IEC 61163-2

Edition 2.0 2020-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Reliability stress screening –
Part 2: Components

Déverminage sous contraintes –
Partie 2: Composants

IEC 61163-2:2020-03(en-fr)

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ELECTROTECHNICAL
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CONTENTS

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RELIABILITY STRESS SCREENING –

Part 2: Components

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International Standard IEC 61163-2 has been prepared by IEC technical committee 56: Dependability.

This second edition cancels and replaces the first edition published in 1998. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) this version of the document is a complete rewrite and restructure from the previous version.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
56/1875/FDIS	56/1887/RVD

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

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

A list of all parts in the IEC 61163 series, published under the general title *Reliability stress screening*, can be found on the IEC website.

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

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- withdrawn,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

INTRODUCTION

Although first developed to stabilize the parameters of manufactured components (burn-in), reliability stress screening (RSS) can be used to remove from a component population the weaker components. This can be done at times where the manufacturing processes for components are difficult to control or for other reasons such as where the components need to be selected (re-qualified) to operate in harsher than usual operating conditions. This is also done where more narrow specifications are required for the application and no alternative courses of action are available.

The use of RSS is normally only a temporary measure when early failures need to be avoided under a specific set of conditions as outlined above.

RSS is an effective tool in identifying and removing flaws due to poor component design and manufacturing deficiencies.

RELIABILITY STRESS SCREENING –

Part 2: Components

1 Scope

This part of IEC 61163 provides guidance on RSS techniques and procedures for electrical, electronic, and mechanical components. This document is procedural in nature and is not, and cannot be, exhaustive with respect to component technologies due to the rapid rate of developments in the component industry.

This document is:

a) intended for component manufacturers as a guideline;

b) intended for component users as a guideline to negotiate with component manufacturers on RSS requirements;

c) intended to allow the planning of an RSS process in house to meet reliability requirements or to allow the re-qualification of components for specific, upgraded, environments;

d) intended as a guideline to sub-contractors who provide RSS as a service.

This document is not intended to provide test plans for specific components or for delivery of certificates of conformance for batches of components.

The use of bi-modal Weibull analysis to select and optimize an RSS process without having to estimate the reliability and life time of all items is described.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
screen
conditions, for example stress level and duration, used for the removal of non-conforming items from a population

3.2
screening
process carried out to detect and remove non-conforming items, or those susceptible to early life failure

Note 1 to entry: Screening may employ representative or elevated stresses.

[SOURCE: IEC 60050-192:2015, 192-09-11, modified – Deletion of “test” in the term, replacement of “test” with "process" in the definition and replacement of “The test” with "Screening" in the Note 1 to entry.]

3.3
RSS
reliability stress screening
process for detecting flaws by applying environmental and/or operational stresses to precipitate them as detectable failures

Note 1 to entry: RSS is designed with the intention of precipitating flaws into detectable failures. An ageing process designed specifically with the intention of stabilizing parameters is not an RSS process and is therefore outside the scope of this document.

Note 2 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-192:2015, 192-09-19, modified – Addition of Note 1 to entry.]

3.4
flaw <of an item>
imperfection that could result in failure

Note 1 to entry: An imperfection in this case is a physical characteristic of the component that leads to a failure to perform in a required way.

[SOURCE: IEC 60050-192:2015, 192-04-03, modified – Addition of Note 1 to entry.]

3.5
early life failure period
infant mortality period
time interval of early life during which the instantaneous failure intensity of a repairable item, or the instantaneous failure rate of a non-repairable item, decreases significantly with time

Note 1 to entry: What is considered “significant” will depend upon the application.

[SOURCE: IEC 60050-192:2015, 192-02-28]

3.6
weak item
item which has a high probability of failure in the early life period due to a flaw

3.7
weak population
subset of the total population of items made up of only weak items

3.8
strong population
subset of the total population of items made up of non-weak items

4 Description of reliability stress screening (RSS)

The process of RSS is used to detect flaws in a population of items, usually components, leading to the subsequent removal of these flawed items from the population. The removal of such components facilitates rapid achievement of the reliability level expected for the population over the useful life.

This can often happen when problems with items are identified and it takes time to fix the design or the production process for the item but the existing items need to be used immediately. This is typically a sorting exercise where the RSS is used to fail the items with problems so they can be identified in the population or batches.

RSS can also be used to sort items to meet specific operating conditions or functional parameters where it is used to select items that meet a requirement higher than what was originally specified from a batch that was lower than what was originally specified, for example screening components for temperature stability or other factors that affect reliability.

Typically RSS is initiated in response to one or more of the following situations:

- customer requirements specify the use of screening;
- field performance identifies an issue with early product failures;
- the production process generates a concern for latent defects;
- to reduce the uncertainty with the introduction of a new product or process;
- to select, from a selection of different components performing the same function but with different technologies/techniques;
- some items need to be screened to meet a tighter or increased specification.

The RSS method is achieved by applying specific environmental or operating conditions to stress the population of items. This applied stress, or combination of stresses, will often have environmental and operating conditions in excess of the stress at normal operating conditions. The stresses usually used are temperature, humidity, vibration, acceleration, electrical stress and similar conditions. A screening may have one or more conditions set at higher than normal levels.

The screening takes places at the item level, which is usually at component level but may include some large packages containing multiple components. RSS of products is covered by [1][1].

The screening will cause flawed components to fail quickly and so be identified in the population. These components are then removed from the population. The remaining components are then referred to as having been screened and the process is similar to sorting, where the RSS is used to split the population into two distinct sets, one that has been failed by the screening and one that has not. In some cases, a sample from a batch is screened to determine whether a lot contains weak components.

NOTE 1 If a screening strength is too high then non-flawed components can also fail and in fact an extremely strong screening could fail the entire population. It can also degrade them without failure but reduce their useful life. For this reason, it is important that a screening procedure is carefully designed according to the physics and materials of the components undergoing the screening and the reasons for the screening.

RSS should not be used as a normal procedure to assure the reliability of individual components. The RSS method can, however, improve the actual reliability of a population or system by removing flawed components that are more likely to cause failure.

The cost of performing RSS should be carefully evaluated and the screening only undertaken if the potential benefits outweigh the cost.

If early failures are caused by the assembly processes for the finished item including the component, and its handling (ESD damage, contamination, etc.) RSS will not be effective and so should not be done. However, it may be possible to perform RSS of the finished item [1].

NOTE 2 The use of RSS is inappropriate if there are no early failures. The failures can be reduced if needed using other methods like design changes [5]. Early failures can be identified using the techniques in [6].

NOTE 3 The use of RSS is inappropriate if the relevant failures can be detected without operating the item over time. Failure detection at zero operating time is carried out by parametric measurement or the use of non-invasive techniques like X-ray, scanning acoustic microscope (SAM) and similar methods.

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1 Numbers in square brackets refer to the Bibliography.

NOTE 4 Using RSS to upgrade component population specifications can lead to problems, for example a logistical problem can occur when similarly screened components are not available at a later date. This can be mitigated by performing RSS on enough components for the repair of the system over its entire service life or by ensuring that the system documentation is sufficient to control component procurement so that all replacement components be similarly screened (see [7]).

Sometimes it is necessary to carry out other actions beyond RSS in order to meet the requirements and many of the principles of reliability growth described in [5] apply. Typically, changes in the design, the manufacturing processes or in the components' use may have to be made. It also may be necessary to adopt a failure mode avoidance strategy that can remove the causes of the failures or at least deal with them when they occur, for example via redundancy.

In some cases, the stress screening will not give the results that are expected and in those cases, further investigation is required to understand what has happened. This can happen when a stress applied has effects that were not predicted in the initial physics of failure analysis (see 7.2). In these cases, a redesign of the stresses applied to be more specific will be necessary.

Some examples of the application of RSS are given in Annex B.

5 Types of RSS

5.1 General

There are a number of types of RSS: constant stress screening, step stress screening, and highly accelerated stress screening (HASS).

The purpose of all of these screening types is to cause relevant failures to occur in the item. Such relevant failures are those that would have prevented the item from achieving its reliability requirements in service.

5.2 Constant stress screening

A constant stress screening is a screening procedure where a constant environmental and/or operational stress is used for the duration of the process.

5.3 Step stress screening

Step stress screening is a screening procedure where environmental and/or operational stresses are changed at planned intervals, usually increasing in strength for the duration of the process.

Step stress screening is often used to shorten process times, and to give some idea of likely failures rates at different stress levels. For this reason it is sometimes used in the RSS planning phase to select those levels.

5.4 Highly accelerated stress screening (HASS)

Highly accelerated stress screening (HASS) is a screening procedure used in conjunction with a highly accelerated limit test (HALT, see IEC 62506 [2], [3]). A HALT is needed before a HASS screening procedure can be started.

NOTE HALT uses very high stress levels, typically high and low temperature, rapid temperature change and mechanical vibration or mechanical shock. HALT is performed on a small sample of items. The output of the HALT is typically the high and low operational limits for example the temperatures when the item stops functioning, but recovers function once the item is brought back to normal operating temperature. Further, the HALT identifies the destruction limits, the temperatures where the item fails permanently i.e. it does not recover as the temperature is brought back to normal. In some cases, the limits cannot be found within the temperature range relevant for the technology of the item. This limit information is used as the basis for setting up a HASS procedure.

HASS, unlike HALT, is intended to be an on-going process either performed on the whole production (100 % screening) or on a sample from the production or from a batch.

The HASS process is typically set up as a rapid temperature change between the upper operating limit reduced by some amount and the lower temperature limit plus the same amount. If no operating limits have been identified, a level as high as appropriate for the item's technology is chosen. Normally the screening strength of the HASS screening is adjusted by increasing or decreasing the number of temperature cycles. The number of cycles in the HASS can be determined and kept optimized using the procedure described in Clause A.3 and [11].

HASS normally stays within the items' operational limits to allow continuous monitoring of the function of the item but operational limits can be exceeded where the items under HASS are not monitored during the screening. The stress levels should stay below the destruction limit for good items. The items should then be tested for function after the HASS. Since HASS is resource and time consuming, requiring specialist equipment, HASS is often performed on a sample from the production.

6 Managing RSS

6.1 Planning

In order to plan RSS, the objectives need to be identified and these objectives will be slightly different according to the underlying reasons for carrying out RSS. The objectives of the RSS will affect the type of screening applied (see 7.3).

The plan should define the objectives and success criteria of the RSS.

The RSS plan should encompass all aspects of the RSS process and is integrated into the overall manufacturing test plans. The plan should be a useful tool for identifying the resources that are required for conducting RSS.

As a minimum, the RSS plan needs to contain the following items:

- overall process flow chart;
- a schedule identifying dates for the completion of RSS procedures and the beginning of RSS;
- which stresses will be employed;
- how the screening procedures will be applied to the item, i.e., RSS parameters, sequence of screening procedures, combination of screening procedures;
- the data collection process and methods of monitoring of items during the RSS;
- screening facilities and equipment used;
- methods for modifying the RSS based on item failures;
- decision-making ground rules applicable to failures;
- subcontractor/supplier RSS requirements;
- RSS organization and management responsibilities;
- personnel and their responsibilities for the various functions within the RSS process.

The RSS process flow should be a closed loop operation, i.e. one that includes feedback of results, in order to be successful.

Deliverables of the RSS process are

- failure reports;
- throughput data;

- RSS performance data.

These deliverables are reviewed for trends and screening effectiveness.

6.2 Termination of RSS

Termination of RSS is normally justified by a substantial amount of failure-free observational data from the process, suggesting that the weak components have been removed or reduced significantly.

RSS may be accepted as a permanent process only in cases where components have to be screened for performance against a particular component parameter (e.g. actual operating temperature limit), where the standard components from the supplier does not fulfil the requirements for the use of the component, or it is a contractual obligation.

7 Design of RSS

7.1 General

Designing an effective screening is an empirical process that can adapt standard RSS processes. This is not to say that certain screening procedures cannot be reasonably effective for similar item configurations, however, as a rule, an individual screening procedure should be tailored to the item being screened, considering both the characteristics of the item and the anticipated defect types.

An effective screening is one that delivers the required failures as quickly as possible without causing other failure mechanisms that would not normally occur in use. The screening also needs to be economically viable. There is often a trade-off between the cost and effectiveness of the screening. A process of optimisation may need to be undertaken to choose the most effective set of screening procedures.

The particular set of screening conditions will require a certain application time before results are seen. The stress level will control how long this application time needs to be and, in general, higher stresses require shorter time.

NOTE The use of the maximum stress level that is appropriate is possible but verification that the chosen combination of stress types and stress levels does not reduce the life time of the strong components is important. This can, for example, be done by exposing a sample of components to 10 times the duration of the planned RSS screening.

Under some circumstances, it is beneficial to use step stress screening [8] where the failures at each stress level are examined and the dwell times at each level are shortened as necessary. This is the case when there are no failures at lower stress levels, perhaps because they are not set up to be harsh enough initially to precipitate failure, or perhaps some other type of failure is occurring that requires further investigation.

7.2 Physics of failure

Before any screening procedure can be defined, it is necessary to have a detailed understanding of the way in which the items under consideration can fail. To do this, information on the failure modes will need to be gathered. Failure mode information is available from a number of sources, the most reliable of which being the item manufacturer.

NOTE 1 Only failure modes that are significant to the overall objective are considered.

Each failure mode that is considered can arise due to a number of different failure mechanisms, and these are based on the basic physics of the item being considered.

Each failure mechanism will have a number of contributory factors that will cause it to occur at a particular rate. Each of these contributory factors will have certain levels that need to be reached before the mechanism will start and the mechanism will run at different rates as the levels of these contributory factors change.

EXAMPLE Corrosion will often lead to open circuit failure as conductors corrode away and corrosion has a particular set of contributory factors that will be present in order to occur, such as moisture, and ionic contaminants.

In order to create an effective screening, the failure mechanisms need to be known so that the screening conditions can induce the required failure mechanisms to occur at a sufficient rate so that the relevant failure mode is precipitated in a short period.

NOTE 2 Arbitrary application of screening stresses is not an effective strategy since the stresses are specifically directed to the problems that are identified.

NOTE 3 It is likely that the most effective screening conditions can require a mix of screening conditions and that the order in which the screening conditions are applied can be significant.

It may be possible to use simulation to model the effect of a screening before applying it to the item so that the screening effectiveness can be judged. To do this, physics of failure models, if available, can be used.

In addition, a number of empirical equations have been developed that allow the effect of stress to be modelled in a general way. Some of the general equations are described in [9] and more specific ones for electrical component types can be found in [10].

7.3 Common screening procedures

There are a number of common types of screening procedures which have been used with some degree of success. These common screening procedures (stresses) are shown in Table 1.

Table 1 – Common screening types and typical defect types precipitated by RSS

Stress	Defect types precipitated
Thermal cycling	Component parameter drift Hermetic seal failure Poor thermal coefficient matches Stress relaxation Loosening of connections or parts Cracks
Vibration	Particle contamination Defective oscillator crystals Poorly bonded internal parts Poorly secured high-mass parts Mechanical flaw Loosening of connections or parts Part mounting issues
Combined thermal cycling and vibration	All mechanisms under vibration and thermal cycling Interaction between mechanisms
High voltage	Shorted connections
Humidity	Sealing properties Hygroscopic contamination Circuit stability Corrosion
High temperature	Performance degradation Chemical reaction