CEN Workshop 10
Standardisation for Defence Procurement
Expert Group 8 Environmental Engineering

Report of Expert Group 8 Environmental Engineering

Selection and Comparison of Standards

Recommendations for Future Harmonisation

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EXECUTIVE SUMMARY

Background

The European Commission has mandated the European Standardisation Organisation CEN to screen and to compare the existing national and international standards related to defence procurement and to give recommendations for preferred application in future.

CEN BT 125 has initiated a CEN Workshop (WS 10) to create a European defence procurement standardisation handbook. As a first activity, a number of European national Ministries for Defence have described their national procurement process and have compiled a database of widely adopted standards used in this procurement process. As a next step eight priority areas were identified for more detailed review by expert groups. The task of these groups was to compare the technical content of various standards with the aim of recommending a reference for European defence procurement.

One of these priority areas was to review available environmental engineering standards including the appropriate environmental testing standards and the environmental program management standards. The appointed expert group (EG 8), mainly comprising of experts of the European umbrella organisation of the societies for environmental engineering CEEES, took over responsibility at the beginning of 2004. The group had a mix of representation from European national Ministries for Defence as well as European Industry. Many of the experts were also active in national or international standards committees. One reason for the strong support of Expert Group 8 was that for the first time in the history of standardisation of environmental engineering a broad comparison survey was been mandated.

Process

The preliminary list of documents generated by WS 10 and delivered to Expert Group 8 comprised some 11500 documents, of this number around 600 were environmentally related standards. This subsidiary list contained a mix of both vertical (product related) and horizontal (non product specific) standards. With the relatively tight time scales imposed by WS10 and to allow the best use of the available resources, it was necessary for Expert Group 8 to initiate several parallel activities.

The first priority of the Expert Groups was to identify the horizontal standards relating to environmental testing. Most standards organisations, whether commercial or military, usually include a number of horizontal standards which are used as building blocks for the vertical, product related, standards. Environmental testing standards are usually located in this horizontal group. Those standards are, in almost all cases, the primary reference source for environmental test procedures. That is the horizontal standards contain the test procedures adopted as the model or benchmark by other standards.

A total of six separate horizontal standards were identified as primary sources of environmental test procedures. This number included one group (ITOPS) added as a result of request made to WS10. Those six separate horizontal standards were;

International Commercial Standards IEC 60068 and IEC 60721

UK National Defence Standard Def Stan 00-35

French National Defence Standard GAM EG 13

US National Defence Standard Mil Std 810F

International NATO Defence Standard STANAG 4370 and its Allied Publications (AECTP's)

Quadripartite {US/UK/F/DE} Agreement ITOP (International Test Operating Procedure)

For each of these standards individual procedures were compared and the result documented. The comparisons were undertaken for in excess of 40 separate groups involving around 160 separate procedures. In order to undertake consistent comparisons a number of assumptions and criteria were identified. These assumptions and criteria were reviewed, refined and finally agreed by the Expert Group as the work proceeded. The outcome of this refinement was a list of ten comparison criteria which were;

- Technical Innovation.
- Up to Date Techniques.
- Reproducibility.

- Strength of Reference.
- Interoperability.
- Suitability for Purpose.
- Disadvantages to European Industry.
- Alignment to European Defence Procurement Strategy.
- Backward Compatibility.
- Equivalence of Standard.

Having derived a process to deal with the horizontal environmental standards the Expert Group needed to review and classify the vertical, product related, standards. The primary concern of the review of the vertical standards was to identify procedures which may have been missed as horizontal standards and others which potentially contained primary source test procedures. Essentially no additional standard was identified which could be classed as a horizontal standard or which contained primary source procedures.

Summary of Review

Based upon the 40 or so separate outcomes of the comparison exercise, an set of overall conclusions with regard each of the six horizontal procedures was generated. A summary of those is set out below.

International Commercial Standards IEC 60068. This group of procedures are consistently formatted with a very clear distinction between guidance information and mandatory requirements. The test procedures are mostly firmly written and should ensure repeatable results regardless of the tester, test facility or test equipment utilised. For this reason the test procedures are idea for setting as contractual requirements and for COTS equipment. The main disadvantages of these test procedures is that they are old, lack technical innovation and often do not utilise up to date & cost effective facilities, techniques or methodologies. Although IEC adopt a maintenance procedure these are slow and do not always bring a test procedure up to the same level of technical innovation as the defence standards. In addition, the standard lacks a basic and credible environmental management strategy as well as incorporating antiquated severities in both EN / IEC 60068 and 60721.Overall the document would require significant and sweeping changes to allow its use for modern defence equipment.

UK and French National Defence Standards Def Stan 00-35 and GAM EG 13. Both of these test standards adopt a clear distinction between guidance information and mandatory requirements. They are firmly written but also supply additional test guidance information on test conduct and severity derivation. The tests are written to facilitate consistency of testing and can be called in contractual requirements with confidence. The tests commonly used for COTS equipment are included in a manner such that they are consistent with other “vertical” standards. In particular Def Stan 00-35 & GAM-EG-13 have made some effort to achieve commonality with EN / IEC 60068. However, they also incorporate additional, defence specific, procedures and include a number technically innovative enhancements to existing tests. Both standards are supported by viable environmental management strategies that is consistent with defence procurement approaches used in the two countries. The standards include credible and up to date test severities which are specific for defence usage. Both standards are compatible with the use of tailored severities and give significant advice on natural, induced and abnormal environmental severities. From a Defence viewpoint both Def Stan 00-35 & GAM-EG-13 comprise a good practical compromise between consistency with commercial standards and technical innovation for use in testing sophisticated defence systems. The restriction on the European wide use of Def Stan 00-35 & GAM-EG-13 is that they have never been targeted outside the two originating countries. Both standards were considered and extensively utilised in the generation of STANAG 4370.

US National Defence Standard Mil Std 810F. The main historical advantage of Mil Std is that it has frequently been at the fore front of introducing technically innovative approaches and methodologies. The procedures within Mil Std 810 have never been particularly consistent with other group of standards often adopting different tolerances, procedure & approach to those of other standards. Also the procedures in the Mil Std do not always adopted a consistent or firm style with no clear distinction between guidance information and mandatory requirements. From a Defence viewpoint the US Mil Std 810 comprises excellent guidance material particularly relating to severities. However, its test procedures are insufficiently well defined to confidently use them in contractual requirements. The test procedures are inconsistent with other standards to an extent that the adoption of the Mil Std for

European defence applications could give the US defence suppliers an undue advantage over European suppliers.

Quadripartite {US/UK/F/DE} Agreement ITOP (International Test Operating Procedure). The ITOP's reviewed proved to be product related and consequently the ITOPS should really be classed as "vertical" standards. Only a few ITOPS relate to environmental testing and then they only encompass an inconsistent and narrow range of topics. Many of the ITOPS were heavily biased towards US procedures and in those cases seemed to take little account of European or International considerations. The environmental ITOPS appear to have no general applicability and the niche role they are purported to fulfil is questionable. The large amount of US content in the ITOPS is a concern as it could be argued that ITOPS are a means of foisting US approaches on European countries. This of course could consequently give US suppliers an unfair advantage over European suppliers. Generally the ITOPS were neither state of the art, technically innovative nor did they appear to be particularly cost effective. The procedures are reasonably well written but do not appear to have any underlying strategy or relationship to any procurement approach.

International NATO Defence Standard STANAG 4370 and its Allied Publications (AECTP's). This procedure contains a significant amount of identifiable content from the UK Def Stan 00-35, the French GAM EG 13 and the US Mil Std 810. As such it identifiably takes cognisance of a range of national European standards. The comparison work has shown that the various individual procedures of STANAG 4370 are either the best procedure for that type of test, are equally as good as those in other standards or have the potential to become the preferred procedure. Overall version 3 of the STANAG encompasses the most technically advanced and innovative components of the three national defence standards that it is based upon. STANAG 4370 is biased towards supplying advice to establish test severities. In this regard the majority of the test severity advice is the latest available. However, for European uses this needs some caution as some of the advice is biased towards US platforms. STANAG 4370 is supported by an environmental management strategy which is consistent with defence procurement approaches used in most European countries, but only in an overarching manner. This has only been achieved with significant compromise and loss of detail. The main deficiency with the STANAG relates to strength of reference as the test procedures do not always have sufficient strength and clarity to allow them to be used in contractual requirements. Several contributory factors appear to be the root case of the poor strength of reference. The lack of industrial participation in generating the standards, the narrow distribution used in reviewing the documents are clearly factors as well the absence of the type of control and secretariat support that acknowledged professional standards bodies find essential.

Recommendations

The environmental management process is a critical feature of both the procurement and development strategies used for defence equipment. The process needs to align with the European Defence procurement strategy and practised equipment design and development methodologies. Currently neither the Mil Std process or the STANAG 4370 AECTP 100 process align with the procurement strategies adopted by many European countries or that proposed for European Defence procurement. The adoption of the US based standard for European procurement would, it could be argued, put the European defence industry at a disadvantage. A similar argument could be made for the NATO standard which also has not withstood the test of sustained usage. The UK and French standards have some shortfalls, but together they are far better than the STANAG 4370 AECTP 100 process. Amalgamation of the French and UK environmental management processes is entirely viable as they cover similar ground but are aimed at different people. Amalgamation of the two processes would also allow integration with the proposed European Defence procurement process.

Almost identical arguments apply to the process used to develop test severities from in-service conditions. Whilst, the STANAG and Mil Std standards acknowledge European based approaches they have not been used to establish many of the fallback severities contained within STANAG 4370. Updating these severities will take time but such an approach is essential if they are to fully encompass European platforms (vehicles, aircraft, ships etc), logistics and in-service conditions. The recommendation made above, of amalgamating the French and UK environmental management processes, would resolve this issue also.

The fallback test severities currently contained in STANAG 4370 are an amalgamation of the fallback severities commonly used in US, UK, France and Germany. As a starting point for European defence procurement these fallback severities are recommended. However, to ensure a viable procurement strategy the ongoing derivation of severities tailored to the required range of European platforms, logistics and in-service conditions is essential.

The Expert Group review of the available test procedures resulted in an overall recommendation is that the STANAG 4370 procedures are consistently better, technically innovative and demonstrably incorporate European approaches and methods. The adoption of the STANAG 4370 procedures would not appear to put European Defence industry at any particular disadvantage. This notwithstanding changes are urgently required to the way the STANAG is managed and controlled. This is necessary to bring the STANAG procedures up to the same quality of firmness and strength of text as other vertical standards. This will almost certainly mean the current management, CNAD, sharing control with a professional standards organisation.

The Expert Group has also considered a sizeable number of vertical (product) standards which in part incorporate environmental test procedures. The recommendation of this Expert Group, along with that of almost all standards organisations, is for the vertical standards to use test procedures available in the horizontal standards. Very few vertical standards were identified were this would not be viable, preferable and cost effective. The only area actively identified were this approach was not viable related to space equipment which normally includes a handful of tests not encompassed by the horizontal environmental test standards.

1. BACKGROUND AND UNDERLYING POLICY

In the course of the political efforts to increasingly see European defence as a joint task and to intensify the co-operation between the armed forces of the individual member states, the European Commission has launched several initiatives. Thereby different obstacles have been identified that up to now have lead to road blocks in common European defence, especially the selection and procurement of equipment. Within the existing framework of well-established but diverse national supply processes it was hardly possible to speak of an open European armament market.

CEN BT/WG 125 elaborated a work program in 2001 that among other things planned to issue at the end of 2005 an internet based European handbook for standardisation at the procurement in the defence equipment. In 2002 WS 10 began its work which was supported and arranged from the beginning by the Western European Armed forces Group (WEAG), thus the ministries of defence of France, Great Britain, Sweden and Germany.

In order to achieve the target of harmonisation of the supply process, commonality of the standards and specifications as necessary. Three years ago the European Commission placed a mandate for working with the European Standardisation Organisation CEN to compile and to compare the existing militarily relevant standards and to make suggestions for a harmonisation. Thereby a hierarchy of the standards could be established. The initial mandate indicated International civil standards should have precedence over international military specifications. Also that national civil or military standards should only to be used if the international documents are not sufficient in a specific case.

The representatives of the national ministries of defence, as first step of the procedure, collected the standards applied in their sectors and compiled them in a common data base. The next phase of this ambitious task has been distributed onto a number of different expert groups

The initial eight priority fields of action were selected in 2004; one of them was the environmental engineering and testing of defence products.

As a starting point the CEN WS 10 EG 8 group has assumed that no underlying fundamental difference exists between the defence and the civil environmental engineering. Specifically that the supporting methodology of environmental engineering is independent of specific applications and in-service conditions. Also that the assessment steps required to verify the suitability of equipment are comparable. In short the Expert Group presumed no intrinsic reason existed for discounting the use of civil standards. The intensity of the environmental conditions and thereby to the testing severities, was not a sufficient reason for not considering civil standards.

According to the European defence policy, the following targets of standardisation have been pointed out:

- Compatibility: Products, processes and services have to be appropriate for the common application under special conditions and have to fulfil the relevant requirements without causing unacceptable reciprocities.
- Replaceability: The ability of a product, process or service to be used as substitute and to fulfil the same requirements.
- Commonness: The application of the same principles, the same procedure or the same equipment.

The aims of standardisation of defence-related equipment and behaviours are:

- Improvement of the interoperability by standardised interfaces
- Reduction of the variety of supply articles by use of standardised components
- Common supply logistics
- Avoidance of parallel efforts for research, development and testing of defence material

The defence sector is increasingly interested to use commercially available products or components. Therefore an essential element of the composition of the future standardisation work is to use the results of the civil standardisation and thereby to widely pass on special military standardisation activities.

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2. STANDARDS IN THE ENVIRONMENTAL ENGINEERING PROCESS

2.1 Historical Background

Many environmental engineering test procedures started as test equipment specific processes , however, by the 1960's common methods were beginning to be written into national and international standards. Not only are some of those early test procedures still in use today but the layout, approach and limitations of those early specifications are still apparent today. At that time most Environmental Engineering standards were little more than a cook book of test procedures with embedded severities. Relatively little choice of procedure was available as this was frequently dictated by available equipment. Moreover, severities were, by necessity, generally simplistic and frequently had only minimal relationship with actual conditions. Environmental testing was expensive and facilities existed at only a few locations.

In the defence sector the main standard was the US Mil-Std 810 which was adopted in various countries partly without any change. In the UK the main defence standard was Def Std 07-55 (now replaced by Def Stan 00-35) and in France GAM EG 13. In Germany there were some environmental engineering standards in the sector of the defense equipment standards (VG) and of the technical supply conditions (TL) but no coherent standardization works comparable to Mil-Std, Def-Stan or GAM. At the same time, in the civil sector, the first of the family of procedures that are now IEC 60068 (but then known by different numbers in different countries) was making an appearance.

By the mid 1970's test facilities were rapidly improving, new test control, monitoring and instrumentation were also becoming available. As a consequence many of the older test procedures were been significantly upgraded. Also the ready ability to make field measurements was starting to indicate deficiencies in the generic and crude test severities of the 1960's. In some military areas the need for a revision of the test severities had become critical as the existing tests were significantly affecting product design, mass, cost or performance. The main area of concern was with so called induced environments (as opposed to the natural environment). Induced environments are those created by the system itself often in-conjunction with its operational conditions. In some cases in-service failures were not been reproduced in test or testing was causing failures not found in-service. A number of empirical methodologies to determine improved severities originate from this time as does work to better understand the mechanism causing induced environmental conditions. severities.

A major issue with the purchasing authority defining fixed cook book severities is that they effectively take all the risk and consequences of inappropriate values. However, they rarely have sufficient information to judge the extent of the risk they were taking. Whilst, some environmental standards included processes to partly alleviate this problem, the real debate, on risk arising from the lack of severities and the need to improve severities, were only widely addressed with the issue of US Mil Std 810 issue D. This turned around previous approaches and put the onus on the equipment supplier to establish an environmental strategy as well as the environmental conditions. This allowed suppliers to adopt representative severities. A process which became known as “tailoring”. In fact this is not a particularly good description as it has little real meaning and tends to be use by different people to mean different parts of the process.

The Mil Std 810D process was supposed to be managed by a series of specified formal documents. These documents were intended to allow the equipment supplier to agree and demonstrate the approach they were adopting. It should be remembered up to that point contract were a set of firmly written requirements allowing the supplier little scope for deviation. The process of Mil Std 810 D was allowing suppliers greater responsibility, scope and flexibility. However, the Mil Std 810 D documents rarely interfaced with the procurement process used by European countries. Indeed experience would suggest they were never widely used by US companies either.

The above notwithstanding the Mil Std 810 D process was fairly widely adopted by the European Defence industry as it had clear advantage when environmental conditions were design drivers. The process also extended to many areas of commercial work. The adoption of the process increased the need for in-service measurements and an explosion of measurement exercises occurred allowing further improvements to the severities embedded into standards. However, the quality of these measurements were not always that good nor were they always matched by an understanding of the mechanisms involved in generating the conditions. In short the methodology for deriving test severities from in-service measurements was not defined and , as a consequence, derived test severities varied enormously.

By the mid 1980’s significantly improved, service based, environmental severities were available and many of the national Defence Standards were starting to incorporate these improvements. Some, notably the French Defence Standard were also starting to incorporate methodologies for deriving test severities from In-service data. However, the different approaches adopted for severity derivation in the various national standards meant that in this respect they were diverging and the need for an international approach for convergence became pressing. The only real international commercial standard was the procedures & severities of EN/IEC 60068 & 60721. However, the severities of these documents were not self consistent nor did they appeared to benefit from any credible measurement exercises. As a consequence even for areas were commercial / military environments overlapped these documents were not considered a credible base for international agreement.

The solution adopted by the NATO STANAG organisation was to initiate a environmental test standard based upon available national standards. The majority of the work on this standard occurred in the early 1990’s and in effect encompassed aspects of Mil Std 810, the French GAM standard and the UK Def Stan.

In parallel with the generation of the first NATO Horizontal Environmental testing standard, during the 1990’s the three main national standards were also been revised. In the case of the French GAM standard, significant additional information and advice was included on the derivation of test severities from measurement and for user defined in-service equipment life cycles. The UK standard additionally included information on induced mechanical and climatic environments as well setting out an environmental management process compatible with the design process and consistent with the UK procurement process. The US Mil Std had been updated in the late 1980’s and again in the late 1990’s these revisions included updated test severities as well as a revised environmental management process. In this period no similar changes either to severities or the management process were made to EN/IEC 60068 or 60721. Indeed it was not till the late 1990’s that, long overdue, work to update the environmental and test severities of the two documents has occurred. Even then that update was restricted to a severity reconciliation between the two documents rather than a fundament review of severities.

2.2 Commercial and Defence Standards

The IEC / EN 60068 series of test procedures is frequently first choice for civil products that contain electrotechnical or electronic components (and this is the majority of all technical products). Various goods of this type are also embedded in defense products. Therefore the IEC 60068 series of procedures can be regarded as basic standard for dual use products.

Any civil product test procedures are unlikely to fulfill in all requirements set by military environmental requirements. Specific environmental conditions occur are for example due to vibrations and shocks which arise when operating guns. Therefore any civil test procedures will at best need to be supplemented by tests which unique original military requirements.

As a starting point to allow comparisons to be undertake Expert Group 8 has assumed that generally there is no fundamental difference between the defence and the civil environmental engineering. Especially with regard the implementation of test tailoring strategies. That is the methodology of environmental engineering is independent of specific environmental conditions and the assessment steps are also comparable. The differences mainly refer to the intensity of the environmental conditions and thereby to the testing severities. As such, whilst, test severities for defence equipment may differ from those required for civil equipment, the test procedure used should not intrinsically be different.

2.3 Test Tailoring

The term “tailoring” is often used to mean the process by which test methods and particularly their severities are adapted to improve the simulation of specific environmental conditions. “Tailoring” in this limited sense is an accepted environmental engineering process. Its development was stimulated by the realisation that conservative test methods and excessive test severities can result in increased materiel development costs with no compensating increase in materiel performance or reliability.

The tailoring process has broader application to materiel development programmes. Therefore, for the purpose of this report “tailoring” is also considered to encompass the optimisation or refinement of the environmental engineering task, to meet the specific needs of a particular materiel development programme.

It should be noted that although the application of tailoring to environmental testing programmes can provide significant benefits with regard to materiel development costs, it can also restrict the user’s operational flexibility to those Service environmental conditions originally specified.

2.3.1 The Use Of Tailored Test Methods And Severities

Tailored environmental test methods and severities are adopted to permit a more accurate simulation of the anticipated Service environments and allow the performance and integrity of the test specimen to be examined whilst being stressed only to representative Service environments. Such tailoring reduces the probability that the test specimen will incur unrepresentative failures.

Although the use of tailored test methods is technically preferred, alternatives, known typically as minimum integrity test methods, are often acceptable. These alternative test methods are generally relatively unsophisticated tests that can be adopted when a precise simulation is not necessary to establish suitability for Service use and when a degree of over testing can be tolerated. Usually generalised (sometimes termed fallback) test severities are used in combination with minimum integrity test methods.

To encompass all levels of materiel sophistication, test methods of both types, i.e. tailored and minimum integrity, are needed. Both tailored and minimum integrity environmental test methods, covering all significant and relevant environments to which materiel may be expected to be subjected, are contained in many of the standards compared by Expert Group 8.

The increasing complexity and availability of advanced laboratory test equipment provides the test specifier with a choice of tailored and minimum integrity test methods for accommodating a particular environment. Tailored test methods are generally no more expensive to conduct than minimum integrity test methods. However, they usually require more sophisticated test equipment which may limit the choice of available test facilities. It is also often more difficult to reproduce the test results should a repeat test be required at a later date. Repeatability is an important consideration should the test be undertaken for Environmental Stress Screening or In-Service Surveillance purposes.

The adoption of tailored test methods and severities is usually essential for materiel whose performance, cost, reliability, mass or configuration could be adversely affected by tests which significantly exceed the stresses produced by the related Service environments. The degree or extent to which tailoring is to be applied should be agreed with the materiel designer, who is usually the best placed to quantify the consequences of overtesting.

When conducting tailored test methods in the earlier phases of a materiel development programme, adequate information may not be available to allow the use of project specific severities. Therefore the suitability of a design may need to be evaluated using generalised or fallback test severities from national or international standards, or from applicable data derived from similar earlier programmes. These generalised test severities should be replaced for Qualification or Type Approval tests by tailored severities from project specific data acquisition programmes.

The adoption of generalised test severities throughout the development programme is acceptable and possibly advantageous where the deployment, location or usage of materiel is difficult to quantify. It is also relevant when the intended usage or role may be expected to change during its Service life. Consequently, for such materiel, the adoption of severities from national or international standards should be considered in comparison with available measured data from appropriate Service environments.

The adoption of generalised test severities can provide a useful means by which a procurement authority ensures the removal of design weaknesses in components and subassemblies before they are incorporated into more sophisticated systems. However, the application of generalised test severities to remove design weaknesses should be tempered with consideration of the potential overdesign penalties in terms of performance limitations, programme costs and delays that could be incurred through their use.

2.3.2 Tailoring The Environmental Test Requirements

The aim of this aspect of tailoring is to generate an Environmental Test and Assessment Specification that provides sufficient evidence for materiel certification together with a cost effective series of tests and assessments. To this end the tailoring process involves making decisions on which environmental tests can be merged together or even eliminated. It also includes making decisions on the balance to be achieved between testing and assessment for demonstrating compliance.

A reason for merging environmental tests is that collectively they exercise the same potential failure modes of the materiel when it is in the same operational state. A reason for eliminating tests is that the materiel exhibits no failure modes associated with that environmental condition.

Tailoring the environmental test and assessment requirements involves knowledge of the likely failure modes of the materiel associated with its exposure to specific environmental conditions. In general, tests should concentrate on the environments to which the materiel is sensitive rather than those to which it is likely to be robust. This advice would not apply to safety tests which are undertaken to demonstrate that a munition is not sensitive to an environment condition. In some instances environmental design aid tests may be needed to generate evidence for the elimination of some conditions and the combination of others.

2.3.3 Tailoring The Test And Compliance Programme

Tailoring the Test and Compliance Programme develops further the tailoring process to address sequential testing and combined environments testing.

The purpose of sequential testing is to replicate the cumulative ageing and degradation that the materiel would experience as a result of exposure to the environmental stresses arising from its planned Service life. In particular the environmental stresses induced by sequential testing should be representative of the conditions set out in the Manufacture to Target or Disposal Sequence (MTDS).

Sequential testing should not induce in the materiel any excessive environmental stresses that could cause unrepresentative failures, but should include environmental stresses that exercise long term damage mechanisms. There is always some risk that sequential testing will result in overtesting as a consequence of the cumulative effects of the marginal overtesting that arises from each test within the sequence.

Sequential testing is usually adopted for ordnance and one shot devices, even though it is only at the end of the test sequence that satisfactory operation can be demonstrated. For these applications sequential testing can be relatively costly and time consuming, because the test sequence may take many weeks to complete. Also, because a failure during the test sequence usually means starting all over again, it imposes a significant risk on completing the materiel development programme on schedule. To minimise this risk, an approach known as “cascade” testing is often adopted, where a relatively large number of test specimens are subjected to the test sequence, and where after each appropriate test stage a number of items are withdrawn for functional testing.

During Service use the materiel will be subjected to several environmental conditions simultaneously, but few environmental tests replicate simultaneously more than one environment. Combined environment testing is necessary when the damaging effects of two or more environments applied simultaneously are envisaged to have greater damaging effects than when the environments are applied separately. The deterrent to undertaking combined environments testing is, almost always, cost. For effective decisions to be made regarding the inclusion of combined environments testing into the Test and Assessment Programme, the Environmental Requirement document should identify when environmental conditions occur simultaneously or when they are expected to do so at a credible level of statistical probability. Based on this information the sensitivity of the materiel to combined environments can be evaluated and suitable tests incorporated into the programme.

2.4 The Environmental Control And Management Process

The objectives of the environmental control and management process are those that can be adopted for any task control and management process, and may be listed as follows:

(a) to ensure that concise and unambiguous requirements are defined

(b) to ensure that a strategy is in place for undertaking the task

(c) to ensure that the task is adequately controlled and managed

(d) to ensure that a mechanism exists for demonstrating compliance with the requirements.

These objectives are translated and developed to form the basic elements of the process. The elements are described as follows:

(a) establish the environmental requirements for the materiel

(b) formulate a strategy for demonstrating the adequacy of the materiel against the environmental requirements

(c) define the environmental tasks and the programme necessary to allow the strategy to be implemented

(d) undertake the defined environmental tasks to the authorised work programme

(e) demonstrate, through assessment of the reported information generated by the environmental tasks, that the materiel meets the environmental requirements.

The environmental control and management process is normally supported by a series of documents. The environmental control and management process and its documentation should interface directly with the overall design certification process. In particular, the inputs to the environmental control and management process are derived directly from requirements emanating from the design certification process. Moreover, the outputs from the environmental control and management process integrate directly into the design certification process evaluating the suitability of the materiel for Service use.

2.4.1 The Process And Its Supporting Documentation

The basic elements of the environmental control and management process and its supporting documentation are indicated in the following paragraphs. Usually the process and its supporting documentation are closely related, such that the steps of the process can be explained by summarising the aims of the key documents.

The process of defining the environmental requirements for the materiel involves the generation of an Environmental Requirement document, which establishes the environmental baseline against which the materiel will be designed and ultimately approved for Service use. The environmental requirements are a set of environmental characteristics representing each phase of the materiel's life as defined in its Manufacture to Target or Disposal Sequence (MTDS).

The strategy demonstrating the adequacy of the materiel against the environmental requirements is set out in the strategy plan. This plan uses the Environmental Requirement as the primary input to set out how compliance for each major environmental requirement is to be achieved. Strategy plan provides up-front visibility of the total qualification task. The major features of the plan include the series of rationales to be adopted and descriptions of the major tasks to be undertaken to achieve cost effective compliance with the requirements.

The definition of the environmental tasks and programmes that implement the environmental management strategy results in two documents, typically known as, the Environmental Test and Compliance Programme and the Environmental Test and Assessment Specification. The former defines the sequence and timing of the environmental tasks to ensure that a Compliance Statement is available on time for each condition specified in the Environmental Requirement, whilst the latter defines the environmental tests and assessments that will provide the evidence for the Compliance Statements.

To ensure effective control and management of the individual environmental engineering tasks the key documentation addressed above generally needs to be augmented. The disposition of the subsidiary documentation within the process will vary from agency to agency. Typically the subsidiary documentation includes Environmental Test Instructions that expand and supplement for a specific test the broad requirements of the Environmental Test and Assessment Specification. The outputs from a specific test are set out in Test Reports and Test Assessments that report respectively, compliance with the requirements of the Environmental Test Instruction, and the Environmental Test and Assessment Specification.

A feature of the process should be that each requirement or specification document has a matching reporting document demonstrating compliance. For example, the Test Report responds to the Test instruction, the Test Assessment responds to the Test Specification and the Compliance Statement responds to the Environmental Requirement.

Assessing compliance against an Environmental Requirement may take one of several forms, but in practice it is likely to take one of the four options. The four options are test only, test plus supporting analytical assessment, analytical assessment plus supporting test or analytical assessment only. A close simulation, often referred to as a tailored test, usually minimises the risk that the materiel will not function in the operational environment. Nevertheless, there may be many reasons, such as cost effectiveness, programme expedience, earlier precedents or engineering judgement, that warrant the selection of an alternative technically acceptable option. The outcome of this assessment process is a Compliance Statement.

The process requires that the environmental conditions that could significantly influence the design of the materiel are verified during the course of the development programme. This requirement is achieved with the aid of an Environmental Verification Plan which contains a strategy and programme for confirming design related environmental characteristics and severities.

The extent to which each document will exist as a separate document is largely a function of the scale and complexity of a specific project. For projects where there are few perceived technical and programme risks, certain documents may be sensibly merged together provided that the basic elements of the process, are fully embodied in any reduced set of documents.

2.5 Process Documentation

This following sets out the purpose and content of the project specific documents that support the control and management process for environmental engineering tasks

2.5.1 Environmental Requirement

The purpose of this document is to identify and define the characteristics, severities and occurrence rates of all relevant natural and induced environments and their combinations to which the materiel may be subject during its Service life. Environmental requirements are derived from the life cycle. The life cycle will usually include transportation, storage, installation, deployment, maintenance, operation and decommissioning of the materiel. The Environmental Requirement document forms the environmental baseline against which the materiel is qualified. The document may form part of the contractual requirement for the materiel development programme and, in such cases, it is particularly important that this document is both technically sound and complete.

The precise definition of certain environments may not be available early in the materiel development particularly for environments that are induced by the materiel itself. Consequently, initial estimates of these environments may need to be revised as the design develops and when more detailed information becomes available from the environmental verification programme.

2.5.2 Environmental Test And Assessment Specification

The purpose of the Environmental Test and Assessment Specification is to provide, in summary form and in one document, the set of tests and assessments on which the certification of the materiel will be based. The content of the document comprises a summary description of each test and assessment needed to provide evidence for the certification process. The document expands the rationales contained in the Environmental Management Plan into specific task requirements. The test and assessment severities are derived from information contained in the Environmental Requirement document. The Environmental Test and Assessment Specification should also include summary descriptions for related tests, such as those for reliability and safety.

The summary description for each test will include the test method to be adopted, the severities to be applied and any other special requirements considered necessary, e.g.: the functional state of the materiel during the test. Some of the tests may involve the application of combined environments.

2.5.3 Environmental Test Instruction

The purpose of the Environmental Test Instruction document is to set out the precise and detailed instructions necessary for laboratory staff to conduct a particular environmental test. Where relevant the Environmental Test Instruction should reference its associated Functional Performance Test Specification.

2.5.4 Environmental Test Reports

The purpose of the Environmental Test Report is to record observations, data and results of an environmental test conducted in accordance with the Environmental Test Instruction. In particular, the content of the Environmental Test Report must respond to each requirement detailed in the Environmental Test Instruction. In addition, any deviations from the Environmental Test Instruction observed during the test must be reported.

The Environmental Test Report is the formal output from the test laboratory. It is not, unless combined with the Environmental Test Assessment document, expected to comment on the success or otherwise of the test, or on any implications arising.

2.5.5 Environmental Test Assessment

The purpose of the Environmental Test Assessment document is to report objectively an evaluation of the test observations, data and results provided by the test laboratory and recorded in the Environmental Test Report. These observations, data and results are evaluated mainly in terms of the materiel's ability to survive without degradation the test conditions specified in the Environmental Test and Assessment Specification. A separate assessment is normally required for each test listed in the Environmental Test and Assessment Specification document.

The Environmental Test Assessment document is expected to state the adequacy of the materiel to withstand or function in the test conditions specified in the Environmental Test and Assessment Specification. Should any materiel inadequacies be apparent, then the assessment should include recommendations for their removal. These recommendations could take the form of further evaluations, analyses, laboratory tests, or data acquisition trials.

3. LIMITATIONS AND RELATED DOCUMENTS

3.1 Limitation of the Study

This study has its focus on environmental testing and engineering, i.e. the evaluation of a product or a military hardware under various environmental influences. Many specifications of products include environmental requirements affecting quality, reliability and service life. There is a huge amount of these standards out on the market. Very often these standards are related to a branch or a group of equipment such as electronics, telecommunication equipment, vehicles, weapons, missiles, ammunitions, aerospace, and personal equipment for the soldier. These specifications and standards are often referred to as ‘vertical standards’ compared to those standards which describe the test procedures independent of the tested products. These standards are often referred to as ‘horizontal standards’ because they can be applied for various groups of products.

The limitation of this investigation is delineated by military needs. Many similar standards have been developed in the past for civilian products and quite a large number of standards are exist for specific purposes and equipment.

This report clearly focuses on universal standards in the area of military hardware and important civilian standards dealing with environmental testing. Many so called ‘dual-use-products’ or ‘commercially-of-the-shelf-products’ (COTS) are to be tested according to these basic test procedures. Due to a limited time schedule and resources not all existing test standards have been evaluated. There are a lot of specific environmental testing standards available, e.g. related to automotive application, aerospace application, optical instruments, telecommunication equipment which could not been addressed in detail.

The experience and knowledge of the experts involved in the field of environmental engineering has ensured that the most important standards have been included in this study. The history of environmental engineering tells us that most testing standards have the same roots. Quite often the newly established standards in a specific branch can be traced back to the basic environmental testing procedures of the area of defence application.

Certain aspects of environmental testing are closely related to and overlap areas of safety and reliability testing. Indeed many test procedures used for these purposes are either based upon or similar to environmental test procedures. The environmental testing to space vehicles and spacecraft equipment was identified as including some unique requirements. To explain these relationships the following paragraphs refer to some specific considerations.

3.2 Reliability Standards In Defence Procurement

The following paragraphs addresses the relationships between the reliability assessment process and the environmental engineering process. For defence equipment the reliability of equipment will almost always need to be assessed but it may also be necessary to incorporate testing activities aimed at demonstrating the ability of the materiel to meet specific reliability targets.

The reliability assessment process should generally be able to utilise information from both the environmental test and the design certification processes. However, the testing undertaken for those purposes may not satisfy all the needs for reliability assessment. The primary intent of environmental testing is usually to demonstrate that the equipment will function at the extremes of the specified operational conditions throughout Service life. To this end qualification tests generally aim to replicate time dependant effects of ageing and degradation. While, the environmental conditions causing ageing and degradation are commonly incorporated into qualification test programmes, the environmental conditions are applied at severity levels which can significantly accelerate the rate of degradation. Accelerating the rate of degradation circumvents the main aim of reliability assessment which is to quantify the failure rate (or its inverse, such as time between failures).

Many of the problems associated with defining tests from which failure rate can be quantified are similar to those associated with replicating ageing and degradation for Life Assessment purposes. In particular the setting of test requirements, able to replicate degradation credibly, inherently dictates the inclusion of assumptions and knowledge of likely failure modes. The value of the resultant estimates of failure rate may be significantly influenced by errors and limitations in those assumptions.

The reliability requirement (including statistical confidence level) will largely influence the approach used for reliability assessment. However, reliability assessment is influenced by the type and cost of the equipment, along with the character of its operational usage

Reliability testing generally commonly adopts two categories of environmental testing, namely Reliability Growth testing to develop improved equipment reliability and Reliability Demonstration testing to ensure that the reliability requirements have been achieved. The purpose of the two categories is stated below:

(a) Reliability Growth: The purpose of Reliability Growth testing, also known as Reliability Development testing, is to improve equipment reliability. In particular it is intended to identify equipment sensitive to environmental conditions. It is important that any failures induced during Reliability Growth testing are realistic and typical of those that are liable to occur during Service use. Consequently, Reliability Growth testing should adopt test severities that are only marginally higher than the mean levels for a specific environmental condition.

(b) Reliability Demonstration: The purpose of Reliability Demonstration testing, also known as Reliability Acceptance testing, is to demonstrate that during Service usage equipment reliability will be compliant with the specified requirements. When this type of testing is conducted on production standard hardware it is often termed Production Reliability Acceptance testing. Reliability Demonstration testing normally adopts severities slightly lower than those selected for Reliability Growth testing. Ideally the severities should be nominal unfactored values for a specific environmental condition, which will ensure that any induced failures are representative of those from Service conditions.

Reliability standards ensure that the deliverable equipment is well designed, free of manufacturing process defects and are demonstrably meeting the contracted reliability levels. The techniques for demonstrating and improving the reliability of complex, high-value electro-mechanical products, such as modern weapon systems, typically involve the prolonged application of vibration and temperature stresses, either separately or in combination to represent the effect of many product lifetimes.

The following table sets out reliability standards which have been identified as overlapping with the environmental engineering process. No recommendation is made between these standards as to do so is outside the terms of reference of Expert Group 8. However, Expert Group 8 would observe that to meet the underlying reliability requirements the reliability standards need to encompass the use of severities based upon service conditions. In that regard the reliability standards need to utilise the same tailoring process as adopted for environmental qualification testing.

	Title	Objective(s)	Benefit(s)	Disadvantage(s)
NATO STANAG 4174	Allied Reliability and Maintainability	Achieving contracted reliability and maintainability	Contract Risk reduction Cost-effective product	Initial investment for testing and proving effort
UK Defence Standard 00-40 00-41 , 00-43 and 00-44	Reliability and Maintainability	Achieving contracted reliability and maintainability in design and development	Contract Risk reduction Cost-effective product	Initial investment for testing and proving effort
US MIL HDBK 781 MIL HDBK 785	Reliability and Maintainability	Achieving required reliability and maintainability in design and development	Contract Risk reduction Cost-effective product	Initial investment for testing and proving effort
US MIL-HDBK-344A	Environmental Stress Screening	Improving production reliability	Defect-free product	Extra supplier cost
IEC 56/951/CD 61163-3 Ed 1:	Reliability Stress screening	Improving production reliability	Includes non-military application	Extra supplier cost
IEST Recommended Practice PR001.1	Management & Technical Guidelines for ESS Process	Improving production reliability	Includes non-military application	Extra supplier cost
IEC 60 605	Equipment reliability testing			

3.3 Abnormal Environments and Safety Tests

Standards containing procedures for environmental test of commercial and defence equipment are usually against environments that that can be expected in normal service use. However, test programmes may also contain tests intended to replicate abnormal environments. In defence procurement reference to abnormal environments is usually used to encompass extreme normal environments, environments occurring as a result of hostile conditions and accidental events. Whilst, equipment is usually expected to be safe and serviceable following the application of tests replicating normal environments, it may only be required to remain safe following the application of testing against abnormal environments. In some cases the only difference between normal and abnormal testing is the severity and the criteria used to determine whether the item has “passed or failed”. In many cases the actual test procedure are identical or at least very similar to those used for replicating normal environments.

The acceptance criteria of safe and serviceable against normal environments and remain safe against abnormal are not necessarily the only two criteria in current use. Safe for immediate disposal is used in extreme cases and safe for use if no visible damage may be used in limited extreme normal cases. Moreover, for dangerous items and particularly energetic materials a whole range of different levels of reaction to the test may be used as the criteria. In such cases the acceptable level will depend upon usage requirements and policy as well as the degree of procedural protection that can be offered.

Whilst, in some cases the actual test procedure used for testing against abnormal environments are identical or very similar to those used for replicating normal environments. Nevertheless a few tests do exist which do not necessarily have an equivalent in normal testing. For Defence Procurement the most commonly encountered tests are those used for safety testing of items which could have significant consequences including loss of life. Such tests, which usually use quite severe severities, do not necessarily have a firm “pass or fail” criteria but rather the resultant effects are used to establish safe working practices and hazard procedures.

The most obvious group of safety tests are those used for energetic materials including explosives and propellants. This group of safety tests are used to verify the sensitivity of Defence Systems to extreme accident and hostile conditions. The purpose is to establish how the system reacts to allow the appropriate safety procedures to be developed. In recent years a number of this group of safety tests have become known as the Insensitive Munition (IM) tests. However, most of these tests have existed for many years (some dating back to the early years of the Vietnam war) prior to the introduction of IM policy only the level of acceptable reaction has changed.

Although the safety tests are intended for energetic materials, the majority of the test procedures are similar to environmental tests. Consequently consideration of the procedures overlaps with the Terms of Reference (TOR) of Expert Group 8 and as such are partly addressed here. Nevertheless, consideration of the acceptable reaction criteria falls well outside the TOR of Expert Group 8 as clearly does considerations of requirements for IM policy.

The usual safety tests for energetic materials are; the fire test, the slow cook off test, the bullet attack test, fragment impact tests, the sympathetic reaction test, the shaped charge jet test, electro-static discharge and the drop test. All of these are designated as IM tests under some policies but some such as the drop test and ESD test are not included in others. As would be expected for safety procedures the tests are firmly written and are written to ensure consistency of use. However, by the nature of these severe tests repeatability is not always easy to ensure and a few are notoriously difficult to repeat exactly. Many of the tests such be preceded by a safety assessment to determine sensitivity i.e. so the item can be tested in its most sensitive orientation, impacted at the most vulnerable point etc. Potential variability is essentially taken into account when assessing the level of acceptable reaction. In recent years environmental objections have been raised against the fire test and some effort has been made to develop modelling approach in place of this and some of the other tests.

Safety tests appear at both national and international level although in recent years a degree of alignment has started has become apparent. In the NATO countries the STANAG safety tests appear to have broadly replaced most top level national procedures or the national procedure intentionally aligns with the STANAG procedure. In some cases lower level nation procedures still exist which have slight differences to the STANAG, this seems to be a matter of historical baggage rather than indicating deliberate intent. However, these do not necessarily appear to be primary source procedures rather this may be the MURAT tests.

Another group of safety test procedures which affects Defence Procurement are the United Nations (UN) recommendations on the transport of dangerous goods. In this case dangerous goods encompasses a wide range of materials as well as energetic materials. United Nations document ST/SG/AC.10/11/Rev.2 is a manual of tests and criteria. It contains a number of separate test procedures as well as test programmes for various class of dangerous goods. Some of these tests are broadly similar to the safety tests used for energetic materials, although, no specific attempts appears to have been made to align the two procedures.

Also differences exist in acceptance criteria. Most countries have incorporated these UN recommendations into their national laws, and mostly this implementation encompasses military equipment.

The United Nations (UN) recommendations on the transport of dangerous goods does not include nuclear materiel which is covered by IAEA (International Atomic Energy Agency) which has produced recommended tests for packaged nuclear materiel. These test procedures do align well with the Safety tests for energetic materials although the acceptance criteria do differ. Again most countries have incorporated these IAEA recommendations into their national laws, and generally this implementation encompasses military equipment.

Yet another group of safety tests relate to guided missile equipment used to ensure range safety (i.e. Flight termination systems). These items are usually required to function in extreme normal environments and range safety criteria usually require an equipment demonstration. In the us an attempt has been made to establish a common range safety criteria for such equipment. This common criteria is reasonably consistent with us commercial and military equivalents (nasa std 7001 & mil std 1540). However, no european equivalents were submitted for consideration by the expert group. In the us standards the actual test procedures are from the national horizontal standard (mil std 810) but with specified severity margins which are imposed on maximum expected (or predicted) environment (mee or mpe). As such the equipment falls within the criteria used for the primary comparison adopted by the expert group.

3.4 Space Technology

3.4.1. Introduction

General philosophy concepts related to the environmental testing of space systems are pretty similar aerospace with regard,

- Overall testing philosophy
- Test conditions and tolerances
- Test documentation

On the contrary, significant discrepancies are usually found in the model philosophy to be adopted. In fact, this approach is, usually, strongly dependent on the number of items involved and, since space activities very often imply a limited number of items, also the related model philosophy can be heavily tailored. For example, when science is involved, considerations about risk management, budget and time available, frequently lead to use flight hardware for qualification, that is the “proto-flight” approach.

For the European space activity within European boundaries, a widely accepted reference document is the ESA ECSS-E-10-03A – Space Engineering – Testing.

It is both a vertical and a horizontal guide. This means that it gives recommendation both for the test to be performed (required or optional) on different equipment category such as antenna, battery, pressure vessel, etc.. (vertical approach) and for the procedure to be followed for each specific item at different level of integration (horizontal approach).

Other standards are available, for example NASA-STD-7002, recalling many other documents such as:

- MIL-STD-461 - Electromagnetic Interference Characteristics Requirements for Equipment
- MIL-STD-462 - Electromagnetic Interference Characteristics, Measurement Of
- MIL-STD-1818 - Electromagnetic Effects Requirements For Systems
- NASA-STD-5001 - Structural Design and Test Factors of Safety for Spaceflight Hardware
- NASA-STD-5002 - Load Analyses of Spacecraft and Payloads
- NASA-STD-7001 - Payload Vibroacoustic Test Criteria

The approach is similar to the ESA one, addressing both considerations on vertical and horizontal philosophy. An overview of the suggested philosophy is given in the following chapters.

3.4.2. Test Procedures

Test procedures used in general space test programme have many common features with aerospace and defence equipment, except of course for the severity values or the duration of the test itself. Tests used for space equipment found elsewhere would typically include;

- Physical properties measurements.
- Functional and performance test.
- Humidity test.

Leakage test.

Pressure test.

Constant acceleration test.

Sinusoidal vibration test.

Random vibration test.

Acoustic test.

Shock test.

Thermal cycling test.

Audible noise test.

EMC and ESD test

Nevertheless some procedures are either unique to general space test programme or seldom seen elsewhere. Such tests would include;

Corona arcing detection. Equipment that is energized during ascent or descent and which is exposed to the critical low pressure atmosphere shall be monitored for corona and multi-pacting detection, as the pressure is reduced from ambient to 0,1 Pa within 10 minutes (minimum) simulating the launch profile; equipment operating at a voltage >500 V, shall be tested for corona arcing as well.

Thermal vacuum test. The purpose of the thermal vacuum test is to demonstrate the ability of the equipment to perform in a thermal vacuum environment that simulates the worst conditions in-orbit, including an adequate margin. The test aims both to verify that, after the outgassing, the equipment maintains its physical / electrical / thermal characteristics and that the environmental pollution is acceptable.

Space Life test. The purpose of the life test is to demonstrate that the equipment can operate during its ground and sustained in-flight life without degradation.

Microgravity environment compatibility test. The purpose of this test is to verify the Microgravity Environment Compatibility (MEC) at equipment level, with respect to the specified microgravity environment limit response spectrum at the receiver location.

3.4.3. Qualification Testing

Environment qualification tests are strongly dependent on the integration level at which they are performed; an usually accepted subdivision is the following:

Equipment (e.g. electronic box)

Subsystem (e.g. attitude control subsystem – i.e. box, inertia wheel, sun sensor, cabling)

Element (e.g. satellite)

System (e.g. launcher + satellite + ground segment)

3.4.3.1 Equipment Qualification

At Equipment level, a qualification test programme comprising many of the test listed above are systematically carried out.

3.4.3.2 Subsystem Qualification

The systematic approach used for equipment testing, defining for each type of equipment a series of required and optional tests, is not feasible for subsystems qualification.

Subsystem testing depends on subsystem type, on project characteristics and verification approach, therefore only general guidelines are usually given in the general standards.

With the objectives to increase project flexibility and control and to reduce cost and schedule, for example, functional qualification of the subsystem may become part of the functional qualification of the element or system, in which they are verified as functions of the whole element or system.

3.4.3.3 Element Qualification

At Element level, qualification testing shall be performed on the following items:

a. Space vehicle. At this level, ad hoc testing specifications are often issued, deeply deviating from standard ones. This approach is especially adopted for telecommunication satellites, is justified by severe constraints dictated by schedule and budget and is analyzed through a careful risk analysis.

The conformance to standards is stricter when a scientific mission is to be designed and qualified, the main reason being the final customer is usually a Space Agency.

b. Launcher. LV qualification testing specifications depend on the LV type, engine concept, mission and performance definition. Qualification tests should be conducted at both equipment and subsystem level, while a modal survey test can be conducted on a complete LV stage in order to validate the corresponding dynamic model and thence the test loads on equipment and subsystems. Complete LV stages shall be submitted to functional qualification tests as well

c. Ground segment. It is constituted by the functional elements (HW and SW) used in the operations of the mission. The aim of the qualification is to obtain assurance prior to launch that the integrated hardware and software facilities perform as intended and that the ground segment can accomplish all operational mission requirements within the constraints imposed by the operational environment. Due to the specific characteristics of the ground segment rigid applicability of the space vehicle test principles should not be imposed. In particular, the ground segment equipment need not to be subjected to precisely the same qualification and test requirements as flight hardware since post-launch maintenance and replacement is possible. Furthermore, many essential space vehicle test requirements are not relevant for ground hardware (e.g. model philosophy and most environmental testing procedures). Nevertheless, a huge amount of test is required to fulfil the above requirements but the description of these activities is thought to be beyond the scope of this document.

3.4.3.4 System Qualification

System qualification tests cover the functional (only) aspects relevant to the interrelationship between two or more elements which constitute the system (i.e. space vehicle, launcher and ground segment) and to interfaces with other systems and projects.

3.4.4 Equipment Acceptance Testing

The purpose of the equipment acceptance test is to detect material and workmanship defects. The set of tests is slightly reduced and the related parameters (in terms of level and duration) are usually much less severe with respect to the qualification tests. The exception is the burn-in test which is a modified thermal cycling test used to accumulate the additional operational hours or cycles required to detect material and workmanship defects that occur early in the equipment life.

3.4.5 Conclusions of Testing of Space Equipment

3.4.5.1 Role of Testing For Space Equipment

The evidence collected from the testing phase of previous satellite projects indicated that in almost every case, anomalies were detected in the spacecraft design, which if undetected, can lead to a major reduction in the spacecraft performance or part failure.

So the role of testing is still very important, but nevertheless, nowadays, sufficient analytical methods exist so that it is theoretically possible to perform a purely analytical verification of a satellite; moreover, active controls (for example on thermal aspects) will widen the bandwidth between equipment operative limits: this makes realistic at least to think in a near future to a virtual qualification process. On the other hand, however, there is no alternative to acceptance test to detect workmanship defects or local anomalies.

3.4.5.2 Space Testing Standards

The verification method for a given satellite is dependent on project aspects such as the number of spacecrafts to be manufactured, the payload function, the spacecraft configuration and the state-of-the-art technology: this means that the test sequence, for example, is strongly customized to the particular mission or satellite.

On the other hand, historically, only a few customers have been driving the space market and all of them have followed the path of NASA approach: then, single test procedures do not differ very much between NASA, ESA or CNES specs.

Moreover, the space agencies have made a significant effort (based on a huge amount of data coming from test and operative sampling) to the standardization of equipment thermal, structural, electromagnetic limits aiming to increase the design margins and to make the design less sensitive to environmental uncertainties.

The above tendency has led to almost standard equipments (and then components) independently of their further application in space programs.

3.4.5.3 Further Developments of Space Testing Standards

Space qualified components and equipments have a narrow market and then high cost and (sometime most important) very long procurement time (e.g., for some rad-hard components the time is around 40 weeks and an ad-hoc export license from US is needed). This kind of problems has suggested to investigate new approaches.

Within this frame, commercial or MIL qualified components (Commercial Off The Shelf components), have been considered for space applications, but this option carries a full set of new problems, for example a completely different reliability approach which means tailored COTS verification plans which have to be approved by the specific program customer.

The subject is far to be fully understood and then standardised, because acceptance criteria change significantly among different customers and, for the same customer, among different programs, but while acceptance process could remain more or less the same, the whole approach to qualification testing could be deeply impacted.

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4. PRELIMINARY REDUCTION PROCESS

4.1 Overview of Process Used To Reduce Number Of Documents

4.1.1 Preliminary List Of Documents

At the start of task Expert Group 8 were supplied with a preliminary list of documents. This list had been generated by CEN WS10 as an outcome of its phase 2 activity. The initial list comprised around 11500 documents, however, (and not very helpfully) a number of separate additional lists were also supplied. As the entire listings of documents were far too large to handle, it was subject to preliminary search to produce a subsidiary list of around 600 environmentally related standards. This was reviewed and several facts noted;

a. The lists contained a mix of both vertical (product related) and horizontal (non product specific) standards.

b. The way the lists had been compiled included a notable inconsistency. For some standards every separate test was listed independently yet other standards were included as a single entry regardless of the number of separate tests it contained . That is some standards had some 40 to 60 separate entries whilst others had only one.

c. The lists contained fewer commercial standards than expected. Based upon the minutes of WS10 an exception existed that the listings would specifically include a number of commercial standards. WS10 had made particular mention of AECMA-STANS yet these were notable absent.

Notwithstanding the consequences of the above observations, it was clear to that several further measures needed to be quickly put in place. These measures were needed to both resolve the shortcomings in the listings and to allow a review of appropriate standards to be initiated. With the relatively tight time scales imposed by WS10 it was necessary to initiate several parallel activities and adopt a process allowing the maximum use of the available resources.

4.1.2 Identification Of Horizontal Standards

The Expert Group took as its first priority to identify the horizontal standards relating to environmental testing. Most standards organisations, whether commercial or military, usually include a number of horizontal standards which are used as building blocks for the vertical, product related, standards. The vast majority of standards organisations maintained standards on environmental testing in their horizontal group. Those standards are, in almost all cases, the primary reference source for environmental test procedures. That is the horizontal standards contain the test procedures adopted as the model or benchmark by other standards.

Vertical, product related, standards commonly adopt the horizontal standards test procedures in their product specific test programme requirements. Some vertical standards do this by direct reference to the horizontal standard others by extracting and reproducing the relevant aspects of the procedure. The environmental test procedures in virtually all vertical standards can be identified as originating from a horizontal standard. One consequence of this is that many environmental test facilities adopt operating procedures based upon the procedures from horizontal standards.

Whilst, most vertical, product related, standards adopt environmental test procedures based upon those of the horizontal standards, they are much less consistent at using test severities from horizontal standards. Whilst, this appears to be more likely for commercial standards than military, it was one of several reasons the Expert Group separated review of test procedures & process from a review of severities.

Initially five separate horizontal standards were identified as primary sources of environmental test procedures. However, this number was increased to six as a result of observations made at the WS10 that an addition group be considered. The final six separate horizontal standards addressed were;

NATO Defence Standard STANAG 4370 and its Allied Publications (AECTP's)

International Commercial Standards IEC 60068 and IEC 60721

UK National Defence Standard Def Stan 00-35

French National Defence Standard GAM EG 13

US Defence Standard Mil Std 810F

Quadripartite {US/UK/F/DE} Agreement ITOP (International Test Operating Procedure)

The identified horizontal standards listed in Annex C to this report include all the primary source defence environmental standards and one of the primary source commercial environmental standards. However, with the identified limitations on the original document listing, concern existed that further horizontal commercial standards may be identified. Should this occur and to prevent having to start the comparison work over again, it was decided to identify one of the horizontal standards as a "reference" against which the others could be compared. The thinking behind this was also that if the comparison task proved to be more extensive than anticipated it could be split into one to one comparisons. In the end this option was not needed and the work compared all the horizontal standards against each other. Nevertheless, should further standards be reviewed in the future the approach originally postulated would undoubtedly be the most effective.

4.1.3 Process For The Comparison of Individual Test Procedures

Six separate horizontal standards was considered a sufficiently manageable number to allow a detailed comparison exercise to be undertaken. The Expert Group identified the individual test procedures for each of the horizontal standards. Whilst, some types of test had an easily identifiable equivalents, this was not always the case. To alleviate this problem an equivalence matrix of the various test procedures was generated. This matrix is set out in Annex A of this report. The purpose of the matrix was to allow separate subgroups to work in parallel.

Based upon the equivalence matrix the detailed comparison task, for the primary source horizontal test procedures, was to be split into six areas of work. The intent was to allow different sub-groups within the Expert Group to undertake separately the required work. The content of these sections was defined as;

- Environmental management standards
- Vibration test group
- Shock test group
- Miscellaneous mechanical test group
- Temperature, humidity and pressure test group
- Natural and manmade contamination test group

In order to undertake consistent comparisons within each test group a number of assumptions and criteria needed to be agreed. These assumptions and criteria were reviewed, refined and agreed by the Expert Group as the work proceeded. The outcome of this refinement was a list of ten comparison criteria which are listed below. Further information on the assumptions and criteria finally used in the individual comparisons of test procedure are detailed separately hereinafter.

Technical Innovation.
Up to Date Techniques.
Reproducibility.
Strength of Reference.
Interoperability.
Suitability for Purpose.
Disadvantages to European Industry.
Alignment to European Defence Procurement Strategy.
Backward Compatibility.
Equivalence of Standard.

4.1.4 Output of Individual Comparisons

The documented output from each of the individual comparisons is set out in Section 6 of this report. The comparisons are set out in the six sections detailed hereinbefore and each comprises five main components viz;

a. The portion of the Equivalence Matrix actually addressed is reproduced by way of an indication to the reader as to the grouping of tests considered in each section.

b. For each test procedure the scope and objectives of the individual test procedures are reproduced. These are mostly extracted from the actual procedures. The intent of these listing was to allow the reader an way of comparing the purpose of the various test procedures. It has to be also said that the compilation of these tables of scope and objectives was a useful way of initiating the comparison exercise.

c. The third component of the comparison comprises historical information as well as indicating compliance and deficiencies against the agreed comparison criteria.

d. The fourth component of the comparison is a textual summary of the results of the comparison along with a recommendation as to the procedure which best meets the criteria.

e. The last component of the comparison comprises a summary table of the recommendations of the Expert Group.

4.1.5 Treatment Of Vertical Standards

Having derived a process to deal with the horizontal environmental standards the Expert Group needed to classify the vertical, product related, standards. The results of the preliminary search had produced a subsidiary list of apparently environmentally related standards. Perusal of this list indicated a number of standards that were not related to the work in hand. However, most related to specific products which were either purely commercial, had joint military / commercial applications or were mostly military related. As a consequence the non-relevant standards were culled from vertical product list with the remainder split between general, military ground (army), military sea (Navy) and military air (airforce). The specific details of the grouping of vertical standards (which is set out in an annex to this report) is reported in detail hereinafter.

The primary concern of the review of the vertical standards was to identify procedures which may have been missed as horizontal standards and others which potentially contained primary source test procedures. Essentially no additional standard was identified which could be classed as a horizontal standard or which contained primary source procedures. However, that statement requires some further caveat.

As already indicated the Expert Group was surprised that the original list supplied by WS10 from the phase 2 work did not appear to contain AECMA-STANS. A list of these was identified part way into the programme and a fair number of environmental related standards identified. The Expert Group found no horizontal standards and all those identified were clearly product related (mostly related to connectors).

The Expert Group identified a considerable number of Swedish National environmental test procedures related to ammunition. These were mostly 10 to 20 years old and could potentially have been considered for inclusion in the comparison process. Despite a significant Swedish representation on the Expert Group, these were not proposed for consideration as National horizontal standard. Moreover, the indications were that these Swedish standards were rarely used today, rather they were effectively superseded by the STANAG.

A number of French standards were identified related to air, sea and land equipment. The test procedures of these were considered derivatives of the procedures included in the horizontal standards already considered.

A commercial aerospace horizontal environmental test standard, RTCA DO160, was identified towards the end of the study. This had not been included in the listings supplied by WS10 and relates to commercial aircraft equipment. Undoubtedly this would have been included in the comparison had it been identified sufficiently early. Nevertheless a review of the procedures indicated the actual procedures were derivatives of the IEC / CEN 60068 procedures and the Mil Std 810 procedures. No primary source environmental procedure was identified.

The Expert Group noted that the listings supplied by WS 10 did not include any space related test procedures. As part of the exercise the Expert Group reviewed an ESA standard for environmental testing and found that the standard contained a number of primary source test procedures that were not included in the horizontal standards reviewed. However, those were all related to specific environments unique to operation in space. These were considered as not essential to Defence procurement. The remaining test procedures were all derivative of those reviewed.

The listings of vertical standards appeared to contain a number of out of date and superseded standards. This is not surprising as defence equipment tends to stay in-service for long periods (10 to 30 years is fairly typical). To facilitate life extension and mid life upgrades standards cannot necessarily be eliminated entirely. As new procurements would not be made against such standards there consideration was not considered necessary.

The listings of vertical standards did not include all the packaging standards containing test procedures. The military requirements for packages usually contain a sizeable section on environmental testing. Those tests are mostly derivatives of the horizontal tests procedures already addressed by this expert group. The Expert Group 8 comparison exercise has included a review of tests which are also intended for both equipment and packages as well as a number of procedures that are solely intended for packages. All the known military packaging test procedures are derivative of the horizontal test procedures already reviewed by Expert Group 8. A caveat to this is that a few packaging test procedures are very old fashioned and have been long superseded in the horizontal tests.

4.2 Assumptions and Criteria Used in Comparison of Test Procedures

4.2.1 Assumptions Used in Review of Horizontal Procedures

The main initial assumption in the review of horizontal procedures was to consider test procedure irrespective of test severity. The rationale for this was that in modern well written horizontal test procedures the process and severity are intrinsically independent. This separation has become encapsulated into military standards in particular over the past 20 years due to the wide spread adoption of test tailoring for the derivation of test severities. That is test severities are now mostly treated as user defined rather than specification defined.

Most horizontal procedures still include a so called “fallback” severities used when no other information is available. However, these tend to be crude and conservative estimates of actual conditions. Attempting to compare these “fallback” severities either separately or along with the procedure would have made the task in hand considerably more complex. Moreover, it would have supplied little real information as the “fallback” are rarely used for defence systems but rather only for COTS and MOTS equipment (and then only if the suppliers knows no better).

The second main assumption was to use the STANAG 4370 as a reference. As already explained, part of the reason for this was an option to split the test procedure comparisons into manageable sections. For example if the group of Swedish standards had been included it would have allowed comparison of them against only the reference horizontal standard rather than all the horizontal standards.

STANAG 4370 was chosen as the reference since it was based on an amalgamation of several National standards and was the one horizontal standard which had the greatest degree of equivalence to the others. A cautionary note was given at the when this approach was discussed that the selection of the STANAG as a reference did not infer that it was the natural preferred standard. As events have transpired the test procedure comparisons have been undertaken against each other with no use of the STANAG as a reference. The STANAG was used as the reference in the equivalence matrix, again this had no outcome on the result.

4.2.2 Criteria Used in Review of Horizontal Procedures

The review of the various test procedures has adopted a number of criteria in comparing the various standards. The criteria set out below have been identified in the course of the review to be the main discriminators between the various standards compared.

i. Technical Innovation. Does the test procedure include technically innovative approaches? Many of the mechanical test procedures originated half a century ago when only limited test facilities were available. Today these are frequently found to be neither good representations of actual conditions nor comprise cost effective approaches. Technically innovative approaches can also allow laboratory simulation of conditions and failure modes that would previously require in-Service evaluation. The implementation of technically innovative approaches generally results in a cost effective approach and testing more able to representatively replicate actual conditions. It also has significant benefits in ensuring equipment does not fail because of a test unrepresentativeness rather than a real weakness.

ii. Up to Date Techniques. Does the test procedure encompasses the use of up to date & cost effective facilities, techniques and methodologies? The use of up to date facilities and techniques such as allowed by up to date computer control system permit either testing that would not otherwise be possible and/or more cost effective testing.

iii. Reproducibility. Would the use of the specified test procedure generate repeatable results which a test specifier can rely upon? A good repeatable test procedure should allow the test to be taken to another test facility or undertaken over a long period of time. A primary goal of standards is to ensure tests which can be reliably be repeated at different facilities over a long period of time.

iv. Strength of Reference. Does the test procedure have sufficient strength and clarity to allow it to be used in contractual requirements? The test procedure needs to be presented in a firm, clear, well formatted manner with an unambiguous distinction between guidance information and the mandatory requirements of the test.

v. Interoperability. Does the test procedure allow the use of COTS equipment and facilitate the use of MOTS equipment without unnecessary re-testing for military use? Many components and subassemblies are no longer produced specifically for defence applications. In such cases the stated capability of the COTS items is likely to be against non-military standards. In practice this criteria is applicable to only a few procedures. Of the mechanical tests only six need be consistent with commercial standards those are; basic vibration, classic waveform shock, handling & drop, bump, bounce and constant acceleration.

vi. Suitability for Purpose. Does the procedure actually achieve the objectives it purports to accomplish? It is very easy for a test procedure to claim it replicates a wide range of in-Service conditions when in fact it only has the ability to replicates a proportion of the potential failure modes.

vii. Disadvantages to European Industry. Does the test procedure disadvantage European industry and give advantage to offshore suppliers? Test procedures that are based upon procedures commonly used by offshore suppliers but not European industry can result in commercial disadvantage to Europe. Such a strategy may be fine for countries without a significant defence industrial but can mean redesign and re-testing of MOTS and COTS equipment.

viii. Alignment to European Defence Procurement Strategy. Does the procedure fit into current procurement strategies? Procurement strategies differ from industry sector to industry sector and in the defence sector have changed in recent years. The equipment environmental assessment process forms part of that overarching strategy and the test procedures should be able to support that strategy.

ix. Backward Compatibility. Does the procedure prevent or limit the use of existing equipment? Defence equipment is frequently in-Service for periods in excess of ten years and not untypical 20 to 30 years. During that period life extension and the purchase of spares, consumables and life limited items should be possible to original requirements. The consequences of the lack of backward compatibility could be removal from use or extensive re-testing.

x. Equivalence of Standard. Are the basic procedures, tolerances & approach identical, comparable or partly comparable with other standards? Broad consistency of procedure, tolerances & approach arising from technical similarity of procedures usually implies a broad range of product applicability and a wider availability of test house availability. Commercial viability require that test facilities have the greatest range of potential application. Conversely a test specifier requires the availability of a number of test facilities.

The above criteria have been identified as applicable in the course of the assessments. The classification of the criteria were found to best discriminate between the various standards. Some overlap exists between the criteria and they are not necessarily mutually exclusive. Nevertheless the criteria generally express issues that arise when selecting and adopting standards for particular applications.

It needs to be appreciated the weighting between the criteria will differ for different types of materiel. Large sophisticated defence system operating in severe environmental condition will probably be biased towards the use of an up-to-date, technically innovative procedure which strongly aligns with the current defence procurement strategy. Conversely a small component or subsystem supplied to a range of defence systems and possibly different industrial sectors will be biased towards a standard which best allows interoperability and repeatability. Views on the weighting between the criteria will also differ for the end user, the purchaser, the system integrator and subsystem supplier.

4.3 Equivalence Matrix of Horizontal Standard Test Procedures

The equivalence matrix presented in an Annex A to this report was created from the listed procedures of the six separate horizontal standards. The individual documents of these horizontal standards are tabulated in Annex C to this report. It was created because the test procedures did not use common terminology of title or scope. Whilst, some tests were listed under the environmental conditions they replicated, others were listed under the type of test facility used. Some additional standards had separate procedures for different variants of similar tests but others grouped them into a single procedure. Mostly an equivalent procedure for most of the older tests could be identified relatively simply. However, greater difficulty was experienced with more recent procedures which tended to have different objectives and scope.

4.4 Grouping Of The Vertical Environmental Test Standards

Tables categorising the vertical environmental standards are listed in Annexes D to G to this report The vertical standards are grouped between general standards (Annex D) , military ground or army standards (Annex E), military sea or Navy standards (Annex F) and military air or airforce (Annex G).

5 CONCLUSIONS AND RECCOMENDATIONS

5.1 Comparison of Horizontal Standards

As described in detail in the previous section the comparison of horizontal standards was undertaken in six groups encompassing over 40 sets of comparisons and around 160 separate procedures. The results of these are extensively detailed in Section 6 of this report. To recap the assumptions and criteria used in the individual comparisons of test procedure were.

- Technical Innovation.
- Up to Date Techniques.
- Reproducibility.
- Strength of Reference.
- Interoperability.
- Suitability for Purpose.
- Disadvantages to European Industry.
- Alignment to European Defence Procurement Strategy.
- Backward Compatibility.
- Equivalence of Standard.

The output of the comparisons of the horizontal test procedures comprise a number of components including individual recommendations and indications of compatibility. However, it was recognised by Expert Group 8 that procedure by procedure recommendations are not particularly helpful when setting procurement requirements. For this reason a standard by standard comparison has been generated for all six horizontal standards, this is firmly based upon the procedure by procedure recommendations.

5.2 Treatment of Vertical Standards

Having derived a process to deal with the horizontal environmental standards the Expert Group needed to classify the vertical, product related, standards. The results of the preliminary search had produced a subsidiary list of apparently environmentally related standards. Perusal of this list indicated a number of standards that were not related to the work in hand. However, most related to specific products which were either purely commercial, had joint military / commercial applications or were mostly military related. As a consequence the non-relevant standards were culled from vertical product list with the remainder split between general, military ground (army), military sea (Navy) and military air (airforce). The specific details of the grouping of vertical standards (which is set out in an Annexes D to G of this report) is reported in detail hereinafter.

The primary concern of the review of the vertical standards was to identify procedures which may have been missed as horizontal standards and others which potentially contained primary source test procedures. Essentially no additional standard was identified which could be classed as a horizontal standard or which contained primary source procedures.

The above not withstanding the following was observed;

The original list supplied by WS10 from the phase 2 work did not appear to contain AECMA-STANS. The Expert Group found no horizontal standards and all those identified were clearly product related (mostly related to connectors).

A number of Swedish National environmental test procedures related to ammunition were identified. These were mostly 10 to 20 years old and appeared to be superseded by the STANAG. Moreover, despite a significant Swedish representation on the Expert Group, these were not proposed for consideration as National horizontal standard.

A number of French standards were identified related to air, sea and land equipment. The test procedures of these were considered derivatives of the procedures included in the horizontal standards already considered.

A commercial aerospace environmental test standard, RTCA DO160, was identified towards the end of the study. This had not been included in the listings supplied by WS10. Undoubtedly this would have been included in the comparison had it been identified sufficiently early. Nevertheless a review of the procedures indicated the actual procedures were derivatives of the IEC / CEN 60068 procedures and the Mil Std 810 procedures. No primary source environmental procedure was identified.

The listings supplied by WS 10 did not include any space related test procedures. As part of the exercise the Expert Group found that space standards contained a few of primary source test procedures that were not included in the horizontal standards reviewed. However, those were all related to specific environments unique to operation in space. These were considered as not essential to Defence procurement. The remaining test procedures were all derivative of those reviewed.

The listings of vertical standards appeared to contain a number of out of date and superseded standards. This is not surprising as defence equipment tends to stay in-service for long periods (10 to 30 years is fairly typical).

The listings of vertical standards did not include all the packaging standards containing test procedures.

5.3 Conclusions of Review of Horizontal Test Procedures

The review of the test procedures, using the criteria set out hereinbefore, produced a series of conclusions and recommendations. These are extensively documented in Section 6 of this report. However, these 40 or so individual recommendations have been reduced to a number of common observations and conclusions relating to each of the horizontal standards reviewed. These overall recommendations are set out below.

5.3.1 International Civil Standard EN / IEC 60068 & 60721

Standard 60068 is the IEC procedure for environmental testing which is also adopted by CEN and embedded into national standards by most European countries. IEC 60068 has an associated standard setting out environmental severities that standard is IEC 60721. IEC 60068 is designated by IEC as a so called “horizontal” standard and is intended for electro-technical products. Its procedures are adopted by a many “vertical” product standards either by direct reference or using a reformatted version of the text. This is particularly the case for the tests which are common used by COTS equipment.

The main advantage of this group of procedures is that they are consistently formatted with a very clear distinction between guidance information and mandatory requirements. The procedures usually also contain guidance on how to undertake the test. The application of the test procedures are mostly firmly written and ensure repeatable results regardless of the tester, test facility or test equipment utilised. For this reason the test procedures are idea for setting as contractual requirements.

The main disadvantages of these tests is that many of the test procedures are quite old and frequently lack technical innovation. Moreover, they often do not utilise up to date & cost effective facilities, techniques or methodologies. Although IEC adopt a maintenance procedure these are slow and even then do not always bring a test procedure up to the same level of technical innovation as the defence standards. As an example one “new” mechanical test technique is still not implemented after five years work, even though at the start of the work that technique was in common use and available in other standards for a decade. Some of the reason for the lack of technical innovation seems to be that the standard has only a limited scope of applicability, intended for only electro-technical items. The procedures of EN / IEC 60068 seem to be intended for equipment whose design, mass, cost and function are not significantly affected by the environment. That is for equipment which can readily withstand the degree of overtesting imposed by the adoption of the existing procedures. Some potential users also cite difficulty in reading these procedures as a reservation.

In addition to the above, the test procedures of EN / IEC 60068 are not supported by an environmental management strategy that would currently be considered credibly viable. The basic strategy is very dated and only integrates with current defence procurement strategies at the most basic level. That is one in which the purchaser takes all the risk and responsibility that the equipment will be suitable. The test severities of EN / IEC 60068 have a significant number of are inconsistencies with the environmental severities in EN / IEC 60721. An attempt to resolve this has resulted in “resolution” section in Part 4 EN / IEC 60721 which are pseudo test schedules inappropriate for most items of defence equipment. The severities of both documents are archaic and do support tailoring. Overall they constitute, by a very wide margin, the crudest and most unacceptable of the severities in any of the standards reviewed.

The EN / IEC 60068 standard are supported by IEC, with a formal secretariat, a defined IEC committee which is in turn supported by national standards organisations. Both IEC and the national standards organisations make the documents publicly available but at a cost. The IEC secretariat operate professionally and ensure discipline in the form of consistency of style and format. However, the generation and extensive commenting procedures can be slow and cumbersome. One cited reason for the unpopularity of EN / IEC 60068 is the cost. It is published in around 80 separate parts with each costing around 40 Euro's. Moreover, some procedures require separate guidance and cross refer to other procedures. It is not uncommon for sections to be re-issued with minor changes. This is in contrast to the Defence Standards which were all publicly and freely available.

The results of this workshop review and comparison has recommend almost no standards originating from EN / IEC 60068. Moreover, of those recommended either defence standards exist which are equally recommended or the procedure has little modern application for defence equipment. Many procedures are missing from EN / IEC 60068, which are essential for defence applications. Moreover, deficiencies exist even within the published procedures of EN / IEC 60068 which are of importance for defence applications.

Overall the adoption of EN / IEC 60068 test procedures would have significant negative implications of the testing of defence system. Indeed its use would put European suppliers of defence system at disadvantage. This is mostly because the capability, mass and performance of defence systems would be compromised by the degree of overtesting imposed by the use of the EN / IEC 60068 test procedures on complete systems. This is not necessarily the case for defence components which require only a few basic test procedures. In those cases the recommendation of procedures that do not at least align with those of certain EN / IEC 60068 would be equally disadvantageous.

It has been questioned whether, at some future date, the EN / IEC 60068 standard could become the recommended standard for environmental testing of Defence equipment. The view of Expert Group 8 is that over the past decade the technical content, quality and innovation of the procedures in EN / IEC 60068 has lagged behind many of the other standards considered. Moreover, the lack of an environmental management strategy as well as the antiquated severities of EN / IEC 60068 and 60721 would require significant and sweeping changes to get them into a form compatible with current European defence procurement methods.

5.3.2 National Defence Standards Def Stan 00-35 (UK) & GAM-EG-13 (France)

Def Stan 00-35 & GAM-EG-13 are respectively the United Kingdom and French national standards for environmental proving of defence equipment. The older tests of both have a clear historic root with older versions of EN / IEC 60068. It appears that interaction with the three test standards occurred in the late 1960's. Both United Kingdom and French national test standards appear to still attempt to keep a reasonable degree of consistency with EN / IEC 60068. Indeed the UK Def Stan makes a statement in the scope of each procedures as to the commonality with EN / IEC 60068.

Both of these test standards adopt a clear distinction between guidance information and mandatory requirements. They are both firmly written but also supply additional test guidance information on both test conduct and severity derivation. The tests are written to facilitate consistency of testing and can be called in contractual requirements with confidence. The tests frequently used for COTS equipment are included in a manner such that they are common to many "vertical" standards.

Although both Def Stan 00-35 & GAM-EG-13 have made some effort to achieve commonality with EN / IEC 60068, they have also incorporated additional, defence specific, procedures and include a number technically innovative enhancements to existing tests. They mostly encompass the use of up to date & cost effective facilities, techniques and methodologies. Both standards were considered and extensively utilised in the generation of STANAG 4370. Whilst, Def Stan 00-35 is still maintained and updated, GAM-EG-13 is no longer supported in favour of STANAG 4370.

Both standards are supported by viable environmental management strategies that is consistent with defence procurement approaches used in the two countries. Although the two strategies differ that is only because they address different aspects of the same issue. Representatives from both countries have long expressed the view that the management aspects of the two documents not only fit together but would be more useful if merged.

Def Stan 00-35 & GAM-EG-13 include credible and up to date test severities which are specific for defence usage. Both standards are compatible with the use of tailored severities and give significant advice on natural, induced and abnormal environmental severities. This advice is clearly separated from the test specifications and frequently includes background information on the mechanisms causing the environment.

Both Def Stan 00-35 & GAM-EG-13 are supported by standards organisations which make the documents publicly available at no real cost - the Def Stan can be downloaded from the DSTAN web site. The two defence standards organisations operate professionally and ensure discipline in the form of consistency of style and format.

From a Defence viewpoint both Def Stan 00-35 & GAM-EG-13 comprise a good practical compromise between consistency with commercial standards and technical innovation for use in testing sophisticated defence systems. The restriction on the European wide use of Def Stan 00-35 & GAM-EG-13 is that they have never been targeted outside the two originating countries.

5.3.3 National Defence Standard Mil Std 810 (US)

The US environmental test standard Mil Std 810 has previously been adopted, for testing defence equipment, by a number of European countries which have not generated their own standards. This US standard has its origins in the late 1960's and over the years has undergone several very radical changes of approach and strategy. Unfortunately, these changes are not always backward compatible with earlier versions and it is not uncommon to find different versions in use with one company for different products.

The procedures within Mil Std 810 have never been notably consistent with other group of standards. Indeed the Mil Std 810 procedures have consistently adopted different tolerances, procedure & approach to those of other standards. Originally the standard was well suited to testing of sub-assemblies and general defence equipment required to be used in a range of situations. However, this has changed over the various revisions, such that today it is more applicable to complete systems.

The majority of the procedures in the Mil Std do not adopted a consistent style. Moreover, they are not written in a firm style with no clear distinction between guidance information and mandatory requirements. In some of the previous versions the test procedures were considered very difficult to read, some of the procedures were poorly defined and contained almost no supporting guidance. To be fair the latest version of the standard contain a considerable amount of new guidance and are considerably easier to read. However, almost all this additional guidance relates to test severities. The current document has the feel of a guidance handbook rather than a firm test procedure capable of been confidently called in contractual requirements. US companies and DOD organisations frequently refer to Mil Std 810 for guidance but for contractual purposes use specifically versions in product related procurement requirements.

The lack of commonality with any international standard has not mattered historically in the US were the defence market is sufficiently large for manufacturers to develop components and sub-systems specifically for US military use. Today that is less so and has rarely been the case in Europe. The lack of commonality with any international & European standard would imply that the adoption of the Mil Std for European defence applications would potentially give US defence suppliers an undue advantage over European suppliers.

The main advantage of Mil Std is that historically the standard has included technically innovative approaches adopting up to date & cost effective facilities, techniques and methodologies. In the defence field the Mil Std has frequently been at the fore front of introducing new techniques and ideas. As a result the Mil Std has broadened its range of environmental conditions encompassed such that it now addresses most of the defence environments. However, some of these are not particularly well integrated and some new chapters relate entirely to the derivation of specific severities, with the procedures themselves not always that different from existing chapters. The enhancement of the standard has also resulted in further degradation of the distinction between test procedures and environmental conditions. This is considered by observers as another indication of the lack of control over the document.

In the early 1980's the Mil Std broke the traditional mould of using simplistic severities by advocating tailored severities as part of a radically different environmental engineering management strategy. Unfortunately, that management strategy does not fit well with procurement practices used today in Europe. Moreover, the adoption of the Mil Std 810 management strategy within the US is at best patchy. The Mil Std is publicly available and can, with its amendments, be freely downloaded from the US DOD organisation web site.

As already mentioned the Mil Std includes a fair amount of information on the derivation of test severities. However, as this is frequently embedded within the test procedures, it is frequently confusing and rarely comprehensive.

In theory the Mil Std is controlled by the US DOD organisation. However, in practice that control is imposed little consistency of style and enforced no clear distinction between guidance information and mandatory requirements. Overall, the level of control indicated by the document is nothing like as rigorous as that used in the UK or French military standards. The US frequently suggest Mil Std 810 has international usage and call for international views. Nevertheless, historically little real evidence exists of the actual inclusion of international views. Indeed attempts to influence the Mil Std has lead to the formation of several national groups and one European wide organisation.

From a Defence viewpoint the US Mil Std 810 comprises excellent guidance material particularly relating to severities. It includes technical innovation as well as promoting up to date methods. However, its test procedures are insufficiently well defined to confidently use them in contractual requirements. The test procedures are inconsistent with other standards to an extent that the adoption of the Mil Std for European defence applications could give the US defence suppliers an undue advantage over European suppliers.

5.3.4 International Defence Procedures ITOP's (US, UK, F, De)

The International Test Operations Procedures (ITOPs) are quadripartite agreements between the US , UK, France & Germany relating to the "mutual acceptance of test and evaluation for the reciprocal procurement of defense equipment". The ITOP working groups are product related (munitions and tracked vehicles) and consequently the ITOPS should really be classed as "vertical" standards. Only a few ITOPS relate to environmental testing and then they only encompass an inconsistent and narrow range of topics.

The level of detail contained in the ITOPS is intended for direct use in the test process. Restricting effort to four-nations is intended to provide for rapid development of procedures (the target is 2 years). The stated aim of the ITOP is that they should duplicate other international documents, but are intended to replace national test procedures.

When the environmental ITOPs were submitted for consideration by this Expert Group it was suggested they were internationally used test procedures, were state-of-the-art as well as promoting technology transfer and mutual use of test facilities. It was also stated that an understanding had been reached to adopt ITOPs by NATO as STANAGs.

When the ITOPS related to environmental testing were reviewed and compared to the other standards it was surprising to find that many were replicating existing STANAGS and in the majority of such cases the ITOP was issued AFTER the STANAG. This seems in conflict with the stated ITOP intent. Of more concern was that in several cases the ITOP and the STANAG differed or conflicted in important aspects. In some cases they also conflicted with existing national approaches. Generally it appeared that ITOPS were not replacing national test procedures indeed the national signatories to ITOPS had in some cases have no effective relationship with national standards organisation controlling defence standards.

The overlap and conflict with existing standards is of concern as it suggests inconsistency of policy within the four nations concerned. Whilst, the stated aim of the NSA (Nato Standards Agency) is to accept the ITOPS as STANAGs, the actual groups involved with environmental testing appear to have no real aspiration to do so.

Several of the ITOPS were heavily biased towards US procedures and in those cases seemed to take little account of European or International considerations. The environmental ITOPS appear to have no general applicability and the niche role they are purported to fulfil is questionable. A considerable number of ITOPS appear to be based upon US TOPS which are frequently re-formatted version of Mil Std 810. The large amount of US content in the ITOPS is a concern as it could be argued that ITOPS are a means of foisting US approaches on European countries. This of course could consequently give US suppliers an unfair advantage over European suppliers.

Generally the ITOPS were neither state of the art, technically innovative nor did they appear to be particularly cost effective. The procedures are modestly well written but do not appear to have any underlying strategy or relationship to any procurement approach. ITOPS appear to have a limited circulation and (apparently by design) are difficult to obtain. However, no real reason for this can be identified as the majority of the content of environmental ITOPS are effectively already publicly available in other standards.

None of the environmental ITOPS contained aspects which justified recommendation as a European Defence standard in either full or part.

5.3.5 Interational Defence Procedure STANAG 4370 (NATO)

For the purpose of the work undertaken by Expert Group 8 utilised STANAG 4370 version 3 and its numerous allied publications (designated AECTP's in this case). That version is essentially complete but not yet promulgated by the NSA (Nato Standards Agency). As such it was the most recently updated of all the standards reviewed. The NATO STANAG is also the newest of the horizontal standards reviewed been initiated less than 20 years ago compared to over 30 year of the other standards.

Version 3 of STANAG 4370 contains a significant amount of identifiable content from the UK Def Stan 00-35, the French GAM EG 13 and the US Mil Std 810. As such it identifiably takes cognisance of a range of national standards. This is in contrast to some other STANAGs, such as AOP 20 (a "vertical" standard relating to fuzes identified from the list of vertical environmental testing standards), which are found to be almost entirely a copy of a US Mil Std. It was because of STANAG 4370's apparent commonality with other national standards that it was used as the "reference" against which the other standards were compared for the purpose of this work.

The comparison work has shown that the various individual procedures of STANAG 4370 are either the best procedure for that type of test, are equally as good as those in other standards or have the potential to become the preferred procedure. Overall version 3 the STANAG encompasses the most technically advanced and innovative components of the three national defence standards that it is based upon. The latest version has achieved a modestly reasonable compromise between the differing US, UK and French national approaches. In this regard the current version acknowledges European contributions to a far greater extent than previous versions. However, in some chapters the majority of the content still originates from the US Mil Std 810.

The current version of STANAG 4370 is also far better written that the two previous versions. With that said it is doubtful whether either of those earlier versions would have passed muster, if managed by a professional national or international standards organisation. Having culled the various national standards the STANAG does include tests for virtually all defence environments likely to be encountered. In this regard the STANAG could be said to be much better than any one of its contributing parts.

STANAG 4370 is supported by a viable environmental management strategy which is broadly consistent with defence procurement approaches used in the US, UK and France (and in turn is probably consistent with that of most European countries). However, achieving that consistency was not without significant compromise and loss of detail. Indeed it is likely that a more tailored strategy could be considered necessary for specific European Defence Procurement needs. In this regard a merger of the existing UK and French national strategies may be more applicable.

STANAG 4370 is still highly biased towards supplying advice to establish test severities. In this regard the majority of the test severity advice is the latest available. However, for European uses this needs some caution as some of the advice is biased towards US platforms. The STANAG is far less helpful, than the French or UK standards, in defining environmental conditions which can be used in the design process. This is of concern for defence systems were the severities are needed for differing purposes such as design, reliability etc. It is of less or no concern to components or subsystems were more generic levels are the norm. In this regard quoting Maximum Predicted Environment (also known as Maximum Expected Environment), as used in the space industry, may be a better approach. Both MPE & MEE are unfactored severities allowing the specifier to set out different factors for different purposes and degree of risk.

As a standard, STANAG 437, is not particularly well formatted with guidance relating to the test procedures not clearly separated from that relating to test severities. Mandatory requirements and guidance information are not clearly identified and quite a lot of text is repetitious or has no real value. In a number of areas confusion appears to exist whether the text was intended for the test specifier or the tester. Moreover, the mandatory requirements of the test procedure are frequently ambiguous and cannot be relied upon to produce a repeatable test or a result the test specifier can rely upon. The fact that several "vertical" STANAGs and some ITOPS are finding it necessary to re-write sections of STANAG 4370 in a more mandatory style is an indication of the current inadequacy. For STANAG 4370 to be used as the common base for equipment specific "vertical" standards better control is clearly required. In all these regards the STANAG appears to have inherited some of the bad habits of the Mil Std..

In theory the STANAG is controlled by the NATO organisation. However, in practice that control is almost entirely vested in the technical group. Little external control appears to occur and circulation for comment happens only at a very limited level and mostly excluding industry. Overall, the level of control indicated by the document is nothing like as rigorous as that used in the UK or French military standards and far less than for commercial standards. The availability of 4370 is, like most STANAGs, patchy but when found is usually freely available. The NATO/PIP caveat has been noted as causing some problems in certain circumstances.

As already detailed the main deficiency with the STANAG relates to strength of reference. That is currently the test procedures do not always have sufficient strength and clarity to allow them to be used in contractual requirements. However, this criticism needs to be put in to context. The procedures are technically sound and generally the most innovative available. From this strong base the test procedures need to be presented in a firm, clear, well formatted manner with an unambiguous distinction between guidance information and the mandatory requirements of the test. This is essentially a control and editorial issue which can relatively easily be resolved with secretariat support and a rigorous commenting procedure. The Expert Group would observe that the reverse is not generally the case, a technically weak and out of date procedure cannot be made good no matter how much editorial control is imposed.

Several contributory factors appear to be the root case of the poor strength of reference. The lack of industrial participation in generating the standards and the narrow distribution used in reviewing the documents are clearly factors. Another is the absence of the control and secretariat support that acknowledged professional standards bodies find essential to ensure a consistency of style and format.

The current controlling body, within NATO, for STANAG 4370 is CNAD (Conference of National Armament Directors). If CNAD are unable or unwilling to supply the necessary control and support to the document then it may be more appropriate for the STANAG to be taken over by a more able body. The NSA (Nato Standards Agency) has the aim of becoming a professional standards organisation. That body may be able to support the existing NATO committee with the necessary control and support. Alternatively, control and management may be invested with a joint body comprising NATO and an appropriate a European standards organisation. It is understood that the NSA already have such arrangements.

5.4 Recommendations

The environmental management process is a critical feature of both the procurement and development strategies used for defence equipment. The process needs to align with the European Defence procurement strategy and a practised equipment design and development methodologies. Currently neither the Mil Std process or the STANAG 4370 AECTP 100 process align with the procurement strategies adopted by many European countries or that proposed for European Defence procurement. The adoption of the US based standard for European procurement would, it could be argued, put the European defence industry at a disadvantage. A similar argument could be made for the NATO standard which also has not withstood the test of widespread usage. Whilst, the UK or French standards have some shortfalls, together they are far better than the STANAG 4370 AECTP 100 process. Amalgamation of the French and UK environmental management processes is entirely viable as they cover similar ground but are aimed at different people. Amalgamation of the two processes would also allow integration with the proposed European Defence procurement process.

Much of the previous argument also applies to the process used to develop test severities from in-service conditions. Whilst, the STANAG and Mil Std standards acknowledge European based approaches they have not been used to establish many of the fallback severities contained within STANAG 4370. Updating these severities will take time but such an approach is essential if they are to fully encompass European platforms (vehicles, aircraft, ships etc), logistics and in-service conditions. The recommendation made above, of amalgamating the French and UK environmental management processes, would resolve this issue also.

The fallback test severities currently contained in STANAG 4370 are an amalgamation of the fallback severities commonly used in US, UK, France and Germany. As a starting point for European defence procurement these fallback severities are recommended. However, to ensure a viable procurement strategy the ongoing derivation of severities tailored to the required range of European platforms, logistics and in-service conditions is essential.

This Expert Group has expended significant effort in reviewing the available test procedures contained in the horizontal standards currently used for the procurement of defence equipment within Europe. As already indicated the overall recommendation is that the STANAG 4370 procedures are consistently better, technically innovative and demonstrably incorporate European approaches and methods. The adoption of the STANAG 4370 procedures would not appear to put European Defence industry at any particular disadvantage. This notwithstanding changes are urgently required to the way the STANAG is managed and controlled. This is necessary to bring the STANAG procedures up to the same quality of firmness and strength of text as other vertical standards. This will probably mean the current management, CNAD, sharing control with a professional standards organisation.

The Expert Group has also considered a sizeable number of vertical (product) standards which in part incorporate environmental test procedures. The recommendation of this Expert Group, along with that of almost all standards organisations, is for the vertical standards to use test procedures available in the horizontal standards. Very few vertical standards were identified were this would not be viable, preferable and cost effective. The only area actively identified were this approach was not viable related to space equipment which normally includes a handful of tests not encompassed by the horizontal environmental test standards.

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6. COMPARISON OF STANDARDS

6.1 Review and Comparison of Environmental Management Standards

6.1.1 Standards Under Consideration

The standards reviewed and compared with regard Environmental Management are set out in the following table.

Matrix Environmental Management Process vs Procedures						
	NATO STANAG 4370	International EN / IEC	UK Def Stan	France GAM-Eg-13 & CIN EG 1 (Method / Procedure)	US Mil Std 810F (Test No / Procedure)	Quadripartite US/UK/F/DE ITOP (Test No)
The Environmental Engineering Process	AECTP 100	Not Addressed	Def-Stan 00-35 Part 1	CIN-EG 01	Mil-Std 810F Part 1	Not addressed
Environmental Conditions (either linked to the life cycle of the materiel or otherwise)	AECTP 200 (STANAGs 2895, 2914, 4242 are being merged in 200)	IEC EN 60721-2 (Natural only) IEC EN 60721-3	Def-Stan 00-35 Part 4, 5 & 6	GAM-EG13 Annex for environmental data	Mil-Std 810F Part 1 & 2 Mil-Hdbk 310C (climatic)	Not addressed
Guidelines For Deriving Test Profiles (Tailoring)	AECTP 200	Not addressed	Def Stan 00-35 Part 4, 5 & 6	CIN EG 1 for all environment GAM-EG13 Annex for mechanical tests specifications	Mil Std 810F (some elements)	ITOP 1-1-050
'Fall Back' Test Severities	AECTP 300 AECTP 400	IEC EN 60721-4	Def-Stan 00-35 Part 3	Guidance documents for specific applications (GAM-EG13 A, B, C, D and E)	Mil-Std 810 F Part 2	ITOP's 1-2-601 5-2-506

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6.1.2 Standard Comparisons

Process	Scope & Limitations
The Environmental Engineering Process	**STANAG 4370 AECTP 100 ENVIRONMENTAL GUIDELINES FOR DEFENCE MATERIEL** Purpose The purpose of this 'Allied Environmental Conditions and Test Publication' is to guide project managers, programme engineers, and environmental engineering specialists in the planning and implementation of environmental tasks. An important function of AECTP 100 is to provide guidance to project managers on the application of AECTP 200 'Environmental Conditions', AECTP 300 'Climatic Environmental Tests', AECTP 400 'Mechanical Environmental Tests' and AECTP 500 'Electrical/Electromagnetic Environmental Tests.' Application: The guidance provided in AECTP 100 is applicable to joint NATO defence materiel projects. It may also be applied to defence materiel (multi-) national projects and is compatible with NATO publication AAP-20, 'Handbook on the Phase Armaments Programming System (PAPS).' AECTP 100 should be useful to environmental engineering specialists during the procurement cycle. Limitations: Although laboratory testing is a valuable tool in the materiel development process, there are certain inherent limitations that must be recognised when applying STANAG 4370, ' Environmental Testing '. The test methods in STANAG 4370 AECTP 300 through 500 do not include all possible forcing functions that may affect system performance or integrity in its service use. These methods are limited to those currently developed for laboratory testing and cannot apply all known possible stress combinations present in natural field/fleet service environments. Therefore, caution must be used in extrapolating laboratory test results to predict the performance, durability and suitability of materiel in actual service use. AECTP 200 through 500 were not developed specifically to cover the following applications, but in some cases they may be applied: Weapon effects other than electromagnetic pulse (EMP); Munitions safety tests ; Packaging testing; Suitability of clothing or fabric items intended for military use; Environmental stress screening (ESS) methods and procedures. Definitions Listed in Annex C are NATO environmental definitions compared to national environmental definitions. An Environmental Documentation Flow Chart is included in Annex D.

Process	Scope & Limitations
	MIL-STD 810 ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS. Purpose. a. This standard contains materiel acquisition program planning and engineering direction for considering the influences that environmental stresses have on materiel throughout all phases of its service life. It is important to note that this document does not impose design or test specifications. Rather, it describes the environmental tailoring process that results in realistic materiel designs and test methods based on materiel system performance requirements. Figure 1-1 summarizes this direction. b. This document supports the functions of three different groups of personnel involved in the materiel acquisition process. Each of these groups is critical to the goal of successfully incorporating environmental considerations into materiel design, test, and evaluation. Although each group has different tasks to perform, none of these tasks can be isolated from the others in a successful acquisition program. As shown on figure 1-2, this information is intended for the following: (1) Materiel acquisition program managers among whose responsibilities is ensuring materiel will function as required in intended operational environments. (See paragraph 4.1 below.) (2) Environmental engineering specialists (EES) who assist combat and materiel developers throughout the acquisition process to tailor their materiel designs and test designs to environmental stresses/constraints expected during the materiel's service life. (See paragraph 4.2 below.) (3) Design, test, and evaluation community analysts, engineers, and facility operators who meet user needs by focusing on tailored designs and tests. (See paragraph 4.3 below, and Part Two of this standard.) Application. The tailoring process described in this standard (i.e., systematically considering detrimental effects that various environmental factors may have on a specific materiel system throughout its service life) applies throughout the materiel acquisition cycle to all materiel developed for military or commercial applications, including nondevelopment item (NDI) procurements, procurements, or modifications of Allied systems or equipment, and co-operative development opportunities with one or more Allied nations to meet user and interoperability needs (DoDD 5000.1). a. Part One lays out a disciplined, tailored approach for acquiring systems that will withstand the stresses of climatic, shock and vibration environments that they expect to see in their service lives. The basic process for acquiring materiel that satisfies users' needs from this environmental engineering viewpoint is at figure 1-1. b. Part Two also is an integral part of the environmental tailoring process. It contains tailoring information, environmental stress data, and laboratory test methods. The environmental data contained in the methods may help, but should not be used exclusively, to define environmental stresses that materiel will encounter throughout its service life. This will help engineers to tailor analyses and tests to specific materiel and its defined life cycle. It is not valid to call out all of the methods in this standard in a blanket fashion for a materiel system; nor is it valid, once a

Process	Scope & Limitations
	method is determined appropriate, to regard the environmental stress data, test criteria, and procedures in the method as unalterable. c. Guidance and test methods of this standard are intended to: Define environmental stress sequences, durations, and levels of materiel life cycles. (1) Be used to develop analysis and test criteria tailored to the materiel and its environmental life cycle. (2) Evaluate materiel performance when exposed to a life cycle of environmental stresses. Identify deficiencies, shortcomings, and defects in materiel design, materials, manufacturing processes, packaging techniques, and maintenance methods. **DEF-STAN 00-35 ENVIRONMENTAL HANDBOOK FOR DEFENCE MATERIEL Part 1** The guidance and information contained in this Standard is structured to cover environmental conditions that are relevant to the complete life of an item of defence materiel; i.e. from leaving its place of manufacture to the end of its Service use or disposal. Nevertheless, this Standard cannot be expected to be exhaustive in its treatment of all environments, some of which require considerably detailed analysis before they can be characterised effectively. The depth of treatment for some environments or related matter may have been determined by the availability of information on the subject, in conjunction with its importance in the light of contemporary environmental engineering problems. Although environments and their effects are covered in some detail in this Standard, methods for minimising degradation of performance or reliability are only specifically addressed in Part 4 for natural environments. The guidance contained in this Standard covers any method of procurement having an influence on environmental engineering and testing between the two extremes given below: a) The procurement authority specifies the host platforms, the regions of the world for operational use, and the modes of transport and storage. In this case the supplier is required to determine and verify the environmental conditions, and to select and conduct the relevant tests. b) The procurement authority specifies the relevant test methods to be conducted, together with the associated test severities covering, for example, temperature, pressure, humidity, vibration and shock conditions. In these circumstances the procurement authority is responsible for the definition of the environmental conditions. In addition this Standard provides guidance on environmental engineering aspects associated with the procurement of "Off the shelf" materiel. The guidance contained in this Standard covers any environmental engineering control and management strategy that falls between the two extremes given below: a) The severities for the critical environments to which an individual item of defence materiel is to be subjected are measured and the materiel is designed and tested to meet those critical and other environments. This strategy is particularly suited to sensitive materiel intended for use on one platform type or in one climatic region.

Process	Scope & Limitations
	b) The materiel is designed and tested to a series of "minimum integrity" environmental test methods and severities quoted in this Standard. This strategy is particularly suited to materiel where a significant measure of over-design can be tolerated, and is usually applicable to materiel intended for use on several host platform types and/or climatic regions. Certain paragraphs in this Standard may indicate situation in which an environment is likely to occur and suggest possible applications for a test. The examples quoted therein are in no way mandatory. Application This Standard addresses the needs of the following users of environmental engineering and testing information. They are those users: a) involved in the preparation of the operational environmental requirements for Staff Targets and Requirements b) responsible for compiling Environmental Requirement documents or undertaking compliance evaluations c) responsible for specification of environmental testing to demonstrate compliance with the Environmental Requirement. The Standard describes both natural and induced environments and related environmental tests for all defence materiel with the exception of those associated with: a) electronic components which are subject to different testing concepts and are covered by BS EN 60068 (converted from BS 2011) b) materiel for deployment in space. British Standard BS EN 60068 converted from BS 2011)contains environmental tests and is directly linked to CENELEC Standard EN 60068.Where BS EN 60068 contains a test method which is suitable for use with defence materiel it is invoked by this Standard. Where a BS EN 60068 test method is suitable but no appropriate severities are listed, this Standard invokes the BS EN 60068 test method and provides suitable severities. The application of this Standard to certain types of materiel is governed by publications relevant to that materiel. For such materiel the appropriate governing publications are to be read in conjunction with this Standard. These governing publications are: a) DEF STAN 00-970 for aircraft equipment b) DEF STAN 05-127 for unmanned air vehicles c) DEF STAN 81-41 for general packaging d) DEF STAN 08-5 for guided weapons, airborne armament stores and torpedoes e) NES 1004 for naval weapon equipment f) DEF STAN 08-8 for packaging of explosives and ammunition g) DEF STAN 00-10 for Service electronic equipment

Process	Scope & Limitations
	h) DEF STAN 13-131 for warheads, propellants and pyrotechnic devices This Standard has been compiled for the derivation of environmental conditions and the specification of tests for use during the design, development and deployment of defence materiel. Nonetheless, much of the content of this Standard may have application for the specification, development or production of equipment outside the scope envisaged. However, no responsibility is implied or accepted for such use, and the Crown will not be liable in any way whatever including but without limitation negligence on the part of the Crown its servants or agents)where the Standard is used for other purposes. When munitions or other devices containing energetic materials are subjected to the test methods contained in this Standard, they may react with violence, varying from burning to detonation, or some may even become propulsive. When testing such munitions or devices, it is the responsibility of the Test Site Safety Officer to ensure the safety of personnel before, during and after the test. In particular, the safety precautions adopted shall provide adequate protection to personnel and, where appropriate, to buildings and facilities in the vicinity of the test site. **CIN-EG01 GUIDELINES FOR ACCOUNTING FOR THE ENVIRONMENT IN MILITARY PROGRAMMES** Purpose of the document The purpose of this document is to act as a precise guide for Taking into account of the Environment in a Military Programme . It is part of the current Defence approach consisting in reducing the costs of the items produced, commissioned and maintained in service in the armed forces. It does not lead to the elaboration of new documents, but leads to the inclusion of certain paragraphs, pages, sheets or appendices into the programme management documents which are already planned. It is intended for : • State and Industrial Programme Directors and Officers (integrated team), Specifiers, Design Offices, Stress offices, . who will be able to use it as a reference on the subject, • Operational users, who will benefit from specific items regarding their involvement in discussions with other partners throughout the programme, • Environment specialists who will therefore have available the majority of information regarding their trade in order to negotiate with their partners to determine the best compromise between technical performance, cost and delivery schedules. The suggested arrangements may be adapted according to: • the magnitude, the complexity and the life cycle duration of the programmes, • the risks to be controlled, • the number of participants. It should also be noted that the process may be simplified for programmes leading to simple tests and even deleted for standard tests.

Process	Scope & Limitations
	The content has some features which are unique , such as : - description of the environmental engineering tasks relative to each phase of a development programme - the validation process makes the distinction between the technical functions and the service functions - the variability of the product resistance to the environment on one hand and of the field environment on the other hand are considered via the uncertainty and the test factors Field of application The present guide may be used for all national military programmes. It covers both the actions to be performed during the design and production of a specific equipment item, as well as those to be conducted when purchasing existing equipment off the shelf . It may also be used as an implementation document for STANAG 4370 - AECTP 100 in the context of European or international co-operative programmes in the military field. It is additionally compatible with documents issued by other military or civilian organisations which cover the same subject No restriction appears to be necessary regarding the use of this document in the civil field. Nevertheless, it is essential to always check the consistency of the actions undertaken, and to adapt these in accordance with the design, production and operating context of the equipment (in particular the environment actually encountered in use).
Environmental conditions	**STANAG 4370 AECTP 200 ENVIRONMENTAL CONDITIONS** AECTP 200 is one of five documents included in STANAG 4370. It provides characteristics and data on environmental conditions for operational events and scenarios that influence the design of defence materiel. Although it is not practicable to provide data to cover all circumstances, AECTP 200 is considered to include the most relevant environmental conditions. AECTP 200 is to be used in conjunction with the four other AECTPs included in STANAG 4370. They are: AECTP 100 Environmental Guidelines for Defence Materiel, AECTP 300 Climatic Environmental Tests, AECTP 400 Mechanical Environmental Tests, and AECTP 500 Electrical Environmental Tests. An important application of AECTP 200 is for users to confirm that the key environmental conditions within project specific environmental requirement documents have been addressed correctly. In particular, when used in conjunction with the other AECTPs, the environmental characteristics and data contained in AECTP 200 should facilitate the development of a comprehensive and cost effective set of environmental tests and assessments. The data presented in AECTP 200 are intended for use during the specification process but also are to be considered when extended life is under focus. Refer to STANAG 4570 with AECTP 600 for guidance. When possible, the use of measured data to develop test severities is recommended. For many environment conditions AECTP 200 provides advice on the derivation of test levels from measured data.

Process	Scope & Limitations
	AECTP 200 does not address abnormal environments arising from accidental or hostile conditions, or nuclear effects. **MIL-STD 810 F ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS** MIL-STD 810 F PART 1 See entry under “The Environmental Engineering Process”. MIL-STD 810 F PART 2 Part Two contains environmental laboratory test methods to be applied according to the general and specific test tailoring guidelines described in Part One. It is important to emphasize that these methods are not to be called out in blanket fashion nor applied as unalterable routines, but are to be selected and tailored to generate the most relevant test data possible. To support the tailoring process described in Part One, each test method in Part Two contains some environmental data and references, and identifies tailoring opportunities for the particular method. Some methods afford a wide latitude for tailoring; some can be tailored up to established limits, and some have relatively few tailoring options. Whenever possible, each method contains background rationale to help determine the appropriate level of tailoring. Each test method supports the test engineer and test facility operator by describing preferred laboratory test facilities and methodologies. Any specific tailoring information and values contained in these test methods should be supplanted by more up-to-date or program-specific information when available. When applied properly, the environmental management and engineering processes described in this standard can be of enormous value in generating confidence in the environmental worthiness and overall durability of materiel system design. However, it is important to recognize that there are limitations inherent in laboratory testing that make it imperative to use proper caution and engineering judgement when extrapolating these laboratory results to results that may be obtained under actual service conditions. In many cases, real-world environmental stresses (singularly or in combination) cannot be duplicated practically or reliably in test laboratories. Therefore, users should not assume that a system or component that passes laboratory tests of this standard also would pass field/fleet verification trials. MIL HDBK 310C This standard provides climatic data primarily for use in engineering analyses to develop and test military equipment and materiel. Purpose: The data provided are intended to serve as natural environmental starting points for the sequence of engineering analyses to derive environmental design criteria for materiel. The climatic data are also intended to provide guidance in the development of environmental tests of materiel. Application. (a) This standard provides climatic information for land, sea, and air environments in which military materiel

Process	Scope & Limitations
	may be required to operate. These data represent free air (ambient) conditions, and are not to be confused with the response of materiel, either to these conditions, or to those of a platform on or within which the materiel might be located. (b) Selection of specific climatic values in this standard should be made only after determining: (1) the area of geographic deployment; (2) handling and logistics requirements; and (3) the operational requirements of the materiel being developed. Limitations. (a) Climatic data for the region south of 60 S latitude are excluded from consideration in this document. (b) The climatic data in this standard should not be used in the development of materiel for a specific geographic location or an anomalous site such as a mountain top. This type of climatic support may be obtained through the Office of Primary Responsibility (OPR) for each military service (see 4-6). (c) The possible adverse effects of climatic conditions upon materiel are not discussed in this standard. (d) This standard does not include induced environments such as may be encountered in storage or transit, or caused by a platform on or within which the materiel might be located. (e) Unless otherwise indicated, information provided for a climatic element does not occur at the same time and/or place as information provided for another climatic element. (f) The climatic data in this standard should not be used directly as test values without consulting MIL-STD-810 or other appropriate environmental test documentation. **DEF-STAN 00-35 ENVIRONMENTAL HANDBOOK FOR DEFENCE MATERIEL Parts 4, 5 & 6** DEF STAN 00-35 PART 4 NATURAL ENVIRONMENTS Part 4 (Natural Environments) of Def Stan 00-35 describes the meteorological and biological environments likely to be experienced by defence materiel in the earth's atmosphere, and the effects of each environment on such materiel. This Part implements STANAG 2895 Edition 1 (Ref.1). In the first two chapters, climatic categories and the diurnal cycles of temperature, humidity and solar radiation in each category are described. These cycles are used in several climatic test methods in Part 3. To facilitate the identification of climatic conditions for inclusion in the Staff Target or Staff Requirement, eleven climatic categories have been chosen to represent distinctive types of climate found on the land surfaces of the world, and a further three have been selected to describe the conditions found at sea away from land. The definition of each climatic category is given in Table 1 together with the identification of some of the more important regions upon which the categorisation is based. The eight categories, A1 to A3 and C0 to C4, relating to the land surface are defined with temperature as the principal consideration, while the remaining three, B1 to B3, represent climates in which high humidity accompanied

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	by a warm temperature is the outstanding characteristic. With respect to the sea surface, two categories M1 and M3 are defined with temperature as the principal consideration; whilst the third, M2, represents a sea climate in which a warm temperature is accompanied by high humidity. The geographical locations to which these climatic categories apply are illustrated approximately in Figures 1A, 1B and 1C. It is considered impractical to attribute categories to specific sea areas, but as a general guide, M1 and M2 apply to regions which experience tropical or temperate conditions respectively, while M3 is representative of arctic conditions. The highest or lowest temperature ever reliably recorded in the location of various climatic categories is given in Table 2. The delineation of the geographical areas in Figures 1A-C is not intended to imply that the climate at each and every location within that area complies exactly with the annual distributions and diurnal cycles appropriate to the indicated climatic category. The maps are provided only as a guide when determining the climatic environmental criteria. If data applicable to a specific region or location are required, then reference should be made to the appropriate sections in this part of the Defence Standard, or the Meteorological Office should be consulted. However, to avoid limitations in deployment, the geographical areas should be used as frequently as possible. The diurnal cycles and annual distribution of temperature, solar radiation and humidity appropriate to each climatic category are summarised in Chapter 1-02 of this section and also discussed in Chapters 2-01, 3-01, and 4-01 respectively of this part. The data cover both meteorological and storage conditions (see Chapter 1-02 for definitions). Although temperature, solar radiation and humidity are the principal environments affecting each climatic category, additional factors may need to be considered. Table 3 lists these other climatic factors and the categories affected. DEF STAN 00-35 PART 5 INDUCED MECHANICAL ENVIRONMENTS The total environment experienced by defence materiel is a combination of natural environments and induced environments. (a) Natural environments consist of those conditions of temperature, pressure, humidity, etc, that the materiel experiences at its physical global location. Natural environmental conditions are those conditions that a static inoperative item of materiel experiences at its external surfaces. (b) Induced environments consist of those conditions of vibration, temperature, chemical contamination, etc, that occur because of the operation, configuration, construction or use of the materiel. This Part describes the range of induced mechanical environments likely to be encountered by materiel. Natural environments are covered in Part 4. Induced climatic environments are covered in Part 6. This Part describes and enumerates a wide range of induced mechanical environments encompassing most types of materiel. Excluded are the deployment platforms themselves, e.g. ship and aircraft structures, propulsion units, land vehicles, and buildings; excepting where the environmental response of a deployment platform forms a significant

Process	Scope & Limitations
	input to the materiel under consideration. Only environmental conditions associated with normal Service are addressed in this Part. The information provided does not cover hostile, deliberate attack or live fire conditions, caused by shell fire or nearby bomb explosions. These conditions should be covered by project specific documentation. The environments arising from the effects of nuclear explosions are addressed in Def Stan 08-4. 1.6 The characteristics and amplitudes of the induced mechanical environments encountered by materiel are identified in this Part by the phase in the logistical and operational sequence from its place of manufacture to its final intended use or disposal. Moreover, this Part has been rigorously structured to allow easy extraction of the information pertaining to each phase and type of deployment platform. The information contained in this Part allows test methods to be selected and associated test severities for many induced environments to be derived, ranging from those for general application to those specific to a particular project. Where relevant the test methods identified in this Part refer to those specified in Part 3 of this Standard. The individual physical characteristics of materiel occasionally prevents the estimation of induced mechanical environments from past experience. Consequently, the measurement of actual conditions expected to arise is often necessary. Advice is given as appropriate in this Part on the derivation of test severities from measured data. Def Stan 00-35 Part 6 Induced Climatic, Chemical and Biological Environments This Part describes the range of induced climatic, chemical and biological environments likely to be encountered by materiel. It also suggests test methods that have been developed to represent the effects of induced environments. Detailed information on the characteristics and effects of natural environments is provided in Part 4. Induced mechanical environments are covered in Part 5. DEF STAN 00-35 PART 6 INDUCED CLIMATIC NATURAL ENVIRONMENTS This Part 6 describes and enumerates a wide range of induced climatic, chemical and biological environments encompassing most types of materiel. Excluded are the deployment platforms themselves, eg: ship and aircraft structures, propulsion units, land vehicles and buildings, except where the materiel under consideration could be subjected to environments generated by a deployment platform. Only environments associated with normal Service conditions are addressed in this Part. That is, information is not provided on abnormal aspects such as fire or crash conditions. Furthermore, the information provided does not cover hostile, deliberate attack by munitions or chemical and nuclear explosions. Where applicable, these conditions should be defined in the project-specific documentation. Tests for abnormal environments should be considered, in principle, in the same way as for normal environments, that is, compliance will be demonstrated by a combination of assessments and tests. The environments arising from the effects of nuclear explosions are addressed in Def Stan 08-4. The environments arising from chemical and biological attack, the techniques for chemical and biological hardening, and the methods and materials used as decontaminates, are given in Def Stan 08-41 Part 1. The characteristics of the induced climatic, chemical and biological environments encountered by materiel are

Process	Scope & Limitations
	identified in this Part by the phase in the logistical and operational sequence from its place of manufacture to its final intended use or disposal. Moreover, this Part has been structured to allow easy extraction of the information pertaining to each phase and type of deployment platform. The information contained in this Part allows test methods to be selected and associated test severities for many induced environments to be derived, ranging from those for general application to those specific to a particular project. Where relevant, the test methods identified in this Part refer to those specified in Part 3 of this Standard. **GAM EG 13 Annex " Environmental Data And Models " (Available In French Only) :** The generalities explain how to use these data all along the process of development. The section dedicated to mechanical data passes through all the types of mechanical environments and proposes real measurements representative of each type. The section dedicated to climatic environments proposes a classification of the environment bases on 11 zones on ground Z1 to Z11 and 3 zones on the sea (Z12, Z13 and Z14). Each of these zone is defined by a bi univocal relation with a geographical zone as presented on maps. Many climatic parameters are defined and characterized for each of these zones. **IEC EN 60721** 60721-2 PART 2 ENVIRONMENTAL CONDITIONS APPEARING IN NATURE This part of the standard sets out environmental conditions appearing in nature. It briefly describes various natural conditions and quantifies the extreme cases. Part 2 comprises 7 sections viz; Section 2.1 – Temperature and Humidity Section 2.2 – Precipitation and Wind Section 2.3 – Air Pressure Section 2.4 – Solar Radiation and Temperature Section 2.5 – Dust, Sand, Salt Mist Section 2.6 – Earthquake vibration and shock Section 2.7 –Fauna and Flora 60721-3 PART 3: CLASSIFICATION OF GROUPS OF ENVIRONMENTAL PARAMETERS AND THEIR SEVERITIES Scope: IEC Publication 60721-3: Classification of Environmental Conditions, Part 3: Classification of Groups of Environmental Parameters and Their Severities, establishes classes of environmental parameters and their severities, covering the extreme (short-term) conditions which may be met by a product when being transported, installed, stored and used. Separate groups of classes are given for different product applications (e.g. weather-

Process	Scope & Limitations
	protected stationary, mounted in ground vehicles, transportation). The classes also take into account the degree of restriction of the use of the product from very restricted conditions (e.g. in temperature- controlled rooms) to unrestricted conditions. The classification covers natural as well as man-made conditions. Object : This Introduction is a guide for the use of all parts of IEC Publication 60721-3. It contains background information including information on application and limitation of the classes given in various parts of IEC Publication 60721-3. It describes the difference between the environmental conditions the product will meet during its life, described by the classes in IEC Publication 60721-3, and conditions of test used to assure that the product will work satisfactorily under such environmental conditions. The use of IEC Publication 60721-3 in the design, limitation of conditions and protection is also included. The differences are explained between extreme environmental conditions with a small probability of being exceeded, normally approached only for short periods, and more long-lasting normal environmental conditions. This introduction also gives guidance for applying factors of duration and frequency of occurrence in characterising the contribution of a significant parameter of a class. Reference to IEC Publication 60721-3-0 is strongly recommended in order to avoid misuse of the classes defined in the other parts of IEC Publication 60721-3.
Guidelines For Deriving Test Profiles (Tailoring)	**STANAG 4370 AECTP 200 ENVIRONMENTAL CONDITIONS** See entry under "The Environmental Engineering Process". **MIL-STD 810 F ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS** See entry under "Environmental Conditions Linked To The Life Cycle Of The Materiel". **DEF-STAN 00-35 ENVIRONMENTAL HANDBOOK FOR DEFENCE MATERIEL Part 4, 5 & 6** See entry under "Environmental Requirements Linked To The Life Cycle Of The Materiel". **CIN EG 1 for all type of environments and GAM-EG13 "Annexe générale mécanique" for mechanical environments (available in French only)** See entry under "The Environmental Engineering Process". **International Test Operations Procedure (ITOP) 1-1-050 Development of Laboratory Vibration Test Schedules** This ITOP presents the considerations and techniques involved in developing laboratory vibration schedules that simulate the field transportation vibration environment associated with tactical vehicles. Scope: Materiel must be designed to withstand the vibration environment normally encountered during ground vehicle and helicopter transport as secured cargo and/or installed equipment without losing the ability to perform its intended mission. To ensure this, laboratory-simulated vibration tests are used extensively in lieu of more time-consuming and less cost-effective loading/installing equipment in various vehicles and operating them for

Process	Scope & Limitations
	appropriate distances over test courses.
Fall Back Test Severities	**STANAG 4370 AECTP 300 and 400 CLIMATIC AND MECHANICAL TESTS** AECTP 300 GENERAL GUIDANCE AND REQUIREMENTS Purpose: To centralise information common to the climatic test methods (AECTP 300). To provide general guidance and requirements for preparing the environmental test specification and/or test plan, and procedures unique to the program under consideration. Application: This Method (301) includes information relative to: Test program development. Test parameter values. Exposure duration. Test item configuration. Information required prior to and following testing. Test parameter tolerances. Characteristics of test facilities. Temperature stabilization. Test controls. Test interruption. Pretest checks. Failure criteria. Each of these items (a-l) must be considered when using any of the AECTP 300 climatic methods. The documents in AECTP 300 contain generic test procedures that are intended to be tailored for the specific test program. Limitations: It is impossible to simulate the total natural environment in a laboratory (chamber). Additionally, gradients through the test item that are produced by the natural environment are, in most cases, difficult to achieve. However, the tests outlined and described in this set of documentation attempt to provide exposure to simulated conditions from which a degree of confidence in the test results can be assumed. Any inability to test all associated equipment at the same time must be considered in evaluating final suitability of the test item and of the test method. Significant limitations relevant to the application of the AECTP 300 climatic methods include: identification and application of all the relevant environmental elements. inability to operate and evaluate the test item as required in service. limited environmental data (response or input). inability of test facilities to apply the climatic elements as they occur in the service environment.

Process	Scope & Limitations
	impracticality of performing tests for durations comparable to field exposure. The responsibility for reconciling these and other limitations to specific program needs lies with the environmental engineering specialist in conjunction with the program manager (see AECTP 100). Any one of the AECTP 300 procedures is not intended to be complete for a particular application. Each procedure shall be tailored and translated into test plans and procedures that satisfy the specific needs of each test program. Guidance On Test Program Development Testing in the Natural Environment: Testing in the natural environment is the most realistic approach. However, since it is not possible to control the natural environment, it is rarely possible to ensure that the required extreme environment is available for the test. For such situations, laboratory testing becomes essential, accepting that all factors contributing to the natural environment may not be capable of accurate replication. Tailoring: The tailoring process (as described in AECTP 100, Guidelines on the Management of Environmental Testing of Defence Materiel, or equivalent national documents) shall be used to determine the appropriate tests and test variables. Whenever possible, data obtained under actual end-use conditions should be utilised to define test parameters. When measured data are not available, analytical derivations and data from similar applications may be used. The requirements documents must, in all cases, define the anticipated operational scenarios for the test item, so that the environmental test conditions can be derived. AECTP 400 MECHANICAL ENVIRONMENTAL TESTS AECTP 400 is one of five documents included in STANAG 4370. It is important for users to note that the content of AECTP 400 is not intended to be used in isolation, but is developed to be used in conjunction with the other four AECTPs to apply the Environmental Project Tailoring process. This process ensures that materiel is designed, developed and tested to requirements that are directly derived from the anticipated service use conditions. It is particularly important that AECTP 400 is used in conjunction with AECTP 100 which addresses strategy, planning and implementation of environmental tasks, and AECTP 200 which provides information on the characteristics of environments and guidelines on the selection of test methods. The test methods contained herein together with associated assessments are believed to provide the basis for a reasonable verification of the materiel's resistance to the effects of the specific mechanical environments. However, it should be noted that the test methods are intended to reproduce the effects of relevant environments and do not necessarily duplicate the actual environmental conditions. Where possible, guidance on the limitations of the intended applications is provided. The use of measured data for the generation of test severities is recommended if available. AECTP 400 Test Methods address mechanical environments, both individually and when combined with other environments, such as climatic environments included in AECTP 300. The application of combined environments is relevant and often necessary where failures could be expected from potential synergistic effects. In developing a test programme, consideration is to be given to the anticipated life cycle of the materiel and to the changes in resistance of the materiel caused by the long term exposure to the various mechanical environments.

Process	Scope & Limitations
	The environmental conditions included by the appropriate materiel platforms are also to be accommodated. Guidance on these aspects and information on the characteristics of environments is provided in AECTP 200. Guidelines for the planning and implementation of environmental tasks is given in AECTP 100. AECTP 400 was not developed specifically to cover the following applications, but in some cases they may be applied : Weapon effects, other than EMP, Munitions safety tests covering abnormal environments, Packaging testing, Suitability of clothing or fabric items intended for military use, Environmental stress screening (ESS) methods and procedures. The enclosed list of AECTP 400 Test Methods reflects those currently developed and completed. It is not comprehensive in that it will be revised as other methods are developed. The methods listed are not to be applied indiscriminately, but rather selected for application as required. **MIL-STD 810 F ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS** See entry under “Environmental Conditions Linked To The Life Cycle Of The Materiel”. **DEF-STAN 00-35 ENVIRONMENTAL HANDBOOK FOR DEFENCE MATERIEL Part 3** The prime purpose of this Part of the Standard is to include test methods which simulate as far as practicable known Service environments for which environmental testing is feasible. The test methods are grouped into sections relating to commonly encountered environments. The tests are applicable to materiel but some tests are also applicable to packages or materials. The test methods as presented within this Part of the Standard are not suitable for direct application without conversion into the appropriate documentation. Guidance on the derivation of Environmental Test Specifications and Environmental Test Instructions is contained in Part 1, Chapter 2-03. General guidance on the selection and sequence of tests is given in Chapter 1-02 of this Part, whilst information on environmental test conditions such as standard laboratory and reference conditions is given in Chapter 1-03 of this Part. The maximum use has been made of environmental tests published in International and British Standards and where these are suitable they are invoked in this Part of the Standard. In cases where the tests are similar but involve some differences, reference is made to the appropriate International or British Standard together with the alternative parameters to be applied. Wherever possible BS EN 60068 (BS 2011) test methods are adopted in this Part of the Standard. SCOPE: This Part of the Standard specifies a range of environmental test methods together with durations and severities that are most likely to be representative of the life cycle of service use. As far as possible, the tests

Process	Scope & Limitations
	adopted are those internationally agreed and published in EN 60068 (IEC 68) and implemented via BS EN 60068 (BS 2011). This Part also gives guidance on applying the test conditions. **GAM-EG13 Test Methods Part Two** The second part of GAM EG 13 addresses the fall back levels . They are split in 5 documents, in function of the sector which is concerned : - GAM EG 13 A for army - GAM EG 13 B for air force - GAM EG 13 C for navy - GAM EG 13 D for missiles - GAM EG 13 E for ground equipments (non board) . These fall back levels were established under the responsibility of each service, except ground equipment which are multi services. **International Test Operations Procedure** ITOP 1-2-601 LABORATORY VIBRATION SCHEDULES This ITOP describes two types of vibration tests conducted in the Laboratory: first, a mission/field secured-cargo test to simulate the transportation of Army materiel as secured cargo during logistical shipments; and second, an application -induced vibration test to simulate the tactical-vibration environment experienced by equipment installed in/on ground vehicles or helicopters, Through application of these tests the design and fabrication of the test item are evaluated for conformance with requirements documents. The tests apply to ammunition (including close-support rockets and missiles), electronic equipment, mechanical equipment, and optical equipment. Scope: a. This ITOP describes two types of vibration tests conducted in the laboratory: first, a mission to field secured-cargo test to simulate the transportation of Army materiel as secured cargo during logistical shipments; and second, an application-induced vibration test to simulate the tactical-vibration environment experienced by equipment installed in/on ground vehicles or helicopters. Through application of these tests the design and fabrication of the test item are evaluated for conformance with requirements documents. The tests apply to ammunition (including close-support rockets and missiles), electronic equipment, mechanical equipment, and optical equipment. b. No attempt is made to address the vibration environments for equipment installed in fixed-wing aircraft missiles, and ships (marine environment). Information on these environments can be obtained from MIL-STD-810E. c. An explanation of the vibration testis contained in Appendix A. Background information and techniques used for developing laboratory vibration test schedules from field data are contained in ITOP 1-1-050. d. The laboratory vibration test schedules for field/mission secured cargo in Appendix B apply to general types of

Process	Scope & Limitations
	cargo and were developed from data acquired on cargo vehicles that were loaded to 75'%of rated payload. For the special circumstances that arise in transporting unique items that load a vehicle above or below the 75% level, load-rating factors have been established and are described in Appendix F. e. ITOP 1-2-601 is a dynamic document. Measurements are continually being made. Schedules will be added as they become available for other vehicles. Forward newly-developed schedules and data for immediate inclusion in this ITOP. ITOP 5-2-506 LABORATORY SHOCK TESTING OF MISSILES AND ROCKETS This ITOP describes procedures for the conduct of mechanical shock tests of missiles, rockets, and related components as specified in weapon system procurement contracts. Shock test specifications are discussed, as well as, equivalent test concepts, instrumentation characteristics, fixture design, methods of generating and controlling the test environment, performance of the test, and data reporting requirements. The procedures describe characteristics of classical (half-sine, sawtooth, trapezoidal, etc.), synthesised (compound waveform), and pyrotechnic shock pulses and the equipment utilised to create the shock pulse such as single impact drop tables, electro-dynamics exciters, electro-hydraulic exciters, resonant impact fixtures, and pyrotechnically induced shock fixtures. Scope: This ITOP describes procedures for the conduct of mechanical shock tests of missiles, rockets, and related components. This ITOP covers shock test specifications, equivalent test concepts, instrumentation characteristics, fixture design, methods of generating and controlling the test environment, performance of the test, and data reporting requirements. Purpose: The purpose of this ITOP is to provide sufficient guidance to conduct accurate and repeatable laboratory shock tests of missiles, rockets, and related components as specified in weapon system procurement contracts. Application: a. These test procedures are specifically targeted at missiles, rockets and their components, however, the procedures may be applied to other items. b. The procedures are applicable for classical (half-sine, sawtooth, trapezoidal, etc.), synthesised (compound waveform), and pyrotechnic shock pulses. Limitations: a. This ITOP describes the generally encountered methods of specifying shock test requirements in military standards and procurement documents. The scope is limited to the conduct of laboratory shock tests and does not include procedures for the measurement of the "real world" environment or derivation and tailoring of test requirements for specific test items. b. Although many of the concepts and procedures maybe applicable, this ITOP does not specifically describe rail impact shocks, transit drop tests, bench handling shocks, gunfire shock, catapult launch and arrested landing or shipborne equipment shock tests.

Process	Scope & Limitations
	c. The procedures in this ITOP are limited to mechanical shock tests and are not intended to be specific instructions. In most cases, each shock test to be conducted is a special case, therefore, specific instructions are not generally appropriate. d. While many types of shock test machines are available this ITOP is chiefly limited to single impact drop tables, electrodynamic exciters, electrohydraulic exciters, resonant impact fixtures, and pyrotechnically induced shock test equipment. **EN / IEC 60721-4 Part 4 Guidance For The Correlation And Transformation Of Environmental Condition Classes** Scope and object: This part of IEC 60721 is a technical report dealing with the correlation and transformation of the conditions given in IEC 60721-3 to the environmental tests defined in IEC 60068-2. It is an introduction to the series of publications IEC 60721-4 which aims at providing the specification writer with guidance together with a set of easy-to-use tables to help correlate and transform these conditions. The purpose of this technical report is to recommend the environmental tests which may be chosen to demonstrate the capability of a product to function or survive satisfactorily as specified in the relevant specification when subjected to the climatic and dynamic conditions given by IEC 60721-3. These test seventies, including their suggested duration, are not intended to demonstrate the reliability of the product, guidance for which should be sought from the publications concerning the field of availability, reliability, maintainability and maintenance support. Whilst it may not be possible to recommend severities for all types of product, locations and applications, it is possible to suggest tests which are adequate for the majority. Guidance information has been included with the suggested tests which describes how the severities have been chosen. The rationale contained in this guidance may also be used to help modify test severities when the conditions found in IEC 60721-3 do not adequately describe a particular environment or application.

6.1.3 Technical Comparison

6.1.3.1 The Environmental Engineering Process.

The inclusion of information in standards on how to conduct the environmental engineering process within a overall design and procurement programme for defence systems, is a relatively new. It originates from the growing strategy of passing responsibility and risk to the system supplier of ensuring the equipment works In-service.

Although the Environmental Engineering process is designated as Part 1 of UK Def Stan 00-35, it was included several years after many of the test procedures and environmental severities had been published. The current environmental engineering process in Def Stan 00-35 was written in the early 1990's and is intended to align with the defence material design process used in the UK. The process sets out to demonstrate the equivalence in terms of documents and processes between the environmental engineering process and the design process. Part 1 sets out an overall idealised process which can be used under almost any procurement approach. It then indicates has this can be tailored into four different procurement strategies. These four strategies encompass the core approaches used for the vast majority of defence equipment procurement. Advice on the risks and responsibilities associated with each of these four strategies is set out. Although the standard explains the process by means of documentation, it concedes the titles of these documents may change from procurement to procurement and also environmental documentation may be incorporated into general design process documentation. Although Part 1 of Def Stan 00-35 sets out the management process it does not supply advice on how to implement strategies and programmes. That aspect is currently in preparation and is to incorporated into Def Stan 00-35 Part 2.

The French military standard CIN EG01 sets out guidelines for accounting for the environment in military programmes. This document was issued relatively recently in 1999 and is founded on earlier work which set out the technical aspects of how to implement strategies and programmes. That is the order of the work was directly reversed from that adopted by the UK. As a consequence of this CIN EG01 is far more extensive than the Def Stan and contains considerably more information on how to implement the process than does the UK document. In this regard the CIN EG01 and the Def Stan appear to be aimed at different people. Intrinsically the two processes are not actually that different, they are both based upon ensuring the defence system is able to operate in the service environment and go through the same five stages of establishing a requirement, formulating a strategy, defining the tasks and work programme, undertake the task and demonstrate compliance. The French military standard CIN EG01 implements a single process but does not explain how this can be used for different procurement strategies. But CIN EG 1 has some features which are unique , such as:

- description of the environmental engineering tasks relative to each phase of a development programme
- the validation process makes the distinction between the technical functions and the service functions

the variabilities of the product resistance to the environment on one hand and of the field environment on the other hand are considered via the uncertainty and the test factors

The US Mil Std 810F sets out an environmental management process that is based upon versions adopted in earlier version of the standard. The process is comprehensive but does not align with either the UK or French approaches. This seems to be because the Mil Std process is very much related to the US defence procurement strategies in which a lot of pre-service environmental testing and assurance is frequently done by DOD agencies rather than the supplier. The Mil Std environmental management process is very much built around documentation which does not appear to be particularly flexible. Indeed experience would suggest it is often not adopted by US defence equipment suppliers.

The environmental management process of STANAG 4370 AECTP 100 is intended as hybrid of US and European approaches. However, it effectively sets up yet another process which complies with none in national European use. It also does not appear to be particularly flexible and has not stood the test of real usage.

Neither the Mil Std process or the STANAG 4370 AECTP 100 process align with the procurement process that is adopted by many European countries. Nor does it necessarily align with that proposed for European Defence procurement. The adoption of the US standard for European procurement would, it could be argued, put the European defence industry at a disadvantage. A similar argument could be made for the NATO standard which has also not stood the test of extensive usage. Although neither the UK DEF STAN

0035 part 1 or French CIN EG 1 have shortfalls, together, they are far and away better than the STANAG 4370 AECTP 100 process. Amalgamation of the French and UK environmental management processes is entirely viable as they cover similar ground but are aimed at different people. Amalgamation of the two processes would also allow integration with the European Defence procurement process.

6.1.3.2 Environmental Conditions

Since the early 1980's it has become the norm to use environmental test severities based upon in-service conditions. When this approach was first initiated it necessitated many data collection exercise. However, since then it has become common to include environmental conditions in Environmental standards. Environmental conditions can be broadly divided into two groups, those which describe the natural environment and those which describe the conditions self induced by defence equipment. Descriptions of the world-wide natural environment should have a degree of commonality to all countries and equipment. Conversely, the induced environments are likely to be unique to a particular platform and consequently country and equipment specific. This notwithstanding some platforms are used by several countries and anyway similar platforms exhibit similarities. Moreover, common methods of transport of defence equipment is frequently a necessity.

Natural climatic conditions are described in a number of standards. These are generally reference documents indicating the extent and likelihood of world-wide natural conditions. Generally, the most commonly referenced values relate to the temperature and humidity conditions occurring world-wide. Also of common concern are the occurrence of sand & dust, salt atmosphere, rain, ice snow etc.

The UK Def Stan 00-35 Part 4 presents an extensive description of natural conditions based upon UK Meteorological Office records. Part 4 of Def Stan 00-35 is extensively based upon information the earlier Def Stan 07-55 and its use has a significant historical base in the UK. Generally, each section in Part 4 addresses a separate natural environment. Each section comprises two chapters the first presenting data from the Meteorological Office records and the second offering advice on how this can be used in defence equipment design. The temperature and humidity distribution maps included in Part 4 are essentially based on 1 in 1000 occurrence and have recently been updated (but the maps are still unpublished) by professional meteorological staff. The revision has utilised the forecasting meteorological office database which has considerably more measurements in terms of both location and samples than the historical bases used by some standards.

The actual meteorological data presented in UK Def Stan 00-35 Part 4 was also the base for the information contained in STANAG 2895. This STANAG is relatively well known as it is intended to be incorporated in STANAG 4370 AECTP 200. It is observed that STANAG 2895 has proven difficult to obtain in the past but now appears to be available from the NATO website. Although containing the same information as the UK Def Stan 00-35 Part 4 the STANAG is generally acknowledged as much easier to use and understand (hence the revision of the Def Stan).

GAM EG 13 “ environmental data and models” also contains natural climatic information which is grouped in a similar manner. The data appears to be based upon French meteorological data, as a consequence, some differences are apparent but they are generally not that great. As was the case in the previous two cases, the extreme temperature and temperature/ humidity conditions are presented in map form. Unlike a lot of GAM EG 13, the climatic conditions are only available in French and this has limited NATO adoption.

In the US natural climatic information is contained in Mil Std 310 (and previously 210). Again this is laid out in a similar manner to he other standards. In this case the data presented are mostly extreme conditions and do not appear to be based upon the same level of detailed information as the STANAG / Def Stan or GAM EG documents.

It would be reasonable to assume that natural climatic information is not limited to defence standards and that civil standards would present similar information. That is the case with IEC / EN 60721 Part 2 presenting information on the natural environment. However, the information is notably less extensive than that presented in the defence standards. Whilst, the extreme temperature and temperature/ humidity conditions are presented in map form, the criteria used to create these is unclear. The maps are quite different to those of the STANAG / Def Stan and appear to be based upon considerably courser information. The information in IEC / EN 60721 Part 2 was last reviewed over15 years ago although currently a programme of revision is underway. That revision only has access to historical database information only and operates without a budget or professional meteorological expertise. As consequence, it seems unlikely that the current revision will produce a result anything like as good as the defence standards.

Of the information on the natural climatic environment, that contained in STANAG 2895 (and shortly to be included in STANAG 4370 AECTP200) appears to be the most widely adopted both in NATO and Europe. It is based upon high resolution UK Meteorological information for world-wide conditions. The UK has updated their own document and hence the STANAG using funded meteorological expertise. It seems unlikely that any other defence or civil standard will approach the quality of the STANAG for sometime to come.

Information on induced environmental conditions is contained within a number of national and international standards. A large majority of this information on induced environmental conditions relates to mechanical conditions which are in turn relates to the particular platforms and methods of operation in use in individual countries. As a consequence commonality of induced environmental conditions is unlikely to be achieved by standards except at a generic level. Even when it is the case that the same platform and method of operation is used in several countries, the resultant description and derived test severity may vary. This is because different countries may adopt different methods and factors in the derivation of environmental descriptions and test severities. As the method of derivation can be significant that aspect is addressed separately in the next section. As a consequence of these issues the view of the Expert Group has been that direct comparison of severities would not be viable or meaningful, nor would any recommendation on induced environmental conditions. Nevertheless the following paragraphs are offered for general information.

Although IEC / EN 60721 Part 2 contains information on the natural environment no information is given at all on induced environmental conditions. IEC / EN 60721 Part 3 contains quantitative information on environmental conditions for a variety of conditions, no descriptive information is supplied. Moreover, the categories for which the quantitative information is supplied are broad, only vaguely defined and frequently considered out of date. The quantitative information itself is very coarsely specified and set out in the form of test severities rather than environmental descriptions. Overall IEC / EN 60721 Part 3 contains the sort of information that was common in the 1960's and 70's but which has not been used for anything but minor defence procurement since the 1980's. Most vertical civil standards which use IEC / EN 60068 test procedures specify their own severities rather than adopt those of IEC / EN 60721 Part 3.

The US national standard Mil-Std 810F Part 2 contains more information on induced environmental conditions than did the earlier versions. However, most of the information is by way of illustration rather than a deliberate intent to specify environmental conditions. Mostly, Mil-Std 810F Part 2 contains fall back test severities which may be based upon actual in-service data. Not only is the method of transformation not generally specified, but different approaches are used for different environments. Some of the in-service environments are unique to US platforms and a few worst of the cases represent platforms no longer in-service use.

The French national standard GAM-EG13 contains an annex for induced environmental data. This supplies sample information for a good range of platforms in common use by the French military for a range of in-service conditions. Similarly the UK Def Stan 00-35 Parts 5 and 6 contains information on induced environmental for mechanical and climatic conditions respectively. Again the standard contains a range of sample information for a good range of platforms in common use by the UK military for a range of in-service conditions.

The NATO standard STANAG 4370 AECTP 200 contains extensive information on induced environments. The base for the induced environments seems to be Part 5 and 6 of UK Def Stan 00-35. However, contributions from the French GAM and the US Mil Std can be identified. Overall AECTP 200 is strongly biased towards European information. Moreover, the AECTP 200 document appears to contain both the most recent and extensive information on environmental conditions. Any such information database is unlikely to be comprehensive and in this case notable absence of data exist from a number of major European countries who manufacture defence equipment.

6.1.3.3 Guidelines For Deriving Test Profiles (Tailoring).

The strategy of deriving test severities from In-service has lead to the need to supply guidance information on methods for the deriving test severities from measured In-service data. This information is mostly by way of guidelines as no single set of procedures has been found to be applicable in all circumstances. As no consensus exists as to appropriate methods it is unlikely that any real recommendation is possible. The following indicates the information available.

CIN EG 1 gives how to tailor disregarding the type of environment , but without presenting the details of operation when they are specific for a type of environment. GAM-EG13 contains a technical annex supplying extensive guidelines on the derivation of test severities for mechanical environments. This technical annex proposes a few generic method which can be consistently applied to the vast majority of in-service conditions. For those methods comprehensive guidelines are supplied which champion a number of novel methods. In this regard the French national standard GAM-EG13 has demonstrated significant technical innovation.

The UK defense standard Def Stan 00-35 presents extensive information on the conditions and mechanisms causing many induced environments. Understanding the conditions causing the environments is considered an essential precursor to the use of any test derivation process. The Def Stan also includes some guidelines on the derivation of test severities but these are neither comprehensive, modern or particularly innovative.

Mil Std 810F contains relatively few guidelines on the derivation of test severities and mostly these relate to specific test types. It does make reference to a fair number of reports. The guidelines that are contained in the Mil Std are mostly derived from those reports although the information is not always well or consistently extracted.

International Test Operating Procedure ITOP 1-1-050 is a Quadripartite agreement between US, UK, F & DE. This particular ITOP is entitled “The development of Laboratory Vibration Test Schedules”. It effectively presents the method used to derive the vehicle vibration test severities contained in Mil Std 810. It sets out the type of (US) test track used and results for a number of individual US vehicles. It also presents a lot of information on basic vibration & shock analysis. However, apart from the one method, it does not expand this basic textbook information to encompass any other test severity derivation methods. The vehicle test derivation method presented is one of two used in Mil Std 810 (the other is entirely different) and it is rarely used in Europe. In short the ITOP is little more than a supporting document for the Mil Std and is not consistent with European practice. Like many of the environmental ITOPS this has almost no discernible European content and relates entirely to US practice. As such it could be argued that it puts European defence system suppliers at a disadvantage.

Stanag 4370 AECTP 200 contains limited guidelines on the derivation of test severities. This is essentially a summary of guidelines presented in the French GAM, the UK Def Stan and supporting papers referenced in the in US Mil Std. For an overview of potential methods the STANAG is quite useful, although users who are attempting to implement these methods are unlikely to find the STANAG particularly helpful. Nevertheless as a starting point the STANAG is recommended.

6.1.3.4 ‘Fall Back’ Test Severities.

Historically all environmental test procedures contained related test severities. However, over the last two decades these have been replaced by a strategy of deriving tests based upon intended In-service use. As a consequence the severities remaining attached to the test severities are intended only for use when no information is available or when the item may be used in many platforms (typically COTS and MOTS items). Mostly use of these fallback severities is intended to be limited to small items, subsystems or components. Many of the remaining test severities are relatively rudimentary and are frequently intended for use on the most basic test equipment.

The test procedures of Def-Stan 00-35 Part 3 mostly have fallback test severities appended. Some procedures also contain guidance on these severities. However, the majority of the guidance is in Parts 4, 5 and 6. The severities are mostly historical and have a long track record. With that said they have all been reviewed for applicability at reasonable intervals. The severities indicate backward compatibility has been considered. Whilst, the fallback severities have a degree of commonality with other specifications, overall they are not precisely equivalent with other standards.

The second part of GAM EG 13 addresses the fall back levels . They are split in 5 documents, in function of the sector which is concerned :

- GAM EG 13 A for army
- GAM EG 13 B for air force
- GAM EG 13 C for navy
- GAM EG 13 D for missiles
- GAM EG 13 E for ground equipments (non board) . These fall back levels were established under the responsibility of each service, except ground equipment which are multi services.

The above fall back levels haven’t been updated from the original issue and are now superseded by STANAG 4370 AECTP200 except for air force (not including aero transport) where DO160 is recommended When STANAG 4370 AECTP200 are not covering the need , GAM EG 13 A, C and D are still applicable. For aero transport , GAM EG 13 B remains applicable when AECTP200 is not covering.

The test procedures of GAM-EG13 also have fallback test severities appended. Again the severities are mostly historical and have a long track record. Until recently they were all reviewed for applicability at reasonable intervals. The severities indicate backward compatibility has been considered. Whilst, the fallback severities have a degree of commonality with other specifications, overall they are not precisely equivalent with other standards.

The test procedures of Mil-Std 810F again contain have test severities. Although a few of these have a long track record, others have changed markedly as the various revisions of 810. Backward compatibility does not seem to have been a strong driver in those that have changed. Whilst, the fallback severities have a degree of commonality with other specifications, overall they are not precisely equivalent with other standards.

A significant proportion of the test procedures of STANAG 4370, specifically the AECTP 300 and 400 series, relates to fallback severities. Indeed the amount of information frequently swamps that the procedure itself resulting in a marked loss of firmness of statement. Generally, the fallback severities are based upon the UK Defence standard, the French GAM and the US Mil Std. In some cases a single fallback severity recommendation results. However, in other a compromise approach of presenting several options is adopted. Although it is intended that the STANAG fallback severities will be broadly implemented, at the moment, it is difficult to identify which severities are used in different countries. It has been argued that in combining the various national requirements, a test schedule more extensive can result than is required by a national defence procurement authority. In this regard the STANAG fallback severities may be resulting in more expensive programmes than is necessary. If the STANAG 4370 fallback severities are adopted for European defence procurement some rubbing off of the gold plating may need to be considered.

International Test Operating Procedures (ITOP's) 1-2-601 & 5-2-506 present fallback shock severities for missiles and vibration severities for wheeled & tracked vehicles as well as the Apache helicopter. All of these are based upon US fallback test severities and were derived using a US procedure not usually considered adequate in Europe. The severities are at odds with the European national standards as well as the STANAG. As is the case for many of the ITOPS considered these ITOPs could be considered to strongly favour the US defence industry over the European defence industry.

As already indicated IEC / EN 60721 Part 3 contains quantitative information on environmental conditions for a variety of conditions. However, a review around 8 years ago indicated a significant number of discrepancies between this document and the test severities set out in the various test procedures of IEC / EN 60068. To resolve these inconsistencies, IEC / EN 60721 Part 4 was generated to recommend a resolution for each Part 3 category. IEC / EN 60721 Part 4 is set out as a series of test schedules for some notional electro-mechanical equipment. As was the case for Part 3 the environmental categories for which test severities are supplied, the categories used are very broad and frequently considered out of line with current commercial (and military) practice. The actual test severities are very rudimentary, out of date and appears to make undefined sweeping assumptions about life cycle (in-service) usage. IEC / EN 60721 Part 4 is based very much on the test definitions of the type common in the 1960's and 70's, an approach which is no longer used for defence procurement for two decades. Vertical civil standards which use IEC / EN 60068 test procedures mostly specify their own severities rather than adopt those of IEC / EN 60721 Part 3 or 4.

Overall the fallback test severities embedded in the STANAG 4370 test procedures of AECTP 300 & 400 contain the most comprehensive array of fallback severities. In the near future these are likely to be embedded into the remaining European national procedures. As a consequence the STANAG fallback severities are likely to become a European standard without any recommendations from this Expert Group. Nevertheless a consequence of combining the various national requirements is potentially test schedules more extensive than required. If the STANAG 4370 fallback severities are adopted for European defence procurement then a strategy for limiting the test schedules may result in acceptable cost savings. .

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6.1.4 Conclusions

A summary of the recommendations is shown in the table below which is expanded in the following paragraphs.

Summary of Recommendations for Environmental Management & Severity Procedures						
	NATO STANAG 4370 AECTP	International EN / IEC 60068 & 60721	UK Def Stan 00-35	France GAM-EG-13 CIN EG 1	US Mil Std 810F	Quadripartite US/UK/F/DE ITOP
The Environmental Engineering Process	Set out in AECTP 100	No equivalent Procedure	Jointly Recommended preferably in a merged form		Set out in Part 1	No equivalent Procedure
Environmental Conditions	STANAG 2895 Recommended for both natural climatic and Induced conditions.	60721 Pt 2 contains Natural Environmental information	STANAG 2895 based upon Def Stan	Annex environmental data and models	Climatic information in Mil Std 331	No equivalent Procedure
Guidelines For Deriving Test Profiles (Tailoring)	Recommended as a good overview	No equivalent Procedure	Both contain information on different methods. In a combined form would constitute a better document than STANAG		Embedded within Procedures	Limited scope
'Fall Back' Test Severities	Recommended	Severities exist all documents				

6.1.4.1 The Environmental Engineering Process.

Neither the Mil Std process or the STANAG 4370 AECTP 100 process align with the procurement process that is adopted by many European countries. Nor does it necessarily align with that proposed for European Defence procurement. The adoption of the US standard for European procurement would, it could be argued, put the European defence industry at a disadvantage. A similar argument could be made for the NATO standard which has also not stood the test of extensive usage. Although neither the UK or French standards have shortfalls, together, they are far and away better than the STANAG 4370 AECTP 100 process. Amalgamation of the French and UK environmental management processes is entirely viable as they cover similar ground but are aimed at different people. Amalgamation of the two processes would also allow integration with the European Defence procurement process.

6.1.4.2 Environmental Conditions.

Information on the natural climatic environment is presented in national defence standards from the UK, France and the US as well as the civil standard IEC / EN 60721 Part 2. ,Information contained in STANAG 2895 (and shortly to be included in STANAG 4370 AECTP200) is based upon that in the UK Def Stan, but is better presented and more usable. The STANAG has existed for some time and appears to be widely adopted both in NATO and Europe. It is based upon high resolution UK Meteorological information for world-wide conditions. The UK has updated their own document and hence the STANAG using funded meteorological expertise. The information in the defence standards is markedly different from that in IEC / EN 60721 Part 2 which is much course no identifiable documented underlying criteria. It seems unlikely that any other defence or civil standard will approach the quality of the STANAG for sometime to come. As a consequence STANAG 2895 is recommended for information on the natural environment.

Currently the NATO standard STANAG 4370 AECTP 200 contains the most extensive information on induced environments and encompasses platforms from a number of countries. It encompasses identifiable data from both the UK and French national standards and is strongly biased towards European originated data. For these reasons this document is recommended. However, this document is far from a comprehensive compilation of induced environmental conditions nor is it likely to be for some time.

6.1.4.3 Guidelines For Deriving Test Profiles (Tailoring).

Stanag 4370 AECTP 200 contains limited guidelines on the derivation of test severities. The content is essentially a summary of extensive guidelines presented in the French CIN EG 1 and GAM EG 13 and the UK Def Stan 0035 as well as supporting papers referenced in the in US Mil Std810. For an overview of potential methods the STANAG is quite useful, although users who are attempting to implement these methods are unlikely to find the STANAG authoritative. Nevertheless as a starting point the STANAG is recommended.

6.1.4.4 'Fall Back' Test Severities.

Overall the fallback test severities embedded in the STANAG 4370 test procedures of AECTP 300 & 400 contain the most comprehensive array of fallback severities. In the near future these are likely to be embedded into the remaining European national procedures. As a consequence the STANAG fallback severities are likely to become a European standard without any recommendations from this Expert Group. Nevertheless a consequence of combining the various national requirements is potentially test schedules more extensive than required. If the STANAG 4370 fallback severities are adopted for European defence procurement then a strategy for limiting the test schedules may result in acceptable cost savings.

6.2 Review and Comparison of Vibration Test Methods

6.2.1 Standards Under Consideration

The standards reviewed and compared with regard vibration inducing test methods are set out in the following table.

Matrix Environmental Test Methods vs Standards						
	NATO STANAG 4370 AECTP (Method No)	International EN / IEC 60068 Part 2 (60068-2-xx)	UK Def Stan 00-35 Part 3 (Chapter / test)	US Mil Std 810F (Test No / Procedure)	France GAM-Eg-13 (Method / Procedure)	Quadripartite US/UK/F/DE ITOP (Test No)
Vibration	401	6 57 59 64 80	2-01 / M1 2-02 / M2	514	1st Part methods 41, 42	2-2-808 1-2-601 1-1-050
Gunfire	405		Included in general vibration procedures	519	Included in general vibration procedures	
Acoustic Tests (Incl. combined with temperature & vibration)	402 413	65	2-08 / M8 2-09 / M9 2-10 / M10	515 523	1st Part method 48	
Buffet Vibration	420		Encompassed in general vibration procedures			
Multi - Exciter Vibration	421					

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6.2.2 Standard Comparison

Test	Scope & Limitations
Vibration	**STANAG 4370 AECTP 400 , METHOD 401** Purpose. The purpose of this test method is to replicate the effects of the vibration environments incurred by systems, subsystems and units, hereafter called materiel, during the specified operational conditions. Application. This test method is applicable where materiel is required to demonstrate its adequacy to resist the specified vibration environment without unacceptable degradation of its functional and/or structural performance. AECTPs 100 and 200 provide additional guidance on the selection of a test procedure for a specific vibration environment. Limitations. It may not be possible to simulate some actual operational service vibration environments because fixture limitations or physical constraints may prevent the satisfactory application of the vibration excitation to the test item. Choice of Test Procedures. The choice of test procedure is governed by many factors including the in-service vibration environment and materiel type. These and other factors are dealt within the General Requirements – AECTP 100 and in the Definition of Environments - AECTP 200. This test method contains four procedures : Procedure I Swept Frequency Sinusoidal Vibration Procedure II Fixed Frequency Sinusoidal Vibration Procedure III Random Vibration Procedure IV Random Vibration (Stores) Table 1 provides a test procedure selection matrix as a function of platform and type of environment. Materiel may be exposed to more than one vibration environment. For example, materiel installed in aircraft will be subjected to both the transportation environment as well as the aircraft induced environment. In such cases the materiel may be required to be tested to more than one procedure. **EN/IEC 60068-2-6, 57, 59,-64, 80** 60068-2-06 TEST FC: VIBRATION (SINUSOIDAL) Scope. This part of IEC 60068 gives a method of test which provides a standard procedure to determine the ability of components, equipment and other articles, hereinafter referred to as specimens, to withstand specified severities of sinusoidal vibration. The purpose of this test is to determine any mechanical weakness and/or degradation in the specified performance of specimens and to use this information, in conjunction with the relevant specification, to decide the acceptability of the specimens. In some cases, the test method may also be used to demonstrate the mechanical robustness of specimens and/or to study their dynamic behaviour. Categorisation of components can also be made on the basis of a selection from within

Test	Scope & Limitations
	the severities quoted in the test. 60068-2-57 TEST FF: VIBRATION – TIME-HISTORY METHOD Introduction. This standard details methods for testing components, equipment and other electrotechnical products (hereinafter referred to as “specimens”) which in service can be subjected to short-duration random type dynamic forces of which typical examples are the stresses induced in equipment as a result of earthquakes, explosions and some phases of transportation. The characteristics of these forces and the damping of the specimen may be such that the vibrational response of the specimen will not reach a steady-state condition. The test consists, after any preliminary vibration response investigation with sinusoidal vibration, in subjecting the specimen to a time-history specified by a response spectrum with characteristics simulating the effects of the dynamic forces. A time-history may be developed or obtained from: a natural event (natural time-history); random sample, a synthesised waveform. The use of a time-history allows a single test wave to envelop a broadband response spectrum. It is possible for all the modes of the structure in the excitation axis (or axes) to be excited at the same time and consequently the stresses derived from the combined effects of the coupled modes are generally taken into account. Procedures are described for conducting the test and for the measurement of the vibration at given points. The requirements for the vibration motion and for the choice of severities (including frequency range, required response spectrum, number of high-stress response cycles and number of time-histories) are also detailed. 60068-2-59 TEST FE: VIBRATION – SINE-BEAT METHOD Introduction. This standard details methods for testing components, equipments and other electrotechnical products (hereinafter referred to as “specimens”) which in service can be subjected to pulsating or oscillating forces of short duration caused, for example, by seismic or explosive phenomena or by vibration in machinery. In this test the specimen is excited at fixed frequencies with a preset number of sine beats (see figure 1). These fixed test frequencies are predetermined frequencies, critical frequencies identified by means of a sinusoidal vibration test (IEC 60068-2-6) or both. Pauses are provided between the individual sine beats in order to allow decay of the free response of the specimen. Object. To provide a standard procedure for determining, by the sine-beat method, the ability of a specimen to withstand specified severities of transient vibration. General description. The purpose of this test is to determine mechanical weakness and/or degradation in specified performance and to use this information, in conjunction with the relevant specification, to decide whether a specimen is acceptable or not. It may also be used, in some cases, to demonstrate the mechanical robustness of specimens and/or to study their dynamic behaviour.

Test	Scope & Limitations
	60068-2-64 TEST FH: VIBRATION, BROAD-BAND RANDOM (DIGITAL CONTROL) AND GUIDANCE Introduction. This standard for broad-band random vibration testing is intended for general application to specimens of electrotechnical products that may be subjected to vibrations of a stochastic nature. The methods and techniques in this standard are based on digital control of random vibration. It permits the introduction of variations to suit individual cases, if these are prescribed by the relevant specification. The standard provides an alternative to the established analogue versions of the random vibration wide-band tests, Test Fd, IEC 60068-2-34 to IEC 60068-2-37. It should be noted that random vibration testing is a complex subject requiring both a good basic understanding of the philosophy of the test and the exercise of considerable engineering judgement. Compared with most other tests, Test Fh is not based on deterministic but on statistical techniques. Broad-band random vibration testing is therefore described in terms of probability and statistical averages. 60068-2-80 TEST FI: VIBRATION - MIXED MODE Scope. This standard for mixed mode vibration testing is intended for general application to testing of specimens, when simulation is required of vibration excitation of a complex and mixed nature. The purpose of this test is to demonstrate the adequacy of specimen to resist the dynamic loads without unacceptable degradation of its functional and/or structural performance when subjected to the specified mixed mode vibration test requirements. It is also to reveal the accumulated effects of stress induced by random vibration, mixed with sine and/or random, and the resulting mechanical weakness and degradation in specified performance and to use this information, in conjunction with the relevant specification, to assess the acceptability of specimens. In some cases, this standard may also be used to demonstrate the mechanical robustness of specimens. This standard is applicable to specimens which may be subjected to vibration of a random and/or a combination of random and deterministic nature resulting from transportation or real life environments, for example in aircraft, space vehicles and for items in their transportation container when the latter may be considered as part of the specimen itself. Although primarily intended for electrotechnical specimens, this standard is not restricted to them and may be used in other fields where desired. **DEF STAN 00-35 TEST M1 and M2** TEST M1 - BASIC VIBRATION TEST Scope. This test is applicable to equipment required to withstand the effects of a vibration environment. The purpose of this test is to demonstrate the adequacy of an equipment to resist unacceptable degradation of its functional and/or structural performance when subjected to the specified vibration severity. The range of procedures encompassed within this test includes basic sinusoidal and random vibration tests together with more complicated composite vibration tests. The test is designed to have general applicability in terms of procedure and severity. However for larger dynamically complicated equipment the procedure of Test M2 may be more applicable. Equipment vibration

Test	Scope & Limitations
	characterisation tests, such as resonance searches, determination of frequency response functions, and model analyses, are not addressed in this Chapter, since published information is readily available. This test includes procedures technically similar to the Sinusoidal and Random vibration tests given in BS EN 60068 (BS 2011). Reasons for variations are summarised in paragraph 7. TEST M2 - COMPLETE STORE VIBRATION TEST Scope. This test is designed to simulate, by mechanical means, the vibratory excitation arising from external carriage on aircraft. It is intended for materiel such as complete guided weapons, torpedoes, airborne armament stores and pods. For the purpose of this test the term store encompasses all these materiel. The principles of this test may be applicable to the simulation of other vibrational environments and equipments, for example large airborne radar or store carriage systems. The purpose of this test is to demonstrate the adequacy of an equipment to resist unacceptable degradation of its functional performance and/or structural performance when subjected to the specified vibration. This test differs from Test M1 - 'Basic vibration test' (see Chapter 2-01) in that it simulates the response of large, high mass, dynamically complex equipment whose excitation may not be mechanically transmitted to the equipment via its normal mounting arrangement. This test may be used to augment tests using acoustic excitations such as Test M8 'Acoustic Noise Test in a reverberation chamber' (see Chapter 2-08) or Test M9 'Acoustic Noise Test in a Progressive Wave Tube' (see Chapter 2-09). In some cases Test M10 'Combined Acoustic, Temperature and Vibration' (see Chapter 2-10) may be used as an alternative to this test. 1.6 Equipment vibration characterisation tests, such as resonance searches, determination of frequency response functions, and modal analyses, are not addressed in this Chapter, since published information is readily available. **MIL STD 810 F METHOD 514** Purpose. Vibration tests are performed to: a. Develop materiel to function in and withstand the vibration exposures of a life cycle including synergistic effects of other environmental factors, materiel duty cycle, and maintenance. Combine the guidance of this method with the guidance of Part One and other methods herein to account for environmental synergism. b. Verify that materiel will function in and withstand the vibration exposures of a life cycle. Application. Use this method for all types of materiel except as noted in MIL-STD-810F, Part One, paragraph 1.3 and as stated in section 1.3 below. For combined environment tests, conduct the test in accordance with the applicable test documentation. However, use this method for determination of vibration test levels, durations, data reduction, and test procedure details. Purpose of test. The test procedures and guidance herein are adaptable to various test purposes including development, reliability, qualification, etc. See Annex B for definitions and guidance. Annex B provides definitions and engineering guidance useful in interpreting and applying this method. Limitations. The test may not suitable for;

Test	Scope & Limitations
	Safety testing. Platform/materiel interaction. Manufacture and maintenance Environmental Stress Screen (ESS). Procedure selection. a. Procedure I - General Vibration. Use Procedure I for those cases where a test item is secured to a vibration exciter and vibration is applied to the test item at the fixture/test item interface. Steady state or transient vibration may be applied as appropriate. b. Procedure II - Loose Cargo Transportation. Use this procedure for materiel to be carried in/on trucks, trailers, or tracked vehicles and not secured to (tied down in) the carrying vehicle. The test severity is not tailorable and represents loose cargo transport in military vehicles traversing rough terrain. c. Procedure III - Large Assembly Transportation. This procedure is intended to replicate the vibration and shock environment incurred by large assemblies of materiel installed or transported by wheeled or tracked vehicles. It is applicable to large assemblies or groupings forming a high proportion of vehicle mass, and to materiel forming an integral part of the vehicle. In this procedure, use the specified vehicle type to provide the mechanical excitation to the test materiel. The vehicle is driven over surfaces representative of service conditions, resulting in realistic simulation of both the vibration environment and the dynamic response of the test materiel to the environment. Generally, measured vibration data are not used to define this test. However, measured data are often acquired during this test to verify that vibration and shock criteria for materiel subassemblies are realistic. d. Procedure IV - Assembled Aircraft Store Captive Carriage and Free Flight. Apply Procedure IV to fixed wing aircraft carriage and free flight portions of the environmental life cycles of all aircraft stores, and to the free flight phases of ground or sea launched missiles. Use Procedure I, II or III for other portions of the store's life cycle as applicable. Steady state or transient vibration may be applied as appropriate. Do not apply Procedure I to fixed wing aircraft carriage or free flight phases. Notes: Tailoring is essential. Select methods, procedures, and parameter levels based on the tailoring process described in Part One, paragraph 4, and Appendix C. Apply the general guidelines for laboratory test methods described in Part One, paragraph 5 of this standard. **GAM EG 13 1st Part methods 41 & 42** METHOD 41 SINUSOIDAL VIBRATION. The sinusoidal vibration tests are not generally representative of the vibratory environment liable to be encountered in use, which in most cases if of a random nature. Nevertheless the sinusoidal vibration tests have the advantage of being simple and very useful in the following cases : - characterisation of the vibration modes of the test item : it provides for prior adaptation to the carrier when

Test	Scope & Limitations
	the in situ environment is known by recording and by vibration tests, and avoids highly damageable critical frequency confusions - study of the nonlinearities of the vibration modes - indication of technological faults and design errors : debug tests whilst developing equipment - equipment mounted on a carrier with clearly defined preferential frequencies : rotation speed of propeller blades, motors or rotating parts - development of insulation against vibrations to adapt as well as possible to the vibratory environment that must be filtered and to the conditions of installation on the carrier. To meet the purpose of the tests the procedures described below can be employed (sec General technical mechanical appendices). Procedure 1 - Critical frequencies research Procedure 2 - Withstanding with frequency sweeping (in a given range) Procedure 3 - Withstanding with fixed frequencies METHOD 42 RANDOM VIBRATION. Check the capacity of equipment and their containers to withstand structurally and/or operate correctly in the vibratory environment liable to be encountered during their life profile, for example during : - their tactical use, gunfire, - their land, sea or air transport. - The vibratory environment is characterised by wide frequency band random vibrations, this band is variable according to the cases considered : - the low frequencies band 0.5 to 50 Hz concerns for example the phenomena produced by : - the state of the sea and the vibrations generated by the propellers of the carrier vessel (naval vessel) - the relief of the ground (ground carrier) - the atmospheric turbulence (air carrier), etc. - the medium frequency bands (5 Hz to 500 Hz) or high frequencies 20 Hz to 2000 Hz or 5000 Hz), concern for example the phenomena produced by : - land carriers - the limit layer turbulence - firing of different weapons (all carriers) - the excitation forced by rotary mechanisms (motors, jets) etc. superposed on wide band random vibration.

Test	Scope & Limitations
	In order to meet the aim of the test, the following procedures are applied : Procedure 1 - vibration test on equipment in operation Procedure 2 - gunfire test Procedure 3 - vibration tests of equipment not in operation Procedure 4 - transport on land of large assemblies Procedure 5 - transport on land without stowing. **ITOP 2-2-808, 1-2-601 and 1-1-050** ITOP 2-2-808 TRACKED VEHICLE MECHANICAL VIBRATION. This document describes the procedures for determining the mechanical shock and vibration levels of tracked vehicles, including on-board equipment during operation over selected courses. Shock and vibration levels of tracked vehicles, components and tank crews are high, causing considerable reduction in the life cycle of the equipment. It is important to determine these in order to reduce characteristics to obtain a basis for constructive improvement in design or alter the shock-and-vibration spectrum in the system. ITOP 1-2-601 LABORATORY VIBRATION SCHEDULES. This ITOP describes two types of vibration tests conducted in the laboratory: first, a mission/field secured-cargo test to simulate the transportation of Army materiel as secured cargo during logistical shipments; and second, an application -induced vibration test to simulate the tactical-vibration environmer experienced by equipment installed in/on ground vehicles or helicopters, Through application of these tests the design and fabrication of the test item are evaluated for conformance with requirements documents. The tests apply to ammunition (including close-support rockets and missiles), electronic equipment, mechanical equipment, and optical equipment. ITOP 1-1-050 DEVELOPMENT OF LABORATORY VIBRATION SCHEDULES. This ITOP presents the considerations and techniques involved in developing laboratory vibration schedules that simulate the field transportation environment associated with tactical vehicles. The term schedule is used to describe acceleration amplitudes as a function of frequency for stated time periods.
Gunfire	**STANAG 4370 AECTP 400 METHOD 405** Purpose. The purpose of this test method is to replicate the gunfire environment response incurred by systems, subsystems, components and units, hereafter called materiel, during the specified operational conditions. Application. This test method is applicable where materiel is required to demonstrate its adequacy to resist the repetitive gunfire environment without unacceptable degradation of its functional and/or structural performance.

Test	Scope & Limitations
	Limitations. It may not be possible to simulate the actual operational in-service gunfire environment response because of fixture limitations or physical constraints that may prevent the satisfactory application of the gunfire excitation to the test item. This test method is not intended to simulate temperature or blast pressure effects due to gunfire. Choice of Test Procedures. The procedures are given in order of preference based on the ability of the test facility to replicate the gunfire environment. Improper test procedure selection may result in a severe under test or over test. Procedure I Direct Reproduction of Measured Materiel Response Data Procedure II Statistically Generated Repetitive Pulse - Mean (deterministic) plus Residual (stochastic) Pulse Procedure III Repetitive Pulse Shock Response Spectrum (SRS) Procedure IV High Level Random, Sine-on-Random (SOR), Narrow band Random on Random (NBROR) Vibration Procedure I is recommended as the most suitable test procedure because it provides the most accurate replication of the dynamic response of the materiel. Procedure II is recommended as the second most suitable procedure because it provides good accuracy of replicating materiel dynamic response in addition to providing flexibility with regard to pulse randomisation and gunfire burst length. Procedure III is inferior to Procedures I and II because materiel time domain gunfire response characteristics cannot be simulated as precisely using SRS techniques, such as complex transient waveform generation. But, Procedure III can be used where test facility limitations preclude the use of Procedures I and II. Procedure IV is applicable when the materiel is distant from the gunfire excitation, and measured data at appropriate hard points of the materiel indicate a random vibration gunfire environment only slightly above the most severe measured random vibration level. Procedure IV is also appropriate for aircraft gunfire in the absence of measured data. Annex D provides guidance for an initial predicted aircraft gunfire environment and test severity where no measured data are available.
Acoustic Noise Combined With Temperature & Vibration	**STANAG 4370 AECTP 400, METHOD 402 & 413** METHOD 402 ACOUSTIC NOISE Purpose. The purpose of this test method is to replicate the acoustic environment incurred by systems, subsystems and units, hereafter called materiel, during the specified operational conditions. Application. This test method is applicable where materiel is required to demonstrate its adequacy to resist the specified acoustic environment without unacceptable degradation of its functional and/or structural performance. It is also applicable for materiel where acoustic noise excitation is used in preference to mechanical vibrator excitation for the simulation of aerodynamic turbulence. AECTPs 100 and 200 provide additional guidance on the selection of a test procedure for a specific acoustic environment.

Test	Scope & Limitations
	Limitations. Where a diffuse field acoustic noise test is used for the simulation of aerodynamic turbulence, it is not necessarily suitable for proving thin shell structures interfacing directly with the acoustic noise. Test procedures. The choice of test procedure is governed by the in-service acoustic environments and test purpose. These environments should be identified from consideration of the Life Cycle Environmental Profile as described in AECTP 100. Three procedures are presented as follows: Procedure I Diffuse Field Acoustic Noise Procedure II Grazing Incidence Acoustic Noise Procedure III Cavity Resonance Acoustic Noise METHOD 413 ACOUSTIC NOISE COMBINED WITH TEMPERATURE AND VIBRATION Purpose. The purpose of this test method is to replicate the environment induced in the internal equipment, hereafter called materiel, of stores and missiles when carried externally on high performance aircraft during the specified operational conditions. To achieve an accurate simulation, this test method combines acoustic noise excitation with mechanical vibration and conditioned airflow to produce the required mechanical and thermal responses in the internal units of the test item. The test method is also capable of reproducing the changes in the vibration and temperature responses that arise during specific aircraft mission profiles. Application. This test is applicable where materiel is required to demonstrate its adequacy to resist the specified environment without unacceptable degradation of its functional and/or structural performance. The principles of this test method may also be applicable to the simulation of other vibration environments, such as those induced during missile flight conditions. AECTPs 100 and 200 provide additional guidance on the selection of a test procedure for a specific environment. Limitations. Where this test is used for the simulation of aerodynamic turbulence, it is not necessarily suitable for proving thin shell structures interfacing directly with the acoustic noise. Use of Measured Data. Where practical, field data should be used to develop test levels. It is particularly important to use field data where a precise simulation is the goal. The parameters and profiles are influenced by store type, aircraft installation, aircraft performance and mission conditions. Profile derivation information is given in Annex A. When measured flight data are not available, sufficient information is presented in Annex A to determine test profiles and levels. **EN/IEC 60068-2-65** Introduction. Acoustic noise may produce significant vibration in components and equipment. In the acoustic noise field, pressure fluctuations impinge directly on the specimen and the response may be different to that produced by mechanical excitation. Items particularly sensitive to acoustic noise include relatively lightweight items whose dimensions are comparable to

Test	Scope & Limitations
	an acoustic wavelength in the frequency range of interest and whose mass per unit area is low, such as dish antennas and solar panels, electronic devices, printed circuit boards, wiring, optical elements, etc. This test is applicable to components, equipment and other products, hereinafter referred to as "specimens", which are liable to be exposed to and/or required to function in conditions of high sound pressure levels. It should be noted that, under service conditions, the specimen may be subjected to simultaneous mechanical and acoustical excitation. High sound pressure levels may be generated by jet engines and other aircraft propulsion systems, rocket motors, high-powered gas circulators, etc. This standard deals with acoustic testing in compressible gases and can also be used to simulate the excitation response caused by turbulence resulting from high-velocity separated gas flows. Testing for the effects of vibration caused by acoustic noise demands a certain degree of engineering judgement and this should be recognised both by the manufacturer/supplier and the purchaser of the specimen. Based on the guidance provided in this part of IEC 60068 the writer of the relevant specification is expected to select the most appropriate method of test and values of severity, taking account of the nature of the specimen and its intended use. Since the acoustic levels occurring during testing are high enough to be potentially damaging to human hearing, appropriate measures need to be taken to reduce preparatory operation and the noise exposure of operators performing the test, to a level regarded as permissible from the standpoint of hearing conservation. Object. To provide standard procedures and guidance for conducting acoustic tests in order to determine the ability of a specimen to withstand vibration caused by a specified sound pressure level environment to which it is, or is liable to be, subjected. For sound pressure level environments of less than 120 dB acoustic tests are not normally required. To determine mechanical weakness and/or degradation in the performance of specimens and to use this information, in conjunction with the relevant specification, to decide their acceptability. In some cases, the methods of test may also be used as a means of establishing the mechanical robustness or fatigue resistance of specimens. **DEF STAN 00-35 TEST M8, M9 & M10** TEST M8 ACOUSTIC NOISE TEST USING A REVERBERATION CHAMBER. This test is conducted to determine the effects on materiel of an acoustic noise field such as that produced by aerospace vehicles, power plants and other sources of high intensity acoustic noise. The test is also applicable where it is preferable to induce vibration into equipment by distribute acoustic excitation rather than at fixed points by means of electro-dynamic shaker systems. This test has been developed from the 'Acoustic Vibration' test in BS 3G 100 which is now obsolescent. The test is technically similar to BS EN60068-2-65:1995. This test method implements the appropriate sections of STANAG 4370, AECTP 400, Edition 2, Method 402 - 'Acoustic Noise' TEST M9 ACOUSTIC NOISE TEST USING A PROGRESSIVE WAVE TUBE. The purpose of this test method is to replicate the effects of convective pressure fluctuations at grazing incidence, such as exist in aerodynamic turbulence over the surface of assembled structures. The test method is relevant to

Test	Scope & Limitations
	materiel where aerodynamic turbulence will excite part or all of the total external surface. Such applications include externally carried airborne stores and missiles. This test method may also have application to aircraft panel assemblies where excitation will exist on one side only. For appropriate applications this test method can be considered as an alternative to Test M8- 'Acoustic Noise Test in a Reverberation Chamber' (see Chapter 2-08.) It may be preferred where it is required to generate high acoustic noise levels with limited acoustic power. It can also be considered as complementary to Test M2 - 'Complete Store Vibration Test' (see Chapter 2-02), where acoustic excitation is required to generate high frequency vibration responses. This test method implements the appropriate sections of STANAG 4370 AECTP 400, Edition 2, Method 402 - 'Acoustic Noise'. The test is technically similar to BS EN60068-2-65 Test F2 Vibration acoustically induced. TEST M10 COMBINED ACOUSTIC, TEMPERATURE AND VIBRATION. The purpose of this test method is to replicate the combined effects of aerodynamic turbulence and temperature incurred by stores, missiles and airborne weapons carried externally on fixed wing high performance aircraft. This test method is applicable where materiel is required to demonstrate its adequacy to withstand the specified combinations of environmental conditions without unacceptable degradation of its functional and structural performance. Although this test method is intended primarily for reliability testing, it is applicable to other test categories. The principles of this test method may also be applicable to the simulation of other vibration environments such as post launch free flight vibration of missiles. This test method implements STANAG 4370, AECTP 400, Edition 2, Method 413 - 'Acoustic noise combined with temperature and vibration'. There is no equivalent British Standard test method. **MIL STD 810 F METHOD 515 & 523** METHOD 515 ACOUSTIC NOISE The acoustic noise test is performed to demonstrate the adequacy of materiel to resist the specified acoustic environment without unacceptable degradation of its functional performance and/or structural integrity. Application. This test is applicable to systems, sub-systems, and units, hereafter called materiel, which must function and/or survive in a severe acoustic noise environment. This test is also applicable for materiel located where acoustic noise excitation is used in combination with or in preference to mechanical vibration excitation for the simulation of aerodynamic turbulence. Limitations. Technical limitations restrict production and control of laboratory acoustic environments. Thus laboratory acoustic fields can be significantly different from many of the real fluctuating pressure loadings classed as "acoustic." Consider these limitations when choosing a test type and test facility as well as in interpreting test results. For example, diffuse field acoustic noise better represents acoustics in internal cavities where local reflection and re-radiation from vibrating structures predominate. For external skins exposed to aerodynamic turbulence or jet noise, grazing incidence acoustic noise more closely represents flow/acoustic wave propagation along skin surfaces.

Test	Scope & Limitations
	METHOD 523 VIBRO-ACOUSTIC/TEMPERATURE Purpose. The vibro-acoustic/temperature procedure is performed to determine the synergistic effects of vibration, acoustic noise, and temperature on externally carried aircraft stores during captive carry flight. Such determination may be useful for, but not restricted to the following purposes: a. To reveal and correct design weaknesses (Test, Analyse and Fix (TAAF) test). b. To determine whether a design meets a specified reliability requirement (Reliability Demonstration test). c. To reveal workmanship or component defects before a production unit leaves the place of assembly (Screening test). d. To estimate the Mean Time Between Failure (MTBF) of a lot of units based upon the test item's time to failure of a small sample of the units (Lot Acceptance test). e. To determine the relative reliability among units based upon the test item's time to failure of a small sample of the units (Source Comparison test). Application. For captivity carried stores, this method is intended primarily to test electronics and other electro-mechanical assemblies within the store for functionality in a vibro-acoustic/temperature environment. As an incidental part of the testing, thermal variation may induce changes in moisture exposure of the store and the effects of such exposure must be noted when interpreting the test result data. Limitations. This method is not intended to provide for: a. An environmental design qualification test of a store or any of its individual components for functionality. (For such testing see method 500.4, Altitude; method 501.4, High Temperature; method 502.4, Low Temperature; method 503.4, Temperature Shock; method 507.4, Humidity; method 513.5, Acceleration; method 514.5, Vibration; method 515.5, Acoustic Noise; method 516.5, Shock; method 517, Pyroshock; and method 520.2, Temperature, Humidity, Vibration, Altitude). b. An environmental design qualification test of a store airframe or other structural components for structural integrity. c. Any test to satisfy the requirements of the Life Cycle Profile except that for the combined vibration, acoustic, and temperature environments related to reliability testing. Note: Tailoring is essential. Select methods, procedures, and parameter levels based on the tailoring process described in Part One, paragraph 4, and Appendix C. Apply the general guidelines for laboratory test methods described in Part One, paragraph 5 of this standard. **GAM EG 13 1st Part Method 48** The purpose of the acoustic vibration test is to check the capacity of an item of equipment to support this environment when not in operation, or to operate correctly in this environment. It can be complementary to the mechanical vibration test if the equipment is subjected to stresses and strains of mechanical and acoustic origins whose paths are different.

Test	Scope & Limitations
Buffet Vibration	**STANAG 4370 AECTP 400 METHOD 420** Purpose. The purpose of this test method is to replicate the short duration vibration environment for wing or fuselage mounted materiel on aircraft during flight induced buffet vibration. The materiel, hereafter referred to as stores, is typically electro-mechanical systems, subsystems, bombs, missiles, Electronic Countermeasure (ECM) pods, and fuel tanks. Buffet vibration is a high amplitude vibration occurring during limited flight manoeuvres due to aerodynamic flow and structural vibration modes. The test considerations are different from Method 401 (Vibration) because of the short duration of the event. Application. The test method includes discussion of the buffet phenomenon, the causes, and aggravating factors. The flight manoeuvres that generate buffet are identified and the relative effects due to store type, aspect ratio, mass, and location are discussed. Interaction between the host aircraft wing or fuselage and the store vibration modes are also addressed. This test method is applicable where stores are required to demonstrate adequacy to resist buffet vibration safely without unacceptable degradation of the store performance and/or structure. Buffet vibration occurs as a result of unsteady aerodynamic pressure acting on aircraft structures, including the externally carried fuselage or wing stores. Another possible source of store vibration in buffet is the excitation of the store skin panels and store fins if equipped. Such responses are highly dependent upon the structural details of the particular store, and not suitable for generalised test methods. The extent of the induced vibration on the store depends primarily upon the following factors. Flight Condition. The angle of attack of the host aircraft is a key parameter influencing the response of the store in buffet. During straight and level flight, stores will be excited by aerodynamic flow over exposed surfaces. A boundary layer will form at the store nose that becomes turbulent and thicker downstream, thus imparting vibration energy to the store. The nature of the turbulent airflow is predominantly low frequency excitation. Short duration aircraft combat or high speed manoeuvres result in loading from centrifugal, gravitational, and aerodynamic forces that induces additional vibration excitation in the store. Aircraft Configuration. The location the store is mounted on the aircraft and number of other stores present in the airflow around the store will influence the susceptibility to buffet. Wing mounted stores generally experience more buffet excitation than under-fuselage stores. The total combined mass of a particular weapon load installed on the aircraft will influence its agility in manoeuvring and also influence the overall dynamic response behaviour and the magnitude of buffet induced responses. Aircraft and Store Dynamic Characteristics. The modal response characteristics of the aircraft and of the installed store will influence the amplitude of vibration response. Buffet can be problematic for flexible high aspect ratio stores because either the store, or their installation, can possess low frequency modes less than 100 Hz. These modes can be associated with Store bending. Rigid body motion of the store arising from the flexibility of its carriage equipment. Rigid body motion arising from aircraft wing bending and torsion. Limitations. Accurate laboratory simulation of buffet vibration requires adequate fixturing for the airframe, store

Test	Scope & Limitations
	mounting, and matching of test equipment and test item impedance to the actual in-service conditions. Common limitations of the laboratory simulation procedures are below. Simulation of the actual in-service buffet environment may not be possible because fixture limitations or test equipment physical constraints prevent the satisfactory uniform application of the vibration excitation to the test item at all locations Current vibration control equipment may not be able to simulate the measured vibration due to a non-Gaussian or transient vibration environment. The test method initial test severities may not be applicable to high aspect ratio stores with a variable diameter along the store length. The test method initial test severities do not include internal store generated vibration excitation..
Multi - Exciter Vibration	**STANAG 4370 AECTP 400 Method 421** Purpose. The purpose of this test method is to replicate the vibration and shock environments incurred by systems, subsystems and units, hereafter called materiel, during the specified operational conditions. Application. This test method is applicable where materiel is required to demonstrate its adequacy to resist the specified dynamic environment without unacceptable degradation, of its functional and/or structural performance. AECTPs 100 and 200 provide additional guidance on the selection of a test procedure for a specific vibration environment. The test method is applicable to either electrodynamic or servohydraulic test equipment. Frequently a test item's weight, physical dimensions, complex dynamic response, or specific in-service environment require the use of multi-exciter methods for laboratory simulation of a dynamic environment. A common multi-exciter application is testing of long slender materiel with a high length to diameter ratio, such as a missile system. Multi-exciter test methods permit a balance of energy distribution on the materiel structure, and typically a higher thrust capability than single exciter systems. When a large force capacity is required, equipment is operated in multi-exciter single axis (MESA) mode for vibration and shock testing. Two or more exciters may also be coupled in phase, or inverted phase, to a horizontal slip table for testing. Tests requirements for simultaneous control of multiple vibration spectrums or multi degree of freedom (DOF) motion are also applicable to multi-exciter testing. The test control is based on multiple exciter drive and response data channels, commonly referred to as multiple input and multiple output (MIMO) control. The most general case is multi-exciter multi-axis (MEMA) control for complete or partial 6 DOF translation and rotation motion control. The control methodology can be either a single frequency spectrum amplitude and phase control or multiple ASD spectrum control. A summary of the most common test equipment configurations is defined below. The configurations are also applicable to multi-axis shock testing, and with some additional considerations, waveform replication testing. Two exciters in phase, or 180 degree inverted phase; a simple MESA configuration

Test	**Scope & Limitations**
	Multiple exciters and single axis motion (MESA) with a single vibration spectrum. Multiple exciters with one or multiple vibration spectrums (MIMO). Multiple exciters and multi-axis motion (MEMA). Limitations. Fixturing design limitations or physical constraints may prevent the satisfactory application of the in-service dynamic excitation to the test item. Test data acquired for typical single axis laboratory dynamic simulations may not be applicable to multi-exciter tests if proper phase and correlation between the data channels is not obtained during the data acquisition process. Similarly, laboratory simulation tests may not fully duplicate in-service failure modes if the test is based on insufficient data acquisition and test documentation methods.

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6.2.3 Technical Comparison

6.2.3.1 Vibration Test Procedures

The general vibration test in UK national defence standard Def Stan 00-35, the two tests in the French national standard GAM EG 13 and two basic vibration tests in the commercial standard EN / IEC 60068 display a distinct common base. However, the point of commonality appears to be some time in the early 1970's.

The original UK Def Stan vibration tests were based upon the tests in BS2011 which was in turn a copy of the IEC 60068 procedures. The original two tests were augmented for military use in the late 1970's and amended to allow the use of digital control equipment. A decade later the original two tests, one encompassing sine sweep vibration testing the other random vibration testing, were combined into a single test procedure. Further additions were made to allow its use for military applications. Those modifications added new procedures that had become commercially available and formalised the method to allow controlled response testing which had become commonly adopted. The modifications also tightened tolerances to improve repeatability. However, even with these extensive changes the procedure made a declared effort to ensure backward compatibility with EN / IEC 60068. Essentially a limited portion of the procedure viz. for basic sine and random tests using single point controlled input, the procedure was entirely compatible with EN / IEC 60068. The UK Def Stan had to adopt its own approach for more complicated tests simply because they were not encompassed by the EN / IEC 60068 tests.

The French GAM EG 13 follows a similar development history to the UK Def Stan excepting that the original vibration tests and the original IEC 60068 tests were developed in parallel with significant overlap and interaction between the two. As a consequence the two groups of test procedures originally had considerable commonality. Although over the years the GAM EG13 test procedures have been augmented for military use and to accommodate commercial advances in test control capabilities. The French GAM still includes separate test procedures for sine and random but the pressure to advance the procedures for military use are apparent and seem identical to those in the UK.

In the early 1970's the commercial standard EN / IEC 60068 included vibration test procedures that were as good as any available. However, since then they have continually lagged behind advances in test control technology. The random test switched to a procedure for digital control systems almost a decade after the UK, French and US military standards. Currently IEC 60068 are developing a new vibration test procedure for “mixed mode” testing (sine on random, narrow band on random etc). After 5 years work that procedure is still not published even though similar procedures were available in the UK Def Stan test and the US Mil Std 810 at the end of the 1980's. Currently, the vibration testing of a large number of defence systems would not be viable using only the procedures in EN / IEC 60068. This not withstanding the procedure of EN / IEC 60068 are adequate for small component and sub-assembly tests. Moreover, for COTS equipment the test procedure of EN / IEC 60068, or more commonly derivatives called in product (vertical) standards, are often adopted.

Unlike the tests so far reviewed the US vibration test procedure of Mil Std 810 has no apparent commonality with any international standard. Every re-issue of Mil Std 810 appears to frequently make significant changes to the vibration test procedures this has generally accommodated commercial advances in test control capabilities. Unfortunately, these advances are frequently not backward compatible with earlier versions or indeed compatible with any other standard. Additionally in recent times the text of the Mil Std 810 procedures have become less firmly written and consequently they are no longer particularly good at ensuring repeatability of testing. Indeed statements indicating equipment is tested to Mil Std 810 no longer has any great value. Traditionally the Mil Std has been used mostly a guidance document and in the US deviations from it are commonly noted. This is not surprising in that the procedure has no clear distinction in layout and terminology between mandatory and advisory (guidance) information. In circumstances were tight control over test procedures are required, such as contractual and manufacturing requirements, the Mil Std use is frequently re-written in a more firm style and issued as procedures such as TOPs (Test Operating Procedures).

The latest version of the vibration test procedure in the NATO STANAG 4370 contains identifiable contributions from the latest US Mil Std, UK Defence Standard and some inputs from the French national defence standard. The vast majority of the vibration standard relates to severities for different types of application. The portion related to the actual test procedure is relatively small and not particularly well laid out. Also the distinction between mandatory and advisory (guidance) is in a fair number of areas unclear. In this regard it seems to adopt much of the guidance style of Mil Std 810 rather than the firm style of EN / IEC

60068, Def Stan 00-35 and GAM EG 13. Those test procedures also have a clear distinction in their layout and terminology between mandatory and advisory (guidance) information. The NATO STANAG 4370 procedure has sufficient similarity with Def Stan 00-35 and GAM EG 13 to allow the more sophisticated vibration testing to be undertaken in an almost identical manner. Although whether it does so with an acceptable degree of repeatability is questionable. For simple controlled input tests used for small components and COTS equipment, the STANAG fails to achieve the clear definition and repeatability of EN / IEC 60068. Overall the STANAG appears to have centred on ensuring commonality with the more sophisticated portions of Mil Std 810, Def Stan 00-35 and GAM EG 13 rather than ensuring it meets the basic requirements necessary of a test procedure.

Three quadripartite agreements (between the US/UK/F/DE) known as ITOP's (International Test Operating Procedures) include three documents related to vibration testing. Of these ITOPS one (2-2-808) concerns procedures for the measurement of vibration in tracked vehicles. Another (1-1-050) contains a more comprehensive description of methods of making measurements and deriving severities. It also contains extensive (entirely US) originated test severity which expand upon those in Mil Std 810. The last of the three (1-2-601) is the only procedure containing a test procedure although the majority of the document relates to severities (again entirely US based). The test procedure is however a cookbook of basis test operations rather than than an overarching test requirement. The procedure appears to be entirely US Mil Std based. Overall the ITOPS have a narrow range of applicability mainly towards ordnance items. The ITOPS are not publically available and the majority of the content are encompassed by other more generally available standards. The ITOPS organisation state that an advantage of these standards is that they can be generated rapidy (less than 2 years). This would imply that these standards incorporate new and innovative approaches. Not only is this not the case for of the three documents reviewed here, but contributions from the UK, France and Germany seem minimal if any at all.

So far this review has centred on the general vibration testing of equipment, however, several of the military standards also include specific test procedures related to testing of complete stores and missiles. Those tests mostly originate from test facility limitations of the 1970's and 80's. Whilst, testing of stores and missiles can still present some difficulties, mostly problems with vibration only testing have been overcome. In this regard the STANAG, Def Stan and Mil Std procedures all resolve the problems with sufficient commonality for none to have any real advantage over the others. In recent times the store & missile vibration test has developed into a combined acoustic / vibration / temperature test and multi-vibrator tests which are addressed separately.

None of the vibration test standards addressed in this section deal comprehensively with the testing of packaged equipment. Whilst, most can accommodate the testing of some packages none can be said to allow all forms of package to be tested reliably. In this regard both very stiff and very soft packages will be difficult to adequately control under test with the current procedures. Also large and palletised equipment can only be tested with difficulty with existing procedures and then neither consistently or repeatable.

In selecting a vibration test procedure as a recommended standard for military equipment it is necessary to consider two apparently conflicting criteria. The test procedure needs to encompass commercial advances in test control capabilities in a manner to allow testing of large sophisticated defence systems in a cost effective manner. However, it also needs to be able to allow simple tests on the large number of smaller less sensitive equipment in a consistent repeatable manner. Such consistency is required for contractual reasons and to ensure consistency in testing of components and COTS items. To achieve consistency and repeatability in such cases a clear distinction in layout and terminology between mandatory and advisory (guidance) information is essential.

Currently the NATO STANAG 4370 encompasses the key portions of the Def Stan 00-35 and GAM EG 13 with regard testing of sophisticated equipment and when using the more complicated vibration test procedures. In this regard the STANAG is as good as the two European contributing standards. However, the manner in which this information is included is poor. Specifically the poor format, consistency in terminology and weak underlying strategy are a concern. The procedure does not, at its core, include a firm and clear mandatory process which a test specifier can contractually rely upon as a basis for purchasing components, sub-systems and COTS equipment. In this regard the two European standards, Def Stan 00-35 and GAM EG 13, combine both tests for sophisticated equipment and a well defined mandatory process which a test specifier can contractually rely upon. Whilst, the commercial standard EN / IEC 60068 contains several very well defined vibration test procedures, they have little technical innovation and marked limitations. Indeed the vibration testing of a large proportion of defence systems would prove practically impossible using only the procedures in EN / IEC 60068.

6.2.3.2 Gunfire Test Procedures

The gunfire vibration / shock test included in several of the military standards are mostly intended to simulate the effects of aircraft gunfire on aircraft equipment and missiles / stores. Although the procedures could be used for other gunfire conditions, the procedures contain no guidance or information on severities for those. None of the procedures are intended to simulate the effects of gunfire blast directly but rather the secondary vibration / transient effects on equipment. Over the years many reports, papers and specific procedures have been generated addressing the effects of gunfire. These have postulated a considerable number of approaches for specific conditions and only a few have also been developed into full blown generic test procedures. Part of the reason for this was the historic difficulty of undertaking a suitable test and establishing suitable test severities. Also historically some of the most commonly used approaches can be undertaken perfectly well with the general vibration test procedures.

Since the Mid 1970's issues of the US Mil Std 810 has contained versions extensive process to establish gunfire vibration severities for aircraft equipment. This historic US Mil Std 810 process was relatively easy to implement as a test as it comprised narrow band random vibration superimposed upon a broad random background. Although frequently subject to technical criticism the severity derivation processes were used for several decades to establish equipment gunfire vibration severities for many aircraft and their equipment.

As the derived test severity could be applied perfectly well with the general vibration test procedures, a common strategy in Europe was to use the US severities with their own general vibration test procedure. Hence, the UK and French military standards consider they include gunfire even though no specifically named test procedure exists. The UK and French military standards would consider their tests procedures are more suitable in a contractual situation.

The main criticism of the historic US Mil Std 810 process was that it was really only applicable for aircraft equipment located some way from the excitation source (in this case the gun muzzle). In those cases the multiple transmission paths and intervening aircraft structure meant that the effect at the equipment was dominated by structural responses not blast pressure pulses. The US Mil Std 810 process usually produced severities that were overly severe when sophisticated muzzle breaks were utilised. Conversely the use of such devices usually means that the narrow band random vibration superimposed upon a broad random test type was valid for equipment located even closer to the muzzle.

For equipment close to the muzzle and for items subject to blast pressure pulses (frequently including missiles and stores), then the waveform experienced is usually dominated by the repeated shock pulses. Several ways of testing for these conditions have been postulated over the years and some included in latter editions of Mil Std 810. However, not all of these were realistically practical and the test procedures were commonly very poorly defined. Although this situation has slowly improved, the alternatives are still quite complicated and considerable user interpretation (and consequently poor repeatability) is still required.

In recent years practical alternative test methods have become available, developed for the automotive industry, which can be adapted to allow simulation of the repeated gunfire shock pulses. Currently there is considerable ongoing activity to verify the efficacy of such methods for this application. As such changes to the existing military standards may be expected in the very near future.

The current US Mil Std 810 contains a much simplified version of the historic test severity derivation process previously used with the narrow band random vibration superimposed upon a broad random test. It also contains three alternative approaches for directly simulating the gunfire shock pulses. Currently the NATO STANAG 4370 procedure is close to a direct copy of the Mil Std test. As such the European commercial concern still exists that the test procedures are not defined adequately for contractual purposes. This can be particularly relevant as gunfire vibration may only occur for a short period but for aircraft equipment it is frequently the major vibration amplitude imposed on the equipment. As such it is often a major consideration in the equipment design process.

6.2.3.3 Acoustic Test Procedures

Acoustic test procedures are usually used to replicate either a high intensity acoustic field or the effects of fluid flow such as the aerodynamic flow effects on aircraft skins and external equipment. The intent may be to simulate the acoustic field itself or more commonly the vibrations that are induced. Testing of equipment using acoustic methods requires large and costly facilities. In consequence such methods are only used for high cost equipment when no other methods are suitable. Acoustic testing of commercial equipment has included items such as satellites, nuclear reactor interior equipment and civil aircraft external surface equipment.

Historically two main types of facility have been available; progressive wave tubes and reverberent chambers. The former originated as simple ducts able to raise high acoustic power levels with modest powered transducers. They are frequently used to establish fatigue damage of panels (typically mounted in one wall of the duct) such as those used on aircraft skins. A reverberent chamber is generally a much larger facility using room reverberations to both to hold the complete equipment and generate the characteristics of the acoustic field.

A generic acoustic test procedure for commercial equipment exists in EN / IEC 60068. However, that is a relatively recent procedure written 10 to 15 years ago. Although this commercial standard claims to include procedures for several different types of acoustic test facility, in fact, it is predominantly only for revereberent chambers and offers little information on progressive wave tubes. The standard sets criteria which are attempts at ensuring the acoustic pressure field has specific reproducible characteristics notably an uncorrected random pressure field with a similar spectra occurring over the entire equipment.

The main use of acoustic test methods in military applications is to simulate the effects of aerodynamic flow on say high performance aircraft equipment, missiles and externally carried stores. Whilst, the acoustic characteristics set out in commercial procedure could achieve the required simulations for these applications, it was found many years ago that better simulations could be achieved by the deliberate contravention some of the criteria of earlier standards. Additionally it was found even better simulations could be achieved by including enhancements to the procedure such as adding mechanical vibrations at low frequency.

The French national defence standard (GAM-EG-13), two of the three UK Def Stan procedures and earlier versions of the US Mil Std all contain acoustic test procedures based around commercial acoustic test procedures. However, they do contain refinements specifically for use in the military testing of externally carried missiles and stores. All theses military procedures contain a significant amount of additional guidance on the derivation of acoustic tests for military applications. The French and UK standards have specific procedures for both revereberent chambers and progressive wave tubes. The third UK procedure and the latest US Mil Std standard incorporate even further refinements for combined acoustic, vibration and temperature testing. The latest version of the NATO STANAG contains significant identifiable contributions from the latest US Mil Std, UK Defence Standard and some inputs from the French national defence standard.

The military use of acoustic testing has developed considerably from the equivalent commercial tests. Indeed the level of evolution of the military test has become so great that the military and commercial tests are now arguably entirely different animals. To illustrate this acoustic test facilities able to undertake the latest and most effective military tests would be prohibited under the commercial standards. Conversely, it would be impracticable to use the commercial standards for military applications. The latest version of the NATO STANAG not only combines the majority of the national standards but also adds additional enhancements.

6.2.3.4 Buffet Vibration Test Procedures

The so called buffet vibration tests are specifically intended to simulate the transitory aerodynamic conditions that occur when an high performance aircraft adopts flight attitudes which give rise to shedding large scale vortices. The creation of these vortices gives rise to vibration at the location they are generated. However, the vibration (and loading) induced is far greater when the vortices impinge, downstream, on aircraft structure. Aircraft shed large scale vortices in only a small range of flight conditions which are only maintained for short periods (a few seconds at most). Moreover, the worst case conditions occur over only a very narrow range of flight conditions, are very location specific and vary considerably from aircraft to aircraft. Vortices normally excite a single response mode of the aircraft structure, wing or external weapon.

An early 1980's version of the US standard Mil Std 810 included buffet in the vibration test procedures. It is understood this inclusion arose from experience and problems with one specific US aircraft. Moreover, the severities were based upon very limited data. Nevertheless, the severity proposed for that aircraft remains to this day. The test severity comprised a crude Power Spectral Density envelope of a single response mode. This was applied separately to the normal flight vibration test severity as its total duration was typically a few hundred seconds. However, it adopted the normal random vibration test procedure. The US , UK and French national military standards all utilised the general random vibration test procedure to apply buffet vibrations.

The above notwithstanding NATO STANAG 4370 includes a specific chapter for buffet. However, the real content is essentially only guidance on test severities. As guidance the content is better than anything else currently available. With that said, it does not use a test procedure different from the general vibration test and the guidance does not justify a separate chapter.

6.2.3.5 Multi - Exciter Vibration

NATO STANAG 4370 includes a specific chapter relating to multi-exciter test methods. Although multi-exciter testing has been undertaken for some time in both the military and automotive fields, they were adopted as solutions to only a very small range of military problems. The STANAG chapter is an attempt to impose a generic military procedure.

Frequently a test item's weight, physical dimensions, complex dynamic response, or specific in-service environment require the use of multi-exciter methods for laboratory simulation of a dynamic environment. A common multi-exciter application is testing of long slender materiel with a high length to diameter ratio, such as a missile system. Multi-exciter test methods can permit a better distribution of vibratory energy on the structure than could be achieved with a single exciter. Two or more exciters may also be coupled in phase, or inverted phase, to a horizontal slip table for testing.

Currently NATO STANAG 4370 is the only military standard containing a multi-exciter system. No equivalent procedure exists in EN / IEC 60068.

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6.2.4 Conclusions

A summary of the recommendations is shown in the table below which is expanded in the following paragraphs.

Summary of Recommendations for Vibration Tests						
	NATO STANAG 4370 AECTP	International EN / IEC 60068	UK Def Stan 00-35	US Mil Std 810F	France GAM-Eg-13	Quadripartite US/UK/F/DE ITOP
Vibration	Could be recommended with better control over mandatory aspects	Inadequate	Joint Recommend-ation	Inadequate	Joint Recommend-ation	Mostly concerned with test severities. Procedure Essentially Mil Std 810
Gunfire	Recommended With reservations on procedure	No equivalent test procedure	No specific procedure rather undertaken using existing methods.	STANAG essentially identical	No specific procedure rather undertaken using existing methods	No equivalent test
Acoustic tests (incl. combined with temperature & vibration)	Recommended	Various very similar test procedures exist, however, these do not necessary encompass all the procedures of the STANAG and/or are as up to date.				No equivalent test.
Buffet	Best guidance available	No equivalent test procedure	Joint Recommend-ation	No specific procedure rather undertaken using existing methods	Joint Recommend-ation	No equivalent test.
Multi - Exciter Vibration	Recommended	No equivalent test procedure				

6.2.4.1 Vibration Test Procedures

In selecting a vibration test procedure as a recommended standard for military equipment it is necessary to consider two apparently conflicting criteria. The test procedure needs to encompass commercial advances in test control capabilities in a manner to allow testing of large sophisticated defence systems in a cost effective manner. However, it also needs to be able to allow simple tests on the large number of smaller less sensitive equipment in a consistent repeatable manner. Such consistency is required for contractual reasons and to ensure consistency in testing of components and COTS items. To achieve consistency and repeatability in such cases the procedure needs to be firmly written with a clear distinction in layout and terminology between mandatory and advisory (guidance) information.

Currently the NATO STANAG 4370 encompasses the key portions of the Def Stan 00-35 and GAM EG 13 with regard testing of sophisticated equipment and when using the more complicated vibration test procedures. In this regard the STANAG is as good as the two European contributing standards. However, the manner in which this information is included is poor. Specifically the poor format, consistency in terminology and weak underlying strategy are a concern. The procedure does not, at its core, include a clear mandatory process a test specifier can contractually rely upon as a basis for purchasing components, sub-systems and COTS equipment. In this regard the two European standards, Def Stan 00-35 and GAM EG 13, combine both tests for sophisticated equipment and a well defined mandatory process which a test specifier can contractually rely upon. Whilst, the commercial standard EN / IEC 60068 contains several very well defined vibration test procedures, they have little technical innovation and for military use are considered out of date. Indeed reliance on these EN/ IEC vibration test procedures make the testing of a significant number of defence systems practically impossible.

The main review undertaken here related to the general vibration testing of equipment. However, several of the military standards also include specific test procedures related to testing of complete stores and missiles. Whilst, testing of stores and missiles can still present some difficulties, mostly problems with vibration only testing have been overcome. In this regard the STANAG, Def Stan and Mil Std procedures all resolve the problems and have sufficient commonality for one to have any real advantage over the others. In recent times the store & missile vibration test has developed into a combined acoustic / vibration / temperature test.

None of the vibration test standards addressed in this section can be considered to adequately deal with the testing of packaged equipment. Whilst, some can accommodate the testing of some packages none can be said to allow any form of package to be tested reliably. In this regard both very stiff and very soft packages will be difficult to adequately control under test with the current procedures. Also large and palletised equipment can only be tested with difficulty with existing procedures and then neither consistently or repeatably.

In summary the NATO STANAG 4370 is technically innovative, up to date and encompasses key components of the two European national standards Def Stan 00-35 and GAM EG 13. However, it lacks firmness of statement and does not include a clear mandatory process such that a test specifier could not contractually rely upon it. The procedures in Def Stan 00-35 and GAM EG 13 successfully demonstrate that both technically innovative and firmness of statement can be practically combined. The procedures in EN / IEC 60068 are by comparison to the military standards limited in scope and outdated. Reliance on these civil procedures could have significant detrimental consequence on equipment weight, size and performance. Indeed vibration testing of a range of defence systems would be essentially impossible. For these reasons the recommendation is for either of the two European national defence standards Def Stan 00-35 and GAM EG 13.

6.2.4.2 Gunfire Test Procedures

Since the Mid 1970's issues of the US Mil Std 810 has contained versions extensive process to establish gunfire vibration severities for aircraft equipment. This historic US Mil Std 810 process was relatively easy to implement as a test as it comprised narrow band random vibration superimposed upon a broad random background. Although frequently subject to some technical criticism the severity derivation processes were used for several decades to establish equipment gunfire vibration severities for many aircraft.

As the derived test severity could be applied perfectly well with the general vibration test procedures, a common strategy in Europe was to use the US severities but with their own general vibration test procedure. Hence, the UK and French military standards consider they include gunfire even though no specifically named test procedure exists. The UK and French military standards would consider their tests procedures are more suitable in a contractual situation.

The main criticism of the historic US Mil Std 810 process was that it was really only applicable for aircraft equipment located some way from the excitation source (in this case the gun muzzle). For equipment close to the muzzle and for items subject to blast pressure pulses (frequently including missiles and stores), then the waveform experienced is usually dominated by the repeated shock pulses. Several ways of testing for these conditions have been postulated over the years and some included in standards such as latter editions of Mil Std 810. However, not all of these were realistically practical and the test procedures were commonly very poorly defined. Although this situation has slowly improved, the alternatives are still quite complicated and considerable user interpretation is still required.

The current US Mil Std 810 contains a much simplified version of the historic test severity derivation process previously used with the narrow band random vibration superimposed upon a broad random test. It also contains three alternative approaches for directly simulating the gunfire shock pulses. Currently the NATO STANAG 4370 procedure is close to a direct copy of the Mil Std test. The European commercial concern still exists that the test procedures are not defined adequately for contractual purposes. This can be particularly relevant as gunfire vibration may only occur for a short period but for aircraft equipment it is frequently the major vibration amplitude imposed on the equipment. As such it is often a major consideration in the equipment design process. Currently there is considerable ongoing activity to verify the efficacy of such methods for this application. As such changes to the existing military standards may be expected in the very near future.

In summary the NATO STANAG 4370 is technically the most complete procedure which includes alternative approaches and is technically compatible with earlier versions. As such it is the recommended procedure. Nevertheless, the procedures are largely written as guidance on the derivation of test severities but not necessarily used in conjunction with their own test procedure.

6.2.4.3 Acoustic Test Procedures

The Acoustic test procedures are usually used to replicate either a high intensity acoustic field or the effects of fluid flow such as the aerodynamic flow. The main use of acoustic test methods in military applications is to simulate the effects of aerodynamic flow on say high performance aircraft equipment, missiles and externally carried stores. Acoustic test methods have developed considerably in the military field from their use in testing commercial items. Indeed the level of evolution of the military test has become so great that the military and commercial tests are now arguably entirely different animals. To illustrate this acoustic test facilities able to undertake the latest and most effective military tests would be prohibited under the commercial standards. Conversely, it would be impracticable to use the commercial standards for military applications. The latest version of the NATO STANAG not only combines the majority of the national standards but also adds additional enhancements.

In summary, the primary reason for using acoustic testing in military applications differs from that of commercial applications. With that said , the actual test procedures for military and commercial applications should be interchangeable. However, the commercial standards are markedly less advanced than the military standards and lack technical innovation. Of the military standards NATO STANAG 4370 are the most sophisticated and recommended.

6.2.4.4 Buffet Vibration

The US , UK and French national military standards all utilised the general random vibration test procedure to apply the so called buffet vibrations. Whilst, NATO STANAG 4370 includes a specific chapter for buffet, the real content is essentially only guidance on test severities. As guidance the content is better than anything else currently available. With that said, it does not use a test procedure different from the general vibration test and the guidance does not justify a separate chapter. Moreover, the existing general random vibration tests of the UK and French national military standards comprise far better test procedures than that of the STANAG. As such either of those are recommended here.

6.2.4.5 Multi - Exciter Vibration

Currently NATO STANAG 4370 is the only military standard containing a multi-exciter system. No equivalent procedure exists in EN / IEC 60068. As such the STANAG 4370 is recommended here.

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6.3 Review and Comparison of Shock Test Methods

6.3.1 Standards Under Consideration

The standards reviewed and compared with regard mechanical shock conditions are set out in the following table.

Matrix Environmental Test Methods vs Standards						
	NATO STANAG 4370 AECTP (Method No)	International EN / IEC 60068 Part 2 (60068-2-xx)	UK Def Stan 00-35 Part 3 (Chapter / test)	US Mil Std 810F (Test No / Procedure)	France GAM-Eg-13 (Method / Procedure)	Quadripartite US/UK/F/DE ITOP (Test No)
Classical Waveform Shock	403	27	2-03 / M3	516	Method 43	5-2-506
Handling And Drop	414	31 32	2-04 / M4 2-05 / M5	516 Proc II,III,IV & VI	Method 43 Proc 3, 4 & 5	4-2-602 7-2-509
Safety Drop Test	STANAG 4375	UN “Orange” BOOK (ST/SG/AC.10/ Rev.12)	5-03 / FX3 BR8541			4-2-601
Shock Response Spectra	417	57 81	2-06 / M6	516	Method 43	5-2-506
Pyroshock	415			517	Method 43 Proc 7	5-2-506
Rail Impact	416	(within 27)	(within 2-03 /M3)	516 Proc VII	Method 43 Proc 6	
Undex Test	419		2-07 / M7			
Ballistic Shock	422			522		
Catapult			(Severity only in Part 5)	516 Proc VIII	Method 43 Proc 8	
Bump		29	2-12 / M12		Method 43 Proc 9	

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6.3.2 Standard Comparisons

Test	Scope & Limitations
Classic Waveform or Basic Shock Test	**STANAG 4370 AECTP 400 Method 403** Purpose. The purpose of this test method is to induce responses in systems, subsystems and units, hereafter called materiel, that are comparable with those likely to be experienced in-service during the specified operational conditions, and that can be readily reproduced in the laboratory using appropriate shock test equipment. The basic intention is not necessarily to replicate the in-service environment. Application. This test method is primarily designed to undertake shock testing involving the classical time history acceleration waveforms, such as the half-sine pulse, the terminal peak sawtooth pulse and the trapezoidal pulse. Descriptions of the shock response spectra (SRS) for these classical waveforms are available in Method 417, SRS Shock, Annex C. Other time domain pulses can be accommodated by this test method, provided that they are within the capabilities of the shock test facility. To provide adequate test repeatability and control, an electro-dynamic or servo-hydraulic test system is preferred for the test procedures, but the test method does not exclude the use of drop or impact type test equipment. For more accurate simulation of complex shock environments with many zero crossings, and whenever possible for measured transient time domain field shock data, the procedures defined in Method 417 are recommended. Moreover, if the test specification is in an SRS format, then Method 417 is recommended. For pyrotechnic shock environment testing, Method 415, Pyroshock, is recommended. Limitations. This test method does not cover complex shock responses, or shocks described in an SRS format. Specifically, this test method does not accommodate environments arising from gun blast, nuclear blast, pyrotechnic shock, underwater explosion, and safety drops. The classical waveform shock pulses in Method 403 do not necessarily replicate the shock environment experienced in-service. Also, it may not be possible to simulate actual operational in-service shock environments because test machine and/or fixture limitations may preclude the satisfactory application of the specified pulse to the test item. **EN/IEC 60068-2-27** Introduction. This test is applicable to components, equipments and other electrotechnical products, hereinafter referred to as “specimens”, which, during transportation or in use, may be subjected to conditions involving relatively infrequent non-repetitive shocks. The shock test may also be used as a means of establishing the satisfactory design of a specimen in so far as its structural integrity is concerned and as a means of quality control. It consists basically of subjecting a specimen to non-repetitive shocks of standard pulse shapes with specified peak acceleration and duration. Scope. To provide a standard procedure for determining the ability of a specimen to withstand specified severities of shock.

Test	Scope & Limitations
	General description. This standard is written in terms of prescribed pulse shapes. Guidance for the selection and application of these pulses is given in annex A and the characteristics of the different pulse shapes are discussed in annex B. Three types of pulse, namely the half-sine pulse, the final-peak saw-tooth pulse and the trapezoidal pulse are included in this standard. The choice of pulse shape depends on a number of factors, and the difficulties inherent in making such a choice preclude a preferred order being given in this standard. **DEF STAN 0035 Test 2-03 M3** The test is intended for unpackaged equipment's and for packaged items where the simulation of the service conditions requires that the package forms an integral part of the equipment. The test provides a method by which responses of components and equipment comparable with those likely to be experienced in practice in the handling, transportation and operational environment can be reproduced in the test laboratory. The basic intention is not necessarily to reproduce the real environment. This test is not intended to reproduce the effects of complex shocks to which certain equipment may be subject. Complex shocks are addressed in Test M6 - 'Operational shock' (see Chapter 2-06). This test is technically similar to that contained in BS EN 60068-2-27 "Shock", except for the differences detailed hereafter : **MIL STD 810 F Test 516** The intent of this test is to disclose failures which may result from, or adjustments necessitated by shocks experienced by materiel during use in the field. Even though materiel has successfully withstood even more severe shocks during shipping or transit shock tests, there are differences in support and attachment methods and in functional checking requirements that make this additional test necessary. Tailoring of the test is required when data are on hand, can be measured, or can be estimated from related data using accepted scaling techniques. **GAM EG 13 1st Part method 43** The purpose of the Test is to simulate the effect of Shocks and/or large scale transient but fairly infrequent vibrations, that the equipment should support in different phases of its use. **ITOP 5-2-506** These test procedures are specifically targeted at missiles, rockets and their components, however, the procedures may be applied to other items. The procedures are applicable for classical (half-sine, sawtooth, trapezoidal, etc.), synthesized (compound waveform), and pyrotechnic shock pulses.
Handling Drops and Impacts	**STANAG 4370 AECTP 400 Method 414** Purpose. The purpose of this test method is to replicate the environment incurred by systems, subsystems and units, hereafter called materiel, during loading, unloading and handling.

Test	Scope & Limitations
	Application. This test is applicable where materiel is required to demonstrate its adequacy to resist the specified handling environment without unacceptable degradation of its functional and/or structural performance. Limitations. This method is not intended to simulate basic shock, blast environments, transportation, or safety drop conditions. The drop tests in this method are uncontrolled except for the drop height and orientations. Controlled tolerance shock test procedures are provided in Methods 403, 415, and 417. Safety drop tests for munitions are covered by STANAG 4375. **EN/IEC 60068-2-31 & 32** 60068-2-31 Test Ec: Drop and topple Object. To assess the effects upon a specimen of simple standard tests intended to be representative of the knocks and jolts likely to occur during repair work or rough handling in use on a table or bench. Tests of this type may also be used to demonstrate a minimum degree of robustness for the purpose of assessing safety requirements. This test is primarily intended for specimens not in their packing and for items in their transport cases, when the latter may be considered as part of the specimens themselves. General The test includes three distinct procedures: a) Dropping on to a face (subclause 3.2.1). b) Dropping on to a corner (subclause 3.2.2). c) Toppling (or pushover) (subclause 3.2.3). The purpose of each of these procedures is basically the same, but they represent different kinds of handling. The test is not intended to be a precise test and a tolerance of ±10 % is allowed on the heights and angles prescribed in clause 3. NOTE – For a more precise shock test, Test Ea: Shock (IEC 60068-2-27) should be used. 60068-2-32 Test Ed: Free fall Introduction This test is divided into two procedures. The first simulates falls which a specimen, normally in the unpacked state, could undergo during handling and is normally restricted to two falls from a prescribed attitude onto a specified surface from a specified height. The second procedure simulates repeated falls which may occur to such devices as connectors or small remote control units which are normally attached to cables during use. Repeated falls onto a specified surface from a specified height are achieved by using a suitable apparatus, e.g. a tumbling (rotating) barrel. Procedure 1 – Free fall. To assess the effects on a specimen of simple standard tests intended to be representative of the fall likely to be experienced during rough handling, or to demonstrate a minimum degree of robustness, for the purpose of assessing safety requirements. This test is primarily intended for

Test	Scope & Limitations
	specimens not in their packing and for items in their transport case when the latter may be considered as part of the specimen itself. Procedure 2 – Free fall – Repeated. This procedure is primarily intended for testing cable-connected devices such as connectors and small remote control units where the apparatus may be dropped frequently onto hard surfaces. **DEF STAN 00-35 TESTS M4 & M5** Test M4 - DROP, TOPPLE AND ROLL TEST Scope**.** This test is intended to demonstrate the ability of packaged or unpackaged equipment to withstand the dropping, toppling and rolling effects likely to occur during its operational life, especially during handling and servicing. This test should be invoked where there is a distinct possibility of the equipment being subjected to dropping, toppling and rolling. In general, equipment which is frequently handled and serviced can be considered to be particularly at risk. This test includes five distinct test procedures which represent typical hazards arising during handling: drop test onto a face, drop test onto a corner, topple test onto a flat surface, topple test onto a steel girder and roll test. This test is technically similar to that contained in BS EN 60068-2-31 "Drop and topple" except for the differences detailed in paragraph 7. This test is also consistent with the test in BS 4826 Part 11 for determining the resistance of filled packages to damage by rolling. Test M5 - IMPACT (VERTICAL AND HORIZONTAL) TEST. Scope. This test is intended to cover vertical impacts (for example, drops) and horizontal impacts (for example, vehicle shunting and collisions when swinging on a crane). The test is applicable to both packaged and unpackaged equipments. The test may be used to assess the ability of equipment to operate, survive or remain safe when subjected to impact. This test is not intended for the safety testing of armament stores, which are covered by Test FX3 - 'Safety Drop Test' (see Chapter 5-03). This test is technically similar to that contained in BS EN 60068-2-32 Procedure 1 - 'Free fall', except for the differences detailed in paragraph 7. **MIL STD 810 F Method 516 Procedure IV - Transient Drop** Procedure IV is intended for materiel either outside or within its transit or combination case, or as prepared for field use (carried to a combat situation by man, truck, rail, etc.). It is used to determine if the materiel is capable of withstanding the shocks normally induced by loading and unloading when it is outside of its transit or combination case, e.g., during routine maintenance, when being removed from a rack, being placed in its transit case, etc., or when it is inside its transit or combination case. Such shocks are, in general, accidental, but may impair the functioning of the materiel. This procedure is not intended for shocks encountered in a normal logistic shipping environment as experienced by materiel inside shipping containers.

Test	Scope & Limitations
	GAM EG 13 Method 43 Procedures 3, 4 & 5 Applicability. Procedure 4 applies to all equipment liable to suffer shocks in transport by mechanical means and manually (loading and unloading). The equipment can be in its transport container, in a cradle, handling frame or in a portable case. Procedure 4 does not apply to the transport conditions which are simulated by a random vibration excitation (see method 42) It does not apply to equipment which is an integral part of the fixed installation. **ITOP 7-2-509 & 4-2-602** ITOP 7-2-509. Scope. This ITOP describes the testing procedures required to determine the ability of systems/items'* to withstand airdrop in compliance with the design requirements. Systems/items within the scope of this ITOP include automotive equipment (and components), marine equipment, weapons, inert ammunition, missile support equipment, and general stores dropped both onto land and into water. Additional safety measures and procedures must be applied to the airdrop of toxic, explosive, or other hazardous material. ITOP 4-2-602. This ITOP provides guidance for testing the ability of military items to withstand the shocks encountered during transportation to or employment on the battlefield. Based on experience and engineering judgement, procedures may be altered to accommodate variations in item and packaging configuration. In general, rough handling tests are performed on those items carried as unsecured cargo in trucks, or on the person of soldiers. These items include: munitions, rifles, rockets, radios, and mortars. Secured-cargo vibration tests simulating transport of packaged items by rail, air, ship, trailer, and truck, including packaged tied-down transportation on the battlefield, are not considered as "rough handling" tests, nor are tests of installed equipment or stowed ammunition. Vibration tests are covered by ITOP I-2-601. The 3m and 12m drop test is part of ITOP 4-2-601b. For ammunition, the rough handling test is just one phase of the safety testing of ammunition covered by ITOPS 4-2-504 (1)C, (2)d, and (3)e. While the test procedures described herein are directly related to ammunition, the procedures may also be used to test other commodities, as applicable. Limitations. This ITOP does not cover vibration testing which is covered in ITOP 1-2-601.
Safety Drop Test	**STANAG 4375** The main objective of this drop test is to determine if munitions can withstand severe shocks caused by drops onto a hard surface and remain safe for disposal. **UN "Orange" Book - Recommendations On The Transport Of Dangerous Goods (ST/SG/AC.10/Rev.12)** These Recommendations have been developed by the United Nations Economic and Social Council's Committee of Experts on the Transport of Dangerous Goods in the light of technical progress, the advent of new substances and materials, the exigencies of modern transport systems and, above all, the requirement to ensure the safety of people, property and the environment. They are addressed to governments and international organisations concerned with

Test	Scope & Limitations
	the regulation of the transport of dangerous goods. They do not apply to the transport of dangerous goods in bulk which, in most countries, is subject to special regulations. The recommendations concerning the transport of dangerous goods are presented in the form of "Model Regulations on the Transport of Dangerous Goods". The Model Regulations aim at presenting a basic scheme of provisions that will allow uniform development of national and international regulations governing the various modes of transport; yet they remain flexible enough to accommodate any special requirements that might have to be met. It is expected that governments, intergovernmental organisations and other international organisations, when revising or developing regulations for which they are responsible, will conform to the principles laid down in these Model Regulations, thus contributing to world-wide harmonisation in this field. Although only a recommendation, the Model Regulations have been drafted in the mandatory sense (i.e., the word "shall" is employed throughout the text rather than "should") in order to facilitate direct use of the Model Regulations as a basis for national and international transport regulations. The scope of the Model Regulations should ensure their value for all who are directly or indirectly concerned with the transport of dangerous goods. Amongst other aspects, the Model Regulations cover principles of classification and definition of classes, listing of the principal dangerous goods, general packing requirements, testing procedures, marking, labelling or placarding, and transport documents. There are, in addition, special requirements related to particular classes of goods. **DEF STAN 00-35 Test FX3** The purpose of the test is to support the assessment of munitions to withstand safely the effects of severe impacts that may occur during in-Service use This test is applicable to all munitions which may be subjected to inadvertent impact. The conditions may arise when the munition is packaged or unpackaged. This test implements STANAG 4375 - Safety Drop Test for Munitions and adopts both the Logistic Impact Test and the Deployment Impact Test included in that Standard. The acceptance criterion for the Logistic Impact Test is that following impact the munition should remain safe for disposal. The Logistic Impact Test broadly covers the principles of BR 8541 and has been used traditionally in the UK for safety impact testing of munitions. The Deployment Impact Test adopts a lower impact velocity than the Logistic Impact Test and utilises the acceptance criterion that, following impact, the munition should be safe for handling and use if no visible damage is apparent. This test does not encompass conditions arising from rough handling, or higher velocity impacts such as those caused by jettison of munitions from aircraft. Also, the test cannot represent impacts with a significant horizontal velocity. **ITOP 4-2-601** This ITOP describes techniques for conducting 12m drop tests of munitions (e.g., cartridges, projectiles, separate loading propellants, in their shipping Configurations, and 3m drop tests of unpackaged ammunition employed by

Test	Scope & Limitations
	combat vehicles; and provides general guidance for drop tests from other heights, including simulated parachute drops using a drop tower, Detailed information regarding test procedures for fuzes is provided in MIL-STD-33 IBa. Although the principles of this ITOP may be used for rockets and missiles, great care must be taken in dropping rockets and missiles due to obvious safety considerations, guidance in ITOP 5-2-619b. Information regarding 2. Im and 1.5m drop tests is contained in ITOP 4-2-602.' This ITOP does not cover actual drops from aircraft, guidance in TOP 7-2-509d. This ITOP does not address simulated airdrop test angles, guidance in TOP 7-2-512.
Shock Response Spectra Based Procedures	**STANAG 4370 AECTP 400 Method 417** Application. This test method is applicable where materiel is required to demonstrate its adequacy to resist the specified complex transient responses without unacceptable degradation of its functional and/or structural performance. It is particularly useful for tailoring shock responses where measured time history data are available for the operational environment, and when used for this purpose, this test method is the preferred alternative to classical waveform shock testing. The test method is based primarily on the use of an electro-dynamic or an servo-hydraulic vibration test system, with an associated control system used as a shock test machine. This method precludes the use of more traditional shock test machines such as the shock drop table. If it can be demonstrated that the materiel exposure shock is more of a classical form e.g., half-sine, terminal peak sawtooth, or trapezoidal, Method 403 Classical Waveform Shock is recommended. AECTP 200 provides additional guidance on the selection of a test procedure for a specific shock environment. Limitations. This test method is not intended to cover close proximity gun blast, nuclear blast, underwater explosion, or safety drop environments. Pyrotechnic shocks are addressed in Method 415 Pyroshock. It may not be possible to simulate some in-service operational high amplitude, high frequency responses because vibration test system power constraints or fixture limitations may prevent the satisfactory application of the SRS shock pulse to the test item. **EN/IEC 60068-2-57 & 81** 60068-2-57 Test Ff: Vibration – Time-history method Introduction. This standard details methods for testing components, equipment and other electrotechnical products (hereinafter referred to as "specimens") which in service can be subjected to short-duration random type dynamic forces of which typical examples are the stresses induced in equipment as a result of earthquakes, explosions and some phases of transportation. The characteristics of these forces and the damping of the specimen may be such that the vibrational response of the specimen will not reach a steady-state condition. The test consists, after any preliminary vibration response investigation with sinusoidal vibration, in subjecting the specimen to a time-history specified by a response spectrum with characteristics simulating the effects of the dynamic forces.

Test	Scope & Limitations
	A time-history may be developed or obtained from: - a natural event (natural time-history); - a random sample - a synthesized signal Object. To provide a standard procedure for determining, by the time-history method, the ability of a specimen to withstand specified severities of transient vibration. General description. The purpose of this test is to determine mechanical weakness and/or degradation in specified performance and to use this information, in conjunction with the relevant specification, to decide whether a specimen is acceptable or not. It may also be used, in some cases, to demonstrate the mechanical robustness of specimens and/or to study their dynamic behaviour. The extent to which a specimen has to function during vibration or merely to survive conditions of vibration shall be stated in the relevant specification. 60068-2-81 Test Ei: Shock –Shock response spectrum synthesis Introduction. This part of IEC 60068, designed for testing with a synthesised shock response spectrum (SRS) is intended for general application for components, equipment and other products, hereinafter referred to as “specimens”, when simulation of transient responses of a complex nature is required. The test method centres on the use of SRS and techniques associated with SRS. Purpose. The purpose of the test is to demonstrate the adequacy of the test specimen to resist the specified transient excitation, without unacceptable degradation of its functional and/or structural performance. It is particularly useful for tailoring shock responses where measured data are available from the operational environment. However, the test is applicable to any transient excitation within the limits of the testing apparatus. Use. The test method is based primarily on the use of an electro-dynamic or a servo-hydraulic vibration generator with an associated computer-based control system used as a shock testing system. Other shock testing machines may be used, provided they fulfil the requirements of this standard. It is emphasised that SRS synthesis testing always demands a certain degree of engineering judgement. Both supplier and purchaser should be fully aware of this fact. The writer of the relevant specification is expected to select the testing procedure and the values of severity appropriate to the specimen and its use. Scope. This part of IEC 60068 specifies tests using a synthesised shock response spectrum (SRS). It is intended for general application to specimens when simulation of transient excitation of a complex nature is required. **DEF STAN 00-35 Test M6** The operational shock test is applicable when simulation is required of materiel transient responses whose waveform is of a complicated nature. It is particularly useful for tailoring shock excitations when measured data is available for

Test	Scope & Limitations
	the operational environment. The operational shock test may also be used as an alternative to the basic shock test. The principles of this test are based on those of the vibration test, which utilises similar test hardware. The purpose of this test is to demonstrate the adequacy of materiel to resist unacceptable degradation of its functional and/or structural performance when subjected to the specified shocks. The test is intended primarily for testing unpackaged equipments and for items in their transit cases where the latter may be considered as an integral part of the equipment. Equipment characterisation tests, such as resonance searches, determination of frequency response functions, and modal analyses, are not addressed in this Chapter, since published information is readily available. **MIL STD 810 F Test 516** The intent of this test is to disclose failures which may result from, or adjustments necessitated by shocks experienced by materiel during use in the field. Even though materiel has successfully withstood even more severe shocks during shipping or transit shock tests, there are differences in support and attachment methods and in functional checking requirements that make this additional test necessary. Tailoring of the test is required when data are on hand, can be measured, or can be estimated from related data using accepted scaling techniques. **GAM EG 13 1st Part method 43** The purpose of the Test is to simulate the effect of Shocks and/or large scale transient but fairly infrequent vibrations, that the equipment should support in different phases of its use. **ITOP 5-2-506** These test procedures are specifically targeted at missiles, rockets and their components, however, the procedures may be applied to other items. The procedures are applicable for classical (half-sine, sawtooth, trapezoidal, etc.), synthesised (compound waveform), and pyrotechnic shock pulses.
Pyroshock	**STANAG 4370 AECTP 400 Method 415** Purpose. The purpose of this test method is to replicate the effects of complex high amplitude and high frequency transient responses which are incurred by systems, subsystems and units, hereafter called materiel, during the specified operational conditions under exposure to pyroshock from pyrotechnic explosive or propellant-activated devices. Application. This method is applicable where materiel is required to demonstrate its adequacy to resist the pyroshock environment without unacceptable degradation of its functional and/or structural performance. Supplemental technical guidance is contained in references a, b, and Annex A.. AECTP's 100 and 200 provide guidance on the selection of a test procedure for the pyroshock environment. Limitations. Because of the highly specialised nature of pyroshock, apply it only after giving careful consideration to information contained in the paragraphs below. In general, it may not be possible to simulate some of the actual in-

Test	Scope & Limitations
	service pyroshock environments because fixture limitations or physical constraints can prevent the satisfactory application of the pyroshock to the test item. This method does not include the shock effects experienced by materiel as a result of any mechanical shock, transient vibration, shipboard shock, or EMI. For these types of shocks see the appropriate method in AECTP 400. This method does not include the effects experienced by fuse systems that are sensitive to shock from pyrotechnic devices. Shock tests for safety and operation of fuses and fuse components may be performed in accordance with other applicable national and international standards specifically addressing fuse system environmental testing. This method does not include special provisions for performing pyroshock tests at high or low temperatures. This method is not intended to be applied to manned space vehicle testing, see reference b and Annex A reference l. This method does not address secondary effects such as induced blast, EMI, and thermal effects. This method does not address effects of ballistic shock on materiel. **MIL STD 810 F Method 517** Pyroshock tests involving pyrotechnic (explosive- or propellant-activated) devices are performed to provide a degree of confidence that materiel can structurally and functionally withstand the infrequent shock effects caused by the detonation of a pyrotechnic device on a structural configuration to which the materiel is mounted. experimentally estimate the materiel's fragility level relative to pyroshock in order that shock mitigation procedures may be employed to protect the materiel's structural and functional integrity. **GAM EG 13 Method 43 Procedure 7** Applicability. Procedure 7 is applicable to an equipment which should resist and/or operate in the presence of shocks produced by a pyrotechnical detonating fuse , by a pyrotechnical transmission relay, by a pyrotechnical detonator, by an explosive bolt, etc. Shocks of this type are characterised by a shock response spectrum which can extend from 100 to 25,000 Hz, with amplitudes that can exceed several thousand g beyond 1000 Hz. The pulse times can run from a few µs to several 10 ms. The pyrotechnical shock test is not required when the shock response spectrum is covered Procedure 7 is applicable to an equipment which should resist and/or operate in the presence of shocks produced by a pyrotechnical detonating fuse , by a pyrotechnical transmission relay, by a pyrotechnical detonator, by an explosive bolt, etc. Shocks of this type are characterised by a shock response spectrum which can extend from 100 to 25,000 Hz, with amplitudes that can exceed several thousand g beyond 1000 Hz. The pulse times can run from a few µs to several 10 ms. The pyrotechnical shock test is not required when the shock response spectrum is covered

Test	Scope & Limitations
	ITOP 5-2-506 These test procedures are specifically targeted at missiles, rockets and their components, however, the procedures may be applied to other items. The procedures are applicable for classical (half-sine, sawtooth, trapezoidal, etc.), synthesised (compound waveform), and pyrotechnic shock pulses.
Rail Impact	**STANAG 4370 AECTP 400 Method 416** Purpose. The purpose of this test method is to replicate the railroad car impact conditions that occur during rail shipment of systems, subsystems and units, hereafter called materiel, and their tiedown arrangements during the specified logistic conditions. Rail impacts tests are also conducted to subject large materiel to specified longitudinal and/or transverse shocks to demonstrate material strength. Application. AECTP 200 provides guidance on the selection of a test procedure for a specific rail impact environment. Further description of procedures for railcar loading and transportation are provided in reference d. Test Procedure I (US Cushioned Coupler Car) is applicable where materiel is required to demonstrate its adequacy to resist the specified railroad car impact environment without unacceptable degradation of its functional and/or structural performance. This test is mandatory for materiel to be transported by rail in the US. Test Procedure II (European Railway) is applicable for the generation of a low-level, long duration shock on large test items, and is a requirement of the European Railway Administration. Test Procedure III (Laboratory Simulation) is a laboratory simulation applicable to items fitted onto or transported by railway vehicles. Limitations. This method is not intended for railcar crash conditions or small individual packages that would normally be shipped mounted on a pallet. **MIL STD 810 F Method 516 Procedure VII - Rail impact** Procedure VII is intended to test materiel that will be transported by rail; to determine the effect of normal railroad car impacts that occur during rail shipment, to verify the structural integrity of the materiel, and to evaluate the adequacy of the tiedown system and the tiedown procedures. Test all items at their maximum gross weight (fully loaded) rating unless otherwise specified in the transportability requirements for the materiel. This procedure is not intended for the separate testing of small, individually packaged pieces of materiel that would normally be shipped (and tested) when mounted on a pallet, or as part of a larger materiel. For tests such as these, the references provide guidance on environments measured during rail impact that may be useful in separate laboratory testing of such items. **GAM EG 13 Method 43 Procedure 6** Procedure 6 applies to large scale assemblies carried by rail, subject to railway impacts resulting from various

Test	Scope & Limitations
	operations (marshalling , etc..). The equipment is in its transport conditions. Procedure 6 does not concern the separate tests of small pieces of equipment packed individually or when they are normally shipped on pallets. These should be tested with the whole of the pallet. The equipment is placed in its transport configuration on a normal wagon, correctly ballasted, at specified speeds, and subjected to a series of impacts. The checks required in $ 3.2 are made before and after the tests. If the test item has only one possible transport orientation, it is subjected to two shocks in each direction of this orientation at the velocity specified. If the test item can be transported along two orientations, it is subjected to one single shock in each direction of each of the orientations at the speeds specified.
Undex Test	**STANAG 4370 AECTP400 METHOD 419** Purpose. The test method procedures are applicable to systems, subsystems, and units, hereafter called materiel, which must function or survive a non-contact underwater explosion (UNDEX) event. The purpose of this test method is to provide an UNDEX assessment method, which uses a multi-discipline approach to the production of a materiel safety and suitability for service statement. The method combines both analytical analysis and physical testing to ensure that materiel deployed or transported at sea can withstand the UNDEX environment. The principle objectives of the test method are the following : Derive an assessment process for materiel such that the safety and suitability for service criteria can be demonstrated with an acceptable and appropriate margin of safety balanced against the risk consequences of failure. Define safety as the prime requirement of an assessment, and provide guidance for serviceability compared with current custom and practice regarding ship design criteria. Integrate UNDEX assessment with the current procedures for assessing the dynamic behaviour of materiel. Provide a materiel UNDEX assessment strategy to enable appropriate questions to be asked and assessment routes identified for independent assessment. Enable existing vibration and shock test facilities to be used for live UNDEX testing of materiel. Application. Transportation by sea is likely at some stage during the life cycle of most materiel. This is particularly the case in times of increased tension or hostility when large quantities of materiel to support services require shipment to front line bases and theatre. Naval weapons are a special case in that they are also deployed on-board naval vessels and often have different packaging or storage arrangements. As a consequence, there is a need to assess the effects of UNDEX events when materiel are stored, deployed or transported on a seagoing vessel. The issues are wider than materiel serviceability in that any compromise of safety has wider implications for the safety of the complete vessel and crew. The increasing structural complexity of materiel and the trend to purchase commercial off the shelf (COTS) hardware from third party sources also requires improvements in assessment methods and data for the provision of relevant

Test	Scope & Limitations
	safety and suitability for service arguments. Integrated and tailored assessment using modelling and historical databases in support of tests provide the opportunity to optimise the assessment process. This is particularly relevant to the assessment of materiel subject to UNDEX events. At present, assessment of materiel subject to the UNDEX environment is usually tested using the traditional Shock Grade Curve Scheme, and where necessary by specialised one-time assessment. Since the traditional methods are not applicable to materiel that exhibit complex dynamic response behaviour, a tailored multi-disciplinary assessment approach using modelling, test and correlation from historical data is required. Therefore, the need exists to formalise the tailored assessment process to compliment the Shock Grade Curve Scheme. This test method defines a tailored UNDEX assessment process that builds on the Shock Grade Curve Scheme, and extends the capability to cover dynamically complex materiel. It describes a rationale and assessment process applicable to a wide range of materiel using a comprehensive and tailored assessment strategy designed to be used in support of safety and suitability for service UNDEX assessments. Where Shock Response Spectrum (SRS) testing forms a part of the assessment process, the AECTP 400 Method 417 methodology should be applied; and Method 403 when classical shocks are specified. **DEF STAN 0035 TEST M7 - SHOCK TESTING FOR WARSHIP EQUIPMENT AND ARMAMENT STORES** Scope**.** This test is intended to demonstrate the resistance of materiel to unacceptable damage as a consequence of shock due to a non-contact underwater explosion. This test is intended for unpackaged equipments and for packaged items where the simulation of the service conditions requires that the package forms an integral part of the equipment. This test is not concerned with the effects of other shocks due to external stimuli, which are covered by Test M3 - 'Basic pulse shock test' or Test M6 - 'Operational Shock' (see Chapter 2-03).
Ballistic Shock	**STANAG 4370 AECTP 422** This method includes a set of ballistic shock tests generally involving momentum exchange between two or more bodies or momentum exchange between a liquid or gas and a solid. The test is performed to: a. Provide a degree of confidence that materiel can structurally and functionally withstand the infrequent shock effects caused by high levels of momentum exchange on a structural configuration to which the materiel is mounted. b. Experimentally estimate the materiel's fragility level relative to ballistic shock in order that shock mitigation procedures may be employed to protect the materiel's structural and functional integrity. Application. The Ballistic shock test method simulates a high-level transient shock that generally results from the impact of projectiles or ordnance on armoured combat vehicles, hardened targets, or other structures. The transient event can be considered as a specific application of transient or pyrotechnic shock. The physical phenomenon is characterised by the overall material and mechanical response at a structure point from elastic or inelastic impact.

Test	Scope & Limitations
	Such impact may produce a very high rate of momentum exchange at a point, over a small finite area or over a large area. The high rate of momentum exchange may be caused by collision of two elastic bodies or a pressure wave applied over a surface. Ballistic Shock Definition. Ballistic shock is a high-level transient shock that generally results from the impact of projectiles or ordnance on armoured combat vehicles. Armoured combat vehicles must survive the shocks resulting from large calibre non-perforating projectile impacts, mine blasts, and overhead artillery attacks, while still retaining their combat mission capabilities. Reference d discusses the relationship between various shock environments (ballistic shock, transportation shock, rail impact shock, etc.) for armoured combat vehicles. Actual shock levels vary with the type of vehicle, the specific munition used, the impact location or proximity, and where on the vehicle the shock is measured. There is no intent in this test method to define the actual shock environment for specific vehicles. Furthermore, it should be noted that the ballistic shock technology is still limited in its ability to define and quantify the actual shock phenomenon. Even though considerable progress has been made in the development of measurement techniques, current instrumentation, such as the shock sensing gages, are bulky and cumbersome to use. The development of analytical (computational) methods to determine shock levels, shock propagation, and mitigation is lagging the measurement technology. The analytical methods under development and in use to date have not evolved to the level where analytical results can be relied upon to the degree that the need for testing is eliminated. That is, the prediction of ballistic shock response is, in general, not possible except in the simplest configurations. When an armoured vehicle is subjected to a non-perforating large calibre munition impact or blast, the structure locally experiences a force loading of very high intensity and of relatively short duration. The force loading is localised, however the entire vehicle is subjected to stress waves travelling over the surface and through the structure. In certain cases, pyrotechnic shocks have been used in ballistic shock simulations. There are several caveats in such testing. The characteristics of ballistic shock are outlined in the following paragraphs. **MIL STD 810 F Method 522** This method includes a set of ballistic shock tests generally involving momentum exchange between two or more bodies or momentum exchange between a liquid or gas and a solid performed to: a. provide a degree of confidence that materiel can structurally and functionally withstand the infrequent shock effects caused by high levels of momentum exchange on a structural configuration to which the materiel is mounted. b. experimentally estimate the materiel's fragility level relative to ballistic shock in order that shock mitigation procedures may be employed to protect the materiel's structural and functional integrity. Ballistic shock is a high level shock that generally results from the impact of enemy projectiles or ordnance on armoured combat vehicles. Armoured vehicles must survive the shock resulting from large calibre non-perforating projectile impacts, mine blasts, and overhead artillery attacks, while still retaining their combat mission capabilities. Reference d discusses the relationship between various shock environments (ballistic shock, transportation shock, rail

Test	Scope & Limitations
	impact shock, etc.) for armoured combat vehicles. Actual shock levels vary with the type of vehicle, the specific munition used, the impact location or proximity, and where on the vehicle the shock is measured. There is no intent here to define the actual shock environment for specific vehicles. Furthermore, it should be noted that the ballistic shock technology is still rather limited in its ability to define and quantify the actual shock phenomenon. Even though considerable progress has been made in the development of measurement techniques, currently used instrumentation (especially the shock sensing gages) is still bulky and cumbersome to use. The development of analytical (computational) methods to determine shock levels, shock propagation, and mitigation is lagging behind the measurement technology. The analytical methods under development and in use to date have not evolved to the level where their results can be relied upon to the degree that the need for testing is eliminated. That is the prediction of response to ballistic shock is, in general, not possible except in the simplest configurations. When an armoured vehicle is subjected to a non-perforating large calibre munition impact or blast, the structure locally experiences a force loading of very high intensity and of relatively short duration. Though the force loading is localised, the entire vehicle is subjected to stress waves travelling over the surface and through the structure. In certain cases pyrotechnic shocks have been used in ballistic shock simulations, however there are several caveats in such testing
Catapult Launch /Arrested Landing	**MIL STD 810 F method 516 Procedure VIII - Catapult Launch/Arrested Landing.** The intent of this test is to verify the functionality and structural integrity of materiel mounted in or on fixed wing aircraft that are subject to catapult launches and arrested landings. **GAM EG 13 Method 43 Procedure 8 -** Catapulting, Stopping on Barriers. Procedure 8 is only referred to here for information. For details refer to the second part GAM EG 13 B relating to aircraft.
Bump	**EN/IEC 60068-2-29** Introduction. This test is applicable to components, equipments and other electrotechnical products, hereinafter referred to as “specimens”, which, during transportation or in use, may be subjected to repetitive shocks. The bump test may also be used as a means of establishing the satisfactory design of a specimen in so far as its structural integrity is concerned and as a means of quality control. It consists basically of subjecting, on a bump tester, a specimen to repetitive shocks of a standard pulse shape with specified peak acceleration and duration. NOTE – The term “bump tester” is used throughout this standard but other means of applying “bumps” are not excluded. Scope. To provide a standard procedure for determining the ability of a specimen to withstand specified severities of bump. General description. This standard is written in terms of a prescribed number of repetitive half-sine pulses with given peak acceleration and duration. The purpose of the test is to reveal the accumulated damage or degradation caused by repetitive shocks, and to use the information, in conjunction with the relevant

Test	Scope & Limitations
	specification, to decide whether a specimen is acceptable or not. It may also be used, in some cases, to determine the structural integrity of specimens or as a means of quality control. This test is primarily intended for unpackaged specimens and for items in their transport case when the latter may be considered as part of the specimen itself. Applicability. The bumps are not intended to reproduce those encountered in practice. Wherever possible, the test severity applied to the specimen should be such as to reproduce the effects of the actual transport or operational environment to which the specimen will be subjected, or to satisfy the design requirements if the object of the test is to assess structural integrity. **DEF STAN 0035 TEST M12 - BUMP TEST** Scope. This test is not intended as a simulation of any particular service condition. However, this test could be useful as a general ruggedness test to provide some confidence in the suitability of equipment for transportation in wheeled vehicles. Where a more realistic representation of vehicle motion is required then consideration should be given to the use of Test M1 - 'Basic Vibration Test' (see Chapter 2-01) and Test M11 - 'Wheeled Vehicle Transportation Bounce Test' (see Chapter 2-11). This guidance, test procedure and information on selecting severities for this test are those specified in BS EN 60068-2-29 - 'Bump'. **GAM EG 13 Method 43 Procedure 9 Bump** Applicability. The Bump test is a conventional one which can be used to simulate repeated shocks most economically. The real environment is simulated more realistically by a random vibration specification. Performance of the Test. The test item is installed on a Bump machine or on a vibration generator via the set up .It is then subjected to bumping in the direction(s) required by the test programme, which stipulates whether the equipment is operating or not. The repetition rate should be such that, between the successive pulses, the relative movement of the equipment is approximately zero. A rate of one or three bumps per second is usually suitable.

6.3.3 Technical Comparison

6.3.3.1 Classic Waveform or Basic Shock Test

The classic waveform or basic shock test procedure is one of the oldest shock test procedure available. In all cases the procedures encompasses three basic shock pulses viz. a half sine pulse, a trapezoidal pulse and a trailing edge saw tooth. All of the procedures allow a range of test equipment to be used provided the requirements to be met. This is because from the very early days a range of different test facilities were in use to generate this type of shock.

This test procedure has been used historically by suppliers of COTS components and sub-system (both military and commercial) to demonstrate their equipment has a degree of hardness against shock conditions. It is important therefore that the test procedure is common to both commercial and military equipment.

By design the UK and French national defence standards have historically adopted the same basic procedure of the International standard that is now EN / IEC 60068. Indeed two way interaction occurred in the generation of the International standard that is now EN / IEC 60068 and the French defence standard. The type of pulse permitted, the tolerances on the pulses and the general confirmation tolerances are all identical in all three standards.

Consistency between standards is not the case for the US Mil Std 810 procedure (although it also appears in other Mil Stds such as 331) which only intrinsically includes trailing edge saw tooth and trapezoidal pulses. The tolerance on the pulses and the general confirmatory approach are also markedly different to those of the EN / IEC 60068 (albeit the tolerances on the pulses are tighter). Additionally the latest US Mil Std sets out a Shock Response Spectra definition as a permitted “alternative” to the use of basic pulses. This “alternative” is intrinsically inconsistent with the basic pulse and differs in both potential damage and tolerances (more lax than EN / IEC 60068). The latest version of the NATO STANAG appears to be broadly based upon the EN / IEC 60068. However, for no explicable reason, the trapezoidal pulse is defined differently and has different tolerances. The defined trapezoidal pulse seems to have no commonality with other standards and is more difficult to achieve than that used in European standards.

Quadripartite (US/UK/F/DE) agreement ITOP 5-2-506 comprises a procedure for shock testing missiles and rockets. It mostly contains a basic pulse shock test procedure but also purports to contain SRS and pyro-shock proceedures. The basic pulse test procedure is basically a reformatted copy of Mil Std 810 which is inconsistant with the UK and French national standards as well as EN / IEC 60068 and effectively precludes there use. Contributions from the UK, France and Germany seem minimal and (in the case of France and the UK) the procedure is inconsistent with existing national approaches and procurement strategy. Moreover, the rationale for the existence of the procedures in ITOP 5-2-506 is unclear. A perfectly adequate procedure existed in commercial standards and national military standards for a very long period. Also, NATO Stanag 4375 existed when the ITOP was issued (1999).

As this test is used by suppliers of COTS equipment commonality between commercial and military procedures is highly desirable. Both the UK and French military standards align with the procedure of EN / IEC 60068. In two out of three cases this is also the case for NATO STANAG 4370. However, the procedure of US Mil Std 810F differs from all others to a significant extent. Moreover, the US Mil Std permits an “alternative” process which can result in yet greater variations. It has to be observed that the use of both the Mil Std or ITOP is disadvantageous to European industry.

6.3.3.2 Handling Drops and Impacts

This group of tests simulates both drops and impacts that occur during packaged and unpackaged handling. They differ from the classic shock tests in that rather than reproduce the effects of the shock they reproduce the causal conditions. In order to reproduce the correct effects of the causal conditions the equipment has to comprise a complete assembly with (if applicable) the equipment in its normal packaging. As a consequence it is not usually possible for this test to be used by suppliers of COTS equipment or OEM suppliers.

A group of tests are actually encompassed viz. vertical drop, topple & roll, horizontal impact and bench drop. The test severities are essentially hardness criteria based only approximately on maximum credible conditions. The equipment (packaged or bare) would be expected to remain “safe & serviceable” following exposure to these tests. For equipment with safety implications (such as those containing dangerous items and particularly energetic material) a significantly more severe “safety impact test” would be adopted. However, in those cases the equipment would be expected to remain “safe only”.

By design the two UK Def Stan tests align with the two EN / IEC 60068 tests, albiet with some slight amendments. The UK Def Stan and to some extent the two EN / IEC 60068 tests are not perscriptive on severities allowing a degree of flexibility to be adopted. Whilst, the Def Stan & EN / IEC tests both include Drop & Topple neither include Bench Handling tests. The vertical impact tests include drops onto each face, corner and edge.

The US Mil Std does not reflect the two EN / IEC 60068 test to any real extent. Moreover, the vertical impact severities are perscriptive and based upon mass of the item. The French GAM test procedures are somewhat similar to the US Mil Std but do include a greater contribution from the two EN / IEC 60068 tests. The vertical impact severities adopt mass related prescriptive severities but are slightly lower than the US procedure. The US and French tests include bench handling tests although the GAM severity appears to be 10 times that of the US test. The horizontal impact test velocities are identical.

The NATO STANAG incudes three procedures vertical impact., horizontal impact and bench handling. The horizontal impact and bench handling impacts are essentially those of the US Mil Std and GAM standards but with the US severity for bench handling. The vertical impact severity is perscriptive and based upon mass of the item (from the US standard).

Quadripartite (US/UK/F/DE) agreement ITOP 4-2-602 includes 2.1 m drop test as part of a series of rough handling tests. Although the ITOP is stated a encompassing any military equipment, the procedure itself repeatedly makes reference to ammunition. It is clear, that this originated as an ammunition specific procedure, but has had pretentions of grandour it cannot actually achieve. The procedure appears to be based upon the NATO saftey drop test (Stanag 4375) but with a lower drop height. This may be useful for facilities undertaking the safety drop test but it effectively precludes equipment tested to either the both UK & French national standards as well as EN / IEC 60068. Once again the rationale for the existence of the procedures in ITOP 4-2-602 is unclear. Generically the test procedures included in this ITOP (loose cargo vibration, temperature cycling and drop tests) have all existed in commercial standards and national military standards for a very long period. Moreover, the NATO standards 4370 & 4375 both existed when the ITOP was first issued (1996) and last modified (1999). ITOP 7-2-509 contains test procedures related to the airdrop of equipment, this really only relates to testing airdrop arrangements, and those arrangements should be designed to protect the equipment against capabilities derived from other tests. As such this test is has only niche applicability and is not considered further.

In practice the NATO STANAG is the US Mil Std with apparently only modest acknowledgment to other specifications. In particular the procedures differs from the two EN / IEC 60068 tests arguably without apparent good cause. Moreover, the use of perscriptive “hardening” severities for the vertical impact test could be seen as limiting the use of commercial equipment and packaging in circumstances were full military hardening criteria are not necessary. Superficially this would suggest an implication on European industry, however, the various procedures have become so intertwined over the years that the effect is likely to be relatively modest. Moreover, this is not usually adopted for COTS equipment.

6.3.3.3 Safety Drop Test

For systems containing dangerous items and particularly energetic materials a separate set of handling tests are commonly mandated either by national or international requirements. These can be grouped as “safety impact test” in which the equipment would be expected to remain “safe only”. In fact several criteria may be adopted dependant upon purpose and whether the equipment or package is under consideration.

The current UK Def Stan 00-35 Test 5-03 (or FX3) was specifically intended for munitions and impliment the requirements of Stanag 4375 issue 1 as well as the requuirements of an earlier UK Def Stan and the safety drop test of UK specification BR8541 (Explosive Safety Requirements for Armament Stores for Naval Use). The UK Def Stan test was required above and beyond the NATO Stanag 4375 because of the need for a potentially greater drop height and drops onto spigots. Nato Stanag 4375 issue 1 required drops of not less that 12 m onto face and edges of the packaged and / or unpackaged weapon. Following the such drops the munition is required to be safe for disposal only. The impact surface was 75 mm of steel on a substantial concrete or gravel base. As this was a more robust impact surface than had been specified previously a concession to use existing surfaces was included. Nato Stanag 4375 issue 1 include a test to verify the munition was ‘safe to use if no visible damage’. The drop height for this was upto 3m. This aspect of the test has been deleated from the latest Nato Stanag 4375 issue 2. Generally the UK Def Stan includes considerably more information than the STANAG test.

Quadripartite (US/UK/F/DE) agreement ITOP 4-2-601 includes a safety drop test as part of a series of drop tests. The procedure appears to be based upon NATO Stanag 4375 (saftey drop test). The rationale for the existence of the procedures in ITOP 4-2-602 is unclear. The test procedures included in this ITOP (loose cargo vibration, temperature cycling and drop tests) have all existed in commercial standards and national military standards for a very long period. Moreover, the NATO standards 4370 & 4375 both existed when the ITOP was issued (1997).

The UN “Orange” Book (or more formally Recommendations On The Transport Of Dangerous Goods ST/SG/AC.10/Rev.12) contains a drop test which is intended as an international requirements for demonsterating the adequacy of packages when transporting dangerous goods. Dangerous goods in this instance are catagorised as a range of materials one of which is explosives. UN certification against nationally implimented versions of this standard is required before dangerous goods can be transported using most commercial means. This is especially the case for international transportation. Although the test procedure of the UN test is relatively similar to all those so far addressed, the severity and criteria differ.The drop height required for explosives in the drop test set out in the UN standard is significantly less than the heights required in the specifically military tests already addressed. However, the criteria required to be achieved are more demanding. These differences will not normally allow the military safety drop tests to encompass the requirements of the UN test or vice versa.

Stanag 4375 is frequently listed along with a number of other safety tests (fire, bullet impact etc). These are frequently used to demonstrate ‘insensitive munition’ (IM) criteria. However, the safety drop test is not strictly a so called IM test.

6.3.3.4 Shock Response Spectra Based Procedures

The Shock Response Spectra (SRS) test method is a relatively new shock procedure made possible by improvements in test equipments over the last 20 years. The procedure allows simulations of the effects of shocks to be achieved rather than attempting to replicate the source of the shock. In many cases this is potentially more realistic than permitted by the basic shock tests. Additionally, the SRS test method is undertaken on vibration test equipment. As such if vibration testing is also been undertaken, (as is usually the case; additional special test equipment and rigs are not required, reducing both test time and costs. A deficiency of the SRS test method is that an SRS severity is not a unique definition and consequently, unless the procedure is specific, can result in lack of repeatability of testing. The problem is such that it can be difficult for a test specifier to be certain as to the test actually undertaken and whether the assumed damage modes have correctly exercised. The generation of adequate acceptance criteria i.e. tolerancing can also be problematic. This problem of repeatability is made worse by the range of methods and assumptions used in the various commercial software packages used to undertake this test.

The UK Def Stan test is probably the oldest of the procedures and was intended primarily to replicate compound decaying sinusoidal type profiles. The problem of ensuring repeatability was circumvented by requiring the components of the shock time history to be defined. The International EN / IEC 60068-2-57 test procedure was originally intended to simulate the effects of earthquakes but was significantly modified to allow the use of SRS severity definitions. Again the method was based largely around decaying sinusoidal type profiles. The latter International EN / IEC 60068-2-81 test procedure is quite recent and is significantly different to its predecessor as it is centred around the more modern wavelet approach. However, it has limitations in terms of ensuring repeatablity relying mostly on extensive guidance as a means of ensuring repeatability.

The original US Mil Std adoption of the SRS test methods lacked any real test procedure and seemed to be a way of allowing more flexible tolerancing of the classic waveform shock. The French GAM method seems to be a reasonable working compromise between the EN / IEC 60068-2-57 test procedure and the Mil Std. The most recent version of the US Mil Std includes more information than earlier versions, but still does not really address the main testing issues.

Quadripartite (US/UK/F/DE) agreement ITOP 5-2-506 comprises a procedure for shock testing missiles and rockets. It mostly contains a basic pulse shock test procedure but also purports to contain SRS and pyro-shock proceedures. The SRS procedure is extremely basic and seems to be based upon an older Mil Std 810 which is inconsistant with the UK and French national standards and effectively precludes there use. The rationale for the existence of the procedures in ITOP 5-2-506 is unclear. The basic test test procedures included in this ITOP has existed in commercial standards and national military standards for a very long period. Moreover, the NATO standards 4375 both existed when the ITOP was issued (1999).

The latest NATO STANAG method is extensively revised from earlier versions. It appears to encompasses issues from the UK Def Stan, the French GAM method and the Mil Std. In addition it contains a lot of background information on the derivation of SRS severities from measurements. However, it does not seem to address issues related to repeatability and is entirely different to the recent EN / IEC 60068-2-81 test procedure.

The latest NATO STANAG method and the recent the EN / IEC 60068-2-81 test procedure undoubtedly comprise the most up to date SRS methods available. However, they are entirely different from each other and so far both are unproven in the real world testing of equipment. Both give considerable flexability to the test house in the conduct of the test and the waveform actually applied. However, this is a disadvantage to the test specifer who canot necessarily be certain the assumed damage modes have correctly exercised. In contrast the UK Def Stan and the French GAM method have been shown to work and address the problems of associated with ensuring repeatability. However, they do not necessarily allow use of the latest techniques included in commercial control software packages.

6.3.3.5 Pyroshock

This procedure is intended to simulate the effects of high frequency shocks such as those induced by the operation of explosively operated cutters, bolts, line cutting charges etc. It could also be used to simulate other high frequency shocks particularly those arising from high velocity impact. For the most part this type of shock is unique to military equipment, the main exception to this is the separation shocks arising in commercial satellites / boosters. Consequently, it is not surprising that this test method is not contained in any general commercial standards (although it is both an ESA and NASA requirement).

Historically a separate pyroshock test was included in military specifications as it required entirely different test equipment and a different approach to that used for other types of shock. At that time simulating high frequency shocks either required very specialist simulation equipment (gas guns etc) or the reproduction of the event itself (by firing the pyrotechnic device). Since then the simulation of the effects of the using SRS methods has become possible albeit for a limited range of conditions.

The latest US Mil Std procedure supplies advice the test specifier on appropriate strategies for simulating or reproducing shock responses. The US procedure also supplies considerable information on how to measure and quantify the shock environment as well as how to verify that the shock has been adequately reproduced. However, it has to be said that the source of this information (an IEST working practices document originally commissioned by the US DOD) is far more comprehensive. As a considerable range of test equipment may be adopted then the procedure is able to give only basic information in this regard. The Mil Std procedure has been enhanced significantly over the years as better simulation and verification methods because more readily available. The French GAM EG13 procedure is slightly older than the latest US Mil Std procedure (or more accurately has not been updated quite as recently) and consequently does not encompass the latest information and methods. However, it is essentially equivalent to the preceding version of the Mil Std.

Quadripartite (US/UK/F/DE) agreement ITOP 5-2-506 comprises a procedure for shock testing missiles and rockets. It mostly contains a basic pulse shock test procedure but also purports to contain SRS and pyro-shock proceedures. The pyro-shock procedure is extremely basic and seems to be based upon parts of Mil Std 810. Once again the rationale for the existence of the procedures in ITOP 5-2-506 is unclear. The basic test test procedures included in this ITOP has existed in commercial standards and national military standards for a very long period. Moreover, the NATO standards 4375 both existed when the ITOP was issued (1999).

The latest NATO STANAG method was revised from earlier versions as well as the latest version of the US Mil Std procedure. It appears to based largely on the Mil Std with additional information but would seem to adequately encompass the relevant aspects of the French GAM EG13 procedure. As such the NATO STANAG would seem to be the best document available. Although firmness of the standard could be an issue with the STANAG, in practice documentation for this type of test is mostly treated as guidance because of the range of methods that can be adopted. Nevertheless if repeatability were essential the user would need to re-write the document.

6.3.3.6 Rail Impact

The rail impact test procedure is essentially intended to simulate the effects of rail shunting shocks on packaged goods. Two different strategies are observed to be adopted by the different standards reviewed. The strategy adopted by one group of standards is simulate the actual rail shunting / impact conditions by forcing rail wagons into one another at defined velocities. The other strategy is to simulate the effects of the impact using procedures such as the classic waveform test procedure with appropriate test severities.

Earlier versions of the US Mil Std test appear to have been based upon a US Federal Test in which rail cars are subject to impact of various velocities. Historically the US Federal Test was utilised for large commercial equipment viz. by US and European car manufacturers. The latest version of the Mil Std has substantially modified the original procedure but it is still US rail system specific and needs to be done with rail wagons.

The French standard GAM-EG-13 also contains a rail impact test. Whilst., this procedure also requires complete rail wagons, very little definitive information is contained in GAM-EG-13.

EN / IEC 60068 does not contain a specific rail procedure, although EN / IEC 60721 (the associated environmental severities) does encompass rail shock by means of classic waveform test procedure. A similar strategy is adopted in the UK standard 00-35 for reasons set out below.

NATO Stanag 4370 contains three procedures; two of these impact loaded rail wagons to produce the shock, the third allows laboratory simulation using either the classic waveform test or the SRS procedures. Of the two procedures that impact loaded rail wagons, one is stated as mandatory for the US rail system (although why it should be mandatory is not clear) the other is indicated as a requirement for the European rail system (again why it should be a requirement is not clear). The required amplitude severities for the latter are quoted, are modest and can be sensibly achieved on laboratory equipment.

In recent times rail shock severities on the European rail systems have decreased substantially. This is because European rail vehicles now use better buffing equipment (hydraulic buffers produce much lower shocks than spring) and more significantly as operating procedures have changed. The latter reducing and eliminating shunting impacts because rail train sets are rarely broken into individual vehicles (especially when loaded). Today the need for a specific procedure to reproduce rail impact appears to originate almost entirely from consideration of the US rail system. For European defence equipment laboratory simulation is the only cost effective and practical approach, that is if a test is needed at all.

The NATO Stanag 4370 appears to contain the most options for undertaking such. However, the European need for such a test is doubtful and the severities (significantly exceed) the European need and commercial standards such as EN / IEC 60721.

6.3.3.7 Undex Test

The simulation of the shock effects from non-contact explosions adjacent to warships have historically used a range of specialist facilities. Generally each of the various facilities had accompanying specific test procedures. Consequently, the test was not usually included in more general military procedures. A move towards the use of a broader range of test facilities has necessitated the inclusion of appropriate test procedures in military procedures. As the type of test is entirely military, no commercial equivalents are available. Of the procures reviewed the UK Def Stan 00-35 includes a very basic procedure aimed at setting up the test but does not include information on tolerances or severities. The NATO Stanag 4370 contains a specific and recent procedure. The procedure contains extensive guidance and allows the use of both general and specific equipment. It also includes information on tolerancing.

6.3.3.8 Ballistic Shock

The Ballistic shock test method simulates a high-level transient shock that generally results from the impact of projectiles or ordnance on armoured combat vehicles, hardened targets, or other structures. Such impact may produce a very high rate of momentum exchange at a point, over a small finite area or over a large area. The high rate of momentum exchange may be caused by collision of two elastic bodies or a pressure wave applied over a surface. Ballistic shock can be considered as a specific application of transient or pyrotechnic shock.

Historically a separate ballistic shock test was included in military specifications as it required entirely different test equipment and a different approach to that used for other types of shock.

The latest NATO STANAG method is effectively identical to the latest US Mil Std procedure. Whilst, the Stanag is somewhat more readable than the Mil Std, the severity defined as a Shock Response Spectra is not included in the Stanag making it essentially inoperable. The test does not appear in French military specification GAM EG13 or the UK Def Stan 00-35. Arguably the ballistic shock requirement is included in those standards within the generic shock test procedures. As it is entirely a military requirement the test method does not exist in IEC or EN commercial standards.

Both the latest NATO Stanag and the Mil Std 810 methods includes several sub-procedures

- i. Ballistic Hull & Turret
- ii. Large Scale Ballistic Shock Simulator
- iii. Light Weight Shock Machine
- iv. Medium Weight Shock Machine
- vi. Drop Table

The first of these sub-procedures uses actual conditions and hence is not strictly a laboratory test. The last sub-procedure uses a commonly available basic drop test facility but the sub-procedure is only permitted for items below 40 Kg. The remaining three sub-procedures relate to US specific facilities which would be expensive to reproduce in Europe. Moreover, alternative methods of simulating ballistic shock, gas guns etc, are not addressed. It has to be concluded that the adoption of the Stanag ballistic shock test could put European industry at a disadvantage. This could be easily resolved in the procedure is written in terms of the real requirement rather than as a procedure relating to specific types of equipment.

6.3.3.9 Catapult Launch /Arrested Landing

The US Mil Std has included, a virtually identical, catapult launch / arrested landing shock test procedure, since almost the earliest version. The test has limited application for Naval aircraft equipment and weapons. It is a relatively simple decaying sinusoidal waveform of modest amplitude (about 2 g). In most cases the severities are likely to significantly encompassed by other environments. Today the test can readily be undertaken on various shock test equipment. The French GAM-EG-13 references a severity for the environment but has no specific procedure rather uses existing shock test procedures. Similarly, the only reference to catapult launch / arrested landing in the UK Def Stan is a severity that uses the SRS test method as the appropriate procedure. Of all the available procedures (but not necessarily intended for this environment) the one that would best replicate this environment is the SRS test procedure of EN / IEC 60068-2-57 time history test procedure. That procedure is essentially the SRS procedure for low frequency applications (earthquakes). Whilst, the EN / IEC procedure is currently the most applicable and up to date method published, a soon to be published revision to the UK Def Stan would be more applicable.

With todays equipment the catapult launch / arrested landing transient can easily be reproduced using existing procedures such as the SRS method. The latest NATO Stanag method does not include a specific test procedure but the SRS procedure could easily be adapted. This seems to align with current thinking that a specific test procedure for this is not required.

6.3.3.10 Bump

The bump test has similar providence to the classic waveform or basic shock test procedure. It is quite an old test using relatively simple mechanical test equipment and allowed the application of repetitive shocks of reasonable amplitude at a time when vibration test equipment was expensive and not widely available. A test using this procedure typically utilises several a half sine pulse, repetitively applied, with a few seconds interval between each pulse. None of the procedures specify a particular item of test equipment, but test equipment specifically for this procedure are relatively cheap and widely available.

The test is generally not considered to replicate a particular environmental condition but rather to demonstrate equipment has a degree of hardness against shock and vibration conditions. It has been used historically by many COTS component and sub-system suppliers (both military and commercial) to indicate the capability of their equipment. Although used to a lesser extent today it is still common to see the test listed in technical specifications for smaller electrical and mechanical components. It is important therefore that the test procedure is common to both commercial and military equipment.

As was also the case for the classic waveform or basic shock test procedure, the UK and French national defence standards have, by design, historically adopted the same basic procedure of the International standard that is now EN / IEC 60068. The test set up, the tolerances on the pulses and the general confirmation tolerances are all identical. The test procedure does not appear in the US standard nor is it addressed in the NATO Stanag. The argument for the latter is that it does not replicate a particular environmental condition.

Although, the original rationale for this test has long been superseded, it is still used by suppliers of COTS and OEM equipment to demonstrate the ruggedness of components and subsystems. For this reason, commonality between commercial and military procedures is highly desirable. Both the UK and French military standards align with the procedure of EN 1 IEC 60068. The test does not appear in NATO Stanag 4370 largely because it does not replicate a particular environmental condition.

6.3.4 Conclusions

A summary of the recommendations is shown in the table below which is expanded in the following paragraphs.

Summary of Recommendations for Shock Test Procedures						
	NATO STANAG 4370 AECTP	International EN / IEC 60068	UK Def Stan 00-35	US Mil Std 810F	France GAM-Eg-13	Quadripartite US/UK/F/DE ITOP
Classical waveform shock	Nearly equivalent to European standards	Jointly Recommended Procedure common to UK / F standards	Equivalent to EN/ IEC 60068	Significantly differs from other standards	Equivalent to EN/ IEC 60068	Reflects US test procedure
Handling & drop	Recommended but concerns over differences with EN/ IEC 60068	Jointly Recommended Procedure common to UK / F standards	Equivalent to EN/ IEC 60068	Differs from other standards	Essentially equivalent to EN/ IEC 60068	Significant reservations (cut down safety drop test)
Safety drop test	Stanag 4375 Recommended	UN "Orange" book drop test also required	Implements STANAG with additions	No equivalent test.		Reservations (differs from Stanag)
SRS shock	Recommended but with concerns on repeatability	Various versions of procedure exist in all standards but differences exist				Reflects US test procedure
Pyroshock	Recommended	No test procedure.		Early version of STANAG	Included by STANAG	Reflects US test procedure
Rail impact	Recommended but question European need	Various procedures and severities exist in all standards but differences exist particularly in severity, reflecting different systems				No equivalent test.
Undex test	Recommended	No equivalent test.	Inadequate as Procedure	No equivalent test.		
Ballistic shock	Recommended but with reservation on disadvantage imposed on European industry	No specific test procedure		Same as STANAG procedure	No specific test procedure.	Reflects US test procedure
Catapult	No specific test but SRS method could be adopted	Recommended but question need	No specific test but SRS method could be adopted	Specific but old fashioned procedure	No specific test but SRS method could be adopted	No equivalent test.
Bump	No equivalent test.	Recommended but question need	Equivalent to EN/ IEC 60068	No equivalent test.	Equivalent to EN/ IEC 60068	No equivalent test.

The simulation of shock events encompasses a wide range of requirements and has historically utilised a wide range of test equipment. Many of the shock methods date back around 50 years when they needed to adopted innovative approaches to allow the simulation of shock events. Whilst, shock analysis & verification methods also date back around 50 years, the common use of these has only been practical with high speed digital computing. In recent years viable techniques to allow representative shocks to be undertaken on vibration test equipment has become commonly available. Just as importantly, the experience to use such facilities has been more widely promulgated.

Historically a number of shock tests have been essentially unique to the military field with little or no general commercial application. Although, with modern methods the distinction has become less clear, the more difficult and specialist methods still remaining the province of only the military test facility. It is not surprising then that in such cases no real commercial test procedures are available. The NATO Stanag appears to comprises the most comprehensive specification incorporating all the specialist test requirements. It also encompasses the requirements of the national military specifications. Moreover, NATO Stanag specification seems to be the most up to date incorporating options that have recently become viable.

The above notwithstanding for a number of shock test types commercial equivalents are available and have been for some considerable time. As some of these tests are used by supplier of COTS and OEM equipment, commonality with commercial procedures is important. The European national military specifications reviewed here appear to take cognisance of this and in such cases reflect the commercial equivalents. That does not seem to be the case for the US national specification which is markedly different from commercial equivalents. The NATO Stanag reflects the essence of both European and US requirements and the resultant compromise does not align as well with the commercial procedures as did the European national military specifications.

6.3.4.1 The Classic Waveform or Basic Shock Test

The Classic Waveform or Basic Shock Test is used by suppliers of COTS equipment commonality between commercial and military procedures is highly desirable. Both the UK and French military standards align with the procedure of EN / IEC 60068. Mostly that is also the case for NATO Stanag 4370, although the form and tolerances on one pulse type differ for no apparently good reason. The procedure of US Mil Std 810F differs from all the other standards to a significant extent. Moreover, the US Mil Std permits an “alternative” process which can result in yet greater variations.

In summary, the difference between the UK and French military standards and EN / IEC 60068. Is insignificant and any of these could be adopted. The US Mil Std 810 procedure differs from all others to an extent that its adoption could be considered a disadvantage to European industry. The NATO STANAG 4370 military standard has the potential to replace any other European military standard or commercial procedures if it were not for ensuring total commonality. Unfortunately, this type of test procedure is likely to be used for COTS equipment and further work is need to align the details of STANAG to European and commercial standards. For this reason the procedure either of the UK and French military standards or EN / IEC 60068 could be recommended.

6.3.4.2 The Handling Test

The Handling Test comprises several procedures. The NATO STANAG incudes three procedures vertical impact., horizontal impact and bench handling. The horizontal impact and bench handling impacts are essentially those of the US Mil Std and GAM standards but with the US severity for bench handling. The vertical impact severity is perscriptive and based upon mass of the item (from the US standard). In practice the NATO STANAG is the US Mil Std with apparently only modest acknowledgment to other specifications. In particular the procedures differs from the two EN / IEC 60068 tests arguably without apparent good cause. Moreover, the use of perscriptive “hardening” severities for the vertical impact test could be seen as limiting the use of commercial equipment and packaging in circumstances were full military hardening criteria are not necessary.

The NATO STANAG 4370 military standards currently cannot be considered a replacement for European military standard or commercial procedures. This type of test procedure is likely to be used for COTS equipment and commonality with commercial standards is . For this reason the procedure either of the UK and French military standards or EN / IEC 60068 could be recommended.

6.3.4.3 The Safety Drop Test

For systems containing dangerous items and particularly energetic materials a separate set of handling tests are commonly mandated either by national or international requirements. These can be grouped as “safety impact test” in which the equipment would be expected to remain “safe only” or “safe only for disposal”.

The main test procedure is Nato Stanag 4375 requires drops of not less that 12 m onto face and edges of the packaged and / or unpackaged weapon. The impact surface is enhanced from previous definitions but the procedure is backwardly with existing surfaces. The current UK Def Stan 00-35 Test sets requirements above and beyond the NATO Stanag 4375 because of specific UK need for a potentially greater drop heights and drops onto spigots. ITOP 4-2-601 includes a safety drop test as part of a series of drop tests. The procedure appears to be based upon NATO Stanag 4375 (saftey drop test). Stanag 4375 is frequently listed along with a number of other safety tests (fire, bullet impact etc). These are frequently used to demonstrate 'insensitive munition' (IM) criteria. However, the safety drop test is not strictly a so called IM test.

The UN "Orange" Book (or more formally Recommendations On The Transport Of Dangerous Goods ST/SG/AC.10/Rev.12) contains a drop test which is intended as an international requirements for demonsterating the adequacy of packages when transporting dangerous goods.The drop height required for explosives in the drop test set out in the UN standard is significantly less than the heights required in the specifically military tests already addressed. However, the criteria required to be achieved are more demanding. These differences will not normally allow the military safety drop tests to encompass the requirements of the UN test or vice versa.

The NATO STANAG 4375 encompasses other national military requirements and is consequently recommend. However, this test does not encompass the UN Transport Of Dangerous Goods drop test which may also additionally be required.

6.3.4.4 The Shock Response Spectra Test

The Shock Response Spectra Test included in the latest NATO Stanag method is extensively revised from earlier versions. It appears to encompasses issues from the UK Def Stan, the French GAM method and the Mil Std. The latest NATO Stanag method and the recent the EN / IEC 60068-2-81 test procedure undoubtedly comprise the most up to date SRS methods available. However, they are entirely different from each other and so far both are unproven in the real world testing of equipment. Both give considerable flexability to the test house in the conduct of the test and the waveform actually applied. However, this is a disadvantage to the test specifer who canot necessarily be certain the assumed damage modes have correctly exercised. In contrast the UK Def Stan and the French GAM method have been shown to work and address the problems of associated with ensuring repeatability. However, they do not necessarily allow use of the latest techniques included in commercial control software packages.

In summary, the primary reason for shock testing in military applications differs from that of commercial applications. Nevertheless, ideally, the actual test procedures for military and commercial applications should be interchangeable. Of the military standards NATO STANAG 4370 is the most sophisticated and uses the most up to date methods, it is consequently recommended. However, the approach is not well proven in real world use and does not address repeatability particularly well. If repeatability is an issue a test specifier may find thee UK Def Stan and the French GAM method are more useful.

6.3.4.5 The Pyrotechnic Test

The Pyrotechnic test procedure is intended to simulate the effects of high frequency shocks such as those induced by the operation of pyrotechnic operated cutters, bolts, line cutting charges etc. Mostly this type of shock is unique to military equipment, the main exception is the separation shocks arising separation systems in commercial satellites / boosters. Consequently, it is not surprising that this test method is not contained in general commercial standards, excepting specialist ESA or NASA requirements. The latest NATO Stanag method is updated from earlier versions as well as the latest version of the US Mil Std procedure. It appears to based largely on the Mil Std with additional information but would seem to adequately encompass the relevant aspects of the French GAM EG13 procedure.

In summary, the NATO Stanag appears to encompass existing tests and is consequently recommended.

6.3.4.6 The Rail Impact Test

The rail impact test procedure is essentially intended to simulate the effects of rail shunting shocks on packaged goods. Two different strategies are observed; one to replicate the actual rail shunting / impact conditions by forcing rail wagons into one another at defined velocities, the other strategy is to simulate the effects of the impact using procedures such as the classic waveform test procedure with appropriate test severities.

The latest version of the Mil Std has substantially modified earlier (Federal) procedures but it is still US rail system specific and needs to be done with rail wagons. The French standard GAM-EG-13 also contains a rail impact test. Whilst., this procedure also requires complete rail wagons, very little definitive information is contained in GAM-EG-13. EN / IEC 60068 does not contain a specific rail procedure, although EN / IEC 60721 (the associated environmental severities) does encompass rail shock by means of classic waveform test procedure. A similar strategy is adopted in the UK Defence Standard 00-35. NATO Stanag 4370 contains three procedures; two of these impact loaded rail wagons to produce the shock, the third allows laboratory simulation using either the classic waveform test or the SRS procedures. Of the two procedures that impact loaded rail wagons, one is stated as mandatory for the US rail system (although the justification for the mandatory statement is questionable) the other is indicated as a requirement for the European rail system (the justification is questionable).

In recent times rail shock severities on the European rail systems have decreased substantially. This is because European rail vehicles now use better buffing equipment (hydraulic buffers produce much lower shocks than spring) and more significantly as operating procedures have changed. The latter reducing and eliminating shunting impacts because rail train sets are rarely broken into individual vehicles (especially when loaded). Today the need for a specific procedure to reproduce rail impact appears to originate almost entirely from consideration of the US rail system. For European defence equipment laboratory simulation is the only cost effective and practical approach, that is if a test is needed at all.

In summary, the NATO Stanag 4370 appears to contain the most options but contains implied requirements for testing and the severities which do not align with commercial standards such as EN / IEC 60721. Concern exists that the STANAG may be over specifying requirement to meet US criteria which do not exist in Europe. Nevertheless as a procedure the STANAG is reccomended.

6.3.4.7 The Undex Test

The Undex Test simulates the shock effects from non-contact explosions adjacent to warships. The test has historically used a range of specialist facilities. Generally each of the various facilities had accompanying specific test procedures. Consequently, the test was not usually included in more general military procedures. A move towards the use of a broader range of test facilities has necessitated the inclusion of appropriate test procedures in military procedures. As the type of test is entirely military, no commercial equivalents are available. Of the procures reviewed the UK Def Stan 00-35 includes a very basic procedure aimed at setting up the test but does not include information on tolerances or severities. The NATO Stanag 4370 contains a specific and recent procedure. The procedure contains extensive guidance and allows the use of both general and specific equipment. It also includes information on tolerancing.

In summary, as a test the NATO Stanag 4370 is really the only coherent procedure as such is recccomended.

6.3.4.8 The Ballistic Shock Test

The Ballistic Shock Test method simulates a high-level transient shock that generally results from the impact of projectiles or ordnance on armoured combat vehicles, hardened targets, or other structures. The latest NATO Stanag method is effectively identical to the latest US Mil Std procedure, although without severity information. The test does not specifically appear in French military specification GAM EG13 or the UK Def Stan 00-35 although it could be argued that it is included within the generic shock procedure. As it is entirely a military requirement the test method also does not exist in IEC or CEN commercial standards. The main issue with both the Mil Std and Stanag procedures is that three of the five sub-procedures utilise US test facilities. Moreover, the only sub-procedure that uses facilities that are commonly available in Europe has limited applicability to equipment with a mass of 40 Kg.

In summary, although the STANAG procedure is recommended, it is with significant reservations as to the disadvantages it imposes on European industry. Also the absence of severities in the Stanag makes the procedure of doubtful practical value. These issues could be resolved with further work to define requirements as is the norm in Europe rather than cook book procedures to use specific test equipment which seems to be the norm in the US.

6.3.4.9 The Catapult Launch /Arrested Landing Test

The Catapult Launch / Arrested Landing Test has appeared in the US Mil since almost the earliest version. The test was intended for Naval aircraft equipment and weapons. The French GAM-EG13, the UK Def Stan and the NATO Stanag refer to a severity but use the existing SRS procedure. If a test is required the SRS test procedure of EN / IEC 60068-2-57 time history test procedure is the most up to date and applicable.

In summary, the EN / IEC 60068-2-57 time history test procedure is the most applicable and up to date procedure even if it was not intended for this application. With that said, the SRS test procedure included in all the defence standards can easily be adapted to this environment if its ever required. Currently such a need is highly questionable given the modest conditions compared with other environments Naval aircraft equipment and weapons are likely to experience.

6.3.4.10 The Bump Test

The Bump Test uses relatively simple test equipment and allowed the application of repetitive shocks of reasonable amplitude at a time when vibration test equipment was not widely available. A test using this procedure typically utilises several a half sine pulse, repetitively applied, with a few seconds interval between each pulse. Although, the original rationale for this test has long been superseded, it is still used by suppliers of COTS and OEM equipment to demonstrate the ruggedness of components and subsystems. For this reason, commonality between commercial and military procedures is highly desirable. Both the UK and French military standards align with the procedure of EN / IEC 60068. The test does not appear in NATO Stanag 4370 largely because it does not replicate a particular environmental condition.

In summary, the procedure of EN / IEC 60068 is reflected in other standards which still contain this test. As a procedure to test both assemblies and sub-assemblies, it is undoubtedly inappropriate, it may still have value for components, but only to a limited extent.

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6.4 Review and Comparison of Miscellaneous Mechanical Test Methods

6.4.1 Standards Under Consideration

The standards reviewed and compared with regard miscellaneous mechanical conditions are set out in the following table.

Matrix Environmental Test Methods vs Standards						
	NATO STANAG 4370 AECTP (Method No)	International EN / IEC 60068 Part 2 (60068-2-xx)	UK Def Stan 00-35 Part 3 (Chapter / test)	US Mil Std 810F (Test No / Procedure)	France GAM-Eg-13 (Method / Procedure)	Quadripartite US/UK/F/DE ITOP (Test No)
CONSTANT ACCELERATION	404	7	2-13 / M13	513	1st Part method 45	
BOUNCE / LOOSE CARGO	406	55	2-11 / M11	514 Procedure II	1st Part method 42 - procedure 5	4-2-602
MATERIEL TIEDOWN	407					
MOTION PLATFORM	418					
LARGE ASSEMBLY TRANSPORT	408		2-14 / M14	514 Procedure III	1st Part method 42 - procedure 4	
MATERIEL LIFTING	409		2-15 / M15			
MATERIEL STACKING	410	UN “Orange” Book ST/SG/AC.10/ Rev.12	2-16 / M16			
MATERIEL BENDING	411		2-17 / M17			
MATERIEL RACKING	412		2-18 / M18			

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6.4.2 Standard Comparison

Test	Scope & Limitations
Constant Acceleration	**STANAG 4370 AECTP 400 METHOD 404** Purpose. The purpose of this test method is to replicate the acceleration environment incurred by systems, subsystems and units, hereafter called materiel, during the specified operational conditions. Application. This test method is applicable where materiel is required to demonstrate its adequacy to resist the specified acceleration environment without unacceptable degradation of its functional and/or structural performance. It is applicable to materiel that is installed in aircraft, helicopter, air carried stores, surface launched missiles, and missiles in free flight. Limitations. This test method takes no account of the rate of change of acceleration. The test method also does not include procedures for combined static acceleration and vibration testing. **EN/IEC 60068-2-7** Object To prove the structural suitability and the satisfactory performance of components, equipment and other electrotechnical products, hereinafter referred to as “specimens”, when subjected to forces produced by steady acceleration environments (other than gravity) such as occur in moving vehicles, especially flying vehicles, rotating parts and projectiles, and to provide a test of structural integrity for certain components. General Equipment, components and other electrotechnical products intended to be installed in moving bodies will be subjected to forces caused by steady accelerations. Naturally, such an environment is most pronounced in flying vehicles and rotating machinery, although in certain conditions accelerations in land vehicles may be of significant magnitude. In general, the accelerations encountered in service have different values along each of the major axes of the moving body, and, in addition, usually have different values in the opposite senses of each axis. **DEF STAN 00-35 Test M13** The purpose of the test is to demonstrate satisfactory performance and structural integrity of both sub-assemblies and equipments subject to forces induced by steady accelerations which can occur in vehicles, aircraft, guided weapons, rotating parts and projectiles. This test is intended to be applied by centrifuge. When a facility other than a centrifuge is required this test procedure may have general applicability. This test is technically similar to that contained in BS EN 60068-2-7 - 'Acceleration, steady state’, except for the following differences :

Test	Scope & Limitations
	- Additional levels have been included for aerospace application - A paragraph has been added referring to alternative test facilities - Additional steps in the test procedure have been added **MIL STD 810 F METHOD 513** The acceleration test is performed to assure that materiel can structurally withstand the steady state inertia loads that are induced by platform acceleration, deceleration, and manoeuvre in the service environment, and function without degradation during and following exposure to these forces. Acceleration tests are also used to assure that materiel does not become hazardous after exposure to crash inertia loads. Application. This test method is applicable to materiel that is installed in aircraft, helicopters, manned aerospace vehicles, air carried stores, and ground-launched missiles. Limitations. Acceleration. As addressed in this method, acceleration is a load factor (inertia load, "g" load) applied slowly enough and held steady for a period of time long enough such that the materiel has sufficient time to fully distribute the resulting internal loads, and such that dynamic (resonant) response of the materiel is not excited. Where loads do not meet this definition, more sophisticated analysis, design, and test methods are required. Aerodynamic loads. Materiel mounted such that any or all surfaces are exposed to aerodynamic flow during platform operations are subject to aerodynamic loads in addition to inertia loads. This method is not generally applicable to these cases. Materiel subject to aerodynamic loads must be designed and tested to the worst case combinations of these loads. This often requires more sophisticated test methods usually associated with airframe structural (static and fatigue) tests. Acceleration versus shock. Acceleration loads are expressed in terms of load factors which, although dimensionless, are usually labelled as "g" loads. Shock environments (methods 516.5 and 517) are also expressed in "g" terms. This sometimes leads to the mistaken assumption **GAM EG 13 1st Part method 45** Purpose of the Test. To check that the equipment resists structurally and operates correctly, when subjected to the constant linear accelerations resulting from its use.
Bounce / Loose Cargo	**STANAG 4370 AECTP 400 METHOD 406** Purpose. The purpose of this test method is to replicate the effects of the transportation shock environment incurred

Test	Scope & Limitations
	by systems, subsystems and units, hereafter called materiel, during transportation as loose cargo in vehicles. In particular, this test method accommodates the unrestrained collision of materiel with the floor and sides of the cargo load bed and with other cargo. Application. The test method is applicable where materiel is required to demonstrate its adequacy to resist the loose cargo environment without unacceptable degradation of its functional and/or structural performance. AECTP's 100 and 200 provide additional guidance on the selection of a test procedure for related vibration and shock environments during transportation. Limitations. This method does not address vibrations as induced by secured cargo transportation or transportation of installed materiel, nor individual shocks or impacts inflicted during handling or accidents. **EN/IEC 60068-2-55** Introduction. This test is applicable to components, equipment and other electrotechnical products, hereinafter referred to as "specimens", which, during transportation on the load-carrying platform of vehicles either not fastened down or with some degree of freedom, may be subjected to dynamic stresses resulting from random shock conditions. The bounce test may also be used as a means of assessing the satisfactory design of a specimen so far as its structural integrity is concerned. NOTE – In practice, this test is primarily applicable to equipment-type specimens. Object. To provide a standard procedure for determining the ability of a specimen to withstand specified severities of bounce. General description. This test is primarily intended for specimens prepared for transportation, including specimens in their transport case when the latter may be considered as part of the specimen itself. Wherever possible, the test severity applied to the specimen shall be related to the operational environment to which the specimen will be subjected during transportation. The relevant specification shall state the criteria upon which the acceptance or rejection of the specimen is to be based. Normally, for this test the specimen is not functioning and it is sufficient that it should survive the conditioning. **DEF STAN 00-35 Test 2-11 / M11** This test applies to packaged items, or any item in its intended state for transportation, either of which may be carried as cargo by wheeled vehicles traversing irregular surfaces where the cargo has some freedom, however slight, to bounce, scuff, or collide within the confines of the vehicle cargo space. The bounce test is not intended as a replacement for the vibration test. It is intended to simulate the repeated shock conditions which loose cargo would experience when being transported over severe terrain. For very large equipments and for equipments that form a high proportion of the vehicle gross weight, Test M14 - 'Test track trial' (see Chapter 2-14) may be more suitable. This test is technically similar to that contained in BS EN 60068-2-55 - Bounce.

Test	Scope & Limitations
	MIL STD 810 F METHOD 514 Procedure II The method contained herein is a general representation based on experience as well as measurement, and is not tailorable. The most realistic alternative for truck, trailer, or other ground transportation is to utilise Procedure III. Note that Procedure III requires the transportation vehicle and a full cargo load. **GAM EG 13 1st Part Method 42 - Procedure 5** Vibration Test Simulating Transport on Land without Stowing (Rebound) Applicability. This test is performed on equipment designed to be transported unpacked or packed , without stowing on the vehicles. The cargo may rebound, knock against each other and strike the walls of the transport vehicle. **ITOP 4-2-602** This ITOP provides guidance for testing the ability of military items to withstand the shocks encountered during transportation to or employment on the battlefield. Based on experience and engineering judgement, procedures may be altered to accommodate variations in item and packaging configuration. In general, rough handling tests are performed on those items carried as unsecured cargo in trucks, or on the person of soldiers. These items include: munitions, rifles, rockets, radios, and mortars. Secured-cargo vibration tests simulating transport of packaged items by rail, air, ship, trailer, and truck, including packaged tied-down transportation on the battlefield, are not considered as “rough handling” tests, nor are tests of installed equipment or stowed ammunition. Vibration tests are covered by ITOP I-2-601. The 3m and 12m drop test is part of ITOP 4-2-601b. For ammunition, the rough handling test is just one phase of the safety testing of ammunition covered by ITOPS 4-2-504 (1)C, (2)d, and (3)e. While the test procedures described herein are directly related to ammunition, the procedures may also be used to test other commodities, as applicable. Limitations. This ITOP does not cover vibration testing which is covered in ITOP 1-2-601.
Material Tie Down	**STANAG 4370 AECTP 400 METHOD 407** Purpose. The purpose of this test method is to represent the loads incurred by materiel, including containers, during specified tiedown conditions. Application. This test method is applicable where materiel is required to demonstrate its adequacy to resist, during tiedown, the specified loads without unacceptable degradation of its structural and/or functional performance. It is particularly applicable to materiel having integral attachments such handles, eye bolts and shackles. Limitations. This test does not address materiel performance while it is tied down.
Motion Platform	**STANAG 4370 AECTP 400 METHOD 418** Purpose. The purpose of this test method is to replicate the motion platform conditions incurred by systems,

Test	Scope & Limitations
	subsystems and units, hereafter called materiel, during the specified operational conditions. Application. This test method is applicable where materiel is required to demonstrate its adequacy to resist the specified motion platform environment without unacceptable degradation of functional and/or structural performance. The most common environment for induced platform motion is a large ship during a rough sea state condition. For combined axis, multi-degree of freedom motion, see Method 421. Limitations. This test is not intended to represent any motion of the materiel mounting platform other than rigid body motion. Use of Measured Data**.** Where practical, measured field operational information should be used to tailor the test levels. Sufficient data should be obtained to adequately describe the conditions being evaluated and experienced by the materiel in each LCEP phase. The measured data and information acquired should as a minimum be sufficient to account for the data variances due to the distribution of the transport platform condition and age, payload capacity and restraint system, operational personnel, and the environmental operating conditions.
Large Assembly Transport	**STANAG 4370 AECTP 400 METHOD 408** Purpose. The purpose of this method is to replicate the vibration and shock environment incurred by large assemblies of materiel installed or transported in wheeled or tracked vehicles. In this test method, the specified vehicle type is used to provide the mechanical excitation to the installed or transported assembly. Application. This test is applicable to: Materiel comprising a large assembly, Materiel forming a high proportion of the vehicle gross mass, Materiel forming an integral part of the vehicle, and which is required to demonstrate its adequacy to resist the specified ground mobility conditions without unacceptable degradation of its functional and/or structural performance. This test method is also applicable where a laboratory test such Test Method 401 - Vibration, or Test Method 406 - Loose Cargo, may not be practical or cost effective. AECTPs 100 and 200 provide additional guidance on the selection of test procedure for ground mobility conditions. Limitations. None specified. **DEF STAN 00-35 Test 2-14 / M14** This test is applicable to very large equipments, to equipments forming a high proportion of the vehicle gross weight, and to equipments which form an integral part of the vehicle which have to function or survive when installed or transported in wheeled or tracked vehicles. This test is also applicable where a laboratory test such as Test M1 - 'Basic Vibration test' (see Chapter 2-01) or Test M11 - 'Wheeled vehicle transportation bounce test' (see Chapter

Test	Scope & Limitations
	2-11) may not be practical or cost effective. There is no equivalent British Standard Test. **GAM EG 13 1st Part Method 42 - Procedure 4** Procedure 4 - Vibration Test Simulating the Transport on Land of Large Assemblies Applicability. The test is applicable to assemblies transported, not in operation, unpacked or in shelters whose dimensions are too large for them to be tested on a vibration generator. The whole of the test item, in a shelter if necessary, is mounted on a vehicle representing the transport, to which a route over a suitable track is imposed for a time, equivalent from the point of view of damage, to that scheduled in transport.
Materiel Lifting, Stacking, Bending And Racking Tests	**STANAG 4370 AECTP 400 METHOD 409, 410, 411, 412** Purpose. The purpose of these test method is to represent the loads incurred by materiel, including containers, during specified lifting, stacking, bending and racking conditions. Application. This test is applicable when materiel is required to demonstrate its adequacy to resist the specified loads during lifting, stacking, bending and racking without unacceptable degradation of the structural and/or functional performance. The lifting method is applicable to lifting attachments on materiel such as handles, eye-bolts and their attachments to the materiel, fork lift attachments, provision for grabs, as well as materiel which is not provided with any specific lifting device. The stacking method is applicable to materiel structural elements that may be subjected to the compressive loads applied to materiel on the bottom of a stack of identical materiel. It is also applicable to materiel that may be subjected to side compression loads that are applied while materiel is being lifted by a net. The bending method is applicable to materiel structural elements that may be subjected to the bending loads caused by it's own mass and/or by top loading with other materiel of different mass and proportions. Limitations. The lifting test method is not applicable to snatch loading conditions and is only applicable to individual items of materiel. When several items are to be handled as a single load, the test Instruction must state the test requirements. The stacking test is not applicable for the simulation of rapidly applied loads that may occur during drop conditions, that could arise during the handling and stacking of materiel. The bending test is normally limited only to materiel whose length exceeds four times the smallest cross sectional dimension. The use of the racking test is normally limited only to materiel in excess of 225 kg (496 lb) gross weight. **DEF STAN 00-35 Test 2-15/ M15 to 2-18/ M18** Test M15 - Lifting Test. The purpose of this test is to demonstrate that container lifting arrangements meet their performance and safety requirements. This test is applicable to such lifting attachments on containers as handles, eye bolts and their attachments to the container, fork lift attachments, and provision for grabs, as well as containers which are not provided with any specific lifting device. This test is only applicable to strap assemblies to BS 2837 and lifting arrangements for individual containers. When a stack of containers is to be handled as a single load, the Environmental Test Specification must state the test requirements for the lifting arrangements. There is no equivalent

Test	Scope & Limitations
	British Standard test. Test M16 - Stacking Static Load Test. This test is applicable to packages which may be subjected to the compressive loads which would be applied to the lower packages in a stack of identical packages. It is also used to simulate the side compressive loads that are applied in a package when it is being lifted by means of a net. There is no equivalent British Standard test in BS 2011, but this test is consistent with the static loading test given in BS 4826. Test M17 - Bending Test. The test is used to assess the resistance of the package to bending whether caused by its own mass or by top loading with other packages of different proportions. This test is normally confined to packages whose length exceeds four times the smallest cross sectional dimension and with contents vulnerable to damage, or to packages whose failure could be the cause of unserviceability of its content. There is no equivalent British Standard test. Test M18 - Racking Test. This test is used to assess the rigidity of packages which are in excess of 225 kg gross weight, and whose design is such that the packaging and its contents are liable to become unserviceable when the packages are lifted under conditions which would produce twisting. There is no equivalent British Standard test. **UN “Orange” Book - Recommendations On The Transport Of Dangerous Goods (ST/SG/AC.10/Rev.12)** These Recommendations have been developed by the United Nations Economic and Social Council's Committee of Experts on the Transport of Dangerous Goods in the light of technical progress, the advent of new substances and materials, the exigencies of modern transport systems and, above all, the requirement to ensure the safety of people, property and the environment. They are addressed to governments and international organisations concerned with the regulation of the transport of dangerous goods. They do not apply to the transport of dangerous goods in bulk which, in most countries, is subject to special regulations. The recommendations concerning the transport of dangerous goods are presented in the form of "Model Regulations on the Transport of Dangerous Goods". The Model Regulations aim at presenting a basic scheme of provisions that will allow uniform development of national and international regulations governing the various modes of transport; yet they remain flexible enough to accommodate any special requirements that might have to be met. It is expected that governments, intergovernmental organisations and other international organisations, when revising or developing regulations for which they are responsible, will conform to the principles laid down in these Model Regulations, thus contributing to world-wide harmonisation in this field. Although only a recommendation, the Model Regulations have been drafted in the mandatory sense (i.e., the word "shall" is employed throughout the text rather than "should") in order to facilitate direct use of the Model Regulations as a basis for national and international transport regulations. The scope of the Model Regulations should ensure their value for all who are directly or indirectly concerned with the transport of dangerous goods. Amongst other aspects, the Model Regulations cover principles of classification and definition of classes, listing of the principal dangerous goods, general packing requirements, testing procedures, marking, labelling or placarding, and transport documents. There are, in addition, special requirements related to

Test	**Scope & Limitations**
	particular classes of goods.

6.4.3 Technical Comparison

6.4.3.1 Constant Acceleration

The constant acceleration procedure is one of the oldest mechanical tests and appears in many compendiums of standards for most types of equipment especially for aerospace components. It is also one the simplest mechanical test procedures with variations mostly centred on guidance and severities. It is frequently the case that this test procedure experiences very few changes most related to guidance and severity. The most common type of test equipment for undertaking this test is a centrifuge although in certain cases sled tracks can also be used. Although the latter are sometimes used for commercial equipment they are more frequently employed on military equipment requiring higher levels of acceleration.

In the majority of cases the use of the constant acceleration tests is likely to be limited to sub-assemblies rather than complete systems (the capabilities of which are likely to established by computation). As these sub-assembles may be COTS equipment it is important that commercial and military test procedures align.

The commercial procedure EN / IEC 60068 and the UK Def Stan procedure are specifically written for use with a centrifuge. Although, both could be adapted for use with sled tracks. The French GAM-EG-13 standard and the US Mil Std both address both centrifuge and sled tracks. The latest STANAG has a degree of commonality with the UK, French and US national standards. However, the latest version contains considerable amount of guidance mixed within the procedural requirements. This is to such an extent that the actual requirements are difficult to ascertain and firmness of content could be considered to have been compromised.

6.4.3.2 Bounce / Loose Cargo

This is again a very old test procedure originally written around a particular piece mechanical test equipment. The test equipment causes a platform able to move in two dimensions onto which sits the packaged equipment under test. When the platform is stimulated at a fixed frequency by cams the packaged equipment moves as a loose item and is able to “bounce” on the platform. The original intent was to crudely simulate the most severe motions of a wheeled transport vehicle and consequently the impacts that an item of loose cargo may experience. The particular piece of mechanical test equipment utilised originates from around the 1950’s and can only be utilised for this specific purpose.

The test amplitudes are set intrinsically by the mechanical construction of the particular piece of test equipment utilised and the only real variable is test duration. The machine uses two cams to produce platform motion each running at a fixed speed but at slightly different speeds from each other. The cams via linkages produces two dimensional motion of the platform.

The test was originally derived for packaged items transported by wheeled vehicles. The test severities were originally developed for commercial applications. However, they are generally no longer considered applicable for that use. This is mostly because vehicles and road surfaces have improved. As a consequence the test was frequently found to induce damage not generated in practice. As the test amplitudes cannot be readily adjusted the use of the test has significantly decreased for commercial applications. The severities were found to be more realistic for military items carried either off-road or on degraded roads. Although, originally intended for packaged equipment, for military applications it is often utilised for unpackaged equipment in its tactical configuration. For military applications the test may be called to simulate transport in tracked vehicles, however, the particular piece of mechanical test equipment used for “bounce” testing has no real technical basis for use in simulating those conditions.

The commercial procedure EN / IEC 60068, the UK Def Stan procedure, the French GAM EG 13 standard and the US Mil Std 810 are essentially written around the use of the original 1950’s mechanical test equipment. A slight difference exists in the way the cams transmit motions to the platform in the US test procedure from that set out in all the other procedures listed. This is a subtle difference as it seems likely to generate a smaller difference in equipment response than the differences between different manufacturers test equipment. The latest STANAG is also written around the use of the original 1950’s mechanical test equipment. However, it does resolve the subtly differences in motion between the US and European national procedures.

Quadripartite (US/UK/F/DE) agreement ITOP 4-2-602 includes a loose cargo test as part of a series of rough handling tests. Although the ITOP is stated a encompassing any military equipment, the procedure itself repeatedly makes reference to ammunition. It is rather clear, that this originated as an ammunition specific procedure, and a rather poor attempt has been made to make it more general. The loose cargo procedure adopts the Mil Std platform motions and is consequently incompatible with either the UK Def Stan procedure, the French GAM EG 13 standard or EN / IEC 60068. As such the ITOP is disadvantageous to European Industry. The rationale for the existence of the procedures in ITOP 4-2-602 is unclear. The test procedures included in this ITOP (loose cargo vibration, temperature cycling and drop tests) have all existed in commercial standards and national military standards for a very long period. Moreover, the NATO standard existed when the ITOP was first issued (1996) and last modified (1999).

Some alternatives to the 1950's mechanical test equipment do exist but none are universally accepted. The UK Def Stan and to some extent the STANAG allow the use of alternative equipment but only provide they generate similar motions to the 1950's mechanical test equipment. Such alternative equipment is usually a two dimensional platform excited by (usually) four hydraulic rams. The (quite old) US Mil Std 331 permits the loose cargo testing of packaged fuzes on a single axis electro-mechanical vibrator. The loose cargo testing of commercial packages is frequently achieved on single dimensional electro-hydraulic or electro-dynamic vibrators as part of a vibration test. Similar methods have been utilised for some specific military ordnance items in several countries. These alternative commercial methods are already enshrined in some product specific international commercial standards. Moreover, generic CEN and ISO standards encompassing such procedures are likely to be issued shortly.

The STANAG has a slight advantage over both EN / IEC 60068 and the various national military standards. Although this is only because it resolves the subtly differences in motion between the US and European national procedures. This notwithstanding, the specific 1950's mechanical test equipment all these methods resolve around is not particularly flexible or repeatable. The use of modern and more flexible test equipment is permitted by some product specific commercial procedures and generic CEN and ISO standards are likely to be available shortly.

6.4.3.3 Materiel Tiedown

NATO STANAG 4370 includes a test method used demonstrate the adequacy of a package or container to resist, during tiedown, the applied loads without unacceptable degradation of its structural and/or its functional performance. It is particularly applicable to materiel having integral attachments such handles, eye bolts and shackles. None of the European national military standards include a similar test nor does EN / IEC 60068. However, various CEN and ISO package standards do include similar basic requirements.

The STANAG test is a basic static loading test of container handling features which does not necessarily encompass CEN, ISO or European legislative requirements. Military use may require loadings in excess of those specified (in CEN & ISO standards) by commercial use. However, the specified lowest loadings should be the commercial standards and European legislative requirements.

6.4.3.4 Motion Platform

NATO STANAG 4370 contains a test to replicate the motion that may be induced on platforms such as a large ship during a rough sea state. The test is intended is intended to replicate rigid body motion in terms of linear and rotational motions. The need for an equipment to operate at different angular positions is requirement of many platforms. Compliance with these requirements is normally verified by a range of methods. These methods are not normally included as environmental tests. Nevertheless ship board equipment may be COTS intended for fixed installation, consequently a standard method of verifying adequacy is useful. Although no equivalent test exists in EN / IEC 60068, a Ship platform specific (vertical) IEC standard does exists and the NATO STANAG 4370 should adopt that procedure.

6.4.3.5 Large Assembly Transport Test

This test procedure was intended to be an alternative to laboratory simulation when items were very large or massive. The procedure may be used for large / heavy packaged items, large packs of artillery rocket, large command & communications shelters or large NBC monitoring systems. Essentially the procedure permits mounting of the equipment on appropriate vehicles which then transits appropriate surfaces (usually test tracks), at appropriate speeds for appropriate durations.

The UK Def Stan 00-35 includes a specific test procedure for large assembly transport testing. It does not specify specific surfaces, speeds or durations. Rather it suggests these should be derived from knowledge of intended usage. A alternative option for large equipment is also permitted in the French GAM-EG standard and the US Mil Std. The latest STANAG includes a specific large assembly transport test procedure as an alternative to laboratory simulation. This reflects all the components of the national standards. Again the basic procedure does not contain specify requirements for surfaces, speeds or durations. Whilst, it does include some guidance, that resolves entirely around US test track surfaces and test operating procedure. No equivalent exists in the commercial procedure EN / IEC 60068.

6.4.3.6 Materiel Lifting, Stacking, Bending And Racking Tests

The four test procedures materiel lifting, stacking, bending and racking tests all originate from packaging test standards. They were originally intended to verify the adequacy of packages but can also be used to verify that the conditions do not degrade the equipment within the package.

The original UK Def Stan 00-35 tests are effectively identical to those of Def Stan 81-41 Part 3. The STANAG 4370 tests reflect the UK Def Stan procedures. The Def Stan 81-41 part 3 test procedures are also those of STANAG 4340 AEPP-3. No equivalent exists in the commercial procedure EN / IEC 60068. However, various CEN and ISO package standards do include similar basic requirements. Given that they encompass a larger range of package type is difficult to understand why the Stanag does not encompass such commercial procedures.

The UN “Orange” Book (or more formally Recommendations On The Transport Of Dangerous Goods ST/SG/AC.10/Rev.12) contains a stacking test which is intended as an international requirements for demonsterating the adequacy of packages when transporting dangerous goods. Dangerous goods in this instance are catagorised as a range of materials one of which is explosives. UN certification against nationally implimented versions of this standard is required before dangerous goods can be transported using most commercial means. This is especially the case for international transportation. Although the test procedure of the UN test is the same as that in the Def Stan & STANAG tests, the severity and criteria differ. Although these differences would currently dictate separate they are not so great as to be insurmountable.

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6.4.4 Conclusions

A summary of the recommendations is shown in the table below which is expanded in the following paragraphs.

Summary of Recommendations for Miscellaneous Mechanical Tests						
	NATO STANAG 4370 AECTP	International EN / IEC 60068	UK Def Stan 00-35	US Mil Std 810F	France GAM-Eg-13	Quadripartite US/UK/F/DE ITOP
Constant acceleration	Could be recommended but with reservations as to quality of procedure	Essentially equivalent to STANAG Test.			Recommended	No equivalent test.
Bounce / loose cargo	Recommended but new CEN/ISO Stds will probably surpass	Essentially equivalent to STANAG procedure but note differences in motion between US/ITOP procedures and European procedures.				
Materiel tiedown	Cannot be recommended in current form	No equivalent test				
Motion Platform	Cannot be recommended in current form	No equivalent test				
Large assembly transport	Recommended	No equivalent test.	Equivalent to STANAG Test.			No equivalent test.
Materiel, lifting, stacking, bending and racking	Recommended	UN “Orange” book test for stacking would also be required.	Equivalent to STANAG Test.	No equivalent test.		

6.4.4.1 Constant Acceleration

The Constant Acceleration test procedure is usually limited to sub-assemblies rather than complete systems (the capabilities of which are likely to established by computation). As these sub-assembles may be COTS equipment it is important that commercial and military test procedures align. The procedure in EN / IEC 60068 and the UK Def Stan are specifically written for use with a centrifuge. Although, both could be used with sled tracks. The French GAM-EG-13 and the US Mil Std both address both centrifuge and sled tracks. The latest STANAG has a degree of commonality with the UK, French and US national standards. It also addresses centrifuge and sled tracks. However, the latest version contains considerable amount of guidance mixed within the procedural requirements. This is to such an extent that the actual requirements are difficult to ascertain and firmness of content could be considered to have been compromised.

In summary, the difference between the various tests is not particularly significant and any of those reviewed could be adopted. The NATO STANAG 4370 has the greatest degree of commonality to the other military standards, however, it is compromised by the lack of firmness of content. As this test is likely to be used for COTS equipment greater effort is also required to align the STANAG to commercial standards. If it were not for this it would be the most applicable single standard and recommended. Otherwise the French GAM-EG-13 is recommended.

6.4.4.2 Bounce / Loose Cargo

The Bounce / Loose Cargo test procedure is quite old and written around a particular piece mechanical test equipment. The test amplitudes are set intrinsically by the mechanical construction of the particular test equipment utilised and the only real variable is test duration. The commercial procedure EN / IEC 60068, the UK Def Stan procedure, the French GAM-EG-13 standard and the US Mil Std 810 are essentially written around the use of the original 1950's mechanical test equipment. The STANAG has a slight advantage over both EN / IEC 60068 the various national military standards. Although this is only because it resolves the subtly differences in motion between the US and European national procedures. This notwithstanding, the specific 1950's mechanical test equipment all these methods resolve around is not particularly flexible or repeatable. The use of modern and more flexible test equipment is permitted by some product specific commercial procedures and generic CEN and ISO standards are likely to be available shortly.

In summary, the NATO STANAG 4370 addresses the slight differences between the US and European approaches, something the EN / IEC test fails to do. As the NATO STANAG has greatest degree of commonality to both civil and other military standards it is recommended here. However, all the procedures utilise very old equipment and badly require a degree of technical innovation to update this approach. Shortly to be available generic CEN and ISO standards are likely to be more applicable than any procedure reviewed.

6.4.4.3 Material Tie-down.

The STANAG test is a basic static loading test of container handling features which does not necessarily encompass CEN, ISO or European legislative requirements. None of the European national military standards include a similar test nor does EN / IEC 60068. However, various CEN and ISO package standards do include similar basic requirements. Military use may require loadings in excess of those specified (in CEN & ISO standards) by commercial use. However, the specified lowest loadings should be the commercial standards and European legislative requirements. As such the STANAG 4370 test cannot be recommended in its current form.

6.4.4.4 Motion Platform.

NATO STANAG 4370 contains a test to replicate the motion that may be induced on platforms such as a large ship during a rough sea state. The test is intended is intended to replicate rigid body motion in terms of linear and rotational motions. The need for an equipment to operate at different angular positions is requirement of many platforms. Compliance with these requirements is normally verified by a range of methods. These methods are not normally included as environmental tests. Nevertheless ship board equipment may be COTS intended for fixed installation, consequently a standard method of verifying adequacy is useful. Although no equivalent test exists in EN / IEC 60068, a Ship platform specific (vertical) IEC standard does exists and the NATO STANAG 4370 should move towards adopting that procedure. As such the STANAG 4370 test cannot be recommended in its current form.

6.4.4.5 Large Assembly Transport

The Large Assembly Transport test procedure was intended to be an alternative to laboratory simulation when items were very large or massive. The UK Def Stan 00-35 includes a specific test procedure for large assembly transport testing. An alternative option for large equipment is also permitted in the French GAM-EG standard and the US Mil Std. The latest STANAG includes a specific large assembly transport test procedure as an alternative to laboratory simulation. This reflects all the components of the national standards. However, the basic procedure does not contain specify requirements for surfaces, speeds or durations. It does include some guidance on this but that resolves around US test track surfaces and test operating procedure. No equivalent exists in the commercial procedure EN / IEC 60068. In summary this test reflects the large nature of certain military equipment and the need to use other than laboratory test facilities. The NATO STANAG 4370 reflects other military standards and is hence recommended.

6.4.4.6. The Four Materiel Lifting, Stacking, Bending And Racking Tests

The Four Materiel Lifting, Stacking, Bending And Racking test procedures all originate from packaging test standards but can also be used to verify that the conditions do not degrade the equipment within the package. The original UK Def Stan 00-35 tests are effectively identical to those of Def Stan 81-41 Part 3. The STANAG 4370 tests reflect the UK Def Stan procedures. The Def Stan 81-41 part 3 test procedures are also those of STANAG 4340 AEPP-3. No equivalent exists in the commercial procedure EN / IEC 60068.

In summary the NATO STANAG 4370 reflects other military standards and is hence recommended. However, the STANAG stacking test does not encompass the UN Transport Of Dangerous Goods stacking test which may additionally be required.

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6.5 Review and Comparison of Temperature, Humidity and Pressure Test Methods

6.5.1 Standards Under Consideration

The standards reviewed and compared with regard temperature, humidity sand pressure test methods are set out in the following table.

Matrix Environmental Test Methods vs Standards						
	NATO STANAG 4370 AECTP (Method No)	International EN / IEC 60068 Part 2 (60068-2-xx)	UK Def Stan 00-35 Part 3 (Chapter / test)	US Mil Std 810F (Test No / Procedure)	France GAM-Eg-13 (Method / Procedure)	Quadripartite US/UK/F/DE ITOP (Test No)
High Temperature	302	2 Test B Dry Heat 14 Change of Temperature	3-01 / CL1 3-02 / CL2 3-11 / CL11	501	Part 1 Method 02 Hot	2-2-816
Low Temperature	303	1 Test A Cold 14 Change of Temperature	3-04 / CL4 3-05 / CL5	502	Part 1 Method 01 Cold	2-2-816
Thermal Shock	304	14 Change of Temperature	3-14 / CL14	503	Part 1 Method 7 Thermal Shock	
Solar Radiation	305	5 Test Sa 9 Guidance	3-03 / CL3	505	Part 1 Method 9 Solar Radiation	4-2-826
Humidity	306	30 Damp Heat Cycle 38 Temperature Humidity Cycle	4-07 / CL7 4-06 / CL6	507	Part 1 Method 03 Humid Heat	4-2-820
Low Pressure	312	13	3-21 / CL21 3-20 / CL 20 3-09 / CL 09	500		
Temperature, Humidity Altitude	317	39 40 41	3-11 / CL 11 3-12 / CL 12 3-13 / CL13	520	05 10 11	
Icing	311		3-10 / CL 10	521	14	
Freeze Thaw	315		3-24 / CL 24		22	

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6.5.2 Standard Comparison

Test	Scope & Limitations
HIGH TEMPERATURE	**STANAG 4370 AECTP 300 Method 302 High Temperature (Including Radiative Heating)** This method presents three procedures, tailorable for cyclic or steady state temperature exposure. Procedure I and II are used to test the materiel in storage or operating conditions and temperature profile used to simulate cyclic variations (such as diurnal conditions, but not only) or steady state conditions. Procedure III is used to simulate high temperature conditions in presence of radiative sources of heat, which can impact the performance of the materiel due to differential thermal stress for instance. This method allows a better simulation of the real thermal stresses, provided a preliminary tailoring work has been made. Purpose: The main objectives of these tests are to determine if: a. the materiel is safe to handle and/or operate during and following exposure to a high temperatures, or b. the materiel can be stored and operated as specified in the requirements documents during and following exposure to the high temperatures (cyclic or constant) that it is expected to encounter during its service life, or c. the materiel experiences physical damage during and/or after experiencing high temperature. Application: This test method is used when the requirements documents state that the materiel is likely to be stored or operated in areas where high temperatures (above standard ambient) occur. The high temperatures may be caused by nearby sources of heat, direct solar loading, or indirect solar loading. When simulation of solar heating is required, the use of measured data from the natural environment, or data obtained as detailed in Method 305, "Solar Radiation," is essential. The application of this Method depends on a knowledge of thermal transfer mechanisms (primarily radiative or primarily conductive/convective). Consideration should be given to the test item enclosure; the sources of heat; the test item surface characteristics, and the test item duty cycles. Although not written for such, this test may be used in conjunction with shock and vibration tests to evaluate the effect of dynamic events (e.g., shipping, handling, shock) on hot materiel. **IEC EN 60068 Part 2** IEC EN 60068-2-2 TESTS B- DRY HEAT This Procedure deals with dry heat tests applicable both to heat-dissipating and non heat-dissipating specimens. For non heat-dissipating specimens, Tests Ba and Bb do not deviate essentially from earlier issues. The object of the dry heat test is limited to the determination of the ability of components, equipment or other articles to be used or stored at high temperature. These dry heat tests do not enable the ability of specimens to withstand or operate during temperature variations to be assessed. In this case, it would be necessary to use Test N: Change of temperature. The dry heat tests are subdivided as follows:

Test	Scope & Limitations
	Dry heat tests for non heat-dissipating specimens a. –with sudden change of temperature, Ba; b. –with gradual change of temperature, Bb. *Dry heat tests for heat-dissipating specimens* a. –with sudden change of temperature, Bc; b. –with gradual change of temperature, Bd. The procedures given in this publication are normally intended for specimens which achieve temperature stability during the performance of the test procedure. The duration of the test commences at the time when temperature stability of the specimen has been reached. For the exceptional cases when the specimen does not reach temperature stability during the performance of the test procedure, the duration of the test commences at the time when the test chamber reaches the test temperature. The relevant specification shall define: a. the rate of change of temperature in the test chamber; b. the time at which the specimens are introduced into the test chamber; c. the time at which the exposure commences; d. the time at which the specimens are energised. IEC EN 60068-2-14 TEST N CHANGE OF TEMPERATURE A change of temperature test is intended to determine the effect on the specimen of a change of temperature or a succession of changes of temperature. It is not intended to show effects which are due only to the high or low temperature. For these effects, the dry heat test or the cold test should be used. The effect of such tests is determined by: a. values of high and low conditioning temperature between which the change is to be effected; b. the conditioning times for which the test specimen is kept at these temperatures; c. the rate of change between these temperatures; d. the number of cycles of conditioning; e. the amount of heat transfer into or from the specimen. Guidance on the choice of suitable test parameters for inclusion in the detail specification is given in IEC 60068-2-33: Basic environmental testing procedures – Part 2: Tests – Guidance on change of temperature tests, which should be read in conjunction with this standard.

Test	Scope & Limitations
	Test Na: Rapid change of temperature with prescribed time of transition This test determines the ability of components, equipment or other articles to withstand rapid changes of ambient temperature. The exposure times adequate to accomplish this will depend upon the nature of the specimen. The specimen is exposed to rapid changes of temperature in air, or in a suitable inert gas, by alternate exposure to low temperature and to high temperature. Test Nb: Change of temperature with specified rate of change This test determines the ability of components, equipment or other articles to withstand and/or function during changes of ambient temperature. **Mil-Std 810 Part 2 Method 501.4 High Temperature** Purpose. Use high temperature tests to obtain data to help evaluate effects of high temperature conditions on materiel safety, integrity, and performance. Application. Use this method to evaluate materiel likely to be deployed in areas where temperatures are higher than standard ambient. **Def-Stan 00-35 Part 3** Chapter 3-01 TEST CL1 - Constant High Temperature - Low Humidity Test This test is applicable to materiel stored or operated in locations where the ambient temperature is high and remains at a relatively constant level. These conditions are found in enclosed spaces such as ship's compartments, machinery spaces, and vehicle and aircraft engine compartments, where the temperature is mainly influenced by heat from equipment and/or machinery. Four test procedures are defined covering high temperature with sudden or gradual change of temperature for both heat-dissipating and non-heat- dissipating items. The preferred durations for the tests are not applicable for assessing long term effects, and guidance should be sought on the specification of duration if such assessments are required. This test is technically similar to BS EN60068-2-2 Part 2 Tests B Dry Heat except for the differences detailed in paragraph 7. Chapter 3-02 TEST CL2 -High Temperature, Low Humidity And Solar Heating Diurnal Cycle Test This test is applicable to materiel located or housed in hot dry conditions where the temperature of any part of the equipment is directly or indirectly influenced by solar radiation. This test is not suitable for evaluation of components. This test is only concerned with the heating effects of solar radiation. Where it is necessary to consider other effects, such as material degradation, then the use of the Test CL3 - "Solar Radiation Test" (See Chapter 3-03) should be considered. In those storage or transit conditions where the diurnal variations are so small as to have insignificant effect on the

Test	Scope & Limitations
	materiel, the use of the Test CL1 - Constant High Temperature - Low Humidity Test" (See Chapter 3-01) may be considered. There is no equivalent British Standard test. **GAM-EG13 Part 1 Method 02 Dry Heat** Purpose of the test: Knowledge of the capacity of an item of equipment to be stored, started and operated at stabilised high temperatures. Control of temperatures reached by the critical components, in the development phase. Possible effects; Change in the electrical characteristics of the materials (reduction in dielectric strength, impairment to semi-conductors and isolators, etc.) Modification to the mechanical characteristics of materials (deformations due to the temperature, unsticking, softening, differential expansion, jamming, seizing, etc. Modification to the viscosity of lubricants and fluids (gas relief, exudation, evaporation, accelerated ageing, etc.) **International Test Operations Procedure (ITOP) 2-2-816 Tracked-Vehicle Climatic Tests** This document describes the procedures for determining the ability of tracked vehicles to meet the climatic requirements of guidance documents. Various climatic conditions can produce many and varying problems with tracked vehicles including on-board equipment, Such problems include systems operation, expansion and contraction of materials, and changing of the properties of matter. Tracked vehicles must be able to support military operations during any season and in climates in various locations. This document addresses preliminary functional checks of selected subsystems in climatic test chambers, and tests at extreme conditions in the natural environment in accordance with relevant ITOPs.
LOW TEMPERATURE	**STANAG 4370 AECTP 300 Method 303 Low Temperature** For the purpose of this document, manipulation is defined as the actions necessary to convert the materiel from a storage to an operational configuration, operate it, and return it to its storage configuration. Purpose The main objectives of low temperature tests are to determine if: a. The safety of the materiel is affected as a result of exposure to low temperature, or b. The materiel can be stored, manipulated and operated within the specified requirements during and after exposure to low temperature that it is expected to encounter during its service life, or c. The materiel experiences physical damage during or after its exposure to low temperature. Application a. This Method is used when the requirements documents state that the materiel is likely to be deployed in

Test	Scope & Limitations
	regions in which the climatic conditions will induce low temperatures (below standard ambient) within the materiel. If the effects of low temperature on the materiel are being determined during other tests for the required extremes and durations (including manipulation), it is not necessary to perform this test. b. Although not written for such, this Method may be used in conjunction with shock and vibration tests (AECTP 400) to evaluate the effects of dynamic events (e.g., shipping, handling, shock) on cold, embrittled materiel. **IEC EN 60068 Part 2 60068-2-1 Test A: Cold** This procedure deals with cold tests applicable both to non heat-dissipating and heat-dissipating specimens. For non heat-dissipating specimens, Tests Aa and Ab do not deviate essentially from earlier issues. The object of the cold test is limited to the determination of the ability of components, equipment or other articles to be used or stored at low temperature. These cold tests do not enable the ability of specimens to withstand or operate during temperature variations to be assessed. In this case, it would be necessary to use Test N: Change of temperature. The cold tests are subdivided as follows: Cold tests for non heat-dissipating specimens with sudden change of temperature, Aa; with gradual change of temperature, Ab. Cold test for heat-dissipating specimens with gradual change of temperature, Ad. The procedures given in this publication are normally intended for specimens which achieve temperature stability during the performance of the test procedure. The duration of the test commences at the time when temperature stability of the specimen has been reached. For the exceptional cases when the specimen does not reach temperature stability during the performance of the test procedure, the duration of the test commences at the time when the test chamber reaches the test temperature. The relevant specification shall define: a) the rate of change of temperature in the test chamber; b) the time at which the specimens are introduced into the test chamber; c) the time at which the exposure commences; d) the time at which the specimens are energised.

Test	Scope & Limitations
	Mil-Std 810 Part 2 Method 502.4 Low Temperature Purpose: Use low temperature testing to measure how low temperature conditions during storage, operation and manipulation affect materiel safety, integrity and performance. Application. Use this method when the materiel is likely to be deployed in a low temperature environment during its life cycle and the effects of low temperature have not been assessed during other tests (e.g., the temperature-altitude test). **Def-Stan 00-35 Part 3** Chapter 3-04 TEST CL4 - CONSTANT LOW TEMPERATURE TEST This test is applicable to materiel which may be transported, stored or used at low temperatures. Low temperatures may occur in many areas of ground deployment as well as in ships and aircraft. Three test procedures are described; low temperature with sudden or gradual change of temperature for non-heat-dissipating items and gradual change of temperature for heat-dissipating items. In many applications diurnal variation of temperature occurs but this will not normally be significant in its effect. For materiel of large thermal mass where the variation may be considered significant, Test CL5 -"Low Temperature Diurnal Cycle Test"(See Chapter 3-05)should be used. Rapid change from a high temperature to a low temperature, or vice versa, is the subject of Test CL14 -"Thermal Shock Test"(See Chapter 3-14). The preferred durations for the tests are not applicable for assessing long-term effects and guidance should be sought on the specification of duration if such assessments are required. This test is technically similar to BS EN60068-2-1 Part 2 Tests A Cold except for the differences detailed in paragraph 7. Guidance: The following guidance is provided to assist in the selection from options test procedures, severities etc.)given later in this chapter. Test selection The test procedures of BS EN60068-2-1 Part 2 Tests A Cold are sub-divided as follows: Test Aa -Cold tests for non-heat-dissipating materiel with sudden change of temperature. Test Ab -Cold tests for non-heat-dissipating materiel with gradual change of temperature. Test Ad -Cold test for heat-dissipating materiel with gradual change of temperature. The procedures given are normally intended for specimens which are required to achieve temperature stability during the performance of the test procedure and the duration of the test commences at the time when temperature stability of the specimen has been reached. For exceptional cases when the specimen does not reach temperature stability during the performance of the test

Test	Scope & Limitations
	procedure, the duration of the test commences at the time when the test chamber reaches the test temperature. Chapter 3-05 TEST CL5 - LOW TEMPERATURE DIURNAL CYCLE TEST This test is a simulation of conditions where the diurnal temperature variation is more applicable than a constant low temperature. For general application to materiel located or housed in low temperatures the simpler Test CL4 -" Constant Low Temperature Test" (See Chapter 3-04) is sufficiently realistic for test purposes. However, in some instances, particularly with equipment of large mass having a thermal time constant comparable to or longer than a diurnal cycle, the closer realism of a cyclic test may be preferred for example to ensure seals and other components are representatively stressed. There is no equivalent British Standard test. **GAM-EG13 Part 1 Method 01 COLD** Purpose of the test Knowledge of the capacity of an item of equipment to be stored, started and operated at low stabilised temperatures without any eventual influence of the altitude. Possible effects Change in the electrical and radio electrical characteristics Impairment to the semi-conductors and isolators Drop in dielectric strength Starting difficulties Deformations due to the temperature, cracks Differential expansion, jamming, seizing Hardening of the vibration insulators and seals Reduction of the mechanical characteristics of the materials Reduction of the viscosity of the lubricant and fluids
SOLAR RADIATION	**STANAG 4370 AECTP 300 Method 305** SOLAR RADIATION Two procedures (I and II) are given: Procedure I uses close simulation of temperature/irradiance diurnal variations to evaluate the thermal response of the materiel. Procedure II uses constant levels of temperature/irradiance to evaluate degradation effects on the materiel Temperature levels are derived from widely agreed climatic cycles representative of natural high temperature

Test	Scope & Limitations
	conditions. Other values may be used when specific data supports a different choice. Purpose: The main objective of this solar radiation test is to determine the actinic (photodegradation) and heating effects of solar radiation on materiel when it is exposed to sunshine during operation or during unsheltered storage at ground level. Application: This Method is applicable to materiel likely to be directly exposed to solar radiation. This Method is for use when close simulation of the spectral distribution of radiation is required such as for assessment of materiel degradation or a combination of degradation and/or thermal response. In certain cases where, for example, paint finishes with unusual characteristics have been applied, it may be necessary to use this Method to establish realistic response temperature cycles on a single item for application in high temperature tests of multiple copies. Once the temperatures have been measured, heating effects of solar radiation may be determined through the High Temperature test (Method 302). Further guidance on high temperature application is provided in Method 301, General Guidance and Requirements, paragraph 3.3. Because of lamp deterioration, this test is more expensive to perform than a high temperature test but may be necessary for determining the initial thermal response characteristics. **IEC 60068 Part 2** IEC EN 60068-2-5 Test Sa SIMULATED SOLAR RADIATION AT GROUND LEVEL Three procedures (A, B and C) are presented: A simulates most severe natural conditions with 24h temperature cycles and 8h solar radiation exposure. B offers a different 24h cycle with 20 h solar radiation exposure at constant high temperature C offers continuous solar radiation exposure at constant high temperature. Level of irradiance is constant at 1120 W/m² for all procedures. The main objective of the test is to determine the effects of solar radiation on equipments resulting of a solar exposure at ground levels. IEC 60068-2-9 GUIDANCE FOR SOLAR RADIATION TESTING Cover major aspects dealing with irradiance, spectral distribution, radiation sources, measurements of temperature and irradiance, as well as health hazards. **Mil-Std 810 Part 2 Method 502.5 Solar Radiation** Purpose: This Method has two purposes: a. To determine the heating effects of direct solar radiation on materiel. b. To help identify the actinic (photodegradation) effects of direct solar radiation. Application: Use this method to evaluate materiel likely to be exposed to solar radiation during its life cycle in the open in hot climates, and when heating or actinic effects are of concern. Limit use of this method to evaluating the

Test	Scope & Limitations
	effects of direct exposure to sunlight (solar spectrum and energy levels at sea level). Although not intended for such, Procedure II may be useful in determining the effects of other ultraviolet sources. **Def-Stan 00-35 Part 3 Chapter 3-03 TEST CL3 - SOLAR RADIATION TEST** This test is for use only when close simulation of the spectral distribution of solar radiation is required, such as for assessment of material degradation or a combination of degradation and thermal response. This test is applicable to those items of materiel which will be fully exposed, packaged or unpackaged, to solar radiation. Tests CL2 - "High Temperature, Low Humidity and Solar Heating - Diurnal Cycle Test" and CL6 -" High Temperature, Humidity and Solar Heating - Diurnal Cycle Test" (See Chapters 3-02 and 3-06 respectively) should be considered when only the thermal response requires to be assessed. However, in certain cases, where, for example, paint finishes with unusual characteristics have been applied, it may be necessary to use this test to establish realistic temperature cycles for application in Tests CL2 and CL6. This test is technically similar to BS 2011: Part 2.1 Sa: Test Sa Simulated solar radiation at ground level. **GAM-EG13 Part 1 Method 01 Solar Radiation** Purpose of the test: The purpose of this test is to determine the performance of equipment subjected directly to solar radiation as on the surface of the earth (quite obviously ruling out equipment under shelter) or in a low atmosphere. In particular, this test: Checks the strength of certain components materials in equipment, for the thermal and/or actinic aspects Controls the internal temperatures reached by all the components. Possible effects Thermal effects Variation in the characteristics of the components and parts Mechanical deformations and reduction in the tight sealing Breaking or making of connections due to differential expansion Cracking of paints, rubber, plastic, etc. Hardening or reduction in the elasticity of the seals Exudation of compound and explosive materials Variation in pressure Actinic effects (In addition to the above) Variation in the colour of the coatings

Test	Scope & Limitations
	Photochemical impairments (notably concerning elastomers and polymers) The combined actions and the two agents should be especially taken into account. **International Test Operations procedure (ITOP) 4-2-826 Solar Radiation Tests** Scope. This ITOP describes tests to determine the effects of solar radiation and high air temperature on military equipment with regard to materiel damage and operational capabilities. It also includes a procedure for determining an equivalent high temperature for use in repetitive high-temperature tests when it would be impractical to use solar radiation each time.
THERMAL SHOCK	**STANAG 4370 AECTP 300 Method 304 Air To Air Thermal Shock** Purpose: The main objectives of the thermal shock test are to determine if: The safety of the materiel is affected as a result of exposure to sudden, extreme changes of temperature. The materiel can be handled and operated within the specified requirements during and after sudden temperature changes (greater than 10^oC per minute) likely to be associated with actual service conditions. The materiel experiences physical damage during or after experiencing temperature shock. Application: This test method is used when the requirements documents specify that the materiel is likely to be deployed where sudden significant changes of air temperature may be experienced (see 2.3.1). This Method is only intended to evaluate the effects of sudden temperature changes of the outer surfaces of materiel, items mounted on the outer surfaces, or internal items situated near the external surfaces. Typically, this addresses: a. The transfer of materiel between heated areas and low temperature environments. b. Ascent from a high temperature ground environment to high altitude via a high performance vehicle (hot to cold only). c. Air drop at high altitude/low temperature from aircraft enclosures when only the external material (packaging or materiel surface) is to be tested. This method may also be used to reveal safety problems and potential flaws in materiel normally exposed to less extreme conditions, as long as the design limitations of the materiel are not exceeded. **Mil-Std 810 Part 2 Method 503.4 Temperature Shock** Purpose: Use temperature shock tests to determine if materiel can withstand sudden changes in the temperature of the surrounding atmosphere without experiencing physical damage or deterioration in performance. For the purpose of this document, "sudden changes" is defined as "greater than 10°C per minute." Application. Normal environment. Use this method when the requirements documents specify the materiel is likely to be deployed where sudden significant changes of air temperature may be experienced. This method is intended to only

Test	Scope & Limitations
	evaluate the effects of sudden temperature changes of the outer surfaces of materiel, items mounted on the outer surfaces, or internal items situated near the external surfaces. Typically, this addresses: The transfer of materiel between heated areas and low temperature environments. Ascent from a high temperature ground environment to high altitude via a high performance vehicle (hot to cold only). Air drop at high altitude/low temperature from heated aircraft enclosures when only the external material (packaging or materiel surface) is to be tested. Safety and screening. Except as noted in paragraph 1.3, use this method to reveal safety problems and potential flaws in materiel normally exposed to less extreme rates of temperature change (as long as the test conditions do not exceed the design limitations of the materiel). Although not intended to be used for environmental stress screening (ESS), with proper engineering this method can also be used as a screening test to reveal potential flaws in materiel exposed to less extreme temperature change conditions. **Def-Stan 00-35 Part 3 Chapter 3-14 Test CL14 - Thermal Shock And Rapid Rate Of Change Of Temperature** This test is applicable to materiel which may experience thermal shock or rapid rates of change of temperature during handling or as a result of operational requirements during its service life. Test procedures are presented to simulate conditioning of materiel, subjected to stepped or rapid rates of change of temperature in air and stepped changes of temperature when transferred from air to water. Also included is a procedure specifically applicable to secondary batteries deployed on land based military vehicles. Test procedures A and B incorporates the test methods of BS 2011: Part 2.1N, Test Na and Nb respectively, with differences detailed in paragraph 7 below. **GAM-EG13 Part 1 Method 7 Thermal Shock** Purpose of the test Knowledge of the capacity of the test item to support one or several very rapid variations of temperature in the air, similar to those which can occur during its use and during certain transport and storage operations. Possible effects Physical or electrical modifications to the materials Impairments resulting from mechanical stresses and strains Momentary or definitive modifications to the functional characteristics Accelerated ageing

Test	Scope & Limitations
HUMID HEAT TESTS	**STANAG 4370 AECTP 306** Purpose: The high humidity tests are used to determine the effects of high humidity and temperature on materiel in storage or use. Application: This Method is applicable to materiel likely to be stored or used wherever high levels of relative humidity can exist, or to provide an indication of potential problems associated with humidity. Further guidance on high temperature application is provided in Method 301, General Guidance and Requirements. Limitations: This Method does not consider all of the effects related to the natural environment and, therefore, it is preferable to test materiel at appropriate natural sites. Not all of the "aggravated" test procedures necessarily simulate any naturally-occurring climatic condition, but may have a relationship to high temperature and humidity conditions anticipated in enclosed areas. The relationship of the procedures in this Method to the effects on non-metallic materials has not been evaluated. This document does not address condensation resulting from changes of altitude for airborne equipment. Additionally, it does not include the synergistic effects of high humidity combined with biological and chemical contaminants, nor does it consider situations in which liquid water may be trapped within packages and retained for substantial periods. **IEC EN 60068** IEC EN 60068 –2-30 TEST DB AND GUIDANCE: DAMP HEAT, CYCLIC (12 + 12-HOUR CYCLE) Scope: To determine the suitability of components, equipment or other articles for use, transportation and storage under conditions of high humidity - combined with cyclic temperature changes and, in general, producing condensation on the surface of the specimen. If the test is being used to verify the performance of a specimen whilst it is being transported or stored in packaging then the packaging shall normally be fitted when the test conditions are being applied. General description: This test comprises one or more temperature cycles in which the relative humidity is maintained at a high level. Two variants of the cycle are given which are identical except for the temperature fall period; during this part of the cycle, variant 2 allows wider tolerances of relative humidity and the rate of temperature fall. The upper temperature of the cycle and the number of cycles (see clause 4) determine the test severity. IEC EN 60068 –2-30 TEST Z/AD TEMPERATURE HUMIDITY CYCLE Test Z/AD is a cyclic temperature/humidity test which is designed to reveal defects in test specimens caused by "breathing" as distinct from the absorption of moisture. This test differs from other cyclic damp heat tests in that it derives its increased severity from: a) A greater number of temperature variations or "pumping" actions in a given time. b) A greater cyclic temperature range. c) A higher cyclic rate of change of temperature. d) The inclusion of a number of excursions to sub-zero temperatures.

Test	Scope & Limitations
	The accelerated breathing and the effect of the freezing of trapped water in cracks and fissures are the essential features of this composite test. It is emphasised however that the freezing effect will occur only if the fissure dimensions are large enough to allow the penetration of a coherent mass of water, as is normally the case in fissures between seals and metal assemblies or between seals and wire terminations. The degree of condensation will depend mainly upon the thermal time constant of the surface of the test specimens and may be negligible for very small specimens but copious for large specimens. Similarly, the breathing effect will be more apparent on specimens which contain relatively large air-filled or gas-filled voids but again the severity of the test will depend to some extent on the thermal characteristics of the specimens. For the reasons given above, it is recommended that this test procedure be limited to component type specimens when the construction of the specimens suggests a "breathing" type of damp heat test combined with icing and where the thermal characteristics are compatible with the rates of change of temperature, etc., of test Z/AD. **Mil-Std 810 Part 2 Method 507.4 Humidity** Purpose: The purpose of this method is to determine the resistance of materiel to the effects of a warm, humid atmosphere. Application: This method applies to materiel that is likely to be stored or deployed in a warm, humid environment or an environment in which high levels of humidity occur. Although it is preferable to test materiel at appropriate natural environment sites, it is not always practical because of logistical, cost, or schedule considerations. Warm, humid conditions can occur year-round in tropical areas, seasonally in mid-latitude areas, and in materiel subjected to combinations of changes in pressure, temperature, and relative humidity. Other high levels of humidity can exist worldwide. Limitations: This method may not reproduce all of the humidity effects associated with the natural environment such as long-term effects, nor with low humidity situations. This method does not attempt to duplicate the complex temperature/humidity environment but, rather, it provides a generally stressful situation that is intended to reveal potential problem areas in the materiel. Therefore, this method does not contain natural or induced temperature/humidity cycles as in previous editions. Specifically, this method does not address: a. Condensation resulting from changes of pressure and temperature for airborne or ground materiel. b. Condensation resulting from black-body radiation (e.g., night sky effects). c. Synergistic effects of humidity or condensation combined with biological and chemical contaminants. d. Liquid water trapped within materiel or packages and retained for significant periods. e. This method is not intended for evaluating the internal elements of a hermetically sealed assembly since such materiel is air-tight. This method may not reproduce all of the humidity effects associated with the natural environment such as long-term

Test	Scope & Limitations
	effects, nor with low humidity situations. This method does not attempt to duplicate the complex temperature/humidity environment but, rather, it provides a generally stressful situation that is intended to reveal potential problem areas in the materiel. Therefore, this method does not contain natural or induced temperature/humidity cycles as in previous editions. Specifically, this method does not address: a. Condensation resulting from changes of pressure and temperature for airborne or ground materiel. b. Condensation resulting from black-body radiation (e.g., night sky effects). c. Synergistic effects of humidity or condensation combined with biological and chemical contaminants. d. Liquid water trapped within materiel or packages and retained for significant periods. e. This method is not intended for evaluating the internal elements of a hermetically sealed assembly since such materiel is air-tight. **Def-Stan 00-35 Part 3** TEST CL7 - CONSTANT HIGH TEMPERATURE - HIGH HUMIDITY TEST This test is applicable to materiel housed in locations where the ambient temperature and humidity are high, and remain at a substantially constant level. Such conditions arise in certain enclosed spaces, for example ship's engine and machinery rooms, galleys, laundries etc., where conditions are greatly influenced by heat and water vapour from machinery and equipment. Also to materiel in wet tropical regions under overcast conditions, or in dense jungle. The test procedure does not allow condensation to form on the specimen. If this is required, Test Procedure B of Chapter 3-06 should be used. This test is technically similar to BS 2011 Part 2.1Cb "Damp heat, steady state, primarily for equipment" except for the differences detailed in paragraph 7. Chapter 3-06 Test C6 - HIGH TEMPERATURE, HUMIDITY AND SOLAR HEATING DIURNAL CYCLE TEST This test is applicable to materiel that may be directly exposed to a natural humid environment typical of the wet tropical areas of the world, including certain coastal areas, during operation, transit or long-term storage. This test is also applicable to materiel transported or stored under extreme conditions of temperature and humidity such as may occur under unventilated tarpaulin covers, in railway boxcars or other vehicles without air conditioning. This test is also applicable to equipment on the masts and exposed upper decks of ships. Three test procedures are described, Procedure 'A' where a realistic simulation of the service conditions for either operational or storage is required, Procedures 'B' or 'C' where close simulation is not essential. This test is only concerned with the heating effects of solar radiation. Where it is necessary to consider other effects, such as material degradation, then the use of Test CL3 - "Solar Radiation Test" - (See Chapter 3-03) should be considered. Guidance on simulating solar radiation is given in Annex A to Chapter 3-03. In those storage/transit conditions where the diurnal variations are so small as to have insignificant effect on the materiel then the use of Test CL7 "Constant High Temperature - High Humidity Test" - (See Chapter 3-07) may be

Test	Scope & Limitations
	considered. Test Procedure 'B' is technically similar to Test Db "Damp Heat, cyclic (12 + 12 hour cycle)" in BS 2011 Part 2.1 except for the differences detailed in paragraph 7. Test Procedures 'A' and 'C' have no equivalent British Standard. Guidance: The following test procedures are available. Test Procedure 'A'. Where a realistic simulation of the service meteorological or storage conditions is required, Test Procedure 'A' should be used. This test procedure is designed to subject the test specimen to either measured conditions specific to the particular application, or to follow the appropriate diurnal temperature-humidity cycles derived from meteorological, and storage data presented in DEF STAN 00-35 Part 4 Chapter for Category B environmental conditions. Where a test is to be carried out under meteorological conditions, a chamber will be required which can provide the radiant heating effect of solar radiation. See also Chapters 3-02 and 3-03. This is usually achieved using arrays of lamps. Although for this test it is not necessary to provide the same spectral distribution as natural sunlight, it may be necessary to adjust the intensity of the radiation in order to provide the correct heating effect. For example, if the source of radiation is high in the infrared (IR) region and the test specimen is painted with IR reflective paint, it will be necessary to increase the radiation intensity above the values given in Part 4 of this Standard. Further guidance on the simulation of solar radiation is given in Annex A to Chapter 3-03. Test Procedure 'B'. This procedure is an approximation to the conditions experienced by materiel exposed directly to hot, humid environments including the effect of direct solar heating. This procedure does not simulate the unventilated storage/transit condition defined in DEF STAN 00-35 Part 4 Chapter 1-01 but is suitable for the assessment of performance of military level packages when transported or stored under ventilated conditions. Procedure 'B' does not permit the simulation of the wet warm climates found in rain forests and other tropical regions when under continuous cloud cover (having no appreciable diurnal cycle or direct solar radiation). In this case either Procedure 'A' must be adopted or consideration given to the use of Test CL7 "Constant High Temperature - High Humidity Test" (See Chapter 3-07). This procedure is based on BS 2011 Part 2.1 Test Db and is intended to facilitate testing in those circumstances where close simulation is not essential. In Procedure 'B' the injection of an aerosol mist at the end of the cooling phase/beginning of the heating phase of the cycle to achieve saturation is applicable to material which may be exposed to dew formation. Test Procedure 'C'. This procedure is an approximation to the conditions experienced by materiel during unventilated storage/transit. Test Procedure 'C' simulates the temperature/humidity conditions that can be attained or exceeded for a total time of approximately 7.4 hours (1% of one month) in the hottest part of the geographical areas described earlier. This test is applicable to materiel housed in locations where the ambient temperature and humidity are high, and remain at a substantially constant level. Such conditions arise in certain enclosed spaces, for example ship's engine and machinery rooms, galleys, laundries etc., where conditions are greatly influenced by heat and water vapour from machinery and equipment. Also to materiel in wet tropical regions under overcast conditions, or in dense jungle. The test procedure does not allow condensation to form on the specimen. If this is required, Test Procedure B of Chapter 3-06 should be used. This test is technically similar to BS 2011 Part 2.1Cb "Damp heat, steady state, primarily for equipment" except for the differences detailed in paragraph 7.

Test	Scope & Limitations
	GAM-EG13 Part 1 Method 03 Damp Heat Purpose of Tests: Knowledge of the capacity of an item of equipment to be stored, started and operated in damp heat conditions. Two procedures are defined : continuous tests and cyclic tests. Possible effects: - Change in the electrical and radioelectrical characteristics Impairment to the semi-conductors and isolators - Drop in dielectric strength - Starting difficulties - Deformations due to the temperature, cracks - Differential expansion, jamming, seizing - Hardening of the vibration insulators and seals - Reduction of the mechanical characteristics of the materials - Reduction of the viscosity of the lubricant and fluids **International Test Operations Procedure (ITOP) 4-2-820 Temperature and Humidity Tests of Ammunition** The objective of this ITOP is to determine the effects of high and low humidity on ammunition in high and low temperature environments. High humidity can cause changes and damage to ammunition that will adversely affect its performance. Corrosion is one of the most common effects of high humidity. In other cases, hydroscopic materials deteriorate rapidly under humid conditions. Combustible cartridge cases may incur a reduced ability to bum. High humidity also imposes a high vapour pressure on materiel which constitutes the force behind moisture migration and penetration. This phenomenon provides a distinction between humidity testing and rain or waterproofness testing. Prolonged exposure to very low humidity, although having the potential of “drying out” certain porous materials, particularly organic rarely in itself has any adverse effect on ammunition. However, a low humidity environment is incorporated into the high temperature cycling test, should it be required. Certain types of ammunition have specifications or standards that provide humidity tests different from those provided. In such cases, the humidity test described in the applicable document will be used.
Low Pressure	**STANAG 4370 AECTP 300 METHOD 312 LOW PRESSURE (ALTITUDE)** Purpose: Low-pressure (altitude) tests are performed to determine if materiel can withstand and/or operate in a low-pressure environment and/or withstand rapid pressure changes. Application: Specific applications are to determine if: a. The materiel can be stored and operated at high ground elevation sites. b. The materiel can be transported or operated in pressurised/un pressurised areas of aircraft. c. The materiel can survive a rapid or explosive decompression and, if not, to determine if it will damage the aircraft

Test	Scope & Limitations
	or present a hazard to personnel. d. The materiel can withstand external carriage on aircraft. Limitations: This method is not intended to be used to test materiel to be installed in space vehicles, aircraft, or missiles that fly at altitudes above 30,000m. **IEC EN 60068 PART 2: 60068-2-13 – TEST M: LOW AIR PRESSURE** This standard deals with low pressure tests at room temperature. The object of this test is to determine the ability of components, equipment or other articles to be stored, transported or used under low air pressure conditions. **DEF STAN 00-35 PART 3** CHAPTER 3-21 TEST CL21 - LOW AIR PRESSURE AND AIR TRANSPORTATION TESTS This test is applicable to: (a) Materiel carried or installed in pressurised or unpressurised regions of service aircraft and other types of flight platform (b) Materiel stored and operated at high ground elevations (c) Materiel including systems or components contained in enclosures with internal atmospheres below standard atmospheric pressure (d) Demonstrating compliance of materiel including packages, with the low pressure requirements of Paragraph 34.8 of Section F of DEF STAN 00-3 for carriage or installation on transport aircraft Where materiel may be subjected to the combined environments of low pressure and high or low temperature, consideration should be given to using the High Temperature-Low Pressure Test of Chapter 3-11 or the Low Temperature-Low Pressure Test of Chapter 3-12. This test does not simulate: (a) Rapid rates of change of pressure associated with manoeuvres of guided weapons and high performance aircraft which is covered by Chapter 3-20, Rapid Pressure Change Test (b) Rapid or explosive decompression of aircraft compartments which is covered by Chapter 3- 09 Rapid or Explosive Decompression Test The Procedures A & C are technically similar to BS 2011:Part 2.1M Test M with the exception that the specimen may be tested in its Service package and preferred pressure severities shall be selected in accordance with paragraph 5.1.1 Neither Test M of BS 2011:Part 2.1M nor any other British Standard test simulates the pressure variations simulated in Test Procedure B.

Test	Scope & Limitations
	CHAPTER 3-20 TEST CL20 - RAPID CHANGE OF PRESSURE The purpose of this test is to demonstrate the ability of materiel to function or survive when subjected to rates of change of air pressure associated with rapid climb and descent of guided weapons and high performance aircraft. This test is applicable to materiel deployed or installed in unpressurised areas of guided weapons and high performance aircraft which experience rapid changes of altitude resulting from deployment. This test is not concerned with sudden loss of pressure in the pressurised areas of aircraft which is covered by Chapter 3-09 - Rapid or Explosive Decompression test, nor with rates of change of pressure which may be experienced by materiel when transported as cargo by air which is covered by Low Air Pressure and Air Transportation tests of Chapter 3-21. Test Procedure A is technically similar to BS 2011:Part 2.1M Test M Low Pressure with the exception that the initial conditions may differ from laboratory ambient pressure and low pressure severities are preferably measured on the intended Service platform. There is no equivalent British Standard test to Test Procedure B or Test Procedure C. CHAPTER 3-09 TEST CL9 - RAPID AND EXPLOSIVE DECOMPRESSION This test is applicable to materiel installed or transported within the pressurised zone of an aircraft. The test is intended to demonstrate whether, in the event of rapid loss of pressurisation or explosive decompression, materiel including packages will survive, or fail in a manner that does not hazard the safety of the aircraft. This test may also be used to demonstrate compliance of materiel with the rapid decompression requirements of Section F of DEF STAN 00-3. This test replaces the differential pressure tests of BS 3G 100: Part 2: Section 3: Sub-section 3.4. **MIL STD 810E METHOD 500.4 LOW PRESSURE (ALTITUDE)** Purpose: Use low pressure (altitude) tests to determine if materiel can withstand and/or operate in a low pressure environment and/or withstand rapid pressure changes. Application: Use this method to evaluate materiel likely to be: a. stored and/or operated at high ground elevation sites. b. transported or operated in pressurised or unpressurised areas of aircraft (consider also method 520.2). c. exposed to a rapid or explosive decompression and, if so, to determine if its failure will damage the aircraft or present a hazard to personnel. d. carried externally on aircraft. Limitations: This method is not intended to be used to test materiel to be installed or operated in space vehicles, aircraft or missiles that fly at altitudes above 30,000m.
Temperature,	**STANAG 4370 AECTP 300 METHOD 317 TEMPERATURE, HUMIDITY, ALTITUDE**

Test	Scope & Limitations
Humidity and Altitude	Purpose : The main objectives of these tests are to determine if: Materiel is safe to handle and/or operate during and following exposure to combined environments involving variations in temperature, humidity and air pressure, or Materiel can be stored and operated as specified in the requirements documents during and following exposure to combined environments involving temperature, humidity and air pressure variations that it is expected to encounter during its service life, or Materiel experiences physical damage during and/or after experiencing exposure to combined environments involving temperature, humidity and ambient pressure variations . Application : Most of the simulated conditions included in this test method relate to unconditioned cargo-bay air transport or external air carriage of materiel, but some others such as high altitude air drop from aircraft may be relevant. This test method is used when the requirements documents state that the materiel is likely to be transported or operated in situations where combination of temperature, humidity and pressure variations may occur. These variations may be caused by displacements of materiel at altitude such as those occurring during aircraft missions (tactical or logistic transport, dropping of materiel, etc.). Some of these situations, such as those encountered with specific jet fighter missions, may produce cyclic variations of those environments due to rapid variations of altitude. The application of this Method relies on the knowledge of these variations. Limitations: This method is not intended to be used to test materiel to be installed in space vehicles, aircraft, or missiles that fly at altitudes above 30,000m. Method 312 should be used when only the low pressure effects on materiel are to be investigated. **IEC EN 60068** IEC EN 60068-2-39 TEST Z/AMD: COMBINED SEQUENTIAL COLD, LOW AIR PRESSURE AND DAMP HEAT TEST Object: To provide a standard environmental test procedure consisting of the application of cold, low air pressure and damp heat; the first two conditions in combination and the second condition combining with the third during the sequential transition from the first. The tests employed are Test A and Test M, but although introduction of moisture is not exactly in accordance with Test D, this letter has been used in the identification Z/AMD as being the most appropriate and informative. The test is intended for components and equipment used in aircraft, particularly in zones that are unheated and unpressurised. General description of the test: The test simulates the conditions encountered within unpressurised and non-temperature-controlled zones of an aircraft during ascent and descent. A non-heat-dissipating component that incorporates elastomeric seals (such as a plug-and-socket connector) will experience hardening of the seals and contraction of materials as it becomes cold, and may suffer failure of such seals, with consequent loss of internal pressure, as the surrounding air pressure decreases. When the aircraft descends into a humid atmosphere and the air pressure increases again, the cold component suffers frosting and the humid atmosphere itself, or free water

Test	Scope & Limitations
	formed by the melting of the frost, may be driven into the component by the differential pressure and be trapped inside by the seals as they recover their normal elasticity. The same sequence may cause water or ice to accumulate inside a piece of equipment with an unsealed but closely fitting cover and no drain holes. 60068-2-40 Test Z/AM: COMBINED COLD/LOW AIR PRESSURE TESTS Purpose: This procedure deals with combined cold (with gradual change of temperature) and low air pressure tests for both heat-dissipating and non-heat-dissipating specimens. The object of the test is to determine the ability of components or equipment or other articles to be stored and used under a simultaneous combination of low temperature and low air pressure. This combined test should normally be used only if the effects of combined environments will not be revealed by subjecting the specimen to single environments. The procedures given in this publication are limited to the case of specimens which achieve temperature stability during the test procedure. In the case of testing heat-dissipating specimens, this procedure applies only to the testing of one specimen at a time. Object: To provide a standard test procedure to determine the suitability of components, equipments or other articles for use and/or storage under a combination of low temperature and low air pressure. General description: This test is a combination of Test Ab or Ad: Cold, and Test M: Low air pressure. IEC EN 60068-2-41 TEST Z/BM: COMBINED DRY HEAT/LOW AIR PRESSURE TESTS This publication deals with combined dry heat (with gradual change of temperature) and low air pressure tests for both heat-dissipating and non-heat-dissipating specimens. The object of the test is to determine the ability of components or equipments or other articles to be stored and used under a simultaneous combination of high temperature and low air pressure. This combined test should normally be used only if the effects of combined environments will not be revealed by subjecting the specimen to single environments. The procedures given in this publication are limited to the case of specimens which achieve temperature stability during the test procedure. In the case of testing heat-dissipating specimens, this procedure applies only to the testing of one specimen at a time. The test procedure applies to air pressure down to about 10 mbar. At air pressures below 10 mbar, phenomena not taken into account in the design of this test procedure become important. The relationship between altitude, pressure and temperature has not been indicated in this publication. Such data should be obtained from special publications. Object: To provide a standard test procedure to determine the suitability of components, equipments or other articles for use and/or storage under a combination of high temperature and low air pressure. General description: This test is a combination of Tests Bb or Bd: Dry heat, and Test M: Low air pressure. The specimen is first subjected to the appropriate severity of dry heat as specified in the relevant specification. In the case of operational tests, a check is then made to ensure that the specimen is capable of operation. With the

Test	Scope & Limitations
	temperature maintained at the prescribed value, the chamber air pressure is then reduced to the appropriate severity as specified in the relevant specification. These conditions are maintained for the specified duration. **DEF STAN 00-35** CHAPTER 3-11 TEST CL 11 - HIGH TEMPERATURE - LOW PRESSURE This test is applicable to materiel which may experience the combined environments of high temperature and low pressure during air carriage and free flight and where it is considered the effects may be different or more stressful than those due to high temperature or low pressure alone. This test is applicable to materiel installed or deployed on Service aircraft, or systems and components of guided weapons and projectiles whose speed during free flight is subsonic. Test Procedure B may be used to simulate the variation of combined high temperature and low pressure, resulting from rapid and wide ranging changes of velocity and altitude in flight. The conditions simulated by this test would not normally apply to materiel carried as cargo. Test Procedure A invokes the procedure of BS 2011: Part 2.1 Z/BM, Test Z/BM, Combined dry heat/low air pressure tests, for those situations where the real life combined environments of high temperature and low pressure may be reasonably represented by stabilised conditions. CHAPTER 3-12 TEST CL12 - LOW TEMPERATURE - LOW PRESSURE TEST This test is applicable to materiel which when deployed or installed on Service aircraft may experience low temperature combined with low air pressure and where the combined environment may produce effects different to or more stressful than those resulting from low temperature or low pressure alone. Such conditions are experienced by materiel deployed as follows: (a) Attached to the external surface of an aircraft structure (b) Installed in partially or non-conditioned aircraft bays (c) As air carried stores for example guided weapons, ordnance and surveillance systems (d) As cargo attached directly or indirectly to the aircraft structure This test does not normally apply to materiel carried as cargo on transport aircraft in which conditioned cargo bays are provided. These conditions are covered by the methods of Test CL21 - "Low air pressure (transportation)" (See Chapter 3-21). This test invokes the procedure of BS 2011 Part 2.1 Z/AM: Test Z/AM Combined Cold/Low Air Pressure, with the exceptions specified in Paragraph 7 below. CHAPTER 3-13 TEST CL13 - LOW TEMPERATURE - LOW PRESSURE - HIGH HUMIDITY This test is applicable to materiel deployed or installed on Service aircraft and liable to be subjected to the combined

Test	Scope & Limitations
	environments of low temperature, low pressure and high humidity during the descent from flight altitude to ground level. Such conditions are experienced by materiel deployed as follows: (a) Attached to the external surface of an aircraft structure (b) Installed in partially or non-conditioned aircraft bays (c) As air-carried stores such as guided weapons, ordnance and target tracking systems (d) As cargo attached directly or indirectly to the aircraft structure If operational requirements in service are such that performance of materiel need only be assessed during the combined low temperature/low pressure condition and it has been ascertained there will be no ingress of moisture resulting from a simultaneous change of air pressure with high humidity, then the test procedure of Chapter 3-12 Low Temperature/Low Pressure is more appropriate. This test is not normally applicable to materiel carried as cargo in conditioned bays of transport aircraft. Such conditions are simulated using Test Procedure B of Chapter 3-21 Low Air Pressure and Air Transportation Test. Test Procedure A is technically similar to BS2011:Part 2.1 Z/AMD: with the exceptions given in Paragraph 7.1. **MIL STD 810E METHOD 520.2 TEMPERATURE, HUMIDITY, VIBRATION, AND ALTITUDE** Purpose. The purpose of this test is to help determine the combined effects of temperature, humidity, vibration, and altitude on airborne electronic and electro-mechanical materiel with regard to safety, integrity, and performance during ground and flight operations. Some portions of this test may apply to ground vehicles, as well. In such cases, references to altitude considerations do not apply. Application. a. Use this method to evaluate materiel likely to be deployed in altitude areas (above ground level) where temperature, humidity, and vibration may combine to induce failures. b. Use this method for engineering development, for support of operational testing, for qualification, and for other similar purposes. This method is primarily intended for actively powered materiel operated at altitude, i.e., aircraft, missiles, etc. c. Use this method to provide an option for use of vibration in combination with the climatic elements, or for use of the climatic tests in combination with each other. This is often noted throughout the text. Generally, the combined environment test simulates those synergistic environmental effects that occur for the majority of the deployment life. Environmental stresses may be tested in combination using method 520.2, or singly using methods 500.4, 501.4, 502.4, 507.4, and 514.5, appropriately. Limitations. a. Limit use of this method to evaluating the combined effects of altitude, temperature, humidity, and vibration. b. Some procedures permit testing for the effects of one forcing function at a time and stressing materiel items beyond realistic limits. Doing so may reduce or eliminate synergistic or antagonistic effects of combined

Test	Scope & Limitations
	stresses, or may induce failures that would not occur under realistic conditions. c. This method does not apply to unpowered materiel transported as cargo in an aircraft. d. The tailored test cycle should not include short duration vibration events or those that occur infrequently in the test cycle. These events include firing of on-board guns, extreme aircraft motion, and shock due to hard landings. Test for these events separately using the appropriate test method. **GAM-EG 13** GAM-EG 13 METHOD 05 ALTITUDE AND TEMPERATURE Purpose of Test: To check the performance of equipment liable to undergo variable low pressure conditions with or without high or low temperatures (conditions encountered for example at high altitude on land or abroad aircraft). These tests limited to simulating a maximum altitude of 30,000 m and therefore do not cover the use phases in a space environment. GAM-EG 13 METHOD 10 TRANSIENT THERMAL VACUUM Purpose of Tests - Knowledge of the performance of an item of equipment liable to undergo the vacuum and temperature conditions encountered during short term ballistic and space missions. - Checking the capacity to operate after and / or during time spent in rarefied atmospheric conditions. GAM-EG 13 METHOD 11 LONG TERM THERMAL VACUUM Purpose of Test - Knowledge, through simulation of a limited duration, of the performance of an item of equipment liable to undergo the “terrestrial orbital life“ conditions encountered during long term space missions (satellites) - Check on the capacity of an item of equipment to operate during and / or after a time spent in “terrestrial orbital life” - Examination for the behaviour of the “thermal test” (thermal balance and correlation of the mathematical mode) - Examination of the performance of the equipment
Icing	**STANAG 4370 AECTP 300 METHOD 311 ICING** Purpose: The icing test is conducted to evaluate the effect of icing on the operational capability of materiel. This Method also provides tests for evaluating the effectiveness of de-icing equipment and techniques, including prescribed means to be used in the field. Application: a. This Method is applicable to materiel that may be exposed to icing such as produced by freezing rain or freezing drizzle (see paragraph 2.1.1 below). b. This Method can be used for ice accretion from sea splash or spray, but the ice thickness may need to be modified to reflect the lower density of the ice.

Test	Scope & Limitations
	Limitations: This Method does not simulate snow conditions or ice build-up on aircraft flying through supercooled clouds. Although frost occurs naturally, the effects are considered less significant and are not specifically addressed in this Method. This Method may not be suitable for the assessment of aerial/antenna performance, (i.e., rime ice saturated with air causes substantial signal reflection). For optional tests for testing vehicle windscreens/windshields, see EEC Directive 78/317/EEC. Also, this Method does not address icing effects from falling, blowing or recirculating snow and wet snow or slush. These are considered less severe than those in paragraph 2.2. **DEF STAN 00-35 PART 3 CHAPTER 3-10 TEST CL10 – ICING** This test is applicable to materiel liable to exposure to icing conditions, to assess its performance or survival when subjected to water, spray, fog or mist at sub-zero temperatures. The test may be used to evaluate the performance or survival of materiel when enveloped in specified depths of ice. A special procedure is included for evaluating the performance of de-icing systems for vehicle windscreens. The test does not simulate frost or icing combined with induced changes of temperature, humidity and air pressure which is covered by Chapter 3-13, nor the immersion of materiel in water following a period at low temperature which may result in the formation of ice which is covered by Test Procedure E of Chapter 3-14. This test does not simulate impact icing conditions during flight which is covered by Chapter 3-23. Test Procedure B is technically similar to EEC Directive 78/317/EEC. **MIL STD 810E METHOD 521.2 ICING/FREEZING RAIN** Purpose. The icing test is conducted to evaluate the effect of icing on the operational capability of materiel. This method also provides tests for evaluating the effectiveness of de-icing equipment and techniques, including prescribed means to be used in the field. Application. a. Use this method to evaluate materiel which may be exposed to icing such as produced by freezing rain or freezing drizzle. (See paragraph 2.2.1.1 below.) b. Use this method to develop ice accretion from sea splash or spray but the ice thickness may need to be modified to reflect the lower density of the ice. Limitations. This method does not simulate snow conditions or ice buildup on aircraft flying through supercooled clouds. Although frost occurs naturally, the effects are considered less significant and are not specifically addressed in this method. This method may not be suitable for the assessment of aerial/antenna performance, (i.e., rime ice saturated with air causes substantial signal reflection). Also not considered are the icing effects from falling, blowing or recirculating snow and wet snow or slush. These are considered less severe than those in paragraph 2.1.1. **GAM-EG 13 METHOD 14 ICE** Purpose of Test : Knowledge of the capacity of an item of equipment to start and / or operate under a layer of ice

Test	Scope & Limitations
	and the efficiency of the possible deicing facilities.
Freeze Thaw	**STANAG 4370 AECTP 300 METHOD 315 FREEZE/THAW** Purpose: The purpose of this test is to determine the ability of materiel to withstand; The effects of moisture phase changes between liquid and solid, in or on the materiel as the ambient temperature cycles through the freeze point ; The effects of moisture induced by transfer from a cold-to-warm or warm-to-cold environment. Application: This test is applicable to materiel that will experience one or more excursions through freeze point while wet or in the presence of moisture (free water or vapour). See paragraph 2.2 for specific examples. Limitations: This test is not intended to evaluate the effects of low temperature, thermal shock, rain or icing. These may be determined by Methods 303, 304, 310 and 311 respectively. **DEF STAN 00-35 PART 3 CHAPTER 3-24 TEST CL24 - FREEZE – THAW** This test is applicable to materiel which may experience temperature cycling through 0°C combined with high humidity, producing a mixture of ice and water and where alternate freezing and melting, may induce stress or cause interference between components and moving parts. There is no equivalent British Standard Test. 2 **GAM-EG 13 METHOD 22 ICING-FREEZINC-THAWING** Purpose of test Knowledge of the capacity of an item of equipment to withstand the variations in temperature on either side of 0 °C in the presence of heavy humidity producing icing and condensation. Note: The general term icing indicates any deposit of ice produced on a surface through the freezing of supercooled drops of water or at a temperature little above 0 °C. There are two types of icing : - white ice, subject of this method which consists of thin sheets spaced apart by air inclusions - transparent ice which is a compact and smooth homogeneous deposit (ice or black ice) , type whose simulation is the subject of method 14 (ice)

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6.5.3 Technical Comparison

6.5.3.1 High and Low Temperature Test Procedures

Constant temperature testing, either hot or cold, is undertaken to demonstrate equipment functions correctly at elevated or reduced temperature. In the defence field this type of constant amplitude test is frequently used by suppliers of COTS equipment to demonstrate a high and low temperature operational capability. In this form the test procedures are relatively old and exists in both Civil standards and national military standards. As it is needed for COTS equipment commonality between civil and defence specifications is important. For this use the specifications should also be firmly written such that the test actually undertaken is well understood.

Many standards have separate hot and cold procedures. However, this comparison found almost identical arguments regardless of whether hot or cold procedures were considered. To avoid repetition they are addressed together here.

It has been found that constant amplitude temperature testing is not particularly useful for testing defence systems. Were a demonstration to operate or survive in a thermal cycle has shown to be more significant. Tests to allow realistic thermal cycling mostly appear in the Defence Standards.

The main difference between the civil procedure international IEC EN 60068 and the military standards is the absence of good temperature cycling procedure. IEC EN 60068-2-1 Cold and IEC EN 60068-2-2 Dry heat are both firmly written constant high temperature test. A separate procedure exists IEC EN 60068-2-14 Test N Change of Temperature which permits a course cyclic test. This latter test is not particularly sophisticated and does not permit user defined temperature cycles. One of the cycle types set out in this procedure was commonly used in the 1960’s and 70’s for defence applications. However, it was found to generate unrepresentative failures and as a consequence the cycle used in most Defence standards now allows the tailoring of the cycle profile to replicate either actual daily cycles or user defined cycles.

The UK national Defence standard Def-Stan 00-35 contains two high temperature test procedures. Test Cl1 Constant High Temperature - Low Humidity Test is essentially identical to IEC EN 60068-2-2 Test B Dry heat test procedure. Test CL2 High Temperature, Low Humidity And Solar Heating Diurnal Cycle Test is technically comparable to test procedures of Method 302 (AECTP 300). Procedure A of the Def Stan corresponds to Procedure I of the AECTP procedure, whilst, procedure B corresponds to procedure II and offers some test temperature values for predetermined situations. The diurnal cycle test uses a representative 24 hour thermal cycle as well as permitting use of older courser cycles for reasons of backward compatibility.

The UK national Defence standard Def-Stan 00-35 also contains two low temperature test procedures. Test CL4 Constant Low Temperature Test is technically similar to BS EN60068-2-1 Part 2 Tests A Cold. Test CL5 - Low Temperature Diurnal Cycle Test is technically comparable to test procedures of Method 303 (AECTP 300).

The French national defence standard GAM-EG13 Cold and Dry Heat test methods are comparable with the IEC constant amplitude methods. The test severities can to be tailored but the amount of guidance information is lower than in other military standards. The French standard also contains a Thermal Cycles procedure as well as a Climatic Cycles procedure. The former is a cycle test which includes a course cycle similar to the IEC procedure as well as more representative “sinusoidal” type cycle. This is more representative than the IEC cycle but not as representative of real conditions as the Def Stan / STANAG cycle. The Climatic Cycles procedures combines hot and cold cycles and is essentially a derivative procedure.

International Test Operating Procedure 2-2-816 is a quadripartite agreement between the UK, US, F & DE. This particular test relates specifically to tracked vehicles and as such could be regarded as a vertical standard. The process set out is very basic subjecting the vehicles to a few constant amplitude tests. It is unclear why such a basic procedure warrants a specific agreement. Moreover, the existence of such an agreement could be used to circumvent more sophisticated and realistic requirements. In this regard the rationale for procedure could be in conflict with European defence procurement strategy.

The high (Method 302) and low (Method 303) temperture tests within Nato STANAG 4370 each includes three procedures the first two of those related to storage and operating. The storage procedure allows both cyclic testing as well constant amplitude testing, the operating procedure is a cyclic test. In both cases the cyclic conditions are based upon a realistic daily thermal cycle. The use of the storage procedure at constant amplitude is very much a secondary option and this aspect is not written in a particularly firm manner which is would allow its use or COTS equipment. The third radiative procedure for the hot test is used when the effects of solar radition need to be included in the cycle but whemn the equipment only experiences indirect heating from solar radiation viz. solar radiation is not experienced directly. The third manipulative procedure within the cold test is used to determine whether equipment can be manually operated, assembled or disasembled. A major benefit offered by Nato Stanag 4370 is its very comprehensive guidance information. This supplies information to the test specifier to tailor the procedure keeping in mind the following aspects:

effects of high temperature on materiel

heat transfer physics

choice of test parameters

determination of test severities

The US National defence Mil-Std 810 procedures for high and low temperature testing are similar to Method 302 & 303 of AECTP 300, but not identical. In this case the "storage" procedure is constant temperature only, whilst, the "operating" procedure allows cyclic or constant temperature testing. Neither constant temperature test procedure is sufficiently firmly to allow its use for COTS equipment. Although radiative heating situations are mentioned, no specific test procedure is presented. The cold test does includes a "manipulation" procedure . This method is not generally practical for:

a. Evaluating time-dependent performance degradation (ageing) effects that occur during constant long-term exposure to high temperatures (under storage or operational modes) where synergetic effects may be involved. For such high temperature ageing effects, test in the natural environment.

b. Evaluating materiel in a high temperature environment where solar radiation produces significant thermal gradients in the materiel. For simulating direct solar impingement, use method 505.4, Proc I.

As already indicated the main difference between defence standards and civil standards with regard high and low temperature testing is that the former includes procedures which allow temperature cycling rather than essentially constant temperature test. Whilst, some defence systems require verification of operation at constant elevated temperature, determining the degradation effects of temperature cycling is also a strong requirement. Historical experience has indicated that temperature cycling procedures identify in-service failure modes that cannot be determined from essentially constant temperature testing. Experience also indicates that unrepresentative cycles induces unrealistic damage and degradation. For this reason the deficiencies in the civil procedures preclude their recommendation with regard temperature cycling. Of the military procedures Stanag 3470 Method 302 contains methods that technically encompass those of the other national defence standards.

Notwthstanding the above constant high and low temperature testing procedures are required for COTS equipment to demonstrate an operational capability. For this purpose the IEC 600068 procedure appears to be common with the Def Stan 00-35 or GAM EG 13 tests and generally suitable for COTS testing. It is a common observation that the existing constant temperature test procedures are not necessarily appropriate for equipment which is self generating significant levels of thermal output.

6.5.3.2 Solar Radiation Test Procedures

For most defence equipment the simulation of the thermal effects of solar radiation is usually far more common than simulating the actinic effects. For defence equipment subject to solar radiation the induced temperatures can be significantly greater than the climatic temperatures. Moreover, operational military requirements may preclude the use of protection against solar radiation. This notwithstanding civil and military test procedures are generally quite similar.

The International civil standard IEC EN 60068 contains both a solar radiation test procedure 60068-2-5 as well as associated guidance 60068-2-9. The latter provides extensive guidance information, but some parts are outdated. The guidance was published in 1975 and gives information on the available radiation sources: carbon arc, xenon, tungsten lamps and mercury vapour lamps. There has been progress in lamps technology since 1975 (metal halide sources can be used for heating effects for instance).

The UK National Defence standard Def-Stan 00-35 Test CL3 Solar Radiation Test is technically similar 60068-2-5. Extensive guidance and bibliography given in Annex A.

The French national Defence standard GAM-EG13 method is comparable with the IEC method.

The US National defence standard Mil-Std 810 simulates the ultraviolet portion of the solar spectrum only in a general way, but most people consider this simulation as adequately representative of levels in most geographic areas. This method does not simulate uniform heating that occurs in enclosed environments or indirect heating in shaded areas, or in covered storage conditions. Due to the possible change in irradiance, this method is not intended to be used for space applications.

International Test Operating Procedure 4-2-826 is a quadripartite agreement between the UK, US, F & DE. This particular test relates to all military equipment and consequently has the same as the STANAG. The process set out is basically a mix of hot wet temperature cycling and solar radiation testing. The procedures are those of the Mil Std 810 and consequently could be deemed to put the European defence industry at a disadvantage. As the STANAG effectively supersedes this agreement its continued existence has doubtful value.

NATO STANAG 4370 contains extensive guidance and bibliography in Annexe A. Most this information is similar to IEC 60068-2-9 but is often more up to date. Guidance paragraphs address the following topics to conduct the tailoring process:

- effects of solar radiation
- rationale for the choice between the two procedures
- specification of the test severities
- warning on the health hazards.

The various solar radiation test procedures are comparable and technically similar. The main difference between them is that NATO STANAG 4370 contains up to date guidance using the latest technology.

6.5.3.3 Thermal Shock

The thermal shock test is a relatively specialist test replicating only a few real world conditions. Historically the test has not been particularly easy to undertake and tailoring the procedure to specific applications has previously had advantage. Real world conditions producing thermal shock exist which are essentially unique to a small range of defence equipment. Generally in those cases the rate of change of temperature is greater than experienced by civil equipment.

Civil International standard IEC EN 60068-2-14 Tests Na and Nb allows a form of thermal shock test to be undertaken.

The Def-Stan 00-35 Part 3 Chapter 3-14 Test procedures A and B incorporates the test methods of IEC EN 60068-2-14 Change of Temperature Tests Na and Nb respectively. However, it changes the rate of change of temperature for defence use.

The French national Defence standard GAM-EG13 method is broadly comparable with the IEC method. It allows different rates of temperature change and multiple cycles.

The US National Defence Standard Mil-Std is not compatible with the IEC test. This method does not address the temperature shock experienced by materiel transferred between air and liquid or two liquids, the thermal shock caused by rapid transient warm-up by engine compressor bleed air, or aerodynamic loading. Except for ESS, this method is inappropriate if the actual transfer time in a service environment will not produce a significant thermal shock.

The International NATO STANAG 4370 method 304 encompasses a procedure able to be used for defence applications specifically related to air to air thermal shocks.

Rapid change of temperature can exercise damage mechanisms that are not exercised by slower temperature cycling tests. The military test procedures include a procedure specifically for this purpose, the civil standard IEC EN 60068-2-14 is a slower temperature cycle and not really comparable. The STANAG 4370 procedure encompasses the relevant national Defence procedures.

6.5.3.4 Humidity

As was the case for high and low temperature testing, two forms of humidity test exist; one at essentially constant temperature / humidity and the other in which temperature and humidity cycle. In this case not only is the constant temperature / humidity test applicable to COTS equipment it is also replicates a few situations in which defence equipment may be cited. Nevertheless the cyclic temperature / humidity is also very commonly adopted for defence systems as it replicates the effects of equipment “breathing” in moisture. It also is a commonly adopted extension of the hot temperature cyclic test. Mostly for defence systems a realistically profiled daily temperature / humidity cycle is adopted.

International civil procedure IEC EN 60068 has two humidity tests; the first 60068-2-30 damp heat cycling and the second 60068-2-38 temperature humidity cycle. The 60068-2-30 damp heat cycling test uses a simple two level temperature cycle during which the humidity is kept at nearly a constant high RH level. The test allows a user defined upper temperature but not a user defined temperature profile. The 60068-2-38 temperature humidity cycle uses a slower rate of rise and fall of the temperature levels and a modest change of humidity. This is to stimulate “breathing” failures caused by the ingress of moisture. However, the test does not readily allow user defined profiles as severities are embedded into the procedure.

The French national defence standard GAM-EG13 Damp Heat test method is comparable with the IEC constant amplitude methods. The test severities can to be tailored but the amount of guidance information is lower than in other military standards. The French standard also contains a Thermal Cycles procedure as well as a Climatic Cycles procedure. The former is a cyclic temperature test but with constant humidity. The Climatic Cycles procedures combines hot and cold cycles but again with constant humidity and is essentially a derivative procedure.

The UK National Standard Def Stan 00-35 contains two humidity tests. The first Is Test Cl7 Constant High Temperature - High Humidity Test. This is technically similar to the IEC / EN constant humidity test. It is firmly written and can be used for either simulating actual defence conditions or COTS equipment. The second procedure is Test C6 High Temperature, Humidity And Solar Heating Diurnal Cycle Test. This is a combined cyclic test which can be used to include the indirect effects of solar radiation. The test includes three procedures; the first procedure uses a realistic daily cycle of humidity and temperature (including if required the indirect effects of solar radiation, the second procedure is a course cycle intended to be equivalent to IEC EN 60068 Test Db And Guidance: Damp Heat, Cyclic, the third procedure is intended to simulate the effects of unventilated storage and transit.

The US national defence standard Mil Std 810 includes a humidity test. This is essentially a constant level test but does allow a specific (aggressive) temperature cycle. This latter cycle would allow the stimulation of “breathing” failure modes.

International Test Operating Procedure 4-2-820 is a quadripartite agreement between the UK, US, F & DE. This particular test relates specifically to ammunition and as such could be regarded as a vertical standard. The procedure sets out essentially the Mil Std 810 temperature / humidity cycle method but using the STANAG 2895 temperature / humidity severity cycles. The STANAG 2895 temperature / humidity severity cycles are now included in STANAG 4370 and are those of the UK Def Stan 00-35. This ITOP procedure was last issued after the STANAG 4370 procedure was published and the need for its continued existence is questionable.

The high humidity (Method 306) test within Nato STANAG 4370 includes two procedures. Procedure II allows constant / stable amplitude humidity conditions and Procedure I a cyclic test. The constant humidity test is mostly intended for replicating in-service conditions but could equally be used for COTS equipment. The procedure is reasonably firmly written and could be used for COTS purposes. A major benefit offered by Nato Stanag 4370 is its very comprehensive guidance information.

Superficially the observations for humidity testing are similar to those for temperature testing. For defence equipment a cyclic test has been found to be more representative and commonly used for defence systems. On the other hand firmly written constant amplitude tests are also required for COTS equipment. This is reflected in the various standards reviewed here, with the defence standards encompassing a far broader range of procedures than the civil standard. To some extent this reflects a difference in overall philosophy between the documents. That is IEC EN 60068 is more concerned with setting a standard for OEM and COTS equipment rather than evaluating systems against in-service use. Although the various defence procedures are incorporated in different ways, the STANAG encompasses the majority of the overarching requirements and contains a useful amount of guidance. As constant amplitude humidity testing is also an in-service defence requirement this aspect is reasonably well written and could be used for COTs equipment with a reasonable degree of confidence. However, it is still not as good as the IEC 600068, Def Stan 00-35 or GAM EG 13. The latter two procedures had a deliberate intent of commonality which is not apparent in the STANAG. Neverthless the STANAG is the best procedure in many areas and acceptable in others, consequently it is reccomended.

6.5.3.5 Low Pressure

The low pressure test exists in civil and defence standards for several reasons. The most common is to demonstrate that equipment survives and / or operates at elevated locations (high ground) and transported by air. For this purpose a constant pressure test is required. However, for defence applications such as air carried missiles, change of pressure can also be significant. For equipment carried inside aircraft the effects of rapid or explosive decompression is also required. Generally the equipment will be required to remain safe and serviceable after rapid decompression but only remain safe following explosive decompression.

The international Civil standard IEC EN 60068-2-13 test for low air pressure is a simplistic test allowing demonstration that equipment will survives and / or operates at elevated locations and can transported by air. It comprises subjecting the equipment to constant low pressure without excessive change of pressure. This test may be used for COTS equipment.

The UK national defence standard Def Stan 00-35 contains three test procedures. The first Test CL21 - Low Air Pressure And Air Transportation Test is technically equivalent to IEC EN 60068-2-13. The second test CL20, Rapid Pressure Change Test is intended the defence related applications related to applying rapid rates of change of pressure associated with maneuvers of guided weapons and high performance aircraft. The third test is CL09 Rapid or Explosive Decompression Test which imposes a very rapid change of pressure to simulate rapid or explosive decompression of aircraft compartments.

The US national defence standard Mil Std 810 encompasses four procedures for equipment; stored and/or operated at high ground elevation sites, transported or operated in pressurized or unpressurised areas of aircraft, exposed to a rapid or explosive decompression and carried externally on aircraft.

The STANAG procedure also includes methods to encompass the defence requirements for low pressure testing. Whilst the procedure is based upon the Mil Std it incorporates the main components of the UK Def Stan and were applicable the IEC EN test procedure. However, the latter does not encompass all defence requirements. Nevertheless the STANAG test is not as firmly written as the IEC EN procedure or the basic constant altitude Def Stan procedure. For COTS equipment either of these two tests may be preferable.

6.5.3.6 Temperature, Humidity Altitude

The various standards reviewed contain procedures allowing the simultaneous application of various aspects of temperature, humidity and altitude (and in some cases vibration also). The objective behind subjecting equipment to such a combined test arises when combining several environmental conditions produces damage or degradation that would not be found by applying the environments singularly. When the effects of several environments combine in this way is often referred to as synergism.

The reason the subjecting equipment to combined environmental conditions will very much depend upon the type of failure expected. Compromises in the way combined conditions are applied can lead to some tests been able to exercise some failure modes better than others. For this reason selecting a specific procedures may be dependant upon the identified failure modes.

For the most part the various procedures adopt those of the individual environmental conditions. As these have largely already been addressed it is not intended to reiterate earlier comparisons. Nevertheless some of the combined procedures, usually encompassing a pair of environments, are intended to be firmly written for specific applications. Conversely others are intended as a model, which a user can make specific amendments for specific equipment.

Procedures intended primarily for equipment located in unheated and unpressurised areas of aircraft (subject to low temperature and low pressure) include IEC EN 60068-2-40, Def Stan 00-35 CL12 and GAM EG 13 method 05.

For aircraft equipment subject to the effects of kinetic heating or imposed thermal conditions tests at altitude may adopt the procedures in IEC EN 60068-2-41, Def Stan 00-35 CL11 and GAM EG 13 method 05.

For equipment subject to a cold soak at high altitude and then rapid decent to lower altitude (higher pressure & temperature) which includes humidity applicable procedures are those of IEC EN 60068-2-39, Def Stan 00-35 CL13. These condition are frequently encountered by missiles were optical sensor systems as well as control surfaces may be degraded by the effects of these environments.

The majority of procedures specifically exclude space applications, however, the French GAM EG 13 includes two specific procedures methods 10 and 11.

The Mil Std 810 and STANAG procedures offer generic procedures which can be adopted by the user to allow the simulation of specific conditions. In this regard the STANAG test in particular can be used as a model for the majority of applications set out above. As it is the most flexible procedure it is generally recommended. However, this strategy may not be contractually acceptable for every application. In those cases the IEC EN, Def Stan and GAM EG procedures are all firmly written and application specific. As such in those cases would be recommended.

6.5.3.7 Icing

Traditionally the icing test procedure has been used to demonstrate the ability of equipment to survive and / or function when exposure to icing conditions when subjected to water, spray, fog or mist at sub-zero temperatures. The procedure also provides a means for evaluating the effectiveness of de-icing equipment and techniques.

The UK national defence standard Def Stan 00-35 icing test procedure includes two methods. The first general method requires a specified depth of ice to be produced on the equipment. This is achieved by spraying water (or salt water solution). The second method in the Def Stan is included specifically to comply with EEC Directive 78/317/EEC to determine the effectiveness of vehicle windscreen de-icing systems.

The French national defence standard includes an icing test very similar to the general procedure in the Def Stan. Both procedures reduce the test item temperature before spraying with water or salt water solution. For ice thickness up to 13 mm this is done at -10 °C whilst for thicknesses of between 25 to 75 mm the test item is at -25 °C. The purpose of the lower temperature appears to be to allow large ice build in a sensible time.

The US national defence standard is again similar to the general method of the Def Stan and the procedure of GAM EG 13. However, the procedure only uses a temperature of -10 °C regardless of ice thickness. The procedure requires at least 4 hours for the ice to harden.

The icing procedure with the international NATO standard STANAG 4370 effectively uses the Mil Std procedure rather than the European methods. Although it has to be said the difference is not that significant. However, the STANAG does incorporate a procedure intended to incorporate the EEC Directive 78/317/EEC to determine the effectiveness of vehicle windscreen de-icing systems.

6.5.3.8 Freeze Thaw

The Freeze thaw test exists mostly in European procedures. The test is applicable to equipment which may experience temperature cycling through 0°C combined with high humidity, producing a mixture of ice and water and where alternate freezing and melting, may induce stress or cause interference between components and moving parts.

The UK national defence standard Def Stan 00-35 includes a Freeze-thaw test procedure. This procedures reduces the temperature of the equipment to -4 °C and then water is sprayed on the item until ice 3 to 6 mm deep is produced. The equipment is then subject to temperature cycle between -4 °C and +2 °C.

The procedure within the French national defence standard GAM EG 13 is markedly different from the UK approach. The French procedure reduces the temperature of the equipment (between -10 °C and -40 °C) and then raises it to 0 °C whilst subject the item to high humidity. The temperature is then reduced again to harden the ice and then brought up to +20 °C.

The NATO STANAG 4370 contains a Freeze – thaw procedure comprising three methods. These appear to be an enhanced variants of the methods in the two European standards. Although the three methods are clearly loosely based upon the GAM EG 13 procedure, they have marked differences. These differences appear to be intended to better simulate actual conditions causing Freeze thaw induced damage.

6.5.4 Conclusions

A summary of the recommendations is shown in the table below which is expanded in the following paragraphs.

Summary of Recommendations for Temperature, Humidity and Pressure Tests						
	NATO STANAG 4370 AECTP	International EN / IEC 60068	UK Def Stan 00-35	France GAM-Eg-13	US Mil Std 810F	Quadripartite US/UK/F/DE ITOP
High Temperature		All three constant temperature tests recommended specifically for COTS equipment.				
	Recommended for cyclic procedure for Defence systems		Cyclic test Equivalent to STANAG			
Low Temperature		All three constant temperature tests recommended specifically for COTS equipment				
	Recommended for cyclic procedure for Defence systems		Cyclic test Equivalent to STANAG			
Solar Radiation	Recommended					
Thermal Shock	Recommended					No equivalent test.
Humidity	Recommended		Equivalent to STANAG		Similar to STANAG	
Low Pressure	Recommended	Suitable for COTS equipment	Essentially equivalent to STANAG	No equivalent test.	Essentially equivalent to STANAG	No equivalent test.
Temperature, Humidity Altitude	Recommended for generic procedure	Recommended for specific applications related to aircraft equipment and space equipment			Essentially equivalent to STANAG	No equivalent test.
Icing	Recommended	No equivalent test	Very similar except UK specification also implements EEC directive		Essentially equivalent to STANAG	No equivalent test.
Freeze Thaw	Recommended	No equivalent test	These procedures differ from each other and the STANAG		No equivalent test	No equivalent test

6.5.4.1 High and Low Temperature Test Procedures

The main difference between defence standards and civil standards with regard high and low temperature testing procedures is that the former include procedures which allow temperature cycling rather than essentially constant temperature test. Whilst, some defence systems require verification of operation at constant temperature, determining the degradation effects of temperature cycling is also a strong requirement. Historical experience has indicated that temperature cycling procedures identify in-service failure modes that cannot be determined from essentially constant temperature testing. Experience also indicates that unrepresentative cycles induces unrealistic damage and degradation. For this reason the deficiencies in the civil procedures preclude their recommendation. Of the military procedures Stanag 3470 Method 302 contains methods that technically encompass those of the national defence standards for that reason it is reccomended. However, for COTS equipment the STANAG ios not sufficiently firmly written and for this purpose only the IEC 600068, Def Stan 00-35 or GAM EG 13 procedures are all suitable.

6.5.4.2 Solar Radiation Test Procedures

The various solar radiation test procedures are comparable and technically similar. The main difference between them is that NATO STANAG 4370 contains up to date guidance using the latest technology, for that reason it is recommended.

6.5.4.3 Thermal Shock

Rapid change of temperature can exercise damage mechanisms that are not exercised by slower temperature cycling tests. The military test procedures include a procedure specifically for this purpose, the civil standard IEC EN 60068-2-14 is a slower temperature cycle and not really comparable. The STANAG 4370 procedure encompasses the relevant national defence procedures and is consequently recommended.

6.5.4.4 Humidity

Superficially the observations for humidity testing are similar to those for temperature testing. For defence equipment a cyclic test has been found to be more representative and commonly used for defence systems. On the other hand firmly written constant amplitude tests are also required for COTS equipment. This is reflected in the various standards reviewed here, with the defence standards encompassing a far broader range of procedures than the civil standard. To some extent this reflects a difference in overall philosophy between the documents. That is IEC EN 60068 is more concerned with setting a standard for OEM and COTS equipment rather than evaluating systems against in-service use. Although the various defence procedures are incorporated in different ways, the STANAG encompasses the majority of the overarching requirements and contains a useful amount of guidance. As constant amplitude humidity testing is also an in-service defence requirement this aspect is reasonably well written and could be used for COTs equipment with a reasonable degree of confidence. However, it is still not as good as the IEC 600068, Def Stan 00-35 or GAM EG 13. The latter two procedures had a deliberate intent of commonality which is not apparent in the STANAG. Neverthless the STANAG is the best procedure in many areas and acceptable in others, consequently it is reccomended.

6.5.4.5 Low Pressure

The STANAG procedure also includes methods to encompass the defence requirements for low pressure testing viz. for equipment; stored and/or operated at high ground elevation sites, transported or operated in pressurized or unpressurized areas of aircraft, exposed to a rapid or explosive decompression and carried externally on aircraft.. Whilst the procedure is based upon the Mil Std it incorporates the main components of the UK Def Stan and were applicable the IEC EN test procedure. However, the latter does not encompass all defence requirements. Nevertheless the STANAG test is not as firmly written as the IEC EN procedure or the basic constant altitude Def Stan procedure. For COTS equipment either of these two tests may be preferable.

6.5.4.6 Temperature, Humidity Altitude

The Mil Std 810 and STANAG procedures offer generic procedures which can be adopted by the user to allow the simulation of specific conditions. In this regard the STANAG test in particular can be used as a model for the majority of applications set out above. As it is the most flexible procedure it is generally recommended. However, this strategy may not be contractually acceptable for every application. In those cases the IEC EN, Def Stan and GAM EG procedures are all firmly written and application specific. In those cases the following are recommended;

For equipment located in unheated and unpressurised areas of aircraft (subject to low temperature and low pressure; IEC EN 60068-2-40, Def Stan 00-35 CL12 and GAM EG 13 method 05.

For aircraft equipment subject to the effects of kinetic heating or imposed thermal conditions tests at altitude; IEC EN 60068-2-41, Def Stan 00-35 CL11 and GAM EG 13 method 05.

For equipment subject to a cold soak at high altitude and then rapid decent to lower altitude (higher pressure & temperature); IEC EN 60068-2-39 and Def Stan 00-35 CL13.

For equipment in space applications; GAM EG 13 methods 10 and 11.

6.5.4.7 Icing

The icing procedure within the international NATO standard STANAG 4370 effectively uses the Mil Std procedure rather than the slightly different European methods. Although it has to be said the difference between the European and US procedures is not that significant. The STANAG incorporates a procedure (from the UK Def Stan) intended to incorporate EEC Directive 78/317/EEC to determine the effectiveness of vehicle windscreen de-icing systems. As the STANAG effectively encompasses all aspects of the need for icing testing, it is recommended.

6.5.4.8 Freeze Thaw

The NATO STANAG 4370 contains a Freeze – thaw procedure comprising three methods. These appear to be an enhanced variants of the methods in the two European standards. Although the three methods are clearly loosely based upon the GAM EG 13 procedure, they have marked differences. These differences appear to be intended to better simulate actual conditions causing Freeze thaw induced damage. As a consequence the STANAG procedure is recommended.

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6.6 Review and Comparison of Natural & Man Made Contaminate Test Methods

6.6.1 Standards Under Consideration

The standards reviewed and compared with regard natural & man made contaminate test methods are set out in the following table.

Matrix Environmental Test Methods vs Standards						
	NATO STANAG 4370 AECTP (Method No)	International EN / IEC 60068 Part 2 (60068-2-xx)	UK Def Stan 00-35 Part 3 (Chapter / test)	US Mil Std 810F (Test No / Procedure)	France GAM-Eg-13 (Method / Procedure)	Quadripartite US/UK/F/DE ITOP (Test No)
Immersion	307	17 18	3-29 / CL29 4-05 / CN5	512	1st Part method 15	
Mould Growth	308	10	4-01 / CN1	508	1st Part method 13	
Salt Fog	309	11 52	4-02 / CN2	509	1st Part method 04	
Rain and Watertightness	310	18	3-27 / CL27 3-28 / CL28	506	1st Part methods 12, 20	
Sand And dust	313	68	3-25 / CL25	510	1st Part method 18	
Contamination By Fluids	314	74	4-04 / CN4	504	1st Part method 16	
Explosive Atmosphere	316			511	1st Part method 24	
Acidic Atmosphere	319	60	4-03 / CN3	518		

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6.6.2 Standard Comparison

Test	Scope & Limitations
Immersion	**STANAG 4370 AECTP 300 METHOD 307 IMMERSION** Purpose: Immersion or fording tests are conducted to determine if materiel can withstand immersion or partial immersion in water and operate as required during or following immersion. Application: This method is applicable to materiel that may be exposed to partial or complete immersion, with or without operation. The immersion test has traditionally been considered to be more severe than the rain test (Method 310) for determining the penetrability of materiel. The immersion test may, in some cases, be used to verify watertightness in lieu of a rain test provided that the materiel configuration would be the same for both situations and the method of water ingress is well understood. However, there are documented situations in which the impact of rain causes pumping of water across seals during the rain test that does not occur during the immersion test as seals are held tight against the backing plate by static pressure. Therefore in most cases both tests should be carried out. Limitations: Immersion tests are not intended to be used for buoyant items unless the life cycle profile identifies specific applications where restraints (including stacking) could hold the materiel under water. **DEF STAN 00-35 PART 3** DEF STAN 00-35 PART 3 CHAPTER 3-29 TEST CL29 - IMMERSION Scope The purpose of this test is to determine the capability of materiel to operate whilst submerged or to survive accidental immersion in water. The test is applicable to materiel which is to be classified as immersion resistant in accordance with DEF STAN 00-7. It is also applicable to military level packages designed to provide protection during partial immersion and operational containers to assess their effectiveness during partial and total immersion. Test Procedures are included for packaged and unpackaged materiel. This test is technically similar to BS 2011: Part 2.1Q Test Q Sealing; Test Qf Immersion except for the differences detailed in paragraph 7 below. This test is not intended to simulate the long term effects of immersion in water such as corrosion. The simulation of corrosion effects of long term immersion in seawater is covered by Chapter 4-05 of Part 3 of this Standard. DEF STAN 00-35 PART 3 CHAPTER 4-05 TEST CN5 - CORROSION TEST FOR MATERIEL IMMERSED IN SALT WATER Scope The purpose of this test is to evaluate the resistance to corrosion of materiel immersed in salt water. Additionally it may give information on the performance of sealing of immersed materiel.

Test	Scope & Limitations
	The test is applicable to all types of materiel intended to be deployed in seawater and is particularly applicable to materiel intended for long term immersion. The test may also give information on the performance of sealing of materiel deployed in seawater. **IEC 60068-2-17 – TEST Q: SEALING** General: This survey indicates the interrelation between the various tests for sealing in Test Q of IEC 60068. Other tests of this category are rain and water tests which are to be included as Tests R. At the same time the opportunity has been taken to make reference to similar tests in IEC 60529. **MIL STD 810 METHOD 512.4 IMMERSION** Purpose. The immersion test is performed to determine if materiel can withstand immersion or partial immersion (e.g., fording) in water and operate as required during or following immersion. Application: Use this method for materiel that may be exposed to partial or complete immersion, with or without operation. This test may, in some cases, be used to verify watertightness in lieu of a rain test, provided the materiel configuration would be the same for both situations, and the method of water ingress is well understood. There are documented situations in which the impact of rain causes pumping of water across seals during the rain test that does not occur when seals are held tight against a backing plate by the static pressure of the immersion test. In most cases, both tests should be performed. Limitations: Immersion tests are not intended to be used for buoyant items unless the life cycle profile identifies specific applications such as restraints (including palletised loads) that could hold the materiel under water. **GAM-EG-13 1st PART METHOD 15 IMMERSION** Purpose of test: Knowledge of the capacity of an item of equipment to be immersed in water without infiltration into its envelope. It is advisable to make this test before and after the set of mechanical tests SO as to assess the possible degradation in the. leak tightness due to these tests. *With immersion in another liquid than water, the test method remains applicable on condition of redefining suitable test severities.
Mould Growth	**STANAG 4370 AECTP 300 METHOD 308 MOULD GROWTH** Purpose: The purpose of this mould growth test is to assess the extent to which the materiel will support mould growth or how the mould growth may affect performance or use of the materiel. The term "mould" as used throughout this document is synonymous with "fungus." The primary objectives of the mould growth test are to determine: If the materials comprising the materiel, or the assembled combination of same, will support mould growth and, if so, what species. (See table 1 for the types of moulds.) How rapidly moulds will grow on the materiel.

Test	Scope & Limitations
	How any mould growth affects the materiel, its mission, and its safety for use following the growth of mould on the materiel. If the materiel can be stored effectively in a field environment. If there are simple reversal processes, e.g., wiping off mould growth. Application: Since microbial deterioration is a function of temperature and humidity and is an inseparable condition of hot-humid tropics and the mid-latitudes, it must be considered in the design of all standard, general-purpose materiel. This method is used to determine if mould growth will occur and, if so, how it may degrade/impact the use of the materiel. Although the basic (documented) resistance of materials to mould growth is helpful in the design of new equipment, the combination of materials, the physical structure of combined materials, and the possible contamination of resistant materials can result in the growth of fungus on materiel that would otherwise be considered resistant. Care must therefore be exercised when using documented evidence to justify waiving laboratory or natural environment tests. Limitations: This test is designed to obtain data on the susceptibility of materiel. It should not be used for testing of basic materials since various other test procedures, including soil burial, pure culture, mixed culture, and plate testing are available. **IEC 60068-2-10 PART 2–10: TESTS – TEST J AND GUIDANCE: MOULD GROWTH** Scope: This part of IEC 60068 provides a test method for determining the extent to which electrotechnical products support mould growth and how any mould growth may affect the performance and other relevant properties of the product. Since mould growth conditions include high relative humidity the test is applicable to electrotechnical products intended for transportation, storage and use under humid conditions over a period of some days at least. **DEF STAN 00-35 Part 3 CHAPTER 4-01 TEST CN1 - MOULD GROWTH** Scope: The purpose of the test is to assess the effects on materiel of exposure to mould growth. The moulds to be applied are those specified in BS 2011: Part 2.1J Test J and guidance - Mould growth. This test is applicable to materiel which is used or stored in temperature and humidity conditions likely to encourage mould growth. The procedure in this Test is identical to that of BS2011: Part 2.1J Test J and guidance - Mould growth. **MIL STD 810 METHOD 508.5 FUNGUS** Purpose. The purpose of this fungus test is to assess the extent to which materiel will support fungal growth and how any fungal growth may affect performance or use of the materiel. The primary objectives of the fungus test are to determine: if the materials comprising the materiel, or the assembled combination of same, will support fungal growth, and if so, of what species.

Test	Scope & Limitations
	how rapidly fungus will grow on the materiel. how fungus affects the materiel, its mission, and its safety for use following the growth of fungus on the materiel. if the materiel can be stored effectively in a field environment. if there are simple reversal processes, e.g., wiping off fungal growth. Application. Since microbial deterioration is a function of temperature and humidity and is an inseparable condition of hot, humid tropics and the mid-latitudes, consider it in the design of all standard, general-purpose materiel. This method is used to determine if fungal growth will occur and, if so, how it may degrade/impact the use of the materiel. Limitations. This test is designed to obtain data on the susceptibility of materiel. Do not use it for testing of basic materials since various other test procedures, including soil burial, pure culture, mixed culture, and plate testing are available. NOTE: Although the basic (documented) resistance of materials to fungal growth is helpful in the design of new materiel, the combination of materials, the physical structure of combined materials, and the possible contamination of resistant materials during manufacture necessitate laboratory or natural environment tests to verify the resistance of the assembled materiel to fungal growth. **GAM-EG-13 1 ST PART METHOD 13 MILDEW** Purpose of Test: This test applicable to equipment liable to be exposed to mildew, when in service, in storage or during transport, is designed to : - study the performance of an item of equipment in the presence of mildew (appearance, operating) - check the absence of “edible” materials composing the equipment - make sure of the efficiency of the fungus-repellent protective coatings (varnish, Paint, ...) This test does not enable the performance of an item of equipment in time to be assessed, but schedules the behaviour.
Salt Fog	**STANAG 4370 AECTP 300 METHOD 309 SALT FOG** Purpose: This salt fog test is designed to give a set of repeatable conditions to determine the relative resistance of materiel to the effects of an aqueous salt atmosphere. Application: All military materiel will be exposed to some form of salt during its life cycle that may affect its performance. The primary value of the proposed test procedure lies in testing coatings and finishes on materiel. Additionally, it can be used to locate potential design problems such as incompatible materials. Limitations: It should be noted that the test has limitations regarding the simulation of real life conditions and successful compliance with the test does not guarantee that particular items of materiel will satisfactorily resist all saline conditions to which they may be subjected in service. In particular the procedure does not duplicate all the effects of a marine atmosphere and it has not been demonstrated that a direct relationship exists between the salt fog test corrosion and corrosion occurring in the natural environment. There is no quantitative relationship between time spent in the chamber and time in the field, so the test has proven to be generally unreliable for predicting the service life of different materials or coatings. This test is not a substitute for evaluating corrosion caused by humidity and fungus because their effects differ from

Test	Scope & Limitations
	salt fog effects and this test is not intended for testing piece parts such as bolts, wires, transistors and integrated circuits, and material coupons. **DEF STAN 00-35 PART 3 CHAPTER 4-02 TEST CN2 - SALT (CORROSIVE) ATMOSPHERES** Scope The purpose of this test is to determine the resistance of materiel to salt-laden atmospheres. The Salt Mist and Salt Corrosion test procedures contained within this chapter are technically similar to BS 2011: Part 2.1: Test Ka and BS EN 60068-2-52 Test Kb respectively. **IEC 60068-2 TESTS KA AND KB** IEC 60068-2-11 TEST KA: SALT MIST Scope: This test is to be applied to compare the resistance to deterioration from salt mist of specimens of similar construction. It is useful for evaluating the quality and the uniformity of protective coatings. General: The following restrictions shall be taken into account: the test is unsuitable as a general salt corrosion test; it is also considered to be unsuitable for the evaluation of individual specimens intended for use in salt-laden atmospheres. For equipment and components, Test Kb is considered to provide more realistic conditions and to provide means of assessment of individual items. If, however, for particular circumstances, the relevant specification requires this test (Ka) to be applied to individual specimens for qualification purposes, then the specimens should be tested as part of the overall assembly or equipment in which they are to be used and be complete with any protection devices (cases, covers, shields, etc.), as in practice. IEC 60068-2-52– TEST KB: SALT MIST, CYCLIC (SODIUM CHLORIDE SOLUTION) Scope: This test is intended for application to components or equipment designed to withstand a salt-laden atmosphere, depending on the chosen severity. Salt can degrade the performance of parts manufactured using metallic and/or non-metallic materials. The mechanism of salt corrosion on metallic materials is electrochemical, whereas the degradation effects experienced on non-metallic materials are caused by complex chemical reactions of the salts with the materials involved. The rate at which corrosive action takes place is dependent, to a large extent, on the supply of oxygenated salt solution to the surface of the test specimen, the temperature of the specimen and the temperature and humidity of the environment. Apart from the corrosive effects, this test may be used to indicate deterioration of some non-metallic

Test	Scope & Limitations
	materials by assimilation of salts. In the following test methods, the period of spraying with the relevant salt solution is sufficient to wet the specimen thoroughly. Because this wetting is repeated after intervals of storage under humid conditions (severities (1) and (2)) and – in some cases severities ((3) to (6)) – supplemented by storage under a standard atmosphere for testing, it goes some way to reproducing the effects of natural environments. Severities (1) and (2) are intended to be used for testing products which are used in a marine environment, or in close proximity to the sea. Severity (1) should be used to test products which are exposed to the environment for much of their operational life (e.g. ship radar, deck equipment). Severity (2) should be used to test products which may be exposed to the marine environment from time to time but will normally be protected by an enclosure (e.g. navigational equipment which will normally be used on the bridge or in a control room). Additionally, severities (1) and (2) are commonly used as a general corrosion test in component quality assurance procedures. Severities (3) to (6) are intended for products where, under normal use, there is a frequent change between salt-laden and dry atmosphere, e.g. automobiles and their parts. Severities (3) to (6), compared to severities (1) and (2), therefore include an additional storage under a standard atmosphere for testing. The period of dry atmosphere may happen, in practice, during breaks of operation, e.g. during the weekend. This inclusion of such a dry period in severities (3) to (6) leads to corrosion mechanism which can be quite different from those under constant humid conditions. The test is accelerated compared with most service conditions. However, it is not possible to establish an overall acceleration factor for all kinds of specimens (see IEC 60355). **MIL STD 810 METHOD 509.4 SALT FOG** Purpose. The salt fog method is performed to determine the effectiveness of protective coatings and finishes on materials. It may also be applied to determine the effects of salt deposits on the physical and electrical aspects of materiel. Application. Use this method for screening purposes only to evaluate the effectiveness and quality of protective coatings and finishes on materiel and material coupons, and to locate potential problem areas, quality control deficiencies, design flaws, etc., in a relatively short period of time. In general, only apply this method to materiel that will experience significant exposure (as opposed to infrequent or irregular) to high levels of salt in the atmosphere. Limitations. The test is not intended to duplicate the effects of a marine atmosphere due to variations in chemical composition and concentrations of the various marine and other corrosive environments. It has not been demonstrated that a direct relationship exists between salt fog corrosion and corrosion due to other

Test	Scope & Limitations
	media. It has not been demonstrated that withstanding the effects of this test guarantees materiel will survive under all corrosive conditions. This test has proven to be generally unreliable for predicting the service life of different materials or coatings. This test is not a substitute for evaluating corrosion caused by humidity and fungus because their effects differ from salt fog effects and the tests are not interchangeable. This test is not intended to be used for sample or coupon testing in lieu of assemblage testing. **GAM-EG-13 1st PART METHOD 04 SALT FOG** Purpose of Test: The test is chiefly designed to check the performance of an item of equipment in a corrosive environment conventionally chosen. It cannot be considered as a test on performance in a marine atmosphere or other chemical effects. It should simply be used as a comparative test to check the quality and uniformity of the coatings on the equipment.
Rain And Watertightness	**STANAG 4370 AECTP 300 METHOD 310 RAIN AND WATERTIGHTNESS** Purpose: These tests are conducted to determine with respect to rain, water spray or dripping water: The effectiveness of protective covers, cases, packaging, or seals; The capability of the materiel to satisfy its performance requirements during or following exposure; The physical deterioration of the materiel due to wetting/moisture ingress; The effectiveness of the water removal systems. Application: This method is applicable to materiel that may be exposed to rain, water spray or dripping water. The immersion test (Method 307) was traditionally considered to be more severe than the rain test for determining the penetrability of materiel. The immersion test may, in some cases, be used to verify watertightness in lieu of a rain test provided that the materiel configuration would be the same for both situations and the method of water ingress is well understood. However, there are documented situations in which the impact of rain causes pumping of water across seals that does not occur in the immersion test because the seals are held tight against the backing plate by the static pressure. In most cases it is more appropriate to carry out both tests. Limitations: These test procedures are not suitable for: Determining the effects of rain erosion; Determining the atmospheric rain effects on propagation of electromagnetic radiation, light, etc.; Evaluating the adequacy of aircraft windshield rain removal devices; Evaluating materiel exposed to only light condensation drip rates (lower than 140 $L/m^2/hr$) caused by an overhead surface. For this case the aggravated humidity cycle of Method 306 will induce a significant amount of free water on

Test	**Scope & Limitations**
	both inside and outside surfaces; Evaluating the effects of pressure washers or decontamination devices. **DEF STAN 00-35 PART 3** DEF STAN 00-35 PART 3 CHAPTER 3-27 TEST CL27 - DRIVING RAIN Scope The purpose of this test is to assess the effect on materiel, including packages, of exposure to driving rain and to demonstrate: The ability of materiel to remain operational during or following exposure to driving rain. The level of protection provided by packages and the effects on their stability and structural integrity during or following exposure to driving rain. This test is applicable to materiel which is liable to be directly exposed to driving rain, UK Military Level packages J & N (NATO equivalent levels 2 & 3) and ammunition packages. This test is also applicable to UK Military Packaging Levels K, M, Q & S now obsolescent. This test is not intended to: Prove the erosion resistance of materiel to driving rain which is covered by Chapter 3-19. Assess the effects of rainfields on radar and electro-optical systems. Information related to these effects can be found in Chapter 6-02 of Part 4 of this Standard. DEF STAN 00-35 PART 3 CHAPTER 3-28 TEST CL28 - DRIPPROOFNESS Scope This test is applicable to materiel which may be subject to dripping water from overhead surfaces, resulting for example, from condensation in unconditioned avionics bays of aircraft or ships compartments. Normally, this test is not necessary for materiel which is required to satisfy the tests of Chapter 3-27 Driving Rain or Chapter 3-29 Immersion. This test is not intended to determine the effect of materiel of soluble impurities which in practice may contaminate dripping condensed water. This test is technically similar to BS2011:Part 2.1R, Water, Test Ra Method 2 Dripbox, except for differences detailed in paragraph 7 below. **MIL STD 810 METHOD 506 RAIN** Purpose: The purpose of this method is to help determine the following with respect to rain, water spray, or dripping water:

Test	Scope & Limitations
	The effectiveness of protective covers, cases, and seals in preventing the penetration of water into the materiel. The capability of the materiel to satisfy its performance requirements during and after exposure to water. Any physical deterioration of the materiel caused by the rain. The effectiveness of any water removal system. The effectiveness of protection offered to a packaged materiel. Application. Use this method to evaluate materiel likely to be exposed to rain, water spray, or dripping water during storage, transit, or operation. If the materiel configuration is the same, the immersion (leakage) test (method 512.4) is normally considered to be a more severe test for determining if water will penetrate materiel. There is generally no need to subject materiel to a rain test if it has previously passed the immersion test and the configuration does not change. However, there are documented situations in which rain tests revealed problems not observed during immersion tests due to differential pressure. Additionally, the immersion test may be more appropriate if the materiel is likely to be placed on surfaces with significant amounts of standing water. In most cases, both tests should be performed if appropriately identified in the life cycle profile. Limitations: Where a requirement exists for determining the effects of rain erosion on radomes, nose cones, fuzes, etc., consider using a rocket sled test facility or other such facility. Since any test procedure involved would be contingent on requirements peculiar to the materiel and the facility employed, a standardised test procedure for rain erosion is not included in this method. Because of the finite size of the test facilities, it may be difficult to determine atmospheric rain effects such as on electromagnetic radiation and propagation. This method is not intended for use in evaluating the adequacy of aircraft windshield rain removal provisions, nor does it address pressure washers or decontamination devices. Additionally, this method may not be adequate for determining the effects of extended periods of exposure to rain. **GAM-EG-13** GAM-EG-13 1st PART METHOD 12 RAIN Purpose of Test: This test is applicable to equipment liable to be exposed to rain, its purpose is to check : - the resistance of the equipment to rain - the operating under or after exposure to rain - the efficiency of the covers and housings as means of protection - if required the tightness against any penetration of water. Its aim is not to simulate the erosion in rain occurring only when the equipment is moving at very high speed. GAM-EG-13 1st PART METHOD 20 WATER JET Purpose of test: The purpose of this test is to check the performance and/or leak tightness of an item of equipment during and after exposure to water spray. The test is differentiated from the rain test by the fact that it simulates the exposure of an item of equipment to heavy water sprays in a11 directions for a relatively short time.

Test	Scope & Limitations
Sand And Dust	**STANAG 4370 AECTP 300 METHOD 313 SAND AND DUST** Purpose: Perform the small-particle dust (<149 mm) procedures to ascertain the ability of materiel to resist the effects of dust (including abrasion) that may obstruct openings, penetrate into cracks, crevices, bearings and joints, and to evaluate the effectiveness of filters. Perform the blowing sand test to determine if materiel can be stored and/or operated under blowing sand (150 to 850 mm particle size) conditions without degradation of performance, effectiveness, reliability, and maintainability due to the abrasion (erosion) or clogging effect of large, sharp-edged particles. Application: This method is applicable to all mechanical, optical, electrical, electronic, electrochemical, and electromechanical devices for which exposure to a dry, blowing sand, blowing dust-laden atmosphere, or settling dust is anticipated. Limitations: This method is not suitable for determining erosion of airborne (in flight) materiel because of the particle impact velocities involved, or for determining the effects of a build up of electrostatic charge. Because of the difficulty of controlling test conditions, this Method does not address sand or dust testing out-of-doors. This method does not address aerosols other than dust. **DEF STAN 00-35 PART 3 CHAPTER 3-25 TEST CL25 - DUST AND SAND** Scope: The purpose of this test is to assess the effects of dust and sand laden atmospheres on the performance and safety of materiel. The test is sub-divided into procedures for settling dust, for turbulent dust and for wind-blown dust and sand conditions. The settling dust procedure is intended to be applied to materiel which is protected from or is not intended for service in, the more severe conditions described in the following paragraph. Such materiel may still be affected by the fall out of dust from the surrounding air. The other procedures are for unprotected or partially protected materiel transported, stored or used in geographical areas where aridity and wind combine to produce dust or sand storms, or where it is liable to be subjected to high concentrations of dust or sand caused by the operation of machinery or the movement of military vehicles. **IEC 60068-2-68 – TEST L: DUST AND SAND** General: This survey indicates the general structure of the dust/sand tests included in this publication. The structuring and a summary of the characteristics of the different tests are given in figure 1 and table 1. It should be noted that the dust test of IEC 60529 has its equivalent in the proposed method La2. See also annex A. Scope: This part of IEC 60068-2 specifies test methods to determine the effects of dust and sand suspended in air, on

Test	Scope & Limitations
	electrotechnical products. The test methods of this standard are not intended for the testing of air filters. Only method Lc2 is suitable for the simulation of the erosion effects of high velocity (more than 100 m/s) particles. Description of test L: The dust and sand test is structured into three groups: La: non-abrasive fine dust. A test which is primarily oriented towards investigation of the seals of the test specimen. The test specimen is exposed to a very fine dust in the form of talc or an equivalent. The effects of temperature cycling resulting in a pressure difference between the inside and outside of the specimen may be reproduced. Lb: free settling dust. A test which is oriented towards investigation of the effects when simulating conditions at sheltered locations. The test specimen is exposed to a low- density dust atmosphere created by the intermittent injection of a small quantity of dust which is allowed to fall by gravity onto the specimen. Lc: blown dust and sand. A test which is oriented towards investigation of the seals and the effect of erosion when simulating outdoor and vehicle conditions. The test specimen is exposed to either a turbulent or a laminar air flow to which is added a quantity of dust, sand or a dust/sand mixture. **MIL STD 810 METHOD 510.4 SAND AND DUST** Purpose: Small-particle dust (d 149 µm) procedures. These tests are performed to help evaluate the ability of materiel to resist the effects of dust that may obstruct openings, penetrate into cracks, crevices, bearings, and joints and to evaluate the effectiveness of filters. Blowing sand (150 to 850 µm particle size) procedures. These tests are performed to help evaluate if materiel can be stored and operated under blowing sand conditions without degrading performance, effectiveness, reliability, and maintainability due to abrasion (erosion) or clogging effects of large, sharp edged particles. Application: Use this method to evaluate all mechanical, optical, electrical, electronic, electrochemical, and electromechanical devices likely to be exposed to dry, blowing sand, blowing dust-laden atmosphere, or settling dust. Limitations. This method is not suitable for determining erosion of airborne (in flight) materiel because of the particle impact velocities involved, or for determining the effects of a build up of electrostatic charge. Additionally, because of control problems, this method does not address sand or dust testing out-of-doors. **GAM-EG-13 1st PART METHOD 18 DUST** Purpose of test: Knowledge of the performance of an item of equipment in an atmosphere linked with fine particles, size less than 150 micrometres, as occurs when a condition of dry soil and a condition of mechanical stirring (wind, blast, travelling in convoys) are combined. This test is not designed to simulate erosion phenomena and it can be observed that the test conditions are such that the effects of surface abrasion, on the impact of dust on the test item exposed, are negligible.

Test	Scope & Limitations
Contamination By Fluids	**STANAG 4370 AECTP 300 METHOD 314 CONTAMINATION BY FLUIDS** Purpose: To determine if materiel is unacceptably affected by temporary exposure to contaminating fluids (liquids) such as may be encountered during its life cycle, either occasionally, intermittently, or over extended periods. Application: Select the tests described in this Method when there is a high probability of fluid contamination during the materiel's life cycle. Contamination may arise from exposure to fuels, hydraulic fluids, lubricating oils, solvents and cleaning fluids, de-icing and anti-freeze fluids, runway de-icers, insecticides, disinfectants, coolant dielectric fluid, and fire extinguishants. Limitations: This test is not intended to demonstrate the suitability of materiel to perform during continuous contact with a fluid, e.g., an immersed fuel pump, nor should it be used to demonstrate resistance to electrolytic corrosion. **DEF STAN 00-35 PART 3 CHAPTER 4-04 TEST CN4 - CONTAMINATION BY FLUIDS** Scope This test is applicable to materiel liable to accidental or intentional temporary exposure to a specific fluid or fluids during its Service life. The test is intended to determine the response of materiel to any potentially damaging effects of contaminating fluids. The test is not applicable to materiel intended to have continuous contact with a specific fluid or fluids in order to carry out its function when in service, e.g. an immersed fuel pump. Testing may be conducted on complete equipments, sub assemblies, components or materials used in construction of materiel liable to contamination by fluids. This test replaces BS3G100: Part 2: Section 3: Subsection 3.12. **MIL STD 810 METHOD 504 CONTAMINATION BY FLUIDS** Purpose: Use contamination by fluids tests to determine if materiel is unacceptably affected by temporary exposure to contaminating fluids (liquids) such as may be encountered during its life cycle, either occasionally1/, intermittently2/, or over extended periods3/. Application. Select the tests described in this method when there is a high probability of fluid contamination during the life cycle of the materiel. Contamination may arise from exposure to fuels, hydraulic fluids, lubricating oils, solvents, and cleaning fluids, de-icing and anti-freeze fluids, runway de-icers, insecticides, disinfectants, coolant dielectric fluid, and fire extinguishants. Limitations. This test is not intended to demonstrate the suitability of materiel to perform during continuous contact with a fluid, e.g., an immersed fuel pump, nor should it be used to demonstrate resistance to electrolytic corrosion. **GAM-EG-13 1st PART METHOD 16 CONTAMINATION BY FLUIDS** Purpose of Test: Determination of the effects of aggressive fluids on the test item. These fluids can be : - either surrounding fluids whose spray or flow are involuntary and contaminate the external parts of the test item (general

Test	Scope & Limitations
	case) or are accidental and can also contaminate the interna1 parts (special case of open equipment) - or the fluids used for maintenance (solvents, cleaners, miscellaneous, etc...) Note : This test does not apply to equipment operating normally in aggressive fluids or in contact with them.
Explosive Atmosphere	**STANAG 4370 AECTP 300 METHOD 316 EXPLOSIVE ATMOSPHERE** Purpose: The explosive atmosphere test is performed to: demonstrate the ability of materiel to operate in fuel-air explosive atmospheres without causing ignition, or demonstrate that an explosive or burning reaction occurring within encased equipment will be contained, and will not propagate outside the test item.. Application :This method applies to all materiel designed for use in the vicinity of fuel-air explosive atmospheres associated with aircraft, automotive and marine fuels at or above sea level. Procedure II specifically relates to atmospheres in a space in which flammable fluids or vapours exist, or can exist, either continuously or intermittently (e.g., in fuel tanks or within fuel systems). NOTE: Materiel tested to Procedure II is designed such that ignition of an explosive mixture is contained within the materiel without igniting the surrounding explosive atmosphere; and, during normal operation, or as a result of any fault, the temperature of any external surface will not rise to a level capable of causing ignition (including hermetically-sealed materiel). Use other explosive atmosphere safety tests (e.g., electrical or mine safety) if more appropriate. Limitations This test utilises an explosive mixture that has a relatively low flash point that may not be representative of some actual fuel-air or aerosol (such as suspended dust) mixtures. The explosive atmosphere test is a conservative test in that if the test item does not ignite the test fuel-air mixture, there is a low probability that the materiel will ignite prevailing fuel vapour mixtures in service. Conversely, the ignition of the test fuel-air mixture by the test item does not mean the materiel will always ignite fuel vapours that occur in actual use. This test is not appropriate for altitudes above approximately 16km where the lack of oxygen inhibits ignition. Because this test is designed for electrical spark ignition, this method is not intended to demonstrate ignition due to high surface temperatures. **MIL STD 810 METHOD 51 EXPLOSIVE ATMOSPHERE** Purpose: The explosive atmosphere test is performed to demonstrate the ability of materiel to operate in fuel-air explosive atmospheres without causing ignition. Application: This method applies to all materiel designed for use in the vicinity of fuel-air explosive atmospheres associated with aircraft, automotive, and marine fuels at or above sea level. Use other explosive atmosphere safety tests (e.g., electrical or mine safety) if more appropriate. 1.3 Limitations: This test utilises an explosive mixture that has a relatively low flash point which may not be representative of some

Test	Scope & Limitations
	actual fuel-air or aerosol (such as suspended dust) mixtures. The explosive atmosphere test is a conservative test. If the test item does not ignite the test fuel-air mixture, there is a low probability that the materiel will ignite prevailing fuel vapour mixtures in service. Conversely, the ignition of the test fuel-air mixture by the test item does not mean the materiel will always ignite fuel vapours that occur in actual use. This test is not appropriate for test altitudes above approximately 16km where the lack of oxygen inhibits ignition. d. This method is not appropriate for determining the capability of sealed materiel to contain an explosion. **GAM-EG-13 1st PART METHOD 24 EXPLOSIVE ATMOSPHERE** The purpose of the test is to prove the capacity of an item of equipment to operate in a flammable atmosphere without causing an explosion. The item of equipment can be either tight sealed in which an interna1 explosion shall not propagate outside its housing, or intrinsic safety equipment, not tight sealed but offering no risks where the explosion is concerned. Two procedures are described corresponding to these two types of equipment.
Acidic Atmosphere	**STANAG 4370 AECTP 300 METHOD 319 ACIDIC ATMOSPHERE** Purpose: To determine the resistance of materials and protective coatings to acidic atmospheres. Application: Use this test method when the requirements documents state that the materiel is likely to be stored or operated in areas where acidic atmospheres exist such as industrial areas or near the exhausts of any fuel-burning device. Limitations: This method is not a replacement for the salt fog method, nor is it suitable for evaluating the effects of hydrogen sulphide. **DEF STAN 00-35 PART 3 CHAPTER 4-03 TEST CN3 - ACID CORROSION** Scope This test is applicable to materiel which is liable to be exposed to acidic atmospheres, particularly when deployed in industrial areas or near exhausts of any fuel burning appliance. The test may be applied to materials, components or sub assemblies in order to avoid unnecessary and expensive testing of complete items of materiel. There is no equivalent British Standard test. **IEC 60068-2-60 PART 2: TESTS – TEST KE: FLOWING MIXED GAS CORROSION TEST** Scope: This part of IEC 60068-2 determines the corrosive influence of operating and storage indoor environments on electrotechnical products components, equipment and materials, particularly contacts and connections, considered separately, integrated into a subassembly or assembled as a complete equipment. It provides test methods giving information, on a comparative basis, to aid the selection of materials, choice of production processes and component design, with regard to corrosion resistance. A guide to the selection of methods and test duration is provided in annex C.

Test	Scope & Limitations
	MIL STD 810 METHOD 518 ACIDIC ATMOSPHERE Purpose. Use the acidic atmosphere test to determine the resistance of materials and protective coatings to corrosive atmospheres. Application. Use this test method when the requirements documents state that the materiel is likely to be stored or operated in areas where acidic atmospheres exist, such as industrial areas or near the exhausts of any fuel-burning device. Limitations. This method is not a replacement for the salt fog method, nor is it suitable for evaluating the effects of hydrogen sulphide that readily oxidises in the test environment to form sulphur dioxide.

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6.6.3 Technical Comparison

6.6.3.1 Immersion

The immersion test procedures are intended to demonstrate the ability of equipment to operate whilst submerged or to survive accidental immersion in water. The test procedures are not intended to replicate the effects, such as corrosion, of long term immersion. The test procedures are relatively simplistic submerging a pre-heated specimen a specified depth below water for a specified period. Mostly the differences between the test procedures relate to severities.

The UK national defence standard (Def Stan) procedure and international civil test procedure in EN / IEC 60068 are technically similar. The specimen is pre-heated to between 5 and 15 °C above the water temperature. A range of partial or fully submerged depths are allowed although 1 m is suggested as the usual case. A duration of the immersion is also suggested.

The French national defence standard GAM EG 13 very similar to the UK and EN / IEC procedures exception the specimen is pre-heated to either 10 or 27 °C (± 2 °C) above the water temperature. The immersion time is generally longer than the previous procedures although a common 1 m / 2 hour test severity appears. The GAM EG 13 appears to have commonality with the US Mil Std procedure.

The US national military standard Mil Std 810 procedure includes an immersion and a fording test which appears to be a particular case were the item is driven into the water rather than lowered into it. The Mil Std uses the same pre-conditioning temperatures as the French national standard. Although the severity is stated in guidance rather than a mandatory section. The depth / duration of immersion is specified as 1 m for 30 minutes.

The NATO defence procedure STANAG 4370 immersion test appears to be a hardly modified copy of the Mil Std procedure. It has the same problem with regard including pre-heating temperatures in guidance and only one recommended severity.

Essentially the test procedures fall into two groups those compatible with EN / IEC 60068 and those compatible with the Mil Std. However, as the French standard falls into the latter the differences are not polarised between the US and Europe. For COTS / MOTS equipment compatibility with EN / IEC 60068 is important for that reason the Def Stan / IEC EN 60068 procedures are jointly recommended for immersion whilst the STANAG is recommended for fording aspects.

6.6.3.2 Mould Growth

The fungal growth tests are intended to determine whether materials are susceptible to fungal growth. Given the right climatic conditions (warm and wet), spores and nutrients that are commonly present will give rise to fungal growth. The purpose of this test is to determine whether material will be damaged or degraded by this growth. The test accelerates growth of selected species to determine whether damage arises. The species are selected as those that will damage particular ranges of material. Normally the test is done on samples of material rather than on defence systems. Over the years the historical tests has generated databases of materials which are susceptible or resistant to fungus induced damage. In the first instance a designer would select material from these databases. this regard the test is really a means of obtaining design information.

The test procedure has potential health risks particularly with certain species. As the test needs to be done under controlled conditions the number of facilities that commonly undertake the test is today very limited.

Until very recently the international civil standard IEC EN 60068-2- 10 Test J, the UK national Defence standard Def Stan 00-35 and the French national defence standard GAM EG 13 all aligned and utilised a common group of mould species. As this has been the case for many years a reasonable base of data has accumulated in Europe.

The US national Defence standard Mil Std 810 uses an entirely different group of species from the IEC, UK and French standards. Again these have been used in the US for some time and reasonable base of data has accumulated in the US. However, it has been observed that access to the listed species outside the US can be difficult.

The very recent update to IEC EN 60068-2- 10 Test J (published whilst the Expert Group was working) has changed the species to a group which are claimed to be as equally effective as the previous species in both the 60068 procedure and those of the Mil std. However, these species are intended to be more readily available and constitute a lower health risk. Obviously no base of data has yet accumulated.

The International STANAG 4370 test procedure lists both European and US species. However, it has been indicated that next edition may include the new IEC species.

If the purpose of this requirement was entirely related to the test then the new IEC EN procedure should be recommended. This is because the procedure has demonstrated technical innovation in the change of species. However, if the purpose really to generate a database for use by designers then the STANAG has the greatest value. As existing databases will undoubtedly continue to be used then the overall recommendation must currently be the IEC EN procedure.

6.6.3.3 Salt Fog

Within the generic group salt fog lies environmental test procedures intended for several objectives. For military purposes the most common usage is to evaluate the resistance of the material to a salt laden atmosphere. The procedure used for that purpose is not necessarily suitable to establish corrosion resistance of an equipment which generally requires some form of cyclic test in a salt laden wet / warm atmosphere. The majority of test procedures used for the first of these objectives quite specifically include the phrase “to evaluate” the resistance of the material to a salt laden atmosphere. This is largely because the salt concentrations are quite high and the test represents an accelerated exposure to actual conditions. However, the relationship to actual conditions is far from clear.

The international civil standard EN / IEC 60068 includes two procedures for salt atmosphere. The first procedure (Ka) is intended to be used to evaluate the resistance of the material to a salt laden atmosphere. The second procedure (Kb) is a cyclic test used to stimulate corrosion. The two test procedures have a clear common base and both procedures are clearly and firmly written allowing them to be set contractually. However, neither test procedure includes any significant guidance on the test procedure and none on severities.

The UK national Defence standard Def Stan 00-35 contains a single salt atmosphere test which contains two sub-procedures. The procedure explicitly states that the two sub-procedures are technically similar to the Ka & Kb procedures of EN / IEC 60068. Unlike the EN / IEC 60068 procedure, the Def Stan procedure supplies guidance on both test procedure and test severity. The 6 or 7 severity options included in the EN / IEC 60068 procedures are reduced to two specific options for each of the two sub-procedures. Essentially testing is undertaken for either 24 hours (limited expose) or 28 days (prolonged expose). Although the Def Stan procedure is both clearly and firmly written it is annoyingly incomplete. In order to determine the salt composition and concentration the user has to refer to the EN / IEC 60068 procedure.

The French national defence test procedure GAM EG 13 also includes a single procedure which fulfils both the objects addressed previously. The GAM EG 13 procedure differs from that of EN / IEC 60068 although whether the effects of the differences are significant is debatable. Like the Def Stan test the GAM EG 13 procedures sets two specific severities and supplies advice on their applicability. Unlike the earlier test procedures addresses the GAM EG 13 gives advice on what to inspect following the application of the test.

The US national Defence Standard Mil Std 810 contains a single test procedure. The test is broadly similar to the EN / IEC 60068 procedure but not precisely so or to the same extent as the UK Def Stan test. The procedure does contain significant amount of information on how to undertake the test. Indeed in this respect is undoubtedly the best information available . However, this guidance is at the cost of firmness of the text. The latest version of the Mil Std procedure aligns much better to the international test than did earlier versions.

The international NATO defence procedure STANAG 4370 is better written than the Mil Std but is not as firmly written as the Def Stan or EN / IEC 60068 procedures. The severities are unclear and this also suggests a degree of unresolved compromise. The procedure does not indicate it is technically similar to EN / IEC 60068 but is probably very close to achieving that.

In this case all the different test procedures seem to have some aspects which is better than the others. The EN / IEC 60068 procedures are the most firmly written, the Def Stan procedure is explicitly technically similar to the EN / IEC 60068 procedures but has best defined severities. The GAM EG 13 procedures has a good advice on inspection whilst the Mil Std has the best advice on how to undertake the test. Whilst, the STANAG seems a credible compromise it also seems to have missed the best parts of the national standards. As a credible compromise it is recommended but with the caveat on poorly defined severities and lack of explicit commonality with EN / IEC 60068 for COTS and MOTS equipment.

6.6.3.4 Rain And Watertightness

The rain and watertightness tests are attempting to replicate a highly variable environmental phenomenon. The rain test procedures generally are based upon historical methods which are in turn based around specific equipments. All the procedures reviewed go into some details of the arrangement of the test equipments and nozzles to be used. They also embed aspects of the test severity within the procedure. As the various procedures define the equipment to be used quite differently, direct comparison of the procedures is not really practical or useful. Excepting to note that almost all the national standards use different equipment and none (except the STANAG) seem to attempt to correlate their procedure with any other.

Notwithstanding the above no real evidence seems to exist that one approach is better than another. Generally the procedures are intended to ensure a degree of reproducibility rather than an accurate replication of environment that is quite difficult to fully replicate.

Generally, the UK national Defence Standard spray's the equipment with droplets whilst the US and French national standards allow drops to fall on the equipment. None of the tests indicate compatibility with IEC / EN 60529 (Degree of Protection Provided by Enclosures) which would seem essential for COTS / MOTS equipment.

The NATO STANAG procedure comprises a composite of the national standards and attempts to put some logic and methodology around the use of each. In short the STANAG has already attempted a comparison and appears to have come to the conclusion that all the approaches need to be included. The STANAG does not make a conclusive recommendation between procedures but rather includes an extensive annex on guidance for tailoring rain. This includes information on the natural environment.

6.6.3.5 Sand And Dust

It is difficult with the sand and dust tests, like many in the group, to cleanly separate test procedure and test severity. The test procedure has aspects of test severity embedded within it. The sand and dust tests generally comprise three different test procedure viz. blowing dust, blowing sand and settling dust. The severities are broadly defined by composition in terms of material and size distribution of the dust and sand as well as the concentrations of sand and dust utilised. Other aspects such as duration, air velocity and temperature also are defined as severities.

In addition to the commercial standard IEC / EN 60068 addressed throughout this comparison, a more commonly used commercial standard is IEC / EN 60529 (Degree of Protection Provided by Enclosures). This latter specification is very commonly used by suppliers of both COTS and MOTS equipment.

The international commercial standard IEC / EN 60068-2-68 provides the three previously indicated procedures viz. blowing dust, blowing sand and settling dust. The blowing dust test is indicated as equivalent to that of IEC / EN 60529.

The UK Defence Standard CL25 also offers the same three procedures and explicitly states that the blowing dust test is equivalent to IP5X of IEC / EN 60529. The procedure explicitly sets out the severities that need to be defined to achieve a repeatable test as well as defining the material composition, with several options available, size content and concentrations to be used. The procedure is clearly defined and its use should ensure a test as repeatable as those of IEC / EN 60529 and IEC / EN 60068-2-68. The procedure offers good guidance which is clearly distinguishable from the mandatory aspects. The procedure indicates specific differences in severity between the UK procedure and the STANAG 4370 procedure. The severities and the associated guidance are related to military applications and service use.

The French Defence standard GAM EG 13 Method 18 is a dust test which appears to be intended to be technically similar to the IEC / EN 60529 procedure but this is not explicitly indicated. The procedure contains less guidance than the previous procedure and is less explicit in definition of the severities. The method has the look and feel of the same test as the UK Def Stan and the STANAG but slightly older in layout and format.

The US Defence standard Mil Std 810 Method 510 has the same three procedures as many of the other procedures viz. blowing dust, blowing sand and settling dust. The general procedures and severities appear to be technically similar to those of the other tests. However, that is neither explicitly stated nor is the information presented in a way that gives any positive indication the procedure was intended to align with international procedures. The guidance and mandatory aspects are not particularly well separated and the firmness of the procedure is seen as a potential issue.

The international NATO defence standard STANAG 4370 Method 313 is much better laid out than the Mil Std although essentially identical paragraphs can be easily identified. The three procedures appear to encompass aspects of the UK standard and are technical to the other tests compared. The procedure is weaker than some others with regard firmness of the standard but not to the extent that it could not be called within a contract. Although a user would need to ensure all aspects of the severity are explicitly defined (the UK Def Stan s more specific in this regard). The procedure refers to IEC / EN 60529 but does not state how it relates to that procedure.

The Sand and Dust tests are used extensively or military items particularly land vehicles land and equipment. The dust test is also very commonly used for commercial equipment and the stated capability against IEC / EN 60529 is commonly quoted for many COTS and MOTS equipments. Generally military severities are quite onerous frequently requiring at least two of the three procedures. All the comparable procedures appear to be technically similar. However, the way severity conditions are embedded differently within the various procedures does makes establishing similarity particularly difficult. The sand and dust procedures are a good example of when statements on technical similarity are particularly useful to a user.

Generally the UK Def Stan appears to have the clearest and best laid out and procedure. Nevertheless the STANAG has sufficient commonality to the others for it to form a reasonable international consensus. However, two particular caveats needs attaching to any recommendation, the firmness of standard is not particularly good and its absence of explicit correlation to IEC / EN 60529 for COTS and MOTS equipment may have equipment procurement cost penalties.

6.6.3.6 Contamination By Fluids

The contamination by fluids test procedures are intended to determine if materiel is unacceptably affected by temporary exposure to contaminating fluids (liquids) such as may be encountered during its life cycle, either occasionally, intermittently, or over extended periods. Generally the procedures used samples of material rather than systems. As such material databases are generated which allows historic information to be used in the design process. Generally the test procedures place the material in the in potential contamination fluid and undertake an inspection for degradation.

Mostly the test specifications supply only a general guidance on the fluids to be considered. This is reasonable as different equipments may experience expose to different fluids and different fluids could arise at any time. The US national defence standard does include the most comprehensive list but is obviously US service life related.

The various test procedures are almost entirely identical. This is useful as databases of material reactions from all the standards are interchangeable. The only exception is the French national defence standard which is different from the others. Mostly it appears to be more severe as it subjects the material to longer periods of exposure. As the STANAG is compatible with the majority of standards it is recommended.

6.6.3.7 Explosive Atmosphere

The explosive atmosphere test is performed to demonstrate the ability of materiel to operate in fuel-air explosive atmospheres without causing ignition or to demonstrate that an explosive or burning reaction occurring within encased equipment will be contained, and will not propagate outside the test item. Only three procedures exist in the standards reviewed and the US national standard Mil Std 810 and the STANAG 4370 procedures are almost identical. The only other procedure is in the French national defence standard GAM EG 13. That procedure is defined slightly differently but appears to be technically similar to the other two.

6.6.3.8 Acidic Atmosphere

The acidic atmosphere test procedures are intended to determine the resistance of materials and protective coatings to acidic atmospheres. Like the contamination by fluids test this procedure is intended to evaluate material rather than attempting to simulate actual conditions. The test severities included in the defence standards represent a highly accelerated evaluation. The defence standards all include a choice of two severities replicating occasional expose to acidic atmosphere and the other to prolonged expose. The test procedures available are all very similar excepting that the temperature for the UK Defence standard test is 40 °C compared to 35 °C for the others. This would suggest the UK standard is somewhat more severe. Other than this the only real differences are firmness of text and guidance. The UK Def Stan is firmly written with little guidance except an explicit severity, the US Mil Std contains significant guidance but the firmness of the standard is poor. The STANAG is compromise between the two and includes an explicit severities.

6.6.4 Conclusions

A summary of the recommendations is shown in the table below which is expanded in the following paragraphs.

Summary of Recommendations for Natural & Man Made Contaminate Tests						
	NATO STANAG 4370 AECTP	International EN / IEC 60068	UK Def Stan 00-35	France GAM-Eg-13	US Mil Std 810F	Quadripartite US/UK/F/DE ITOP
Immersion	Recommended for Fording aspects	Jointly Recommended for Immersion aspects		Technically similar to STANAG for Immersion	Technically similar to STANAG	
Mould growth	Compatible with three national defence standards	Recommended as Latest Procedure				
Salt fog	Recommended but needs to be made compatible with commercial standards	Technically similar			Technically similar to STANAG	
Rain and water-tightness	Recommended as procedure encompasses various national methods					
Sand and dust	Recommended but needs to be made compatible with IEC / EN 60529					
Contaminat-ion by fluids	Recommended	Technically Similar to STANAG			Technically Similar to STANAG	
Explosive atmosphere	Recommended			Technically Similar to STANAG	Technically Similar to STANAG	
Acidic atmosphere	Recommended		Technically Similar to STANAG		Technically Similar to STANAG	

6.6.3.1 Immersion

Essentially the test procedures fall into two groups those compatible with EN / IEC 60068 and those compatible with the Mil Std. However, as the French standard falls into the latter the differences are not polarised between the US and Europe. For COTS / MOTS equipment compatibility with EN / IEC 60068 is important for that reason the Def Stan / IEC EN 60068 procedures are jointly recommended for immersion whilst the STANAG is recommended for fording aspects.

6.6.4.2 Mould Growth

If the purpose of this requirement was entirely related to the test then the new IEC EN procedure should be recommended. This is because the procedure has demonstrated technical innovation in the change of species. However, if the purpose really to generate a database for use by designers then the STANAG has the greatest value. As existing databases will undoubtedly continue to be used then the overall recommendation must currently be the IEC EN procedure.

6.6.4.3 Salt Fog

The international NATO defence procedure STANAG 4370 is better written than the Mil Std but is not as firmly written as the Def Stan or EN / IEC 60068 procedures. The severities are unclear and this also suggests a degree of unresolved compromise. The procedure does not indicate it is technically similar to EN / IEC 60068 but is probably very close to achieving that.

In this case all the different test procedures seem to have some aspects which is better than the others. The EN / IEC 60068 procedures are the most firmly written, the Def Stan procedure is explicitly technically similar to the EN / IEC 60068 procedures but has best defined severities. The GAM EG 13 procedures has a good advice on inspection whilst the Mil Std has the best advice on how to undertake the test. Whilst, the STANAG seems a credible compromise it also seems to have missed the best parts of the national standards. As a credible compromise it is recommended but with the caveat on poorly defined severities and lack of explicit commonality with EN / IEC 60068 for COTS and MOTS equipment.

6.6.4.4 Rain And Watertightness

The STANAG 4370 procedure is recommended as it has attempted to reconcile the diverse methods of test procedure included in the various standards. These national standards are almost impossible to compare as they define important aspects of the test by setting out physical details and arrangements of the equipment to used to create the rain. The STANAG solution is essentially to encompass the various national standards and give guidance on how to select the most appropriate. Despite this it seems likely that users will continue to use the method they have historically used and this is possible within the STANAG.

6.6.4.5 Sand And Dust

The Sand and Dust tests are used extensively or military items particularly land vehicles land and equipment. The dust test is also very commonly used for commercial equipment and the stated capability against IEC / EN 60529 is commonly quoted for many COTS and MOTS equipments. Generally military severities are quite onerous frequently requiring at least two of the three procedures. All the comparable procedures appear to be technically similar. However, the way severity conditions are embedded differently within the various procedure does makes establishing similarity particularly easy. The sand and dust procedures are a good example of when statements on technical similarity are particularly useful to a user.

Generally the UK Def Stan appears to have the clearest and best laid out and procedure. Nevertheless the STANAG has sufficient commonality to the others for it to form a reasonable international consensus. However, two particular caveats needs attaching to any recommendation, the firmness of standard is not particularly good and its absence of explicit correlation to IEC / EN 60529 for COTS and MOTS equipment may have equipment procurement cost penalties.

6.6.4.6 Contamination By Fluids

The various test procedures are almost entirely identical. This is useful as databases of material reactions from all the standards are interchangeable. The only exception is the French national defence standard which is different from the others. Mostly it appears to be more severe as it subjects the material to longer periods of exposure. As the STANAG is compatible with the majority of standards it is recommended.

6.6.4.7 Explosive Atmosphere

The STANAG test is recommended as essentially identical to the procedure in the US national defence standard and technically similar to the procedure in the French national standard GAM EG 13.

6.6.4.8 Acidic Atmosphere

The test procedures available are all very similar excepting that the temperature for the UK Defence standard test which would suggest it is somewhat more severe. Other than this the only real differences are firmness of text and guidance. The UK Def Stan is firmly written with little guidance except an explicit severity, the US Mil Std contains significant guidance but the firmness of the standard is poor. The STANAG is compromise between the two and gives an explicit severities. As such it is recommended.

ANNEX A

Matrix Environmental Test Methods vs Standards (Equivalence sheet)

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ANNEX A Matrix Environmental Test Methods vs Standards (Equivalence sheet)

	NATO STANAG 4370 AECTP (Method No)	**INTERNATIONAL IEC 60068 Part 2 (60068-2-xx)**	**UK Def Stan 00-35 Part 3 (Chapter / Test)**	**GAM EG 13**	**US Mil Std 810F (Test No)**	**Quadripartite {US/UK/F/DE} ITOP (Test No)**
THE ENVIRONMENTAL ENGINEERING PROCESS	AECTP 100	Not Addressed	Def-Stan 00-35 Part 1	CIN-EG 01	Mil-Std 810F Part 1	Not addressed
ENVIRONMENTAL CONDITIONS (EITHER LINKED TO THE LIFE CYCLE OF THE MATERIEL OR OTHERWISE)	AECTP 200 (STANAGs 2895, 2914, 4242 are being merged in 200)	IEC EN 60721-2 (Natural only) IEC EN 60721-3	Def-Stan 00-35 Part 4, 5 & 6	GAM-EG13 Annex for environmental data	Mil-Std 810F Part 1 & 2 Mil-Hdbk 310C (climatic)	Not addressed
GUIDELINES FOR DERIVING TEST PROFILES (TAILORING)	AECTP 200	Not addressed	Def Stan 00-35 Part 4, 5 & 6	CIN EG 1 for all environment GAM-EG13 Annex for mechanical tests specifications	Mil Std 810F (some elements)	ITOP 1-1-050
'FALL BACK' TEST SEVERITIES	AECTP 300 AECTP 400	IEC EN 60721-4	Def-Stan 00-35 Part 3	Guidance documents for specific applications (GAM-EG13 A, B, C, D and E)	Mil-Std 810 F Part 2	ITOP's 1-2-601 5-2-506
HIGH TEMPERATURE (INCLUDING RADIATIVE HEATING)	302	2 14	3-01 / CL1 3-02 / CL2 3-11 / CL11	1st Part methods 02, 08	501	2-2-816(1) - vehicles
LOW TEMPERATURE	303	1 14	3-04 / CL4 3-05 / CL5	1st Part methods 01, 08	502	2-2-816(1) - vehicles
AIR-TO-AIR THERMAL SHOCK	304	14	3-14 / CL14	1st Part method 07	503	
SOLAR RADIATION	305	5 9	3-03 / CL3	1st Part method 09	505	4-2-826

	NATO STANAG 4370 AECTP (Method No)	INTERNATIONAL IEC 60068 Part 2 (60068-2-xx)	UK Def Stan 00-35 Part 3 (Chapter / Test)	GAM EG 13	US Mil Std 810F (Test No)	Quadripartite {US/UK/F/DE} ITOP (Test No)
HUMID HEAT	306	30 38 66 67 78	3-06 / CL6 3-07 / CL7	1st Part method 03	507	4-2-820 - ammunition
IMMERSION	307	17 18	3-29 / CL29 4-05 / CN5	1st Part method 15	512	
MOULD GROWTH	308	10	4-01 / CN1	1st Part method 13	508	
SALT FOG	309	11 52	4-02 / CN2	1st Part method 04	509	
RAIN AND WATERTIGHTNESS	310	18	3-27 / CL27 3-28 / CL28	1st Part methods 12, 20	506	
ICING	311		3-10 / CL10	1st Part methods 14		
LOW PRESSURE (ALTITUDE)	312	13	3-21 / CL21 3-20 / CL20		500	
SAND AND DUST	313	68	3-25 / CL25	1st Part method 18	510	
CONTAMINATION BY FLUIDS	314	74	4-04 / CN4	1st Part method 16	504	
FREEZE / THAW	315		3-24 / CL24	1st Part method 22	521	
EXPLOSIVE ATMOSPHERE	316			1st Part method 24	511	
TEMPERATURE, HUMIDITY, ALTITUDE	317	39 40 41	3-11 / CL11 3-12 / CL12 3-13 / CL13	1st Part method 05, 10, 11	520	

	NATO STANAG 4370 AECTP (Method No)	**INTERNATIONAL IEC 60068 Part 2 (60068-2-xx)**	**UK Def Stan 00-35 Part 3 (Chapter / Test)**	**GAM EG 13**	**US Mil Std 810F (Test No)**	**Quadripartite {US/UK/F/DE} ITOP (Test No)**
		61				
ACIDIC ATMOSPHERE	319	60	4-03 / CN3		518	
VIBRATION	401	6 57 59 64 80	2-01 / M1 2-02 / M2	1st Part methods 41, 42	514	2-2-808 1-2-601 1-1-050
ACOUSTIC NOISE	402	65	2-08 / M8 2-09 / M9	1st Part method 48	515	
CLASSICAL WAVEFORM SHOCK	403	27	2-03 / M3	1st Part method 43	516	
CONSTANT ACCELERATION	404	7	2-13 / M13	1st Part method 45	513	5-2-506
GUNFIRE	405				519	
LOOSE CARGO	406	55	2-11 / M11	1st Part method 42 - procedure 5	514	
MATERIEL TIEDOWN	407	47				
LARGE ASSEMBLY TRANSPORT	408		2-14 / M14	1st Part method 42 - procedure 4	514	
MATERIEL LIFTING	409		2-15 / M15			
MATERIEL STACKING	410		2-16 / M16			
MATERIEL BENDING	411		2-17 / M17			
MATERIEL RACKING	412		2-18 / M18			
ACOUSTIC NOISE COMBINED WITH TEMPERATURE & VIBRATION	413		2-10 / M10		523	
HANDLING	414	31	2-04 / M4	1st Part method	516	4-2-601 - Drop

	NATO STANAG 4370 AECTP (Method No)	INTERNATIONAL IEC 60068 Part 2 (60068-2-xx)	UK Def Stan 00-35 Part 3 (Chapter / Test)	GAM EG 13	US Mil Std 810F (Test No)	Quadripartite {US/UK/F/DE} ITOP (Test No)
		32	2-05 / M5	43 - procedures 3, 4 & 5		4-2-602(1) - Rough Handling
PYROSHOCK	415			1st Part method 43 Procedure 7	517	5-2-506
RAIL IMPACT	416			1st Part method 43 - procedure 6	516	
SRS SHOCK	417	57 81	2-06 / M6	1st Part method 43	516	
MOTION PLATFORM	418					
UNDEX ASSESSMENT AND TEST	419		2-07 / M7			
BUFFET VIBRATION	420				514	
MULTI - EXCITER VIBRATION AND SHOCK TESTING	421					
BALLISTIC SHOCK	422				522	
Non STANAG 4370 Tests						
Bullet Attack Test for Munitions	STANAG 4241		5-01 / FX1			
Standard Liquid Fuel Fire	STANAG 4240		5-02 / FX2			
Safety Impact Test for Munitions	STANAG 4375		5-03 / FX3			4-2-601
Slow Heating Tests for Munitions	STANAG 4382		5-04 / FX4			
Sympathetic Reaction	STANAG 4396		5-05 / FX5			
Laboratory Shock Testing of Missiles and Rockets	STANAG 4612					5-2-506
Airdrop of Equipment	STANAG 4611					7-2-509 (1)
Kinetic (Aerodynamic) Heating			3-08 / CL8			

	NATO STANAG 4370 AECTP (Method No)	INTERNATIONAL IEC 60068 Part 2 (60068-2-xx)	UK Def Stan 00-35 Part 3 (Chapter / Test)	GAM EG 13	US Mil Std 810F (Test No)	Quadripartite {US/UK/F/DE} ITOP (Test No)
Rapid and Explosive Decompression			3-09 / CL9			
Air Pressure (above standard atmospheric)			3-15 / CL15	1st Part method 21		
High Winds			3-16 / CL16			
Elevated Ground Temperature/Humidity Diurnal Cycles			3-17 / CL17			
Driving Snow			3-18 / CL18			
Erosion and Structural Damage in Flight by Rain Hail Dust or Sand			3-19 / CL19			
Snow Load			3-22 / CL22	1st Part method 17		
Mist Fog and Low Cloud			3-26 / CL26			
Sealing (Pressure Differential)		17	3-30 / CL30			
Change of temperature		14 33		1st Part method 06		
Temperature, vibration		50 51 53				
Bump test		29	2-12 / M12	1st Part method 43 procedure 9		
Hammer test		75				
Body Strength		77				
Catapult / arrested landing			Severity only	1st Part method 43 procedure 8	516	
Tracked Vehicle Mechanical Vibration						2-2-808(1)
Development Of Laboratory Vibration						1-1-050

	NATO STANAG 4370 AECTP (Method No)	**INTERNATIONAL IEC 60068 Part 2 (60068-2-xx)**	**UK Def Stan 00-35 Part 3 (Chapter / Test)**	**GAM EG 13**	**US Mil Std 810F (Test No)**	**Quadripartite {US/UK/F/DE} ITOP (Test No)**
Laboratory Vibration Schedules						1-2-601(1)
Electronic Measurement of Airblast Overpressure and Impulse Noise						4-2-822

ANNEX B

Summary of Recommendations for Specific Test Procedures

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ANNEX B Summary of Recommendations for Specific Test Procedures

Environmental Test Group	NATO STANAG 4370 AECTP	International EN / IEC 60068 & 60721	UK Def Stan 00-35	France GAM-EG-13 CIN EG 1	US Mil Std 810F	Quadripartite US/UK/F/DE ITOP
The Environmental Engineering Process	Set out in AECTP 100	No equivalent Procedure	**Jointly Recommended** preferably in a merged form			No equivalent Procedure
Environmental Conditions	STANAG 2895 **Recommended** for both natural climatic and Induced conditions.	60721 Pt 2 contains Natural Environmental information	STANAG 2895 based upon Def Stan	Annex environmental data and models	Climatic information in Mil Std 331	No equivalent Procedure
Guidelines For Deriving Test Profiles (Tailoring)	**Recommended as a good overview**	No equivalent Procedure	**Recommended for specific detail. In a combined form would constitute a better document than STANAG**		Limited scope	
'Fall Back' Test Severities	**Recommended**	Severities exist all documents				
Vibration	Could be recommended with better control over mandatory aspects	Inadequate	**Joint Recommendation**		Inadequate	Mostly concerned with test severities. Procedure Essentially Mil Std 810
Gunfire	**Recommended** With reservations on procedure	No equivalent test procedure	No specific procedure rather undertaken using existing methods.	No specific procedure rather undertaken using existing methods	STANAG essentially identical	No equivalent test
Acoustic tests (incl. combined with temperature & vibration)	**Recommended**	Various very similar test procedures exist, however, these do not necessary encompass all the procedures of the STANAG and/or are as up to date.				No equivalent test

Environmental Test Group	NATO STANAG 4370 AECTP	International EN / IEC 60068 & 60721	UK Def Stan 00-35	France GAM-EG-13 CIN EG 1	US Mil Std 810F	Quadripartite US/UK/F/DE ITOP
Buffet	Best guidance available	No equivalent test procedure	**Joint Recommendation**		No specific procedure rather undertaken using existing methods	No equivalent test.
Multi - Exciter Vibration	**Recommended**	No equivalent test procedure				
Classical waveform shock	Nearly equivalent to European standards	**Jointly Recommended** Procedure common to UK / Fr standards			Significantly differs from other standards	Reflects US test procedure
Handling & drop	**Recommended** but concerns over differences with EN/ IEC 60068	Jointly Recommended Procedure common to UK / F standards	Equivalent to EN/ IEC 60068	Essentially equivalent to EN/ IEC 60068	Differs from other standards	Significant reservations (cut down safety drop test)
Safety drop test	**Stanag 4375 Recommended**	UN “Orange” book drop test also required	Implements STANAG with additions	No equivalent test.		Reservations (differs from Stanag)
SRS shock	**Recommended** but with concerns on repeatability	Various versions of procedure exist in all standards but differences exist				Reflects US test procedure
Pyroshock	**Recommended**	No test procedure.		Included by STANAG	Early version of STANAG	Reflects US test procedure
Rail impact	**Recommende**d but question European need	Various procedures and severities exist in all standards but differences exist particularly in severity, reflecting different systems				No equivalent test
Undex test	**Recommended**	No equivalent test.	Inadequate as Procedure	No equivalent test.		

Environmental Test Group	NATO STANAG 4370 AECTP	International EN / IEC 60068 & 60721	UK Def Stan 00-35	France GAM-EG-13 CIN EG 1	US Mil Std 810F	Quadripartite US/UK/F/DE ITOP
Ballistic shock	**Recommended** but with reservation on disadvantage imposed on European industry	No specific test procedure		No specific test procedure.	Same as STANAG procedure	Reflects US test procedure
Catapult	No specific test but SRS method could be adopted	**Recommended** but question need	No specific test but SRS method could be adopted	No specific test but SRS method could be adopted	Specific but old fashioned procedure	No equivalent test.
Bump	No equivalent test.	**Recommended** but question need	Equivalent to EN/ IEC 60068	Equivalent to EN/ IEC 60068	No equivalent test.	No equivalent test.
Constant acceleration	Could be recommended but with reservations as to quality of procedure	Essentially equivalent to STANAG Test.		**Recommended**	Essentially equivalent to STANAG Test	No equivalent test
Bounce / loose cargo	**Recommended** but new CEN/ISO Stds will probably surpass	Essentially equivalent to STANAG procedure but note differences in motion between US/ITOP procedures and European procedures.				
Materiel tiedown	Cannot be recommended in current form	No equivalent test				
Motion Platform	Cannot be recommended in current form	No equivalent test				
Large assembly transport	**Recommended**	No equivalent test.	Equivalent to STANAG Test.			No equivalent test.

Environmental Test Group	NATO STANAG 4370 AECTP	International EN / IEC 60068 & 60721	UK Def Stan 00-35	France GAM-EG-13 CIN EG 1	US Mil Std 810F	Quadripartite US/UK/F/DE ITOP
Materiel, lifting, stacking, bending and racking	**Recommended**	UN "Orange" book test for stacking would also be required.	Equivalent to STANAG Test.	No equivalent test.		
High Temperature		All three constant temperature tests **Recommended specifically for COTS equipment.**				
	Recommended for cyclic procedure for Defence systems		Cyclic test Equivalent to STANAG			
Low Temperature		All three constant temperature tests **Recommended specifically for COTS equipment**				
	Recommended for cyclic procedure for Defence systems		Cyclic test Equivalent to STANAG			
Solar Radiation	**Recommended**					
Thermal Shock	**Recommended**					No equivalent test.
Humidity	**Recommended**		Equivalent to STANAG		Similar to STANAG	
Low Pressure	**Recommended**	Suitable for COTS equipment	Essentially equivalent to STANAG	No equivalent test.	Essentially equivalent to STANAG	No equivalent test.
Temperature, Humidity Altitude	**Recommended for generic procedure**	**Recommended for specific applications related to aircraft equipment and space equipment**			Essentially equivalent to STANAG	No equivalent test

Environmental Test Group	NATO STANAG 4370 AECTP	International EN / IEC 60068 & 60721	UK Def Stan 00-35	France GAM-EG-13 CIN EG 1	US Mil Std 810F	Quadripartite US/UK/F/DE ITOP
Icing	**Recommended**	No equivalent test	Very similar except UK specification also implements EEC directive		Essentially equivalent to STANAG.	No equivalent test
Freeze Thaw	**Recommended**	No equivalent test	These procedures differ from each other and the STANAG		No equivalent test	
Immersion	**Recommended** for Fording aspects	Jointly **Recommended** for Immersion aspects		Technically similar to STANAG for Immersion	Technically similar to STANAG	
Mould growth	Compatible with three national defence standards	**Recommended** as Latest Procedure				
Salt fog	**Recommended** but needs to be made compatible with commercial standards	Technically similar			Technically similar to STANAG	
Rain and water-tightness	**Recommended** as procedure encompasses various national methods					
Sand and dust	**Recommended** but needs to be made compatible with IEC / EN 60529					
Contaminat-ion by fluids	**Recommended**	Technically Similar to STANAG			Technically Similar to STANAG	

Environmental Test Group	**NATO STANAG 4370 AECTP**	**International EN / IEC 60068 & 60721**	**UK Def Stan 00-35**	**France GAM-EG-13 CIN EG 1**	**US Mil Std 810F**	**Quadripartite US/UK/F/DE ITOP**
Explosive atmosphere	**Recommended**			Technically Similar to STANAG	Technically Similar to STANAG	
Acidic atmosphere	**Recommended**		Technically Similar to STANAG		Technically Similar to STANAG	

ANNEX C

GENERIC
Environment related (Horizontal) Standards
(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

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ANNEX C GENERIC, Environment related (Horizontal) Standards

(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
International	**IEC 60068-1**	**ENVIRONMENTAL TESTING** Part 1: General and Guidance	**88-01-00**	
International	IEC 60068-1	General and guidance; Amendment 1 to IEC 60068-1:1988	92-05-00	
		Part 2: Test Procedures		
International	IEC 60068-2-1	Test A: Cold; Amendment 2	94-05-00	
International	IEC 60068-2-2	Test B: Dry heat; Amendment 2	94-05-00	
~~International~~	~~IEC 60068-2-3~~	~~Test Ca: Damp heat, steady state~~	~~69-00-00~~	Replaced by IEC 60068-2-78
International	IEC 60068-2-5	Test Sa: Simulated solar radiation at ground level	75-00-00	
International	IEC 60068-2-6	Test Fc: Vibration (sinusoidal)	95-03-00	
International	IEC 60068-2-7	Test Ga and guidance: Acceleration, steady state	86-00-00	
International	IEC 60068-2-9	Guidance for Solar Radiation testing; Amadment, Corrigendum 1989	75-01-00	
International	IEC 60068-2-10	Test J and guidance : Mould growth	88-00-00	
International	IEC 60068-2-11	Test Ka: Salt mist	81-00-00	
International	IEC 60068-2-13	Test M: Low air pressure	83-00-00	
International	IEC 60068-2-14	Test N: Change of temperature	86-00-00	
International	IEC 60068-2-17	Test Q: Sealing	94-07-00	
International	IEC 60068-2-18	Test R and guidance: Water	00-10-00	
International	IEC 60068-2-20	Test T: Soldering	87-00-00	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
International	IEC 60068-2-21	Test U: Robustness of terminations and integral mounting devices	99-01-00	
International	IEC 60068-2-27	Test Ea and guidance: Shock	87-00-00	
International	IEC 60068-2-29	Test Eb and guidance: Bump	87-00-00	
International	IEC 60068-2-30	Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)	85-00-00	
International	IEC 60068-2-31	Test Ec: Drop and topple, primarily for equipment-type specimens	82-00-00	
International	IEC 60068-2-32	Test Ed: Free fall; Amendment 2 1990	75-00-00	
International	IEC 60068-2-33	Guidance on change of temperature tests	78-00-00	
International	IEC 60068-2-38	Test Z/AD: Composite temperature/humidity cyclic test	74-00-00	
International	IEC 60068-2-39	Test Z/AMD: Combined sequential cold, low air pressure, and damp heat test	76-00-00	
International	IEC 60068-2-40	Test Z/AM: Combined cold/low air pressure tests	83-00-00	
International	IEC 60068-2-41	Test Z/BM: Combined dry heat/low air pressure tests	83-00-00	
International	IEC 60068-2-42	Test Kc: Sulphur dioxide test for contacts and connections	82-00-00	
International	IEC 60068-2-43	Test Kd: Hydrogen sulphide test for contacts and connections	03-05-00	
International	IEC 60068-2-44	Guidance on test T: Soldering	95-01-00	
International	IEC 60068-2-45	Test XA and guidance: immersion in cleaning solvents; amendment 1 1993	80-01-00	
International	IEC 60068-2-46	Guidance to Test Kd: Hydrogen sulphide test for contacts and connections	82-00-00	
International	IEC 60068-2-47	Test methods - Mounting of components, equipment and other articles for vibration, impact and similar dynamic tests	99-10-00	
International	IEC 60068-2-48	Guidance on the application of the tests of IEC publication 60068 to simulate the effects of storage	82-00-00	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
International	IEC 60068-2-49	Guidance to Test Kc: Sulphur dioxide test for contacts and connections	83-00-00	
International	IEC 60068-2-50	Tests Z/AFc: Combined cold/vibration (sinusoidal) tests for both heat-dissipating and non-heat-dissipating specimens	83-00-00	
International	IEC 60068-2-51	Test Z/BFc: Combined dry heat/vibration (sinusoidal) tests for both heat-dissipating and non-heat-dissipating specimens	83-00-00	
International	IEC 60068-2-52	Test Kb: Salt mist, cyclic (sodium chloride solution)	96-01-00	
International	IEC 60068-2-53	Guidance to Tests Z/AFc and Z/BFc : Combined temperature (cold and dry heat) and vibration (sinusoidal) tests.	84-00-00	
International	IEC 60068-2-54	Test TA: Soldering. Solderability testing by the wetting balance method	85-00-00	
International	IEC 60068-2-55	Test Ee and guidance : Bounce.	87-00-00	
~~International~~	~~IEC 60068-2-56~~	~~Test Cb: Damp heat, steady state, primarily for equipment~~	~~88-00-00~~	Replaced by IEC 60068-2-78
International	IEC 60068-2-57	Test Ff: Vibration - Time-history method	99-11-00	
International	IEC 60068-2-58	Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)	04-07-00	
International	IEC 60068-2-59	Test Fe: Vibration; sine-beat method	90-11-00	
International	IEC 60068-2-60	Test Ke: Flowing mixed gas corrosion test	95-12-00	
International	IEC 60068-2-61	Test Z/ABDM: Climatic sequence	91-06-00	
International	IEC 60068-2-64	Test Fh: Vibration, broad-band random (digital control) and guidance	93-05-00	
International	IEC 60068-2-65	Test Fg; Vibration, acoustically induced	93-11-00	
International	IEC 60068-2-66	Test Cx: Damp heat, steady state (unsaturated pressurized vapour)	94-06-00	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
International	IEC 60068-2-67	Test Cy: Damp heat, steady state, accelerated test primarily intended for components	95-12-00	
International	IEC 60068-2-68	Test L: Dust and sand	94-08-00	
International	IEC 60068-2-69	Test Te: Solderability testing of electronic components for surface mount technology by the wetting balance method	95-12-00	
International	IEC 60068-2-70	Test Xb: Abrasion of markings and letterings caused by rubbing of fingers and hands	95-12-00	
International	IEC 60068-2-74	Test Xc: Fluid contamination	99-06-00	
International	IEC 60068-2-75	Test Eh: Hammer tests	97-08-00	
International	IEC 60068-2-77	Test 77 - Body strength and impact shock	99-01-00	
International	IEC 60068-2-78	Test Cab: Damp heat, steady state	01-08-00	
International	IEC 60068-2-81	Test Ei: Shock Shock responce spectrum synthesis	03-07-00	
		Part 3: Guidance		
International	IEC 60068-3-1	Background information. Section One - Cold and dry heat tests; Supplement A 1978, Corrigenda 1980	74-00-00	
International	IEC 60068-3-2	Background information. Section Two - Combined temperature/low air pressure tests	76-00-00	
International	IEC 60068-3-3	Guidance: Seismic test methods for equipments	91-02-00	
International	IEC 60068-3-4	Supporting documentation and guidance; Damp heat tests	01-08-00	
International	IEC 60068-3-5	Supporting documentation and guidance; Confirmation of the performance of temperature chambers / Note: Applies in conjunction with IEC 60068-3-6 and IEC 60068-3-7	01-08-00	
International	IEC 60068-3-6	Supporting documentation and guidance; Confirmation of the performance of temperature/humidity chambers / Note: Applies in conjunction with IEC 60068-3-5 and IEC 60068-3-7	01-08-00	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
International	IEC 60068-3-7	Supporting documentation and guidance; Measurements in temperature chambers for test A and B (with load) / Note: Applies in conjunction with IEC 60068-3-5 and IEC 60068-3-6	01-08-00	
International	IEC 60068-3-8	Supporting documentation and guidance; Selecting amongst vibration tests	03-08-00	
International	IEC 60068-4	Information for specification writers; Test summaries; Amendment 2 1994	87-01-00	
International	IEC 60068-5-1	Guide to drafting of test methods; General principles	91-06-00	
International	IEC 60068-5-2	Guide to drafting of test methods; Terms and definitions	90-12-00	
International	IEC 60721-1	**CLASSIFICATION OF ENVIRONMENTAL CONDITIONS**	1995-04-00	
International	IEC 60721-1	**Part 1: Environmental parameters and their severities, Edition 2.2**	02-10-01	
International	IEC 60721-2-1	**Part 2: Environmental conditions appearing in nature. Temperature and humidity**.	02-10-01	
International	IEC 60721-2-2	Precipitation and wind	88-00-00	
International	IEC 60721-2-3	Air pressure.	87-00-00	
International	IEC 60721-2-4	Solar radiation and temperature	02-10-01	
International	IEC 60721-2-5	Dust, sand, salt mist	91-07-00	
International	IEC 60721-2-6	Earthquake vibration and shock	90-12-00	
International	IEC 60721-2-7	Fauna and flora.	87-00-00	
International	IEC 60721-2-8	Fire exposure	94-06-00	
International	IEC 60721-3-0	**Part 3: Classification of groups of environmental parameters and their severities. Introduction**	02-10-01	
International	IEC 60721-3-1	Storage	97-02-00	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
International	IEC 60721-3-2	Transportation	97-03-00	
International	IEC 60721-3-3	Stationary use at weatherprotected locations	02-10-01	
International	IEC 60721-3-4	Stationary use at non-weatherprotected locations	96-11-00	
International	IEC 60721-3-5	Ground vehicle installations	97-03-00	
International	IEC 60721-3-6	Ship environment; Amendment 2 1996	87-01-01	
International	IEC 60721-3-7	Portable and non-stationary use	02-10-01	
International	IEC 60721-3-9	Microclimates inside products; Amendment / Corrigendum 1995	93-01-01	
International	IEC TR 60721-4-0	**Part 4: Guidance for the Correlation and Transformation of Environmental Classes of IEC-60721-3 to the Environmental Tests of IEC 60068. Introduction**	02-08-01	
International	IEC TR 60721-4-1	Storage	03-08-01	
International	IEC TR 60721-4-2	Transportation	03-08-01	
International	IEC TR 60721-4-3	Stationary use at weatherprotected locations	03-08-01	
International	IEC TR 60721-4-4	Stationary use at non-weatherprotected locations	03-08-01	
International	IEC TR 60721-4-5	Ground vehicle installations	03-08-01	
International	IEC TR 60721-4-6	Ship environment	03-08-01	
International	IEC TR 60721-4-7	Portable and non-stationary use	03-08-01	
NATO	**STANAG 4370**	**ENVIRONMENTAL TESTING**	**April 2005**	Note: Ed 3 Pre-promulaged version used for EG 8 work
NATO	AECTP 100	Environmental Guidelines for Defence Materiel - Management Planning		
NATO	AECTP 200	Environmental Conditions		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
NATO	AECTP 300	Climatic Environmental Tests		
NATO	Meth 301	General Requirements		
NATO	Meth 302	High Temperature		
NATO	Meth 303	Low Temperature		
NATO	Meth 304	Thermal Shock		
NATO	Meth 305	Solar Radiation		
NATO	Meth 306	Humid Heat		
NATO	Meth 307	Immersion		
NATO	Meth 308	Mould Growth		
NATO	Meth 309	Salt Fog		
NATO	Meth 310	Rain		
NATO	Meth 311	Icing		
NATO	Meth 312	Low Pressure		
NATO	Meth 313	Sand & Dust		
NATO	Meth 314	Contamination by Fluids		
NATO	Meth 315	Freeze Thaw		
NATO	Meth 316	Explosive Atmosphere		
NATO	Meth 317	Temperature Humidity Altitude		
NATO	Meth 319	Acidic Atmosphere		
NATO	AECTP 400	Mechanical Environmental Tests		
NATO	Meth 401	Vibration		
NATO	Meth 402	Acoustic		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
NATO	Meth 403	Shock		
NATO	Meth 404	Acceleration		
NATO	Meth 405	Gunfire		
NATO	Meth 406	Loose Cargo		
NATO	Meth 407	Material Tiedown		
NATO	Meth 408	Large Assembly Transport		
NATO	Meth 409	Material Lifting		
NATO	Meth 410	Material Stacking		
NATO	Meth 411	Material Bending		
NATO	Meth 412	Material Racking		
NATO	Meth 413	Combined Environment. Vibration + Temperature + Acoustic		
NATO	Meth 414	Handling		
NATO	Meth 415	Pyroshock		
NATO	Meth 416	Rail Impact		
NATO	Meth 417	SRS Shock		
NATO	Meth 418	Motion Platform		
NATO	Meth 419	Undex Test		
NATO	Meth 420	Buffet Vibration		
NATO	Meth 421	Multi-Exciter Vibration and Shock Testing		
NATO	Meth 422	Ballistic Shock		
NATO	**STANAG 2895**	**Extreme Climatic Conditions And Derived Conditions For Use In Defining Design/Test Criteria For Nato Forces Materiel**	**90-02-15**	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
NATO	**STANAG 2914**	**Mechanical Environmental Conditions To Which Materiel Intended For Use By Nato Forces Could Be Exposed - AECP-1**	**90-01-12**	
UK	**DEF STAN 00-35,**	**Environmental handbook for defence materiel**	**1999-05-07**	
UK	Part 1	**Control and management**		
UK	Part 2	**Environmental handbook for defence materiel, Control and management**	1999-05-07	
UK	Part 3	**Environmental handbook for defence materiel, Environmental test methods**	1999-05-07	
UK	SECTION 1	GENERAL		
UK	SECTION 2	MECHANICAL		
UK	Test M1	Basic Vibration Test		
UK	Test M2	Complete Store Vibration Test		
UK	Test M3	Basic Pulse Shock Test		
UK	Test M4	Drop topple and Roll Test		
UK	Test M5	Impact (Vertical and Horizontal) Test		
UK	Test M6	Operational Shock Simulation Test		
UK	Test M7	Shock Testing for Warship Equipment and Armament Stores		
UK	Test M8	Acoustic Noise Test using a Reverberation Chamber		
UK	Test M9	Acoustic Noise Test using a Progressive Wave Tube		
UK	Test M10	Combined Acoustic, Temperature and Vibration		
UK	Test M11	Wheeled Vehicle Transportation Bounce Test		
UK	Test M12	Bump Test		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
UK	Test M13	Steady State Acceleration Test		
UK	Test M14	Test Track Trial		
UK	Test M15	Lifting Test		
UK	Test M16	Stacking Static Load Test		
UK	Test M17	Bending Test		
UK	Test M18	Racking Test		
UK	SECTION 3	CLIMATIC		
UK	Test CL1	Constant High Temperature - Low Humidity Test		
UK	Test CL2	High Temperature, Low Humidity and Solar Heating Diurnal Cycle Test		
UK	Test CL3	Solar Radiation Test		
UK	Test CL4	Constant Low Temperature Test		
UK	Test CL5	Low Temperature Diurnal Test		
UK	Test CL6	High Temperature, Humidity and Solar Heating Diurnal Cycle Test		
UK	Test CL7	Constant High Temperature - High Humidity Test		
UK	Test CL8	Kinetic (Aerodynamic) Heating		
UK	Test CL9	Rapid and Explosive Decompression		
UK	Test CL10	Icing		
UK	Test CL11	High Temperature - Low Pressure		
UK	Test CL12	Low Temperature - Low Pressure Test		
UK	Test CL13	Low Temperature - Low Pressure Test - High Humidity		
UK	Test CL14	Thermal Shock and Rapid Rate of Change of Temperature		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
UK	Test CL15	Air Pressure (above atandard atmospheric)		
UK	Test CL16	High Winds		
UK	Test CL17	Elevated Ground Temperature / Humidity Diurnal Cycles		
UK	Test CL18	Driving Snow		
UK	Test CL19	Erosion and Structural Damage in Flight by Rain, Hail, Dust or Sand		
UK	Test CL20	Rapid Change of Pressure		
UK	Test CL21	Low Air Pressure and Air Transportation Tests		
UK	Test CL22	Snow Load		
UK	Test CL23	Impact Icing		
UK	Test CL24	Freeze - Thaw		
UK	Test CL25	Dust and Sand		
UK	Test CL26	Mist, Fog and Low Cloud		
UK	Test CL27	Driving Rain		
UK	Test CL28	Dripproofness		
UK	Test CL29	Immersion		
UK	Test CL30	Sealing (Pressure Differential)		
UK	SECTION 4	CHEMICAL AND BIOLOGICAL		
UK	Test CN1	Mould Growth		
UK	Test CN2	Salt (corrosive) Atmospheres		
UK	Test CN3	Acid Corrosion		
UK	Test CN4	Contamination by Fluids		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
UK	Test CN5	Corrosion Tests for Materiel Immersed in Salt Water		
UK	SECTION 5	ABNORMAL (ACCIDENTAL & HOSTILE)		
UK	Test FX1	Bullet Attack Test for Munitions		
UK	Test FX2	Standard Liquid Fuel Fire		
UK	Test FX3	Safety Impact Test for Munitions		
UK	Test FX4	Slow Heating Tests for Munitions		
UK	Test FX5	Sympathetic Reaction, Munition Test		
UK	Part 4	Natural environments	1999-05-07	
UK	Section 1	General		
UK	Section 2	Temperature		
UK	Section 3	Solar Radiatiom		
UK	Section 4	Humidity		
UK	Section 5	Wind		
UK	Section 6	Rain		
UK	Section 7	Hail, Snow and Ice		
UK	Section 8	Deleterious Atmospheres		
UK	Section 9	Dust and Sand		
UK	Section 10	Atmospheric Pressure		
UK	Section 11	Biological Hazards		
UK	Section 12	Atmospheric Electricity		
UK	Part 5	Induced mechanical environments	1999-05-07	
UK	Section 1	General		

SOURCE NATION	**STANDARD NUMBER**	**TITLE (ENGLISH**	**DATE of current Issue**	**Comments**
UK	Section 2	Transportation		
UK	Section 3	Handling and Storage		
UK	Section 4	Man Mounted and Portable		
UK	Section 5	Non-Mobile and Fixed Installations		
UK	Section 6	Deployment on Land Vehicles		
UK	Section 7	Deployment on Fixed Wing Aircraft		
UK	Section 8	Deployment on Rotary Wing Aircraft		
UK	Section 9	Deployment on Ships		
UK	Section 10	Weapons		
UK	Section 11	Measurement and Assessment		
UK	Part 6	Induced climatic, chemical and biological environments	2000-04-01	
UK	Section 1	General		
UK	Section 2	Transportation		
UK	Section 3	Handling and Storage		
UK	Section 4	Man Mounted and Man-Portable		
UK	Section 5	Deployment or Installation in Non-Mobile and Fixed Installations		
UK	Section 6	Deployment or Installation on Vehicles		
UK	Section 7	Deployment or Installation on Fixed Wing Aircraft		
UK	Section 8	Deployment or Installation on Rotary Wing Aircraft		
UK	Section 9	Deployment or Installation on Ships		
UK	Section 10	Munitions (Bombs, Missiles, Torpedoes, etc)		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
UK	**Def Stan 08-123**	**Requirements for Design and Testing of Equipments to Meet Environmental Conditions (Category 2)**	**2000-04-01**	
US	**MIL-STD-810F(3)**	**ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS**	**2003-05-05**	
US	PART ONE	ENVIRONMENTAL ENGINEERING PROGRAM GUIDELINES	2003-05-05	
US	Appendix A	Environmental Management and Engineering Tasks		
US	PART TWO	LABORATORY TEST METHODS	2003-05-05	
US	500	Low Pressure (Altitude)		
US	501	High Temperature		
US	502	Low Temperature		
US	503	Temperature Shock		
US	504	Contamination by Fluids		
US	505	Solar Radiation (Sunshine)		
US	506	Rain		
US	507	Humidity		
US	508	Fungus		
US	509	Salt Fog		
US	510	Sand and Dusta		
US	511	Explosive Atmosphere		
US	512	Immersion		
US	513	Acceleration		
US	514	Vibration		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
US	515	Acoustic Noise		
US	516	Shock		
US	517	Pyroshock		
US	518	Acidic Atmosphere		
US	519	Gunfire Vibration		
US	520	Temperature, Humidity, Vibration and Altitude		
US	521	Icing / Freezing Rain		
US	522	Ballistic Shock		
US	523	Vibro-Acoustic / Temperature		
US	**MIL-HDBK-310**	**Global Climatic Data For Developing Military Products**	**1997-06-23**	
FR	**GAM EG 13**		**june 1986**	
FR		**GENERA**L		
FR		CLIMATIC TEST METHODS		
FR	Method 01	Cold		
FR	Method 02	Dry Heat		
FR	Method 03	Damp Heat		
FR	Method 04	Salt Fog		
FR	Method 05	Altitude and Temperature		
FR	Method 06	Temperature Variations		
FR	Method 07	Thermal Shock		
FR	Method 08	Climatic Cycles		
FR	Method 09	Solar Radiation		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
FR	Method 10	Transient Thermal Vacuum		
FR	Method 11	Long Term Thermal Vacuum		
FR	Method 12	Rain		
FR	Method 13	Mildew		
FR	Method 14	Ice		
FR	Method 15	Immersion		
FR	Method 16	Contamination by Fluids		
FR	Method 18	Dust		
FR	Method 19	Gas Tightness with Internal Overpressure		
FR	Method 20	Water Jet		
FR	Method 21	Gas Tightness with External Overpressure		
FR	Method 22	Icing - Freezing Thawing		
FR	Method 24	Explosive Atmosphere		
FR		MECHANICAL TEST METHODS		
FR	Method 41	Sinusoidal Vibrations		
FR	Method 42	Random Vibrations		
FR	Method 43	Shocks		
FR	Method 45	Constant Acceleration		
FR	Method 48	Acoustic Vibrations		
FR	Method 49	Acoustic Disturbance		
FR	**GAM-EG13A**	**Guidance For Application To Army Materiel**		
FR	**GAM-EG13B**	**Guidance For Application To Air Materiel**		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
FR	GAM-EG13C	Guidance For Application To Navy Materiel		
FR	GAM-EG13D	Guidance For Application To Missiles		

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ANNEX D

GENERAL

Specific or Product related (Vertical) Standards

(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

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ANNEX D GENERAL Specific or Product related (Vertical) Standards

(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
International	IEC 60605-3-1	Equipment Reliability Testing, Part 3: Preferred test Conditions - Indoor Portable Equipment - Low Degree of Simulation	1986-01-01	
International	IEC 60605-3-2	Equipment Reliability Testing, Part 3: Preferred Test Conditions - Equipment for Stationary Use in Weatherprotected Locations - High Degree of Simulation	1986-01-01	
International	IEC 60605-3-3	Equipment Reliability Testing, Part 3: Preferred Test Conditions, Section 3: Equipment for Stationary Use in Partially Weatherprotected Locations - Low Degree of Simulation	1992-01-01	
International	IEC 60605-3-4	Equipment Reliability Testing, Part 3: Preferred Test Conditions, Section 4: Equipment for Portable and Non-Stationary Use - Low Degree of Simulation	1992-01-01	
International	IEC 60605-3-5	Equipment Reliability Testing, Part 3: Preferred Test Conditions, Section 5: Ground Mobile Equipment - Low Degree of Simulation	1992-01-01	
International	IEC 60605-3-6	Equipment Reliability Testing, Part 3: Preferred Test Conditions, Section 6: Outdoor Transportable Equipment - Low Degree of Simulation	1992-01-01	
International	EN ISO 10012	Measurement management systems. Requirements for measurement processes and measuring equipment	2003	Replace ISO 10012-1
International	ISO 2533 ADD 2	Standard atmosphere; Addendum 2: Extension to -5000 m and standard atmosphere as a function of altitude in feet	1997-11-00	
International	ISO 2631-1	Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 1: General requirements	1997-05-00	
International	ISO 7243	Hot environments; estimation of the heat stress on working man, based on the WBGT-index (wet bulb globe temperature)	1989-08-00	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
International	ISO 7730	Moderate thermal environments - Determination of the PMV and PPD indices and specification of the conditions for thermal comfort	1994-12-00	
International	ISO 7933	Hot environments; analytical determination and interpretation of thermal stress using calculation of required sweat rate	1989-07-00	
European	EN 27243	Hot environments. Estimation of the heat stress on working man, based on the wbgt-index (wet bulb globe temperature)	1993-01-01	
European	EN 12515	Hot environments. Analytical determination and interpretation of thermal stress using calculation of required sweat rate	1997-06-01	
Fr	NF X41-002	Protection against physical, chemical and biological agents. Salt spray test.	1975-08-01	
GE	VG 58390	Environmental testing of optical instruments; selection from the standard series of DIN 58390	1991-12-01	
GE	VG 95210-1	Test methods for electronic and electrical component parts; environmental, physical- and electrical-characteristics tests; summary, introduction	1970-03-01	
GE	VG 95210-11	Test methods for electronic and electrical component parts; environmental method, Method 110 - sand and dust	1970-03-01	
GE	VG 95210-12	Test methods for electronic and electrical component parts; environmental method, Method 111 - flammability (external flame)	1970-03-01	
GE	VG 95210-13	Test methods for electronic and electrical component parts; environmental method, Method 112A - seal	1970-03-01	
GE	VG 95210-16	Test methods for electronic and electrical component parts; mechanical methods, Method 201A - vibration	1970-03-01	
GE	VG 95210-17	Test methods for electronic and electrical component parts; mechanical methods, Method 202C - shock (specimens weighing not more than 4 pounds)	1970-03-01	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
GE	VG 95210-18	Test methods for electronic and electrical component parts; mechanical methods, Method 203A - random drop	1970-03-01	
GE	VG 95210-19	Test methods for electronic and electrical component parts; mechanical methods, Method 204B - vibration, high frequency	1970-03-01	
GE	VG 95210-2	Test methods for electronic and electrical component parts; environment method, Method 101C: salt spray (corrosion)	1970-03-01	
GE	VG 95210-20	Test methods for electronic and electrical component parts; mechanical methods, Method 205D - shock, medium impact	1970-03-01	
GE	VG 95210-21	Test methods for electronic and electrical component parts; mechanical methods, Method 206 - life (rotational)	1970-03-01	
GE	VG 95210-22	Test methods for electronic and electrical component parts; mechanical methods, Method 207A - high-impact shock	1970-03-01	
GE	VG 95210-23	Test methods for electronic and electrical component parts; mechanical methods,Method 208B - solderability	1970-03-01	
GE	VG 95210-24	Test methods for electronic and electrical component parts; mechanical methods, Method 209 - radiographic	1970-03-01	
GE	VG 95210-25	Test methods for electronic and electrical component parts; mechanical methods, Method 210 - resistance to soldering heat	1970-03-01	
GE	VG 95210-26	Test methods for electronic and electrical component parts; mechanical methods, Method 211A - terminal strength	1970-03-01	
GE	VG 95210-27	Test methods for electronic and electrical component parts; mechanical methods, Method 212 - acceleration	1970-03-01	
GE	VG 95210-28	Test methods for electronic and electrical component parts; mechanical methods, Method 213A - shock (specified pulse)	1970-03-01	
GE	VG 95210-29	Test methods for electronic and mechaniical component parts; electrical methods, Method 214 - random vibration	1970-03-01	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
GE	VG 95210-3	Test methods for electronic and electrical component parts; environment method, Method 102A: temperature cycling	1970-03-01	
GE	VG 95210-4	Test methods for electronic and electrical component parts; environment methods, Method 103B: humidity (steady state)	1970-03-01	
GE	VG 95210-5	Test methods for electronic and electrical component parts; environment methods, Method 104A: immersion	1970-03-01	
GE	VG 95210-6	Test methods for electronic and electrical component parts; environment methods, Method 105C - barometric pressure (reduced)	1970-03-01	
GE	VG 95210-7	Test methods for electronic and electrical component parts; environment methods, Method 106C - moisture resistance	1970-03-01	
GE	VG 95210-8	Test methods for electronic and electrical component parts; environment methods, Method 107C - thermal shock	1970-03-01	
GE	VG 95210-9	Test methods for electronic and electrical component parts; environment methods, Method 108A - life (at elevated ambient temperature)	1970-03-01	
SWE	FSD 6104	Salt-spray testing	1978	
SWE	FSD A4701:1	Environmental classes		
US	ABC-STD-20	Shock And Vibration Terminology		
US	ABC-STD-37B	Reference Values For Use In Reporting Mechanical Vibration Levels		
US	ABC-STD-38	Methods For Specifying And Calibrating Shock And Vibration Instruments		
US	ADV-PUB-61/102/15	Human Tolerance To Parachute Opening Shock Including Criteria For Parachute Opening Injury		
US	ADV-PUB-61/103/3A	Vibration exposure limits		
US	ADV-PUB-	Human tolerance to repeated mechanical shock (inc change 1)		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
	61/103/4(1)			
US	DI-ENVR-80706	Shock test extension request		
US	DI-ENVR-80708	Shock test report		
US	DI-ENVR-80709	High-impact shock test procedures		
US	DI-ENVR-80710	Shock qualification data sheets		
US	DI-ENVR-81030	Analysis report, dynamic shock		
US	DI-ENVR-81031	Mathematical model report, dynamic shock analysis		
US	DI-ENVR-81279	Dynamic shock analysis extension request		
US	DI-ENVR-81280	Shock management plan		
US	MIL-HDBK-2164A	Environmental stress screening process for electronic equipment	1996-09-16	
US	MIL-HDBK-344A	Environmental stress screening (ess) of electronic equipment	1993-08-16	
US/GE	ITOP 6-3-033	Vibration Sensors for Interior Applications	1990-10-04	
US/UK/FR/DE	ITOP 1-1-050	Development of Laboratory Vibration	1997-06-06	
US/UK/FR/DE	ITOP 7-2-509(1)	Airdrop of Equipment		
FR/GE/US	ITOP 6-2-533	Random Test Procedure	1998-05-11	
US/UK/FR/DE	ITOP 1-2-601	Laboratory Vibration Schedules	1998-12-23	
US/FR/DE	ITOP 4-2-822	Electronic Measurement of Airblast Overpressure and Impulse Noise	2000-09-25	
GE/US	ITOP 4-2-826	Solar Radiation Tests	1983-09-21	
US/UK/FR/DE	ITOP 4-2-828	Ballistic Shock Testing	2000-01-05	

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ANNEX E

GROUND FORCES
Specific or Product related (Vertical) Standards

(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

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ANNEX E GROUND FORCES Specific or Product related (Vertical) Standards

(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
GE	BWB-TL 1340-0020T002	Artillery rocket 110 mm, Regulation A - conduct of environmental test	1976-05-00	
GE	BWB-TL 1340-0020T003	Artillery rocket 110 mm, Regualtion B - conduct of environmental tests	1976-05-00	
NATO	AEP-09 3 - VOL II	Nato manual of simulators of nuclear weapons effects - simulators of blast (or shock) effects	1995-07-01	
NATO	STANAG 1428	Environmental factors affecting mechanical and influencing minesweeping performance		
NATO	STANAG 4138	Vibration resistant equipment testing requirements	1976-02-18	
NATO	STANAG 4188	Explosives, shock sensitivtiy tests	2002-09-12	
NATO	STANAG 4242	Vibration tests method and severities for munitions carried in tracked vehicles - aop- 34	2002-04-15	
NATO	STANAG 4337	Surface-launched munitions appraisal, sfety and environmental tests	1998-12-16	
NATO	STANAG 4357	Allied vehicle testing publications (AVTPS)	19 91-08-06	
SWE	FSD 0044	Environmental tolerance testing of ammunition. Testing at low air pressure	1988	
SWE	FSD 0045	Environmental tolerance testing of ammunition. Testing in moisture, methods A and B	1988	
SWE	FSD 0046	Environmental tolerance testing of ammunition. Testing with lightning	1990	
SWE	FSD 0047	Environmental tolerance testing of ammunition. Testing with static electricity	1980	
SWE	FSD 0058	Environmental tolerance testing of ammunition. Testing of	1983	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
		circuits with electric igniters		
SWE	FSD 0059	Environmental tolerance testing of ammunition. Testing with temp. alternation and temp change	1989	
SWE	FSD 0060	Safety testing of ammunition	1988	
SWE	FSD 0072	Environmental tolerance testing of ammunition. Testing in cold, methods A, B and C	1988	
SWE	FSD 0073	Environmental tolerance testing of ammunition. Testing in heat methods A, B and C	1988	
SWE	FSD 0098	Environmental testing of amm. Testing with constant acceleration	1988	
SWE	FSD 0099	Environmental testing of amm. Testing by shock firing	1981	
SWE	FSD 0100	Environmental testing of amm. Testing with electromagnetic field	1981	
SWE	FSD 0101	Environmental testing of amm. Testing with inductive disturbance of wiring	1982	
SWE	FSD 0102	Environmental testing of amm. Testing with sinusoidal vibration	1988	
SWE	FSD 0103	Environmental testing of amm. Testing with tumbling	1989	
SWE	FSD 0104	Environmental testing of amm. Testing with broadband noise vibration	1988	
SWE	FSD 0105	Environmental testing of amm. Testing with drop from max 12 metres	1982	
SWE	FSD 0107	Environmental testing of amm. Testing with drop from great height	1981	
SWE	FSD 0112	Environmental testing of amm. Testing of electrical igniters	1987	
SWE	FSD 0113	Environmental testing of amm. Testing with shaking	1988	
SWE	FSD 0114	Environmental testing of amm. Testing with impact	1988	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
SWE	FSD 0115	Environmental testing of amm. Testing with impact high peak value short duration	1982	
SWE	FSD 0116	Environmental testing of amm. Testing with high-frequency transient vibration	1982	
SWE	FSD 0117	Environmental testing of amm. Testing by firing hand-guns	1982	
SWE	FSD 0118	Environmental testing of amm. Testing with jolt	1982	
SWE	FSD 0119	Environmental testing of amm. Recommended strictness in electr. and electrom.	1982	
SWE	FSD 0120	Environmental testing of amm. Testing by static loading	1989	
SWE	FSD 0121	Environmental testing of amm. Testing by firing fragments	1982	
SWE	FSD 0122	Environmental testing of amm. Testing with percussion waves in water	1983	
SWE	FSD 0123	Environmental testing of amm. Testing with noise	1982	
SWE	FSD 0124	Environmental testing of amm. Recommended test strictness with mech. Testing	1982	
SWE	FSD 0125	Environmental testing of amm. Testing in salt spray cyclie testing	1988	
SWE	FSD 0126	Environmental testing of amm. Testing with water spray	1988	
SWE	FSD 0127	Environmental testing of amm. Testing by simulated solar radiation	1983	
SWE	FSD 0128	Environmental testing of amm. Testing with high water pressure	1988	
SWE	FSD 0129	Environmental testing of amm. Recommended strictness in climatic testing	1982	
SWE	FSD 0130	Environmental tolerance testing. Testing with gaseous air contaminants and ozone	1989	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
SWE	FSD 0159	Environmental testing of amm. Testing with air shock wave	1983	
SWE	FSD 0160	Environmental tolerance testing of ammunition. Heat/vibration	1989	
SWE	FSD 0161	Environmental tolerance testing of ammuntion. Cold/vibration	1989	
SWE	FSD 0162	Environmental tolerance testing of ammunition comb. test heat/low air pressure	1989	
SWE	FSD 0163	Environmental tolerance testing ammunition testing cold/low air pressure	1989	
SWE	FSD 0164	Environmental testing of amm. Recommended strictness in combined testing	1983	
SWE	FSD 0165	Environmental testing of amm. Testing with fire	1983	
SWE	FSD 0166	Environmental testing of amm. Testing with heating	1984	
SWE	FSD 0167	Environmental testing of amm. Recommended strictness in fire and explosion	1984	
SWE	FSD 0168	Environmental testing of amm. Types of environment	1989	
SWE	FSD 0212	Environmental testing of amm. Testing of systems containing electric igniters	1987	
SWE	FSD 0213	Environmental testing of amm. Testing of ignition systems	1986	
SWE	FSD 0214	Environmental tolerance testing of ammunition	1999	
SWE	FSD 0223	Environmental testing of ammunition. Lifetime work	1988	
SWE	FSD 0224	Environmental tolerance testing of amm. Testing with contaminants	1989	
UK	Def Stan 81-41, Part 3	Packaging of defence materiel, Environmental testing	1998-12-04	
UK	MIL-STD-2225	Vibration and noise testing for instrument bearings		
UK	MIL-STD-331B(8)	Fuze and fuze components performance tests for		

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
		environmental and		
UK	QSTAG-360	Climatic environmental conditions affecting the design of military materiel (ABCA 360)		
US/UK/FR/DE	ITOP 4-2-601	Drop Tests for Munitions	1997-04-08	
US/UK/FR/DE	ITOP 4-2-602(1)	Rough Handling Tests, Bounge / Loose Cargo	1999-04-12	
US/UK/FR/DE	ITOP 2-2-808(1)	Tracked Wehicle Mechanical Vibration	1987-05-15	
US/UK/FR/DE	ITOP 2-2-816(1)	High Temperature Test of Vehicle	1987-05-21	
US/UK/FR/DE	ITOP 2-2-816(1)	Low Temperature Test of Vehicle	1987-05-21	
US/UK/FR/DE	ITOP 4-2-820	Humidity Tests of Ammunition	1999-09-09	

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ANNEX F

AIR FORCE
Specific or Product related (Vertical) Standards

(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

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ANNEX F AIR FORCE Specific or Product related (Vertical) Standards

(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
Civil Standard	ISO 2685	Aircraft - Environmental test procedure for airborne equipment - Resistance to fire in designated fire zones	1998-12-00	
International	DO-160 E	Environmental Conditions and Test Procedures for Airborne Equipment	2004	
European	ESA ECSS-E-10-03A	Space Engineering - Testing		
NATO	STANAG 4612	International test operation procedures (itop) on testing of missiles and rockets		
US - MIL	MIL-A-8870C	Airplane strength and rigidity vibration, flutter, and divergence		
US - MIL	MIL-STD-2102A NOT 2	Aircrew escape propulsion systems; vibration and shock tests for	1980-08-18	
US - MIL	AIR-STD-20/18C(1)	Environmental test methods for aircraft stores suspension and release equipment		
US - MIL	AIR-STD-20/34(1)	Environmental test methods for aircraft stores		
US - MIL	MIL-STD-1670A NOT 1	Environmental criteria and guidelines for air-launched weapons	1976-07-30	
US/UK/FR/DE	ITOP 5-2-506	Laboratory Shock Testing of Missiles and Rockets	1999-06-04	
European	**AECMA-STAN**			**Also known as**
AECMA-STAN		**Aerospace Series - Cables, Electrical, Aircraft Use - Test Methods**		
AECMA-STAN	EN 3475-410	Part 410, thermal endurance	01/10/2002	.. L 52-250-410
AECMA-STAN	EN 3475-407	Part 407: flammability	01/08/2004	
AECMA-STAN	EN 3475-401	Part 401, accelerated ageing	05.11.2002	.. L 52-250-401
AECMA-STAN	EN 3475-404	Part 404, thermal shock	05.11.2002	.. L 52-250-404

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
AECMA-STAN	EN 3475-407	Part 407, flammability	05.11.2002	.. L 52-250-407
AECMA-STAN		**Aerospace Series - Circuit Breakers - Test Methods -**		
AECMA-STAN	EN 3841-401	Part 401 = sand and dust	14.03.2003	
AECMA-STAN	EN 3841-402	Part 402 = corrosion	01/12/2004	
AECMA-STAN	PREN 3841-403	Part 403 = humidity	14.03.2003	
AECMA-STAN	PREN 3841-404	Part 404 = explosion proofness	01/12/2004	
AECMA-STAN	EN 3841-405	Part 405 = fluid resistance	01/12/2004	
AECMA-STAN	EN 3841-406	Part 406 = flammability	01/12/2004	
AECMA-STAN	PREN 3841-506	Part 506 = vibration performance	14.03.2003	
AECMA-STAN	PREN 3841-507	Part 507 = mechanical shocks	14.03.2003	
AECMA-STAN	PREN 3841-508	Centrifugal acceleration	14.03.2003	
AECMA-STAN	EN 3841-511	Part 511 = combined test = temperature, altitude and vibration	01/12/2004	
		Aerospace Series - Elements Of Electrical And Optical Connection - Test Methods		
AECMA-STAN	EN 2591-301	Part 301 = endurance at temperature	05.02.1993	L 54-002-020
AECMA-STAN	EN 2591-302	Part 302 - climatic sequence -	20.03.1998	L 54-002-021
AECMA-STAN	EN 2591-303	Part 303 - cold/low pressure and damp heat -	20.03.1998	L 54-002-022
AECMA-STAN	EN 2591-304	Part 304 - damp heat steady state -	20.03.1998	L 54-002-023
AECMA-STAN	EN 2591-305	Part 305 - rapid change of temperature -	20.03.1998	L 54-002-024
AECMA-STAN	EN 2591-306	Part 306 - moult growth -	20.09.1998	L 54-002-025
AECMA-STAN	EN 2591-307	Part 307 - salt mist -	20.09.1998	L 54-002-026
AECMA-STAN	EN 2591-308	Part 308 - sand and dust -	20.09.1998	L 54-002-027
AECMA-STAN	EN 2591-309	Part 309 - dry heat -	20.03.1998	L 54-002-028

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
AECMA-STAN	EN 2591-310	Part 310 - cold -	20.09.1998	L 54-002-029
AECMA-STAN	EN 2591-311	Part 311 - low air pressure -	20.03.1998	L 54-002-030
AECMA-STAN	EN 2591-312	Part 312 - air leakage -	05.04.1998	L 54-002-031
AECMA-STAN	EN 2591-313	Part 313 - artificial rain -	05.04.1998	L 54-002-032
AECMA-STAN	EN 2591-314	Part 314 - immersion at low air pressure -	05.04.1998	L 54-002-033
AECMA-STAN	EN 2591-315	Part 315 - fluid resistance -	20.09.1998	L 54-002-034
AECMA-STAN	EN 2591-316	Part 316 - ozone resistance -	05.04.1998	L 54-002-035
AECMA-STAN	EN 2591-317	Part 317 - flammability -	20.09.1998	L 54-002-036
AECMA-STAN	EN 2591-318	Part 318 - fire-resistance -	20.09.1998	L 54-002-037
AECMA-STAN	EN 2591-320	Part 320 - simulated solar radiation at ground level -	05.04.1998	L 54-002-039
AECMA-STAN	EN 2591-321	Part 321 - damp heat, cyclic test -	05.04.1998	L 54-002-040
AECMA-STAN	EN 2591-322	Part 322 - hermeticity -	20.09.1998	L 54-002-041
AECMA-STAN	EN 2591-323	Part 323 - thermal shock -	20.09.1998	L 54-002-042
AECMA-STAN	EN 2591-401	Part 401 = acceleration, steady state	05.02.1993	L 54-002-044
AECMA-STAN	EN 2591-402	Part 402, shock	20.12.1998	L 54-002-045
AECMA-STAN	EN 2591-403	Part 403, sinusoidal and random vibration	20.12.1998	L 54-002-046
AECMA-STAN	EN 2591-421	Part 421 = free fall	01/06/2002	
AECMA-STAN	EN 2591-6301	Part 6301, optical elements - endurance at temperature	05.11.2002	.. L 54-002-106
AECMA-STAN	EN 2591-6303	Part 6303, optical elements - cold/low pressure and damp heat	05.11.2002	.. L 54-002-107
AECMA-STAN	EN 2591-6305	Part 6305, optical elements - rapid change of temperature	20.10.2002	.. L 54-002-108
AECMA-STAN	EN 2591-6306	Part 6306, optical elements - mould growth	20.10.2002	.. L 54-002-109
AECMA-STAN	EN 2591-6307	Part 6307, optical elements - salt mist	20.10.2002	.. L 54-002-110

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
AECMA-STAN	EN 2591-6314	Part 6314, optical elements - immersion at low air pressure	20.10.2002	.. L 54-002-117
AECMA-STAN	EN 2591-6315	Part 6315, optical elements - fluid resistance	05.11.2002	.. L 54-002-118
AECMA-STAN	EN 2591-6316	Part 6316, optical elements - ozone resistance	05.11.2002	.. L 54-002-119
AECMA-STAN	EN 2591-6317	Part 6317, optical elements - flammability	05.11.2002	.. L 54-002-120
AECMA-STAN	EN 2591-6318	Part 6318: optical elements - fire resistance	05.11.2002	.. L 54-002-121
AECMA-STAN	EN 2591-7301	Part 7301, electrical elements - endurance at temperature for couplers	05.11.2002	.. L 54-002-156
		Cable Ties For Hardnesses - Test Methods -		
AECMA-STAN	PREN 4057-302	Part 302 - Flammability	28.02.2001	
AECMA-STAN	PREN 4057-303	Part 303 - resistance to fluids	28.02.2001	
AECMA-STAN	PREN 4057-306	Part 306 - heat ageing test	28.02.2001	
AECMA-STAN	PREN 4057-307	Part 307 - resistance to ultra violet radiation	31.03.2001	
AECMA-STAN	PREN 4057-402	Part 402 - life cycle	28.02.2001	
AECMA-STAN	PREN 4057-404	Part 404 - low temperature installation	28.02.2001	
AECMA-STAN	PREN 4057-301	Part 301, salt mist test	28.06.2002	
AECMA-STAN	PREN 4057-405	Part 405, compass safe distance	28.06.2002	
		Cables, Electrical, Aircraft Use - Test Methods -		
AECMA-STAN	PREN 3475-415	Part 415 - rapid change of temperature	29.03.2002	
AECMA-STAN	PREN 3475-416	Part 416 - thermal ageing	31.03.2002	
AECMA-STAN	PREN 3475-307	Part 307, corona extinction voltage	29.03.2002	
AECMA-STAN	EN 3475-401	Part 401 -- accelerated ageing	31.03.1999	
AECMA-STAN	EN 3475-404	Part 404 -- thermal shock	31.08.1992	
AECMA-STAN	EN 3475-405	Part 405 -- bending at ambient temperature	31.08.1992	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
AECMA-STAN	EN 3475-409	Part 409 -- air-excluded ageing	31.08.1992	
AECMA-STAN	EN 3475-410	Part 410 -- thermal endurance	31.08.1992	
AECMA-STAN	PREN 3475-411	Part 411 - resistance to fluids	30.11.1999	
AECMA-STAN	PREN 3475-412	Part 412 = humidity resistance	30.09.1997	
AECMA-STAN	EN 3841-407	Circuit breakers test methods part 407 temperature variation	14.03.2003	
		Electrical Cables, Installation - Protection Sleeve - Test Methods -		
AECMA-STAN	PREN 6059-406	Part 406 - vibration	31.07.2001	
AECMA-STAN	PREN 6059-301	Part 301 = sun light exposure	30.09.1997	
AECMA-STAN	PREN 6059-302	Part 302 = high temperature exposure	30.09.1997	
AECMA-STAN	PREN 6059-303	Part 303 = resistance to fluids	31.07.2001	
AECMA-STAN	PREN 6059-304	Part 304 = flamability	30.09.1997	
AECMA-STAN	PREN 6059-305	Part 305 = fluid absorption	30.09.1997	
AECMA-STAN	PREN 6059-306	Part 306 = mould growth	30.09.1997	
		Elements Of Electrical And Optical Connection - Test Methods -		
AECMA-STAN	PREN 2591-220	Part 220 - contact/conductor joint ageing by current and temperature cycling	31.10.2000	
AECMA-STAN	PREN 2591-325	Part 325 - ice resistance	29.05.1998	
AECMA-STAN	PREN 2591-613	Part 614 -- optical elements -- impact test	30.09.1995	
AECMA-STAN	PREN 2591-617	Part 617 = optical elements - temperature cycling	31.10.1997	
AECMA-STAN	PREN 2591-6321	Part 6321 = optical elements - damp heat, cyclic test	28.11.1997	
AECMA-STAN	PREN 2591-6323	Part 6323 = optical elements - thermal shock (hermetically sealed devices)	29.12.1995	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
AECMA-STAN	PREN 2591-C2	Part c2 -- climatic sequence	05.06.1992	
AECMA-STAN	PREN 2591-C3	Part c3 -- cold/low pressure and damp heat	05.06.1992	
AECMA-STAN	PREN 2591-C4	Part c4 -- damp heat steady state	01.10.1992	.. L 54-002-23
AECMA-STAN	PREN 2591-C5	Part c5 -- rapid change of temperature	01.10.1992	.. L 54-002-24
AECMA-STAN	PREN 2591-C6	Part c6 -- mould growth	01.10.1992	.. L 54-002-25
AECMA-STAN	PREN 2591-C7	Part c7 -- salt mist	05.06.1992	
AECMA-STAN	PREN 2591-C8	Part c8 -- sand and dust	01.10.1992	.. L 54-002-27
AECMA-STAN	PREN 2591-C9	Part c9 -- dry heat	05.06.1992	
AECMA-STAN	PREN 2591-C10	Part c10 -- cold	05.06.1992	
AECMA-STAN	PREN 2591-C11	Part c11 -- low air pressure	05.06.1992	
AECMA-STAN	PREN 2591-C12	Part c12 -- air leakage	05.06.1992	
AECMA-STAN	PREN 2591-C13	Part c13 -- driving rain <artificial>	01.10.1992	.. L 54-002-32
AECMA-STAN	PREN 2591-C14	Part c14 -- immersion at low air pressure	05.06.1992	
AECMA-STAN	PREN 2591-C15	Part c15 -- fluid resistance	05.06.1992	
AECMA-STAN	PREN 2591-C16	Part c16 -- ozone resistance	05.06.1992	
AECMA-STAN	PREN 2591-C17	Part c17 -- flammability	05.06.1992	
AECMA-STAN	PREN 2591-C18	Part c18 -- fire-resistance	05.06.1992	
AECMA-STAN	PREN 2591-C20	Part c20 -- simulated solar radiation at ground level	05.06.1992	
AECMA-STAN	PREN 2591-C21	Part c21 -- damp heat, cyclic test	05.06.1992	
AECMA-STAN	PREN 2591-C22	Part c22 -- hermeticity	05.06.1992	
AECMA-STAN	PREN 2591-C23	Part c23 -- thermal shock	05.06.1992	
AECMA-STAN	PREN 2591-D3	Part d3 -- sinusoidal and random vibrations	05.06.1992	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
AECMA-STAN	PREN 2591-FC1	Part fc1 -- optical elements -- endurance at temperature	30.06.1993	
AECMA-STAN	PREN 2591-FC3	Part fc3 -- optical elements -- cold/low pressure and damp heat	30.06.1993	
AECMA-STAN	PREN 2591-FC5	Part fc5 -- optical elements -- rapid change of temperature	30.06.1993	
AECMA-STAN	PREN 2591-FC6	Part fc6 -- optical elements -- mould growth	30.06.1993	
AECMA-STAN	PREN2591-FC7	Part fc7 -- optical elements -- salt mist	30.06.1993	
AECMA-STAN	PREN 2591-FC14	Part fc14 -- optical elements -- immersion at low air pressure	30.06.1993	
AECMA-STAN	PREN 2591-FC15	Part fc15 -- optical elements -- fluid resistance	30.06.1993	
AECMA-STAN	PREN 2591-FC16	Part fc16 -- optical elements -- ozone resistance	30.06.1993	
AECMA-STAN	PREN 2591-FC17	Part fc17 -- optical elements -- flammability	30.06.1993	
AECMA-STAN	PREN 2591-FC18	Part fc18 -- optical elements -- fire resistance	30.06.1993	
AECMA-STAN	PREN 2591-FD1	Part fd1 -- optical elements -- acceleration steady state	29.10.1993	
AECMA-STAN	PREN 2591-FD2	Part fd2 -- optical elements -- shock	29.10.1993	
AECMA-STAN	PREN 2591-FD3	Part fd3 -- optical elements -- vibrations	29.10.1993	
		Requirements And Test Procedures For Relays And Contactors -		
AECMA-STAN	PREN 2349-402	Part 402 - corrosion, sflt spray	31.01.2000	
AECMA-STAN	PREN 2349-405	Part 405 - resistance fluid	31.01.2000	
AECMA-STAN	PREN 2349-407	Part 407 - cold/low pressure and moist heat	31.01.2000	
AECMA-STAN	PREN 2349-409	Part 409 - ozone resistance	31.01.2000	
AECMA-STAN	PREN 2349-410	Part 410 - mould	31.01.2000	
AECMA-STAN	PREN 2349-411	Part 411 - temperature change	31.01.2000	
AECMA-STAN	PREN 2349-412	Part 412 - seal	31.01.2000	
AECMA-STAN	PREN 2349-413	Part 413 - vibration, sinuosidal and random	31.01.2000	

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
AECMA-STAN	PREN 2349-414	Part 414 - mechanical shock	31.01.2000	
AECMA-STAN	PREN 2349-415	Part 415 - acceleration	31.01.2000	
AECMA-STAN	PREN 2349-601	Part 601 - compass safety distance	31.01.2000	
		Fibes And Cables, Optical, Aircraft Use - Test Methods,		
AECMA-STAN	PREN 3745-401	Part 401 - accelerated ageing	31.05.1999	
AECMA-STAN	PREN 3745-404	Part 404 - thermal shock	31.05.1999	
AECMA-STAN	PREN 3745-406	Part 406 - cold bend test	31.05.1999	
AECMA-STAN	PREN 3745-407	Part 407 - flammability	31.05.1999	
AECMA-STAN	PREN 3745-412	Part 412 - humidity resistance	31.05.1999	
		Fibre Reinforced Plastics -		
AECMA-STAN	PREN 4238	Determination of the effect of dry heat - on physical and mechanical characteristics	27.02.1998	
AECMA-STAN	PREN 3615	Procedure for the determination of the conditions of exposure to humid atmosphere and the determination of moisture absorption	01.04.1992	.. L 17-457
AECMA-STAN	PREN 3615	Procedure for the determination of the conditions of exposure to humid atmosphere and the determination of moisture absorption	30.11.1998	
AECMA-STAN	PREN 6038	Test method - determination of the compression strength after impact	30.11.1995	
AECMA-STAN	EN 2243-5	Structural adhesives - test method - part 5 - ageing tests	28.12.2001	

ANNEX G

NAVY

Specific or Product related (Vertical) Standards

(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

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ANNEX G NAVY Specific or Product related (Vertical) Standards

(Standards and Standard-Like Documents For Development and Procurement of Defence Materiel)

SOURCE NATION	STANDARD NUMBER	TITLE (ENGLISH	DATE of current Issue	Comments
GE	BV 0052	Environmental conditions (Surface Ships and submarine)	2001-11-02	
NATO	ANEP-25 1	Guidelines for environmental factors in nato surface ships	1991-02-01	
NATO	STANAG 4141	Shock testing of equipment for surface ships	1976-12-15	
NATO	STANAG 4142	Shock resistance analysis of equipment for surface ships	1977-03-08	
NATO	STANAG 4150	Shock testing of heavyweight surface ship equipment in floating shock vehicles	1979-04-24	
NATO	STANAG 4293	Guidelines for the acoustical environment in nato surface ships	1990-06-19	
NATO	STANAG 4549	Testing of surface ship equipments on shock testing machines	2000-05-18	
US - MIL	MIL-S-901D	Shock tests. H.i. (high-impact) shipboard machinery, equipment, and systems, requirements for	1989-03-17	
US - MIL	MIL-STD-167-1 NOT 1	Mechanical vibrations of shipboard equipment (type 1 - environmental and type ii - internally excited)	1987-06-19	
US - MIL	MIL-STD-167-2A	Mechanical vibrations of shipboard equipment (reciprocating machinery and propulsion system and shafting) types iii, iv, and v (controlled distribution)	1992-05-21	
US - MIL	MIL-STD-798(1) NOT 2	Nondestructive testing, welding, quality control, material control and identification and hi-shock test requirements for piping system components for naval shipboard use	1968-11-27	
US - MIL	MIL-T-18404(2) NOT 2	Torpedoes, Environmental Requirements,		

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ANNEX H

STANDARD ORGANIZATIONS

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ANEX H   STANDARD ORGANIZATIONS

AECPT	Allied Environmental Conditions and Test Publications / STANAG	NATO / Mil
AECMA	European Association of Aerospace Industries	European
AEP	Allied Engineering Publication	NATO / Mil
AFNOR	Association Francaise de Normalisation French National Standardization Organization	FR
ANEP	Allied Naval Engineering Publication	NATO / Mil
ANSI	American National Standards Institute	USA
ASTM	American Society for Testing and Materials	USA
BSI	British Standards Institution	GB
BW	Bundesamt für Wehrtechnik / the Federal Office of Military Technology	GE
BWB/FODTP	Bundesamt für Wehrtechnik & Beschaffung / Federal Office of Defense Technology & Procurement	GE
BWB-TL	Bundesamt für Wehrtechnik und Beschaffung - Vorläufige Technische Lieferbedingungen / the German Procurement Agency	GE
CEN	European Committee for Standardization	European
CENELEC	European Committee for Electrotechnical Standardization	European
DEF STAN	Ministry of Defence, UK Defence Standard	UK / Mil
DIN	Deutsches Institut fûr Normung E.V. German Standards Institution	GE
DO	RTCA standards	USA / Int
DOD	U.S. Department of Defence	USA / Mil
EN	European Standards	European
ESA	European Space Agency	European
FSD	Swedish Defence Standards	Swe / Mil
GAM EG	Guerre Air Mer - Essais Généraux / War Air Sea - General Tests - French National Defence Standard	FR / Mil
IEC	International Electrotechnical Comission	International
ISO	International Organization for Standardization	International
ITOP	International Test Operations Procedures Quadripartite (US/UK/FR/GE) Agreement	US/UK/FR/GE
MIL-STD	US Defence Standard	USA / Mil
NEMA	US National Electrical Manufacturers Asssociation	USA
NF	Norme Francaise / French Standards	FR
QSTAG	Quadripartite Standardization Agreements	NATO / Mil
RTCA	Radio Technical Commission for Aeronautics	USA / Int
STANAG	Standardization Agreement North Atlantic Treaty Organization (NATO)	NATO / Mil
VG	Verteidigungsnorm – German Defence Standard	GE

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