemblies are not put directly under stress conditioning without the initial function check.

The extent and the details of the functional checking before, during and after the stress conditioning depend strongly on the nature and intended function of the assemblies in question. This standard contains no guidance in that respect. The procedures described hereafter, however, presume that the function checks are efficient in evidencing failures.

The further details of the screening procedures depend on the time phase from product design to mature production. Three stages are considered:

- planning of reliability stress screening;
- pilot-production reliability stress screening;
- mature production reliability stress screening.

5.2 Failure categories

Assemblies that fail during a reliability stress screening shall be carefully examined in order to establish the failure modes, mechanisms, and/or causes.

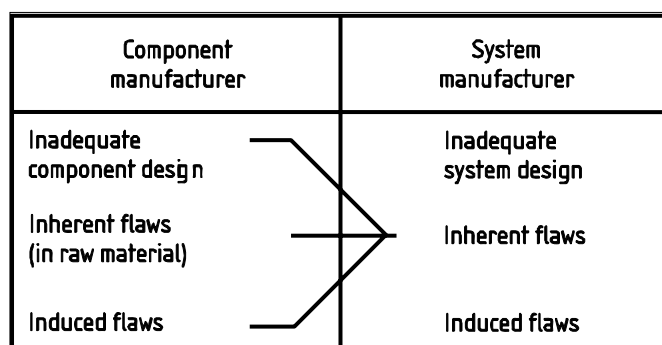
For the purpose of defining corrective actions, the failure shall be classified according to the following three categories, based on an assessment of the above-mentioned examination result:

- a) inadequate product design;
- b) inherent flaws;
- c) induced flaws.

Referring to Figure 5, the classification may differ depending on whether the assessment takes place at the component manufacturer's or at the assembly manufacturer's.

Inadequate component design and flaws induced into the component by the component manufacturer become inherent flaws for the assembly manufacturer.

In most cases, only the induced and inherent flaws can be weeded out by the screening process. However, in some cases a screening process may be applied to cater for marginal design problems, and/or for processes, which are difficult to control.



IEC 1030/06

Figure 5 – Dependency of categories of failures

5.3 Time of occurrence of failures

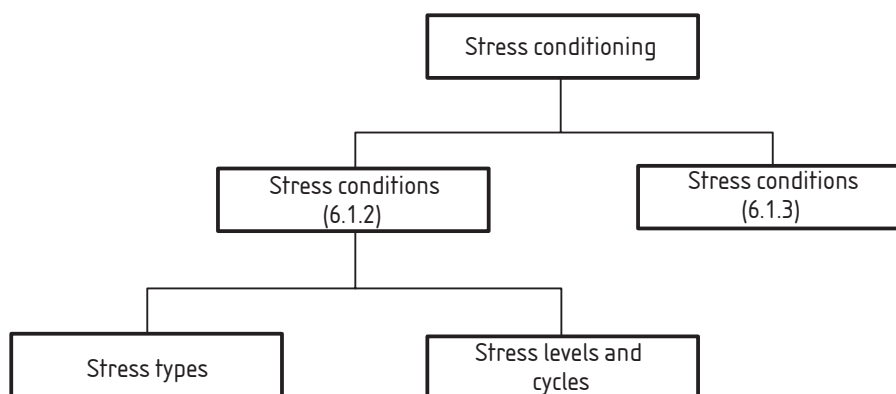
The time of occurrence of failures shall be recorded and evaluated. This is a vital part of the reliability stress screening process, making it possible to monitor it permanently in order to ensure that the failure data used for the design of the process are still relevant.

6 Planning

6.1 Stress conditioning

6.1.1 General

Stress conditioning is composed of the screening duration and the stress conditions as illustrated in Figure 6. Stress conditions are defined in terms of levels, cycles and type.



IEC 1031/06

Figure 6 – Elements of stress conditioning

6.1.2 Stress conditions

Preferably, the stress conditions should be tailored for the assemblies under consideration. They shall aim at excitation of flaw-related failure mechanisms likely to create failures in the field, without altering the characteristics of sound assemblies or sound parts of an assembly.

The procedure for the choice of stress condition is as follows:

- a) consider the expected field conditions, i.e. the operational and environmental stresses in the field, and list as far as possible the weaknesses likely to give early failures under these conditions, taking into account the design and the manufacturing process of the assembly. The weaknesses considered should not only include previously seen failures but also failure modes that, from an engineering point of view, are possible.
- b) group the weaknesses listed into the following three groups:
 - 1) weaknesses that can be removed cost-effectively by design or process modifications. Reliability stress screening should not be applied to remove weaknesses of this kind.
 - 2) weaknesses that can be removed cost-effectively by some kind of inspection or process control during production. These should not be taken care of by reliability stress screening. Visual inspection, process control or reliability indicator screening should be used.
 - 3) the remaining weaknesses constitute the flaws that can be removed by reliability stress screening.

NOTE In cases 1 and 2 screening can be used until the changes are implemented and effective.

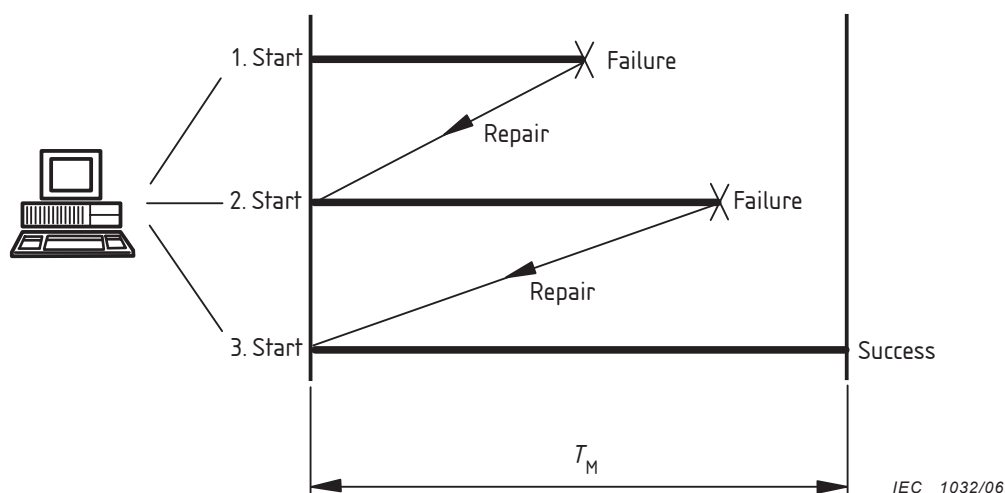
- c) consider the flaws and evaluate the environmental and/or operational stresses which are most likely to develop these flaws into failures. Guidance concerning the effect of different stress conditions can be found in Annexes B to G.
- d) select among the stresses identified the most efficient stress condition/conditions, including their sequence and/or combinations. The stresses selected may not be directly related to the field conditions. Guidance concerning preferred stress conditions and their efficiency can be found in Annex A.
- e) for each stress condition, evaluate the maximum stress level, which can be used without overstressing any component in the assembly under consideration. This will normally mean that the stress should be within the specified operating limits of the assembly, rather than the constituent component, unless specifically agreed upon ('highly accelerated stress screening').

6.1.3 Screening duration

The screening duration is the accumulated relevant time during which an assembly is exposed to the screening stress conditions. It is a stochastic variable, which depends on how many times the assembly has to be repaired before it has survived a predetermined failure-free period (see Figure 7).

For an assembly without flaws, the screening duration is likely to be one failure-free period.

For an assembly with many flaws, or susceptible to induction of flaws (for example during repair), the screening duration will generally be longer. For technical and/or economical reasons, it may be necessary to limit the maximum permissible number of repairs. Assemblies exceeding that number shall be scrapped (see Figure 4). A method for the calculation of the average screening duration appears in Annex I.



NOTE 1 The total length of the "thick" lines constitutes the screening duration.

NOTE 2 The assembly should show a failure-free period T_M before being accepted.

Figure 7 – Assembly showing screening duration

6.2 Evaluation of the failure-free period T_M

6.2.1 General considerations

If sufficient information is available, for example from previous similar products, the failure-free period may be estimated as shown in 6.2.3 and 6.3. After the pilot production screening (see Clause 7) the estimated T_M is updated.

If sufficient information is not available, the pilot production screening can be made with a T_M that is of sufficient length that all flaws are expected to be precipitated. The analysis of the pilot production screening will confirm if this is the case (the failure curve will have levelled out – see Figure J.4) and thus allow the optimum, shorter T_M to be estimated.

6.2.2 Collection of information

The necessary information for the determination of the failure-free period, T_M , includes the following:

- the fraction of weak components in each of the rogue component classes;
- the mean time to failure for the weak components in each of the rogue component classes;
- the sum of the numbers, N , of components in the rogue component classes;
- the acceptable fraction, p_B , of weak assemblies that can be submitted to the next level of production, or to the customer.

The first step is to identify the rogue component classes, which for a good design should be few. Previous experience from reliability stress screening and/or field failure reports on systems, for which similar assembling and component technology has been applied, can be used.

For the determination of the fraction of weak components and the mean times to failure of the weak components in the rogue component classes, it is necessary to make some educated guesses, which also can be based on previous experience as indicated above. The values of the mean times to failures should be assessed for the proposed stress screening conditions.

A very high degree of accuracy is not necessary in the planning procedure, as corrections can be made after pilot production and/or during actual production. If sufficient information is not available, it is recommended that a large T_M be chosen, as described in 6.2.1 and that the estimate be updated after the pilot-production screening.

The value of N is accurately calculated by counting the number of components in the rogue component classes in the assembly.

Finally, the choice of a value for p_B is a decision, which should be based on market requirements and customer requirements.

For reliability stress screening on several production levels, the value of p_B for the final product should be decided first. The p_B values for the intermediate production levels should then be determined in order to achieve the final value.

6.2.3 Determination of the failure-free period T_M

The analysis of the pilot-production screening is based on the Weibull distribution. However, for the first determination of the failure free period, a simpler model is used. This model for screening assumes that the lifetime distribution for the weak assemblies is exponential and that the strong assemblies in practical terms have infinite lifetimes. This assumption is useable for engineering purposes.

The procedure for the determination of the failure-free period, T_M , consists of six steps.

Step 1: The various rogue component classes are lumped together as one "anonymous" component class.

- the early failure fraction, p_C , is set equal to the largest of the values evaluated under 6.2.2.
- the mean time to failure, m_{F1} , for the weak components in this class is set equal to the largest of the values evaluated under 6.2.2.

Step 2: Compute the expected fraction, p_s , of weak assemblies at time zero before screening, using the following formula:

$$p_s = 1 - (1 - p_C)^N \quad (1)$$

where

p_C is the early failure fraction of the "anonymous" rogue component class;

N is the total number of components in the "anonymous" rogue component class in the assembly.

Step 3: Compare p_B with the value of p_s determined in step 2.

If $p_B > p_s$ screening is not necessary.

If $p_B < p_s$ screening is necessary. Then proceed to step 4.

Step 4: Look up the time graph in 6.3 that corresponds to the early failure fraction, p_c (see step 1). If p_c is not on the graphs, then choose the nearest value and recalculate the N values on the graphs by:

$$N_n = N' \frac{p'_c}{p_c} \quad (2)$$

where

N' and p'_c are the printed values on the actual time graph;

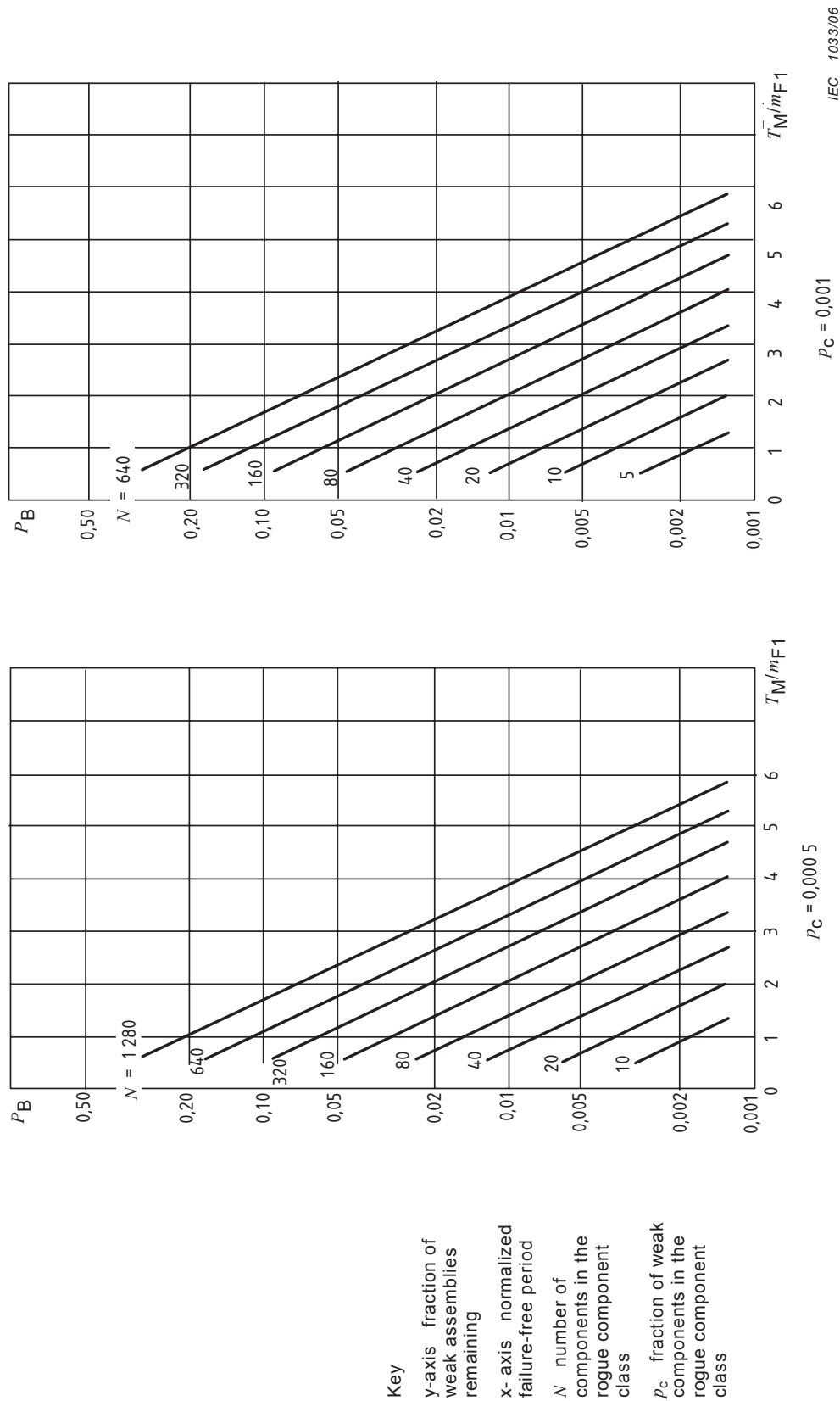
N_n is the recalculated N values corresponding to the present value of p_c .

Step 5: Find the value of p_B on the vertical scale on the selected time graph and draw a horizontal line to intersect the curve for the specific value of N , the total number of components in the "anonymous" rogue component class.

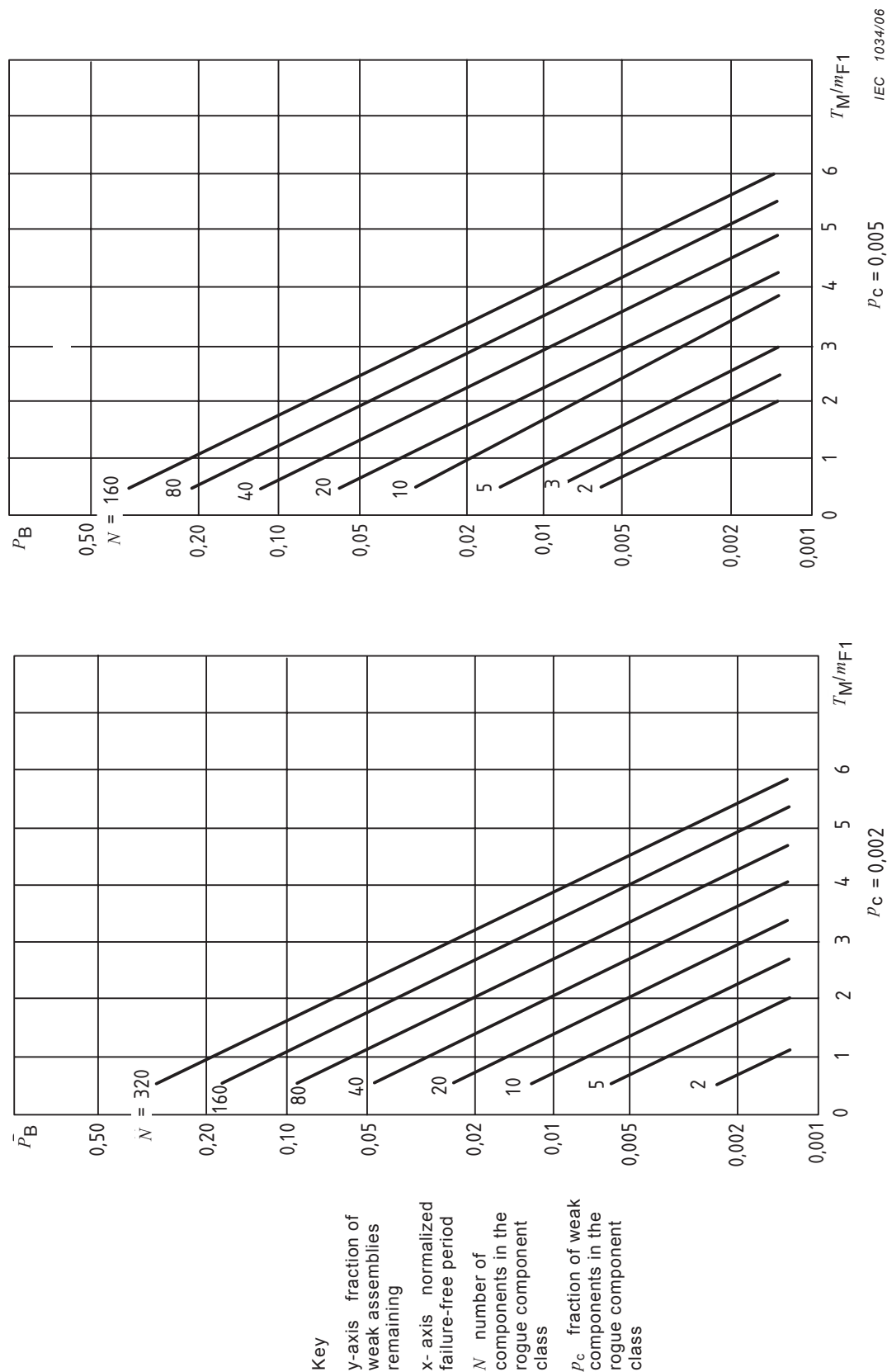
Step 6: At the point of intersection, read off the value on the horizontal scale. This is the failure-free period, normalized with respect to m_{F1} (see step 1). Multiply this value by m_{F1} to find the failure-free period T_M .

6.3 Time graphs for determination of the failure-free period

Figures 8a to 8h give the normalized failure-free period T_M as function of the fraction p_B of weak assemblies remaining after reliability stress screening and as a function of the total number, N , of components in the "anonymous" rogue components class.



Figures 8a and 8b – Time graphs for the determination of the failure free period



Figures 8c and 8d – Time graphs for the determination of the failure free period (continued)

