FIDES Guide 2004 issue A
Reliability Methodology
for Electronic Systems

DGA - DM/STTC/CO/477-A

FIDES Group
AIRBUS France - Eurocopter - GIAT Industries – MBDA missile systems - Thales Airborne Systems
Thales Avionics - Thales Research & Technology - Thales Underwater Systems

FOREWORD

FIDES methodology has been developped under the supervision of **DGA** (french MoD), **STTC/CO** and **CELAR**. DGA reference for this document is: **DM/STTC/CO/477-A**.

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Evolutions of issue A

Pages	Modifications
64	Corrections in lines CQFP, Cerquad ; PBGA BT 1mm ; PBGA CSP BT 0.8 and 0.75 mm ; PBGA flex 0.8 mm ; CPGA
65	Update of the graphics
72	$\Pi_{TH\text{-}EL}$ becomes Π_{Th} and $\lambda_{0\ TH\text{-}EL}$ becomes $\lambda_{0\ Th}$
92	Correction of the λ_{0PCB} formula
92	T_{PCB} becomes $T_{Board\ ambient}$
93	Correction of the reference value for the relative humidity
94	Correction of λ_{Type} for connectors
99	Splitting of the $\lambda_{physical}$ formula; addition of an explanation
100	Correction of the thermal cycling formula
151 - 345	Correction of the marks according to the weightings of the recommandations tables
314 - 315	Correction of the association of recommandations 161 and 163 according to the recommandations tables

Contents

I
Introduction to the FIDES Guide

1. Introduction

The FIDES Guide is a global methodology for reliability engineering in electronics. It has two parts:

- A reliability prediction guide,
- A reliability process control and audit guide.

The FIDES Guide aims to enable a realistic assessment of the reliability of electronic equipment, including systems operating in severe environments (defense systems, aeronautics, industrial electronics, transport, etc.). The FIDES Guide also aims to provide a concrete tool to develop and control this reliability.

Its key features are:

- Providing models both for electrical, electronic, and electromechanical components, and for the PWAs or some subassemblies.
- Revealing and taking into consideration all technological and physical factors that play an identified role in a product's reliability.
- Taking into precise consideration the mission profile.
- Taking into consideration the electrical, mechanical and thermal overstresses.
- Taking into consideration the failures linked to the development, production, field operation and maintenance processes.
- The possibility of distinguishing several suppliers of a same component.

By identifying the factors contributing to reliability, whether technological, physical or process-based, the FIDES Guide makes it possible to revise product definition and intervene throughout the product lifecycle, to improve and control reliability.

2. Warning about the FIDES Methodology

The consortium that developed the FIDES methodology is formed by French industrialists from the fields of aeronautics and defense. This consortium was created under the aegis of the Délégation Générale pour l'Armement (DGA, French armament industry supervision agency).

The FIDES methodology is based on the physics of failures and supported by the analysis of test data, field returns and existing modeling. It is therefore different from the traditional methods developed mainly through statistical analysis of field returns.

This process yields predicted reliability results that are not influenced by the industrial domains of the methodology's creators.

However, after fine-tuning the models, the methodology was calibrated on the basis of the experience of the consortium members, particularly as regards the process factors.

3. Terminology

3.1. Acronyms

COTS : Commercial Off-The-Shelf
CRT : Cathode Ray Tube
DGA : Délégation Générale pour l'Armement
EEE : Electrical, Electronic, Electromechanical
EIDE : Enhanced Integrated Drive Electronic
EOS : Electrical Overstress
ESD : Electro Static Discharge
FIT : Failure In Time (1 FIT equals 10^{-9} failures per hour)
Grms : G root mean square
LCD : Liquid Crystal Display
MoD : Ministry of Defence
MOS : Mechanical Overstress
PCB : Printed Circuit Board
PWA : Printed Wire Assembly
RH : Relative Humidity
SCSI : Small Computer System Interface
STN : SuperTwisted-Nematic
TCy : Thermal Cycling
TFT : Thin-Film Transistor
TOS : Thermal Overstress
TTF : Time to failure

3.2. Definitions

Reliability
The ability for an item to perform a required function under given conditions for a given time interval.
Reliability is usually expressed quantitatively through appropriate characteristics. In some applications, one of these characteristics is an expression of this capability through a probability, also called reliability.

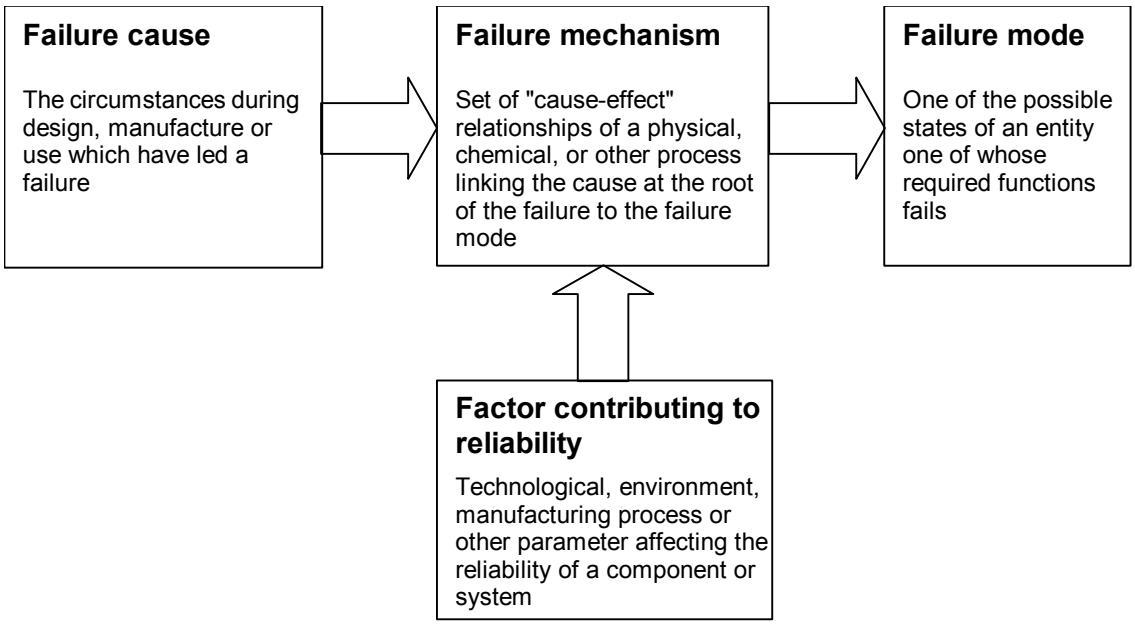
Failure mechanism
Set of "cause-effect" relationships in a physical, chemical, or other process linking, the cause at the root of the failure to the failure mode.

Failure mode
One of the possible states of an entity one of whose required functions fails.

Failure cause
The circumstances during design, manufacture or use which have led to a failure.

Factor contributing to reliability – Factor affecting reliability
Technological, environment, manufacturing process or other parameter affecting the reliability of a component or system.

The logic underlying the above definitions is summarized in the diagram below:



4. References

Definition reference

IEC 60050 (191) A1 (1999-03)
Electro-technical vocabulary – Chapter 191: Reliability and safety engineering and service quality

Reliability modeling

MIL-HDBK-217F (+ manual 1 and 2)
Reliability prediction of electronic equipment

UTE C 80-810
RELIABILITY DATA HANDBOOK: RDF 2000 – A universal model for reliability prediction of electronic components, PCBs and equipment

IEC 62380 TR Ed.1 (2003)
Reliability Data Handbook - A universal model for reliability prediction of electronics components, PCBs and equipment

IEC 1709
Electronic components – Reliability – Reference conditions for failure rates and constraints influence models for conversion

PRISM® software tool - RAC Project A06839, March 17 1997
Denson, W.K. and S.K. Keene, “New System Reliability Assessment Methods”

SSB-1.003
EIA Engineering Bulletin - Acceleration Factors - November 1999 and September 2002

5. Scope

5.1. Application Domains

The FIDES methodology applies to all domains using electronics:

- Military.
- Aeronautics.
- Navy.
- Automobile.
- Railways.
- Space.
- Industry.
- Production and distribution of electricity.
- Telecommunications.
- IT, home automation systems, electrical appliances.
- etc.

5.2. Model Coverage

The FIDES methodology models failures whose origins are intrinsic (item technology or manufacturing and distribution quality) and extrinsic (equipment specification and design, selection of the procurement route, equipment production and integration) to the items studied.

The methodology takes the following into account:

- failures resulting from development or manufacture errors.
- overstresses (electrical, mechanical, thermal) linked to the application and not listed as such by the user (the occurrence of the overstress remains hidden).

The methodology does not handle the following failures:

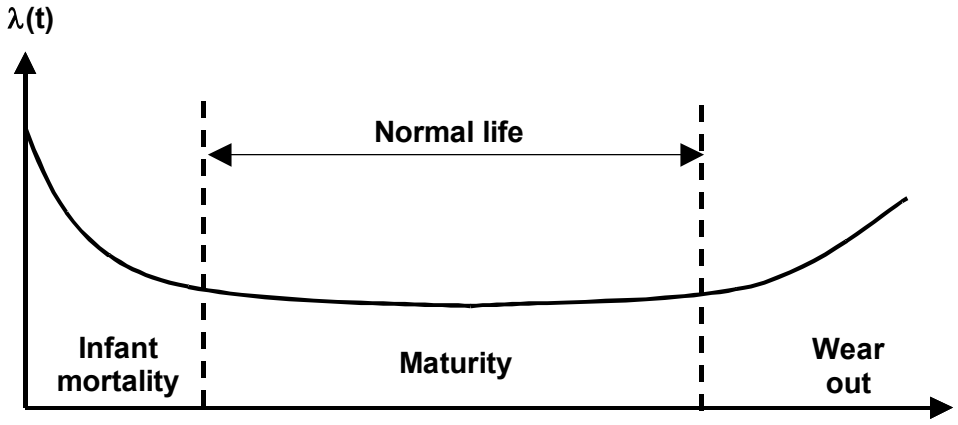
- software failures.
- unconfirmed failures.
- failures linked to unperformed preventive maintenance operations.
- failures linked to accidental aggressions when identified or acknowledged (propagation of failures, use outside the specifications, improper handling: the occurrence of the overstress is known).

The FIDES methodology covers non-operating phases, whether standby periods between utilizations or actual storage.

5.3. Nature of the Prediction

The FIDES methodology gives reliability predictions that are failure rates, noted λ.

Experimental observation shows that plotting the failure rates versus time usually gives the curve below, called a "bathtub curve".



Thus a component's lifetime can be divided into three periods:

- Infant mortality, precocious failures.
- Useful life, failure rates significantly constant.
- Wear out, wear failures.

During its infant mortality period, the failure rates decrease. A component's probability of failure decreases over time. This is period in which failures are caused by process implementation problems and environmental stress screening.
The useful life is represented by a constant failure rate. The probability of failure is independent of the equipment's number of hours in operation (random failures). This period, often non-existent for mechanical goods, is the reference period for electronics.
During the wear out period, the probability of failure increases with the number of hours of operation: the older the equipment, the greater the chance of a failure. This type of behavior is typical of systems subject to wear or other progressive degradation corresponding to climbing failure rates.

The FIDES evaluation model proposes a reliability prediction with constant failure rates. The infant mortality and wear out periods are excluded from the prediction, for the following reasons:

- Firstly, the infant mortality is representative of an equipment or system's end-of-development phase. Controlling the rise in reliability in this phase is crucial to achieve good reliability rapidly.

- The wear out period is also excluded from FIDES because it is in principle sufficiently far away as regards the useful life of electronics systems as covered by FIDES. However, it is essential to check during system design that this is the case. For components whose lifetime is insufficient, approaches other than the sole predicted reliability must be used to address this point, such as the definition of preventive maintenance.

- It is true that at microscopic level very few failure mechanisms strictly meet a "constant rate" type law. Nevertheless:
  - Many cumulative failure mechanisms (increasing with time), have a dispersion value that makes them similar to a constant for the periods under consideration.
  - The multiplicity and diversity of components, even for a single board, make the accumulation close to a constant.
  - The age differences between equipment of a single system or a pool produces a constant rate for an observer of the system.

For these reasons, using a constant failure rate remains the most pertinent approach for a system reliability prediction.

5.4. Prediction Confidence Rate

The FIDES methodology is intended to predict realistic reliability levels, close to the average values usually observed (by contrast with pessimistic or conservative values).

An essential question when predicting reliability is the degree of confidence in the value. This question is all the more important that the users have no confidence in the raw results produced by previous methodologies, and that reliability control (quantification and engineering) has become essential for all projects.

One of the aims of the FIDES project is to build this confidence. However, obtaining an exact prediction is not the sole purpose of the FIDES methodology: identifying and controlling the factors affecting reliability may be considered even more important.

As a general rule, a prediction of reliability cannot be linked to a confidence interval, as can be done when measuring failure rates from field returns. In the case of FIDES, it might be possible to calculate a confidence interval for some basic failure rates, but it is practically impossible to predict the confidence rate for all adjustment parameters, even for known and widely used physical acceleration laws.

It is important to keep in mind that reliability belongs to the field of probability: in the same way that it is impossible to predict what will be the life of a product, it is impossible to predict exactly when a failure will occur, or why. The physics of failure is used in some cases to give lifetime probabilities (Time To Failure) and this type of prediction is complementary to the reliability prediction.

Note: Using values with several significant digits in the models does not imply the precision of the expected results.

The prediction's representativeness increases with the number of components considered. The predictions do not usually apply at item level. It is better to avoid comparing reliability prediction and observed reliability below PWA level, and it is better still to compare them at equipment level (assembly of PWAs) or above.

5.5. Items Covered

The FIDES methodology covers items from elementary electronic components to electronic modules or subassemblies with well-defined functions.
The FIDES coverage of component families is not fully exhaustive. However, it is sufficient to allow a representative assessment of the reliability in almost all cases.

The methodology applies to COTS (for which it was originally developed) and also to specific items whose technical characteristics match those described in this guide.

The COTS (Commercial Off-The-Shelf) acronym designates all catalog-bought items, available on the domestic or foreign market, with a supplier P/N, and for which the customer has no input on the definition or production. This item may be modified, its production or maintenance stopped with no possible opposition from the customer. There may be only one or several suppliers for each item.

5.5.1. Components

FIDES covers the following components:

INTEGRATED CIRCUITS
MOS (silicon) digital, linear, mixed MOS memory: SRAM, DRAM, Flash EEPROM, EEPROM, EPROM, MOS programmable circuits (Silicon): CPLD, FPGA, *PAL** Bipolar circuits (silicon): LV mixed, linear BICMOS circuits (silicon): LV mixed
DISCRETE SEMICONDUCTORS
Low power diodes (diodes with signal up to 1 A: PIN, Schottky, signal; rectifier diodes 1 to 3 A; Zener diodes < 1.5 W) Power diode (Rectifier diodes > 3A; Protection diodes > 5 kW; Thyristors, triacs > 3 A) Si low-power transistors (Bipolar, JFET, MOS) < 1W Si power transistors (Bipolar, JFET, MOS) > 1W; IGBT Optocouplers
CAPACITORS AND THERMISTORS (CTN)
Ceramic capacitors type I and II Solid tantalum capacitors Wet tantalum capacitor Aluminum capacitors (liquid electrolyte) Aluminum capacitors (solid electrolyte) *Aluminum capacitors (polymer electrolyte)** *Plastic film capacitors** *Variable capacitors** *Thermistors**
RESISTORS AND POTENTIOMETERS
"Minimelf" common use (RC) high stability (RS) low power film resistor Power film resistor Low power wirewound precision resistor Power wirewound resistor *Bulk metal foil resistors** Resistive chips CERMET adjustment potentiometer *Wirewound adjustment potentiometers** *Conductive plastic element precision potentiometers**
INDUCTORS AND TRANSFORMERS
Low current wirewound inductors High current (or power) wirewound inductors Multi-layer ceramic chip inductor Low power (or low level) transformer High power transformer
RELAYS
Hermetically sealed electromechanical relays
PCB and CONNECTORS
PCB
Connectors
PIEZOELECTRIC PARTS
Resonators
Crystal quartz oscillators

Families in italics and marked with an asterisk (*) shall be addressed subsequently.

5.5.2. PWAs

The wired board model serves to make a macroscopic reliability evaluation of a board without having recourse to component, PCB and connector models. It is intended on the one hand for COTS boards and on the other, for the early phases of a project, two situations in which the elements of detailed definition (parts lists, electrical diagrams, etc.) are not available.

For this approach, given the integration and constant technological progress of electrical components, a classification by board electronic technical function has been used, rather than by PWA devoted to a function. Thus each board is broken down into a sum of electronic functions.

The electronic functions covered are divided into 3 main families:

Digital electronic functions, comprising:

- CPU function.
- Simple or complex logic function.
- Volatile and non-volatile memory function.
- Clock function.
- Power supply monitoring function.
- Extension Bus interface function (buffer).
- Level adaptation function (line drivers): RS422, RS232, etc.
- Galvanic isolation function (optocoupling).
- Transistor switching function (outputs).
- Specific protocol interface function (transceiver + controller): PCI, ETHERNET, ADC, LON, 1553, ARINC, DIGIBUS, etc.

Analog electronic functions, comprising:

- Analog-to-digital and digital-to-analog conversion functions.
- Transmission/reception, amplification, summing, integration, filtering functions.
- Relay switching function.

Electronic power functions, comprising:

- Power transmission function.
- Power supply function: linear regulation, DC/DC conversion (chopping).

5.5.3. Miscellaneous Subassemblies

FIDES also covers the following other subassemblies:

- hard disks,
- CRT monitors,
- LCD screens,
- *plasma screens*,*
- *DC/DC voltage converters*,*
- *power supply modules*.*

Remark: Families in italics and marked with an asterisk (*) shall be addressed subsequently.

II
Reliability Prediction Guide

1. Introduction to the Models

1.1. Origin of the Data

The data used to construct the models was taken from recent failure analysis databases from the weapon systems and civil aeronautics domains and also supplied by component and subassembly manufacturers.

The data was used to develop and calibrate the models according to three methods:

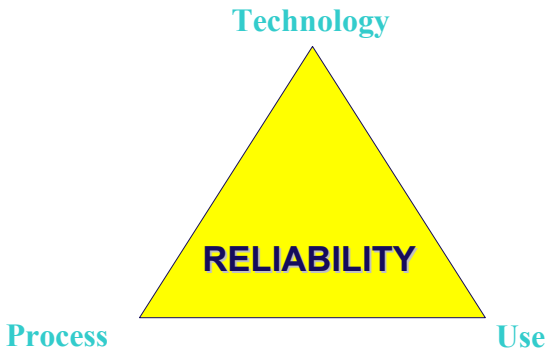
Method 1: using operating data (aeronautical and military) from failure mechanism databases.

Method 2: using component and subassembly manufacturers' data (environmental tests, technological data, etc.).

Method 3: using existing state-of-the-art reliability prediction models. This last method is used when existing models can be adapted satisfactorily to the requirements of the FIDES methodology.

1.2. FIDES Approach

The FIDES reliability approach is based on three components: Technology, Process and Use. These components are considered throughout the lifecycle, from product specification through to the field operation and maintenance phase.



Technology covers both the item itself and its integration in the equipment.
The Process considers all procedure and good practices from COTS product specification to its replacement.
Use includes both the use constraints defined by the equipment manufacturer in the design phase, and the operating constraints defined by the final user.

The models therefore consider a Technology with regard to Use constraints, through an approach comprising failure mechanisms and associated contributing factors, and in particular they weight the risk of failure through all process contributing factors that can initiate, accelerate or reduce these mechanisms.

1.3. General Model

The general FIDES model is based on the equation below:

$$\lambda = \left(\sum \text{Physical\_contribution}\right)\left(\prod \text{Process\_contributions}\right)$$

Where:

- $\sum \text{Physical\_contribution}$ is a chiefly additive term representing the physical and technological contributions to reliability.
- $\prod \text{Process\_contributions}$ is a multiplicative term representing the effects of the development, production and operation processes on reliability.

In the practice, this equation becomes:

$$\lambda = \lambda_{\text{Physical}} \cdot \prod_{\text{Part\_manufacturing}} \cdot \prod_{\text{Process}}$$

Where:

- $\lambda_{\text{Physical}}$ is the physical contribution.
- $\prod_{\text{Part\_manufacturing}}$ is the quality and technical control of the item's manufacture.
- $\prod_{\text{Process}}$ is the quality and technical control of the processes of development, manufacture and operation of the product containing the item.

1.4. Mission Profile and Time Unit

The failure rates predicted by the FIDES methodology are hourly failure rates expressed in calendar hours and based on the application of a yearly profile of use.

The failure rates of each phase are weighted by the phase's duration:

$$\lambda_{Physical} = \sum_{i}^{Phases} \left(\frac{Annual\_time_{phase-i}}{8760} \cdot \lambda_{phase-i} \right)$$

A non-leap year has 8760 calendar hours. All models are presented with this value, which may of course be adapted if the mission profiles considered are better described over longer or shorter periods, but calculation over a year remains the general recommendation.

The predicted failure rates are expressed in FIT (1 FIT equals 1 failure per 10^9 hours).

Remarks:

- These are therefore not failure rates expressed per hour of operation and for this reason (among others), the failure rates predicted by the FIDES methodology cannot be compared directly with results obtained using other approaches.
- To calculate a failure rate over a period other than one year (for instance, specific mission phase), simply replace in the formulas the time-based weighting value, set to 8760 hours (1 year), by the actual duration of the period considered (if the period is too short to allow the constraints to be correctly taken into consideration, thermal cycling in particular, this might entail taking special precautions).

1.5. Equipment Failure Rates

The general FIDES model serves to calculate the failure rates of electronic equipment before any considerations of redundancy or architecture.

The global failure rates of electronic equipment are obtained by adding the failure rates of each of the items making it up.

$$\lambda_{equipment} = \left(\sum_{Item} \lambda_{Item} \right)$$

Or, expressed differently:

$$\lambda_{equipment} = \left(\begin{array}{l} \sum_{Components} \lambda_{Components} \\ + \sum_{PCB} \lambda_{PCB} \\ + \sum_{PWA} \lambda_{PWA} \\ + \sum_{Other\_subassys} \lambda_{Other\_subassys} \end{array} \right)$$

1.6. Physical and Technological Contributing Factors $\lambda_{physical}$

The physical contribution can be subdivided into various sub-contributions, as shown below:

$$\lambda_{Physical} = \left[\sum_{Physical\_contributions} \left(\lambda_0 \cdot \Pi_{acceleration} \right) \right] \cdot \Pi_{induced}$$

Where:

- The term between square brackets is the contribution of the rated constraints.
- $\Pi_{induced}$ is the contribution of induced factors (overstress) inherent to a field of application.

1.6.1. Rated Constraints

This element of the general model comprises the base failure rates assigned to each item, the contribution of the characteristics of the technology used, and the acceleration factors used to assign to the item the physical constraints it is subjected to during its operational use.

$$\lambda_{Physical} = \left[\sum_{Physical\_contributions} \left(\lambda_0 \cdot \Pi_{acceleration} \right) \right] \cdot \Pi_{induced}$$

Where:

- λ_0 is the base failure rate.
- $\Pi_{acceleration}$ is an acceleration factor indicating sensitivity to the conditions of use.

An item's technological characteristics are taken into account:

- either directly in the choice of λ_0.
- or using parameters in the expression of $\Pi_{acceleration}$.

These factors, and the $\Pi_{acceleration}$ factor in particular, exist for each physical constraint. A physical constraint is any rated constraint applied to the equipment during operational use, including design aspects. The physical constraints are classified into several families:

- Thermal: $\Pi_{Thermal}$
- Electrical: $\Pi_{Electrical}$
- Thermal cycling: Π_{TCy}
- Mechanical: $\Pi_{Mechanical}$
- Humidity: Π_{RH}
- Chemical: $\Pi_{Chemical}$

The contribution of these physical constraints is additive, except in some families of components for which the thermal and electrical contributions are combined: $\Pi_{Thermoelectrical}$.

1.6.2. Overstress: $\Pi_{induced}$

The induced factors considered are of mechanical (MOS), electrical (EOS) and thermal (TOS) origin.

The $\Pi_{induced}$ factor is the contribution of overstresses not classified as such. It is calculated for each phase of the mission profile.

It is as follows:

$$\Pi_{induced-i} = \left(\Pi_{placement} \times \Pi_{application-i} \times \Pi_{ruggedizing}\right)^{0.511 \times \ln\left(C_{Sensitivity}\right)}$$

- $\Pi_{Placement}$ is the influence of the item's position in the equipment or system. The placement here indicates the position of the item or the function in which it participates (in particular, interface or not).
- $\Pi_{Application}$ is the influence of the operating environment of the application of the product containing the item. For example, exposure to mechanical overstress is in principle more important for the electronics of a mobile system than for a fixed system.
- $\Pi_{ruggedizing}$ is the influence of the policy of overstress integration in product development.
- $C_{sensitivity}$ is the coefficient of sensitivity to overstress inherent in the technology of the COTS

The $\Pi_{induced}$ factor theoretically varies between 1 (best case) and 100. However, only a limited part of this range is covered in the practice, the worst cases are never encountered simultaneously.

1.7. Process Contributing Factors

1.7.1. The $\Pi_{Part\_manufacturing}$ Factor

The $\Pi_{Part\_manufacturing}$ factor is representative of component quality. The assessment method depends on the nature of the item considered (EEE electronic component, boards, other subassemblies).

It is as follows:

$$\Pi_{Part\_manufacturing} = e^{\delta_1 (1 - Part\_Grade) - \alpha_1}$$

where:
$$Part\_Grade = \left[\frac{(QA_{manufacturer} + QA_{component} + RA_{component}) \times \varepsilon}{36} \right]$$

The evaluation method takes into account the manufacturer quality assurance ($QA_{manufacturer}$) and component quality assurance ($QA_{component}$) criteria and also the experience that the buyer of the item may have of his supplier (ε).
δ_1 and α_1 are correlating factors that determine the extent of the effects of $\Pi_{Part\_manufacturing}$ on the item's reliability.

For active components, the $\Pi_{Part\_manufacturing}$ factor evaluation principle also takes into account the qualification and periodic monitoring tests both on the unit and on the active part. This data is in particular to be found in reliability reports and audit results (component reliability assurance, $RA_{component}$).

The $\Pi_{Part\_manufacturing}$ factor varies from 0.5 (supplier above state-of-the-art) to 2 (worst case).

If $\Pi_{Part\_manufacturing}$ is not calculated, a default value of 1.7 is proposed for active components and 1.6 for other components, boards and miscellaneous subassemblies. Using the default value may degrade the accuracy of the final results.

1.7.2. The $\Pi_{Process}$ Factor

The $\Pi_{Process}$ factor is representative of the quality and technical control of the reliability in the product lifecycle.

It is as follows:

$$\Pi_{Process} = e^{\delta_2 (1 - Process\_Grade)}$$

Where *Process_grade* is a grade indicating process control, and δ_2 a correlation factor that determines the range of the $\Pi_{Process}$ factor

The evaluation method is based on the level of application of recommendations covering the entire lifecycle. The product lifecycle can be broken down as follows:

1. Specification.
2. Design.
3. Equipment production (manufacture).
4. System integration (manufacture).
5. Field operation and maintenance.

These five phases that constitute a sequence in time are combined with a set of transverse activities:

6. Support activities such as quality and Human Resources .

The $\Pi_{Process}$ factor varies from 1 (best process) to 8 (worst process).

If $\Pi_{Process}$ is not calculated, a default value of 4.0 is proposed.
Using the default value may degrade the accuracy of the final results.

1.7.3. Remark Concerning Procurement

Item procurement corresponds to a phase in its life between exit from the factory where the item was manufactured and the time of integration (e.g. mounting on a board) at the equipment manufacturer's facilities. Its incidence on reliability is paramount and close to that of $\Pi_{Part\_manufacturing}$. It is known to depend on:

- the equipment manufacturer's buying policy,
- the component selection policy (upstream technological studies),
- the component storage, environmental stress screening, handling and inspection policy.

These points are set forth in recommendations that depend on the lifecycle phases: *support, design, and equipment production*. Procurement therefore is not involved, neither as a specific factor nor as a complement, in the calculation of $\Pi_{Part\_manufacturing}$. It is taken into account in the calculation of $\Pi_{Process}$.

2. Input Data

2.1. Generic Input Data

Generically, the input data is:

Data about the environments and conditions of use of the product.
Typically:

- Operating temperature.
- Amplitude and frequency of thermal cycles.
- Vibration level.
- Relative humidity.
- Ambient pollution level.
- Exposure to overstress (type of application).

This data must be expressed for each phase of the product's lifecycle. The fineness of the description of the product's profile of use within an operating system determines the accuracy of the reliability assessment. Thus this step of the prediction analysis must be carried out very carefully.

Product definition data.
Typically:

- Parts lists.
- Item technical or technological characteristics taken from the manufacturers' data sheets.
- Component constraint or load levels (dissipated power, charge powered up, etc.).
- Local aggravations (or improvements) of temperature or another environmental parameter.

Product lifecycle.
This data must be gathered through an audit of specification, product development, production, field return and maintenance processes. The audit's rigor and depth must obviously be adapted to the required level of reliability.

Data about the suppliers of items used in the product.
This data is provided by the item supplier and the knowledge the industrialist has of his supplier.

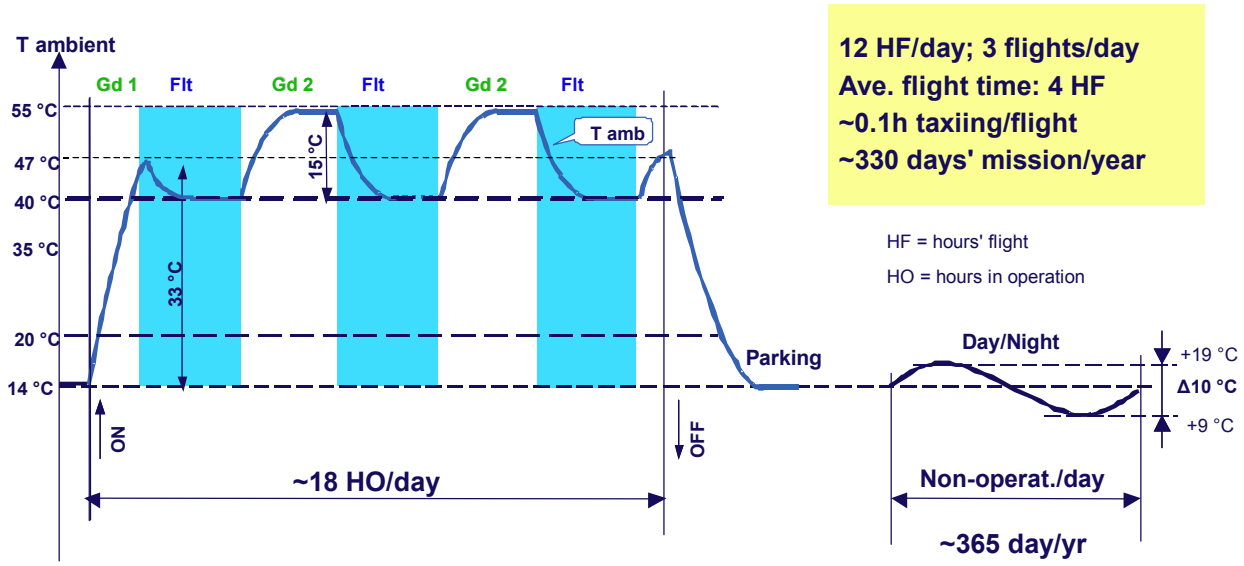
2.2. Mission Profiles

2.2.1. Mission Profile Description Rules

The mission profile description rules are presented through a case study. The example of a civil aeronautics profile of use has been chosen.

1st step: profile of use breakdown into successive phases.

The analysis of the thermal profile is taken as the basis for the breakdown, but a specific phase must be distinguished each time the environmental conditions change significantly regarding the constraints encountered.



In the case shown above, 5 characteristic operating conditions will be distinguished regarding the constraints associated with these phases.

Phase name	Description	Calendar time (hours)	Details
Ground-operating-1	System on the ground after powerup	660	330 days of missions x 2 h
Ground-operating-2	System on the ground between flights	1320	330 days of missions x 2 inter-flights x 2 hours
Ground-taxiing	System upon takeoff/landing	99	330 days of missions x 3 flights x 0.1 hour
Flight-operating	System in flight	3861	330 days of missions x 3 flights x 4 hours (- taxiing)
Ground-dormant	System at rest shut down	2820	330 days of missions x 6 hours rest + 35 days

The times are expressed in hours. Total calendar time = 1 year = 8760 hours.

2nd step: survey of the physical constraints associated with each phase.

- **Thermal constraint**

This constraint is directly associated with the operating phases of the equipment powered up.

The input data to include in the model is:

- The ambient temperature associated with the operating phase.
- The operating or non-operating status (the thermal constraint disappears in non-operation).

Phase name	Operation	Ambient temperature (°C)	Calendar time (hours)
Ground-operating-1	On	47 °C	660
Ground-operating-2	On	55 °C	1320
Ground-taxiing	On	47 °C	99
Flight-operating	On	40 °C	3861
Ground-dormant	Off	14 °C	2820

To take into account the thermal constraint it is important to consider the local temperature rises. As a general rule, the temperature to consider here is the temperature of the milieu of the item studied, not the temperature of any outside environment or the temperature of the item itself; when necessary, the models specifically address the rise of the item's temperature relative to its milieu (in particular for active components).

For reliability evaluations at component level, the ambient temperature to consider is the ambient temperature around the PWA. For example, for a board integrated in a piece of equipment, the value to use is the ambient temperature inside the equipment. This temperature must as a general rule take into account temperature rises linked to the thermal dissipation of the components.

For reliability evaluations at assembled board level, the same rule applies as for components.

For reliability evaluations of subassemblies other than boards, the ambient temperature of the milieu is used. The temperature rise information for subassemblies is usually not directly accessible, so models have been designed to dispense with it.

➢ **Thermal cycling constraint**

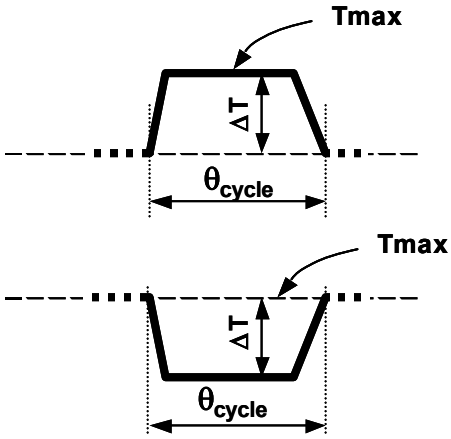
This constraint is associated with the temperature cycles of the equipment either in operation or dormant, taking into account the temperature variations linked to its operation (in particular, ON/OFF) and those of the environment (e.g. day/night).

Input data to include in the model for each phase:

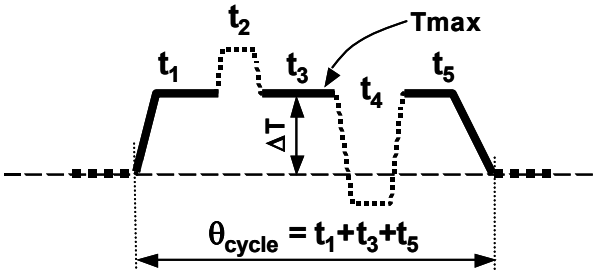
- Amplitude of the temperature cycle ΔT.
- Associated number of cycles over a year.
- Cycle duration θ_{cycle}. For cycles shorter than 2 hours, the cycle duration is a reducing factor in the thermal cycling constraint.
- Cycle maximum temperature.

These factors are estimated according to the following rules:

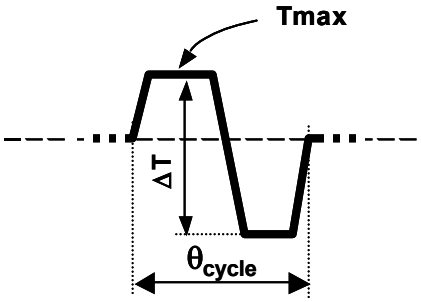
- Cycle appreciation starts at an initial equipment guideline temperature; e.g. equipment at rest (off).
- A cycle generally corresponds to a temperature difference ΔT relative to the guideline temperature; the cycle time θ_{cycle} extends until the initial temperature is reached once again.



- Other cycles may overlap with or be contained in a cycle; in this case, the subcycle time must be subtracted from the time of the primary cycle.



- In some special cases (low thermal amplitude), a cycle may be considered as a temperature variation around an average temperature (e.g. case of day/night cycling).



- In many cases, $\theta_{cycle} = \frac{\text{Calendar time}}{\text{Number of annual cycles}}$, but not always.
- A cycle ΔT must correspond to an identified phenomenon generating the constraint. E.g.: powerup, increasing the altitude, overheating linked to a system state. A cycle must be considered as a whole and not divided into several arbitrary subcycles that do not correspond to the actual time of a profile phase.
- A profile may comprise several identical cycles in succession. In this case, the number of identical cycles is counted.

In the example, for simplification purposes three types of thermal cycling are chosen:

- Cycles linked to powerup and extending throughout operation.
- Cycles linked to equipment heating when the aircraft on the ground between flights.
- Day/night thermal cycles.

Phase name	Calendar time	ΔT (°C)	No. of cycles /year	Cycle duration (h)	Maximum temperature during cycling	
Gd-operating-1	660	33°	330	14	47°	(1)
Gd-operating-2	1320	15°	660	2	55°	(2)
Ground-taxiing	99		0		55°	
Flight-operating	3861		0		40°	
Ground-dormant	2820	10°	117	24	19°	(3)

(1) 330 = Number of days of mission per year; h = operating time – time between flights (per day).
(2) 660 = Number of intervals between flights x number of missions per year; 2h = duration of an interval between flights on the same day.
(3) 117 = Time not in operation /24 h

➢ **Mechanical constraint**

This constraint is associated with the lifecycle phases where the equipment is subjected to random vibrations.

The data to include in the mission profile description is:

- The level of random vibration expressed in Grms, in the relevant frequency range for the product considered.

Phase name	Random vibrations (Grms)	Calendar time
Ground-operating-1	0	660
Ground-operating-2	0	1320
Ground-taxiing	5	99
Flight-operating	0.6	3861
Ground-dormant	0	2820

Total of calendar times: 8760 hours = one year.

➢ **Relative humidity constraint**

This constraint is associated with the relative humidity in the product's atmosphere.

The input data to include in the model is:

- The phase ambient temperature (see the thermal constraint).
- The rate of relative humidity associated with the phase.
- The non-operating or operating status (the relative humidity constraint is canceled in operation in most cases).

In estimating the rate of relative humidity, it is important to consider the level of relative humidity actually seen by the components. E.g., it is necessary to consider the equipment's hermeticity, the possibility of humidity being trapped in hermetically sealed equipment or the role of desiccant measures that can significantly reduce the rate of humidity inside a piece of equipment relative to the rate in the surrounding environment.

Phase name	Operation	Rate of humidity (%)	Ambient temperature (°C)	Calendar time
Ground-operating-1	On	70	47 °C	660
Ground-operating-2	On	70	55 °C	1320
Ground-taxiing	On	70	47 °C	99
Flight-operating	On	60	40 °C	3861
Ground-dormant	Off	60	14 °C	2820

Note: hours in operation + hours in storage = 8760 = 1 year whatever the mission profile.

➢ **Chemical constraint**

The chemical contribution to equipment reliability is expressed via four contributing factors linked to equipment use.

- In its environment:
  - Natural chemical contribution (mainly salinity, but also for example dust).
  - Industrial chemical contribution (pollution).
- In its system:
  - Chemical contribution due to the equipment's position in the system (local pollution).
  - Product protection level within the system (caution, this is not component hermeticity).

In the case of a civil aeronautics profile of use, for equipment in the cabin, the result is shown in the table below:

Phase name	**Calendar time**	**Saline pollution level** Low High	**Industrial pollution level** Negligible Urban area Urban + heavy industry area	**Area of application** Inhabited Uninhabitable Motor	**Product protection level** Hermetically sealed Non-hermetically sealed
Ground-operating-1	660	Low	Urban area	Inhabited	Non-hermetically sealed
Ground-operating-2	1320	Low	Urban area	Inhabited	Non-hermetically sealed
Ground-taxiing	99	Low	Negligible	Inhabited	Non-hermetically sealed
Flight-operating	3861	Low	Negligible	Inhabited	Non-hermetically sealed
Ground-dormant	2820	Low	Urban area	Inhabited	Non-hermetically sealed

➢ **Induced constraint**

The contribution of overstress depends on the phase of use.

Different criteria are used to appreciate the severity of a phase of use in terms of exposure to overstress. Evaluating these criteria serves to calculate the $\Pi_{application}$ parameter. The full method is explained in detail in the calculation sheets. The criteria are:

- User type: Shows professionalism, compliance with procedures, weight of operating constraints.
- User qualification: Shows the user or operator's skill in a given operating context.
- System mobility: Shows the unpredictable events linked to the movement possibility of the system.
- Product handling: Shows the frequency of incorrect handling, shocks, falls, etc.
- Power supply type: Shows the level of electrical interference expected on the power supplies and signals: powerups, power supply switching, connection/disconnection.
- Exposure to human activity: Shows the exposure to unpredictable events linked to human activity: shocks, change of destination, etc.
- Exposure to machine interference: Shows the unpredictable events linked to the operation of machines, motors, actuators: shocks, overheating, electrical interference, aggressive fluids.
- Exposure to the elements: Shows exposure to rain, hail, frost, sandstorms, lightning, dust, etc.

In the case of a civil aeronautics profile of use, for equipment in the cargo compartment:

Phase name	**Calendar time**	$\Pi_{application}$
Ground-operating-1	660	4.8
Ground-operating-2	1320	2.0
Ground-taxiing	99	1.2
Flight-operating	3861	1.1
Ground-dormant	2820	3.3

2.2.2. Examples of Typical Mission Profiles

Below are some examples of mission profiles for the following typical profiles of use.

- medium-range civil aeronautics.
- armed aircraft / fighter.
- armored tracked military vehicle.
- helicopter for military, broader public sector or rescue missions.
- helicopter for offshore or liaison missions.
- military portable radio.
- desktop PC.

The fineness of the description of the product's profile of use within an operating system determines the accuracy of the reliability assessment. Thus this step of the prediction analysis must be carried out very carefully. The typical profiles shown below must be considered as base examples to develop further if necessary.

Medium//long-range civil aeronautics profile of use, computer in the bay														
Constraint		**Thermal and Humidity**			**Thermal cycling**				**Mechanical**	**Chemical**				**Induced**
Phase name	Calendar time (hours)	On/Off	Ambient temperature (°C)	Rate of humidity (%)	ΔT (°C)	Number of cycles (/year)	Cycle duration (hours)	Maximum temperature during cycling (°C)	Random vibrations (Grms)	Saline pollution	Industrial pollution	Area of application	Protection level	Π application
Ground-operating-1	797	On	47	30	33	330	2	47	-	Low	Urban	Uninhabitable	Non-hermetically sealed	4.8
Ground-operating-2	1193	On	55	30	15	647	1.5	55	-	Low	Urban	Uninhabitable	Non-hermetically sealed	2.0
Ground-taxiing	84	On	47	5	-	-	-	-	5	Low	Negligible	Uninhabitable	Non-hermetically sealed	1.2
Flight-operating	4083	On	40	5	-	-	-	-	0.6	Low	Negligible	Uninhabitable	Non-hermetically sealed	1.1
Ground-dormant	2603	Off	14	70	10	108	24	19	-	Low	Urban	Uninhabitable	Non-hermetically sealed	3.3

Armed aircraft/ fighter profile of use, computer in the avionics bay														
Constraint		**Thermal and Humidity**			**Thermal cycling**				**Mechanical**	**Chemical**				**Induced**
Phase name	Calendar time (hours)	On/Off	Ambient temperature (°C)	Rate of humidity (%)	ΔT (°C)	Number of cycles (/year)	Cycle duration (hours)	Maximum temperature during cycling (°C)	Random vibrations (Grms)	Saline pollution	Industrial pollution	Area of application	Protection level	Π application
Ground-operating	112	On	50	50	36	250	0.448	50	-	Low	Negligible	Uninhabitable	Non-hermetically sealed	5.8
Ground-taxiing	13	On	55	55	-	-		-	8	Low	Negligible	Uninhabitable	Non-hermetically sealed	4.9
Flight-operating-1	83	On	65	40	15	250	0.2	65	8	Low	Negligible	Uninhabitable	Non-hermetically sealed	4.2
Flight-operating-2	83	On	-15	70	75	250	0.2	60	8	Low	Negligible	Uninhabitable	Non-hermetically sealed	3.9
Flight-operating-3	83	On	25	60	40	250	0.2	65	8	Low	Negligible	Uninhabitable	Non-hermetically sealed	4.9
Ground-maintenance	250	On	40	50	20	250	1	40	-	Low	Negligible	Uninhabitable	Non-hermetically sealed	5.8
Ground-dormant	8136	Off	14	70	10	343	24	19	-	Low	Negligible	Uninhabitable	Non-hermetically sealed	4.2

Tracked armored military vehicle profile of use														
Constraint		**Thermal and Humidity**			**Thermal cycling**				**Mechanical**	**Chemical**				**Induced**
Phase name	Calendar time (hours)	On/Off	Ambient temperature (°C)	Rate of humidity (%)	ΔT (°C)	Number of cycles (/year)	Cycle duration (hours)	Maximum temperature during cycling (°C)	Random vibrations (Grms)	Saline pollution	Industrial pollution	Area of application	Protection level	Π application
Fixed powered	152	On	50	40	36	48	5.06	50	0	Low	Negligible	Inhabited	Non-hermetically sealed	6.2
Mobile powered	91	On	50	40					4	Low	Negligible	Inhabited	Non-hermetically sealed	6.7
Mobile not powered (transport logistics)	100	Off	14	70					0.5	Low	Negligible	Inhabited	Non-hermetically sealed	5.2
Fixed not powered	8417	Off	14	70	10	351	24	19	0	Low	Negligible	Inhabited	Non-hermetically sealed	7.5

Helicopter profile of use for military, broader public sector or rescue missions. Inhabitable area														
Constraint		**Thermal and Humidity**			**Thermal cycling**				**Mechanical**	**Chemical**				**Induced**
Phase name	Calendar time (hours)	On/Off	Ambient temperature (°C)	Rate of humidity (%)	ΔT (°C)	Number of cycles (/year)	Cycle duration (hours)	Maximum temperature during cycling (°C)	Random vibrations (Grms)	Saline pollution	Industrial pollution	Area of application	Protection level	Π application
Ground-operating	100	On	60	50	15	724	0.14	65	-	Low	Negligible	Habitable	Non-hermetically sealed	7.9
Flight-operating-1	300	On	45	50	31	362	0.82	50	6	Low	Negligible	Habitable	Non-hermetically sealed	4.0
Ground-dormant	8360	Off	14	70	10	348	24	19	-	Low	Negligible	Habitable	Non-hermetically sealed	7.1

Helicopter profile of use for offshore or liaison missions														
Constraint		**Thermal and Humidity**			**Thermal cycling**				**Mechanical**	**Chemical**				**Induced**
Phase name	Calendar time (hours)	On/Off	Ambient temperature (°C)	Rate of humidity (%)	ΔT (°C)	Number of cycles (/year)	Cycle duration (hours)	Maximum temperature during cycling (°C)	Random vibrations (Grms)	Saline pollution	Industrial pollution	Area of application	Protection level	Π application
Ground-operating	400	On	60	50	15	2500	0.16	65	-	Low	Negligible	Habitable	Non-hermetically sealed	1.9
Flight-operating-1	1000	On	45	50	31	500	2	50	6	Low	Negligible	Habitable	Non-hermetically sealed	1.7
Ground-dormant	7360	Off	14	70	10	306	24	19	-	Low	Negligible	Habitable	Non-hermetically sealed	3.6

Profile of use for military portable radio (typical)														
Constraint		**Thermal and Humidity**			**Thermal cycling**				**Mechanical**	**Chemical**				**Induced**
Phase name	Calendar time (hours)	On/Off	Ambient temperature (°C)	Rate of humidity (%)	ΔT (°C)	Number of cycles (/year)	Cycle duration (hours)	Maximum temperature during cycling (°C)	Random vibrations (Grms)	Saline pollution	Industrial pollution	Area of application	Protection level	Π application
Ground fixed	600	On	40	40	15	100	6	40	0.5	Low	Negligible	Inhabited	Hermetically sealed	5.7
Ground mobile	600	On	40	45	15	100	6	40	1.5	Low	Negligible	Inhabited	Hermetically sealed	6.2
Ground-dormant 1	3960	Off	11	70	8	165	24	15	-	Low	Negligible	Inhabited	Hermetically sealed	4.3
Ground-dormant 2	3600	Off	11	70	8	200	18	15	-	Low	Negligible	Inhabited	Hermetically sealed	5.0

Profile of use for desktop PC														
Constraint		**Thermal and Humidity**			**Thermal cycling**				**Mechanical**	**Chemical**				**Induced**
Phase name	Calendar time (hours)	On/Off	Ambient temperature (°C)	Rate of humidity (%)	ΔT (°C)	Number of cycles (/year)	Cycle duration (hours)	Maximum temperature during cycling (°C)	Random vibrations (Grms)	Saline pollution	Industrial pollution	Area of application	Protection level	Π application
Ground in operation	2920	On	55	40	35	180	6	55	0.3	Low	Urban	Inhabited	Non-hermetically sealed	3.1
Ground dormant	5840	Off	20	70	5	243	24	25	-	Low	Urban	Inhabited	Non-hermetically sealed	1.6

III
Reliability Prediction Guide

Calculation Sheets

Electronic Components

Induced Factor

Factors contributing to overstress

$$\Pi_{induced\_i} = \left(\Pi_{placement} \times \Pi_{application\_i} \times \Pi_{ruggedizing}\right)^{0.511 \times \ln(C_{sensitivity})}$$

The index i designates the phase considered.

Factors contributing to the $C_{sensitivity}$ factor

	Relative sensitivity (out of 10)			
	EOS	MOS	TOS	$C_{sensitivity}$
Active components				
Integrated circuit	10	2	1	6.30
Discrete semiconductor circuit	8	2	1	5.20
Optocoupler	8	2	1	5.20
Passive components				
"Minimelf" common use (RC) high stability (RS) low power film resistor	5	2	4	3.85
Power film resistor	2	3	1	2.25
Low power wirewound precision resistor	2	1	3	1.75
Power wirewound resistor	2	3	1	2.25
Cermet adjustment potentiometer	1	5	2	2.50
Resistive chip	5	4	6	4.75
SMD resistive grid	4	5	3	4.25
Ceramic capacitor with defined temperature coefficient (Type I)	7	6	1	6.05
Ceramic capacitor with non-defined temperature coefficient (Type II)	7	6	1	6.05
Solid tantalum capacitor	8	7	1	6.95
Liquid electrolyte, Aluminum electrolytic capacitor	7	7	1	6.40
Solid electrolyte, Aluminum electrolytic capacitor	7	7	1	6.40
Low current wirewound inductor	5	2	6	4.05
Power wirewound inductor	10	7	1	8.05
Multi-layer ceramic chip inductor	4	6	1	4.40
Low power (or low level) transformer	8	6	4	6.90
High power transformer	8	6	3	6.80
Quartz resonator (HCxx type through-hole mount component)	1	10	5	4.55
Quartz resonator (surface mount)	1	10	5	4.55
Crystal quartz oscillator (XO type through-hole mount component)	8	10	2	8.10
Crystal quartz oscillator (XO type MCSO surface-mounted component)	8	10	2	8.10
Electromechanical components				
Hermetically sealed electromechanical relay	7	10	2	7.55

The relative sensitivities to EOS (Electrical OverStress), TOS (Thermal OverStress), MOS (Mechanical OverStress) are not taken into account for the calculation. They are given for information only.

Factors contributing to the $\Pi_{Placement}$ factor

	$\Pi_{placement}$
Non-interface digital function	1.0
Interface digital function	1.6
Non-interface low level analog function	1.3
Interface low level analog function	2.0
Non-interface power analog function	1.6
Interface power analog function	2.5

Factors contributing to the $\Pi_{application}$ factor

$$\Pi_{application_i} = \frac{1}{66} \cdot \sum_{k=Criteria} Wgrades_k \cdot Wos_k$$

The $\Pi_{application}$ parameter is calculated by rating a series of criteria. Each criterion has a specific effect on overstress (W_{OS}):

$\Pi_{application}$: Table 1

Criteria	Description	Levels	Comments or examples	Weight W_{OS}	Application and phase of use level		
					0	1	2
Type of user in the phase considered	Defines the capability to comply with procedures with regard to the weight of operating constraints.	0: Industrialist 1: General public 2: Military	The strictest level must be adopted for defence systems	20			
User skill level in the phase considered	Defines the user or technician's qualification or skill regarding an operating context	0: Highly qualified 1: Qualified 2: Few qualifications or little experience	In some phases the user to consider is the one in charge of maintenance or upkeep	10			
System mobility	Defines the unpredictable events linked to the system's degree of movement	0: Few unpredictable events: stable environment 1: Moderate level of unpredictable events 2: High level of unpredictable events: high variability	Examples: 0: airliner in cruise phase 1: railway transport 2: car	4			
Product handling	Defines the possibility of incorrect handling, shocks, falls, etc.	0: No handling 1: Handling without movement or disassembly 2: Handling with movement or disassembly	If maintenance possible on the product in the phase considered, adopt level 2	15			
System power supply	Defines the expected level of electrical interference on the electrical power supplies, signals and lines: powerup, power source switching, connection/disconnection	0: power supply undisturbed 1: power supply little disturbed 2: power supply subject to disturbance	The grid type is system data that may change at product level in some cases Examples: 0: Dedicated regulated power supply 1: Public power grid 2: On-board power supply	4			
Product exposure to human activity	Defines the exposure to unpredictable events resulting from human activity: shock, change of destination, etc.	0: Uninhabitable area 1: Activity possible in the product's area 2: Normal activity in the product's area	The product may be exposed to human activity even if not handled in normal conditions	8			
Product exposure to machine interference	Defines the unpredictable events linked to the operation of machines, motors, actuators: shocks, overheating, electrical interference, pollutants, etc.	0: Null 1: Indirect exposure 2: High or direct exposure	Examples 0: Office computer 1: Product in the hold of a combat aircraft 2: Product in the engine area	3			
Product exposure to bad weather	Defines the exposure to rain, hail, frost, sandstorms, lightning, dust, etc.	0: Null 1: Indirect exposure 2: Outdoors	Examples: 0: House 1: Hold, station hallway 2: Car engine	2			

Factors contributing to the $\Pi_{application}$ factor (cont'd)

Each criterion (type of user, system mobility, etc.) must receive a response to indicate a low, medium or high level:

- It is important to determine the $\Pi_{application}$ for each phase of use. Exposure to overstress varies considerably with the context. For instance, it is interesting to indicate increased exposure in the maintenance phases (if any).
- Some criteria apply at product level (i.e. the electronic unit, equipment or subassembly studied) and other at system level (i.e. the assembly in which the product is integrated, e.g. an aircraft or car). It is important to remember this point of view when evaluating the criteria.

Each level -low, medium and high- is assigned a specific weight, defined in the table below:

$\Pi_{application}$: Table 2

Grade	Grade weighting (W_{grades})
0, low level	1
1, medium level	3.2
2, high level	10

Based on these tables and the replies to the criteria, $\Pi_{application}$ is obtained with the formula:

$$\Pi application = \frac{1}{66} \cdot \sum_{k=Criteria} Wgrades_k \cdot Wt_k$$

Where:
W_{grades_k} is the weight of the grades given to each criterion ($\Pi_{application}$: Table 2).
W_{OS_k} is the weight of each criterion ($\Pi_{application}$: Table 1).

Factors contributing to the $\Pi_{Ruggedizing}$ factor

To determine the $\Pi_{Ruggedizing}$ factor the following questionnaire must be filled in.

The replies and the proof provided by the audited person serve to set a ***level of compliance*** with the recommendation (level N1 to N4):

- N1 = the recommendation is not applied → certain reliability hazards,
- N2 = the recommendation is only partly applied → potential reliability hazards,
- N3 = the recommendation is almost fully applied → few reliability hazards,
- N4 = the recommendation is fully applied and is the subject of a procedure → Reliability control.

		Level of compliance			
Recommendation	**Weight**	**N1**	**N2**	**N3**	**N4**
Write full procedures for all operation and maintenance activities	7				
Provide training and manage operation and maintenance skill upkeep	7				
Guarantee compliance with the product's procedures and the rules of each trade through an appropriate followup system	7				
Make a review of maintenance operations by the final user and process his recommendations	4				
Ensure the completeness of environment specifications. Specification completeness checking criteria: analysis, testing, field return, compliance with rules	4				
Justify the compliance with the environment specifications	4				
Carry out a product improvement process (e.g.: highly accelerated stress tests) in order to limit product sensitivity to environmental constraints (interference, environment, overstress)	7				
Carry out a process analysis of the operation and maintenance activities	4				
Compliance (by both supplier and supplied) with a power supply standard (standard defining possible interference and possible variations type EN2282)	4				
Carry out an analysis of failure cases that could result in fault propagation	4				
Integrate maintenance and production environments in the product specification environment	4				
Study and handle the risk of product deterioration under test through failures of the testing equipment. Criteria: risks analyzed during the test equipment and tested unit design phases, implementation of appropriate prevention measures	4				
Identify and handle any reasonable predictable abnormal use of the product through the appropriate prevention measures	4				
Identify and handle through the appropriate prevention measures any reasonably predictable weather-related aggressions	4				
Design electrical protection devices: - identify the electrical protection devices - guarantee their testability and maintainability - integrate in the definition of the maintenance policy the case where these devices exist	4				
Compliance, both by the product and by the system hosting it, with a standard concerning the conducted and radiated electromagnetic interference	3				

Factors contributing to the $\Pi_{Ruggedizing}$ factor (cont'd)

The grade for each level is as follows:

Level	Grade
N1	0
N2	1
N3	2
N4	3

Each recommendation is weighted by a specific ***Recom_Weight***.

The $\Pi_{Ruggedizing}$ factor is calculated as follows:

$$\Pi_{ruggedizing} = e^{0.7 \times (1 - recom - grade)}$$

where: $Recom\_grade = \frac{1}{225} \sum_{i}^{Recommendations} Recom\_weight_i \times Compliance\_grade_i$

Where:

- Recom_weight is the weight associated with a recommendation
- Compliance_grade is the grade obtained for this recommendation (0, 1, 2 or 3).

Remarks:

- The **Recom_grade** factor varies from 0 (worst case: no recommendation applied) to 1 (best case).
- The "225" factor is the score obtained giving the best grade to each recommendation. If one (or more) recommendations are deemed inapplicable and not pertinent for a given project, this total can be updated, as is done for the process factor calculation.

If $\Pi_{Ruggedizing}$ is not calculated, a default value of 1.7 is proposed. Using the default value may degrade the accuracy of the final results.

Active Integrated Circuits and Discrete Semiconductors: Part Manufacturing Factor

Model associated with the $\Pi_{Part\_manufacturing}$ factor:

$$\Pi_{Part\_Manufacturing} = e^{1.39.(1-Part\_Grade)-0.69}$$

where $$Part\_Grade = \left[\frac{(QA_{manufacturer} + QA_{component} + RA_{component}) \times \varepsilon}{36}\right]$$

Model associated with the $QA_{manufacturer}$ risk

Description of the manufacturer Quality Assurance level	Position relative to state of the art	$QA_{manufacturer}$ risk
TS16949	Above	3
Certified ISO 9000 version 2000 or MIL PRF 38535	Equivalent	2
Certified ISO 9000 version 1994	Below	1
No information or not certified ISO 9000 version 1994	Considerably below	0

Model associated with the $QA_{component}$ risk

Description of the component Quality Assurance level	Position relative to state of the art	$QA_{component}$ risk
Qualified per AEC Q100,Q101, or JESD47	Above	3
Qualified per standards JESD22, JEP143 or QML and identification of "front-end" and "back-end" manufacture sites	Equivalent	2
Manufacturer in-house qualification program and unidentified manufacture sites	Below	1
No information	Considerably below	0

The $QA_{component}$ parameter is a qualifier that mainly takes into account the qualification methodology ignoring the severity of the tests defined in the applicable standards. The test severities are defined by the $RA_{component}$ factor

Model associated with the $RA_{component}$ risk for integrated circuits.

Name of the accelerated aging test	High Temperature Operating Life (HTOL)	Preconditioning before TC, THB or HAST	Temperature Cycling (TC)	Pressure Cooker Test (PCT)	Highly Accelerated Stressed Tests (HAST)	Temperature Humidity Biased (THB)	
Reference standards	EIA JESD-22-A108 A or equivalent	EIA JESD-22-A113A or equivalent	EIA JESD-22-A104 or equivalent	EIA JESD-22-A102 or equivalent	EIA JESD-22-A110 or equivalent	EIA JESD-22-A101 or equivalent	
	Test results						$RA_{component}$ *risk*
Very reliable level A	1000h, 125 °C, Vmax, 231/0 (1) 1500/0*	Performed	1000 cycles - 55 °C/+150 °C or 500 cycles - 65 °C/+150 °C 231/0 or 1000 cycles –55 °C/125 °C 385/0	168 h at 121 °C/100 %RH 231/0	168 h at 130 °C/85%RH 231/0	168 h at 130 °C/85%RH 231/0	**3**
Very reliable level B	1000h, 125 °C, Vmax, 154/0 (1) 900/0*	Performed	1000 cycles - 55 °C/+125 °C, 154/0	96 h at 121 °C/100 %RH, 154/0	96 h at 130 °C/85%RH, 154/0	96 h at 130 °C/85%RH, 154/0	**2**
Reliable	1000h, 125 °C, Vmax, 77/0(1) 231/0*	Performed	500 cycles –55 °C/+125 °C 154/0	96 h at 121 °C/100 %RH, 77/0	96 h at 130 °C 85%HR, 77/0	1000 h at 85 °C/85%RH, 154/0	**1**
Unreliable	Dimensioning below reliable level	Not performed	Dimensioning below reliable level				**0**

Each box in the table gives a description of the test conditions with the expected result in the form XXX/Y, where XXX is the number of parts under test and Y the number of faults (in practice, Y=0)

(1): Applicable to a product or a Front End process for a given unit
*: applicable to all Front End processes for a given unit.

If the levels are not the same for the various test types, the lowest one shall be selected.

Model associated with the $RA_{component}$ risk for discrete semiconductor components.

Name of the accelerated aging test	High Temperature Reverse Bias (HTRB)	High Temperature Gate Bias (HTGB)	Intermittent Operating Life[2] Or Power and Temperature Cycle [2]	Preconditioning before TC, THB or HAST	Temperature Cycling (TC)	Pressure Cooker Test (PCT)	High Humidity High Temperature Reverse Bias (H^3TRB)	
Reference standards	EIA JESD-22-A108 A or equivalent	EIA JESD-22-A108 A or equivalent	MIL-STD-750 Method 1037 EIA JESD22 A-105	EIA JESD-22-A113A or equivalent	EIA JESD-22-A104 or equivalent	EIA JESD-22-A102 or equivalent	EIA JESD-22-A101 or equivalent	
	Test results							$RA_{component}$ *risk*
Very reliable level A	1000h, 125 °C, 80% at 100% of rated voltage, 231/0[1] 1500/0*	1000h, 150 °C, 80% at 100% of rated voltage 231/0[1] 1500/0*	Ta=25 °C. product polarized to obtain ΔTj ≥100 °C (without reaching the absolute maximum ratings) 231/0[1] 1500/0*	Performed	1000 cycles - 55 °C/+150 ° C or 500 cycles - 65 °C/+150 ° C 231/0 or 1000 cycles – 55 °C/125 ° C 385/0	2000 h at 85 °C/85% RH 154/0	168 h at 130 °C/85%RH 231/0	**3**
Very reliable level B	1000h, 125 °C, 80% at 100% of rated voltage, 154/0[1] 900/0*	1000h, 150 °C, 80% at 100% of rated voltage 154/0[1] 900/0*	Ta=25 °C. product polarized to obtain ΔTj ≥100 °C (without reaching the absolute maximum ratings) 154/0[1] 900/0*	Performed	1000 cycles – 55 °C/+125 ° C, 154/0	96 h at 121 °C/100%RH, 154/0	2000 h at 85 °C/85%RH 154/0	**2**
Reliable	1000h, 150 °C, 80% at 100% of rated voltage, 77/0[1] 231/0*	1000h, 150 °C, 80 to 100% of rated voltage, 77/0[1] 231/0*	Ta=25 °C. product polarized to obtain ΔTj ≥100 °C (without reaching the absolute maximum ratings), 77/0[1] 231/0*	Performed	500 cycles – 55 °C/+125 ° C, 154/0	96 h at 121 °C/100%RH, 77/0	1000 h at 85 °C/85%RH, 154/0	**1**
Unreliable	Dimensioning below reliable level			Not performed	Dimensioning below reliable level			**0**

Each box in the table gives a description of the test conditions with the expected result in the form XXX/Y, where XXX is the number of parts under test and Y the number of faults (in practice Y=0)

(1): Applicable to a product or a Front End process for a given unit.
(2): Test conditions as defined in AEC-Q101.
*: applicable to all Front End processes for a given unit.

If the levels are not the same for the various test types, the lowest one shall be selected.

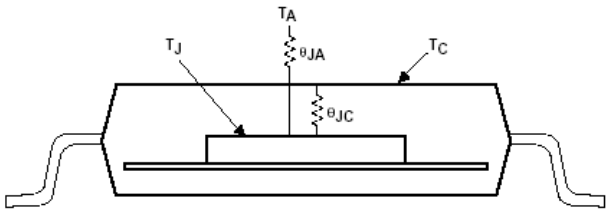
Model associated with the ε experience factor:

The epsilon factor indicates the experience that the component buyer may have of his supplier. This factor is therefore specific to each Industrialist. Its role as a multiplication factor in the model reveals the importance of the knowledge of the suppliers in the reliability of components.

Description of the risk linked to using this manufacturer	**Value of ε**
Known manufacturer - Mature processes for the product under consideration	4
Known manufacturer - Processes not analyzed or not mature for the product under consideration	3
Unknown manufacturer (e.g. never audited or audited over 6 years ago) Low volume production	2
Prior disqualification or field return problem	1

Active Components: Thermal Resistance

For active components, the thermal constraint model uses the component junction temperature. This requires calculating the rise in the junction temperature relative to the ambient temperature. This evaluation is usually based on the power dissipated by the component and its thermal resistance between the junction and the ambient temperature. The thermal resistance data published by the suppliers must be used. If impossible, a thermal resistance evaluation method for active components is proposed.



Integrated circuits

$$R_{JA\_0m/s} = C_{type}.Np^{-0.58}.K$$

$$R_{JA\_2m/s} = \frac{R_{JA\_0m/s}}{1.5}$$

R_{JA_V} = thermal resistance between junction and ambient temperature, relative to the airflow speed
V = 0 m/s or 2 m/s = airflow rate, depending on environmental convection (0 m/s = natural convection)
Ctype = Constant depending on the case type
Np = Number of pins in the case
K = Constant depending on the value of thermal conductivity in the board plane (kx=ky)

Note:

- Low Conductivity: $k_x < 15 \frac{W}{m.K}$
- High Conductivity: $k_x \geq 15 \frac{W}{m.K}$

Case Type	C_{type}	Range		
CerDIP/CDIP	320	8	< Np <	48
Power QFP (HQFP, RQFP, etc.)	340	160	< Np <	304
PDIP	360	8	< Np <	68
PPGA	380	28	< Np <	447
PLCC	390	20	< Np <	84
SOIC	400	8	< Np <	32
SOJ	400	24	< Np <	44
CPGA	410	68	< Np <	655
SOP	410	8	< Np <	32
Power BGA-1.27mm (SBGA, TBGA, etc.)	450	256	< Np <	956
J-CLCC	470	28	< Np <	84
CBGA	480	255	< Np <	1156
Cerpack	480	20	< Np <	56
TQFP, VQFP, LQFP	480	32	< Np <	208
PBGA-1.27mm	530	119	< Np <	729
Power BGA-1mm (SBGA, TBGA, etc.)	550	256	< Np <	1508
SSOP	560	8	< Np <	64
CQFP	560	64	< Np <	256
PQFP	570	44	< Np <	304
TSSOP	650	8	< Np <	64
PBGA-1mm	670	100	< Np <	1156
PBGA-0.8mm	700	48	< Np <	484
TSOP	750	16	< Np <	56

Board thermal conductivity	K
Low Conductivity	1.15
Unknown conductivity	0.94

For BGA cases, given the diversity of possible forms, it might be preferable to refer to the manufacturer data.

Discrete semiconductors

R_{JA} = junction-to-ambient temperature thermal resistance (model for natural convection only, airflow = 0 m/s) in °C/W
R_{JC} = junction-case thermal resistance in °C/W
Np = Number of pins of the case
kx = Thermal conductivity in the board plane (kx = ky) in W/m.K

Low Conductivity: $k_x < 15 \frac{W}{m.K}$

& High Conductivity: $k_x \geq 15 \frac{W}{m.K}$

			Low conductivity		High conductivity	
Case type	**Equivalent names**	**Np**	**"Rja" with V = 0 m/s**	**Rjc**	**Rja with V = 0 m/s**	**Rjc**
DO15	**DO-204AC**	**2**	**60**	*5*	*42*	*4*
DO27	**DO-201AA**	**2**	**41**	*1*	*30*	*1*
DO35	**DO-204AH**	**2**	**378**	*134*	*241*	*123*
DO41	**DO-204AL**	**2**	**73**	**45**	*50*	*41*
DO92		**3**	**195**	**150**	*126*	*137*
DO220 *		**3**	**65**	**4**	*45*	*4*
DPAK *	**TO-252AA, SC63, SOT428**	**4**	**97**	**4**	**71**	**4**
D2PAK *	**TO-263, SC83A, SMD-220**	**4**	**58**	**1**	*40*	*1*
IPACK *	**TO-251AA**	**3**	**96**	**3**	**50**	**3**
I2PAK		**3**	**63**	**1**	*44*	*1*
ISOTOP *	**SOT227, TO-244, Half-Pak**	**4**	**35**	**1**	*26*	*1*
F126		**2**	**40**	*1*	*29*	*1*
SIL	**SIL, ZIP**	**(See manufacturer specification)**				
SIP	**SIL, ZIP**	**(See manufacturer specification)**				
SOD6	**DO-214AA, SMB-J**	**2**	**88**	**27**	*59*	*24*
SOD15	**DO-214AB, SMC-J**	**2**	**67**	**2**	*46*	*2*
SOD80	**Mini-MELF, DO213AA**	**2**	**568**	*172*	*361*	*157*
SOD87	**DO-214AC, SMA-J**	**2**	**110**	*41*	*73*	*37*
SOD110		**2**	**315**	*119*	*202*	*108*
SOD123		**2**	**337**	**130**	*216*	*119*
SOD323	**SC76**	**2**	**428**	*146*	*273*	*133*
SOD523	**SC79**	**2**	**93**	*31*	*62*	*28*

(continued overleaf)

			Low conductivity		High conductivity	
Case type	**Equivalent names**	**Np**	**"Rja" with V = 0 m/s**	**Rjc**	**Rja with V = 0 m/s**	**Rjc**
SOT23	**TO-236AB**	**3**	**443**	**130**	**360**	**100**
SOT23	**SC74A, SOT25**	**5**	**285**	**106**	**136**	**81**
SOT23	**SC74, SOT26, SOT457**	**6**	**212**	**110**	**133**	**80**
SOT82 *	**TO225**	**3**	**100**	**8**	*67*	*7*
SOT89	**SC62, TO-243AA**	**4**	**142**	**100**	**125**	*91*
SOT90B		**6**	**500**	*160*	*318*	*146*
SOT143	**TO-253AA, SC61B**	**4**	**473**	*155*	**250**	*141*
SOT223	**SC73, TO261AA**	**4**	**84**	**21**	**57**	*19*
SOT323	**SC70**	**3**	**516**	*164*	*328*	**150**
SOT343	**SC82**	**4**	**215**	*88*	*139*	*80*
SOT346	**SC59, TO-236AA**	**3**	**500**	*160*	*318*	*146*
SOT353	**SC70-5, SC88A**	**5**	**358**	**144**	**229**	**138**
SOT363	**SC70-6, SC88**	**6**	**553**	*164*	*351*	**150**
TO18	**TO-71, TO-72, SOT31, SOT18**	**3**	**475**	**150**	*302*	*137*
TO39	**SOT5**	**3**	**219**	**58**	*142*	*53*
TO92	**SOT54, SC43, TO226AA**	**3**	**180**	**66**	*117*	*60*
TO126	**SOT32, TO-225AA**	**3**	**95**	**3**	*64*	*3*
TO218 *	**ISOWATT218**	**3**	**40**	**1**	*29*	*1*
TO220 *	**TO220-5, ISOWATT220, TO220XX**	**3**	**58**	**4**	*40*	*4*
TO247 *	**Max247, Super247, SOT429**	**3**	**47**	**1**	*34*	*1*

Note:

1. The *data in italics* are orders of magnitude resulting from regression analyses based on averages per case type.
   There are no standardized tests to measure the thermal resistance of discrete semiconductor cases; the thermal performance of these components therefore depends solely on the manufacturer.
   This *data in italics* is given as an indication; for the cases concerned, it is highly recommended to refer to the manufacturer data contained in the data sheets.

2. *: For power cases (type TO218, DPAK, ISOTOP, etc.), thermal resistance "R_{JA}" must be applied only if the case is directly mounted on the board; otherwise, when the case is for instance screwed onto a metal structure or if it has a heat sink, it is better to apply thermal resistance "R_{JC}".

3. If DeltaT_component is very high (DeltaT = R_{JA}.Prated> 150 °C), it is better to look for the conditions of thermal measurements in the specification and to apply the thermal resistance value "R_{JA}" supplied by the manufacturer, if it is smaller than that given by FIDES; otherwise, thermal resistance "RJC" should be applied (as it provides for a better metallization below the component).

Integrated Circuits

General model associated with the family

$\lambda = \lambda_{Physical} . \Pi_{Part} . \Pi_{Process}$ where:

$$\lambda_{Physical} = \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \left(\lambda_{0TH} . \Pi_{Therm} + \lambda_{0TCy_{Casing}} . \Pi_{TCy_{Casing}} + \lambda_{0TCy_{Solder\_joints}} . \Pi_{TCy_{Solder\_joints}} + \lambda_{0RH} . \Pi_{RH} + \lambda_{0mech} . \Pi_{mech} \right)_i . \Pi_{Induced-i}$$

Base failure rates associated with the cases

The base failure rates for the various physical constraints are given by the equation:

$\lambda_{0\_Restriction} = e^{-a} . Np^{b}$

Where:

- *a* and *b* are constants that vary with case type and number of pins, as shown in the table below.
- *Np* is the number of pins of the case.

Usual name	Description	Np	λ_{0RH} (FIT)		λ_{0TCy_Case} (FIT)		$\lambda_{0TCy\_Solder\ joints}$ (FIT)		$\lambda_{0\ mechanical}$ (FIT)	
			a	b	a	b	a	b	a	b
PDIP, TO116	Plastic Dual In line Package	8 to 68	5.88	0.94	9.85	1.35	8.24	1.35	12.85	1.35
CERDIP, CDIP	Ceramic Dual-In-Line Package	8 to 20 24 to 48	λ_{0RH}=0		6.77	1.35	5.16 4.47	1.35 1.35	8.38 7.69	1.35 1.35
PQFP	Plastic Quad Flatpack, L lead	44 to 240 244 to 304	11.16	1.76	12.41	1.46	10.80 10.11	1.46 1.46	14.71 14.02	1.46 1.46
SQFP TQFP, VQFP, LQFP	Plastic Shrink (thickness) Quad Flatpack, L lead Plastic Thin Quad Flatpack, L lead	32 to 120 128 to 208	7.75	1.13	8.57	0.73	6.96 5.57	0.73 0.73	11.57 10.18	0.73 0.73
Power QFP (RQFP, HQFP, PowerQuad, EdQuad, etc.)	Plastic Quad Flatpack with heat sink, L lead	160 to 240 244 to 304	14.17	2.41	15.11	1.96	13.50 12.81	1.96 1.96	17.41 16.72	1.96 1.96
CERPACK		20 to 56	λ_{0RH}=0		12.41	1.46	10.80	1.46	14.02	1.46
CQFP, Cerquad	Ceramic Quad Flat Pack	64 to 132 144 to 256	λ_{0RH}=0		12.41	1.46	10.80 9.19	1.46 1.46	14.02 12.41	1.46 1.46
PLCC	Plastic Leaded Chip Carrier J-Lead	20 to 52 68 to 84	9.36	1.74	18.52	3.15	16.91 15.52	3.15 3.15	21.11 19.72	3.15 3.15
J-CLCC	Ceramic Leadless (and Leaded) Chip Carrier	20 32 44 52 68	λ_{0RH}=0		18.52	3.15	14.96 14.83 14.71 14.71 14.61	3.15 3.15 3.15 3.15 3.15	18.18 18.05 17.93 17.93 17.83	3.15 3.15 3.15 3.15 3.15

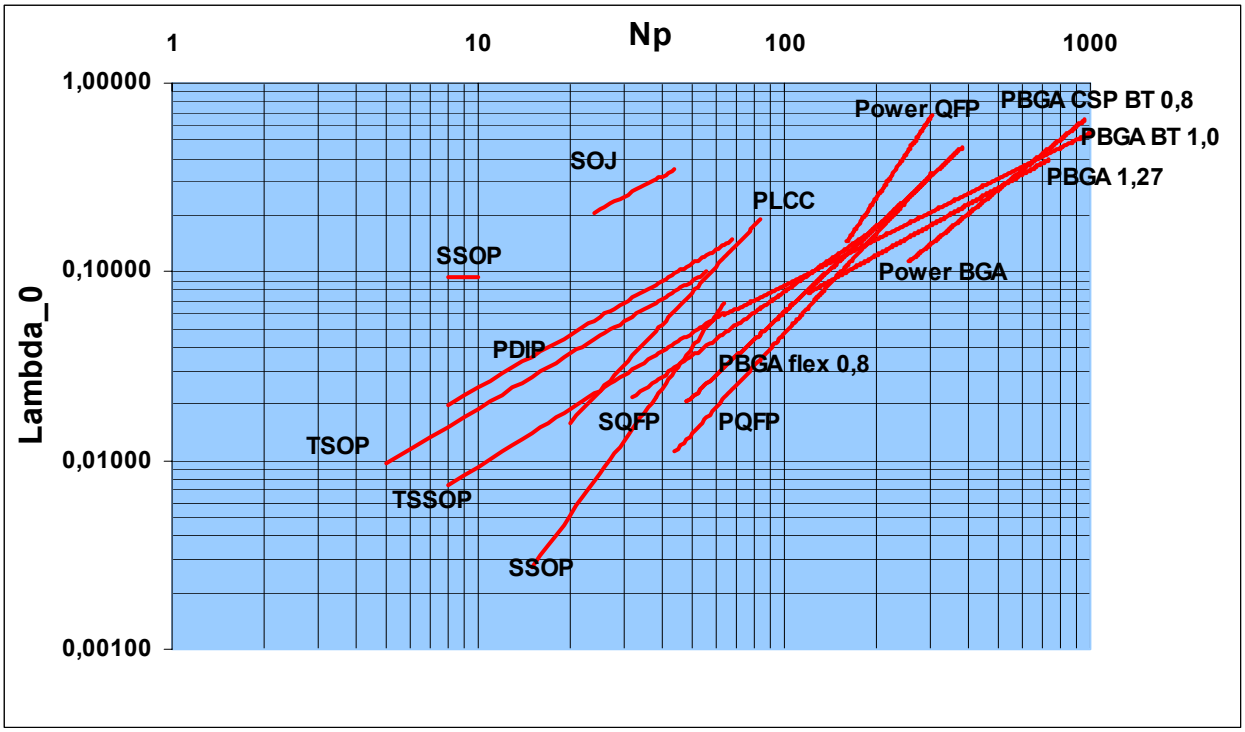
(continued overleaf)

Usual name	Description	Np	λ_{0RH} (FIT)		λ_{0TCy_Case} (FIT)		$\lambda_{0TCy\_Solder\ joints}$ (FIT)		$\lambda_{0\ mechanical}$ (FIT)	
			a	b	a	b	a	b	a	b
SOJ	Plastic Small Outlines J-Lead	24 to 44	4.31	0.86	8.36	1.39	6.75	1.39	11.36	1.39
SO, SOP, SOL, SOIC, SOW	Plastic Small Outlines, L lead	8 to 14 16 to 18 20 to 28 32	8.23	1.17	13.36	2.18	11.75 11.06 10.36 10.14	2.18 2.18 2.18 2.18	16.36 15.66 14.97 14.75	2.18 2.18 2.18 2.18
TSOP I **TSOP II**	Thin Small Outlines, leads on small edges, L lead Thin Small Outlines, leads on long edges, L lead	5 to 16 28 to 32 40 to 44 54 to 56	6.21	0.97	9.05	0.76	7.44 6.05 5.83 5.36	0.76 0.76 0.76 0.76	12.05 10.66 10.44 9.97	0.76 0.76 0.76 0.76
SSOP, VSOP, QSOP	Plastic Shrink (pitch) Small Outlines, L lead	8 to 10 16 to 64	2.36 11.95	0 2.23	4.22 16.28	0 2.60	2.61 14.67	0 2.60	7.22 19.28	0 2.60
TSSOP, MSOP, µSO, µMAX, TVSOP	Thin Shrink Small Outlines, L lead	8 to 28 32 to 48 56 64	7	1.01	13.02	1.84	11.41 10.72 10.02 9.62	1.84 1.84 1.84 1.84	16.02 15.32 14.63 14.22	1.84 1.84 1.84 1.84
PBGA CSP BT 0.8 & 0.75 mm	Plastic Ball Grid Array with solder ball pitch = 0.8 mm et 0.75 mm	48 to 384	9,7	1,50	12,13	1,49	9,13	1,49	12,82	1,49
PBGA flex 0.8 mm	Plastic Ball Grid Array with solder ball pitch = 0.8 mm et 0.75 mm	48 to 288	9,7	1,50	12,13	1,49	8,57	1,49	12,26	1,49
PBGA BT 1.00 mm	Plastic Ball Grid Array with solder ball pitch = 1.0 mm	64 to 305 320 to 388 416 to 1156	6,2	0,81	10,89	1,00	7,67 7,89 7,67	1,00 1,00 1,00	11,36 11,58 11,36	1,00 1,00 1,00
PBGA 1.27mm	Plastic Ball Grid Array, with solder ball pitch = 1.27 mm	119 to 352 388 to 432 503 to 729	6.87	0.90	10.36	0.93	7.36 7.14 6.67	0.93 0.93 0.93	11.05 10.83 10.36	0.93 0.93 0.93
Power BGA (TBGA SBGA, etc.)	Tape BGA, PBGA with heat sink, die top down pitch=1.27 mm Super BGA, PBGA with heat sink, die top down Pitch=1.27 mm	256 to 352 360 to 956	9.44	1.31	15.73	1.68	12.73 12.33	1.68 1.68	16.42 16.02	1.68 1.68
CBGA	Ceramic Ball Grid Array	255 to 1156	11.78	1.72	15.37	1.87	11.56	1.87	14.56	1.87
DBGA	Dimpled BGA	255 to 1156	11.78	1.72	15.37	1.87	12.15	1.87	15.15	1.87
CI CGA	Ceramic Land GA + interposer, Ceramic column GA	255 to 1156	11.78	1.72	15.37	1.87	11.81	1.87	14.81	1.87
CPGA	Ceramic Pin Grid Array	68 to 250 255 to 655	λ_{0RH}=0		8.07	0.93	5.77 4.85	0.93 0.93	8.76 7.85	0.93 0.93

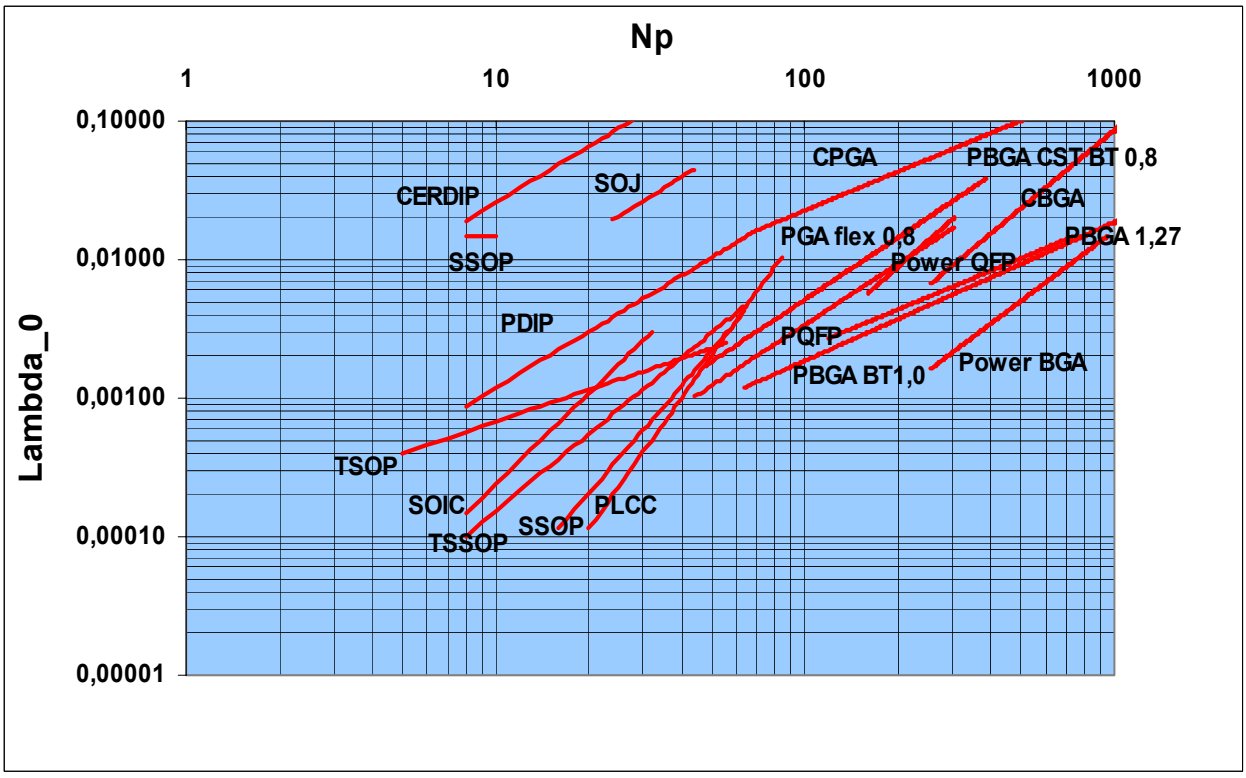
Note:

- For hermetically sealed cases, the failure rate due to a damp atmosphere is null (λ_{0RH}=0).
- The base failure rates for solder joints were estimated based on assumptions concerning the Printed Circuit Board type (the selected type is FR4), the CTE difference between PCB and component, the pin material, the CQFP pin camber, the substrate type of CBGA, Flex BGA, PBGA. These parameters affect reliability but cannot usually be addressed in a predicted reliability study.

Variations of λ_{0RH} by case type and number of pins



Variations of λ_{0Tcy_case} by case type and number of pins



Base failure rates associated with the chip

Type		λ_{0TH} **(FIT)**
SILICIUM MOS	Digital circuit	0.056
	Linear circuit	0.270
	Mixed circuit	0.11
	SRAM	0.067
	DRAM	0.091
	FLASH EEPROM	0.025
	EEPROM	0.026
	EPROM	0.056
	CPLD (EEPROM)	0.291
	FPGA (SRAM)	0.129
	FPGA (Antifuse)	0.396
BIPOLAR SILICON	Linear Circuit	0.059
	Mixed LV Circuit	0.34
	PAL (bipolar)	0.26
BICMOS SILICON	Digital Circuit	0.05
	LV Circuit	0.17

Mixed = digital / linear technology

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$RH_{ambient}$: humidity rate associated with a phase (%)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
Grms : vibration level associated with each phase de random vibrations (Grms)

Application data

$T_{J\_component}$: component junction temperature during an operating phase (°C)
$T_{J\_component} = T_{ambient} + R_{JA\_V} \cdot P_{rated}$
P_{rated} : specific power dissipated by the component (W)

Factors contributing to physical stresses

$\Pi_{Thermal\_}$	In an operating phase : $e^{11604 \times 0.7 \times \left[\frac{1}{293} - \frac{1}{(T_{j-component} + 273)}\right]_i}$ In a non-operating phase : $\Pi_{Thermal} = 0$
Π_{TCy} Case	$\left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{4} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$
Π_{TCy} Solder joints	$\left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$
Π_{Mech}	$\left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$
Π_{RH}	$\left(\frac{RH_{ambient}}{70}\right)_i^{4.4} \times e^{11604 \times 0.9 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)}\right]_i}$ In an operating phase : $\Pi_{RH} = 0$

Discrete Semiconductors

General model associated with the family

$\lambda = \lambda_{Physical} \Pi_{Part} \Pi_{Process}$ where:

$$\lambda_{Physical} = \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \left(\lambda_{0TH} . \Pi_{Therm} + \lambda_{0TCy_{Casing}} . \Pi_{TCy_{Casing}} + \lambda_{0TCy_{Solder\_joints}} . \Pi_{TCy_{Solder\_joints}} + \lambda_{0RH} . \Pi_{RH} + \lambda_{0mech} . \Pi_{mech} \right)_i . \Pi_{Induced-i}$$

Base failure rates associated with the cases

Case	Equivalent Names	Description	λ_{0RH} (FIT)	λ_{0Tcy_Case} (FIT)	$\lambda_{0Tcy\_Solder\ joints}$ (FIT)	$\lambda_{0\ Mechanical}$ (FIT)
CB417		Through hole, small signal, plastic	0.0310	0.00110	0.0055	0.00011
CB429						
DO13	DO202AA					
DO15	DO204AC					
DO27	DO201AA					
DO35	DO204AH					
DO41	DO204AL					
DO92						
F126						
SIL, SIP	SIL, SIP, ZIP					
TO92	SOT54, SC43, TO226AA					
TO126	SOT32, TO225AA					
TO202						
SOT23-3	TO236AB	SMD, small signal, L-lead, plastic	0.0055	0.00057	0.00285	0.000057
SOT23-5	SC74A, SOT25					
SOT23-6	SC74, SOT26, SOT457					
SOT143	TO253AA, SC61B					
SOT323	SC70					
SOT346	SC59, TO236AA					
SOT353	SC70-5, SC88A					
SOT363	SC70-6, SC88					
SOD123						
SOD323	SC76					
SOD523	SC79					
SOT223	SC73, TO261AA	SMD, medium power, small heatsink, L-lead, plastic	0.0126	0.00091	0.00455	0.000091
SOT243						
SOT343	SC82					
SOT89	SC62, TO243AA					
SOT194						
TO218	ISOWATT218	Through hole, power, plastic	0.0589	0.00303	0.01515	0.0003
TO220	TO220-5, ISOWATT220, TO220XX					
TO247	Max247, Super247, SOT429					
ISOWATT						
DO220						
IPACK	TO251AA					
SOT82	TO225					

(continued overleaf)

Case	Equivalent Names	Description	λ_{0RH} (FIT)	λ_{0Tcy_Case} (FIT)	$\lambda_{0Tcy\_Solder\ joints}$ (FIT)	$\lambda_{0\ Mechanical}$ (FIT)
SOD6	DO214AA, SMB-J	SMD, small signal, C-lead, plastic	0.0124	0.00091	0.00455	0.00009
SOD15	DO214AB, SMC-J					
SOD87	DO214AC, SMA-J					
DPAK	TO252AA, SC63, SOT428	SMD, power, large heatsink, L-lead, plastic	0.0335	0.00413	0.02065	0.00041
D2PAK	TO263, SC83A, SMD220					
D3PAK	TO268					
ISOTOP	SOT227, TO244, Half-Pak	SMD, high power, screw, plastic	0.99	0.03333	0.16665	0.0033
SOD80	Mini-MELF, DO213AA	SMD, Hermetically sealed glass	0	0.00781	0.03905	0.00078
SOD87	MELF, DO213AB					
TO18	TO71, TO72, SOT31, SOT18	Through hole, metal	0	0.0101	0.0505	0.00101
TO39	SOT5					
TO52						
TSSOP 8 – Discrete		Thin Shrink Small Outlines, L lead, plastic	0.0266	0.00085	0.00425	0.000425
TSOP 6 – Discrete		Thin Small Outlines, leads on long edges, L lead, plastic	0.0321	0.00116	0.0058	0.00058
SO 8 - Discrete		Plastic Small Outlines, L lead, plastic	0.0193	0.00117	0.00585	0.000585

Note:

- For hermetically sealed cases, the failure rate due to a damp atmosphere is null.

Base failure rates associated with the chip

Low power diodes	
	λ_{0TH} **(FIT)**
Diodes, signal up to 1 A (PIN, Schottky, signal)	0.0315
Rectifier diodes 1 to 3 A	0.0380
Zener diodes up to 1.5 W	0.0380

Power diodes	
	λ_{0TH} **(FIT)**
Rectifier diodes > 3A	0.0590
Protection diodes > 5 kW (10 µs/100 µs peak)	0.329
Thyristors, triacs > 3 A	0.192

Low power transistor	
	λ_{0TH} **(FIT)**
Silicon, junction < 5W	0.0170
Silicon JFET < 5W	0.0146
Silicon MOS < 5W	0.0172

Power transistor	
	λ_{0TH} **(FIT)**
Silicon junction > 5 W	0.0938
Silicon MOS > 5 W	0.0102
IGBT	0.249

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$RH_{ambient}$: humidity rate associated with a phase (%)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)

Application data

$T_{J\_component}$: component junction temperature during an operating phase (°C)
$T_{J\_component} = T_{ambient} + R_{JA} \cdot P_{rated}$
P_{rated} : specific component power (W)

Factors contributing to physical stresses

$\Pi_{Thermal}$	In an operating phase : $e^{11604 \times 0.7 \times \left[\frac{1}{293} - \frac{1}{(T_{j-component} + 273)}\right]_i}$ In a non-operating phase : $\Pi_{Thermal} = 0$
Π_{TCy} Case	$\left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{4} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$
Π_{TCy} Solder joints	$\left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$
Π_{Mech}	$\left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$
Π_{RH}	$\left(\frac{RH_{ambient}}{70}\right)_i^{4.4} \times e^{11604 \times 0.9 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)}\right]_i}$ In an operating phase : $\Pi_{RH} = 0$

Optocouplers: Part Manufacturing Factor

Model associated with the $\Pi_{Part\_manufacturing}$ factor

$$\Pi_{Part\_Manufacturing} = e^{1.39(1-Part\_Grade)-0.69}$$

Where:

$$Part\_Grade = \left[\frac{(QA_{manufacturer} + QA_{component}) \times \varepsilon}{24}\right]$$

Model associated with the $QA_{manufacturer}$ risk

This factor is calculated as for active integrated circuits and discrete semiconductors.

Model associated with the $QA_{component}$ risk

This factor is calculated as for active integrated circuits and discrete semiconductors.

Model associated with the ε experience factor:

This factor is calculated as for active integrated circuits and discrete semiconductors.

Optocouplers

General model associated with the family

$\lambda=\lambda_{Physical}.\Pi_{Part}.\Pi_{Process}$ where:

$$\lambda_{Physical} = \sum_{i}^{Phases}\left(\frac{t_{annual-phase}}{8760}\right)_i.\left(\begin{array}{l}\lambda_{0_{TH}}.\Pi_{Th}+\\ \lambda_{0_{TCy_{Casing}}}.\Pi_{TCy_{Casing}}+\\ \left(\lambda_{0_{TCy_{Solder\_joints}}}+\lambda_{0_{TCy_{Chips}}}\right)\Pi_{TCy_{Solder\_joints}}+\\ \left(\lambda_{0_{Casing\_Mech}}+\lambda_{0_{Chip\_Mech}}\right)\Pi_{Mech}+\\ \lambda_{0_{RH}}.\Pi_{RH}\end{array}\right)_i.\Pi_{Induced-i}$$

Base failure rates associated with the component

Component description	Activation energy (eV)	λ_{0_TH}	$\lambda_{0\ TCY\_chips}$	$\lambda_{0\ Chips\_MECH}$
Optocoupler with phototransistor	0.7	0.062	0.004	0.002
Optocoupler with photodiode	0.7	0.31	0.02	0.01

When there are *N* optocouplers in the same package, the $\lambda_{0\_TH\text{-}EL}$, $\lambda_{0TCY\_chips,}$ and $\lambda_{0\ Chips\_MECH}$ must be multiplied by $\sqrt{N}$.

The values of $\lambda_{0\ Tcy\ Units}$, $\lambda_{0\ Tcy\ Solder\ joints,}$ $\lambda_{0\ Unit\_mech}$ and $\lambda_{0\ RH}$ are given in the base failure rates tables associated with the packages of integrated circuits or discrete semiconductors.

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$RH_{ambient}$: humidity rate associated with a phase (%)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)

Application data

$T_{J\_component}$: component junction temperature during an operating phase (°C)
$T_{J\_component} = T_{ambient} + R_{JA} \cdot P_{rated}$
P_{rated} : specific component power (W)

Factors contributing to physical stresses

$\Pi_{Thermal}$	In an operating phase : $e^{11604 \times 0.7 \times \left[\frac{1}{293} - \frac{1}{(T_{j-component} + 273)}\right]_i}$ In a non-operating phase : $\Pi_{Thermal} = 0$
Π_{TCy} Case	$\left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{4} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$
Π_{TCy} Solder joints	$\left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$
Π_{Mech}	$\left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$
Π_{RH}	$\left(\frac{RH_{ambient}}{70}\right)_i^{4.4} \times e^{11604 \times 0.9 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)}\right]_i}$ In an operating phase : $\Pi_{RH} = 0$

Passive Components: Part Manufacturing Factor

Model associated with the $\Pi_{Part\_manufacturing}$ factor

$$\Pi_{Part\_Manufacturing} = e^{1.39(1-Part\_Grade)-0.69}$$

Where:

$$Part\_Grade = \left[\frac{(QA_{manufacturer} + QA_{component}) \times \varepsilon}{24}\right]$$

Factor *$QA_{manufacturer}$*

This factor is calculated as for active integrated circuits and discrete semiconductors.

Model associated with the *$QA_{component}$* risk

Description of the component Quality Assurance level	**Position relative to state of the art**	***$QA_{component}$ risk***
Qualified per standards CECC, ESA, MIL and AEC Q200 and identification of manufacture sites and site certification level	Above	3
Manufacturer in-house qualification program and unidentified manufacture sites	Equivalent	1
No information	Below	0

Experience factor ε:

This factor is calculated as for active integrated circuits and discrete semiconductors.

Resistors

General model associated with the family

$\lambda = \lambda_{Physical} . \Pi_{Part} . \Pi_{Process}$ where:

$$\lambda_{Physical} = \lambda_{0\_Resistor} . \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i . \left(\Pi_{Thermoelectrical} + \Pi_{TCy} + \Pi_{Mechanical} + \Pi_{RH} \right)_i . \Pi_{Induced-i}$$

Base failure rates associated with the component

Component description	$\lambda_{0\text{-Resistor}}$ (FIT)	A (°C)	$\gamma_{TH\text{-}EL}$	γ_{TCy}	γ_{Mech}	γ_{RH}
"Minimelf" common use (RC) high stability (RS) low power film resistor	0.1	85	0.04	0.89	0.01	0.06
Power film resistor	0.4	130	0.04	0.89	0.01	0.06
Low power wirewound precision resistor	0.3	30	0.02	0.96	0.01	0.01
Power wirewound resistor	0.4	130	0.01	0.97	0.01	0.01
Cermet adjustment trimmer	0.3	65	0.42	0.35	0.22	0.01
Resistive chip	0.01	70	0.01	0.97	0.01	0.01

General rule for resistor networks:
Take the failure rates for a component of the type under consideration and multiply it by the square root of the number of such components in the network; e.g.:

Component description	$\lambda_{0\text{-Resistor}}$ (FIT)	A (°C)	$\gamma_{TH\text{-}EL}$	γ_{TCy}	γ_{Mech}	γ_{RH}
SMD resistive grid	$0.01 \times \sqrt{\text{Number of resistors}}$	70	0.01	0.97	0.01	0.01

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$RH_{ambient}$: humidity rate associated with a phase (%)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : vibration level associated with each random vibration phase (Grms)

Application data

$P_{applied}$: power dissipated by the component in the application (W)

Technical characteristics data

P_{rated} : maximum power that the component can dissipate, specified by the supplier (W)

Factors contributing to physical stresses

$\Pi_{Thermoelectrical}$	In an operating phase : $\gamma_{TH-EL} \times e^{11604 \times 0.15 \times \left[\frac{1}{293} - \frac{1}{\left(T_{board\_ambient} + 273 + A \times \frac{P\_applied}{P\_rated}\right)}\right]_i}$ In a non-operating phase : $\Pi_{Thermoelectrical} = 0$
Π_{TCy}	$\gamma_{TCy} \times \left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycing}}{20}\right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$
$\Pi_{Mechanical}$	$\gamma_{Mech} \times \left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$
Π_{RH}	$\gamma_{RH} \times \left(\frac{RH_{ambient}}{70}\right)_i^{4.4} \times e^{11604 \times 0.9 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)}\right]_i}$ In an operating phase : $\Pi_{RH} = 0$

Ceramic Capacitors

General model associated with the family

$\lambda = \lambda_{Physical} \cdot \Pi_{Part} \cdot \Pi_{Process}$ where:

$$\lambda_{Physical} = \lambda_{0\_Capacitor} \cdot \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \cdot \left(\Pi_{Thermoelectrical} + \Pi_{TCy} + \Pi_{Mechanical} \right)_i \cdot \Pi_{Induced-i}$$

Base failure rates associated with the component

Component description	$\lambda_{0\text{-}Capacitor}$ (FIT)	Activation energy (eV)	$S_{reference}$	$\gamma_{TH\text{-}EL}$	γ_{TCy}	γ_{Mech}
Ceramic capacitor with defined temperature coefficient (Type I) with a low CV product	0.03	0.1	0.3	0.70	0.28	0.02
Ceramic capacitor with defined temperature coefficient (Type I) with a medium CV product	0.05	0.1	0.3	0.71	0.28	0.01
Ceramic capacitor with defined temperature coefficient (Type I) with a high CV product	0.50	0.1	0.3	0.71	0.28	0.01
Ceramic capacitor with non-defined temperature coefficient (Type II) with a low CV product	0.08	0.1	0.3	0.70	0.28	0.02
Ceramic capacitor with non-defined temperature coefficient (Type II) with a medium CV product	0.15	0.1	0.3	0.71	0.28	0.01
Ceramic capacitor with non-defined temperature coefficient (Type II) with a high CV product	2.34	0.1	0.3	0.46	0.53	0.01

CV product

	Type I	Type II
Low CV product	Less than 1.0 10^{-9} V.F	Less than 1.0 10^{-7} V.F
Medium CV product	Between 1.0 10^{-9} V.F and 1.0 10^{-7} V.F	Between 1.0 10^{-7} V.F and 1.0 10^{-5} V.F
High CV product	Greater than 1.0 10^{-7} V.F	Greater than 1.0 10^{-5} V.F

Mission profile data

t_{annual} : time associated with each operating phase over a year (hours)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : stress associated with each random vibration phase (Grms)

Application data

$V_{applied}$: voltage applied to the component in the application (V)

Technical characteristics data

V_{rated} : maximum voltage applicable to the component specified by the supplier (V)

Factors contributing to physical stresses

$\Pi_{Thermoelectrical}$	In an operating phase : $\gamma_{TH-EL} \times \left(\frac{1}{S_{reference}} \times \frac{V_{applied}}{V_{rated}} \right)_i^3 e^{11604 \times Ea \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)} \right]_i}$ In a non-operating phase : $\Pi_{Thermoelectrical} = 0$
Π_{TCy}	$\gamma_{TCy} \times \left(\frac{12.N_{annual\_cy}}{t_{annual}} \right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2} \right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20} \right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)} \right]_i}$
$\Pi_{Mechanical}$	$\gamma_{Mech} \times \left(\frac{G_{RMS}}{0.5} \right)_i^{1.5}$

Aluminum Capacitors

General model associated with the family

$\lambda = \lambda_{Physical} \cdot \Pi_{Part} \cdot \Pi_{Process}$ where:

$$\lambda_{Physical} = \lambda_{0\_Capacitor} \cdot \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \cdot \left(\Pi_{Thermoelectrical} + \Pi_{TCy} + \Pi_{Mechanical} \right)_i \cdot \Pi_{Induced-i}$$

Base failure rates associated with the component

Component description	$\lambda_{0\text{-}Capacitor}$ (FIT)	Activation energy (eV)	$S_{reference}$	$\gamma_{TH\text{-}EL}$	γ_{TCy}	γ_{Mech}
Liquid electrolyte aluminum capacitor	0.21	0.4	0.5	0.85	0.14	0.01
Solid electrolyte aluminum capacitor	0.4	0.4	0.55	0.85	0.14	0.01

Mission profile data

t_{annual} : time associated with each operating phase over a year (hours)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : stress associated with each random vibration phase (Grms)

Application data

$V_{applied}$: voltage applied to the component in the application (V)

Technical characteristics data

V_{rated} : maximum voltage applicable to the component specified by the supplier (V)

Factors contributing to physical stresses

$\Pi_{Thermoelectrical}$	In an operating phase : $\gamma_{TH-EL} \times \left(\frac{1}{S_{reference}} \times \frac{V_{applied}}{V_{rated}} \right)_i^3 e^{11604 \times Ea \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)} \right]_i}$ In a non-operating phase : $\Pi_{Thermoelectrical} = 0$
Π_{TCy}	$\gamma_{TCy} \times \left(\frac{12.N_{annual\_cy}}{t_{annual}} \right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2} \right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20} \right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)} \right]_i}$
$\Pi_{Mechanical}$	$\gamma_{Mech} \times \left(\frac{G_{RMS}}{0.5} \right)_i^{1.5}$

Tantalum Capacitors

General model associated with the family

$\lambda = \lambda_{Physical} \cdot \Pi_{Part} \cdot \Pi_{Process}$ where:

$$\lambda_{Physical} = \lambda_{0\_Capacitor} \cdot \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \cdot \left(\Pi_{Thermoelectrical} + \Pi_{TCy} + \Pi_{Mechanical} \right)_i \cdot \Pi_{Induced-i}$$

Base failure rates associated with the component

Remarks:

- For wet tantalum capacitors, by default take a Silver case and hermetically sealed.
- For solid tantalum capacitors, by default take a SMD packaging.

Wet tantalum capacitor

Component description	$\lambda_{0\text{-}Capacitor}$ (FIT)	Activation energy (eV)	$S_{reference}$	$\gamma_{TH\text{-}EL}$	γ_{TCy}	γ_{Mech}
Wet tantalum capacitor Silver case, elastomer sealed	0.77	0.15	0.6	0.87	0.01	0.12
Wet tantalum capacitor Silver case, hermetically sealed	0.33	0.15	0.6	0.81	0.01	0.18
Wet tantalum capacitor Tantalum case, hermetically sealed	0.05	0.15	0.6	0.88	0.04	0.08

Solid electrolyte Tantalum capacitor

Component description	$\lambda_{0\text{-}Capacitor}$ (FIT)	Activation energy (eV)	$S_{reference}$	$\gamma_{TH\text{-}EL}$	γ_{TCy}	γ_{Mech}
Solid tantalum capacitor drop packaging	1.09	0.15	0.4	0.86	0.12	0.02
Solid tantalum capacitor SMD packaging	0.54	0.15	0.4	0.84	0.14	0.02
Solid tantalum capacitor Axial metal packaging	0.25	0.15	0.4	0.94	0.04	0.02

Mission profile data

t_{annual} : time associated with each operating phase over a year (hours)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : stress associated with each random vibration phase (Grms)

Application data

$V_{applied}$: voltage applied to the component in the application (V)

Technical characteristics data

V_{rated} : maximum voltage applicable to the component specified by the supplier (V)

Factors contributing to physical stresses

$\Pi_{Thermoelectrical}$	In an operating phase : $\gamma_{TH-EL} \times \left(\frac{1}{S_{reference}} \times \frac{V_{applied}}{V_{rated}} \right)_i^3 e^{11604 \times Ea \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)} \right]_i}$ In a non-operating phase : $\Pi_{Thermoelectrical} = 0$
Π_{TCy}	$\gamma_{TCy} \times \left(\frac{12.N_{annual\_cy}}{t_{annual}} \right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2} \right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20} \right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)} \right]_i}$
$\Pi_{Mechanical}$	$\gamma_{Mech} \times \left(\frac{G_{RMS}}{0.5} \right)_i^{1.5}$

Magnetic Components: Inductors and Transformers

General model associated with the family

$\lambda = \lambda_{Physical} \cdot \Pi_{Part} \cdot \Pi_{Process}$ where:

$$\lambda_{Physical} = \lambda_{0\_Magnetic} \cdot \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \cdot \left(\Pi_{Thermoelectrical} + \Pi_{TCy} + \Pi_{Mechanical} \right)_i \cdot \Pi_{Induced-i}$$

Base failure rates associated with the component

Component description	$\lambda_{0\text{-}Magnetic}$ (FIT)	Activation energy Ea (eV)	$\gamma_{TH\text{-}EL}$	γ_{TCy}	γ_{Mech}	ΔT (°C)
Low current (or low level) wirewound inductor	0.025	0.15	0.01	0.73	0.26	10
Power wirewound inductor	0.05	0.15	0.09	0.79	0.12	30
Multi-layer ceramic chip inductor	0.05	0.15	0.71	0.28	0.01	10
Low power (or low level) transformer	0.125	0.15	0.01	0.73	0.26	10
High power transformer	0.25	0.15	0.15	0.69	0.16	30

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : stress associated with each random vibration phase (Grms)

Application data

ΔT : component temperature rise relative to the ambient temperature. The table above gives typical ΔT values to use if a better estimate is not available.

Factors contributing to physical stresses

$\Pi_{Thermoelectrical}$	In an operating phase : $\gamma_{TH-EL} \times e^{11604 \times Ea \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + \Delta T + 273)}\right]_i}$ In a non-operating phase : $\Pi_{Thermoelectrical} = 0$
Π_{TCy}	$\gamma_{TCy} \times \left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy},2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling}+273)}\right]_i}$
$\Pi_{Mechanical}$	$\gamma_{Mech} \times \left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$

Piezoelectric Parts: Oscillators and Quartz

General model associated with the family

$\lambda = \lambda_{Physical} \cdot \Pi_{Part} \cdot \Pi_{Process}$ where:

$$\lambda_{Physical} = \lambda_{0\_Piezoelectric} \cdot \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \cdot \left(\Pi_{Thermoelectrical} + \Pi_{TCy} + \Pi_{Mechanical} + \Pi_{RH} \right)_i \cdot \Pi_{Induced\_i}$$

Base failure rates associated with the component

Component description	$\lambda_{0\text{-}Piezoelectric}$ (FIT)	$\gamma_{TH\text{-}EL}$	γ_{TCy}	γ_{Mech}	γ_{RH}
Quartz resonator (case type HCxx through-hole mount component)	0.85	0.07	0.88	0.04	0.01
Quartz resonator (surface mount)	0.85	0	0.82	0	0.18
Crystal quartz oscillator (XO case, through-hole mount component)	3.5	0.67	0.3	0.03	0
Crystal quartz oscillator (XO case, MCSO surface-mounted)	3.5	0.18	0.7	0.1	0.02

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$RH_{ambient}$: humidity rate associated with a phase (%)
$T_{board\_ambient}$: average board temperature during a phase (°C))
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : vibration level associated with each random vibration phase (Grms)

Application data

I_{output} : current supplied by the component in the application (A)

Technical characteristics data

I_{max_output} : maximum current that the component can supply in operation (A)

Factors contributing to physical stresses

<table>
<tr><td>$\Pi_{Thermoelectrical}$</td><td>In an operating phase :

$\gamma_{TH-EL} \times \Pi_{rating\_TH-i} \times \Pi_{rating\_EL-i}$

Description of conditions of use : — Value of Π_{rating_TH}
Tboard_ambient < (Tambient-max manufacturer – 40 °C) — 1
Tboard_ambient ≥ (Tambient-max manufacturer – 40 °C) — 5

Description of conditions of use : — Value of Π_{rating_EL}
Quartz resonator: — 1
Oscillator : $I_{output} < 0.8 \times I_{max\_output}$ — 1
Oscillator : $I_{output} \geq 0.8 \times I_{max\_output}$ — 5

In a non-operating phase : $\Pi_{Thermoelectrical} = 0$</td></tr>
<tr><td>Π_{TCy}</td><td>$\gamma_{TCy} \times \left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy},2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling}+273)}\right]_i}$</td></tr>
<tr><td>$\Pi_{Mechanical}$</td><td>$\gamma_{Mech} \times \left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$</td></tr>
<tr><td>Π_{RH}</td><td>$\gamma RH \times \left(\frac{RH_{ambient}}{70}\right)_i^{4.4} \times e^{11604 \times 0.9 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient}+273)}\right]_i}$

In an operating phase : $\Pi_{RH} = 0$</td></tr>
</table>

Hermetically Sealed Electromechanical Relays

General model associated with the family

$\lambda = \lambda_{Physical} . \Pi_{Part} . \Pi_{Process}$ where:

$$\lambda_{Physical} = 1 \times \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i . \left(\Pi_{Thermal} + \Pi_{electrical} + \Pi_{TCy} + \Pi_{Mechanical} \right)_i . \Pi_{induced}$$

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : vibration level associated with each random vibration phase (Grms)

Application data

$V_{contact}$: Contacts voltage(V)
$I_{contact}$: Contacts current (A)
U_{bob} : Coil voltage (V)

Technical characteristics data

V_{rated} : Rated contacts voltage (V)
I_{rated} : Rated contacts current (A)
U_{rated} : Rated coil voltage (V)
N_{switch} : Number of active switch-type "reset" or "latch" contacts
$N_{inverter}$: Number of active inverter-type "reset" and "latch" contacts
$N_{contact}$: Number of active switch-type and inverter-type contacts: $N_{contact} = N_{inverter} + N_{switch}$

Factors contributing to physical stresses

$\Pi_{Thermal}$

In a non-operating phase : $\Pi_{Thermal} = 0$
In an operating phase :

$$0.32 \times \Pi_{Th\_Cutoff} \times \Pi_{Contact\ type\_Th} \times e^{11604 \times 0.25\left[\frac{1}{293} - \frac{1}{T_{board\_ambient}+273}\right]} \times (N_{switch} + 1.8 \times N_{inverter})$$

Technological attribute: Cutoff power	Π_{Th_Cutoff}
Cutoff power < 2A	1.8
Cutoff power ≥ 2A	1.2

Technological attribute: Contact type	$\Pi_{Th\_Contact\ type}$
Golden contact	1.5
Silver contact	1

$\Pi_{Electrical}$

In a non-operating phase : $\Pi_{electrical} = 0$
In an operating phase :

$$0.60 \times \Pi_{El\_cutoff} \times \Pi_{El\_Actuation} \times \left[\left(\frac{V_{contact}}{V_{rated}}\right)^{m_1} \times \left(\frac{I_{contact}}{I_{rated}}\right)^{m_2} \times \left(\frac{U_{rated}}{U_{winding}}\right)\right] \times N_{Contacts}$$

If $\frac{V_{contact}}{V_{rated}} \le 1$	then $m_1 = 3$
If $\frac{V_{contact}}{V_{rated}} > 1$	then $m_1 = 8.8$

If $\frac{I_{contact}}{I_{rated}} \le 1$	then $m_2 = 3$
If $\frac{I_{contact}}{I_{rated}} > 1$	then $m_2 = 5.9$

Number of actuations/h	$\Pi_{El\_Actuations}$
< 1	1
≥ 1	$\sqrt{(No\_of\_actuations/h)}$

Technological attribute: Cutoff power	Π_{El_Cutoff}
Cutoff power < 2A	1.5
Cutoff power ≥ 2A	1.2

Π_{TCy}

$$0.02 \times \left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling}+273)}\right]_i}$$

$\Pi_{Mechanical}$

$$0.06 \times \Pi_{Mech\_Cutoff} \times \Pi_{Mech\_Actuations} \times (\Pi_{Contact\ type\_Mech\ 1} + \Pi_{Contact\ type\_Mech\ 2}) \times \left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$$

Number of actuations/h	$\Pi_{Mech\_Actuations}$
< 1	1
≥ 1	$\sqrt{(No\_of\_actuations/h)}$

Technological attribute: Cutoff power	Π_{Mech_Cutoff}
Cutoff power < 2A	3
Cutoff power ≥ 2A	1

Number of switch-type "standby" or "work" active contacts	$\Pi_{Contact\ type\text{-}Mech\ 1}$
No contacts of this type	
1	0
2	1
3	1.5
4	2
	2.5

Number of inverter-type "standby" or "work" active contacts	$\Pi_{Contact\ type\text{-}Mech\ 2}$
No contacts of this type	
1	0
2	1.8
3	3
4	4.3
6	5.5
	8

PCB and Connectors

Induced Factor

Factors contributing to overstress

$$\Pi_{induced-i} = \left(\Pi_{placement-i} \times \Pi_{application-i} \times \Pi_{ruggedizing}\right)^{0.511 \times \ln(C_{sensitivity})}$$

The index i designates the phase considered.

Factors contributing to the $\Pi_{placement}$ and $C_{sensitivity}$ factors

	Relative sensitivity (out of 10)				
	EOS	MOS	TOS	$C_{sensitivity}$	$\Pi_{placement}$
Printed Circuit Board (PCB)	4	10	8	6.5	1
Connectors	1	10	3	4.4	1

The relative sensitivities to EOS (Electrical OverStress), TOS (Thermal OverStress), MOS (Mechanical OverStress) are not taken into account. They are given for information only.

Factors contributing to the $\Pi_{application}$ factor

The contribution is calculated as for the other components.

Factors contributing to the $\Pi_{ruggedizing}$ factor

The contribution is calculated as for the other components.

Part Manufacturing Factor

Model associated with the $\Pi_{Part\_manufacturing}$ factor

$$\Pi_{Part\_Manufacturing} = e^{1.39(1-Part\_Grade)-0.69}$$

Where:

$$Part\_Grade = \left[\frac{(QA_{manufacturer} + QA_{subassembly}) \times \varepsilon}{24}\right]$$

Factor $QA_{manufacturer}$

Description of the manufacturer Quality Assurance level	Position relative to state of the art	$QA_{manufacturer}$ risk
Certified ISO 9000 version 2000, Qualifas*	Above	3
Certified ISO 9000 version 1994	Equivalent	1
No information or not certified ISO 9000 version 1994	Below	0

Model associated with the $QA_{subassembly}$ risk

Description of the subassembly Quality Assurance level	Position relative to state of the art	$QA_{subassembly}$ risk
Performance of severe environment resistance tests and Accelerated Stress Tests	Above	3
Known manufacturer in-house qualification/environmental stress screening procedure	Equivalent	1
No information	Below	0

Experience factor ε:

This factor is calculated as for active integrated circuits and discrete semiconductors.

Printed Circuit Board (PCB)

General model associated with the family

$\lambda=\lambda_{Physical}.\Pi_{Part}.\Pi_{Process}$ where:

$$\lambda_{Physical} = \lambda_{0PCB}.\sum_{i}^{phases}\left(\frac{t_{annual}}{8760}\right)_i\left(\Pi_{TCy}+\Pi_{Mechanical}+\Pi_{RH}+\Pi_{Chemical}\right)_i.\Pi_{Induced-i}$$

Technical characteristics data

Base failure rates:

$$\lambda_{0PCB} = 5.10^{-4}.\left(N_{layers}\right)^{\frac{1}{2}}.\left(\frac{N_{mount}}{2}\right).e^{a.\left(T_{Board\_ambient}-110\right)}.\Pi_{Class}.\Pi_{PCB-Techno}$$

Description of technological factors:

N_{layer} : Number of layers of the PCB
N_{mount} : Number of mounting points (surface-mounted + through-hole)

Temperature range considered	Value of a
$T_{Board\_ambient}$ < 110 °C	0
$T_{Board\_ambient}$ > 110 °C	0.2

Routing class identification	Value of Π_{Class}
Class1	1
Class 2	2
Class 3	3
Class 4	4
Class 5	5
Class 6	6

PCB technology identification	Value of Π_{PCB_Techno}
Via	0.25
Blind via	0.5
Micro-via technology	1
Pad on via technology	2.5

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$RH_{ambient}$: humidity rate associated with a phase (%)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : stress associated with each random vibration phase (Grms)

Factors contributing to physical stresses

Π_{TCy}	$0.6\times\left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i\times\left(\frac{\min(\theta_{cy},2)}{2}\right)_i^{\frac{1}{3}}\times\left(\frac{\Delta T_{cycling}}{20}\right)_i^{1.9}\times e^{1414\times\left[\frac{1}{313}-\frac{1}{(T_{max-cycling}+273)}\right]_i}$
$\Pi_{Mechanical}$	$0.2\times\left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$
Π_{RH}	$0.18\times\left(\frac{RH_{ambient}}{40}\right)_i^{4.4}\times e^{11604\times0.8\times\left[\frac{1}{293}-\frac{1}{(T_{board\_ambient}+273)}\right]_i}$
$\Pi_{Chemical}$	$0.02\times\Pi_{Sal\_i}\times\Pi_{Indus\_i}\times\Pi_{Areas\_i}\times\Pi_{Prot\_i}$

Saline pollution level	Π_{sal}	**Industrial pollution level**	Π_{indus}
Low	1	Uninhabited area	1
High	2	Urban area	1.5
		Urban + heavy industry area	2

Area of application	Π_{Area}	**System protection level**	Π_{Prot}
Inhabited	1	Hermetically sealed	0
Uninhabitable	2	Non-hermetically sealed	1
Motor	4		

Connectors

General model associated with the family

$\lambda = \lambda_{Physical} \cdot \Pi_{Part} \cdot \Pi_{Process}$ where:

$$\lambda_{Physical} = \lambda_{0\_Connector} \cdot \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \cdot \left(\Pi_{Thermal} + \Pi_{TCy} + \Pi_{Mech} + \Pi_{RH} + \Pi_{Chemical} \right)_i \cdot \Pi_{Induced-i}$$

$$\lambda_{0\_Connector} = \lambda_{Type} \cdot \Pi_{report} \cdot \Pi_{contact} \cdot \Pi_{Cycle}$$

Technical characteristics data

Model for a connector half pair

Connector type

Connector type	λ_{type}
Round and rectangular connectors	0.05
Coaxial connectors	0.07
Connectors for PCBs (and equivalent)	0.1
Component supports	0.1

Mount type

Mount type	Π_{mount}
Insertion (press fit)	1
Soldered (through-hole mount component)	6
Soldered (SMD)	10
Wrapping (braid)	3
Wrapping (wire)	2

Number of contacts

$$\Pi_{Contact} = (N_{Contact})^{0.5}$$

Where $N_{contact}$ is the number of connector contacts.

Connection frequency

$$\Pi_{Cycles} = 0.2 \times (N_{annual\_cycles})^{0.25}$$

Where N_{annual_cycles} is the number of cycles (a cycle is one connection plus one disconnection) per year. If $N_{annual\_cycles} < 1$ per year let $\Pi_{cycles} = 0.2$.

Insert temperature rise

Gauge	32	30	28	24	22	20	18	16	12
a	3.256	2.856	2.286	1.345	0.989	0.64	0.429	0.274	0.1

$\Delta T_{insert} = a \times I_{contact}^{1.85}$

Where $I_{contact}$ is the average current across a pin (in amperes).

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$RH_{ambient}$: humidity rate associated with a phase (%)
Note: The RH of connectors at the interface of a piece of equipment may differ from that of other items.
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over a year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : vibration level associated with each random vibration phase (Grms)

Application data

ΔT : Insert temperature rise

Factors contributing to physical stresses

$\Pi_{Thermal}$	In an operating phase : $0.58 \times e^{11604 \times 0.1 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + \Delta T + 273)}\right]_i}$ In a non-operating phase : $\Pi_{thermal} = 0$
Π_{Tcy}	$0.04 \times \left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy},2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{1,9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling}+273)}\right]_i}$
$\Pi_{Mechanical}$	$0.05 \times \left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$
Π_{RH}	$0.13 \times \left(\frac{RH_{ambient}}{70}\right)_i^{4.4} \times e^{11604 \times 0.8 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient}+273)}\right]_i}$
$\Pi_{Chemical}$	$0.20 \times \Pi_{Sal-i} \times \Pi_{Indus-i} \times \Pi_{Area-i} \times \Pi_{Prot-i}$

Saline pollution level	Π_{sal}	**Industrial pollution level**	Π_{indus}
Low	1	Uninhabited area	1
High	2	Urban area	1.5
		Urban + heavy industry area	2

Area of application	Π_{Area}	**System protection level**	Π_{Prot}
Inhabited	1	Hermetically sealed	0
Uninhabitable	2	Non-hermetically sealed	1
Motor	4		

Wired Boards

Induced Factor

Factors contributing to overstress

$$\Pi_{induced-i} = \left(\Pi_{placement-i} \times \Pi_{application-i} \times \Pi_{ruggedizing}\right)^{0.511 \times \ln(C_{sensitivity})}$$

The index i designates the phase considered.

Factors contributing to the $\Pi_{placement}$ and $C_{sensitivity}$ factors

Digital functions	$\Pi_{placement}$	$C_{sensitivity}$
Complex function CPU (> 16 bits), DSP	1.0	6.14
Simple function CPU (8-16 bits)	1.0	6.14
Complex function logic (EPLD, FPGA)	1.0	6.14
Simple function logic (PAL, counter, glue)	1.0	6.14
Memory function SRAM/DRAM	1.0	6.14
Memory function EPROM / EEPROM / FLASH	1.0	6.14
Clock function	1.0	6.33
Power supply monitoring function	1.0	6.14
Extension Bus interface function (buffer)	1.6	5.81
Level adaptation function (Line drivers): RS422, RS232, etc.	1.6	5.81
Galvanic isolation function (optocoupling)	1.6	7.55
Transistor switching function (input/output)	1.6	4.87
Specific protocol interface function (Transceiver+Controller): PCI, ETHERNET, ADC, LON, 1553, ARINC, DIGIBUS, etc.	1.6	5.81

Analog functions	$\Pi_{placement}$	$C_{sensitivity}$
Conversion function, analog-to-digital	2.0	6.14
Conversion function digital-to-analog	2.0	6.14
Reception, amplification, summing, integration, filtering function	2.0	5.04
Transmission, amplification function	2.0	4.87
Relay switching function	2.0	7.55
Power transmission function	1.6	4.87
Power supply function: linear regulation	2.5	4.87
Power supply function: chopping DC/DC conv. < 25 W	2.5	6.07
Power supply function: chopping DC/DC conv. 25-100 W	2.5	6.87

Factors contributing to the $\Pi_{application}$ factor

The contribution is calculated as for the components.

Factors contributing to the $\Pi_{ruggedizing}$ factor

The contribution is calculated as for the components.

Part Manufacturing Factor

Model associated with the $\Pi_{Part\_manufacturing}$ factor

$$\Pi_{Part\_Manufacturing} = e^{1.39(1-Part\_Grade)-0.69}$$

Where:

$$Part\_Grade = \left[\frac{(QA_{manufacturer} + QA_{subassembly}) \times \varepsilon}{24}\right]$$

Factor $QA_{manufacturer}$

Description of the manufacturer Quality Assurance level	Position relative to state of the art	$QA_{manufacturer}$ risk
Certified ISO 9000 version 2000, Qualifas*	Above	3
Certified ISO 9000 version 1994	Equivalent	1
No information or not certified ISO 9000 version 1994	Below	0

Model associated with the $QA_{subassembly}$ risk

Description of the subassembly Quality Assurance level	Position relative to state of the art	$QA_{subassembly}$ risk
Performance of severe environment resistance tests and Accelerated Stress Tests	Above	3
Known manufacturer in-house qualification/environmental stress screening procedure	Equivalent	1
No information	Below	0

Experience factor ε:

This factor is calculated as for active integrated circuits and discrete semiconductors.

On-Board Electronic Functions

General model associated with the family

$\lambda = \lambda_{Physical} \cdot \Pi_{Part} \cdot \Pi_{Process}$ where:

$$\lambda_{Physical\_function} = \sum_{i}^{Phases} \left(\left(\frac{t_{annual}}{8760} \right)_i \lambda_{0\_function} \cdot \left(\Pi_{Th} + \Pi_{TCy} + \Pi_{Mechanical} + \Pi_{RH} + \Pi_{Chemical} \right)_i \cdot \Pi_{Induced-i} \right)$$

$$\lambda_{Physical\_board} = \sum_{j}^{Functions} \lambda_{Physical\_function_j}$$

Base failure rates

Digital functions	$\lambda_{0\text{-function}}$ (Fit)
Complex function CPU (> 16 bits), DSP	3.09
Simple function CPU (8-16 bits)	1.55
Complex function logic (EPLD, FPGA)	3.09
Simple function logic (PAL, counter, glue)	1.55
Memory function SRAM/DRAM	5.87
Memory function EPROM / EEPROM / FLASH	4.33
Clock function	1.20
Power supply monitoring function	1.24
Extension Bus interface function (buffer)	1.07
Level adaptation function (Line drivers): RS422, RS232, etc.	1.07
Galvanic isolation function (optocoupling)	0.46
Transistor switching function (input/output)	0.54
Specific protocol interface function (Transceiver+Controller): PCI, ETHERNET, ADC, LON,1553, ARINC, DIGIBUS, etc.	2.14

Analog functions	$\lambda_{0\text{-function}}$ (Fit)
Conversion function, analog-to-digital.	1.14
Conversion function digital-to-analog.	1.63
Reception, protection, amplification, summing, integration, filtering function.	3.62
Transmission, amplification function.	3.13
Relay switching function.	2.32
Power transmission function.	6.43
Power supply function: linear regulation.	1.87
Power supply function: chopping DC/DC conv. < 25 W	2.55
Power supply function: chopping DC/DC conv. 25-100 W	4.25

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$RH_{ambient}$: humidity rate associated with a phase (%)
$T_{board\_ambient}$: average board temperature during a phase (°C)
$\Delta T_{cycling}$: variation amplitude associated with a cycling phase (°C)
$T_{max\text{-}cycling}$: maximum board temperature during a cycling phase (°C)
$N_{annual\ cy.}$: number of cycles associated with each cycling phase over one year (cycles)
θ_{cy} : cycle duration (hours)
G_{RMS} : stress associated with each random vibration phase (Grms)

Technological data

Inventory of all functions on the board: for each function type, count the number of time it is met.

Factors contributing to physical stresses

$\Pi_{Thermal}$	In an operating phase : $0.303 \times e^{11604 \times 0.95 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)}\right]_i}$ In a non-operating phase : $\Pi_{thermal} = 0$
Π_{TCy}	$0.427 \times \left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{4.6} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$
$\Pi_{Mechanical}$	$0.074 \times \left(\frac{G_{RMS}}{0.5}\right)_i^{2.8}$
Π_{RH}	$0.012 \times \left(\frac{RH_{ambient}}{70}\right)_i^{4.4} \times e^{11604 \times 0.8 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)}\right]_i}$ In an operating phase : $\Pi_{RH} = 0$
$\Pi_{Chemical}$	$0.184 \times \Pi_{Sal-i} \times \Pi_{Indus-i} \times \Pi_{Area-i} \times \Pi_{Prot-i}$ **Saline pollution level** — Π_{sal}: Low 1; High 2 **Industrial pollution level** — Π_{indus}: Uninhabited area 1; Urban area 1.5; Urban + heavy industry area 2 **Area of application** — Π_{Area}: Inhabited 1; Uninhabitable 2; Motor 4 **System protection level** — Π_{Prot}: Hermetically sealed 0; Non-hermetically sealed 1

Caution: To check the type and number of functions on the board, the preliminary design documents or the manufacturer's functional diagram must be used.
In all cases, refer only to **hardware** description items (no software or testability description).

Miscellaneous Subassemblies

Induced Factor

Factors contributing to overstress

$$\Pi_{induced-i} = \left(\Pi_{placement} \times \Pi_{application-i} \times \Pi_{ruggedizing}\right)^{0.511 \times ln(C_{sensitivity})}$$

The index i designates the phase considered.

Factors contributing to the $C_{sensitivity}$ factor

			EOS	MOS	TOS	$C_{sensitivity}$
LCD screens		**TFT**	*7*	*2*	*1*	**2.40**
		STN	*3*	*2*	*1*	**1.80**
Hard disks	**Normal use**	**Protection against shocks/vibrations**	*2*	*6*	*2*	**4.00**
		Qualification for shocks/vibrations	*2*	*8*	*2*	**5.00**
		No special protection or qualification	*2*	*10*	*2*	**6.00**
	Intensive use, ventilated	**Protection against shocks/vibrations**	*2*	*6*	*5*	**5.05**
		Qualification for shocks/vibrations	*2*	*8*	*5*	**6.05**
		No special protection or qualification	*2*	*10*	*5*	**7.05**
	Intensive use, not ventilated	**Protection against shocks/vibrations**	*2*	*6*	*8*	**6.10**
		Qualification for shocks/vibrations	*2*	*8*	*8*	**7.10**
		No special protection or qualification	*2*	*10*	*8*	**8.10**
CRT screens			*2*	*5*	*1*	**3.15**

Factors contributing to the $\Pi_{placement}$ factor

		EOS	MOS	TOS	$\Pi_{placement}$
LCD screens	**Portable**	*3*	*5*	*1*	**1.6**
	Fixed	*2*	*1*	*1*	**1.0**
Hard disks	**External or removable**	*5*	*10*	*2*	**2.5**
	Fixed	*2*	*6*	*2*	**1.8**
CRT screens		*1*	*4*	*1*	**1.4**

The EOS, MOS and TOS sensitivities are only given as an example.

Factors contributing to the $\Pi_{application}$ factor

The contribution is calculated as for the components.

Factors contributing to the $\Pi_{ruggedizing}$ factor

The contribution is calculated as for the components.

Part Manufacturing Factor

Model associated with the $\Pi_{part\_manufacturing}$ factor

$$\Pi_{Part\_Manufacturing} = e^{1.39 \cdot (1 - Part\_Grade) - 0.69}$$

Where:

$$Part\_Grade = \left[\frac{(QA_{manufacturer} + QA_{subassembly}) \times \varepsilon}{24} \right]$$

Model associated with the *$QA_{manufacturer}$* risk

This factor is calculated as for wired boards.

Model associated with the *$QA_{subassembly}$* risk

This factor is calculated as for wired boards.

Experience factor ε:

This factor is calculated as for active integrated circuits and discrete semiconductors.

LCD Screens (TFT, STN)

General model associated with the family: **ⓘ Caution: limited lifetime**

$\lambda = \lambda_{Physical} . \Pi_{Part} . \Pi_{Process}$ where:

$$\lambda_{Physical} = \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i . \left(\lambda_{Thermal\_Screen} . \Pi_{Thermal} + \lambda_{Mechanical\_Screen} . \Pi_{Mechanical} \right)_i . \Pi_{Induced-i}$$

Failure rates associated with the subassembly

Subassembly description	$\lambda_{Mechanical\_Screen}$ **(FIT)**	$\lambda_{Thermal\_Screen}$ **(FIT)**	Activation energy (eV)
LCD screens TFT	$130 . D^{1.1}$	$690.e^{\frac{P}{120}}$	0.7
LCD screens STN	$11 . D^{2.5}$	$350.e^{\frac{P}{11}}$	0.5

Technical characteristics data

D: Screen size, diagonal (inches): 6"< D_{TFT} < 70" and 6"< D_{STN} < 17"

P: Power (Watts): P_{TFT} < 300W and P_{STN} < 40 W

Remark: If P unknown, for 6" < D < 20", let: $P(D) = 2.4.e^{0.18.D}$

Lifetime in operation: in the absence of manufacturer data, let DDV = 20000 hours

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$T_{ambient}$: average ambient temperature associated with a phase (°C)
G_{RMS} : stress associated with each random vibration phase (Grms)

Factors contributing to physical stresses

$\Pi_{Thermal}$	In an operating phase : $e^{11604 \times Ea \times \left[\frac{1}{293} - \frac{1}{(T_{ambient} + 273)}\right]_i}$ In a non-operating phase : $\Pi_{thermal} = 0$
$\Pi_{Mechanical}$	$\left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$

Hard Disks (EIDE, SCSI)

General model associated with the family: **ⓘ Caution: limited lifetime**

$\lambda = \lambda_{Physical} \cdot \Pi_{Part} \cdot \Pi_{Process}$ where:

$$\lambda_{Physical} = \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \cdot \left(\lambda_{Thermal\_Hard\_disk} \cdot \Pi_{Thermal} + \lambda_{Mechanical\_Hard\_disk} \cdot \Pi_{Mechanical} \right)_i \cdot \Pi_{Induced-i}$$

Failure rates associated with the subassembly

Subassembly description	$\lambda_{Mechanical\_hard\ disk}$ **(FIT)**	$\lambda_{Thermal\_hard\ disk}$ **(FIT)**
EIDE hard disk	$\Pi_S \cdot [120 - 60 \cdot \ln(Ft)]$	$\Pi_S \cdot \left[5.1 + \left(\frac{Ta}{9.6} \right)^{5.0} \right]$
SCSI hard disk	$\Pi_S \cdot [60 - 29 \cdot \ln(Ft)]$	$\Pi_S \cdot \left[2.6 + \left(\frac{Ta}{11} \right)^{5.0} \right]$

Description of technological factors

Ft: Hard disk format (inches): 1" < Ft < 5.25"
Ta: Average access time (ms): Ta < 20 ms

Calculating the Π_S solicitation factor

$$\Pi_S(Pc, Dc) = \frac{Pc \cdot Dc + 3}{Pc + 3}$$

Technical factor data

Dc: Duty Cycle defined by:

$$Dc = \frac{\left(\sum_a Access\_time + \sum_b Read\_time + \sum_c Write\_time \right)}{Time\_in\_use}$$

Pc: Disk platter count
Remark: if Pc unknown, let: $Pc = integer\left(\frac{1 + Nh}{2} \right)$ where Nh: Number of heads.
Lifetime in operation: see manufacturer data

Mission profile data

t_{annual} : time associated with each phase over a year (hours)
$T_{ambient}$: average ambient temperature associated with a phase (°C)
G_{RMS} : stress associated with each random vibration phase (Grms)

Factors contributing to physical stresses

$\Pi_{Thermal}$	In an operating phase : $e^{11604 \times 0.785 \times \left[\frac{1}{293} - \frac{1}{(T_{ambient} + 273)}\right]_i}$ In a non-operating phase : $\Pi_{thermal} = 0$
$\Pi_{Mechanical}$	$\left(\frac{G_{RMS}}{0.5}\right)_i^{2.5}$

CRT Monitors

General model associated with the family **ⓘ Caution: limited lifetime**

$\lambda = \lambda_{Physical} \cdot \Pi_{Part} \cdot \Pi_{Process}$ where:

$$\lambda_{Physical} = \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760} \right)_i \cdot \left(\lambda_{Thermal\_Moni} \cdot \Pi_{Thermal} + \lambda_{Mechanical\_Moni} \cdot \Pi_{Mechanical} + \lambda_{HR\_Moni} \cdot \Pi_{HR} \right)_i \cdot \Pi_{Induced\,i}$$

Failure rates associated with the **subassembly**:

$\lambda_{Mechanical\_Moni}$ **(FIT)**	$\lambda_{Thermal\_Moni}$ **(FIT)**	λ_{HR_Moni} **(FIT)**
$\left(560 + e^{\frac{Wt-11}{4.0}}\right)$	$\left[32 + \left(\frac{P}{29}\right)^{2.5} + \frac{510}{\sqrt{Rh}}\right]$	$\left(440 + e^{\frac{D-15}{1.2}}\right)$

Description of technological factors

Wt : Monitor weight without unit (kg): P < 40 kg
D : Screen size, diagonal (inches): D < 25"
Rh : Max horizontal refresh rate (kHz): 30 kHz < Fh < 150 kHz
P : Max power in operation (Watts): P < 200 W

Remark: If P unknown, let: $P(D) = 0.78.D^{1.72}$

Lifetime in operation: in the absence of manufacturer data, let DDV = 20000 hours

Necessary mission profile data

t_{annual} : time associated with each phase over a year (hours)
$T_{ambient}$: average ambient temperature associated with a phase (°C)
$RH_{ambient}$: humidity rate associated with a phase (%)
G_{RMS} : stress associated with each random vibration phase (Grms)

Factors contributing to physical stresses

$\Pi_{Thermal}$	In an operating phase : $e^{11604 \times 0.35 \times \left[\frac{1}{293} - \frac{1}{(T_{ambient} + 273)}\right]_i}$ In a non-operating phase : $\Pi_{thermal} = 0$
$\Pi_{Mechanical}$	$\left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$
Π_{RH}	$\Pi_{Prot} \times \left(\frac{RH_{ambient}}{70}\right)_i^{4.4} \times e^{11604 \times 0.8 \times \left[\frac{1}{293} - \frac{1}{(T_{ambient} + 273)}\right]_i}$ **Subassembly protection level: Value of Π_{Prot}** Hermetically sealed 0 Non-hermetically sealed 1 In an operating phase : $\Pi_{RH} = 0$

IV
Reliability Process Control and Audit Guide

1. Lifecycle

The table below details the full lifecycle of a product used to build its reliability. The FIDES methodology covers evaluation and reliability control throughout this lifecycle.

Phases		**Main activities**	
1	SPECIFICATION	1.1	Specification of requirements by the instructing parties
		1.2	Formalization of system requirements
		1.3	Definition of the architecture
		1.4	Attribution of system requirements
		1.5	Formalization of subassembly requirements
2	DESIGN	2.1	Feasibility/Preliminary design
		2.2	Detailed design
		2.3	Testing and fine-tuning
		2.4	Qualification
		2.5	Preparation for production
		2.6	Preparation of Logistic Support
3	EQUIPMENT PRODUCTION	3.1	Reception/Input check
		3.2	Storage
		3.3	Assembling of subassemblies
		3.4	Testing (subassemblies)
		3.5	Equipment integration
		3.6	Environmental stress screening (subassemblies, equipment)
		3.7	Acceptance
		3.8	Equipment delivery
4	SYSTEM INTEGRATION	4.1	Reception/Input check
		4.2	Storage
		4.3	System assembly
		4.4	System testing
		4.5	Environmental stress screening (System)
		4.6	System acceptance
		4.7	System delivery
5	FIELD OPERATION & MAINTENANCE	5.1	Transfer to the user
		5.2	Operational use
		5.3	Sustained readiness support
6	SUPPORT	6.1	Management of subcontractors
		6.2	Management of reliability, procurements, incidents
		6.3	Management of the quality system, resources

2. The Process Factor

The process factor is indicated by $\Pi_{Process}$ in the guide evaluation part.
The values are assigned by answering questionnaires about the product development, manufacture and operation processes. The questionnaire replying procedure is described in the audit guide.

3. Trade Recommendations - Reliability Control

A set of reliability recommendations is given in each phase or activity of the lifecycle.
The recommendations are either global and may concern all phases (in which case they are associated with the SUPPORT phase), or specific and acknowledged as affecting reliability during particular activities in one or more phases of the lifecycle.

Applying these recommendations makes it possible to implement reliability control actions (Reliability Engineering) and assess the reliability assurance level for each phase of the process. The reliability control procedure consists in using the results of a preliminary assessment to control those activities that affect the results.

The recommendations of the Process Reliability guide mainly concern the procedures and organization throughout the lifecycle. The Process Reliability guide does not aim to give technology recommendations concerning the use of components, boards or subassembly in electronic equipment.

4. Calculating the Process Factor $\Pi_{Process}$

The $\Pi_{process}$ is based on a grade (***Process_Grade***) indicating process quality, established following an audit of the lifecycle's different phases.

4.1. Relative Influence of the Lifecycle Phases

The lifecycle is divided into 6 phases:

- Specification
- Design
- Production
- System integration
- Field operation and maintenance
- Support activities

Each of these phases has a specific effect on product reliability. To quantify this value, each phase is assigned a scale factor to determine its relative weight. If known, the distribution corresponding to the audited Industrialist may be used.

The distribution by default is as follows:

PHASE	**Phase contribution (%)**
Specification	8
Design	16
Production	24
System integration	12
Field operation and maintenance	20
Support activities	20
Total:	100

4.2. Level of Compliance with the Recommendations

The audit is carried out by phases, through questions (concerning the recommendations) that assess the way in which the activities have been carried out.
The answers and proof provided by the audited person set a ***level of compliance*** with the recommendation (level N1 to N4):

- N1 = the recommendation is not applied → certain reliability hazards,
- N2 = the recommendation is only partly applied → potential reliability hazards,
- N3 = the recommendation is almost fully applied → few reliability hazards,
- N4 = the recommendation is fully applied → no particular reliability hazard.

The grade for each level is as follows:

Level	Grade
N1	0
N2	1
N3	2
N4	3

Each recommendation is weighted by a specific ***Recom_weight***; e.g.:

- 1 → the recommendation associated with the question has little effect on reliability,
- 10 or more → the recommendation associated with the question has a strong effect on reliability.

The appended implementation tables list for each phase the recommendations (with the associated audit question) and their specific ***Recom_weight***. Each recommendation has an associated sheet containing a precise description of the recommendation and the compliance criteria for each of the four levels of compliance.

Multiplying a recommendation's grade by its weight gives a number of ***Raw Points***; for recommendation i:

$$Recom\_weight_i \times Compliance\_Level_i = Raw\_Points_i$$

These points are then weighted by the ***scale_factor*** (determined below) of phase j before being added by phase:

$$Weighted\_Points_i = Raw\_Points_i \times Scale\_Factor_j$$

4.3. Calibration

This step neutralizes the questions about activities that do not apply for the product/process considered (case of "*not applicable questions*" in the calculation tables).

The first step of the calculation therefore consists in determining the **max weighted grade** per phase.

The ***Max_Grade*** of a phase is a "perfect" audit with level of compliance N4 to all applicable questions:

$$Recom\_weight_i \times 3 = Max\_Points_i$$

and adding the Max_Points for all recommendations (i=1 to n) of the entire phase j:

$$Max\_grade_j = Max\_Points\_Phase_j = \sum_{i=1}^{n} Max\_Points_i$$

Proceeding in the same way for the 6 phases, the maximum number of points possible for the selected process is obtained:

$$Max\_Points\_Process = \sum_{j=1}^{6} Max\_Points\_Phase_j$$

The scale factor (***scale_factor***) of each phase includes the relative influence (against all phases of the process) of the phase considered on the reliability, starting from a known distribution.

The **scale factor** is calculated for each phase j (j = specification, design, etc.):

$$Scale\_factor_j = Contribution\_phase_j \times \frac{Max\_Points\_Process}{Max\_Points\_Phase_j}$$

The ***Max_Weighted_Grade*** is thus calculated for phase j as:

$$Max\_Weighted\_Grade_j = Max\_Grade_j \times Scale\ Factor_j$$

The ***Max_Weighted_Grade_Process*** is calculated by adding the 6 ***Max_Weighted_Grade***$_j$:

$$Max\_Grade\_Process = \sum_{j=1}^{6} Max\_Weighted\_Grade_j$$

4.4. Calculating the Audit Grade

This step consists in performing the FIDES audit itself on personnel intervening at the different phases of the process, and defining the level of compliance according to the proof provided. The procedure to apply is given in the Audit Guide.

The process is carried out phase by phase, answering each question. The question's level of compliance, graded **0**, **1**, **2** or **3,** multiplied by the recommendation's weight gives the ***Raw_Points*** for the question:

$$Recom\_weight_i \times Compliance\_Level\ (0, 1, 2, 3)_i = Raw\_Points_i$$

These points are then weighted by the scale factor for phase j:

$$Weighted\_Points_i = Raw\_Points_i \times Scale\_Factor_j$$

The ***Audit_Grade*** for phase j is the sum of all ***Weighted_Points*** of the selected recommendations for the phase in question:

$$Audit\_Grade_j = \sum_{i=1}^{n} Weighted\_Points_i$$

4.5. Calculating the Process Factor

The formula to calculate the process factor is:

$$\Pi_{Process} = e^{\delta_2 (1 - Process\_Grade)}$$

The δ_2 factor determines the process factor range. It has been set at **2.079**, making the process factor range from 1 to 8.

The ***Process_grade*** is calculated using the phase ***Audit_Grade*** obtained before:

$$Process\_Grade = \frac{\sum_{j=1}^{6} Audit\_Grade_j}{Max\_Grade\_Process}$$

The ***Process_grade*** varies between 0 and 1:

- **0** is a process with incorrect answers to the audit questions;
  $\rightarrow \Pi_{Process} = 8$
- **1** is a "perfect" process with correct answers to all audit questions;
  $\rightarrow \Pi_{Process} = 1$

Note: a $Process\_Grade_j$ can be calculated for each phase j to determine the phase quality level:

$$Process\_Grade_j = \frac{Audit\_Grade_j}{Max\_Weighted\_Grade_j}$$

5. Audit Guide

The guide is used to audit a company. The audit procedure is generic, in order to give a degree of freedom relative to the company.

The FIDES methodology identifies a list of recommendations whose application favors the construction of a system's reliability. This set of recommendations has been expressed as a set of questions.

A company's answers to these questions serve to:

- measure its capability to build reliable systems,
- quantify the process factors used in the calculation models,
- identify actions for improvement.

5.1. Audit Procedure

To perform an audit, the auditor must:

- Prepare the audit.
- Undertake the audit.
- Gather the proof.
- Process the collected data.
- Draw the conclusions.
- Write an audit report.
- Present the audit results.

5.2. Preparing the Audit

Preparing an audit consists in:

- Identifying the scope of the audit (full, partial, for a program applicable to certification, information sought, duration, etc.).
- Identifying the audit's context.
- Identifying the correct targets (FIDES targets specified in the table below).
- Identifying the nature and scope of the audit.
- Establishing an audit plan (timetable with deadlines, summons, preparation of data-gathering documents, preparation of output document templates, involvement of the audit requesting party and the organization to audit, calculation of maximum possible scores for the audit in hand, exposition of the rules, etc.).
- Validating the audit plan (by the external or internal audit requesting party and by the representative of the audited company).
- Starting to implement the audit plan (sending the summons).
- Notifying within a sufficient deadline the audited person of the contents of the audit, knowing that proof not supplied shall be considered as lacking.

5.3. Undertaking the Audit

Undertaking the audit consists in:

- Presenting the audit (reminder of its goals, scope, rules).
- Asking the questions (if applicable, asking any additional questions needed to determine the level achieved for the criterion).
- Noting the replies of the audited targets beside each question.
- Gathering any proof immediately to append it to the report.
- Classify the proof gathered during the audit.
- Include any additional proof.

During the audit, if not done in the audit preparation phase, the auditor will mark in the appropriate place any irrelevant questions (i.e. whose process activities do not apply): this operation will help recalculate the maximum score expected for the audit in hand.

5.4. Processing the Collected Data

Processing the data consists in assessing, for each recommendation, the audited entity's position relative to the criteria, using the answers to the questions, the supporting proof supplied with the answers, and the weighting associated with each recommendation.

The result of the processing:

- determines the level of reliability associated with the audited entity,
- determines the value of the process factor ($\Pi_{Process}$) to use,
- identifies, if applicable, any improvement ways for the audited entity.

5.5. Drawing the Conclusions

The conclusions will provide:

- a reminder of the purpose of the audit,
- the decision concerning the qualification,
- the coefficients to use in the FIDES models.

The auditor will draft a report summarizing the context, the analysis of the results and the conclusions of the audit.

5.6. Presenting the Audit Results

The auditor will present the audit results to the instructing party and the audited party at the end of the audit. This presentation will address:

- the purpose of the audit,
- the audit plan and its implementation,
- the audit results,
- any identified improvement ways,
- the conclusions (final or partial, e.g.: at the end of the day).

Subsequently the report will be written and handed to the instructing party.

5.7. Qualification Rules

The auditor must have calculated the maximum possible score for the audit in hand.

The minimum possible score retained corresponds to a process meeting none of the FIDES criteria. The FIDES methodology does not have a fixed rule setting the minimum acceptable score for the FIDES methodology to be considered applicable. Such rules can only result from the practical use of the methodology in the industry.

Based on the answers to the questions and the evaluation of the answers against criteria, taking into account the weighting factors, the auditor will calculate the score obtained by the audited organization.

Depending on the position of this score relative to the maximum possible score, the audited entity may be qualified as having:

1. a "very high reliability" level (score within the top quarter of the range between the minimum and maximum possible),
2. a "high reliability" level (score within the second highest quarter of the range between the minimum and maximum possible),
3. a "reliable" level (score within the second lowest quarter of the range between the minimum and maximum possible),
4. an "unreliable" level (score within the lowest quarter of the range between the minimum and maximum possible).

5.8. Profile of the Audit Players

5.8.1. Auditor Profile

The auditors must:

- Be engineers, executives or technicians with at least 5 years' experience.
- Know the ISO 9000 standards Version 2000.
- Have the skills and theoretical and practical experience in the field of reliability.
- Be trained to conduct audits.

These requirements must be supplemented by a thorough knowledge of the FIDES methodology.

5.8.2. Profile of the Audited Parties

Given the diversity of organizations that may be audited, the audited parties may have widely varying profiles.
Nevertheless, they shall belong to the population of eighteen targets identified by FIDES. In the case of a partial audit, the audited parties may only represent a subassembly of these targets.

No.	Target population	Description
1	Purchasing	- People in charge of the process guideline (creation, implementation) and purchasing documents. - Project buyer: in charge of the Technical Clauses/Costs negotiation and of meeting the commitments.
2	Engineering department/Design	- Analysis or production of the specification of requirements, the technical specifications, and justification and traceability files. - Setting up of design, evaluation, approval, validation teams. Management of schedules, reviews, indicators (costs, quality, etc.).
3	Customer (instructing party)	- In charge of the specification of RAMS requirements and related specifications (profiles of use, analysis guidelines, etc.).
4	Head office	- In charge of the management of the overall site resources (design, production, industrialization).
5	Document management	- Saving/archival and consultation (making available) the archived documentation (definition files, specifications, purchasing files, etc.). - Project documentation manager
6	Operation	- In charge of utilization: compliance with recommendations, operating documentation, user training. - Final users
7	Indus./Prod./Integr.: Methods and quality management	- Traceability of products and production/industrialization/integration files (Industrialization manager). - Quality control of workplace services, fluids and environment. - Guideline (creation, implementation), checks, etc.
8	Indus./Prod./Integr.: Site and resources management	- Control of inspection resources (workshop manager). - Control of test and inspection procedures and reports.
9	Indus./Prod./Integr.: operators	- Testing (resources, schedules, etc.).

(continued overleaf)

No.	Target population	Description
10	Maintenance	- Compliance with maintenance resources and procedures, with recommendations, and processing of anomalies (sustained readiness support). - In charge of dispensing maintenance (maintenance technician).
11	Handling/Logistics	- Transport/handling/packaging/storage procedures and clauses.
12	Project	- Management and specification/creation of supplier or in-house clauses: - Synthesis of reliability and safety engineering, logistic support, obsolescence, qualification, Quality, handling / packaging / storage etc., production, customer support, etc. activities - Risk management (technical, planning, non-conformity).
13	Quality	Process description and implementation: - Product traceability for design, production, delivery and clientele. - Assurance of the implementation of and compliance with trade guidelines and QA. - Monitoring of process for handling anomalies or non-conformities.
14	Human Resources	- Adapting the load/qualification/human resources and fruition of knowledge and experience.
15	Customer Support	- Processing customer complaints customers and anomalies or non-conformities.
16	Components Service/Supplier Qualifications/Technology watch survey/Procurement	- Guideline (creation, implementation) for inspections and qualification (functional, technical) of procured items.
17	Logistic support	- Project player for the implementation of support analyses - Guideline (creation, implementation) for logistic support process (process description, analysis and substantiation tests, qualification tests)
18	Reliability and safety engineering	- Project driver for the implementation of the RAMS/guideline (resources, means), project monitoring (indicators, specifications, risk management, RAMS feasibility, etc.) and increasing RAMS awareness in other entities - Guideline (creation, implementation, production).

V
Recommendations of the Reliability Process Control and Audit Guide

1. Recommendation Tables with Weightings.
2. Detailed Recommendation Sheets.

Recommendation Tables with Weightings

Specification

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is there a financing item for the reliability studies? Have the needs been identified in terms of means and personnel?	Assign the resources in terms of personnel and means to the reliability studies	2	10.7						
Are the overall reliability requirements allocated to the subassemblies? What allocation method was used?	Allocate the reliability requirements to the subassemblies	3	10.4						
Is there a description and a characterization of the environment in which the system is going to be stored, transported, used and maintained?	Completely describe the environment in which the system is going to the used and maintained	31	12.4						
What is considered to be a system failure?	Define what a system failure is	34	10.3						
How is the demonstration of the system's reliability being considered?	Define the method used for demonstrating the system's reliability in the operational phase	35	9.8						
Has the System's utilization profile been defined for which the reliability performances are expected?	Define the System's utilization profile for which the Reliability performances are expected	38	9.9						
What is the context associated with a System's reliability requirements?	Indicate the context associated with a System's Reliability requirements	46	8.1						
Is the feedback put to good use for maintaining a good level of confidence in the upholding of the reliability performances?	Make the best possible use of feedback	80	8.5						
Is the reliability requirement expressed in quantitative terms?	Formulate the reliability requirement quantitatively	85	8.2						
Have the technical risks impacting reliability been identified?	Formally identify the technical risks impacting reliability	103	12.4						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Has a type of time measurement been identified (operating hours, flight hours, cycles, etc.) for the reliability performances?	Identify the type of time measurement for the reliability performances	95	6.6						
Have the customer's requirements been identified, documented and traced?	Identify the customer requirements	97	7.3						
Are the technological state of the art and the cost/performance optimization taken into account in the system's design at the time of the reliability requirement negotiations with the customer?	Negotiate the reliability requirements with the customer	144	10.7						
Is a system design review organized where the reliability aspects are examined?	Organize a system design review where the Reliability aspects are examined	147	10.3						
Are the reliability requirements examined in a system requirements review	Organize a review of the system requirements where the reliability aspects are examined	148	7.8						
Does the Operating Dependability discipline take part in the system's functional and detailed design?	Take part in the system's functional and detailed design	150	12.6						
How is the system's maintenance policy (requested by the customer) taken into account?	Take the system's maintenance policy (customer request) into account	164	5.8						
Has a System reliability plan been drawn up?	Draw up a System reliability plan	170	7.6						
What process is implemented to ensure: the collection of technical events, the writing up of problem reports and the measurement of improving reliability? How are equipment changes managed?	Process the problems	195	8.3						

Design

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
What steps have been taken to ensure that the personnel has the knowledge of the test means and of the standards and of how to interpret the measurements?	Adopt the steps so that the personnel has the knowledge of the test means and of the standards and of how to interpret the measurements	45	5.8						
Is the viewpoint of the various disciplines involved in engineering taken into account?	Ensure the involvement at each step of a person responsible for support, industrialization, purchasing, development and RAMS (concurrent engineering)	105	16.7						
Are the subassembly's technical data available for the development of the production test?	Ensure the completeness of the information on the subassembly to establish (complete) the Subassembly Test Manual	27	7.8						
Is there a list of substantiating items?	A document substantiating the reliability preliminary technical studies must be made available	57	8.0						
Is there a discipline procedures management system in place?	Know-how capitalization must be made available through discipline procedures	65	13.8						
Is there a skill procedures management system in place?	Put in place and manage a nominative table of skills required per activity	66	24.5						
Is there a preferential list of COTS items?	Establish and maintain a preferential list of COTS items	67	8.0						
Is the most made of feedback to improve future designs?	Existence of a database capitalizing on the feedback	62	24.2						
Is there a database capitalizing on the reliability assessment studies?	Existence of a database capitalizing on the reliability assessment studies	63	10.6						
Is there a database on the design history and substantiation?	Existence of a database on the design history and the design substantiations	64	7.8						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Have the means been identified and implemented for protecting subassemblies during certain equipment production activities?	Identify and implement the means for protecting subassemblies	93	7.3						
Have the technical risks impacting reliability been identified?	Formally identify the technical risks impacting reliability	103	21.0						
What is the process for constructing the reliability of the systems put in place in the company?	Involve the reliability discipline in the design of the equipment	32	7.5						
Is it verified that test coverage is maximal and that it is based on the specification? Is there a substantiating document?	Maximize test coverage on the basis of the specification and substantiation for the prototype tests	193	6.0						
Are there procedures in place for verifying the design?	Implement design verifications	76	27.1						
Is there a maintenance concept?	Implement a maintenance concept as part of logistical support	56	5.4						
Is a system design review organized where the reliability aspects are examined?	Organize a system design review where the reliability aspects are examined	147	12.1						
Is there a reliability management plan identifying the key skills (specialists)?	Write up a management plan where the key skills (specialists) are identified	58	17.7						
Is there a list of discipline recommendations on the handling and storage operations on the customer's premises?	Write up a list of discipline recommendations on the handling and storage operations on the user's premises	61	7.7						
Is there an acceptance specification for the production tests?	Write up an acceptance specification	191	7.8						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is there a product/supplier qualification procedure?	Make sure that there is a product/supplier qualification procedure	68	7.6						
Is there a definition of the test points and an application of the recommendations for the in-production tests?	Make sure that there is a definition of the production test points and that the test recommendations are applied	192	6.0						
Is there a procedure for qualifying the products and manufacturing process?	Make sure that there is a product/process qualification procedure	69	7.2						
Are new components qualified before being used?	Make sure that the manufacturing of the new component is qualified	71	7.2						
Is there an analysis documentation for assessing the reliability?	Make sure that there is an analysis documentation for assessing the reliability	74	7.5						
Are there design rules in place for adapting the choice of a component for a given level of reliability?	Make sure that there are design rules for adapting the choice of a component for a given level of reliability	77	12.7						
Is there a formalized tool for calculating reliability? Is there a formalized reliability book (MIL, adjusted MIL, RDF, personal REX)?	Make sure that the forecast reliability calculation is carried out using an acknowledged tool (MIL, adjusted MIL, RDF, personal REX)	78	7.7						
Are the choices relative to test coverage documented?	Take into account the self-test reliability/complexity balance on the coverage of the tests	30	10.2						
Are validated and recognized means of modeling used?	Utilization of validated and recognized means of modeling	197	13.5						

Equipment Production

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is a final test of the equipment performed? Do test result non-conformities give rise to processing: at the level of the equipment; at the level of the process? Are the test results recorded?	Improve the equipment final test seen in Design and Specification to increase the test coverage and draw up a test assessment	6	6.0						
Is there monitoring of the inspection parameters during the varnishing activity?	Ensure monitoring of the inspection parameters during the varnishing activity	18	9.9						
Is corrective maintenance carried out as soon as a problem appears on the production resources or on the subassemblies produced?	Ensure corrective maintenance is carried out as soon as a problem appears on the production resources or on the subassemblies produced	19	6.9				-		
Is preventive maintenance provided to correct drifts in the production resources' parameters?	Ensure preventive maintenance to correct drifts in the production resources' parameters	20	4.0				-		
Is there a periodic verification of the programming means to ensure that the software loading operation is carried out correctly?	Perform a periodic verification of the programming means to ensure that the software loading operation is carried out correctly	22	4.1				-		
Is there a systematic audit of the final test operators' skills?	Systematically audit the operators to monitor there skills	23	4.1				-		
Is the production and handling of boards automated?	Automate handling to limit the possible degradations of the boards	24	6.5				-		
Is there management of the data loaded into the programmable means of production?	Check and maintain (by updating) the data loaded into the programmable means of production	29	2.8				-		
Is the check of board varnishing performed by a person other than the varnishing operator?	Delegate the general inspection of the board varnishing operation in order to optimize filtering before pursuing the process	42	4.4				-		

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is the post-varnishing drying activity entrusted to experienced personnel?	Have experienced personnel in place for the post-varnishing board drying activity	43	5.6				-		
Are the instructions (protocol and special instructions to be observed) given to the operators?	Give the instructions (protocol and special instructions to be observed) to the operators	47	7.4				-		
Are temperature profile recordings made for each of the brazing system's programs?	Perform temperature profile recordings for each of the brazing system's programs to ensure that the article is not aggressed	49	6.9				-		
How is it ensured that the means of production are suited to the articles to be produced?	Eliminate any possibility of ambiguity relative to the use of a tool so as not to have a mismatch between the means of production and the subassembly to which it is applied	50	7.2				-		
How are the technical events or problem reports recorded?	Record (on a Problem Sheet) the problems that must lead to the application of corrective and / or preventive actions	52	7.6				-		
How are the priorities managed according to the end-of-dossier dates?	Manage the priorities to be complied with according to the end-of-dossier dates	90	3.1				-		
Have the means for protecting subassemblies during certain equipment production activities been identified and implemented?	Identify and implement the means for protecting the subassemblies	93	7.3				-		
Is the measurement of the contamination of brazing baths by sample-taking (so as not to exceed the contamination rates during this activity) effectively carried out?	Measure the contamination of brazing baths by sample-taking (frequency to be defined) so as not to exceed the contamination rate during this activity	127	5.8				-		
Is self-checking to filter out human errors (that could reduce the reliability of the subassembly) carried out?	Put in place a self-checking system to filter out human errors that could reduce the reliability of the subassembly	131	5.3				-		

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Are there indicators in place making it possible to check that there will be a good solder at the time of COTS item die bonding?	Put in place indicators making it possible to check that there will be a good solder at the time of COTS item die bonding	132	6.0				-		
Have you put in place specific counter-ESD protections for subassemblies during handling and storage?	Put in place specific counter-ESD protections for subassemblies during handling and storage	208	26.0				-		
Are there periodic verifications in place enabling the follow up of the tools used to check the means of production?	Put periodic verifications in place enabling the follow up of the tools used to check the means of production	133	4.9						
Are there adequate protections in place to ensure that the subassemblies are not degraded when they are cleaned?	Put adequate protections in place to ensure that the subassemblies are not degraded when they are cleaned	134	6.0						
Is there a "filtering" by the logisticians at the time of entry into the stores with exclusion of nonconforming articles?	Put in place a "filtering" by the logisticians at the time of entry into the stores (exclusion of nonconforming articles)	135	6.0						
Is there a self-test of the test tools making it possible to detect any problems before utilization on the subassembly?	Put in place a self-test of the test tools making it possible to detect any problems	136	5.1						
Is a cross-check performed to optimize the final check of the varnishing of the subassemblies?	Put in place a cross-check to optimize the final check of the varnishing of subassemblies	137	5.6						
Is there a check of the equipment production process by SPC card (Statistical Process Control)?	Put in place a check of the equipment production process by SPC card (Statistical Process Control)	138	4.5						
Is there a detailed description of the varnishing protocol?	Put in place a detailed description of the varnishing protocol	139	5.8						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is there a labeling system in place making it possible to identify and withdraw expired consumables?	Put in place a labeling system making it possible to identify and withdraw expired consumables	140	6.4						
Is there real-time processing of the test follow-up indicators to prevent degradation of the article as soon as a problem appears?	Put in place real-time processing of the test follow-up indicators to prevent degradation of the article as soon as a problem appears	141	4.7						
Is there a preventive maintenance system (in the framework of metrology) preventing any possibility of the article being aggressed?	Put in place a preventive maintenance system (in the framework of metrology) preventing any possibility of the article being aggressed	142	5.9						
Is a check of the drift and malfunctioning (by means of probes or other monitoring systems) used to validate or authorize oven operation?	Only validate and authorize oven operation by checking any drift or malfunctioning (by means of probes or other monitoring systems)	143	6.1						
Are high and low safeties connected to the control and monitoring systems (systematic cycle shutdown and analysis by a technician before restarting) provided for?	Possess high and low safeties connected to the control and monitoring systems (systematic cycle shutdown and analysis by a technician before restarting)	157	5.7						
Is there a qualification plan for removing the varnishing masking used so as not to reduce the reliability of the subassembly?	Have in place a qualification plan for removing the varnishing masking used so as not to reduce the reliability of the subassembly	162	6.5						
Is there an inspection step (even visual) on the correct application of the masking installation activity before varnishing?	Put in place an inspection step (even visual) on the correct application of the masking installation activity before varnishing	168	6.5						
Is there a preventive maintenance procedure making it possible to detect any possible problems, before a means of production is used on a subassembly?	Put in place a preventive maintenance procedure making it possible to detect any problems, before a means of production is used on a subassembly	169	4.7						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is there a rest period between each screen printing operation so as not to overstress the article?	Respect a rest period between each screen printing operation so as not to overstress the article	171	6.4						
Are the maintenance plans relative to the means of production for eliminating any possibility of degradation on the COTS connections revised and made robust?	Revise and make robust the maintenance plans relative to the means of production to eliminate any possibility of degradation on the COTS item connections	173	6.7						
Is the efficiency of the final inspection of varnishing quality checked by a strict application of the inspection procedure?	Ensure the efficiency of the final inspection of varnishing quality through a strict application of the inspection procedure	174	5.2						
Is varnish preparation (dosing) controlled by means of a qualified procedure and verification measurements?	Control varnish preparation (dosing) by means of a qualified procedure and verification measurements	175	5.9						
Is operator awareness promoted and are ways in place for examining how to perform real-time updating of their skills?	Promote operator awareness and examine ways for ensuring the real-time updating of their skills	178	4.4						
Is it checked that there is maintenance of the means available and that this maintenance is subject to follow-up?	Make sure that there is maintenance of the means and that this maintenance is subject to follow-up	179	5.9						
Is it checked that the operator has received the appropriate training (qualification) for the activity?	Make sure that the operator has received the appropriate training (qualification) for the activity	180	8.5						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is it checked that the procedure for implementing the means is known?	Make sure that the procedure for implementing the means is known	181	5.1						
Is it checked that the software loaded is the right one and is the identification of its version kept?	Make sure that the software loaded is the right one and keep the identification of its version	182	6.7						
Are the means made secure (oven T°) by means of direct monitoring using probes and recordings to avoid overstress?	Secure the means (oven T°) through direct monitoring using probes and recordings to avoid overstress	183	6.6						
Is personnel awareness promoted relative to performing a visual inspection of the boards after placement and before re-fusion?	Promote personnel awareness relative to performing a visual inspection of the boards after placement and before re-fusion	187	5.9						
Is operator awareness promoted relative to the verification of the quality of the soldering flux deposit (implementation of a check, which must be indicated in the article's follow-up sheet)?	Promote operator awareness relative to the verification of the quality of the soldering flux deposit (implementation of a check, which must be indicated in the article's follow-up sheet)	188	5.9						
What process is implemented to ensure: the collection of technical events, the writing up of problem reports and the measurement of growing reliability? How are equipment changes managed?	Process the problems	195	8.3						
Is the putting in place of stock inventories ensured with automation of reminders?	Ensure inventories are put in place with automation of reminders (exclusion of nonconforming articles)	201	5.5						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is it checked, by means of an inspection operation (bar code reading, reading of the S/N) that you have the right piece of equipment before starting the test?	Check by means of an inspection operation (bar code reading, reading of the S/N) that you have the right piece of equipment before starting the test	205	6.1						
Is it checked that the test coverage for the burn-in is correctly formalized?	Check that the test coverage for the burn-in is correctly formalized	206	5.2						

System Integration

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Have the handling and transport operations been defined?	Ensure handling	7	8.8						
What process is implemented to ensure: the collection of technical events, the writing up of problem reports and the measurement of improving reliability? How are equipment changes managed?	Ensure the implementation of the corrective actions	8	15.4						
Do the procedures relative to the preventive actions include: the utilization of appropriate sources of information? The determining of appropriate steps? The triggering of preventive actions and the application of means of control?	Ensure the implementation of the preventive actions	9	15.6						
Does the supplier control the packing, preservation and marking processes to ensure conformity with the specified requirements? Is there a list of the equipment requiring preservation?	Ensure preservation	11	12.3						
Are there designated storage areas or rooms? Are they used to prevent any damage to or deterioration of the product? Are appropriate measures taken to authorize reception in and shipping from these areas?	Ensure storage	12	10.8						
How is product traceability ensured?	Ensure product traceability	13	16.5						
Does the supplier take steps to maintain the quality of the product after the final inspections and tests? When contractually specified, is this maintenance extended to include delivery to the destination?	Ensure the delivery conditions	14	17.5						
Is there a risk that a product that has not satisfied the inspections and tests specified for a given phase might go on to the next phase without any corrective action?	Ensure the inspections and tests during the phase	15	7.2						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Have all the final inspections and tests been carried out in conformity with the quality plan and/or the written procedures?	Perform the final inspections and tests	16	7.9						
Is an incoming product submitted to appropriate inspections and tests before being put into use?	Carry out the inspections and tests specific to acceptance	17	6.7						
Is a policy implemented with a view to identifying, assessing and managing the potential risks associated with nonconformities, not only on the products but also on all of the design, planning, manufacturing, assembly processes, etc?	Implement a control policy for the risks associated with nonconformities	21	13.1						
Is the description of the accepted nonconformity or of the repairs carried out recorded to indicate the product's real condition?	Define the degree of nonconformity	37	10.3						
Have the means required for the inspections and tests on the product been defined?	Define the means required for the inspections and tests on the product	40	11.6						
Are there documents making it possible to perform an incoming check on supplies?	Have available the documents making it possible to perform the incoming check on supplies	44	8.8						
Are there written procedures for verifying the conformity of the products with respect to the specified requirements?	Establish procedures for verifying the conformity of the products with respect to the specified requirements	53	10.6						
Is the responsibility relative to the investigation and the decision to process a nonconforming product defined?	Examine and process the nonconformities	55	13.6						
Is there documentation for the special processes? Is this documentation kept up to date?	Identify the documentation for the special processes	94	12.2						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Have the means concerning the special processes been identified?	Identify the means concerning the special processes	99	13.1						
Are the human resources concerning the special processes managed?	Identify the human resources concerning the special processes	101	11.7						
How is the appropriateness of the inspection, measuring and test equipment controlled with respect to the requirements?	Control the appropriateness of the inspection, measuring and test equipment with respect to the requirements	112	9.6						
How is the environment of the inspection, measuring and test equipment controlled?	Control the environment of the inspection, measuring and test equipment	113	7.9						
How is the workplace environment controlled?	Control the workplace environment	114	9.6						
Is documentation control correctly ensured? Does it take into account all the changes made to equipment?	Control the documentation	117	12.2						
How is the control of the product inspection and test documentation ensured?	Control the product inspection and test documentation	107	9.3						
How is the control of the production equipment, the tools and the programs of the NC machines ensured?	Control the production equipment, the tools and the programs of the programmable machines	108	10.5						
How is the control of changes to processes ensured?	Control the changes made to processes	123	13.9						
How is the control of handling, storage, conditioning, preservation and delivery operations ensured?	Control the handling, storage, conditioning, preservation and delivery operations	109	6.5						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
How is the control of special processes ensured?	Control the special processes	124	14.4						
How is the control of the workplace's services and fluids ensured?	Control the workplace's services and fluids	110	10.1						
Have you put in place specific counter-ESD protections for subassemblies during handling and storage?	Put in place specific counter-ESD protections for subassemblies during handling and storage	208	18.4						
Are records made and kept providing the proof that the product has undergone the inspections and/or tests in conformity with the defined criteria? Do the records make it possible to identify the person who performed the inspections?	Have the inspection and test records in your possession	160	5.3						
Is there an inspection dossier grouping together all the acceptance criteria, the sequential list of inspection and test operations, the documents recording the results of inspections, the list of specific and non-specific inspection instruments?	Have an inspection dossier in your possession	161	5.7						
Is there documentation specific to the nonconformity?	Have the documentation specific to the nonconformity in your possession	163	11.1						
Is the conformity of purchased products checked?	Check the conformity of purchased products	202	8.6						

Operation and Maintenance

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Have the handling and transport procedures been defined?	Ensure handling	7	9.9						
What process is implemented to ensure: the collection of technical events, the writing up of problem reports and the measurement of improving reliability? How are equipment changes managed?	Ensure the implementation of the corrective actions	8	17.5						
Do the procedures relative to the preventive actions include: the utilization of appropriate sources of information? The determining of appropriate steps?	Ensure the implementation of the preventive actions	9	17.7						
Does the supplier control the packing, preservation and marking processes to ensure conformity with the specified requirements?	Ensure preservation	11	13.8						
Are there designated storage areas or rooms? Are they used to prevent any damage to or deterioration of the product?	Ensure storage	12	15.6						
How is product traceability ensured?	Ensure product traceability	13	9.2						
Is there any risk that a product that has not satisfied the inspections and tests specified for a given phase might go on to the next phase without any corrective action?	Ensure the inspections and tests during the phase	15	11.2						
Have all the final inspections and tests been carried out in conformity with the quality plan and/or the written procedures?	Perform the final inspections and tests	16	10.4						
Is a policy implemented with a view to identifying, assessing and managing the potential risks associated with nonconformities, not only on the products but also on all of the design, planning, manufacturing, assembly, inspection processes, etc?	Implement a control policy for the risks associated with nonconformities	21	16.3						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is the description of the accepted nonconformity or of the repairs carried out recorded to indicate the product's real condition?	Define the degree of nonconformity	37	12.8						
Have the means required for the inspections and tests on the product been defined?	Define the means required for the inspections and tests on the product	40	14.3						
Are there documents making it possible to perform an incoming check on supplies?	Have available the documents making it possible to perform the incoming check on supplies	44	9.9						
Are there written procedures for verifying the conformity of the products with respect to the specified requirements?	Establish procedures for verifying the conformity of the products with respect to the specified requirements	53	6.8						
Is the responsibility relative to the investigation and the decision to process a nonconforming product defined?	Examine and process the nonconformities	55	17.0						
Is there documentation for the special processes? Is this documentation kept up to date?	Identify the documentation for the special processes	94	12.2						
Have the means concerning the special processes been identified?	Identify the means concerning the special processes	99	13.1						
Is there management of the human resources concerning the special processes?	Identify the human resources concerning the special processes	101	13.7						
How is the appropriateness of the inspection, measuring and test equipment controlled with respect to the requirements?	Control the appropriateness of the inspection, measuring and test equipment with respect to the requirements	112	11.3						
How is the environment of the inspection, measuring and test equipment controlled?	Control the environment of the inspection, measuring and test equipment	113	11.7						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
How is the workplace environment controlled?	Control the workplace environment	114	10.8						
Is documentation control correctly ensured? Does it take into account all the changes made to equipment?	Control the documentation	117	5.6						
How is the control of product testability and maintainability ensured?	Control product testability and maintainability	119	17.6						
How is the control of the production equipment, the tools and the programs of the NC machines ensured?	Control the production equipment, the tools and the programs of the programmable machines	108	11.3						
How is the control of changes to processes ensured?	Control the changes made to processes	123	13.9						
How is the control of handling, storage, conditioning, preservation and delivery operations ensured?	Control the handling, storage, conditioning, preservation and delivery operations	109	11.3						
How is the control of special processes ensured?	Control the special processes	124	15.2						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
How is the control of the workplace's services and fluids ensured?	Control the workplace's services and fluids	110	12.2						
Have you put in place specific counter-ESD protections for subassemblies during handling and storage?	Put in place specific counter-ESD protections for subassemblies during handling and storage	208	17.4						

Support Activities

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is there an inspection dossier grouping together all the acceptance criteria, the sequential list of inspection and test operations, the documents recording the results of inspections, the list of specific and non-specific inspection instruments?	Have an inspection dossier in your possession	161	5.7						
Is there documentation specific to the nonconformity?	Have the documentation specific to the nonconformity in your possession	163	13.9						
Are the conclusions of the reliability studies in terms of the infrastructures required in production and integration taken into account?	Allocate the infrastructures required for the correct accomplishment of the production operations	4	7.4						
Does the company have reliability engineering improvement targets? Are there indicators relative to the actual situation with respect to these targets?	Continually improve the company's Engineering Reliability	5	6.6						
Is there a system in place for collecting the customer's remarks relative to the system's reliability in operational functioning?	Collect the customer's remarks relative to the system's reliability in operational functioning	26	7.9						
Are there improvement targets for the system's reliability construction process?	Describe the system's reliability improvement process and the associated targets	33	6.3						
Is the company certified IS0 9001 V2000 ?	Launch the company quality certification process	51	6.5						
Is the training of the people involved in reliability suited to the criticality of the reliability performances expected for the system?	Train the personnel concerned by Reliability or employ personnel qualified in terms of Reliability	83	7.5						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Are the technical data required for the reliability studies accessible? Are the necessary tools available? Have the necessary time and financing been provided for?	Provide the resources necessary for the Reliability studies	87	8.3						
Is there management of the reliability study documents?	Configuration manage the Reliability study documents	88	5.4						
Have the risks linked to the reliability of the products been identified with the subcontractors?	Identify the Reliability risks with at the subcontractors' facilities	102	7.2						
What process has been put in place in the company to construct systems' reliability?	Involve the reliability discipline in the design of the equipment	32	7.5						
Is the topic of reliability present in the company's quality policy?	Integrate reliability in the company's quality policy	104	7.4						
How is the control of the monitoring and measuring devices, and the metrology of the measuring apparatuses and industrial resources ensured?	Control the monitoring and measuring devices, and the metrology of the measuring apparatuses and industrial resources	121	7.8						
Are reliability measurements effectively performed on the systems in operation?	Measure the reliability of the systems in operation	128	8.0						
Has a reliability studies manager been appointed?	Appoint a reliability studies manager	145	8.5						
Are periodic meetings organized with the subcontractor on the subject of reliability?	Organize periodic meetings with the Subcontractor on the subject of reliability	146	5.7						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Are the reliability criteria taken into account in the systems' architecture, in the choice of COTS items, in the packaging?	Take part in the functional and detailed design of the system	28	8.8						
Are the tasks relative to reliability taken into account in the projects' timetables?	Plan the accomplishment of the tasks including those relative to reliability	151	6.3						
Is the communication process with the subcontractor organized?	Plan the communication process with the subcontractor	152	4.1						
Are the reliability activities, including reliability improvement, organized?	Plan the reliability activities including reliability improvement	154	9.1						
Are the reliability studies scheduled?	Plan the reliability studies	155	7.3						
Are measures taken to preserve the reliability of the system in production?	Preserve the system's reliability in production	165	8.1						
Are periodic consultations planned with the customers for the reliability aspects?	Plan periodic consultations with the customers linked to the Reliability aspects	166	7.3						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Are the COTS items used selected with respect to reliability criteria?	Select the COTS items used	185	12.9						
Are the suppliers of the COTS items selected with respect to reliability criteria?	Select the suppliers of the COTS items	186	10.8						
Are the subcontractor's corrective actions relative to reliability followed up?	Follow up and control the Subcontractor's corrective actions relative to the Reliability of the products	190	7.2						
Is the reliability aspect covered in the management review?	Cover the reliability aspect at the management review	194	5.6						
What process is implemented to ensure: the collection of technical events, the writing up of problem reports and the measurement of growing reliability? How are equipment changes managed?	Process the problems	195	8.3						
Are statistical methods used that are suited to the analysis of the feedback?	Use statistical methods that are suited to the analysis of the feedback	198	6.0						

Audit question	Recommendation	Reference No.	Recommendation weighting	Application level				Raw points	Weighted points
				L1	L2	L3	L4		
			Mark =>	0	1	2	3		
Is a FRACAS (Failure Reporting, Analysis and Corrective Action System) type system used in the company?	Use a FRACAS (Failure Reporting, Analysis and Corrective Action System) type system in the company	199	8.0						
Is the subcontractor's reliability management baseline validated?	Validate the subcontractor's reliability management baseline	200	7.7						

Detailed Recommendation Sheets

Mark : **10.7**

Phase : 1 SPECIFICATION

N° : 2

Recommendation : ***Assign the resources in terms of personnel and means to the reliability studies***

Financing is allocated to the project's Reliability Manager. This is the subject of a separate item (at the accounting level) in project management. The personnel and the means required for the satisfactory accomplishment of the Reliability studies are placed at the disposal of the system's reliability manager.

Level 1 criterion: No specific resources are allocated to the reliability studies: integrated with the other studies where the specific allocation is not formalized

Level 2 criterion: The resources allocated to the reliability studies are identified at the level of project management and are formalized in a document.

Level 3 criterion: The resources allocated to the reliability studies are identified at the level of project management and are formalized in a validated plan.

Level 4 criterion: The resources allocated to the reliability studies are identified at the level of project management and are formalized in a validated plan. Proof of the real availability of the resources is established.

Mark : **10.4**

Phase : 1 SPECIFICATION

N° : 3

Recommendation : ***Allocate the reliability requirements to the subassemblies***

The Operating dependability (Reliability) discipline takes part in the allocation of the requirements to the subassemblies.

Level 1 criterion: There is not or will not be any allocation of reliability requirements to the subassemblies

Level 2 criterion: People in charge of reliability engineering have defined (or taken part in) the allocation of the reliability requirements to the subassemblies. There is no validated document certifying this allocation

Level 3 criterion: People in charge of reliability engineering have defined or taken part in the allocation of the reliability requirements to the subassemblies. There are validated documents certifying this participation.

Level 4 criterion: People in charge of reliability engineering have defined or taken part in the allocation of the reliability requirements to the subassemblies. There are validated documents certifying this participation. This allocation is based on earlier data relative to similar equipment (technology, utilization environment)

Mark : **12.4**

Phase : 1 SPECIFICATION

N° : 31

Recommendation : ***Completely describe the environment in which the system is going to be used and maintained***

Describe the environment in which the system is going to be stored, transported, used and maintained:

Describe the mean and maximum quantitative values concerning the following characteristics:

Temperature
Humidity
Impacts
Vibrations
Pressure
Penetration/abrasion
Ambient light
Assembly position
Weather (wind, rain, snow)
Operators' level of qualification

Level 1 criterion: The system's environment is not or practically not known, no formal assumption has been established by the manufacturer

Level 2 criterion: The system's environment is partially known (the applicable parameters defined in the recommendation are partially known) but there is no document listing these parameters and the complementary assumptions

Level 3 criterion: The system's environment is partially known (the applicable parameters defined in the recommendation are partially known). These complementary assumptions have been made by the manufacturer and formalized in a document

Level 4 criterion: The system's environment is perfectly known (the applicable parameters defined in the recommendation are known). A document lists all of these parameters

Mark : **10.3**

Phase : 1 SPECIFICATION

N° : 34

Recommendation : ***Define what a system failure is***

Define precisely what will be considered to be a system failure (possibilities of acceptable degraded modes).

Level 1 criterion: No description of a system failure was defined at the time of the call to tender (or of the contract). The customer has not provided any list of the feared events.
The customer has not defined any degraded mode.
The manufacturer has not defined these elements for its study.

Level 2 criterion: The description of the system failure and/or the list of feared events, and/or of the system's degraded modes have been established by the manufacturer without any formal validation by the customer.

Level 3 criterion: The description of the system failure and/or the list of feared events, and/or of the system's degraded modes have been established by the manufacturer with a formal validation by the customer.

Level 4 criterion: The system failures are perfectly identified by the call to tender (or contract).
The list of feared events has been provided in the call to tender (or contract).
The degraded modes are also described in the call to tender (or contract).

Mark : **9.8**

Phase : 1 SPECIFICATION

N° : 35

Recommendation : ***Define the method used for demonstrating the system's reliability in the operational phase***

Define the method used to demonstrate the system's reliability (this method must be accepted by the customer).

Clearly describe the method adopted for demonstrating the conformity of the system with respect to the specified reliability:
- taking account of the real mission profile
- neutralization of the early life period
- level of confidence used for the measurement (e.g. > upper limit at 60%)
- define the attributable failures. The following causes can be assigned for example:
  e.g. in the following classification of the origin of the technical events, classes C, E, F, V1 can be assigned and accounted for in the MTBF
  C : Random failure of a component
  E : Incomplete study (or defective design)
  F : Non-standard manufacturing (or production defect)
  M : Over-harsh handling (or non-compliance with the user and maintenance documentation)
  O : Specific check (correct operation verification)
  P : Preventive maintenance
  R : Application of a retrofit
  S : Consequence of another failure (or secondary failure)
  V : Equipment aging (1 Unforeseen wear, 2 life limits exceeded)
  X : Utilization outside of the specifications
  Y : Abnormal technical events (or non-confirmed problem)
  ? Unknown origin or cause
- Measuring method: e.g. number of flight hours / number of attributable failures

As a general rule the conformity with a requirement can be verified using one of the following four methods depending on its nature :
Inspection (I) : Visual or dimensional verification of the system's component parts. The verification is based on the human senses (sight, feel) or uses simple measuring and manipulation methods. No stimulus is required. Passive means such as a ruler, microscope, gauge, etc. can be used.
· Analysis (A) : Verification relying on analytical proof obtained by calculation, without any intervention on the system's components. The techniques used are: modeling, simulation and prediction. E.g. calculation of the forecast reliability.
· Demonstration (D) : Verification of the characteristics observable on the system's components in operation, without using physical measurements. Examples:
demonstration of a startup sequence, of the functioning of a safety system, of the operation of a built-in test
· Test (T) : Verification of the measurable characteristics, whether directly or indirectly accessible. Standard or specific test equipment is usually required.
E.g. operational reliability measurement.

Level 1 criterion: No request for a demonstration of the system's reliability is stipulated in the call to tender (or contract).

Level 2 criterion: A request for a demonstration of the reliability is made without any stipulation of the measurement method in the call to tender (or contract).

Level 3 criterion: A request for a demonstration of the reliability is made in the call to tender (or contract), the description of the method to be used only corresponds partially

to the recommendation.

Level 4 criterion: The method for demonstrating the system's reliability is defined perfectly in the call to tender or contract (according to the content of the recommendation)

Mark : **9.9**

Phase : 1 SPECIFICATION

N° : 38

Recommendation : ***Define the System's utilization profile for which the Reliability performances are expected***

Indicate the System's utilization profile (breakdown into operational scenarios for which the Reliability performances are expected).

Indicate the system's successive utilization phases (environment / phase duration pair)

The description must at least cover the following phases:

- Storage (System not in operation, protected environment, only a slight temperature variation, controlled hygrometry, etc.)
- Non operation (System possibly in its operational environment)
- Ground operation
- Operational functioning in Harsh environment (e.g. FLIGHT, Naval, etc.)

Level 1 criterion: The system's utilization profile is not indicated in the call to tender.

Level 2 criterion: The system's utilization profile is not indicated in the call to tender, but has been completely or partially defined by the manufacturer without customer validation.

Level 3 criterion: The utilization profile indicated in the call to tender (contract) partially satisfies the recommendation, or has been partially defined by the manufacturer and formally validated by the customer.

Level 4 criterion: The utilization profile indicated in the call to tender (contract) satisfies the recommendation or has been completely defined by the manufacturer and formally validated by the customer.

Mark : **8.1**

Phase : 1 SPECIFICATION

N° : 46

Recommendation : ***Indicate the context associated with a System's Reliability requirements***

The following essential points must be taken into account in the formulation of a reliability specification's requirements:

1) Quantitative formulation of the reliability requirements
2) Complete description of the environment in which the system is going to be stored, transported, used and maintained
3) The System's utilization profile for which the Reliability performances are expected
4) Clear identification of the type of time measurements (operating hours, flight hours, cycles, etc.)
5) Clear definition of what constitutes a failure
6) Clear description of the method adopted for demonstrating the conformity of the system with the specified reliability
7) Associate penalties with the non-compliance with the reliability requirements

Level 1 criterion: The recommendation has not been taken into account by the customer and the necessary information (according to the recommendation) has not been provided.

Level 2 criterion: Partial identification of the customer's reliability requirements such as they are requested by the recommendation.

Level 3 criterion: Complete and contractual identification of the customer's reliability requirements such as they are requested by the recommendation.

Level 4 criterion: Complete identification in the customer's call to tender (or contract) of the reliability requirements such as they are requested by the recommendation.

Mark : **8.5**

Phase : 1 SPECIFICATION

N° : 80

Recommendation : ***Make the best possible use of feedback***

Make the best possible use of feedback obtained from similar systems used in similar environments so as to give a high degree of confidence in the upholding of the reliability performances

Feedback is also used to calibrate the forecast reliability methods (e.g. utilization of an adjusted MIL-HDBK-217).

This studies require a great deal of time to collect the operational data and record the problems encountered with the greatest care.

The input data are as follows:
- the recordings of the problems observed in the system,
- the system's utilization conditions (mission profile, operational environment, length of utilization),
- the analysis of the cause of the failure (attributable to the manufacturer).

The output data are as follows:
- the operational reliability.

This operational reliability can be extrapolated to different environments and mission profiles by means of models provided by system engineering.

Level 1 criterion: No feedback is available (measurement of the operational reliability on previous projects).

Level 2 criterion: Feedback exists, but is not used, or formalized in any documents.

Level 3 criterion: The manufacturer's feedback is used and formalized in a document. This feedback corresponds exactly to the technologies currently used.
Adjustment coefficients have been defined.

Level 4 criterion: The manufacturer's feedback is used and formalized in a document. This feedback corresponds to the technologies currently used or formal similarity studies have been carried out and formalized to assess the differences (document).
Adjustment coefficients have been defined, and are regularly updated.

Mark : **8.2**

Phase : 1 SPECIFICATION

N° : 85

Recommendation : Formulate the reliability requirement quantitatively

1) For the specification of the reliability performances (which must be quantitative), at least one of the following three types of specifications must be used.
A) The MTBF: which is a definition suited to repairable systems which have a long service life and/or whose missions are of a short duration with respect to their MTBF. This specified MTBF does not give any assurance on the level of reliability achieved during its initial period of utilization, except if the assumption of an exponential distribution of the failures can be proved.
B) The probability of survival for a given period of time. This specification is used when a high level of reliability is required throughout the duration of the mission.
C) The probability of success independently from time for "one shoot" cases, such as the flight of a missile. It can also be used for cyclic utilization devices such as launchers.

These quantitative values shall be expressed as mean values (design targets) or as acceptable minimum values, below which the customer will find that the system is absolutely unsatisfactory with respect to its operational requirements.

Level 1 criterion: No assumption with respect to the system's environment has been described in the call to tender or contract, but the manufacturer has put forward assumptions.

Level 2 criterion: One of the three types of performance specification (according to the recommendation) is included in the call to tender (or contract).
No assumption with respect to the system's environment has been described in the call to tender or contract, but the manufacturer has put forward assumptions.

Level 3 criterion: One of the three types of performance specification (according to the recommendation) is included in the call to tender (or contract).
Not all of the assumptions relative to the system's environment are completely described, but the manufacturer has put forward assumptions and has had them validated by the customer.

Level 4 criterion: One of the three types of performance specification (according to the recommendation) is included in the call to tender (or contract).
All of the characteristics relative to the system's environment are also completely described.

Mark : **12.4**

Phase : 1 SPECIFICATION

N° : 103

Recommendation : ***Formally identify the technical risks impacting reliability***

Formally identify the requirements and the critical factors linked to reliability. This information will be used by the risk management procedure. Trace and manage the risks. Existence of an action plan.

Level 1 criterion: There is no risk management with respect to the reliability performances.

Level 2 criterion: An initial analysis of the risks linked to obtaining the reliability performances has been carried out, but risk management has not been formalized or is incomplete.

Level 3 criterion: An initial analysis of the risks linked to obtaining the reliability performances has been carried out. It is formalized, but risk management is not maintained over time: cooperation has been put in place between the equipment manufacturer and the system integrator to assess the risks linked to the product's environment.

Level 4 criterion: The risks linked to obtaining the reliability performances have been perfectly identified.
The manufacturer has a procedure for managing these risks and it is followed up. Cooperation has been put in place between the equipment manufacturer and the system integrator to assess the risks linked to the environment of product n.
A risk sheet has been written up for each risk, and is kept up to date.
In particular, this sheet presents quantitative approaches relative to the risk's probability, its severity (cost, timetable, performance), the solutions proposed for reducing the risk, and the cost of the solutions.

Mark : **6.6**

Phase : 1 SPECIFICATION

N° : 95

Recommendation : ***Identify the type of time measurement for the reliability performances***

Identify the type of time measurement for the reliability performances (Operating hours, Flight hours, cycles, etc.)

Level 1 criterion: The type of time measurement is not completely described in the call to tender or contract and the manufacturer has not provided this information.

Level 2 criterion: The type of time measurement is not completely described in the call to tender or contract but the manufacturer has completed these data with assumptions without having had them validated by the customer.

Level 3 criterion: The type of time measurement is not completely described in the call to tender or contract but the manufacturer has completed these data with assumptions that have been validated by the customer.

Level 4 criterion: The type of time measurement is completely described in the call to tender or contract.

Mark : **7.3**

Phase : 1 SPECIFICATION

N° : 97

Recommendation : ***Identify the customer requirements***

The customer's original requirements must be identified, documented and traced with respect to the input documents.

Level 1 criterion: The customer requirements linked to reliability have not been identified.

Level 2 criterion: The customer requirements linked to reliability have been identified, listed in a document without a revision index, the traceability of the changes made to these requirements is not ensured (no substantiation or recording in a document).

Level 3 criterion: The customer requirements linked to reliability have been identified, listed in a document (e.g. reliability plan) without a revision index, the traceability of the changes made to these requirements is not ensured (no substantiation or recording in a document).

Level 4 criterion: The customer requirements linked to reliability have been identified, listed in a document and kept up to date (successive versions if justified) with their revision index, the traceability of the changes made to these requirements is ensured (substantiation and recording in a document).

Mark : **10.7**

Phase : 1 SPECIFICATION

N° : 144

Recommendation : ***Negotiate the reliability requirements with the customer***

The reliability requirements must be negotiated to take into account the technological state of the art and the cost/performance optimization of the system's design and of the reliability studies.

For an initial objective requested by the customer, a prime contractor study will be carried out to assess the cost of obtaining the reliability performances and to propose alternatives so as to optimize the cost of obtaining the reliability performances.

The results of the negotiations shall be included in the final offer remitted to the customer

Level 1 criterion: No negotiation, fixed requirements.

Level 2 criterion: Informal negotiations, or after the contract has been signed.

Level 3 criterion: Negotiations with the customer leading to an optimization of the costs/performances for obtaining the reliability performances.

Level 4 criterion: Negotiations with the customer leading to an optimization of the costs / performance for obtaining the reliability performances, existence of an official document describing these negotiations.

Mark : **10.3**

Phase : 1 SPECIFICATION

N° : 147

Recommendation : ***Organize a system design review where the design aspects are examined***

Organize a system design review. Check that the system reliability requirements are met.

The following shall be defined:
- the reliability allocations
- the utilization conditions (mission profile)

Level 1 criterion: No system design review.

Level 2 criterion: Organization of a system design review where the reliability aspects are examined incompletely or examined by people who are not reliability specialists.

Level 3 criterion: Organization of a system design review where the reliability aspects are examined completely, by reliability specialists.

Level 4 criterion: Organization of a system design review where the reliability aspects are examined completely, by reliability specialists. A directive imposes this review.

Mark : **7.8**

Phase : 1 SPECIFICATION

N° : 148

Recommendation : ***Organize a review of the system requirements where the reliability aspects are examined***

Organize a review of the system requirements, check that all the reliability requirements have been identified and that there is an understanding between customer and supplier. It must be possible to validate, achieve and check these requirements (conformity means).

Level 1 criterion: No system requirements review has been, nor will be, organized for the project.

Level 2 criterion: An informal system requirements review has been put in place (or is planned as the project progresses). There is no record available of the participation in this review of the people in charge of reliability engineering.

Level 3 criterion: A system requirements review has been put in place (or is planned as the project progresses). The people in charge of reliability engineering have been consulted to take part in the review or in the validation of the documents, and records of this participation exist.

Level 4 criterion: A formal system requirements review has been put in place (or is planned as the project progresses). These requirements can be validated, achieved and verified (conformity means). The people in charge of reliability engineering have been consulted to take part in the review or in the validation of the documents (records of this participation exist).

Mark : **12.6**

Phase : 1 SPECIFICATION

N° : 150

Recommendation : ***Take part in the system's functional and detailed design***

The Operating dependability (Reliability) discipline takes part in the system's functional and detailed design.

Level 1 criterion: No one in charge of reliability engineering takes part in the system's functional and detailed design.

Level 2 criterion: People in charge of reliability engineering are partially involved (incomplete service in the sense of the recommendation) in the system's functional and detailed design, there is no document certifying this participation.

Level 3 criterion: People in charge of reliability engineering are completely involved (complete service in the sense of the recommendation) in the system's functional and detailed design, there is no document certifying this participation.

Level 4 criterion: People in charge of reliability engineering are completely involved in the system's functional and detailed design, there are documents formalizing and certifying this participation.

Mark : **5.8**

Phase : 1 SPECIFICATION

N° : 164

Recommendation : ***Take the system's maintenance policy (customer request) into account***

The maintenance policy requested by the customer must be taken into account in this activity in order to preserve the reliability of the system over time.

Level 1 criterion: The system's maintenance policy has not been defined.

Level 2 criterion: The maintenance policy has been defined without taking into account the reliability aspects.

Level 3 criterion: The maintenance policy has been defined taking into account the reliability aspects (identification and follow-up of the critical elements)

Level 4 criterion: The system's maintenance policy making it possible to preserve the system's reliability over time is perfectly defined and is covered by a document.
Participation of reliability specialists in the definition of the maintenance policy (identification and follow-up of the critical elements).

Mark : **7.6**

Phase : 1 SPECIFICATION

N° : 170

Recommendation : ***Draw up a System reliability plan***

A System Reliability plan is written. The following content is proposed: (see WP3 methodological guide).

Level 1 criterion: No reliability plan has been drawn up (or officially validated).

Level 2 criterion: The reliability plan has been drawn up but does not completely meet the requirements of the recommendation.

Level 3 criterion: The reliability plan has been drawn up in conformity with the recommendation. This document, drawn up at the outset, is not updated (ever).

Level 4 criterion: The reliability plan has been drawn up in conformity with the recommendation. This document is maintained throughout the project according to the events that are liable to make it change.

Mark : **8.3**

Phase : 1 SPECIFICATION

N° : 195

Recommendation : ***Process the problems***

Put in place a system for processing problems liable to occur throughout the FIDES life cycle.

This system is intended to:

- Record the circumstances in which the problem occurred, and the P/N of the defective article.
- Propose a remedial action
- Analyze the causes of the problem
- Propose corrective/preventive actions
- Check the effectiveness of the corrective/preventive actions

This system includes processing making it possible to:
- quickly find the identical problems that have been observed previously,
- draw up statistics,
- be used for feedback purposes.

Level 1 criterion: No problem processing system has been put in place.

Level 2 criterion: A problem processing system has been put in place by the manufacturer, it partially meets the requirements of the recommendation. It is not completely applied to the project.

Level 3 criterion: A problem processing system has been put in place by the manufacturer, it partially meets the requirements of the recommendation. It is completely applied to the project.

Level 4 criterion: A problem processing system has been put in place by the manufacturer, it completely meets the requirements of the recommendation. It is completely applied to the project.

Mark : **5.8**

Phase : 2 DESIGN

N° : 45

Recommendation : ***Adopt the steps so that the personnel has the knowledge of the test means and of the standards and of how to interpret the measurements***

Steps must be taken to ensure that the personnel masters the test resources and standards, and the interpretation of the measurements: training provided and followed up.

Level 1 criterion: No steps taken.

Level 2 criterion: Training in place but no follow-up, no individualization of training courses.

Level 3 criterion: Training in place, with individual follow-up.

Level 4 criterion: Training in place, with individual follow-up and updating.
Knowledge assessment by an external organization.

Mark : **16.7**

Phase : 2 DESIGN

N° : 105

Recommendation : ***Ensure the involvement at each step of a person responsible for support, industrialization, purchasing, development and RAMS (concurrent engineering)***

Ensure the involvement at each step of a person responsible for support, industrialization, purchasing, development and RAMS. Make sure that the baseline used imposes concurrent engineering:

The company's organization is based on permanent specialists of the function.

Level 1 criterion: The baseline does not impose concurrent engineering.

Level 2 criterion: Existence of a general instruction that does not stipulate the methods. No formal organization.

Level 3 criterion: Existence of a general instruction imposing concurrent engineering but which is not suited to the company's organization : the positions responsible for support, industrialization, purchasing, development and RAMS are assigned independently from their disciplines.

Level 4 criterion: Existence of a procedure imposing concurrent engineering. The company's organization is based on permanent specialists of the function.

Mark : **7.8**

Phase : 2 DESIGN

N° : 27

Recommendation : ***Ensure the completeness of the information on the subassembly to establish (complete) the Subassembly Test Manual***

Have available the technical data for the subassembly with a view to developing the production test.

Level 1 criterion: No technical data for the subassembly relative to the test.

Level 2 criterion: Existence of non-validated data that is partially usable.

Level 3 criterion: Existence of validated data that is partially usable.

Level 4 criterion: Existence of complete data that has been validated and is usable.

Mark : **8.0**

Phase : 2 DESIGN

N° : 57

Recommendation : ***Availability of a document substantiating the reliability preliminary technical studies***

Make sure that all the data substantiating the requirement are available and have been validated in a reliability preliminary studies document. A directive imposes the writing of this document

Level 1 criterion: No substantiating document.

Level 2 criterion: An informal substantiating document exists.

Level 3 criterion: A formalized and identified document exists in the substantiating dossier, it ensures completeness with respect to the needs.

Level 4 criterion: A formalized and identified document exists in the substantiating dossier, it ensures completeness with respect to the needs. A directive imposes the writing of this document.

Mark : **13.8**

Phase : 2 DESIGN

N° : 65

Recommendation : ***Availability of know-how capitalization through discipline procedures***

A system of capitalization of know-how and of the technical standards through discipline procedures must be available and these procedures must be managed and followed up according to the technical changes.

Level 1 criterion: No discipline procedures.

Level 2 criterion: Existence of incomplete rules, that are not updated.

Level 3 criterion: Complete rules, updated, not managed or validated.

Level 4 criterion: Procedure formalizing the rules and their follow-up and application management.

Mark : **24.5**

Phase : 2 DESIGN

N° : 66

Recommendation : ***Put in place and manage a nominative table of skills required per activity***

Make sure that the skills required for an activity are assigned by name in a skills table that is regularly reviewed and periodically check the appropriateness of the training with respect to the activities.

Level 1 criterion: No follow-up of the appropriateness of the training.

Level 2 criterion: Existence of a skills table, not followed up at the level of training.

Level 3 criterion: Regular updating of the training tables, but no periodic verification of the appropriateness of the training with respect to the activities.

Level 4 criterion: Existence of a skills table with periodically updated training follow-up. Regular assessment of the appropriateness of the training with respect to the company's objectives.

Mark : **8.0**

Phase : 2 DESIGN

N° : 67

Recommendation :Establish and maintain a preferential list of COTS items

Establish and maintain a preferential list of COTS items taking into account the reliability characteristics.

Level 1 criterion: No preferential list of COTS items.

Level 2 criterion: Existence of a preferential list of COTS items, that is not formalized or validated.
It only contains the technical characteristics.

Level 3 criterion: Existence of a preferential list of COTS items, that is managed and formalized with standardization objectives. Validated by purchasing, methods and technical services. It only contains the technical characteristics.

Level 4 criterion: Existence of a preferential list of COTS items, that is managed and formalized with standardization objectives. Validated by purchasing, methods and technical services. It contains not only the technical characteristics but also information on the components' reliability and failure modes.

Mark : **24.2**

Phase : 2 DESIGN

N° : 62

Recommendation : Existence of a database capitalizing on the feedback

Make sure that there exists a methodology for:

- gathering,
- updating,
- and making the most of technical events

for the capitalization of feedback with a view to improving the reliability of future designs.

Make sure that the most is made of past experiences in concrete terms at the level of the designers:
existence of a capitalization methodology.

Level 1 criterion: No capitalization methodology.

Level 2 criterion: Methodology initialized but not updated.

Level 3 criterion: Methodology updated but not usable/used (due to a lack of information for example).

Level 4 criterion: Methodology updated, usable and used.

Mark : **10.6**

Phase : 2 DESIGN

N° : 63

Recommendation : ***Existence of a database capitalizing on the reliability assessment studies***

Make sure that there is a centralized management of the reliability assessment studies making it possible to re-use past calculations with the constraints:
- clearly identified basic assumptions,
- extractable and reusable data.

Level 1 criterion: No database.

Level 2 criterion: Existence of a database but which is not centralized or configuration-managed.

Level 3 criterion: Existence of a non-centralized database but which is configuration-managed and updated.

Level 4 criterion: Existence of a database that is centralized, configuration-managed, updated, extractable and usable.

Mark : **7.8**

Phase : 2 DESIGN

N° : 64

Recommendation : ***Existence of a database on the design history and the design substantiations***

Make sure that the design traceability and substantiation is ensured with a view to controlling the designs and the changes.
Existence of a methodology enabling access to this information within the Design Office.

Level 1 criterion:	No database, nor any personal knowledge on the experts' behalf.
Level 2 criterion:	No explicit database but personal knowledge and experience of the experts.
Level 3 criterion:	Formalization of the knowledge and of the substantiation history of the designs in a database but without updating and configuration management procedures.
Level 4 criterion:	Existence of database updating and management procedures.

Mark : **7.3**

Phase : 2 DESIGN

N° : 93

Recommendation : ***Identify and implement the means of protecting subassemblies***

Draw up a list of the means of protection and implement them so as not to reduce the reliability of the subassembly.

Level 1 criterion: No particular means of protection have been identified.

Level 2 criterion: The means of protection have been identified, but are only partially applied in the different activities.

Level 3 criterion: The means of protection have been identified and there application has been verified.

Level 4 criterion: The means of protection have been identified subsequent to a periodic analysis of the problems observed and their application has been verified.

Mark : **21.0**

Phase : 2 DESIGN

N° : 103

Recommendation : ***Formally identify the technical risks impacting reliability***

Formally identify the requirements and the critical factors linked to reliability. This information will be used by the risk management procedure. Trace and manage these risks. Existence of an action plan.

Level 1 criterion: No risk management is carried out with respect to the reliability performances.

Level 2 criterion: An initial analysis of the risks linked to obtaining the reliability performances has been done, but risk management is not formalized or is incomplete.

Level 3 criterion: An initial analysis of the risks linked to obtaining the reliability performances has been done. This is formalized, but risk management is not maintained over time: cooperation between the equipment manufacturer and the systems integrator has been put in place to assess the risks linked to the product's environment.

Level 4 criterion: The risks linked to obtaining the reliability performances have been perfectly identified.
The manufacturer has a procedure for managing all these risks and follows it up. Cooperation between the equipment manufacturer and the systems integrator has been put in place to assess the risks linked to the environment of product n
A risk sheet is drawn up for each risk, and is kept up to date.
In particular, this sheet presents the quantitative approaches concerning the risk's probability, seriousness (cost, timetable, performance), solutions proposed for reducing the risk, and the cost of the solutions.

Mark : **7.5**

Phase : 2 DESIGN

N° : 32

Recommendation : ***Involve the reliability discipline in the design of the equipment***

The reliability discipline must be involved in the design phase at the earliest possible stage with authority concerning the choice to redesign equipment if the goals are not met. (Act on the redesign of the architecture, the choice of components, suppliers, etc.)

Level 1 criterion: No involvement of the reliability discipline.

Level 2 criterion: Insufficient involvement: no allocation at the origin. Poorly defined utilization profile. Late involvement, remittal of the dossier at the time of the Detailed Designed Review (DDR) at the latest.

Level 3 criterion: Involvement right from the detailed design phase with complete assessment of the reliability.

Level 4 criterion: The reliability discipline is involved in the preliminary design phase with authority concerning the choice to redesign equipment if the goals are not met. (Act on the redesign of the architecture, the choice of components, suppliers, etc.)

Mark : **6.0**

Phase : 2 DESIGN

N° : 193

Recommendation : ***Maximize test coverage on the basis of the specification and substantiation for the prototype tests***

Make sure that test coverage is maximal and that it is based on the specification. Substantiation of the coverage in a document.

Level 1 criterion: No substantiation plan on the coverage of the prototype tests.

Level 2 criterion: Existence of a substantiation plan but no design substantiation dossier (DSD).

Level 3 criterion: Existence of a substantiation dossier making it possible to ensure that each subsystem has been covered by a specification.

Level 4 criterion: Existence of a substantiation dossier making it possible to ensure that each subsystem has been covered by a specification and a validation.

Mark : **27.1**

Phase : 2 DESIGN

N° : 76

Recommendation : ***Implement design verifications***

Implement design verifications: these procedures must be based on re-readings, the approval circuit and reviews with a view to ensuring that the orientation actions and the selected elements are correct.

Level 1 criterion: No design verification procedures.

Level 2 criterion: Existence of non-formalized verification procedures.

Level 3 criterion: Existence of formal verification procedures.

Level 4 criterion: Existence of formal verification procedures which are revised periodically, integrating peer reviews.

Mark : **5.4**

Phase : 2 DESIGN

N° : 56

Recommendation : ***Implement a maintenance concept as part of logistical support***

Make sure that the maintenance concept is formalized and validated by the customer. Example of documents to be presented in response to the requirements of the concept:

- integrated logistical support plan,
- aptitude for logistical support dossier

Level 1 criterion: No support requirements planned. End-customer's organization not taken into account.

Level 2 criterion: Support requirements exist but they are only partially formalized: one-off or even incoherent. Not related to the equipment: the manufacturer does not have any integrated logistical support organization.

Level 3 criterion: Formalized support requirements. Response to the formalized requirements but which are not validated and are considered to be secondary: requirements only partially substantiated or not achieved.

Level 4 criterion: Formalized support requirements: maintenance concept. The manufacturer has a project organization for meeting the requirements of the customers in the form of a logistical support plan. The support requirements are taken into account right from the design phase, broken down to the equipment level, substantiated and validated in an aptitude for logistical support dossier. The elements of the support system (documents, training, spare part kits, tooling and test resources, etc,) exist and are coherent and validated.

Mark : **12.1**

Phase : 2 DESIGN

N° : 147

Recommendation : ***Organize a system design review where the Reliability aspects are examined***

Organize a system design review. Check that the system reliability requirements are met.

The following shall be defined:
- the reliability allocations,
- the utilization conditions (mission profile)

Level 1 criterion: No system design review.

Level 2 criterion: Organization of a system design review where the reliability aspects are examined incompletely or are examined by people who are not reliability specialists.

Level 3 criterion: Organization of a system design review where the reliability aspects are examined completely by reliability specialists.

Level 4 criterion: Organization of a system design review where the reliability aspects are examined completely by reliability specialists. A directive imposes this review.

Mark : **17.7**

Phase : 2 DESIGN

N° : 58

Recommendation : ***Write up a management plan where the key skills (specialists) are identified***

Make sure that the adjustments to the baseline are detailed in the management plan. Make sure that the skills are committed to the project in the management plan and that there is a schedule.

Level 1 criterion: No management plan, or timetable describing the tasks to be performed. No organization in place.

Level 2 criterion: Existence of an incomplete management plan: it does not detail any adjustments that may have been made to the baseline, the timetable describing the tasks to be performed and the organization put in place are imprecise: incompatible with the available resources.

Level 3 criterion: Existence of an incomplete management plan: it does not detail any adjustments that may have been made to the baseline, the timetable describing the tasks to be performed and the organization put in place are precise but have not been validated.

Level 4 criterion: Existence of a complete management plan: detailing all the adjustments that may have been made to the baseline; the timetable describing the tasks to be performed and the organization put in place are precise and have been validated: good match with the company's work load.

Mark : **7.7**

Phase : 2 DESIGN

N° : 61

Recommendation : ***Write up a list of discipline recommendations on the handling and storage operations on the user's premises***

At Logistical Support: ensure that there is a list of discipline recommendations on the handling and storage operations on the user's premises and that it is applied. This list must be enhanced by feedback.

Level 1 criterion: No list of recommendations nor any procedures for processing feedback.

Level 2 criterion: Existence of a non-formalized and non-managed list of recommendations. Feedback not systematically processed.

Level 3 criterion: Existence of a formalized list of recommendations, not necessarily applicable to the project (not referenced to the project) and not validated. Feedback formalized in a database that is not managed and not broadly used in the design phase.

Level 4 criterion: Formalized and validated list of recommendations referenced to the project. Formalized and validated feedback referenced to the project, that can be used and serving as design input data to improve reliability.

Mark : **7.8**

Phase : 2 DESIGN

N° : 191

Recommendation : ***Write up an acceptance specification***

Make sure that there is an acceptance specification and check its pertinence.

The acceptance specification is written up on the basis of a test-oriented equipment dossier describing the adjacent units, presenting a functional description, and the inputs/outputs.

Level 1 criterion: No acceptance specification.

Level 2 criterion: Existence of an acceptance specification but drawn up in production independently from the development teams.

Level 3 criterion: Existence of an acceptance specification drawn up during development integrating the configuration follow-up but not validated or traced.

Level 4 criterion: The acceptance specification is suited to the product (proof of application traceability to the product and its configuration) and has been validated.

Mark : **7.6**

Phase : 2 DESIGN

N° : 68

Recommendation : ***Make sure that there is a product/supplier qualification procedure***

Make sure that the suppliers are qualified and follow up the following aspects:

- sustainability
- quality follow-up

Level 1 criterion: The suppliers are not qualified.

Level 2 criterion: A partial qualification of the suppliers is carried out in an informal way.

Level 3 criterion: The company baseline requires that a supplier qualification is carried out according to the reliability criterion (and/or manufacturing quality), this is effective and based on the analysis of the data provided by the suppliers.

Level 4 criterion: The company baseline requires that the suppliers should be selected according to the reliability criterion (and/or manufacturing quality), this is effective and based on the formal activities: (interview with the suppliers, analysis of earlier services, audits, ISO certification).

Mark : **6.0**

Phase : 2 DESIGN

N° : 192

Recommendation : ***Make sure that there is a definition of the production test points and that the test recommendations are applied***

Make sure that the test operation constraints, detailed by the test manager, are integrated in the design of the product by the developer.

Existence of a precise test methodology.

Level 1 criterion: Production does not have any information on the method for applying the test to the product.

Level 2 criterion: The production manager is aware of how the test operations will be carried out and took part in drawing up the test recommendations.

Level 3 criterion: The production manager is aware of how the test operations will be carried out and took part in drawing up the test recommendations.
Existence of a validated list of recommendations explaining how the tests are performed but without any guarantee that they will be applied.

Level 4 criterion: The production managers take part in defining the production test. Existence of a validated list of recommendations explaining how the tests are performed with proof of application of the recommendations.

Mark : **7.2**

Phase : 2 DESIGN

N° : 69

Recommendation : ***Make sure that there is a product/process qualification procedure***

For the manufacturing processes, make sure that there is a product/process qualification procedure.

Level 1 criterion: No product/process qualification procedure.

Level 2 criterion: The manufacturing processes have been made to match the product in an informal way. This is neither traced nor validated.

Level 3 criterion: The manufacturing processes have been made to match the product in a formal way, but have not been validated.

Level 4 criterion: The company baseline imposes a product/process qualification procedure.

Mark : **7.2**

Phase : 2 DESIGN

N° : 71

Recommendation : ***Make sure that the manufacturing of a new component is qualified***

Make sure that there is a qualification procedure for assessing the risks linked to the utilization of the new-technology component (by extrapolation of its utilization to a similar environment for example).

Level 1 criterion: No procedure.

Level 2 criterion: Existence of informal rules.

Level 3 criterion: Existence of a procedure.

Level 4 criterion: Existence of a procedure that is managed and follows the technological changes.
Validated by the competent technical services.

Mark : **7.5**

Phase : 2 DESIGN

N° : 74

Recommendation : ***Make sure that there is an analysis documentation for assessing the reliability***

Make sure that there is a documentation of the project substantiating and detailing the reliability data.

Level 1 criterion: No data traced.

Level 2 criterion: The design dossier (DD) includes studies but they are not updated (coherent with the rest of the dossier) or validated.

Level 3 criterion: The design dossier includes up-to-date studies, but they have not been validated.

Level 4 criterion: The design dossier includes up-to-date studies and has been validated.

Mark : **12.7**

Phase : 2 DESIGN

N° : 77

Recommendation : ***Make sure that there are design rules for adapting the choice of a component for a given level of reliability***

Make sure that there is a design methodology requiring the designers to apply rules with a view to improving reliability. Make sure that the application of the rules is verified.

Level 1 criterion: No reliability-oriented design rules.

Level 2 criterion: Existence of rules but they are not formalized (or updated or validated), or retranscribed, or validated.

Level 3 criterion: Existence of formalized rules, which are updated but not validated.

Level 4 criterion: Existence of formalized, updated and validated rules.

Mark : **7.7**

Phase : 2 DESIGN

N° : 78

Recommendation : ***Make sure that the forecast reliability calculation is carried out using an acknowledged tool (MIL, adjusted MIL, RDF, personal REX)***

Make sure that the forecast reliability calculation is carried out using an acknowledged tool associated with the selected calculation methodology (MIL, adjusted MIL, RDF, personal REX).

Level 1 criterion: Origin of the reliability calculations not controlled. Tool not acknowledged.

Level 2 criterion: Origin of the calculations traced but not pertinent.

Level 3 criterion: Origin pertinent but not validated. Tool acknowledged.

Level 4 criterion: Existence of a selection and validation procedure for the tools used.

Mark : **10.2**

Phase : 2 DESIGN

N° : 30

Recommendation : ***Take into account the self-test reliability/complexity balance on the coverage of the tests***

With a view to ensuring efficient coverage, make a trade-off between the complexity of the self-test and its reliability. Ask for a presentation on the subject.

Level 1 criterion: No documents presented substantiating the test coverage.

Level 2 criterion: Reliability calculation carried out without taking into account the self-test or equipment in a non-stabilized version.

Level 3 criterion: Reliability calculation carried out taking into account the self-test or equipment in a stabilized version, but not validated.

Level 4 criterion: The reliability calculation is carried out on equipment in a stabilized version, and has been substantiated and validated.

Mark : **13.5**

Phase : 2 DESIGN

N° : 197

Recommendation : ***Utilization of validated and recognized means of modeling***

Utilization of validated and recognized means of modeling.

Demonstrate the follow-up and updating of the tools.

Level 1 criterion: The modeling means are neither validated or recognized.

Level 2 criterion: The modeling means are recognized and have been validated, but are not followed up.

Level 3 criterion: The modeling means are recognized and have been validated, are followed up but there is no one assigned to the management of the tools.

Level 4 criterion: The modeling means are recognized, have been validated and are followed up. Follow-up management.

Mark : **6.0**

Phase : 3 EQUIPMENT PRODUCTION

N° : 6

Recommendation : ***Improve the equipment final test seen in Design and Specification to increase the test coverage and draw up a test assessment***

The final test of the equipment and more particularly the level of coverage achieved by that test must be studied and defined with respect to the equipment's Specification and Design.
This test must check the equipment according to the procedures of a System Testability Manual while:

Orienting towards a processing in the case of a nonconformity,
Recording the results in the manual to ensure test follow-up.

Level 1 criterion: No revision of the predefined test coverage rate is carried out.

Level 2 criterion: An equipment test assessment may be carried out with a view to revising and improving the predefined coverage rate. However, there is no document formally describing the related actions.

Level 3 criterion: The final equipment tests are regularly revised even after the specification and design phases. The goal is to increase the predefined test coverage. Documents describe the procedure to be adopted.

Level 4 criterion: The final equipment tests are regularly revised even after the specification and design phases. The goal is to increase the predefined test coverage. Documents describe the procedure to be adopted. These have been validated by an authority that is independent from the operating entity.

Mark : **9.9**

Phase : 3 EQUIPMENT PRODUCTION

N° : 18

Recommendation : ***Ensure monitoring of the inspection parameters during the varnishing activity***

The subassembly varnishing activity, which must lead to an immunity with respect to a certain number of stresses that could reduce the reliability of the subassembly, must be carried out with a permanent inspection relative, in particular, to the monitoring of the main parameters, that is to say:

The humidity rate,
The temperature,
The quality of the varnish's components,
The varnish's deposit thickness,
Furthermore the viscosity of the varnish must be checked at least once daily.

Level 1 criterion: None of the inspection parameters are monitored during the varnishing activity.

Level 2 criterion: The varnishing activity is monitored by supervising a certain number of the stipulated parameters at the stipulated frequency, but these are not subject to a documented formal follow-up or have not been the subject of a study indicating their criticality for the subassembly's reliability.

Level 3 criterion: The varnishing activity is monitored by supervising all the stipulated parameters at the stipulated frequency. These parameters are followed up and are the result of a critical analysis of the varnishing activity with respect to the reliability of the subassembly. But this criticality plan was drawn up without being validated by an independent authority.

Level 4 criterion: The varnishing activity is monitored by supervising all the stipulated parameters at the stipulated frequency. These parameters are followed-up and are the result of a critical analysis of the varnishing activity with respect to the reliability of the subassembly. This criticality plan was drawn up and then validated (parameters followed up and implemented) by an independent authority.

Mark : **6.9**

Phase : 3 EQUIPMENT PRODUCTION

N° : 19

Recommendation : ***Ensure corrective maintenance is carried out as soon as a problem appears on the production means or on the subassemblies produced***

The maintenance procedures relative to the corrective actions in equipment production must include:

- the effective processing of complaints and nonconformity reports relative to the subassemblies,
- the search for the causes of the nonconformities relative to the process and the recording of the results of that search,
- the determination of the corrective actions required to eliminate the causes of nonconformities,
- the application of control means for ensuring that the corrective action is implemented and that it produces the required effect.

Level 1 criterion: There is no corrective maintenance subsequent to the appearance of a problem on a means of equipment production or on a subassembly.

Level 2 criterion: Corrective actions are carried out directly at the place where the problem was detected without any corrective maintenance plan being put in place.

Level 3 criterion: Real maintenance procedures relative to the corrective actions are implemented, they are the subject of a corrective maintenance plan that is formalized but not validated by an authority independent from the operating entity.

Level 4 criterion: Real maintenance procedures relative to the corrective actions are implemented, they are the subject of a corrective maintenance plan that is formalized and has been validated by an authority independent from the operating entity.

Mark : **4.0**

Phase : 3 EQUIPMENT PRODUCTION

N° : 20

Recommendation : ***Ensure preventive maintenance to correct drifts in the production resources' parameters***

According to the preventive maintenance plan that has been defined and subsequent to its implementation, a correction is made by:

- adjusting the baselines relative to the means of production,
- replacement of the consumables,
- replacement of parts that are worn and therefore potentially defective (probes and inspection tools).

Level 1 criterion: There is no preventive maintenance for correcting any possible drift in the equipment production means.

Level 2 criterion: Preventive actions are carried out directly at the place where the problem is likely to be detected without any formal preventive maintenance plan being put in place.

Level 3 criterion: Real maintenance procedures relative to the preventive actions are implemented, they are subject to a formalized preventive maintenance plan that has not been validated by an authority independent from the operating entity.

Level 4 criterion: Real maintenance procedures relative to the preventive actions are implemented, they are subject to a formalized preventive maintenance plan that has been validated by an authority independent from the operating entity.

Mark : **4.1**

Phase : 3 EQUIPMENT PRODUCTION

N° : 22

Recommendation : ***Perform a periodic verification of the programming means to ensure that the software loading operation is carried out correctly***

This verification is less cumbersome than a scheduled preventive maintenance action, and comes under the responsibility of the user of the means concerned (this is part of the operator's training). The purpose is to ensure that the operation will be correctly accomplished and that it will deliver the expected result (by the right software being loaded or a correct configuring operation). The frequency of the verifications (to be defined) may be systematic before each utilization or after a given number of time the means are used.

Level 1 criterion: There is no periodic verification of the programming means that are used to load the software.

Level 2 criterion: A certain number of verifications of the production means are carried out. These verifications are succinct and do not necessarily take into account all the software loading rules. There is no clear formalization of the accomplishment or of the limits of these verifications.

Level 3 criterion: The planning of the verifications has been subject to a study, this plan is respected and all the points checked (and the way this was done) are covered by a written document.

Level 4 criterion: A strict planning of the verifications has been subject to a study, this plan is respected and all the points checked (and the way this was done) are covered by a written document. This document was drawn up taking into account all of the software loading process and has been validated by an authority independent from the operating entity.

Mark : **4.1**

Phase : 3 EQUIPMENT PRODUCTION

N° : 23

Recommendation : ***Systematically audit the operators to monitor their skills***

This filter makes it possible to ensure that the last verification milestone, that is to say the final test, is performed by competent personnel and, above all, whose skills are subject to monitoring guaranteeing that the latest requirements are taken into account.

The audit ensures that the operator's mastery of critical procedures and points are reviewed, to provide absolute confidence in the implementation of the final test.

Level 1 criterion: No audit ensuring the monitoring of the operators' skills is performed.

Level 2 criterion: The equivalent of an audit ensuring the monitoring of the skills of the operators whose function is to perform the equipment final test is carried out but is not formalized.

Level 3 criterion: An audit ensuring the monitoring of the skills of the operators whose function is to perform the equipment final test is carried out according to an identified formalism, but it has not been validated by an authority independent from the operating entity.

Level 4 criterion: An audit ensuring the monitoring of the skills of the operators whose function is to perform the equipment final test is carried out according to an identified formalism. This audit has been validated by an authority independent from the operating entity.

Mark : **6.5**

Phase : 3 EQUIPMENT PRODUCTION

N° : 24

Recommendation : ***Automate handling to limit the possible degradations of the boards***

Every effort must be made to keep the subassembly handling operations to a minimum during the production phase in order to limit the risks of mechanical impacts and other overstresses.

Furthermore, the automation of the handling operations between activities during the complete equipment production phase must make it possible to avoid a great number of failures caused by human interventions.

Level 1 criterion: None of the subassembly handling operations are automated.

Level 2 criterion: A certain number of the subassembly handling operations are automated.

Level 3 criterion: The subassembly handling operations are automated. The degree of automation has been the subject of a feasibility and result study.
The whole procedure is formalized although the study has not been validated by an authority independent from the operating entity.

Level 4 criterion: The subassembly handling operations are automated. The degree of automation has been the subject of a feasibility and result study.
The whole procedure is formalized and has been validated by an authority independent from the operating entity.

Mark : **2.8**

Phase : 3 EQUIPMENT PRODUCTION

N° : 29

Recommendation : ***Check and maintain (by updating) the data loaded into the programmable means of production***

In the framework of task automation, for a reliable accomplishment of the activities it is essential to specifically follow and maintain (update) the references (coordinates, batch numbers, etc.) loaded into the production tools.

Level 1 criterion: There is no check on the updating of the programming data in the programmable means of production.

Level 2 criterion: A check and/or updating of the parameters loaded into the programmable means of production is carried out but there is no formalization of the actions to be performed to guarantee this updating.

Level 3 criterion: A check and updating of the data programmed into the means of production is performed, according to an identified formalism (document, verification procedures, updating procedure).

Level 4 criterion: A check and updating of the data programmed into the means of production is performed, according to an identified formalism (document, verification procedures, updating procedure). All of the documents have been validated by an authority independent from the operating entity.

Mark : **4.4**

Phase : 3 EQUIPMENT PRODUCTION

N° : 42

Recommendation : ***Delegate the general inspection of the board varnishing operation in order to optimize filtering before pursuing the process***

The delegation of the general inspection ensures a good degree of objectivity making it possible to better filter out any errors that could have been made during one of the processes implemented for varnishing subassemblies that is critical for reliability.

The information on the follow-up sheet ensures the traceability of all the operations and interventions performed during this varnishing.

Level 1 criterion: There is no general inspection at the end of varnishing.

Level 2 criterion: A person other than the operator in charge of varnishing ensures a general inspection of this operation but this inspection is not based on any formal document describing the procedure.

Level 3 criterion: A person other than the operator in charge of varnishing ensures a general inspection of this operation. This inspection is carried out according to a procedure formalized but this document has not been validated by an independent authority.

Level 4 criterion: A person other than the operator in charge of varnishing ensures a general inspection of this operation. This inspection is carried out according to a procedure formalized by a document that has been validated by an authority independent from the operating entity.

Mark : **5.6**

Phase : 3 EQUIPMENT PRODUCTION

N° : 43

Recommendation : ***Have experienced personnel in place for the post-varnishing board drying activity***

The specific subassembly drying task during the varnishing activity requires a know-how on the operator's behalf, who must therefore be experienced to avoid overstressing the subassemblies. Indeed, reduced reliability due to too high a temperature, too long an application or to imperfect drying, may be the cause of serious degradations during the rest of the process.

Level 1 criterion: Board drying is not carried out by experienced personnel.

Level 2 criterion: The operators performing the board drying operation are experienced. Their experience is based on activities that are very similar to board drying but they have not been the subject of specific training.

Level 3 criterion: The operators performing the board drying operation are experienced. It has been possible to determine their experience by means of formal documents that have not been validated by an independent authority.

Level 4 criterion: The operators performing the board drying operation are experienced. Their experience is based on similar drying activities. It has been possible to determine this capitalization of experience by means of formal documents that have been validated by an independent authority.

Mark : **7.4**

Phase : 3 EQUIPMENT PRODUCTION

N° : 47

Recommendation : ***Give the instructions (protocol and special instructions to be obeyed) to the operators***

A workstation sheet or any other means of information describing the actions to be performed and the various instructions and protocols to be implemented must be provided to the operators.

Level 1 criterion: There are no instructions for the operators.

Level 2 criterion: A certain number of instructions are made available at the workstation, but they are not necessarily given to the operator.

Level 3 criterion: The instructions relative to the activity to be performed exist and are formalized in documents (workstation sheets, protocols, etc.). They are given to each operator in charge of performing an activity. These documents have not been validated by an authority independent from the operating entity.

Level 4 criterion: The instructions relative to the activity to be performed exist and are formalized in documents (workstation sheets, protocols, etc.). They are given to each operator in charge of performing an activity. These documents have been validated beforehand by an authority independent from the operating entity.

Mark : **6.9**

Phase : 3 EQUIPMENT PRODUCTION

N° : 49

Recommendation : ***Perform temperature profile recordings for each of the brazing system's programs to ensure that the article is not aggressed***

Take readings of the temperature profiles for each of the brazing system's programs to make it possible to know precisely what levels have been applied (amplitude and duration so as to verify that the desired range is complied with during the accomplishment of the activity).

Level 1 criterion: No readings are taken during the accomplishment of the program.

Level 2 criterion: A certain number of readings taken during the accomplishment of the program can be used to trace the levels applied to the subassembly. These readings are taken episodically and do not comply with any precise formalism.

Level 3 criterion: Readings are taken making it possible to know precisely what levels were applied to the subassemblies. They are taken according to a predefined formalism (document indicating the protocol, the frequency, etc.) but have not been validated by an authority independent from the operating entity.

Level 4 criterion: Readings making it possible to know precisely what levels were applied to the subassemblies are taken. They are taken according to a predefined formalism (document indicating the protocol, the frequency, etc.) and these documents have been validated by an authority independent from the operating entity.

Mark : **7.2**

Phase : 3 EQUIPMENT PRODUCTION

N° : 50

Recommendation : ***Eliminate any possibility of ambiguity relative to the use of a tool so as not to have a mismatch between the means of production and the subassembly to which it is applied***

The description of the actions to be performed when applying a production tool to a subassembly must be sufficiently explicit to prevent any interpretation by the operator that would result in the accidental use of an inappropriate means.

It must be ensured that the reliability of subassemblies will not be altered by the unsuitability of the tools used.

Level 1 criterion: There is no explicit description ensuring that there will not be any mismatch between the means of production and the subassembly.

Level 2 criterion: A certain number of criteria to be verified to ensure the appropriateness of the means with respect to the subassembly exist, but they are not formally identified in a document.

Level 3 criterion: A certain number of criteria to be verified to ensure the appropriateness of the means with respect to the subassembly exist. They have been formally identified in a document which has not been validated by an authority independent from the operating entity.

Level 4 criterion: Each means of production is accompanied by a description of the set of parameters to be checked before being used on a subassembly.
This description is sufficiently explicit to ensure that the means identified is suited to the subassembly. The set of parameters to be checked is formalized in a document which has been validated by an authority independent from the operating entity.

Mark : **7.6**

Phase : 3 EQUIPMENT PRODUCTION

N° : 52

Recommendation : ***Record (on a Problem Sheet) the problems that must lead to the application of corrective and/or preventive actions***

The recording on a Problem Sheet type document makes it possible to follow up any malfunctioning.

This problem sheet is one of the main documents enabling the implementation of preventives and/or corrective maintenance actions.
This fits into a traceability system enabling the management of nonconformities (products and means).

Level 1 criterion: There is no record or traceability of the problems encountered during equipment production.

Level 2 criterion: The critical points are identified and can be transmitted to initiate corrective actions, but there is no formalization.

Level 3 criterion: Each problem relative to equipment production, whatever its nature, is identified, recorded in a document provided for that purpose and can therefore be used for preventive and corrective maintenance. However, there has not been any validation of this form of capitalization.

Level 4 criterion: Each problem relative to equipment production, whatever its nature, is identified, recorded in a document provided for that purpose according to a predefined formalism. This and more particularly the way of recording the information for reuse during preventive and corrective maintenance, has been validated by an authority independent from the operating entity.

Mark : **3.1**

Phase : 3 EQUIPMENT PRODUCTION

N° : 90

Recommendation : ***Manage the priorities to be complied with according to the end-of-dossier dates***

The production of the various subassemblies and their integration is carried out on the basis of scheduled tasks that can correspond to simultaneous activities. The priorities must be managed in order to ensure that only a minimum number of subassemblies have to be stored (any delay in the production routing of a piece of equipment is equated with storage, and additional handling of the subassemblies) and therefore limit the possibilities of the parts' reliability being degraded.

Level 1 criterion: There is no prioritization in the production of equipment.

Level 2 criterion: According to the equipment production schedule, a certain priority is given to the subassemblies so as to minimize the handling and storage operations. These priorities are not covered by formal documents.

Level 3 criterion: A real priority management system has been put in place according to the end-of-dossier dates. This schedule is based on formal documents but they have not been validated by an authority independent from the operating entity.

Level 4 criterion: A real priority management system has been put in place according to the end-of-dossier dates. This schedule is based on formal documents that have been validated by an authority independent from the operating entity.

Mark : **7.3**

Phase : 3 EQUIPMENT PRODUCTION

N° : 93

Recommendation : ***Identify and implement the means for protecting the subassemblies***

List and implement the means of protection required to ensure that the reliability of the subassembly is not reduced.

Level 1 criterion: No particular means of protection have been identified.

Level 2 criterion: The means of protection have been identified, but they are only partially applied in the various activities.

Level 3 criterion: The means of protection have been identified and their application verified.

Level 4 criterion: The means of protection have been identified subsequent to a periodic analysis of the problems observed and their application is verified.

Mark : **5.8**

Phase : 3 EQUIPMENT PRODUCTION

N° : 127

Recommendation : ***Measure the contamination of baths by sample-taking (frequency to be defined) so as not to exceed the contamination rate during this activity***

Measure the contamination of the baths by sample-taking (frequency to be defined) so as not to exceed the contamination rate authorized during this activity.

Any excess contamination will increase the risks of the solder's reliability being reduced.

Level 1 criterion: There is no measurement of the solder bath's contamination rate.

Level 2 criterion: Measurements of the solder bath's contamination rates are carried out. These measurements are carried out at random and are not subject to any formalization.

Level 3 criterion: Measurements of the solder bath's contamination rates are carried out. These measurements are carried out according to a protocol and an identified frequency. All of these points which must be complied with are described in a document, but it has not been validated by an authority independent from the operating entity.

Level 4 criterion: Measurements of the solder bath's contamination rates are carried out. These measurements are carried out according to a protocol and an identified frequency. All of these points which must be complied with are described in a document that has been validated by an authority independent from the operating entity.

Mark : **5.3**

Phase : 3 EQUIPMENT PRODUCTION

N° : 131

Recommendation : ***Put in place a self-checking system to filter out human errors that could reduce the reliability of the subassembly***

Put in place a self-checking system to filter out human errors that could reduce the reliability of the subassembly.

Level 1 criterion: No self-check of the task performed has been put in place.

Level 2 criterion: There is a self-check procedure at the end of the activity, but it does not correspond to any formal document.

Level 3 criterion: There is a self-check procedure at the end of the activity. It is carried out according to a predefined protocol formalized by a document.

Level 4 criterion: There is a self-check procedure at the end of the activity. It is carried out according to a protocol that has been validated by an authority independent from the operating entity. This protocol is formalized by a document.

Mark : **6.0**

Phase : 3 EQUIPMENT PRODUCTION

N° : 132

Recommendation : ***Put in place indicators making it possible to check that there will be a good solder at the time of COTS item die bonding***

There must not be any possibility of the reliability being reduced by nonconforming solders (missing, excess or off-center) at the time of electronic component die bonding activities. Indicators (quantity removed, appearance after die bonding, etc) must be identified and their follow-up must be put in place (check by the operator, etc.) in order to detect all these causes of reduced subassembly reliability.

Level 1 criterion: There are no indicators making it possible to check good soldering at the time of die bonding.

Level 2 criterion: Indicators making it possible to ensure that the solders put in place are correct. They are not, however, based on a formal study or do not meet any formally expressed criteria.

Level 3 criterion: Indicators making it possible to ensure that the solders put in place are correct. They are based on a document giving their level of information, however this document has not been validated by an independent authority.

Level 4 criterion: Indicators making it possible to ensure that the solders put in place are correct. They are based on a document giving their level of information and the protocol to be applied. Furthermore, these documents have been validated by an authority independent from the operating entity.

Mark : **26.0**

Phase : 3 EQUIPMENT PRODUCTION

N° : 208

Recommendation : ***Put in place counter-ESD protections for subassemblies during handling and storage***

Put in place counter-ESD protections for the subassemblies during handling and storage.

Level 1 criterion: Counter-ESD protection is not covered.

Level 2 criterion: The counter-ESD protection is subject to non-formalized rules and practices.

Level 3 criterion: The counter-ESD protection is subject to validated procedures defining recognized practices for protecting the subassemblies.

Level 4 criterion: The counter-ESD protection is subject to validated procedures whose follow-up control is effective.

Mark : **4.9**

Phase : 3 EQUIPMENT PRODUCTION

N° : 133

Recommendation : ***Put periodic verifications in place enabling the follow-up of the tools used to check the means of production***

A certain number of parameters relative to the production means are provided by the verification tools (probes, sensors, detectors, etc.).

A follow-up of these verification tools is required periodically (frequency to be defined) to ensure the reliability of the measurements performed.
The difference between the stress really applied by the means of production and the measurement of that stress must be minimal and perfectly measurable.

Level 1 criterion: There is no periodic verification for following up the tools used to check the means of production.

Level 2 criterion: The tools and instruments used to check the means of production are verified on a one-off basis but without following a formal verification plan.

Level 3 criterion: The tools and instruments used to check the means of production are verified periodically. These verifications (frequency and procedures) are formalized by documents but these latter are not subject to a validation by an authority independent from the operating entity.

Level 4 criterion: The tools and instruments used to check the means of production are checked periodically. These verifications (frequency and procedures) are formalized by documents and these latter are validated by an authority independent from the operating entity

Mark : **6.0**

Phase : 3 EQUIPMENT PRODUCTION

N° : 134

Recommendation : ***Put adequate protections in place to ensure that the subassemblies are not degraded when they are cleaned***

Put adequate protections in place, if necessary, so as not to degrade the article during this activity.

Since the purpose of these protections is to isolate part of the subassembly, their efficiency after accomplishment of the activity must be appreciable (checks, measurements).

Level 1 criterion: No specific protection is used when cleaning the subassemblies.

Level 2 criterion: A certain number of protections are put in place at the time of the subassembly cleaning activity. These protections may be specific to certain boards but are not covered by formal documents.

Level 3 criterion: A certain number of protections are put in place at the time of the subassembly cleaning activity. The identification of the protections according to the types of subassembly and the adequate procedures to be applied are formalized in one or more documents.

Level 4 criterion: A certain number of protections are put in place at the time of the subassembly cleaning activity. The identification of the protections according to the types of subassembly and the adequate procedures to be applied are formalized in one or more documents which have been validated by an authority independent from the operating entity.

Mark : **6.0**

Phase : 3 EQUIPMENT PRODUCTION

N° : 135

Recommendation : ***Put in place a "filtering" by the logisticians at the time of entry into the stores (exclusion of nonconforming articles)***

A so-called "filtering" step must be identified and must be implemented before any definitive entry of articles into the stores.

The logisticians must therefore ensure that any problem that has not been detected until then will not enable a nonconforming article, which could therefore potentially reduce reliability during the rest of the process, to enter the stores.

Level 1 criterion: There is no filtering by the logisticians before articles enter the stores.

Level 2 criterion: Certain parameters are monitored at the time of entry into the stores but they are not subject to any formalization.

Level 3 criterion: A real filtering of the articles is performed by each logistician before they enter the stores. This filtering is formally described (parameters, special points, etc.) by means of a set of documents. However, no authority independent from the logisticians has validated these documents.

Level 4 criterion: A real filtering of the articles is performed by each logistician before they enter the stores. This filtering is formally described (parameters, special points, etc.) by means of a set of documents. The pertinence of the information contained in these documents, and the way it is implemented, are subject to validation by an authority independent from the operating entity.

Mark : **5.1**

Phase : 3 EQUIPMENT PRODUCTION

N° : 136

Recommendation : ***Put in place a self-test of the test tools making it possible to detect any problems***

Put in place a self-test of the testers making it possible to detect any problems.

It must not be possible to perform any test if the self-test is not conclusive or if a traced concession (authorization to perform the test but with marking and signed follow-up sheet that cannot be separated from the article) does not accompany the article thus tested.

Level 1 criterion: No self-test is performed on the testers.

Level 2 criterion: A self-test of the testers is performed. This self-test is performed without any formal document or study that determines its efficiency and the limits.

Level 3 criterion: A self-test of the testers is performed. This self-test is covered by documents making it possible to know the degree of efficiency and the procedure. But these documents are not subject to any validation by an authority independent from the operating entity.

Level 4 criterion: A self-test of the testers is performed. This self-test is covered by documents making it possible to know the degree of efficiency and the procedure. Furthermore these documents have been validated by an authority independent from the operating entity.

Mark : **5.6**

Phase : 3 EQUIPMENT PRODUCTION

N° : 137

Recommendation : ***Put in place a cross-check to optimize the final check of the varnishing of subassemblies***

This cross-check ensures a filtering out of nonconformities before the subassembly continues through the equipment production process.

The final check activity is the last stage at which an error, caused by unreliable varnishing and which could reduce the subassembly's reliability, can be identified.

Level 1 criterion: There is no cross-check at the level of the final check of the varnishing.

Level 2 criterion: A cross-check is performed at the time of the final check of the subassembly varnishing activity. However this inspection method is not covered by a documented formal description.

Level 3 criterion: A cross-check is performed at the time of the final check of the subassembly varnishing activity. The effectiveness of this method has been measured and the procedure and the scope of the check are formally described in documents.

Level 4 criterion: A cross-check is performed at the time of the final check of the subassembly varnishing activity. The effectiveness of this method has been measured and the procedure and the scope of the check are formally described in validated documents.

Mark : **4.5**

Phase : 3 EQUIPMENT PRODUCTION

N° : 138

Recommendation : ***Put in place a check of the equipment production process by SPC card (Statistical Process Control)***

The utilization of statistical process control by drawing up SPC (Statistical Process Control) cards will make it possible to check the correct accomplishment of certain activities at precise moments in the equipment production phase.

The activities that are checked in this way are those where there is the greatest probability (statistical) of having a nonconformity that would reduce the reliability of the subassembly.

Level 1 criterion: There is no process control in production using SPC cards.

Level 2 criterion: A means of process control in equipment production using SPC cards or a similar method exists, but it is not formally described in a document.

Level 3 criterion: A means of process control in equipment production with SPC cards is used. This statistical control is formalized and its effectiveness is known with respect to the process to be checked.

Level 4 criterion: A means of process control in equipment production with SPC cards is used. This statistical control is formalized and its effectiveness is known with respect to the process to be checked. The means has been validated by an authority independent from the operating entity.

Mark : **5.8**

Phase : 3 EQUIPMENT PRODUCTION

N° : 139

Recommendation : ***Put in place a detailed description of the varnishing protocol***

The special nature of the varnishing activity requires a precise description of the protocol and actions to be performed in parallel to ensure reliable accomplishments of the task.

Level 1 criterion: There is no description of the varnishing procedure for the operator.

Level 2 criterion: The various actions to be performed to accomplish board varnishing are known and are available via various documents. However, these documents are too broadly dispersed to provide the operator with a view of the clearly expressed protocol.

Level 3 criterion: The various actions and operations to be performed to accomplish board varnishing are covered by document formalizing the protocol to be applied. This document has not, however, been validated by an authority independent from the operating entity.

Level 4 criterion: The various actions and operations to be performed to accomplish board varnishing are covered by a document formalizing the protocol to be applied. Furthermore, this document has been read and validated by an authority independent from the operating entity.

Mark : **6.4**

Phase : 3 EQUIPMENT PRODUCTION

N° : 140

Recommendation : ***Put in place a labeling system making it possible to identify and withdraw expired consumables***

Since the unintentional use of expired consumables (which are no longer reliable) may have a negative impact on the quality and therefore on the reliability of the equipment, a certain number of methods appropriate for the preservation, identification and, if necessary, the withdrawal of the incriminated consumables must be implemented.

The systematic reading of the labels identifying each product, and giving all the information relative to its expiry, before the product is used, makes it possible to reduce the risks of using products that will degrade the equipment's reliability.

Level 1 criterion: There is no labeling or sign indicating the expiry dates of the consumables.

Level 2 criterion: The consumables are identified by a label or another means but there is no formal document indicating what information must be provided on these labels.

Level 3 criterion: The consumables are correctly identified by a label.
All of the information required for this identification is formally described in documents, but they have not been subject to any validation by an authority independent from the operating entity.

Level 4 criterion: The consumables are correctly identified by a label.
All of the information required for this identification is formally described in documents, which have been validated by an authority independent from the operating entity.

Mark : **4.7**

Phase : 3 EQUIPMENT PRODUCTION

N° : 141

Recommendation : ***Put in place real-time processing of the test follow-up indicators to prevent degradation of the article as soon as a problem appears***

This involves monitoring of the test follow-up indicators to make it possible to intervene immediately, with:

- a definition of the tolerances outside of which it is considered that there is a problem
- an alarm as soon as a problem is detected
- a suspension of the activity in progress so as not to stress the subassembly
- a compulsory intervention and correction of the problem before there is any possibility of resuming and pursuing the activity.

Level 1 criterion: There is no real-time processing of the test follow-up indicators.

Level 2 criterion: There are a certain number of indicators that are used to identify any problem that has occurred during the test. These indicators are not subject to any formal plan.

Level 3 criterion: All of the test follow-up indicators are processed in real time. Documents formalize the way that these indicators are to be processed. However, these data have not been validated by an authority independent from the operating entity.

Level 4 criterion: All of the test follow-up indicators are processed in real time. Documents formalize the way that these indicators are to be processed. Furthermore, these documents have been validated by an authority independent from the operating entity.

Mark : **5.9**

Phase : 3 EQUIPMENT PRODUCTION

N° : 142

Recommendation : ***Put in place a preventive maintenance system (in the framework of metrology) preventing any possibility of the article being aggressed***

This maintenance by metrological follow-up of the production tool parameters must make it possible to overcome the risk of reliability of an element being degraded due to the aggression of the subassembly (overstress). Furthermore, the application of parameters that do not correspond exactly to those stipulated (too low a temperature, etc.) does not make it possible to guarantee the reliable nature of the operation.

Level 1 criterion: No preventive maintenance measures by metrological follow-up have been put in place.

Level 2 criterion: A certain number of metrology actions, that can be equated with preventive maintenance, are carried out.

Level 3 criterion: A real metrological follow-up is included in the preventive maintenance plan which is applied. One or more documents formalize these actions even if they have not been the subject of a validation by an organization independent from the operating entity.

Level 4 criterion: A real metrological follow-up is included in the preventive maintenance plan which is applied. One or more documents formalize these actions and this preventive maintenance plan has been validated by an organization independent from the operating entity.

Mark : **6.1**

Phase : 3 EQUIPMENT PRODUCTION

N° : 143

Recommendation : ***Only validate and authorize oven operation by checking any drift or malfunctioning (by means of probes or other monitoring systems)***

The activity must be carried out under a permanent monitoring of a certain number of fundamental parameters and it must be possible to identify whether, during the activity, the subassembly has undergone any overstress or been the victim of a malfunctioning.

Level 1 criterion: There is no particular verification conditioning the operation of the ovens.

Level 2 criterion: There are a certain number of malfunction indicators on the ovens. They can provide information to the operator wishing to bake a subassembly. However, there is no formal document that serves as baseline to pronounce any operating authorization.

Level 3 criterion: A real monitoring of any drift and of the malfunction indicators is carried out by the operator. There are documents that serve as baseline to authorize oven operation, even if they have not been the subject of any validation by an authority independent from the operating entity.

Level 4 criterion: A real monitoring of any drift and of the malfunction indicators is carried out by the operator. There are documents that serve as baseline to authorize oven operation. These documents have been validated by an authority independent from the operating entity.

Mark : **5.7**

Phase : 3 EQUIPMENT PRODUCTION

N° : 157

Recommendation : ***Possess high and low safeties connected to the control and monitoring systems (systematic shutdown and analysis by a technician before restarting)***

Possess high and low safeties connected to the control and monitoring systems (systematic shutdown of the cycle and analysis by a technician before restarting).

Level 1 criterion: There is no control parameter value resulting in the systematic shutdown of the activity when this value is reached.

Level 2 criterion: The control and monitoring means can cause an interruption of the activity. However, there are no documents indicating the values beyond which there must be a systematic shutdown.

Level 3 criterion: There are high and low safeties on the control and monitoring means. They are formally identified in a document specific to each system.

Level 4 criterion: There are high and low safeties on the control and monitoring means. They are formally identified in a document specific to each system. Furthermore, these documents and shutdown procedures have been validated by an authority independent from the operating entity.

Mark : **6.5**

Phase : 3 EQUIPMENT PRODUCTION

N° : 162

Recommendation : ***Have in place a qualification plan for the method of removing the varnishing masking used so as not to reduce the reliability of the subassembly***

Have in place a qualification plan for the method used to remove the masking used so as not to reduce the reliability of the subassembly.

Indeed, the risks of humidity penetrating and thus degrading the reliability of the subassembly are great if certain precautions are not taken by the operator.

Level 1 criterion: There is no plan specific to the method used for removing the masking.

Level 2 criterion: The masking is removed according to a particular method but there is no formal document describing it.

Level 3 criterion: A plan for qualifying the method of removing the masking after varnishing of the subassemblies is applied by the operators. This plan is formally explained by means of specific documents.

Level 4 criterion: A plan for qualifying the method of removing the masking after varnishing of the subassemblies is applied by the operators. This plan is formally explained by means of specific documents which have been validated by an authority independent from the operating entity.

Mark : **6.5**

Phase : 3 EQUIPMENT PRODUCTION

N° : 168

Recommendation : ***Put in place an inspection step (even visual) of the correct application of the masking installation activity before varnishing***

Put in place an inspection step (even visual) of the correct application of masking installation for varnishing.

Level 1 criterion: There is no particular visual inspection for the installation of the masking before varnishing.

Level 2 criterion: An inspection specific to the installation of masking for varnishing is carried out, however there is no document describing the procedure to be applied for this inspection.

Level 3 criterion: An inspection step specific to the installation of masking for varnishing is carried out. This particular inspection is subject to a correctly formalized procedure. These documents have not, however, been validated by an independent authority.

Level 4 criterion: An inspection step specific to the installation of masking for varnishing is carried out. This particular inspection is subject to a correctly formalized procedure. These documents have been validated by an independent authority.

Mark : **4.7**

Phase : 3 EQUIPMENT PRODUCTION

N° : 169

Recommendation : ***Put in place a preventive maintenance procedure making it possible to detect any problems, before a means of production is used on a subassembly***

Put in place (by implementing a plan based on a maintenance strategy) a preventive maintenance procedure making it possible to detect any problems before utilization on the article.

This maintenance must be covered by a maintenance plan indicating the periodicity, parameters to be checked, critical levels, margins, etc.

Level 1 criterion: There is no preventive maintenance plan at the level of equipment production.

Level 2 criterion: A certain number of parameters have to be checked in the framework of preventive maintenance. These points are not exhaustive and are not covered by a formal document.

Level 3 criterion: There is preventive maintenance on the means of equipment production. This is detailed in a documented maintenance plan.
This plan has not been validated as a whole.

Level 4 criterion: There is preventive maintenance on the means of equipment production. This is detailed in a documented maintenance plan which has been validated by an authority independent from the operating entity.

Mark : **6.4**

Phase : 3 EQUIPMENT PRODUCTION

N° : 171

Recommendation : ***Respect a rest period between each screen printing operation so as not to overstress the article***

A rest period between each screen printing operation must be left for the thermalization of the board so as not to overstress the article.

There must be a procedure specifying this requirement and describing the method.

Level 1 criterion: There is no particular rest period left between the various die bonding operations on a subassembly.

Level 2 criterion: A certain number of measures are implemented at the time of component die bonding to comply with the rest period between two screen printing operations so as not to reduce the reliability of the subassembly. These actions are not, however, formalized by any documents.

Level 3 criterion: There is a document explicitly describing the times and actions to be respected at the level of die bonding components to the board. This document has not, however, been validated by an authority independent from the operating entity.

Level 4 criterion: There is a document explicitly describing the times and actions to be respected at the level of die bonding components to the board. Furthermore, this document has been validated by an authority independent from the operating entity.

Mark : **6.7**

Phase : 3 EQUIPMENT PRODUCTION

N° : 173

Recommendation : ***Revise and make robust the maintenance plans relative to the means of production to eliminate any possibility of degradation on the COTS item connections***

The set of preventive and corrective maintenance operations for maintaining the condition of the production means and tools, must be the subject of a plan that is revised periodically in order to prevent any utilization of a tool whose parameters may have changed (drift, etc.) and could therefore cause damage (physical deformations of a COTS item's connections) at the time of the placement operations.

Level 1 criterion: There is no revision and recording of the maintenance plan relative to the means of production specifically concerning the handling of COTS.

Level 2 criterion: The maintenance plans for the means of production are revised but there is no document describing the frequency of these revisions, nor the particular points liable to change.

Level 3 criterion: There is a documentation describing the points to be revised and made robust in terms of maintenance of the means of production. The frequency of these revisions and all of the actions aiming to reduce the possibilities of degradations due to the drift of parameters has not, however, been the subject of validation by an authority independent from the operating entity.

Level 4 criterion: There is a documentation describing the points to be revised and made robust in terms of maintenance of the means of production. The frequency of these revisions and all of the actions aiming to eliminate the possibilities of degradations due to the drift of parameters has been validated by an authority independent from the operating entity.

Mark : **5.2**

Phase : 3 EQUIPMENT PRODUCTION

N° : 174

Recommendation : ***Ensure the efficiency of the final inspection of varnishing quality through a strict application of the inspection procedure***

Ensure the efficiency of the final inspection of varnishing quality through a strict application of the inspection procedure. This ultimate inspection must be performed to check that the subassembly has passed each basic step and its associated inspection (verification of the various validations of the documents associated with the subassembly) in compliance with a formalized procedure.

Level 1 criterion: There is no procedure describing this final inspection.

Level 2 criterion: The final inspection of all the varnishing activities is carried out by reviewing a certain number of points considered critical, even if a document is not formally applied to perform these actions.

Level 3 criterion: The final inspection of all the varnishing activities is carried out by reviewing a certain number of points considered critical. The various actions to be performed are subject to a documented procedure.

Level 4 criterion: The final inspection of all the varnishing activities is carried out by reviewing a certain number of points considered critical. The various actions to be performed are subject to a documented procedure. Furthermore, this document has been validated by an authority independent from the operating entity.

Mark : **5.9**

Phase : 3 EQUIPMENT PRODUCTION

N° : 175

Recommendation : ***Control varnish preparation (dosing) by means of a qualified procedure and verification measurements***

Control varnish preparation (dosing) by means of a qualified procedure and measurements making it possible to check this before utilization.

Level 1 criterion: No qualified procedure or check for verifying the quality of the varnish prepared.

Level 2 criterion: The preparation of the varnish is controlled by the verification of a certain number of points. However, there is no document formalizing this verification.

Level 3 criterion: The preparation of the varnish is controlled by the verification of a certain number of points. These points and the procedure to be applied are formalized in a document.

Level 4 criterion: The preparation of the varnish is controlled by the verification of a certain number of points. These points and the procedure to be applied are formalized in a document which has been validated by an independent authority.

Mark : **4.4**

Phase : 3 EQUIPMENT PRODUCTION

N° : 178

Recommendation : ***Promote operator awareness and examine ways for ensuring the real-time updating of their skills***

Promote operator awareness for the final test activities and examine how to ensure real-time updating of their skills.

Level 1 criterion: There is no plan in place for promoting awareness and bringing the operators' knowledge up to standard.

Level 2 criterion: Promotion of the operators' awareness of particular activities and the one-off updating of their skills is ensured. However, there is no document formalizing these actions.

Level 3 criterion: Promotion of the operators' awareness of particular activities and the one-off updating of their skills according to the needs is ensured. These actions are covered by documents carefully describing the actions to be performed. But these documents have not been validated.

Level 4 criterion: Promotion of the operators' awareness of particular activities and the one-off updating of their skills according to the needs is ensured. These actions are covered by documents carefully describing the actions to be performed and these documents have been validated by an authority independent from the operating entity.

Mark : **5.9**

Phase : 3 EQUIPMENT PRODUCTION

N° : 179

Recommendation : ***Make sure that there is maintenance of the means and that this maintenance is subject to follow-up***

Make sure that there is maintenance of the means of production and that this maintenance is subject to follow-up, ensuring in particular that the latest nonconformities are taken into account.

Level 1 criterion: There is no follow-up of the maintenance of the means of production.

Level 2 criterion: The means of production are subject to maintenance and this maintenance is followed up. However, there is no formal documented maintenance plan indicating the frequency of this maintenance and its compulsory application points.

Level 3 criterion: A real maintenance of the means of production is in place. It is subject to follow-up based on a plan indicating all the compulsory application points and the frequency of the various actions.

Level 4 criterion: A real maintenance of the means of production is in place. It is subject to follow-up based on a plan indicating all the compulsory application points and the frequency of the various actions. Furthermore, these documents have been validated by an authority independent from the operating entity.

Mark : **8.5**

Phase : 3 EQUIPMENT PRODUCTION

N° : 180

Recommendation : ***Make sure that the operator has received the appropriate training (qualification) for the activity***

Make sure that the operator has received appropriate training (qualification) for the activity.

Level 1 criterion: There is no verification of the appropriateness of the training provided to an operator for a workstation.

Level 2 criterion: There is a verification making it possible to ensure that the operator who has to perform the task has actually received appropriate training beforehand.

Level 3 criterion: There is a verification making it possible to ensure that the operator who has to perform the identified task has actually received appropriate training beforehand. This verification complies with a formal procedure for a complete review of the various points.

Level 4 criterion: There is a verification making it possible to ensure that the operator who has to perform the identified task has actually received appropriate training beforehand. This verification complies with a formal procedure for a complete review of the various points. The procedure has been validated by an authority independent from the operating entity.

Mark : **5.1**

Phase : 3 EQUIPMENT PRODUCTION

N° : 181

Recommendation : ***Make sure that the procedure for implementing the means is known***

Make sure that the procedure for implementing the means at an equipment production workstation is known by the person who is to perform the task.

Level 1 criterion: There is no procedure or the operator does not have access to it at the workstation.

Level 2 criterion: A procedure explicitly describing the implementation of the means of production at the workstation exists. However, the operator can implement the means without any assurance that he is aware of that procedure. The format proposed is not suited to ensuring that he is systematically made aware of it.

Level 3 criterion: A procedure explicitly describing the implementation of the means of production at the workstation exists. It is formalized in such a way as to oblige the operator to take cognizance of it before implementing the means (visual warning when the means is put into operation, etc).

Level 4 criterion: A procedure explicitly describing the implementation of the means of production at the workstation exists. It is formalized in such a way as to oblige the operator to take cognizance of it before implementing the means (visual warning when the means is put into operation, etc.). Furthermore, this formalism has been validated by an authority independent from the operating entity.

Mark : **6.7**

Phase : 3 EQUIPMENT PRODUCTION

N° : 182

Recommendation : ***Make sure that the software loaded is the right one and keep the identification of its version***

Make sure that the software loaded is the right one and, more particularly, that it actually corresponds to the latest version to be used in the subassembly.

This identification information must, in addition, be the subject of traceability through the rest of the process.

Level 1 criterion: There is no identification of the software loaded.

Level 2 criterion: After loading of the software in a hardware subassembly, an identifier of the software loaded is provided, ensuring that it is conform to the subassembly. However, there is no document describing precisely the format or the recording of this identifier.

Level 3 criterion: Each time a software is loaded, the operator has the version of the software to be used. An identifier of the version used is provided after the operation.

Level 4 criterion: Each time a software is loaded, the operator has the version of the software to be used. An identifier of the version used is provided after the operation.
A cross-check is formalized.

Mark : **6.6**

Phase : 3 EQUIPMENT PRODUCTION

N° : 183

Recommendation : ***Secure the means (oven T°) through direct monitoring using probes and recordings to avoid overstress***

It must be possible to detect and quantify (moment of occurrence, stress level with respect to the required parameters) any overstress.

It must be possible to visualize this detection in real time and not only at the end of the activity so that it is possible to intervene during the application, thus reducing the overstress on the subassembly and therefore limit its degradation.

Level 1 criterion: There is no particular safety.

Level 2 criterion: There are monitoring systems or other indicators in place making it possible to know whether the parameters to be applied by the means to the subassembly have been respected. However there is no study or formal document covering these special monitoring actions.

Level 3 criterion: There are monitoring systems or other indicators in place making it possible to know whether the parameters to be applied by the means to the subassembly have been respected. There are documents formalizing the level of coverage and the putting in place of these direct monitoring systems.

Level 4 criterion: There are monitoring systems or other indicators in place making it possible to know whether the parameters to be applied by the means to the subassembly have been respected. There are documents formalizing the level of coverage and the putting in place of these direct monitoring systems. The monitoring plan thus drawn up has been validated by an authority independent from the operating entity.

Mark : **5.9**

Phase : 3 EQUIPMENT PRODUCTION

N° : 187

Recommendation : ***Promote personnel awareness relative to performing a visual verification after placement and before re-fusion***

With a view to reducing the number of problems that are not detected at the time of inspections relying on human factors (visual inspection in this case), it is important to promote the awareness of the personnel in charge of this activity in order to reduce as much as possible the risk linked to human factors or to the non-detection of a problem.

Level 1 criterion: There is no particular verification performed after the placement of the components and before re-fusion.

Level 2 criterion: A verification of the correct accomplishment of the placement activity before re-fusion can be performed by the operator. This verification is not, however, described formally.

Level 3 criterion: A verification of the correct accomplishment of the placement activity before re-fusion is performed by the operator. This verification is carried out in accordance with a procedure (from the mentioning of a simple visual inspection through to the description of the points to be checked systematically).

Level 4 criterion: A verification of the correct accomplishment of the placement activity before re-fusion is performed by the operator. This verification is carried out in accordance with a procedure (from the mentioning of a simple visual inspection through to the description of the points to be checked systematically). Furthermore, this procedure has been validated by an authority independent from the operating entity.

Mark : **5.9**

Phase : 3 EQUIPMENT PRODUCTION

N° : 188

Recommendation : ***Promote operator awareness relative to the verification of the quality of the soldering flux deposit (implementation of a check which must be indicated in the article's follow-up sheet)***

Promote operator awareness relative to the verification of the quality of the soldering flux deposit. Since this operation requires a special verification at the end of its accomplishment, the putting in place of an electronic bar code reading as verification phase must enable a satisfactory follow-up of this verification and the performance of this verification must be recorded in the article's follow-up sheet.

Level 1 criterion: There is no particular verification performed for checking the correct deposit of the solder flux.

Level 2 criterion: A verification of the satisfactory accomplishment of the solder flux depositing activity (quantity, appearance, etc.) is performed by the operator. This verification is not, however, formally described.

Level 3 criterion: A verification of the satisfactory accomplishment of the solder flux depositing activity (quantity, appearance, etc.) is performed by the operator. This verification is carried out according to a procedure enabling traceability (bar code reading of the manufacturing follow-up sheet for example).

Level 4 criterion: A verification of the satisfactory accomplishment of the solder flux depositing activity (quantity, appearance, etc.) is performed by the operator. This verification is carried out according to a procedure enabling traceability (bar code reading of the manufacturing follow-up sheet for example). Furthermore, these means of verification and there putting in place has been validated by an authority independent from the operating entity.

Mark : **8.3**

Phase : 3 EQUIPMENT PRODUCTION

N° : 195

Recommendation : ***Process the problems***

Put in place a system for processing the problems that could cover the whole FIDES life cycle.

This system is designed to:
Record the circumstances under which the problem occurred
The P/N of the defective article
Propose a remedial action
Analyze the causes of the problem
Propose corrective/preventive actions
Check the effectiveness of the corrective/preventive actions

This system includes processing making it possible to:
- quickly find any identical problems that have been detected previously
- draw up statistics
- and which can be used for feedback purposes.

Level 1 criterion: There is no problem processing system in place

Level 2 criterion: A problem processing system has been put in place by the manufacturer, and it partially meets the requirements of the recommendation. It is not completely applied to the project.

Level 3 criterion: A problem processing system has been put in place by the manufacturer, and it partially meets the requirements of the recommendation. It is applied completely to the project.

Level 4 criterion: A problem processing system has been put in place by the manufacturer, and it completely meets the requirements of the recommendation. It is applied completely to the project.

Mark : **5.5**

Phase : 3 EQUIPMENT PRODUCTION

N° : 201

Recommendation : ***Ensure inventories are put in place with automation of reminders (exclusion of nonconforming articles)***

The putting in place of inventories with the assurance of reminders being issued in the case of non-validation of the periodic verification (to be defined) of the stock makes it possible to increase the overall reliability by ensuring the exclusion of any part that does not meet the following criteria:
- expiry
- correct designation or identification
- correct geographical location at the time of storage.

Level 1 criterion: No inventory or automatic inventory reminder is performed.

Level 2 criterion: A certain number of inventories are performed. The frequency of these inventories is not, however, the subject of any formal plan.

Level 3 criterion: Regular inventories are performed. In the case of non-compliance with the date of an inventory a reminder is systematically issued through to validation of a new inventory. There are documents formalizing the actions to be performed as well as the various follow-up forms that have to be updated.

Level 4 criterion: Regular inventories are performed. In the case of non-compliance with the date of an inventory a reminder is systematically issued through to validation of a new inventory. There are documents formalizing the actions to be performed as well as the various follow-up forms that have to be updated. The whole system has been validated by an authority independent from the operating entity.

Mark : **6.1**

Phase : 3 EQUIPMENT PRODUCTION

N° : 205

Recommendation : ***Check by means of an inspection operation (bar code reading, reading of S/N) that you have the right piece of equipment before starting the test***

Check by means of an inspection operation (bar code reading, reading of the S/N) that you have the right piece of equipment before starting the test.

Level 1 criterion: No verification is performed to ensure that the right piece of equipment is going to be submitted to the test to be performed.

Level 2 criterion: A verification is performed on the type of equipment with respect to the test to be performed. This verification is not formally described.

Level 3 criterion: A systematic verification is performed by identifying the equipment to be tested. This is based on a documented procedure indicating the procedure to be applied (bar code reading of an identifier, etc.).

Level 4 criterion: A systematic verification is performed by identifying the equipment to be tested. This is based on a documented procedure indicating the procedure to be applied (bar code reading of an identifier, etc.). This means of verification has been validated by an authority independent from the operating entity.

Mark : **5.2**

Phase : 3 EQUIPMENT PRODUCTION

N° : 206

Recommendation : ***Check that the test coverage for the burn-in is correctly formalized***

Check that the test coverage for the burn-in is correctly formalized.

Level 1 criterion: There is no verification of the test coverage rate during the burn-in phase.

Level 2 criterion: The test coverage rate during burn-in was verified when it was put in place. No further verification has been performed with respect to any possible changes (new technologies, etc.) .

Level 3 criterion: The test coverage rate during burn-in is verified. There is a document describing the changes requiring a verification as well as the procedure to be implemented.

Level 4 criterion: The test coverage rate during burn-in is verified. There is a document describing the changes requiring a verification as well as the procedure to be implemented. This whole document has been validated by an authority independent from the operating entity.

Mark : **8.8**

Phase : 4 SYSTEM INTEGRATION

N° : 7

Recommendation : ***Ensure handling***

Are there product handling methods and means in place for preventing the product from being damaged or deteriorated?

· Define and specify the transport procedures.
· Individualize the means of handling

Level 1 criterion: The handling methods have not been defined, there are no specific means for avoiding deteriorating the product when it is being handled.

Level 2 criterion: General handling constraints have been defined, but they are not specific to a piece of equipment.

Level 3 criterion: Handling methods specific to a piece of equipment have been defined, specific means are available for avoiding any deterioration during handling. There is no verification of their application

Level 4 criterion: The product handling procedures are specifically defined, and associated means are provided to avoid any deterioration of the product when it is being handled. Verifications are performed to ensure these methods are applied.

Mark : **15.4**

Phase : 4 SYSTEM INTEGRATION

N° : 8

Recommendation : Ensure the implementation of the corrective actions

Do the procedures relative to the corrective actions include the following?

- the effective processing of customer complaints and nonconformity reports relative to the product.

- the search for the causes of the nonconformity with respect to the product, process and quality system and the recording of the results of that search.
- the determining of the corrective actions required to eliminate the causes of nonconformities.
- the application of the control means for ensuring that the corrective action is implemented and produces the required effect.

Level 1 criterion: There are no procedures relative to corrective actions

Level 2 criterion: Corrective actions are implemented in the event of customer complaints or nonconformity reports, but they are not formalized.

Level 3 criterion: The procedures relative to the corrective actions include:

- the effective processing of customer complaints and of nonconformity reports relative to the product.
- the search for the causes of nonconformities relative to the product, process and quality system and the recording of the results of this search.
- the determining of the corrective actions required to eliminate the causes of nonconformities. These procedures do not define the application of the control means for ensuring that the corrective action is implemented and that it produces the required effect

Level 4 criterion: The procedures relative to the corrective actions include:

- the effective processing of customer complaints and of nonconformity reports relative to the product.
- the search for the causes of nonconformities relative to the product, process and quality system and the recording of the results of this search.
- the determining of the corrective actions required to eliminate the causes of nonconformities.
- the application of the control means to ensure that the corrective action is implemented and that it produces the required effect.

Mark : **15.6**

Phase : 4 SYSTEM INTEGRATION

N° : 9

Recommendation : Ensure the implementation of the preventive actions

Do the procedures relative to the preventive actions include the following?

- the utilization of appropriate sources of information such as processes and operations affecting the quality of the product, concessions, audit results, quality-related records, maintenance reports and customer complaints, in such a way as to detect, analyze and eliminate the potential causes of nonconformities.

- the determining of appropriate steps for processing any problems requiring a preventive action.
- the triggering of preventive actions and the application of control means for ensuring that they produce the required effect.
- the assurance that the pertinent information relative to the actions implemented is submitted to the management review.

Level 1 criterion: No procedure relative to preventive actions is implemented.

Level 2 criterion: The procedures relative to the preventive actions include:
- the utilization of appropriate sources of information such as processes and operations affecting the quality of the product, concessions, audit results, quality-related records, maintenance reports and customer complaints, in such a way as to detect, analyze and eliminate the potential causes of nonconformities.
- the determining of appropriate steps for processing any problems requiring a preventive action.

The application of means making it possible to ensure that the preventive actions produce the required effect is not ensured.

Level 3 criterion: The procedures relative to the preventive actions include:
- the utilization of appropriate sources of information such as processes and operations affecting the quality of the product, concessions, audit results, quality-related records, maintenance reports and customer complaints, in such a way as to detect, analyze and eliminate the potential causes of nonconformities.
- the determining of appropriate steps for processing any problems requiring a preventive action.
- the triggering of preventive actions and the application of control means for ensuring that they produce the required effect.
- the assurance that the pertinent information relative to the actions implemented is not valid.

Level 4 criterion: The procedures relative to the preventive actions include:
- the utilization of appropriate sources of information such as processes and operations affecting the quality of the product, concessions, audit results, quality-related records, maintenance reports and customer complaints, in such a way as to detect, analyze and eliminate the potential causes of nonconformities.

- the determining of appropriate steps for processing any problems requiring a preventive action.
- the triggering of preventive actions and the application of control means for ensuring that they produce the required effect.

- the assurance that the pertinent information relative to the actions implemented is submitted to the management review.

Mark : **12.3**

Phase : 4 SYSTEM INTEGRATION

N° : 11

Recommendation : ***Ensure preservation***

Are the packing, preservation and marking processes controlled to ensure conformity with the specified requirements?

- Define a list of equipment requiring preservation.
- Propose a means of managing the specific means of preservation per product (dates, modes, duration, etc.).
- Periodically check the quality of the means of preservation.
- Use means of preservation that are appropriate and specific to the products.

Level 1 criterion: The preservation of the equipment is not defined, the materials used for this preservation are used according to their availability.
The information on the preservation dates, management modes and checks to be performed is not filled in.

Level 2 criterion: Standard preservation is used for the equipment.
The preservation information is filled in.
No specific checks are performed on the preservation.

Level 3 criterion: Preservation specific to the product is provided for, with the associated documentations.
No specific checks are performed on the preservation.

Level 4 criterion: Preservation specific to the product is provided for, with the associated documentations.
A regular specific check of the preservations is provided for.
There is a procedure for regularly verifying the application of the periodic checks.

Mark : **10.8**

Phase : 4 SYSTEM INTEGRATION

N° : 12

Recommendation : ***Ensure storage***

Are designated storage areas or premises used to prevent any damage or deterioration of the product?

- Are appropriate measures taken to authorize reception in these areas and shipping from them?
- Is the condition of the product in stock assessed at appropriate intervals in order to detect any deterioration?
- Manage and check the storage area atmospheres.
- Individualize the positioning in storage.
- Manage the periodic interventions making it possible to maintain the product's characteristics in storage (powering up, etc.).

Level 1 criterion: The equipment storage areas are not specific, the storage environment is not taken into account.

Level 2 criterion: The equipment storage areas are not specific, the storage environment is controlled and suited to the stored products.

Level 3 criterion: The equipment storage areas are specific.
The storage environment is controlled and suited to the stored products.
The storage positions are individualized.
The periodic interventions making it possible to maintain the product's characteristics are performed.

Level 4 criterion: The equipment storage areas are specific.
The storage environment is controlled and suited to the stored products.
The storage positions are individualized.
The periodic interventions making it possible to maintain the product's characteristics are performed.
The condition of the products in store is regularly checked, the stock is verified and the storage conditions are regularly optimized.

Mark : **16.5**

Phase : 4 SYSTEM INTEGRATION

N° : 13

Recommendation : ***Ensure product traceability***

When traceability is required, the system implemented must make it possible to: maintain the product's identification throughout the life cycle, know the history (design dossier + changes) and the destination (deliveries, scrapping) of all the products manufactured from the same batch of raw materials or from the same manufacturing batch, find the identity of an assembly's component parts and of the components of the next higher assembly, find the sequential documentation relative to the production (manufacturing, assembly, inspection) of any given product (e.g. configuration follow-up sheet with recording of the operations performed and of any problems observed).

The traceability system must make it possible to know the configuration of the product ready to be delivered, including any deviations between the real condition and the stipulated condition.

Level 1 criterion: No traceability of the product during its life cycle, the product is identified in a unique way by its marking.

Level 2 criterion: There is traceability making it possible to identify the product but it does not make it possible to know its origin or its history.

Level 3 criterion: There is traceability making it possible to identify the product and know its history (Design Dossier + changes), however it does not make it possible to know what documentation is associated with its life cycle (e.g. no configuration follow-up sheet with recording of the operations performed and of the problems observed).

Level 4 criterion: There is traceability making it possible to identify the product and know its history (Design Dossier + changes), including the components – e.g. Date Code.
It makes it possible to know what documentation is associated with its life cycle (e.g. configuration follow-up sheet with recording of the operations performed and of the problems observed).
Exhaustive application of the recommendation.

Mark : **17.5**

Phase : 4 SYSTEM INTEGRATION

N° : 14

Recommendation : ***Ensure the delivery conditions***

Does the supplier take steps to protect the quality of the product after the inspections and final inspections?

- when that is specified contractually, is this protection extended to include delivery to destination?
- does the supplier ensure, at the time of delivery, the presence of the accompanying documentation relative to the product such as specified in the order and that it is protected against loss and deterioration?

Level 1 criterion: The usual means for protecting the product at the time of delivery are not used.

Level 2 criterion: Means of protecting the product's quality at the time of delivery to the customer are used. The supplier does not ensure the presence of the accompanying documents.

Level 3 criterion: Means of protecting the product's quality at the time of delivery to the customer are used. The supplier ensures the presence of the accompanying documents, but does not protect them against loss or deterioration.

Level 4 criterion: The supplier takes measures to protect the quality of the product at the time of delivery to destination.
It ensures the presence of the accompanying documentation relative to the product such as specified in the order and that it is protected against loss and deterioration

Mark : **7.2**

Phase : 4 SYSTEM INTEGRATION

N° : 15

Recommendation : Ensure the inspections and tests during the phase

The product must be inspected during the phase and be subject to tests in accordance with the quality plan and/or the written procedures.

The product must remain blocked until the required inspections and tests have been completed or until the required reports have been received and checked.

Level 1 criterion: No inspection or tests during the phase.

Level 2 criterion: Inspections are performed during the phase, but they are not formalized in the form of written procedures or of a quality plan.

Level 3 criterion: Inspections are performed during the phase, and they are formalized in the form of written procedures or of a quality plan. The completeness of these inspections and tests is not always effective.

Level 4 criterion: Inspections are performed during the phase, and they are formalized in the form of written procedures or of a quality plan. The completeness of these inspections and tests is effective.

Mark : **7.9**

Phase : 4 SYSTEM INTEGRATION

N° : 16

Recommendation : ***Perform the final inspections and tests***

Perform all the final inspections and tests in accordance with the quality plan and/or the written procedures.

- Do the quality plan and/or the procedures for the final inspections and tests require that all the specified inspections and tests, including those specified for acceptance of the product, should be performed and be conform with the requirements?
- Is it checked before delivery that:
  - all the activities specified in the quality plan and/or the written procedures have been satisfactorily accomplished?
  - the data and the associated documentation are available and have been accepted?

Level 1 criterion: No final inspection or tests.

Level 2 criterion: Final inspections and tests are performed, but they are not described in strict procedures or in a quality plan.

Level 3 criterion: Final inspections and tests are performed, and they are described in strict procedures or in a quality plan. The application of these inspections and tests is not verified and validated.

Level 4 criterion: Final inspections and tests are performed in accordance with the quality plan and/or written procedures.

- The quality plan and/or the procedures for the final inspections and tests require that all the specified inspections and tests, including those specified for acceptance of the product or during its manufacture, should be performed and that all the results should be conform to the requirements.
- It is verified before delivery that:
  - all the activities specified in the quality plan and/or the written procedures have been satisfactorily accomplished.
  - the data and the associated documentation are available (document of the follow-up sheet type which records the configuration, the operations performed and the problems observed) and have been accepted.

Mark : **6.7**

Phase : 4 SYSTEM INTEGRATION

N° : 17

Recommendation : ***Carry out the inspections and tests specific to acceptance***

Make sure that the incoming product is not used or implemented as long as it has not been inspected or as long as its conformity with the specified requirements has not been verified in another way.

- The verification of conformity with the specified requirements must be carried out in accordance with the quality plan and/or with the written procedures;
- The inspections performed on the subcontractors' premises and the proof of conformity provided must be taken into account to determine the importance and nature of the inspections to be performed at the time of reception;
- When, for reasons of urgency, the incoming product is released before it has been checked, it must be identified and this release recorded.

Level 1 criterion: No acceptance inspection or tests.

Level 2 criterion: Inspections and tests are performed on reception, but there is no description of the procedures specific to these actions.

Level 3 criterion: The verification of the conformity with the specified requirements is carried out in accordance with a quality plan and/or written procedures. There is no follow-up of the products that have entered without any inspection in the case of urgency.

Level 4 criterion: The verification of the conformity with the specified requirements is carried out in accordance with a quality plan and/or written procedures.
The inspections performed on the subcontractors' premises and the proof of conformity provided are taken into account to determine the importance and nature of the inspections to be performed at the time of reception.
When, for reasons of urgency, the incoming product is released before it has been checked, it is identified and this release is recorded.

Mark : **13.1**

Phase : 4 SYSTEM INTEGRATION

N° : 21

Recommendation : ***Implement a control policy for the risks associated with nonconformities***

Is a policy implemented with a view to identifying, assessing and managing the potential risks associated with nonconformities, not only for the products but also for all the design, scheduling, manufacturing, assembly, inspection processes, etc?

Does this policy take into account the potential risks associated with human factors?

Level 1 criterion: There is no policy implemented with a view to assessing the risks of nonconformity.

Level 2 criterion: A policy is applied with a view to identifying, assessing and managing the potential risks associated with nonconformities, only on the products, but not on all the design, scheduling, manufacturing, assembly, inspection processes, etc.

Level 3 criterion: A policy is applied with a view to identifying, assessing and managing the potential risks associated with nonconformities, not only on the products, but also on all the design, scheduling, manufacturing, assembly, inspection processes, etc.

This policy does not take into account the potential risks associated with human factors.

Level 4 criterion: A policy is applied with a view to identifying, assessing and managing the potential risks associated with nonconformities, not only on the products, but also on all the design, scheduling, manufacturing, assembly, inspection processes, etc.

This policy takes into account the potential risks associated with human factors.

Mark : **10.3**

Phase : 4 SYSTEM INTEGRATION

N° : 37

Recommendation : ***Define the degree of nonconformity***

Is the description of the accepted nonconformity or of the repairs performed recorded to indicate the product's real condition?

· Are written procedures kept up to date defining the following at least?

- The processes for classifying the nonconformities and the control of the utilization of nonconforming components in the finished products.
- The formal authorization process and the area of application for the personnel authorizing the utilization of replacement materials and/or nonconforming products (concession procedures).
- The process for controlling scrapped parts.

Level 1 criterion: There is no indication of the product's degree of nonconformity.

Level 2 criterion: The indication of the products' degree of nonconformity is only implemented as an indication, its goal is not to take the decision concerning the utilization of nonconforming material.

Level 3 criterion: The description of the accepted nonconformity or of the repairs performed is recorded to indicate the product's real condition.
There are written procedures defining the process for classifying the nonconformities and the control of the utilization of nonconforming components in the finished products.
The process for authorizing the personnel to use replacement materials and/or nonconforming products is not formalized.

Level 4 criterion: The description of the accepted nonconformity or of the repairs performed is recorded to indicate the product's real condition.
There are written procedures defining:
- the process for classifying nonconformities and for controlling the utilization of nonconforming components in the finished products.
- the formal authorization process and the area of application for the personnel authorizing the utilization of replacement materials and/or nonconforming products.
- the process for controlling scrapped parts.

Mark : **11.6**

Phase : 4 SYSTEM INTEGRATION

N° : 40

Recommendation : ***Define the means required for the inspections and tests on the product***

The procedures for inspecting and testing the product must specify the resources (human, material), the methods to be implemented, the acceptance criteria, and the methods to be used to record the results.

These procedures must also define the training and, if necessary, specify the qualifications required of the operators.

Level 1 criterion: There are no specified product inspection or test procedures.
There is no description of the acceptance methods and criteria.

Level 2 criterion: The product inspection and test procedures are specified.
The acceptance methods and criteria are described.
The results are not kept.

Level 3 criterion: The product inspection and test procedures are specified. The acceptance methods and criteria are described. The results are not recorded or used for feedback purposes. The procedures also describe the operators' training and qualification.

Level 4 criterion: The product inspection and test procedures are specified.
The acceptance methods and criteria are described.
The results are recorded and used for feedback purposes.
The procedures also describe the operators' training and qualification.

Mark : **8.8**

Phase : 4 SYSTEM INTEGRATION

N° : 44

Recommendation : ***Have available the documents making it possible to perform the incoming check on supplies***

Where applicable, the purchasing documents must include the following:

- the type, category and any other precise identification,
- the title or any another formal identification and the edition applicable to the specifications, drawings, requirements, in terms of processes, inspection instructions and other pertinent technical data,
- the title, identifier and edition of the quality system standard to be applied, the purchasing documents reviewed and approved before distribution concerning their appropriateness with respect to the requirements.

Where applicable, the documented procurement requirements must include the following:

- the customer's tests, examinations, inspections and acceptance conditions and all related instructions or requirements,
- the requirements relative to the specimens (production method, number, storage conditions) for the inspections, investigations or audits, the requirements relative to the notification of problems, to design changes and the approval of their processing.

The customer requirements must be made clear to the suppliers.

Level 1 criterion: No documentation specific to the incoming check of supplies.

Level 2 criterion: The only documents enabling the incoming check of supplies are the product's identification documents.

Level 3 criterion: The purchasing documents include a precise identification, the applicable edition of the specifications, drawings, requirements in terms of processes, inspection instructions and other pertinent technical data, the title, identifier and edition of the quality system standard to be applied, the purchasing documents reviewed and approved before distribution concerning their appropriateness with respect to the requirements.

Level 4 criterion: The purchasing documents include a precise identification, the applicable edition of the specifications, drawings, requirements in terms of processes, inspection instructions and other pertinent technical data, the title, identifier and edition of the quality system standard to be applied, the purchasing documents reviewed and approved before distribution concerning their appropriateness with respect to the requirements.

The documented procurement requirements also include the following:

- the customer's tests, examinations, inspections and acceptance conditions and all related instructions or requirements,
- the requirements relative to the specimens (production method, number, storage conditions) for the inspections, investigations or audits, the requirements relative to the notification of problems, to design changes and the approval of their processing.

The customer requirements are notified to the suppliers

Mark : **10.6**

Phase : 4 SYSTEM INTEGRATION

N° : 53

Recommendation : ***Establish procedures for verifying the conformity of the products with respect to the specified requirements***

Establish written procedures to ensure that the purchased product is conform to the specified requirements.

Define the procurement terms and conditions and the responsibilities of all the people involved.

Check the application of the procedures.

Level 1 criterion: No product conformity procedures with respect to the specified requirements. Nothing formal.

Level 2 criterion: Generic procedures (all products) are defined to ensure the conformity of the purchased product.
Formal proof exists: e.g. note.

Level 3 criterion: Procedures specific to the product are defined in a validated plan for ensuring the conformity of the purchased product. The procurement terms and conditions and the responsibilities of the people involved are not described.

Level 4 criterion: Procedures specific to the product are defined in a validated plan for ensuring the conformity of the purchased product. The procurement terms and conditions and the responsibilities of the people involved are described. There is proof of the assessment of these procedures.

Mark : **13.6**

Phase : 4 SYSTEM INTEGRATION

N° : 55

Recommendation : ***Examine and process the nonconformities***

Is the responsibility relative to the examination and the decision to process nonconforming product defined?

- Is the nonconforming product examined according to written procedures?
- Do these procedures indicate that the nonconforming product can be:
  - reworked to meet the specified requirements?
  - accepted with a concession with or without a repair?
  - declassified for other applications?
  - rejected or scrapped?
- If so required by the contract, is the proposal to use or repair the nonconforming product submitted to the customer or its representative?
- Is the repaired and/or reworked product inspected again in conformity with the requirements of the quality plan and/or of the written procedures?

Level 1 criterion: Nonconforming product is not examined.

Level 2 criterion: Nonconforming product is examined and described but these actions are performed without written procedures.

Level 3 criterion: Nonconforming product is examined and described according to written procedures, but these procedures do not provide for modifications of the product or acceptance without any modifications.

Level 4 criterion: Nonconforming product is examined and described according to written procedures.

- These procedures indicate that the product may be:
  - reworked to meet the specified requirements.
  - accepted under a concession with or without repair.
  - declassified for other applications.
  - rejected or scrapped.
- If so required by the contract, the proposal to use or repair the nonconforming product is submitted to the customer or its representative.
- the repaired and/or reworked product is inspected again in conformity with the requirements of the quality plan and/or of the written procedures.

Mark : **12.2**

Phase : 4 SYSTEM INTEGRATION

N° : 94

Recommendation : ***Identify the documentation for the special processes***

Are the records concerning the processes, equipment and personnel kept up to date?

Level 1 criterion: There is no documentation concerning the special processes.

Level 2 criterion: The associated documentation only concerns the processes, the associated equipment and human resources are not taken into account.

Level 3 criterion: The records concern the processes, equipment and personnel associated with the special processes, but these procedures are not kept up to date.

Level 4 criterion: Records concerning the processes, equipment and personnel are kept up to date.

Mark : **13.1**

Phase : 4 SYSTEM INTEGRATION

N° : 99

Recommendation : Identify the means concerning the special processes

Have the qualification requirements for the process's operations, including the associated equipment and personnel, been specified?

Level 1 criterion: The means concerning the special processes have not been formally identified.

Level 2 criterion: There are documents identifying the technical means dedicated to the special processes. The equipment and personnel associated with these processes have not been defined.

Level 3 criterion: The qualification requirements for the process's operations, including the associated equipment and personnel, have been specified.

Level 4 criterion: The qualification requirements for the process's operations, including the associated equipment and personnel, have been specified. The documents identifying these requirements are regularly updated.

Mark : **11.7**

Phase : 4 SYSTEM INTEGRATION

N° : 101

Recommendation : ***Identify the human resources concerning the special processes***

Are the special processes performed by qualified operators and/or are they subject to continual monitoring and a control of the process's parameters to guarantee the conformity with the stipulated requirements?

Level 1 criterion: The special processes are not associated with qualified human resources.

Level 2 criterion: The special processes are performed by operators who have been trained but their skills are not subject to regular verification.

Level 3 criterion: The special processes are performed by qualified operators or are subject to continual monitoring.

Level 4 criterion: The special processes are performed by qualified operators and are subject to continual monitoring.

Mark : **9.6**

Phase : 4 SYSTEM INTEGRATION

N° : 112

Recommendation : ***Control the appropriateness of the inspection, measuring and test equipment with respect to the requirements***

Is the inspection, measuring and test equipment used in such a way as to ensure that the measurement uncertainty is known and compatible with the required capability in terms of measuring?

Are the test software or the comparison baselines used as the means of inspection verified before being put into service to demonstrate that they are capable of checking that the product is acceptable?

Level 1 criterion: There is no procedure defining the appropriateness of the inspection, measuring and test equipment with respect to the requirements.

Level 2 criterion: There are procedures defining the appropriateness of the inspection, measuring and test equipment with respect to the requirements. There is no check to ensure that they are taken into account.

Level 3 criterion: The inspection, measuring and test equipment are used in such a way as to ensure that the measurement uncertainty is known and is compatible with the required capability in terms of measuring. The inspection equipment is not subject to a verification before being put into service.

Level 4 criterion: The inspection, measuring and test equipment are used in such a way as to ensure that the measurement uncertainty is known and is compatible with the required capability in terms of measuring.
The test software or the comparison baselines used as the means of inspection are verified before being put into service to demonstrate that they are capable of checking that the product is acceptable.
Systematic verification before utilization is industrially impossible but metrological procedures are used (validation period and definition of the class of instruments in the test procedure). The class is defined at an earlier stage.

Mark : **7.9**

Phase : 4 SYSTEM INTEGRATION

N° : 113

Recommendation : ***Control the environment of the inspection, measuring and test equipment***

Do the handling, preservation and storage of the inspection and measuring equipment make it possible to ensure that the exactness and aptitude for use are maintained?

Is the inspection, measuring and test equipment, including the test benches and test software, protected against any manipulations that would invalidate the calibration settings?

Level 1 criterion: The environment of the inspection, measuring and test equipment is not taken into account.

Level 2 criterion: The inspection, measuring and test equipment is protected against any aggressions that could deteriorate it.

Level 3 criterion: The inspection, measuring and test equipment is protected against any aggressions that could deteriorate it; it is also protected against any manipulations that would invalidate the calibration settings. The handling, preservation and storage of the inspection equipment are not, however, defined by strict procedures.

Level 4 criterion: The inspection, measuring and test equipment is protected against any aggressions that could deteriorate it; it is also protected against any manipulations that would invalidate the calibration settings. The handling, preservation and storage of the inspection equipment are defined by strict procedures.

Mark : **9.6**

Phase : 4 SYSTEM INTEGRATION

N° : 114

Recommendation : ***Control the workplace environment***

When the workplace environment is important for the quality of the product, appropriate limits must be specified, controlled and verified (workshop layout, workstation ergonomics, etc).

Level 1 criterion: The workplace environment is not taken into account for the processing of the equipment. The layout of the workshops is not carried out according to the products being processed.

Level 2 criterion: The workstations are specific to the equipment, and the working environment is controlled.

Level 3 criterion: The workstations are specific to the equipment.
The working environment is controlled and checked.

Level 4 criterion: The workstations are suited to the specific needs of the equipment.
The working environment is controlled and checked.
The layout of the workshops makes it possible to optimize maintenance

Mark : **12.2**

Phase : 4 SYSTEM INTEGRATION

N° : 117

Recommendation : ***Control the documentation***

Store and preserve the product and process documentation placed at the disposal of the workshop.

Regularly draw up an inventory of the documentation.
Periodically update the documentation.
Train a workshop personnel entity in the area of technical documentation management.

Possess technical documentation relative to the products.
Possess documentation specific to the maintenance inspections and tests.
Associate this product technical documentation with the processes implemented.
When the documents are supplied, analyze the validity of this product documentation.

Possess process control documentation.
Specify technical documentations for each process.
Make this process documentation available and usable.

Possess documentation specific to the inspection and tests.

Level 1 criterion: No documentation specific to the products or processes, there are no means in place for making specific documentation available.

Level 2 criterion: The documentation specific to the products or processes exists, however its updating is not always effective, the validity of the documents is not analyzed.

Level 3 criterion: The documentation specific to the products or processes exists, its updating is periodic and planned, the validity of the documents used is not analyzed.

Level 4 criterion: The documentation specific to the products or processes exists, its updating is periodic and planned, the validity of the documents used is analyzed.

Precise procedures for storing and preserving the documentation are implemented.

Mark : **9.3**

Phase : 4 SYSTEM INTEGRATION

N° : 107

Recommendation : ***Control the product inspection and test documentation***

It is necessary to establish and keep up to date written inspection and test procedures in order to verify that the requirements specified for the product are complied with.

Level 1 criterion: No documentation concerning the inspections and tests performed on the product.

Level 2 criterion: The documentation concerning the product inspections and tests are limited to the test program: it contains the reference to the specifications of the equipment to be tested, the references of the equipment to be tested, the traceability of the test program, the framework of the test, the functions to be tested.
There is no formalism concerning the test report.

Level 3 criterion: The documentation includes a program, and a test report which, besides the information on the test itself, contains all of the results with a list of the problems outstanding at the end of the test.

Level 4 criterion: The documentation includes a program, the test report, the specifications of the test means and the definition of the test means.

Mark : **10.5**

Phase : 4 SYSTEM INTEGRATION

N° : 108

Recommendation : ***Control the production equipment, the tools and the programmable machines***

Make sure that for all the production equipment, tools and programs, there are written procedures describing the following activities:
- validation before utilization,
- maintenance,
- periodic check according to written procedures,

Level 1 criterion: The tools are not subject to any check or validation before being used.

Level 2 criterion: The tools are subject to checks before being used, but these checks are not all formalized.

Level 3 criterion: The periodic check of the tools is subject to validation, there are formal procedures identifying the periodic checks to be performed.

Level 4 criterion: The periodic check of the tools is subject to validation, there are formal procedures identifying the periodic actions and checks to be performed.
There are formal procedures describing tool maintenance.

Mark : **13.9**

Phase : 4 SYSTEM INTEGRATION

N° : 123

Recommendation : ***Control the changes made to processes***

A clear designation of the people authorized to approve changes to process must exist.

Changes requiring customer acceptance must be identified before being applied.

Any change concerning the processes, production equipment, tools and programs, must be documented and must generate a procedure for controlling its implementation.

Is a check performed to verify that the results of the process changes produce the required effect and that these changes do not alter the quality of the product?

Level 1 criterion: Changes are made to processes without being recorded; these modifications are not subject to any authorization.

Level 2 criterion: Changes made to processes are recorded and are subject to authorization.
These changes are not documented, they do not generate any procedure for controlling their implementation.

Level 3 criterion: Changes made to processes are recorded, the people authorized to approve the changes made to production processes are clearly designated.
Changes requiring customer acceptance are identified before any application.
All changes concerning the processes, the production equipment, tools and programs, are documented and generate a procedure for controlling its implementation.
However, it is not systematically verified that the results of changes made to processes produce the required effect or that these changes do not alter the quality of the product.

Level 4 criterion: Changes made to processes are recorded, the people authorized to approve the changes made to production processes are clearly designated.
Changes requiring customer acceptance are identified before any application.
All changes concerning the processes, the production equipment, tools and programs, are documented and generate a procedure for controlling its implementation.
It is systematically verified that the results of changes made to processes produce the required effect and that these changes do not alter the quality of the product.

Mark : **6.5**

Phase : 4 SYSTEM INTEGRATION

N° : 109

Recommendation : ***Control the handling, storage, conditioning, preservation and delivery operations***

There must be a procedure taking into account, at the various steps of the phase and, if applicable, in conformity with the manufacturer's recommendations and/or the applicable regulation, the requirements for:
- cleaning
- preventing, detecting and removing foreign matter
- handling suited to sensitive products
- marking and labeling, including the safety marking
- controlling shelf lives and stock rotations
- dangerous materials

· Establish specific procedures for managing perishable articles
· Eliminate all expired or unidentified products
· Propose criteria for assessing and analyzing the quality of the storage conditions
· List and analyze the defects linked to non-quality in storage

Level 1 criterion: The handling, storage, conditioning, preservation and delivery conditions are not codified, the accomplishment of these operations is not perfectly controlled.

Level 2 criterion: The handling, storage, conditioning, preservation and delivery conditions are codified, they give rise to procedures that can be adapted to all of the equipment.
The accomplishment of these operations is not specific to one item of equipment.

Level 3 criterion: The handling, storage, conditioning, preservation and delivery conditions are codified, they give rise to procedures specific to the equipment.

Level 4 criterion: The handling, storage, conditioning, preservation and delivery conditions are codified, they give rise to procedures specific to the equipment.
Considerations such as expiry, sensitivity of products to stress, the dangerousness of products are also codified and implemented.

Mark : **14.4**

Phase : 4 SYSTEM INTEGRATION

N° : 124

Recommendation : ***Control the special processes***

When the production operations involve special processes:

- are the special processes to be implemented identified?
- has the supplier checked that all the special process parameters (e.g. materials, personnel, procedures and software) produce the appropriate results?
- has the supplier identified and documented the significant operations and the parameters of the process to be controlled in production?
- during the production phase, are all the modifications made to these operations and parameters subject to a proposal justifying the modification and guaranteeing that it does not introduce any negative effect on the result of the process?
- has the supplier checked the special processes by making one or more standard parts under the conditions defined for the production phase?
- are the special processes or is the subcontracting of the special process qualified before being used?
- does the supplier keep up to date qualified special processes?

Level 1 criterion: The special processes are not identified.

Level 2 criterion: The special processes are identified. The parameters of these processes (materials, personnel, procedures and software) are assessed. These processes are not documented, or defined by strict procedures.

Level 3 criterion: The special processes are identified. The parameters of these processes (materials, personnel, procedures and software) are assessed.

- the significant operations and the parameters of the process to be controlled in production have been identified and documented.
- during the production phase, all the modifications made to these operations and parameters are subject to a proposal justifying the modification and guaranteeing that it does not introduce any negative effect on the result of the process.
- the special processes have not been verified by making one or more standard parts under given conditions.

Level 4 criterion: The special processes are identified.

- it is verified that all the parameters of the special processes (e.g. materials, personnel, procedures and software) produce the appropriate results.
- the significant operations and the parameters of the process to be controlled in production have been identified and documented.
- during the production phase, all the modifications made to these operations and parameters are subject to a proposal justifying the modification and guaranteeing that it does not introduce any negative effect on the result of the process.
- the special processes have been verified by making one or more standard parts under given conditions.
- the special processes or the subcontracting of the special process are qualified before being used.

Mark : **10.1**

Phase : 4 SYSTEM INTEGRATION

N° : 110

Recommendation : ***Control the workplace's services and fluids***

When they have an influence on the quality and reliability of the product, the services and supplies such as the water, compressed air, electricity and chemical products used must be controlled and verified regularly to ensure that their effect on the process is constant.

Level 1 criterion: The services and supplies such as the water, compressed air, electricity and chemical products are not subject to any verification

Level 2 criterion: The services and supplies such as the water, compressed air, electricity and chemical products are checked on a one-off basis and when a problem is detected (see ISO 14000).

Level 3 criterion: The services and supplies such as the water, compressed air, electricity and chemical products used are controlled and checked periodically to ensure that their effect on the process is constant.

Level 4 criterion: The services and supplies such as the water, compressed air, electricity and chemical products used are controlled and checked continuously to ensure that their effect on the process is constant.

Mark : **18.4**

Phase : 4 SYSTEM INTEGRATION

N° : 208

Recommendation : ***Put in place counter-ESD protections for subassemblies during handling and storage***

Put in place counter-ESD protections for the subassemblies during handling and storage.

Level 1 criterion: Counter-ESD protection is not covered.

Level 2 criterion: The counter-ESD protection is subject to non-formalized rules and practices.

Level 3 criterion: The counter-ESD protection is subject to validated procedures defining recognized practices for protecting the subassemblies.

Level 4 criterion: The counter-ESD protection is subject to validated procedures whose follow-up control is effective.

Mark : **5.3**

Phase : 4 SYSTEM INTEGRATION

N° : 160

Recommendation : ***Have the inspection and test records in your possession***

Are records established and kept that provide the proof that the product has undergone the inspections and/or tests in conformity with the criteria that have been defined?

- do the records make it possible to identify the person who performed the inspections and authorized the product's release?
- do the test records indicate the measured values when they are required by the specification or the acceptance plan?
- If so specified, can the supplier demonstrate product qualification?

Level 1 criterion: There are no records of the inspections and tests.

Level 2 criterion: Records of the inspections and tests are established but are not kept.

Level 3 criterion: Records of the inspections and tests are established and kept but they do not make it possible to identify the inspection source (people, machine)

Level 4 criterion: There are records proving that the product has undergone the inspections and/or the tests in conformity with the criteria that have been defined.
The records make it possible to identify the person who performed the inspections and authorized the product's release.
The test records indicate the values measured when they are required by the specification or the acceptance plan.

Mark : **5.7**

Phase : 4 SYSTEM INTEGRATION

N° : 161

Recommendation : Have an inspection dossier in your possession

The inspection dossier must contain:

- the acceptance or refusal criteria,
- a sequential list of inspection and test operations to be performed,
- the documents for recording the results of the inspections,
- a list of the specific and non-specific inspection instruments,
- the documents associated with the specific inspection instruments making it possible to design, produce, validate, manage, use and maintain them.

Level 1 criterion: No inspection dossier.

Level 2 criterion: The inspection dossier is limited to the definition of the acceptance or refusal criteria.

Level 3 criterion: The inspection dossier defines the acceptance or refusal criteria, along with the list of operations to be performed. It proposes documents for recording the inspection results.

Level 4 criterion: The inspection dossier contains:

- the definition of the acceptance or refusal criteria.
- the sequential list of inspection and test operations to be performed.
- the documents for recording the results of the inspections,
- the list of the specific and non-specific inspection instruments,
- the documents associated with the specific inspection instruments making it possible to design, produce, validate, manage, use and maintain them.

Mark : **11.1**

Phase : 4 SYSTEM INTEGRATION

N° : 163

Recommendation : ***Have the documentation specific to the non-conformity in your possession***

The nonconformity documents must give:

- the product's identification,
- the description of the nonconformity,
- the cause of the nonconformity,
- the actions taken to avoid the recurrence of the nonconformity,
- the reworking or repairs if necessary,
- the inspection of the characteristics affected by the reworking or repairs,
- the final decision.

Level 1 criterion: There is no documentation specific to the nonconformity.

Level 2 criterion: The documentation specific to the nonconformity only serves to identify the nonconforming product.

Level 3 criterion: The nonconformity documents give the product's identification, the description of the nonconformity, and the cause of the nonconformity.
However the actions are not formalized to avoid the recurrence of the nonconformity, the reworking or repairs if necessary and the check of the characteristics affected by the reworking or repairs,

Level 4 criterion: The nonconformity documents give the product's identification, the description of the nonconformity, and the cause of the nonconformity.
Actions are formalized to avoid the recurrence of the nonconformity, the reworking or repairs if necessary and the check of the characteristics affected by the reworking or repairs is performed.

Mark : **8.6**

Phase : 4 SYSTEM INTEGRATION

N° : 202

Recommendation : ***Check the conformity of purchased products***

Implement measures for verifying purchased products, such as :

- examination of the required documentation,
- inspection and audit of the purchase source,
- examination of the products at the delivery.

Level 1 criterion: The conformity of the purchased products is not checked.

Level 2 criterion: The conformity of the purchased products is only checked by examining the required documentation.

Level 3 criterion: The conformity of the purchased products is only checked by examining the products at delivery and by examining the required documentation.

Level 4 criterion: The conformity of the purchased products is checked by examining the products at delivery, examining the required documentation and by inspecting and auditing the purchase source.

Mark : **9.9**

Phase : 5 OPERATION AND MAINTENANCE

N° : 7

Recommendation : ***Ensure handling***

Are there methods and means for handling the product that prevent it from being damaged or deteriorated?

- Define and specify the transport procedures.
- Individualize the handling modes.

Level 1 criterion: The handling methods have not been defined, there are no specific means for preventing deterioration when the product is handled.

Level 2 criterion: General handling constraints have been defined, they are not specific to a piece of equipment.

Level 3 criterion: Handling methods specific to a piece of equipment have been defined, and specific means are made available to prevent any deterioration during the handling operations.
There is no verification of their application

Level 4 criterion: Product handling procedures have been specifically defined, associated means are in place to make it possible to avoid any deterioration of the product when it is being handled. Verifications of the application of these methods are performed.

Mark : **17.5**

Phase : 5 OPERATION AND MAINTENANCE

N° : 8

Recommendation : Ensure the implementation of the corrective actions

Do the procedures relative to the corrective actions include the following?

- Effective processing of customer complaints and of product nonconformity reports.
- The search for the causes of nonconformities relative to the product, process and quality system and the recording of the results of that search.
- The determination of the corrective actions necessary for eliminating the causes of nonconformities.
- The application of the means of control for ensuring that the corrective action is implemented and that it produces the required effect.

Level 1 criterion: There are no procedures relative to the corrective actions.

Level 2 criterion: Corrective actions are implemented relative to customer complaints or nonconformity reports, but they are not formalized.

Level 3 criterion: The procedures relative to the corrective actions include:
- the effective processing of customer complaints and of product nonconformity reports.
- the search for the causes of nonconformities relative to the product, process and quality system and the recording of the results of that search.
- the determination of the corrective actions necessary for eliminating the causes of nonconformities. These procedures do not define the application of the means of control for ensuring that the corrective action is implemented and produces the required effect.

Level 4 criterion: The procedures relative to the corrective actions include:
- the effective processing of customer complaints and of product nonconformity reports.
- the search for the causes of nonconformities relative to the product, process and quality system and the recording of the results of that search.
- the determination of the corrective actions necessary for eliminating the causes of nonconformities.
- the application of the means of control to ensure that the corrective action is implemented and that it produces the required effect.

Mark : **17.7**

Phase : 5 OPERATION AND MAINTENANCE

N° : 9

Recommendation : Ensure the implementation of the preventive actions

Do the procedures relative to the preventive actions include the following?:

- The utilization of appropriate sources of information such as the processes and operations affecting the quality of the product, concessions, audit results, quality-related records, maintenance reports and customer complaints, to make it possible to detect, analyze and eliminate the potential causes of nonconformities.

- The determination of appropriate steps for processing any problem requiring a preventive action.
- The triggering of preventive actions and the application of the means of control to ensure that they produce the required effect.
- The assurance that pertinent information relative to the actions implemented is submitted to the management review.

Level 1 criterion: No procedure relative to the preventive actions is implemented.

Level 2 criterion: The procedures relative to the preventive actions include:

- The utilization of appropriate sources of information such as the processes and operations affecting the quality of the product, concessions, audit results, quality-related records, maintenance reports and customer complaints, to make it possible to detect, analyze and eliminate the potential causes of nonconformities.
- The determination of appropriate steps for processing any problem requiring a preventive action.
- The application of means making it possible to ensure that the preventive actions produce their effect is not ensured.

Level 3 criterion: The procedures relative to the preventive actions include:

- The utilization of appropriate sources of information such as the processes and operations affecting the quality of the product, concessions, audit results, quality-related records, maintenance reports and customer complaints, to make it possible to detect, analyze and eliminate the potential causes of nonconformities.
- The determination of appropriate steps for processing any problem requiring a preventive action.
- The triggering of preventive actions and the application of the means of control to ensure that they produce the required effect.
- The assurance that pertinent information relative to the actions implemented is not valid.

Level 4 criterion: The procedures relative to the preventive actions include:

- The utilization of appropriate sources of information such as the processes and operations affecting the quality of the product, concessions, audit results, quality-related records, maintenance reports and customer complaints, to make it possible to detect, analyze and eliminate the potential causes of nonconformities.
- The determination of appropriate steps for processing any problem

requiring a preventive action.

- The triggering of preventive actions and the application of the means of control to ensure that they produce the required effect.
- The assurance that pertinent information relative to the actions implemented is submitted to the management review.

Mark : **13.8**

Phase : 5 OPERATION AND MAINTENANCE

N° : 11

Recommendation : ***Ensure preservation***

Are the packing, preservation and marking processes controlled to ensure conformity with the specified requirements?

- Draw up a list of equipment requiring preservation.
- Propose a means of managing the specific preservations by product (dates, modes, duration, etc.).
- Periodically check the quality of the preservations.
- Use appropriate preservation that is specific to the products.

Level 1 criterion: The preservation of the equipment is not defined, the materials used for this preservation are used according to their availability.
The information on the preservation dates, management methods, inspections to be performed is not provided.

Level 2 criterion: Standard means of preservation are used for the equipment.
Information relative to the preservation is not provided.
There are no specific verifications performed on the preservations.

Level 3 criterion: Specific preservation is provided for the product and there is associated documentation.
There are no specific verifications performed on the preservations.

Level 4 criterion: Specific preservation is provided for the product and there is associated documentation.
Regular specific verifications are performed on the preservations.
There is a procedure for regularly checking the application of the periodic verifications.

Mark : **15.6**

Phase : 5 OPERATION AND MAINTENANCE

N° : 12

Recommendation : ***Ensure storage***

Are designated storage areas or premises used to prevent any damage or deterioration of the product?

- Are appropriate measures taken to authorize reception in these areas and shipping from them?
- Is the condition of the product in stock assessed at appropriate intervals in order to detect any deterioration?
- Manage and check the storage area atmospheres.
- Individualize the positioning in storage.
- Manage the periodic interventions making it possible to maintain the product's characteristics in storage (powering up, etc.).

Level 1 criterion: The equipment storage areas are not specific, the storage environment is not taken into account.

Level 2 criterion: The equipment storage areas are not specific, the storage environment is controlled and suited to the stored products.

Level 3 criterion: The equipment storage areas are specific.
The storage environment is controlled and suited to the stored products.
The storage positions are individualized.
The periodic interventions making it possible to maintain the product's characteristics are performed.

Level 4 criterion: The equipment storage areas are specific.
The storage environment is controlled and suited to the stored products.
The storage positions are individualized.
The periodic interventions making it possible to maintain the product's characteristics are performed.
The condition of the products in store is regularly checked, the stock is verified and the storage conditions are regularly optimized.

Mark : **9.2**

Phase : 5 OPERATION AND MAINTENANCE

N° : 13

Recommendation : ***Ensure product traceability***

When traceability is required, the system implemented must make it possible to: maintain the product's identification throughout the life cycle, know the history (design dossier + changes) and the destination (deliveries, scrapping) of all the products manufactured from the same batch of raw materials or from the same manufacturing batch, find the identity of an assembly's component parts and of the components of the next higher assembly, find the sequential documentation relative to the production (manufacturing, assembly, inspection) of any given product (e.g. configuration follow-up sheet with recording of the operations performed and of any problems observed).

The traceability system must make it possible to know the configuration of the product ready to be delivered, including any deviations between the real condition and the stipulated condition.

Level 1 criterion: No traceability of the product during its life cycle, the product is identified in a unique way by its marking.

Level 2 criterion: There is traceability making it possible to identify the product but it does not make it possible to know its origin or history.

Level 3 criterion: There is traceability making it possible to identify the product and know its history (Design Dossier + changes), however it does not make it possible to know what documentation is associated with its life cycle (e.g. no configuration follow-up sheet with recording of the operations performed and of the problems observed).

Level 4 criterion: There is traceability making it possible to identify the product and know its history (Design Dossier + changes), including the components – e.g. Date Code.
It makes it possible to know what documentation is associated with its life cycle (e.g. configuration follow-up sheet with recording of the operations performed and of the problems observed).
Exhaustive application of the recommendation.

Mark : **11.2**

Phase : 5 OPERATION AND MAINTENANCE

N° : 15

Recommendation : Ensure the inspections and tests during the phase

The product must be inspected during the phase and be subject to tests in accordance with the quality plan and/or the written procedures.

The product must remain blocked until the required inspections and tests have been completed or until the required reports have been received and checked.

Level 1 criterion: No inspection or tests during the phase.

Level 2 criterion: Inspections are performed during the phase, but they are not formalized in the form of written procedures or of a quality plan.

Level 3 criterion: Inspections are performed during the phase, and they are formalized in the form of written procedures or of a quality plan. The completeness of these inspections and tests is not always effective.

Level 4 criterion: Inspections are performed during the phase, and they are formalized in the form of written procedures or of a quality plan. The completeness of these inspections and tests is effective.

Mark : **10.4**

Phase : 5 OPERATION AND MAINTENANCE

N° : 16

Recommendation : ***Perform the final inspections and tests***

Perform all the final inspections and tests in accordance with the quality plan and/or the written procedures

- Do the quality plan and/or the procedures for the final inspections and tests require that all the specified inspections and tests, including those specified for acceptance of the product, should be performed and be conform with the requirements?
- Is it checked before delivery that:
  - all the activities specified in the quality plan and/or the written procedures have been satisfactorily accomplished?
  - the data and the associated documentation are available and have been accepted?

Level 1 criterion: No final inspection or tests.

Level 2 criterion: Final inspections and tests are performed, but they are not described in strict procedures or in a quality plan.

Level 3 criterion: Final inspections and tests are performed, and they are described in strict procedures or in a quality plan. The application of these inspections and tests is not verified and validated.

Level 4 criterion: Final inspections and tests are performed in accordance with the quality plan and/or written procedures.

- The quality plan and/or the procedures for the final inspections and tests require that all the specified inspections and tests, including those specified for acceptance of the product or during its manufacture, should be performed and that all the results should be conform to the requirements.
- It is verified before delivery that:
  - all the activities specified in the quality plan and/or the written procedures have been satisfactorily accomplished.
  - the data and the associated documentation are available (document of the follow-up sheet type which records the configuration, the operations performed and the problems observed) and have been accepted.

Mark : **16.3**

Phase : 5 OPERATION AND MAINTENANCE

N° : 21

Recommendation : ***Implement a control policy for the risks associated with nonconformities***

Is a policy implemented with a view to identifying, assessing and managing the potential risks associated with nonconformities, not only for the products but also for all the design, scheduling, manufacturing, assembly, inspection processes, etc?

Does this policy take into account the potential risks associated with human factors?

Level 1 criterion: There is no policy implemented with a view to assessing the risks of nonconformity.

Level 2 criterion: A policy is applied with a view to identifying, assessing and managing the potential risks associated with nonconformities, on the products only, but not on all the design, scheduling, manufacturing, assembly, inspection processes, etc.

Level 3 criterion: A policy is applied with a view to identifying, assessing and managing the potential risks associated with nonconformities, not only on the products, but also on all the design, scheduling, manufacturing, assembly, inspection processes, etc.

This policy does not take into account the potential risks associated with human factors.

Level 4 criterion: A policy is applied with a view to identifying, assessing and managing the potential risks associated with nonconformities, not only on the products, but also on all the design, scheduling, manufacturing, assembly, inspection processes, etc.

This policy takes into account the potential risks associated with human factors.

Mark : **12.8**

Phase : 5 OPERATION AND MAINTENANCE

N° : 37

Recommendation : ***Define the degree of nonconformity***

Is the description of the accepted nonconformity or of the repairs performed recorded to indicate the product's real condition?

· Are written procedures kept up to date defining the following at least?

- The processes for classifying the nonconformities and the control of the utilization of nonconforming components in the finished products.
- The formal authorization process and the area of application for the personnel authorizing the utilization of replacement materials and/or nonconforming products (concession procedures).
- The process for controlling scrapped parts.

Level 1 criterion: There is no indication of the product's degree of nonconformity.

Level 2 criterion: The indication of the products' degree of nonconformity is only implemented as an indication, its goal is not to take the decision concerning the utilization of nonconforming material.

Level 3 criterion: The description of the accepted nonconformity or of the repairs performed is recorded to indicate the product's real condition.
There are written procedures defining the process for classifying the nonconformities and the control of the utilization of nonconforming components in the finished products.
The process for authorizing the personnel to use replacement materials and/or nonconforming products is not formalized.

Level 4 criterion: The description of the accepted nonconformity or of the repairs performed is recorded to indicate the product's real condition.
There are written procedures defining:
- the process for classifying nonconformities and for controlling the utilization of nonconforming components in the finished products.
- the formal authorization process and the area of application for the personnel authorizing the utilization of replacement materials and/or nonconforming products.
- the process for controlling scrapped parts.

Mark : **14.3**

Phase : 5 OPERATION AND MAINTENANCE

N° : 40

Recommendation : ***Define the means required for the inspections and tests on the product***

The procedures for inspecting and testing the product must specify the resources (human, material), the methods to be implemented, the acceptance criteria, and the methods to be used to record the results.

These procedures must also define the training and, if necessary, specify the qualifications required of the operators.

Level 1 criterion: There are no specified product inspection or test procedures.
There is no description of the acceptance methods and criteria.

Level 2 criterion: The product inspection and test procedures are specified.
The acceptance methods and criteria are described.
The results are not kept.

Level 3 criterion: The product inspection and test procedures are specified. The acceptance methods and criteria are described. The results are not recorded or used for feedback purposes. The procedures also describe the operators' training and qualification.

Level 4 criterion: The product inspection and test procedures are specified.
The acceptance methods and criteria are described.
The results are recorded and used for feedback purposes.
The procedures also describe the operators' training and qualification.

Mark : **9.9**

Phase : 5 OPERATION AND MAINTENANCE

N° : 44

Recommendation : ***Have available the documents making it possible to perform the incoming check on supplies***

Where applicable, the purchasing documents must include the following:

- the type, category and any other precise identification,
- the title or any another formal identification and the edition applicable to the specifications, drawings, requirements, in terms of processes, inspection instructions and other pertinent technical data,
- the title, identifier and edition of the quality system standard to be applied, the purchasing documents reviewed and approved before distribution concerning their appropriateness with respect to the requirements.

Where applicable, the documented procurement requirements must include the following:

- the customer's tests, examinations, inspections and acceptance conditions and all related instructions or requirements,
- the requirements relative to the specimens (production method, number, storage conditions) for the inspections, investigations or audits, the requirements relative to the notification of problems, to design changes and the approval of their processing.

The customer requirements must be made clear to the suppliers.

Level 1 criterion: No documentation specific to the incoming check of supplies.

Level 2 criterion: The only documents enabling the incoming check of supplies are the product's identification documents.

Level 3 criterion: The purchasing documents include a precise identification, the applicable edition of the specifications, drawings, requirements in terms of processes, inspection instructions and other pertinent technical data, the title, identifier and edition of the quality system standard to be applied, the purchasing documents reviewed and approved before distribution concerning their appropriateness with respect to the requirements.

Level 4 criterion: The purchasing documents include a precise identification, the applicable edition of the specifications, drawings, requirements in terms of processes, inspection instructions and other pertinent technical data, the title, identifier and edition of the quality system standard to be applied, the purchasing documents reviewed and approved before distribution concerning their appropriateness with respect to the requirements.

The documented procurement requirements also include the following:

- the customer's tests, examinations, inspections and acceptance conditions and all related instructions or requirements,
- the requirements relative to the specimens (production method, number, storage conditions) for the inspections, investigations or audits, the requirements relative to the notification of problems, to design changes and the approval of their processing.

The customer requirements are notified to the suppliers

Mark : **6.8**

Phase : 5 OPERATION AND MAINTENANCE

N° : 53

Recommendation : Establish procedures for verifying the conformity of the products with respect to the specified requirements

Establish written procedures to ensure that the purchased product is conform to the specified requirements.

Define the procurement terms and conditions and the responsibilities of all the people involved.

Check the application of the procedures.

Level 1 criterion: No product conformity procedures with respect to the specified requirements. Nothing formal.

Level 2 criterion: Generic procedures (all products) are defined to ensure the conformity of the purchased product.
Formal proof exists: e.g. note.

Level 3 criterion: Procedures specific to the product are defined in a validated plan for ensuring the conformity of the purchased product. The procurement terms and conditions and the responsibilities of the people involved are not described.

Level 4 criterion: Procedures specific to the product are defined in a validated plan for ensuring the conformity of the purchased product. The procurement terms and conditions and the responsibilities of the people involved are described. There is proof of the assessment of these procedures.

Mark : **17.0**

Phase : 5 OPERATION AND MAINTENANCE

N° : 55

Recommendation : ***Examine and process the nonconformities***

Is the responsibility relative to the examination and the decision to process nonconforming product defined?

- Is the nonconforming product examined according to written procedures?
- Do these procedures indicate that the nonconforming product can be:
  - reworked to meet the specified requirements?
  - accepted with a concession with or without a repair?
  - declassified for other applications?
  - rejected or scrapped?
- If so required by the contract, is the proposal to use or repair the nonconforming product submitted to the customer or its representative?
- Is the repaired and/or reworked product inspected again in conformity with the requirements of the quality plan and/or of the written procedures?

Level 1 criterion: Nonconforming product is not examined.

Level 2 criterion: Nonconforming product is examined and described but these actions are performed without written procedures.

Level 3 criterion: Nonconforming product is examined and described according to written procedures, but these procedures do not provide for modifications of the product or acceptance without any modifications.

Level 4 criterion: Nonconforming product is examined and described according to written procedures.

- These procedures indicate that the product may be:
  - reworked to meet the specified requirements.
  - accepted under a concession with or without repair.
  - declassified for other applications.
  - rejected or scrapped.
- If so required by the contract, the proposal to use or repair the nonconforming product is submitted to the customer or its representative.
- The repaired and/or reworked product is inspected again in conformity with the requirements of the quality plan and/or of the written procedures.

Mark : **12.2**

Phase : 5 OPERATION AND MAINTENANCE

N° : 94

Recommendation : ***Identify the documentation for the special processes***

Are the records concerning the processes, equipment and personnel kept up to date?

Level 1 criterion: There is no documentation concerning the special processes.

Level 2 criterion: The associated documentation only concerns the processes, the associated equipment and human resources are not taken into account.

Level 3 criterion: The records concern the processes, equipment and personnel associated with the special processes, but these procedures are not kept up to date.

Level 4 criterion: Records concerning the processes, equipment and personnel are kept up to date.

Mark : **13.1**

Phase : 5 OPERATION AND MAINTENANCE

N° : 99

Recommendation : Identify the means concerning the special processes

Have the qualification requirements for the process's operations, including the associated equipment and personnel, been specified?

Level 1 criterion: The means concerning the special processes have not been formally identified.

Level 2 criterion: There are documents identifying the technical means dedicated to the special processes. The equipment and personnel associated with these processes have not been defined.

Level 3 criterion: The qualification requirements for the process's operations, including the associated equipment and personnel, have been specified.

Level 4 criterion: The qualification requirements for the process's operations, including the associated equipment and personnel, have been specified. The documents identifying these requirements are regularly updated.

Mark : **13.7**

Phase : 5 OPERATION AND MAINTENANCE

N° : 101

Recommendation : ***Identify the human resources concerning the special processes***

Are the special processes performed by qualified operators and/or are they subject to continual monitoring and a control of the process's parameters to guarantee the conformity with the stipulated requirements?

Level 1 criterion: The special processes are not associated with qualified human resources.

Level 2 criterion: The special processes are performed by operators who have been trained but their skills are not subject to regular verification.

Level 3 criterion: The special processes are performed by qualified operators or are subject to continual monitoring.

Level 4 criterion: The special processes are performed by qualified operators and are subject to continual monitoring.

Mark : **11.3**

Phase : 5 OPERATION AND MAINTENANCE

N° : 112

Recommendation : ***Control the appropriateness of the inspection, measuring and test equipment with respect to the requirements***

Is the inspection, measuring and test equipment used in such a way as to ensure that the measurement uncertainty is known and compatible with the required capability in terms of measuring?

Are the test software or the comparison baselines used as the means inspection verified before being put into service to demonstrate that they are capable of checking that the product is acceptable?

Level 1 criterion: There is no procedure defining the appropriateness of the inspection, measuring and test equipment with respect to the requirements.

Level 2 criterion: There are procedures defining the appropriateness of the inspection, measuring and test equipment with respect to the requirements. There is no check to ensure that they are taken into account.

Level 3 criterion: The inspection, measuring and test equipment are used in such a way as to ensure that the measurement uncertainty is known and is compatible with the required capability in terms of measuring. The inspection equipment is not subject to a verification before being put into service.

Level 4 criterion: The inspection, measuring and test equipment are used in such a way as to ensure that the measurement uncertainty is known and is compatible with the required capability in terms of measuring.
The test software or the comparison baselines used as the means of inspection are verified before being put into service to demonstrate that they are capable of checking that the product is acceptable.
Systematic verification before utilization is industrially impossible but metrological procedures are used (validation period and definition of the class of instruments in the test procedure). The class is defined at an earlier stage.

Mark : **11.7**

Phase : 5 OPERATION AND MAINTENANCE

N° : 113

Recommendation : ***Control the environment of the inspection, measuring and test equipment***

Do the handling, preservation and storage of the inspection and measuring equipment make it possible to ensure that the exactness and aptitude for use are maintained?

Is the inspection, measuring and test equipment, including the test benches and test software, protected against any manipulations that would invalidate the calibration settings?

Level 1 criterion: The environment of the inspection, measuring and test equipment is not taken into account.

Level 2 criterion: The inspection, measuring and test equipment is protected against any aggressions that could deteriorate it.

Level 3 criterion: The inspection, measuring and test equipment is protected against any aggressions that could deteriorate it; it is also protected against any manipulations that would invalidate the calibration settings. The handling, preservation and storage of the inspection equipment are not, however, defined by strict procedures.

Level 4 criterion: The inspection, measuring and test equipment is protected against any aggressions that could deteriorate it; it is also protected against any manipulations that would invalidate the calibration settings. The handling, preservation and storage of the inspection equipment are defined by strict procedures.

Mark : **10.8**

Phase : 5 OPERATION AND MAINTENANCE

N° : 114

Recommendation : ***Control the workplace environment***

When the workplace environment is important for the quality of the product, appropriate limits must be specified, controlled and verified (workshop layout, workstation ergonomics, etc).

Level 1 criterion: The workplace environment is not taken into account for the processing of the equipment. The layout of the workshops is not carried out according to the products being processed.

Level 2 criterion: The workstations are specific to the equipment, and the working environment is controlled.

Level 3 criterion: The workstations are specific to the equipment.
The working environment is controlled and checked.

Level 4 criterion: The workstations are suited to the specific needs of the equipment.
The working environment is controlled and checked.
The layout of the workshops makes it possible to optimize maintenance

Mark : **5.6**

Phase : 5 OPERATION AND MAINTENANCE

N° : 117

Recommendation : ***Control the documentation***

Store and preserve the product and process documentation placed at the disposal of the workshop.

Regularly draw up an inventory of the documentation.
Periodically update the documentation.
Train a workshop personnel entity in the area of technical documentation management.

Possess technical documentation relative to the products.
Possess documentation specific to the maintenance inspections and tests.
Associate this product technical documentation with the processes implemented.
When the documents are supplied, analyze the validity of this product documentation.

Possess process control documentation.
Specify technical documentations for each process.
Make this process documentation available and usable.

Possess documentation specific to the inspection and tests.

Level 1 criterion: No documentation specific to the products or processes, there is no means in place for making specific documentation available.

Level 2 criterion: The documentation specific to the products or processes exists, however its updating is not always effective, the validity of the documents is not analyzed.

Level 3 criterion: The documentation specific to the products or processes exists, its updating is periodic and planned, the validity of the documents used is not analyzed.

Level 4 criterion: The documentation specific to the products or processes exists, its updating is periodic and planned, the validity of the documents used is analyzed.

Precise procedures for storing and preserving the documentation are implemented.

Mark : **17.6**

Phase : 5 OPERATION AND MAINTENANCE

N° : 119

Recommendation : ***Control product testability and maintainability***

Control the capability of the products to detect their own failures, control the means for detecting failures, facilitate maintenance

Level 1 criterion: No built-in tests, maintenance is implemented when a system failure occurs.

Level 2 criterion: On-board surveillance by means of indicator lights and alarms.

Level 3 criterion: Built-in tests: P Bit, C bit, I Bit (Power up built-in test, Continuous built-in test, Interrupt Built-in test).

Level 4 criterion: Built-in tests and complementary testability using a system maintenance PC (or other test means according to the type of product).

Mark : **11.3**

Phase : 5 OPERATION AND MAINTENANCE

N° : 108

Recommendation : ***Control the production equipment, the tools and the programmable machines***

Make sure that for all the production equipment, tools and programs, there are written procedures describing the following activities:
- validation before utilization,
- maintenance,
- periodic check according to written procedures,

Level 1 criterion: The tools are not subject to any check or validation before being used.

Level 2 criterion: The tools are subject to checks before being used, but these checks are not all formalized.

Level 3 criterion: The periodic check of the tools is subject to validation, there are formal procedures identifying the periodic checks to be performed.

Level 4 criterion: The periodic check of the tools is subject to validation, there are formal procedures identifying the periodic actions and checks to be performed.
There are formal procedures describing tool maintenance.

Mark : **13.9**

Phase : 5 OPERATION AND MAINTENANCE

N° : 123

Recommendation : ***Control the changes made to processes***

A clear designation of the people authorized to approve changes to process must exist.

Changes requiring customer acceptance must be identified before being applied.

Any change concerning the processes, the production equipment, tools and programs, must be documented and must generate a procedure for controlling its implementation.

Is a check performed to verify that the results of the process changes produce the required effect and that these changes do not alter the quality of the product?

Level 1 criterion: Changes are made to processes without being recorded; these modifications are not subject to any authorization.

Level 2 criterion: Changes made to processes are recorded and are subject to authorization.
These changes are not documented, they do not generate any procedure for controlling their implementation.

Level 3 criterion: Changes made to processes are recorded, the people authorized to approve the changes made to production processes are clearly designated.
Changes requiring customer acceptance are identified before any application.
All changes concerning the processes, production equipment, tools and programs, are documented and generate a procedure for controlling its implementation.
However, it is not systematically verified that the results of changes made to processes produce the required effect or that these changes do not alter the quality of the product.

Level 4 criterion: Changes made to processes are recorded, the people authorized to approve the changes made to production processes are clearly designated.
Changes requiring customer acceptance are identified before any application.
All changes concerning the processes, production equipment, tools and programs, are documented and generate a procedure for controlling its implementation.
It is systematically verified that the results of changes made to processes produce the required effect and that these changes do not alter the quality of the product.

Mark : **11.3**

Phase : 5 OPERATION AND MAINTENANCE

N° : 109

Recommendation : ***Control the handling, storage, conditioning, preservation and delivery operations***

There must be a procedure taking into account, at the various steps of the phase and, if applicable, in conformity with the manufacturer's recommendations and/or the applicable regulation, the requirements for:
- cleaning
- preventing, detecting and removing foreign matter
- handling suited to sensitive products
- marking and labeling, including the safety marking
- controlling shelf lives and stock rotations
- dangerous materials

· Establish specific procedures for managing perishable articles
· Eliminate all expired or unidentified products
· Propose criteria for assessing and analyzing the quality of the storage conditions
· List and analyze the defects linked to non-quality in storage

Level 1 criterion: The handling, storage, conditioning, preservation and delivery conditions are not codified, the accomplishment of these operations is not perfectly controlled.

Level 2 criterion: The handling, storage, conditioning, preservation and delivery conditions are codified, they give rise to procedures that can be adapted to all of the equipment.
The accomplishment of these operations is not specific to one item of equipment.

Level 3 criterion: The handling, storage, conditioning, preservation and delivery conditions are codified, they give rise to procedures specific to the equipment.

Level 4 criterion: The handling, storage, conditioning, preservation and delivery conditions are codified, they give rise to procedures specific to the equipment.
Considerations such as expiry, sensitivity of products to stress, the dangerousness of products are also codified and implemented.

Mark : **15.2**

Phase : 5 OPERATION AND MAINTENANCE

N° : 124

Recommendation : ***Control the special processes***

When the production operations involve special processes:

- are the special processes to be implemented identified?
- has the supplier checked that all the special process parameters (e.g. materials, personnel, procedures and software) produce the appropriate results?
- has the supplier identified and documented the significant operations and the parameters of the process to be controlled in production?
- during the production phase, are all the modifications made to these operations and parameters subject to a proposal justifying the modification and guaranteeing that it does not introduce any negative effect on the result of the process?
- has the supplier checked the special processes by making one or more standard parts under the conditions defined for the production phase?
- are the special processes or is the subcontracting of the special process qualified before being used?
- does the supplier keep up to date qualified special processes?

Level 1 criterion: The special processes are not identified.

Level 2 criterion: The special processes are identified. The parameters of these processes (materials, personnel, procedures and software) are assessed. These processes are not documented, or defined by strict procedures.

Level 3 criterion: The special processes are identified. The parameters of these processes (materials, personnel, procedures and software) are assessed.

- the significant operations and the parameters of the process to be controlled in production have been identified and documented.
- during the production phase, all the modifications made to these operations and parameters are subject to a proposal justifying the modification and guaranteeing that it does not introduce any negative effect on the result of the process.
- the special processes have not been verified by making one or more standard parts under given conditions.

Level 4 criterion: The special processes are identified.

- it is verified that all the parameters of the special processes (e.g. materials, personnel, procedures and software) produce the appropriate results.
- the significant operations and the parameters of the process to be controlled in production have been identified and documented.
- during the production phase, all the modifications made to these operations and parameters are subject to a proposal justifying the modification and guaranteeing that it does not introduce any negative effect on the result of the process.
- the special processes have been verified by making one or more standard parts under given conditions.
- the special processes or the subcontracting of the special process are qualified before being used.

Mark : **12.2**

Phase : 5 OPERATION AND MAINTENANCE

N° : 110

Recommendation : ***Control the workplace's services and fluids***

When they have an influence on the quality and reliability of the product, the services and supplies such as the water, compressed air, electricity and chemical products used must be controlled and verified regularly to ensure that their effect on the process is constant.

Level 1 criterion: The services and supplies such as the water, compressed air, electricity and chemical products are not subject to any verification

Level 2 criterion: The services and supplies such as the water, compressed air, electricity and chemical products are checked on a one-off basis and when a problem is detected (see ISO 14000).

Level 3 criterion: The services and supplies such as the water, compressed air, electricity and chemical products used are controlled and checked periodically to ensure that their effect on the process is constant.

Level 4 criterion: The services and supplies such as the water, compressed air, electricity and chemical products used are controlled and checked continuously to ensure that their effect on the process is constant.

Mark : **17.4**

Phase : 5 OPERATION AND MAINTENANCE

N° : 208

Recommendation : ***Put in place counter-ESD protections for subassemblies during handling and storage***

Put in place counter-ESD protections for the subassemblies during handling and storage.

Level 1 criterion: Counter-ESD protection is not covered.

Level 2 criterion: The counter-ESD protection is subject to non-formalized rules and practices.

Level 3 criterion: The counter-ESD protection is subject to validated procedures defining recognized practices for protecting the subassemblies.

Level 4 criterion: The counter-ESD protection is subject to validated procedures whose follow-up control is effective.

Mark : **5.7**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 161

Recommendation : ***Have an inspection dossier in your possession***

The inspection dossier must contain:

- the acceptance or refusal criteria,
- a sequential list of inspection and test operations to be performed,
- the documents for recording the results of the inspections,
- a list of the specific and non-specific inspection instruments,
- the documents associated with the specific inspection instruments making it possible to design, produce, validate, manage, use and maintain them.

Level 1 criterion: No inspection dossier.

Level 2 criterion: The inspection dossier is limited to the definition of the acceptance or refusal criteria.

Level 3 criterion: The inspection dossier defines the acceptance or refusal criteria, along with the list of operations to be performed. It proposes documents for recording the inspection results.

Level 4 criterion: The inspection dossier contains:

- the definition of the acceptance or refusal criteria.
- the sequential list of inspection and test operations to be performed.
- the documents for recording the results of the inspections,
- the list of the specific and non-specific inspection instruments,
- the documents associated with the specific inspection instruments making it possible to design, produce, validate, manage, use and maintain them.

Mark : **13.9**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 163

Recommendation : ***Have the documentation specific to the non-conformity in your possession***

The nonconformity documents must give:

- the product's identification,
- the description of the nonconformity,
- the cause of the nonconformity,
- the actions taken to avoid the recurrence of the nonconformity,
- the reworking or repairs if necessary,
- the inspection of the characteristics affected by the reworking or repairs,
- the final decision.

Level 1 criterion: There is no documentation specific to the nonconformity.

Level 2 criterion: The documentation specific to the nonconformity only serves to identify the nonconforming product.

Level 3 criterion: The nonconformity documents give the product's identification, the description of the nonconformity, and the cause of the nonconformity.
However the actions are not formalized to avoid the recurrence of the nonconformity, the reworking or repairs if necessary and the check of the characteristics affected by the reworking or repairs,

Level 4 criterion: The nonconformity documents give the product's identification, the description of the nonconformity, the cause of the nonconformity.
Actions are formalized to avoid the recurrence of the nonconformity, the reworking or repairs if necessary and the check of the characteristics affected by the reworking or repairs is performed.

Mark : **7.4**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 4

Recommendation : ***Allocate the infrastructures required for the correct accomplishment of the production operations***

Allocate the infrastructures required for the production and integration operations to obtain the level of reliability stipulated by the reliability studies performed at the time of system design (no degradation of reliability during these phases). Accomplishment of the Process FMECA.

Example: making available suitable power networks, clean rooms, ergonomic buildings (Application of the 5S methods). Improvement of the environment may consist of:

Increasing the surface areas (to facilitate handling)
Improving the lighting
Reducing operator fatigue
Imposing storage and cleanliness standards
Improving the quality of the tools
Promoting the personnel's awareness of reliability

Level 1 criterion: No assessment of the impact has been carried out, there are no specific systems for protecting the products.

Level 2 criterion: Some product protection systems have been put in place (storage premises), partial personnel awareness.

Level 3 criterion: The workshops are fitted with structures making it possible to protect against the risks of the equipment being degraded by unsuitable infrastructures (example: electrostatic discharges), the personnel has been trained for their utilization.

Level 4 criterion: The workshops are fitted with structures making it possible to protect against the risks of the equipment being degraded by unsuitable infrastructures (example: electrostatic discharges), the personnel has been trained for their utilization.
Formal studies have been carried out with a view to preserving the product in production (e.g. Process FMECA).

Mark : **6.6**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 5

Recommendation : ***Continually improve the company's Engineering Reliability***

Put in place Engineering Reliability indicators. Set the company's Engineering Reliability improvement targets; audit the company's Reliability Engineering (ensure that the reliability specialists take advanced training courses, communicate at reliability congresses).

Level 1 criterion: No Reliability Engineering indicators have been put in place. No Reliability discipline actions are performed.

Level 2 criterion: No Reliability Engineering indicators have been put in place, the company's baseline system includes documents linked to Reliability Engineering: Directives and guides regularly updated.

Level 3 criterion: Some indicators have been put in place (upholding of the performances, performances of the provisional methods, etc.), the company's baseline system includes documents linked to Reliability Engineering: Directives and guides regularly updated.

Level 4 criterion: Indicators have been put in place, the company's baseline system includes documents linked to Reliability Engineering: Directives and guides regularly updated. The company's Reliability Engineering improvement targets have been set; the company's Reliability Engineering is audited regularly (advanced training of the personnel, presentations to reliability congresses).

Mark : **7.9**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 26

Recommendation : ***Collect the customer's remarks relative to the reliability of the system in operational functioning***

Collect from the customers and users of the system the information relative to the system's reliability in an operational environment and implement the associated action plans.

Level 1 criterion: No information relative to the customer's perception of the product's reliability is available.

Level 2 criterion: Some information relative to the customer's perception of the product's reliability is available.

Level 3 criterion: Customer satisfaction surveys have been carried out where the reliability aspect is examined.

Level 4 criterion: Customer satisfaction surveys have been carried out where the reliability aspect is examined, action plans aiming to improve the reliability have been implemented, the results have been noted by the customer.

Mark : **6.3**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 33

Recommendation : ***Describe the system's reliability improvement process and the associated targets***

Set the company's Reliability Engineering improvement targets annually.

Level 1 criterion: There is no process for constructing reliability in the company.

Level 2 criterion: The reliability construction process has been described.

Level 3 criterion: The reliability construction process has been described, improvement actions have been defined informally.

Level 4 criterion: The reliability construction process has been described, and it is maintained and applied completely. Annual improvement targets are set, action plans have been defined, and an assessment of the results obtained is drawn up.

Mark : **6.5**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 51

Recommendation : ***Launch the company quality certification process***

Certify the company's quality system per ISO 9000 V2000

Level 1 criterion: The manufacturer has not put in place a quality system.

Level 2 criterion: The manufacturer has put in place a quality system but it is not covered by a quality certification standard, e.g. ISO 9000.

Level 3 criterion: The manufacturer has put in place a quality system which is covered by a quality certification standard, e.g. ISO 9000 V2000.

Level 4 criterion: The manufacturer has put in place a quality system which is covered by a quality certification standard, e.g. ISO 9000 V2000. It regularly performs an internal audit of its reliability activity (at least annually) to define improvement actions.

Mark : **7.5**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 83

Recommendation : ***Train the personnel concerned by Reliability or employ personnel qualified in terms of Reliability***

Train the personnel concerned by reliability, from awareness through to advanced expertise for the reliability managers, according to the criticality of the reliability performances expected for the system.

Promotion of the production personnel's awareness of the non-degradation of the products.

Level 1 criterion: The reliability specialist has not received any specific training (initial or continuous training).

Level 2 criterion: There are no awareness promotion activities in the company, but the personnel responsible for the reliability studies have received training.

Level 3 criterion: The personnel in the company concerned by reliability have been made aware of reliability (e.g. promotion of the production personnel's awareness of the non-degradation of the products)
The personnel responsible for the reliability studies have received training and are experienced.

Level 4 criterion: The personnel in the company concerned by reliability have been made aware of reliability (e.g. promotion of the production personnel's awareness of the non-degradation of the products).
The personnel is experienced, discipline activities are organized in the company. The personnel take part in reliability congresses and present papers.

Mark : **8.3**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 87

Recommendation : ***Provide the resources necessary for the Reliability studies***

Allocate the necessary resources (material means, access to the technical data, and time required to perform the reliability studies).

Level 1 criterion: There is no clear allocation of means to the reliability activities.

Level 2 criterion: There are means allocated to the reliability activities, but in an insufficient way (skilled personnel, appropriate tools, too short a time for performing the studies).

Level 3 criterion: The means (human and material) are allocated in a satisfactory way to the reliability activity,

Level 4 criterion: The means (human and material) are allocated in a satisfactory way to the reliability activity, these means are described in a project management plan.

Mark : **5.4**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 88

Recommendation : ***Configuration manage the***
Reliability study documents

Control of the documentation linked to the reliability studies: recording, backing up, archiving, validating the documents and managing their configuration.

Level 1 criterion: The reliability documents are not configuration managed.

Level 2 criterion: Certain documents are configuration managed.

Level 3 criterion: The assumptions linked to the forecast calculations are detailed in the documents. The documentation linked to the reliability studies is controlled, but not systematically: recording, backing up, archiving, validating, managing the configuration of the documents not performed systematically.

Level 4 criterion: The assumptions linked to the forecast calculations are detailed in the documents. The documentation linked to the reliability studies is controlled: recording, backing up, archiving, validating, managing the configuration of the documents. The forecast reliability study documents are accessible more than 5 years after being drawn up (for comparative forecast/operational studies).

Mark : **7.2**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 102

Recommendation : ***Identify the Reliability risks at the subcontractors' facilities***

Before signing the contract (with the subcontractor), identify the risks linked to the reliability of the subcontracted product.

Level 1 criterion: No analysis of the reliability-related risks is carried out with the subcontractor before signing the contract (no specific provisions).

Level 2 criterion: No analysis of the reliability-related risks is carried out with the subcontractor before signing the contract, but the risks are identified during the project. There is no management of these risks.

Level 3 criterion: The analysis of the reliability-related risks was carried out before the contract was signed and was the subject of a formal document. There is no management of these risks.

Level 4 criterion: The analysis of the reliability-related risks was carried out before the contract was signed and was the subject of a formal document. The risks identified are covered by risk sheets which are regularly updated.

Mark : **7.5**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 32

Recommendation : ***Involve the reliability discipline in the design of the equipment***

The reliability discipline must be involved in the design phase at the earliest possible stage with authority to choose to redesign equipment in the event of the targets not being met. (Act on the redesign of the architecture, choice of components, of suppliers, etc.)

Level 1 criterion: No involvement of the reliability discipline.

Level 2 criterion: Insufficient involvement: no allocation at the outset. Poorly defined job description. Late involvement, remittal of the dossier to the Detailed Design Review (DDR) at the latest.

Level 3 criterion: Involvement from the moment of the detailed design phase with complete assessment of the reliability.

Level 4 criterion: The reliability discipline is involved in the preliminary design phase with authority to choose to redesign equipment in the event of the targets not being met. (Act on the redesign of the architecture, choice of components, of suppliers, etc.)

Mark : **7.4**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 104

Recommendation : ***Integrate reliability in the company's quality policy***

Integrate the Reliability theme in the company's quality policy and explain this policy to the levels concerned by Reliability Engineering.

Level 1 criterion: The quality policy does not take reliability into account.

Level 2 criterion: Reliability is mentioned indirectly in the goals of the quality policy.

Level 3 criterion: Reliability is mentioned in the company's quality policy

Level 4 criterion: Reliability is one of the key issues in the quality policy.

Mark : **7.8**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 121

Recommendation : ***Control the monitoring and measuring devices, and the metrology of the measuring apparatuses and industrial resources***

Control the monitoring and measuring devices, and the metrology of the measuring apparatuses and industrial resources. Control the verification, calibration and benchmarking of the measuring apparatuses and test benches used by the company. The measuring apparatuses are linked to the national standards.

Level 1 criterion: There is no procedure for verifying, calibrating and benchmarking the measuring apparatuses and tests benches in the company.

Level 2 criterion: There is a procedure for verifying, calibrating and benchmarking the measuring apparatuses and tests benches in the company, but it is not complied with.

Level 3 criterion: There is a procedure for verifying, calibrating and benchmarking the measuring apparatuses and tests benches in the company, and it is applied.

Level 4 criterion: The verification, calibration and benchmarking of the measuring apparatuses and test benches used by the company is controlled (accreditation, certification, etc.). The measuring apparatuses are linked to the national standards.

Mark : **8.0**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 128

Recommendation : Measure the reliability of the systems in operation

Measure the operational reliability of the systems in operation (follow-up of technical events, analysis of the causes of failures, allocation of responsibility for the failures, recording of the system's real utilization profile, assessment of the reliability, analysis of these measurements and taking into account of the result for new system studies).

Level 1 criterion: No assessment of the reliability by analysis of the operational feedback.

Level 2 criterion: Observation and gathering of information concerning the equipment failure rates, the only feedback concerns an assessment of the reliability.

Level 3 criterion: Feedback for assessment of the reliability data, analysis of the causes of failures, allocation of responsibility for the failures, recording of the system's real utilization profile.
Feedback serves as records, no utilization for quantification of the reliability of new projects.

Level 4 criterion: Feedback for assessment of the reliability data, analysis of the causes of failures, allocation of responsibility for the failures, recording of the system's real utilization profile.
Analysis of these measurements and taking into account of the results for new system studies.

Mark : **8.5**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 145

Recommendation : ***Appoint a reliability studies manager***

For each project, appoint a reliability manager who will be the guarantor of the system's reliability targets being met. This person will have to report on study progress, and on any problems encountered.

Level 1 criterion: There is no identified reliability studies manager.

Level 2 criterion: There is a reliability studies manager in practice, but there are no records available concerning his/her appointment.

Level 3 criterion: A reliability studies manager has been appointed, but he/she does not report to anyone on the progress made with the reliability studies.

Level 4 criterion: A reliability studies manager has been appointed, this person has been trained and has the required experience in the area. He/she reports regularly on study progress at the time of meetings or by means of reports.

Mark : **5.7**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 146

Recommendation : ***Organize periodic meetings with the Subcontractor on the subject of reliability***

Organize periodic meetings with the subcontractor to systematically examine the reliability aspects of the subcontracted product.

Level 1 criterion: Periodic meetings with the subcontractor at which the reliability aspects of the subcontracted product are systematically examined are neither planned nor held.

Level 2 criterion: Although they are not planned, meetings are held with the subcontractor at which the reliability aspects are examined.

Level 3 criterion: Periodic meetings with the subcontractor where the reliability aspects are examined are provided for in the business plans. But they are held randomly.

Level 4 criterion: Periodic meetings with the subcontractor where the reliability aspects are examined are provided for in the business plans. They are held in conformity with the plan / timetable.

Mark : **8.8**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 28

Recommendation : ***Take part in the functional and detailed design of the system***

Use reliability engineering to optimize the architecture of systems, and the choice of COTS items, while limiting the physical stress of the COTS items to the strict necessary.

Level 1 criterion: There is no reliability engineering participation in the design of the system.

Level 2 criterion: The participation of reliability engineering during the design of the system is random and/or partial, systems engineering is only involved for assessing the reliability.

Level 3 criterion: Reliability engineering takes part in the upstream system architecture tasks, the company's baseline system describes this participation, which can be demonstrated.

Level 4 criterion: Reliability engineering takes part in the upstream system architecture tasks, the company's baseline system describes this participation, which can be demonstrated. Use the recommendations of the FIDES reliability construction guide.

Mark : **6.3**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 151

Recommendation : ***Plan the accomplishment of the tasks including those relative to reliability***

Integrate the information relative to the systems engineering tasks in the project's various timetables.

Level 1 criterion: The reliability tasks are not planned.

Level 2 criterion: The reliability tasks to be performed are identified but are not described in a plan.

Level 3 criterion: The reliability tasks are described and are subject to a timetable.

Level 4 criterion: The reliability tasks are described and are subject to a timetable which is linked to the company's other timetables.

Mark : **4.1**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 152

Recommendation : ***Plan the communication process with the subcontractor***

Integrate in the project's management plan the means of "communication on the reliability aspects" with the subcontractor: frequency and nature of the meetings, permanent agenda, content of the reports, reliability aspects of the communications.

Level 1 criterion: There is no reliability-related communication with the subcontractor.

Level 2 criterion: There is communication with the subcontractor relative to the reliability aspects.

Level 3 criterion: The provisions relative to communication with the subcontractor on the reliability aspects are described in a project management plan, but only a partial application of these provisions can be demonstrated.

Level 4 criterion: The provisions relative to communication with the subcontractor on the reliability aspects are described in a project management plan, and are applied (proof of this application).

Mark : **9.1**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 154

Recommendation : ***Plan the reliability activities including reliability improvement***

Plan the activities relative to improving reliability in the reliability plan. Describe the activities (fundamental) linked to improving reliability in plans, and implement those plans while keeping records of the actions.

Level 1 criterion: No activity linked to improving product reliability has been planned or accomplished.

Level 2 criterion: There are activities linked to improving reliability but they do not appear in any specific plans.

Level 3 criterion: Activities linked to improving reliability (fundamental) are described in plans and are partially accomplished.

Level 4 criterion: Activities (fundamental) linked to improving reliability are described in plans and are accomplished fully. Records are kept of these actions.

Mark : **7.3**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 155

Recommendation : ***Plan the reliability studies***

Plan the reliability studies to guarantee that the system's reliability targets are met and to ensure synchronization between the reliability studies and the system design.

Level 1 criterion: No reliability study plans are drawn up.

Level 2 criterion: Although they are stipulated in a plan, the reliability studies do not appear in a timetable.

Level 3 criterion: The reliability studies appear in a timetable.

Level 4 criterion: The reliability studies are included in all the projects' study timetables. This studies are monitored.

Mark : **8.1**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 165

Recommendation : ***Preserve the system's reliability in production***

Preserve the system's reliability in production: analyze the potential degradations that could occur during the production operations; integration in the design phase (e.g. Process FMECA).

Level 1 criterion: No analysis of the potential degradations that could occur during the production operations is carried out.

Level 2 criterion: Some one-off analysis is performed on the degradation that has occurred during production operations, in order to remedy the faults that have been detected.

Level 3 criterion: A process FMECA has been carried out at least once to assess and reduce the risks of product reliability being degraded.

Level 4 criterion: A process FMECA is carried out systematically to assess and reduce the risks of reliability being degraded on new products or ranges of products.

Mark : **7.3**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 166

Recommendation : ***Plan periodic consultations with the customers linked to the Reliability aspects***

Regularly consult the customers on the operational reliability aspects and take into account these remarks for the design of new systems.

Level 1 criterion: No feedback from the customers on their perception of the reliability of the products is available.

Level 2 criterion: Feedback from the customers concerning reliability is available, but it is only rarely used.

Level 3 criterion: Feedback from the customers concerning reliability is available and is used to improve the design, development and production of the product.

Level 4 criterion: The company regularly consults its customers on the reliability of its products (formal interviews or surveys by means of questionnaires). This feedback is used and is subject to an action plan whose results are sent to the customer. The effectiveness of this process can be demonstrated by the customer's degree of satisfaction.

Mark : **12.9**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 185

Recommendation : ***Select the COTS items used***

Select the COTS items used, analyze the market, assess the reliability of the COTS items.

Level 1 criterion: No selection of the COTS items is made.

Level 2 criterion: A selection of the COTS items is made according to the reliability (or manufacturing quality) criterion in an informal way.

Level 3 criterion: The company's baseline stipulates that the COTS items must be selected according to the reliability (and/or manufacturing quality) criterion without indicating how. This is effective but is only based on manufacturer data.

Level 4 criterion: The company's baseline stipulates that the COTS items must be selected according to the reliability (and/or manufacturing quality) criterion. This is effective and is based on in-depth analysis: (analysis of the manufacturing data, audit of the manufacturers, assessment of the technologies used, etc.).

Mark : **10.8**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 186

Recommendation : ***Select the suppliers of the COTS items***

Select the suppliers of the COTS items, analyze the market. Assessment of how the COTS items' reliability is taken into account.

Level 1 criterion: The suppliers of COTS items are not selected.

Level 2 criterion: A partial selection of COTS items is carried out in an informal way.

Level 3 criterion: The company's baseline stipulates that the COTS item suppliers must be selected according to the reliability (and/or manufacturing quality) criterion. This is effective but is only based on manufacturer data.

Level 4 criterion: The company's baseline stipulates that the COTS item suppliers must be selected according to the reliability (and/or manufacturing quality) criterion. This is effective and is based on formal activities: (interview with the suppliers, analysis of work accomplished previously, audit, ISO certification).

Mark : **7.2**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 190

Recommendation : ***Follow up and control the Subcontractor's corrective actions relative to the Reliability of the products***

Follow up and control (plan, record) the subcontractor's corrective actions relative to the reliability of the product.

Level 1 criterion: No system has been put in place for following up the corrective actions that the Subcontractor is asked to perform.

Level 2 criterion: The follow-up of the corrective actions requested by the manufacturer is partially seen at the time of meetings with the subcontractor.

Level 3 criterion: A system for the periodic follow-up of the corrective actions that the Subcontractor is asked to perform has been put in place, but it is not fully or satisfactorily controlled.

Level 4 criterion: A system for the periodic follow-up of the corrective actions that the Subcontractor is asked to perform has been put in place and there is proof demonstrating that this follow-up is effective.

Mark : **5.6**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 194

Recommendation : Cover the reliability aspect at the management review

Cover the theme of systems reliability in the agenda of the Management Reviews (progress target, action plan, measurement of the targets being met, and assessment of systems reliability with the customers).

Level 1 criterion: Product reliability is not examined by the Management Reviews.

Level 2 criterion: Product reliability is mentioned irregularly at the time of the Management Reviews.

Level 3 criterion: Product reliability is systematically examined at the time of the Management Reviews.

Level 4 criterion: Product reliability is systematically examined at the time of the Management Reviews, progress targets are defined, the meeting of these targets is assessed.

Mark : **8.3**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 195

Recommendation : ***Process the problems***

Put in place a system for processing the problems liable to cover the whole FIDES life cycle.

This system is designed to:

- record the circumstances in which the problem occurred,
- record the P/N of the defective article,
- propose a remedial action,
- analyze the causes of the problem,
- propose corrective/preventive actions,
- check the effectiveness of the corrective/preventive actions.

This system includes processing making it possible to:
- quickly find identical problems that have been observed previously,
- draw up statistics,
- and be used for feedback.

Level 1 criterion: No problem processing system has been put in place.

Level 2 criterion: A problem processing system has been put in place by the manufacturer, it partially meets the requirements of the recommendation. It is not completely applied to the project.

Level 3 criterion: A problem processing system has been put in place by the manufacturer, it partially meets the requirements of the recommendation. It is completely applied to the project.

Level 4 criterion: A problem processing system has been put in place by the manufacturer, it completely meets the requirements of the recommendation. It is completely applied to the project.

Mark : **6.0**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 198

Recommendation : ***Use statistical methods that are suited to the analysis of the feedback***

Use statistical methods that are suited to the analysis of the feedback.

Level 1 criterion:	The feedback is neither observed or recorded.
Level 2 criterion:	The feedback is recorded, but it is not analyzed or is analyzed with inappropriate and non-formalized statistical methods.
Level 3 criterion:	The feedback is recorded and is analyzed using suitable, but non-formalized methods (no generalized methods).
Level 4 criterion:	The feedback is recorded and is analyzed using pertinent statistical methods and is issued to the users.

Mark : **8.0**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 199

Recommendation : ***Use a FRACAS (Failure Reporting, Analysis and Corrective Action System) type system in the company***

Use a FRACAS (Failure Reporting, Analysis and Corrective Action System) type problem processing system that identifies and records the following in a database: the problems, the description of the problems, the remedial actions implemented, the search for the causes of the problem, the corrective or preventive actions decided on, and the measurement of the effectiveness of these actions.

Level 1 criterion: There is no system in the company for processing the problems.

Level 2 criterion: A problems processing system exists but it is not described, and it is only partially applied.

Level 3 criterion: A FRACAS (Failure Reporting, Analysis and Corrective Action System) type problems processing system which identifies and records in a database the problems, the description of the problems, the remedial actions implemented, the search for the causes of the problem, the corrective or preventive actions decided on, and the measurement of the effectiveness of these actions has been put in place in the company and functions in a partial or incomplete way.

Level 4 criterion: A FRACAS (Failure Reporting, Analysis and Corrective Action System) type problems processing system which identifies and records in a database the problems, the description of the problems, the remedial actions implemented, the search for the causes of the problem, the corrective or preventive actions decided on, and the measurement of the effectiveness of these actions has been put in place in the company and functions perfectly (indicators are available, regular analysis for the assessment report, the benefits of the system put in place are visible).

Mark : **7.7**

Phase : 6 SUPPORT PROCESS ACTIVITIES

N° : 200

Recommendation : ***Validate the subcontractor's reliability management baseline***

Check that the contract's reliability requirements are effectively taken into account by the subcontractor and that its project baseline effectively takes them into account.

Level 1 criterion: Although the contractual requirements concerning Reliability are applicable, they have not been sent to the subcontractor.

Level 2 criterion: The manufacturer transmits to the subcontractor the contractual or internal requirements linked to reliability, but the subcontractor has not written any document guaranteeing the application of these requirements.

Level 3 criterion: A reliability management baseline has been established (management plan or reliability plan) by the subcontractor, it includes the original requirements of the prime contractor. The application of this baseline is not checked by the manufacturer.

Level 4 criterion: A reliability management baseline has been established (management plan or reliability plan) by the subcontractor, it includes the original requirements of the prime contractor. The application of this baseline is validated by the manufacturer (progress meeting, audit, etc.).