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Edition 2.0 2017-01

TECHNICAL SPECIFICATION

SPECIFICATION TECHNIQUE

colour inside

Estimation of the reliability of electrical connectors

Estimation de la fiabilité des connecteurs électriques

IEC TS 61586:2017-01(en-fr)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
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ESTIMATION OF THE RELIABILITY OF ELECTRICAL CONNECTORS

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 61586, which is a technical specification, has been prepared by IEC technical committee 48: Electrical connectors and mechanical structures for electrical and electronic equipment.

This second edition cancels and replaces the first edition published in 1997. This edition constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

- A specific “basic” testing protocol is defined which utilizes a single test group subjecting connectors to multiple stresses.
- Additional information is provided concerning test acceleration factors.
- A discussion of the limitations of providing MTTF/MTBF estimates for connectors has been added.
- The bibliography has been expanded.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
48/563/DTS	48/568/RVC

Full information on the voting for the approval of this technical specification 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.

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

The reliability of electronic assemblies depends on the reliability of the passive electrical connections between the active components, as well as on the reliability of the components themselves. There is a common perception that interconnections, specifically connectors, are a major source of failures, often of the "no fault found" variety, in electronic assemblies. Whether this perception is true is not the subject of this technical document, but connector reliability is a concern. Much of the increasing attention being given to reliability of electrical connectors focuses on the basic question of how the reliability of electrical contacts and connectors can be meaningfully determined.

The definition of reliability which will be assumed in this document is the following:

> The probability of a product performing a specific function under defined operating conditions for a specified period of time.

Reliability is therefore a function of:

a) The expected lifetime of the part.
b) The application stresses (electrical, thermal, mechanical, chemical, etc.) the part will be subjected to during its life.
c) The specified failure criteria.

Since these factors will be different for every application in which the connector may be used, a given connector will have a different reliability for every application in which it may be used. Therefore, a connector manufacturer cannot provide a reliability estimate for a contact or connector until the customer has provided a detailed description of the factors listed above for the application in which the connector will be used. To provide a numerical estimate of connector reliability, the manufacturer will then need to use the information provided by the customer to design a test program to simulate the application intended.

Some factors which are to be taken into account in addressing this definition are the subject of this document. The reliability assessment methodology to be discussed centres on appropriate statistical analysis of test data, based on proper consideration of the following issues.

d) The active degradation mechanisms are to be identified and categorized by their importance for the application.
e) Appropriate environmental tests, with corresponding acceleration factors, where practical and appropriate, and exposures, are to be determined for these degradation mechanisms.
f) Use of a test sequence which provides an opportunity for the interaction of the potential degradation mechanisms as is necessary to realistically simulate the effects of the expected application.
g) The statistical approach to estimating reliability from the test data is to be agreed upon.
h) An acceptance criterion appropriate for the application of interest is to be established.

Items d), e and f) relate to the ability of the product to continue to perform its designated function under the degradation mechanisms it is subjected to in its operating environment. In addition, the need for an acceleration factor is fundamental to assessing the operating life of the product.

Item g) is necessary, since the reliability definition is based on probability which requires statistical treatment of appropriate data.

Finally, item h) is a result of the fact that the reliability to be assessed is based on the product performing a defined function.

The level of knowledge and understanding available to address these issues varies appreciably. Each topic is considered in a separate subclause.

It is to be noted that there are a number of other factors which have an effect on connector reliability. Among these are:

i) the connector manufacturing process;

j) assembly/application procedures of the equipment manufacturer;

k) abuse/misuse of the equipment by the end user.

The importance of these application or extrinsic factors cannot be denied and may well be the final determinants of connector reliability. However, extrinsic factors are highly variable and, therefore, difficult to account for in any estimation of reliability. For these reasons, this document will focus on intrinsic connector reliability, i.e. the reliability of the design/materials of the connector itself as evaluated by the procedures listed previously. This intrinsic reliability represents the greatest reliability which the connector can achieve. The extrinsic factors will result in a reduction in reliability.

It is also to be noted that the approach to reliability estimation in this document differs significantly from that based on a base failure rate which is modified by application-specific factors as, for example, in IEC 60863 or MIL Handbook 217.

The two approaches are related in that the base failure rate could be determined by a different statistical treatment from the same data which are used in assessing reliability by the method to be discussed. The test environments and exposures would determine the standard conditions which are defined for the base failure rate. In addition, the derating factors used in the failure rate approach can, in principle, be derived from the same data used to determine acceleration factors in the proposed statistical method.

The advantage of the approach recommended in this document is that the standard conditions, acceptance criteria, and statistical treatment are specifically defined for the application under consideration. This is in contrast to a base failure rate starting point which is frequently poorly defined and documented.

ESTIMATION OF THE RELIABILITY OF ELECTRICAL CONNECTORS

1 Scope

This technical specification deals with the estimation of the inherent design reliability of electrical connectors through the definition and development of an appropriate accelerated testing programme. The basic intrinsic degradation mechanisms of connectors, which are those mechanisms which exist as a result of the materials and geometries chosen for the connector design, are reviewed to provide a context for the development of the desired test programme. While extrinsic degradation mechanisms may also significantly affect the performance of connectors, they vary widely by application and thus are not addressed in this document.

2 Normative references

There are no normative references in this document

3 Terms and definitions

No terms and definitions are listed in this document.

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

4 General considerations

4.1 General

Degradation leading to failure of a contact or connector can occur in many ways. For our purpose, it is convenient to divide the mechanisms into two categories, intrinsic and extrinsic.

4.2 Intrinsic degradation mechanisms

As mentioned in the introduction, intrinsic degradation mechanisms are those related to the design and materials of manufacture of the contact or connector. Examples are corrosion, loss of normal force through stress relaxation, and excessive Joule heating leading to temperature-related degradation.

4.3 Extrinsic degradation mechanisms

Extrinsic degradation mechanisms are related to the application of the contact or connector. Examples are inadequate controls during manufacture of the connector, improper assembly processes during equipment manufacture, contamination during application, degradation caused by use of the connector outside its rated temperature range (both ambient and enclosure-related) or by application of currents exceeding the product specification (in both single and distributed modes), and contact abuse resulting from improper mating practices (mating at excessive angles, pulling on cables, etc.) by the end user.

4.4 Control of extrinsic degradation

Extrinsic degradation can be taken into account by incorporating design features in the connector to reduce the potential for such degradation by proper specification of product performance by the connector manufacturer, and by proper use of the available information by the equipment manufacturer and end user. This is a joint responsibility which merits attention. The connector manufacturer can include strain relief for cables, finishes on contacts, improved crimps and other features intended to provide robustness against extrinsic degradation, but these can always be overcome through abuse or misapplication by the user. The concept of user includes the electrical equipment manufacturer as well as the ultimate user of the equipment. However, extrinsic degradation mechanisms, due to their variety and application dependence, are not something which can be straightforwardly analyzed, modelled or simulated. This limitation makes estimation of the effects of extrinsic degradation mechanisms on connector reliability problematic despite the fact that, as mentioned, such degradation mechanisms may be the major determinant of connector reliability in actual use. For this reason, when evaluating a system in which a connector will be used, an estimate of the reliability of a connector based on testing of the connector in isolation should be primarily used in conjunction with estimates of reliability of other components of the system to provide an initial prediction of system reliability. But as with any other component, the actual reliability of the connector in a system can be determined only through appropriate testing of the system in which it is used.

4.5 Failure effects, failure modes and failure (degradation) mechanisms

4.5.1 General

Given the context of the previous remarks, in this document the discussion is limited to a few aspects of intrinsic degradation, in order to describe an approach to connector reliability evaluation. For clarity, it is important to distinguish between failure effects, failure modes and failure (degradation) mechanisms.

A failure effect is the specific problem in operation which the customer will see. Examples specific to contact and connector failures are loss of signal, loss of power, overheating/burning, shorting, etc.

A failure mode is a physical description of the change in a part which may directly or indirectly result in a failure effect observed by the customer. Examples of failure modes specific to connectors or contacts are high resistance, reduced normal force, low insulation resistance, etc.

A failure or degradation mechanism is the physical, chemical or other process which resulted in the failure mode.

Note that while the term failure mechanism is often used, the term degradation mechanism more clearly describes what is being discussed. A degradation mechanism can often occur without causing failure if the level of degradation remains below some critical value. Therefore, for the remainder of this document, the term degradation mechanism will be used.

4.5.2 Failure modes

Only one failure mode, the variation in contact resistance, will be considered in this document, although many others exist, both mechanical (broken latches, bent pins, etc.) and electrical (crosstalk, leakage between contacts, etc.).

4.5.3 Degradation mechanisms

Three intrinsic degradation mechanisms which are well understood and which are known to have a major impact on contact resistance stability are considered:

- corrosion;
- stress relaxation;
- plating wear.

Corrosion of the contact interface causes an increase in contact resistance due to the formation of non conductive material in the contact interface. Stress relaxation results in loss of contact normal force which in turn can lead to increased contact resistance either directly, in the case of extreme loss of normal force, or indirectly through increased susceptibility to mechanical or corrosive degradation. Plating wear can lead to increased contact resistance if wear-through occurs to the contact underplate or base material, both of which are typically more susceptible to corrosion than the surface plating materials. These degradation mechanisms result, generally, in increases in contact resistance. The amount of degradation which occurs before reliability is affected depends on the application in which the connector is used and is, therefore, application specific, as will be discussed. A primary concern is that individually these degradation mechanisms may cause little or no increase in resistance. However, they can interact to cause contact failure.

Experience with the product, or with similar products or applications, allows us to categorize and rank the degradation mechanisms. Such categorization and ranking is necessary to define an appropriate testing programme and identify, when possible, how the test conditions relate to field performance and lifetime.

5 Test methods and acceleration factors

The objective of reliability testing is to cause in the test specimens levels of degradation which accurately reflect the levels of degradation which will be found in parts when they are used in the application being simulated. Once these levels of degradation have been caused by subjecting the test specimens to the specified test conditions, the performance of the test specimens can be evaluated against appropriate application failure criteria and the reliability of the parts in the application simulated by the test can be estimated. To be of use, the testing needs to accelerate the rates of degradation so that the required performance evaluation can be completed in a reasonable time. To know how much application time has been simulated by the test, it is necessary to know the acceleration factor of the test. In simple terms, the objective is to be able to state that *X* days of exposure to the test conditions used, which may activate a given degradation mechanism, are equivalent to *Y* years of service in the expected application conditions. The acceleration factor between the test exposure and field exposure is the time in the field which the test simulated divided by the time in the test. Note that other test duration units such as cycles may be used in place of time as appropriate.

Unfortunately, there are only a few tests appropriate for contacts and connectors for which such acceleration factors have been developed or determined. One of these tests, MFG (mixed flowing gas) exposure, stresses the degradation mechanism of corrosion and is primarily designed for use on contacts with noble metal based plating systems. Work to develop various MFG tests has been done at several laboratories in different countries and in some cases provides the required data from which acceleration factors can be derived.

Another test exposure for which acceleration factors can be determined is dry heat exposure, also known as temperature life or heat age exposure. This test accelerates the degradation mechanism of stress relaxation. Stress relaxation data are available for a broad range of copper alloys used in connectors. Consideration of these data will allow an acceleration factor to be defined for temperature life testing. However, stress relaxation is not linear with time. Therefore given a known application operating temperature and a specified test temperature it is still not possible to determine the acceleration factor of the test since the acceleration factor will change as the time in test increases. As a result of this non linear response of stress relaxation with time, increasing the test duration by a factor of X will not increase the lifetime simulated by the test by the same factor of X. In fact for a given test temperature, small increases in the lifetime which the test is used to simulate can cause very large increases in the required duration of the test. A method for determining the acceleration factor for dry heat exposures is provided in informative Annex A.

An important issue to note with stress relaxation testing is that stress relaxation relates only to the contact normal force and not directly to reliability as evaluated by resistance stability. Studies have shown that a large reduction in stress relaxation, and therefore normal force, can occur with minimal change in resistance Therefore, the effects of stress relaxation on contact reliability as assessed by contact resistance stability shall be evaluated in conjunction with other test exposures following a temperature life exposure. For example, exposing contacts in a mated state to a dry heat test and then exposing the same contacts to a vibration test which may cause motion at the contact interface may reveal a reduction in resistance stability which would be expected in actual use of the contact but which would not be evident through the use of a dry heat test only.

Other tests applied to electrical contacts and connectors but for which no acceleration factors are typically defined include:

- temperature cycling with high humidity typically used to assess corrosion effects in non noble metal plated contacts;
- mating/unmating or durability cycling used to assess wear effects;
- mechanical shock and/or vibration used to assess wear effects in general, fretting corrosion of non noble plated contacts, and fretting corrosion of noble plated contacts in which the noble metal surface plating has been worn through in vibration or other testing such as durability cycling performed prior to vibration;
- salt spray used to assess corrosion effects for products used in harsh environments such as marine applications and automotive applications in which the connector is directly exposed to the outside environment.

As these tests have no established acceleration factors, when used in isolation they indicate only the relative performance of connectors. The resulting data indicate only the behaviour of the connector system under the tests. They are not reliability tests yielding data on which estimates of behaviour under operating conditions can be based. However, these tests can be used within a properly designed sequence of test exposures which also includes MFG exposure and/or dry heat exposure to create a useful estimate of contact and/or connector reliability.

6 Basic contact and connector reliability testing protocol

The primary degradation mechanisms of concern when assessing changes in contact resistance may occur individually without having a significant detrimental effect on contact resistance. For example, environmental corrosion of a contact surface can create corrosion products around the contact interface. But as the actual microscopic points of metal to metal contact within the interface are essentially gas tight, the corrosion processes which occur in most applications will take much longer than the expected lifetimes of contacts before disrupting these points of contact and causing a noticeable increase in resistance. Similarly with stress relaxation, a significant decrease in contact normal force may occur without a significant increase in contact resistance. During mating, to create a clean metal to metal interface with a low electrical resistance, a relatively high normal force may be required, especially for non noble plated contacts. This force is necessary to displace oxides and other non conductive materials which may have accumulated the contact surface prior to mating. However, once this interface is created, in the absence of stresses which will cause the contact interface to move, the normal force required to maintain the low resistance interface is much less than that which was required to create the interface initially. Thus, if the contact interface does not move, normal may be reduced significantly without a detrimental increase in resistance. Since the primary degradation mechanisms in contacts have limited effect in most cases when occurring individually, a well designed contact will usually exhibit only a few mΩ of resistance change in testing when subjected to individual stresses which activate a single degradation mechanism.

However, in actual use, contacts are subjected to multiple stresses which can activate all of primary degradation mechanisms simultaneously. And these stresses can interact directly and indirectly to cause changes in resistance which are sufficiently large to cause failures in the systems in which the contacts are used. For example, an environment which may cause minimal corrosion on a new contact with intact plating may cause significant levels of corrosion if the contact plating has been worn through due to the action of mating and unmating or vibration. Further, the motion which caused the plating damage allowing corrosion to occur will also shift the location of the contact potentially moving it into a location where corrosion exists. If in addition to these stresses, stress relaxation has occurred causing a reduction in contact normal force, the contact interface will have a lower mechanical stability. As a result, vibration levels and temperature cycling which may not have caused motion at the interface when the contact was new may now cause motion. And with the reduced normal force, the ability of the contact to displace non conductive material such as corrosion products will be reduced. In addition, the reduced normal force may make the contact susceptible to small (typically less than 0,1 mm) cyclic motions when subjected to vibration or temperature cycling. If these motions do occur in non noble metal plated interfaces or in noble metal plated interfaces in which the non noble metal under-plating or base metal is exposed, the degradation mechanism of fretting corrosion can occur and cause increased resistance.

Because it is the interactions of these degradation mechanisms which are most likely to cause contact failures, an effective reliability test protocol shall include tests which can potentially activate all these mechanisms in the same parts and in conjunction with potential contact interface motion drivers. A basic reliability test protocol should thus include the following:

a) Tests such as vibration and durability cycling which can cause damage to plating.
b) Tests such as mixed flowing gas (MFG) for noble metal plated contacts and temperature cycling with humidity for non noble plated contacts which can cause corrosion. Vibration and temperature cycling may also cause fretting corrosion in non noble plated contacts or noble plated contacts with damaged plating.
c) Dry heat exposure to accelerate stress relaxation and cause reduced normal force.
d) Tests such as temperature cycling, thermal shock, vibration, and mechanical shock which can cause motion at the contact interface.

Additional test exposures may be included as needed depending on the intended application. For example, power contacts which carry sufficient current to create increases in temperature sufficient to accelerate various degradation mechanisms should be subjected to current cycling. Testing of contacts to be used in areas of high particulate exposure may include dust exposure.

For each test method included in the reliability test sequence, the level of stress applied and the duration should be chosen such that the exposure causes a degradation which equals that expected to be caused during the life of the product in its intended application. In other words, they should place the test specimens in an end-of-life state. Therefore, it is desired that there be known acceleration factors for all the tests used. But as noted earlier, reliable acceleration factors are known for only dry heat stress relaxation tests and some MFG corrosion tests. Fortunately, due to the way the contact interfaces respond to certain stresses, a lack of acceleration factors for some tests does not prevent them being used in reliability evaluations.

One of the most important aspects of contact interface behaviour which allows tests without acceleration factors to still be used in reliability testing is that the degradation of contacts to certain stresses is not continuous. In other words, certain stresses do not cause a change in the contact interface until they cross some threshold level of severity. Further, once crossing a certain level of stress, these degradation mechanisms will then occur very quickly. One example of this type of stress is temperature cycling. As temperature increases and decreases, expansion and contraction of the contact or connector components will occur resulting in mechanical forces on the contact interface. Unless these forces are sufficient to overcome the frictional force at the interface, which is a function of the normal force and the coefficient of friction between the contact surface materials, no motion and thus no degradation will occur. But if the temperature cycles are at a level to cause motion at the interface in a non noble plated contact, fretting corrosion will occur and significant resistance change will be identified in relatively few test cycles, e.g. fewer than 1 000 cycles in tin interfaces and fewer than 100 in nickel interfaces.

Another common test that behaves in this manner is vibration. Within some domain of frequency, amplitude and/or acceleration levels, no movement will be caused in the contact interface. Beyond these levels, once movement is caused millions of cycles of motion will often occur in less than an hour which may cause significant wear and possibly fretting corrosion depending on the metallurgy of the contact interface.

When these types of tests, which do not cause degradation below some stress threshold and then can potentially cause rapid degradation above these levels, are used in a reliability test program they essentially determine if the application stresses are too severe for the contact or connector design. Given this, a critical aspect to ensure when these tests are used is that they do not significantly exceed the expected application stresses. If they do, they may cause motions in the contact interface which will not occur in actual use and thus cause failures in testing which are not representative of performance which would occur in the application.

Another category of tests which do not have an acceleration factor but which can still be used in a reliability test program includes tests which can be performed at the same level and rate as the expected application stress and still place the product in its expected end-of-life degradation state in a reasonable amount of time. One example from this category of tests is durability, or mate/unmate, cycling. Obviously one unmate/mate cycle in a test is equivalent to one unmate/mate cycle in the application. Therefore, if during the life of a product it is expected that 100 durability cycles will occur, then a reliability test duplicating this with 100 cycles can be done.

A valid reliability test program can therefore be created using tests which both do and do not have known acceleration factors if those without known acceleration factors fit in one of the categories described above. Further, as was previously discussed, the reliability test shall be designed such that all the critical degradation mechanisms can interact. Ideally the design would excite all the degradation mechanisms simultaneously. In practice this is not possible. The tests required have conditions which are mutually exclusive. For example, MFG corrosion tests are normally run at temperatures in the range of 20 °C to 40 °C whereas a dry heat stress relaxation tests are run at temperatures exceeding 90 °C. Because of this, connector reliability test programs shall apply the required stresses using a sequence of test exposures. The sequence in which the tests are applied then becomes important. For example, at least some durability cycling which may damage plating needs to be performed before corrosion testing begins since in actual use the plating may be damaged when corrosion stresses occur.

Based on the issues discussed above, a core test protocol to evaluate reliability using resistance change as the performance criterion can be defined for contacts and connectors. The core testing shall place the contacts in an end-of-life state for the degradation mechanisms of wear, corrosion, and stress relaxation and then subject the test specimens to appropriate potential motion drivers such as temperature cycling and vibration. For a non noble metal plated contact system, the core testing will be:

Durability cycling: This can potentially cause plating damage or wear making the contact more susceptible to subsequent corrosion tests. The number of cycles will typically be representative of the number expected during the life of the product in the intended application. If the product is expected to be mated and unmated regularly during life, the test cycles may be performed in sets starting before and then performed periodically during a corrosion test.

Dry heat: This test will cause stress relaxation in mated contacts. It is done before fretting corrosion stress tests such as temperature cycling and vibration as contact interface motion which causes fretting corrosion will be more likely when contact normal force has been reduced due to stress relaxation.

Temperature cycling: This test may cause interface motion leading to fretting corrosion. For tin plated interfaces it will typically require 500 to 1 000 cycles before the effects of fretting corrosion are seen. Nickel interfaces typically exhibit the effects of fretting corrosion after 50 to 100 cycles. As was noted previously, the temperature extremes used in the test may be beyond those in the expected application to provide a margin of safety. However, setting the test conditions significantly beyond the application conditions may cause interface motion and thus failures which are not representative of the performance which will occur in the application.

Vibration: This test may cause interface motion leading to wear or fretting corrosion or both. If the vibration level causes motion at the interface, significant changes in resistance will typically occur within a few (typically one to eight) hours. As was noted previously, the maximum frequency and amplitude/acceleration levels used in vibration testing may be beyond those in the expected application to provide a margin of safety. However, setting the test conditions significantly beyond the application conditions may cause interface motion, and thus failures, which are not representative of the performance which will occur in the application being simulated. Further, if vibration is not a significant stress in the application environment, this test should not be included.

For a noble metal plated contact system, the core testing will be:

Durability cycling: This can potentially cause plating damage or wear making the contact more susceptible to subsequent corrosion tests. The number of cycles will typically be representative of the number expected during the life of the product in the intended application. If the product is expected to be mated and unmated regularly during life, the test cycles may be performed in sets starting before and then performed periodically during a corrosion test.

Dry heat: This test will cause stress relaxation in mated contacts. It is done before fretting corrosion stress tests such as temperature cycling and vibration as contact interface motion which causes fretting corrosion will be more likely when contact normal force has been reduced due to stress relaxation. Note that contacts with noble platings will typically exhibit fretting corrosion only if the surface plating has been worn through thus exposing the non-noble under-plate, if used, or base metal.

Mixed flowing gas: This may cause corrosion due to poor quality plating or damage to plating from assembly, mate/unmate cycling, etc. It may also cause corrosion in areas which do not contain noble plating. This corrosion may occur very near to the contact area or may spread across non-noble or unplated surfaces into the area surrounding the contact interface. Subsequent motion drivers may cause the contact interface to shift into an area of corrosion. Consideration should be given to whether the connector should be mated or unmated during part or all of the exposure. Also, if the connector will be unmated during any of the exposure, typically only one half, plug or receptacle, of each connector pair will be exposed. The half chosen for unmated exposure should be based on the intended application. An example would be a cable used in a computer workstation or server to accommodate future addition of peripheral devices such as a data storage device. This cable would include several plugs which are not initially used and thus may remain in an unmated state for two to five years of service in the system prior to being mated to a new storage device. The receptacle on the new storage device will be in a virgin state. To simulate this application then, the plug used on the cable would be exposed in an unmated state to an MFG test for a duration simulating up to five years of use in the intended application. After this it would be mated to an unexposed receptacle and the pair would then additional MFG exposure of the mated pair would be done for a duration simulating the additional expected lifetime of the intended application.

Temperature cycling: This test may cause interface motion resulting in the contact interface shifting to an area with corrosion. If non noble under-plate or contact base metal are exposed prior to temperature cycling fretting corrosion may occur during this test. As was noted previously, the temperature extremes used in the test may be beyond those in the expected application to provide a margin of safety. However, setting the test conditions significantly beyond the application conditions may cause interface motion, and thus failures, which are not representative of the performance which will occur in the application.

Vibration: This test may cause interface motion resulting in the contact interface shifting to an area with corrosion. If non noble under-plate or contact base metal are exposed prior to this test fretting corrosion may occur during this test. If the vibration level causes motion at the interface significant changes in resistance will typically occur within a few (typically one to eight) hours. As was noted previously, the maximum frequency and amplitude/acceleration levels used in vibration testing may be beyond those in the expected application to provide a margin of safety. However, setting the tests conditions significantly beyond the application conditions may cause interface motion, and thus failures, which are not representative of the performance which will occur in the application. Further, if vibration is not a significant stress in the application environment, this test should not be included.