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Space product assurance

Derating and end-of-life parameter drifts — EEE components

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Foreword

This Standard is one of the series of ECSS Standards intended to be applied together for the management, engineering and product assurance in space projects and applications. ECSS is a cooperative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards.

Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

The formulation of this Standard takes into account the existing ISO 9000 family of documents.

This Standard has been prepared and maintained under the authority of the Space Components Steering Board (SCSB) in partnership with the European Space Agency (ESA), national space agencies (NSA's) and the European space industry, reviewed by the ECSS Product Assurance Panel and approved by the ECSS Steering Board.

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Introduction

This Standard specifies derating requirements applicable to electronic, electrical and electromechanical components and end-of-life drifts in component parameters to be used in worst case analyses.

Derating is a long standing practice applied to components used on spacecrafts. Benefits of this practice are now proven, but for competitiveness reasons, it becomes necessary to find an optimized reliability. Too high a derating can lead to over-design, over-cost and over-sizing of components, the direct consequence being excess volume and weight. The aim is to obtain reliable and high performance equipment without over-sizing of the components. For this reason and if possible, this Standard provides derating requirements depending on mission duration and mean temperature, taking into account demonstrated limits of component capabilities.

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Scope

This Standard applies to all parties involved at all levels in the realization of space segment hardware and its interfaces.

The objective of this Standard is to provide customers with a guaranteed performance and reliability up to the equipment end-of-life. To this end, the following are specified:

- Load ratios or limits to reduce stress applied to components;
- Estimation of end-of-life drifts due to ageing;
- Application rules and recommendations.

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Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

ECSS-P-001	Glossary of terms
ECSS-Q-60	Space product assurance — Electrical, electronic and electromechanical (EEE) components

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Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ECSS-P-001 and the following apply.

3.1.1
assurance level
amount of testing applied to a component during procurement, such as screening and lot acceptance levels, to ensure that it performs in a reliable manner

3.1.2
case temperature
temperature comprising board temperature and self-heating of the component during maximum operating conditions, unless otherwise specified

NOTE Unless specified otherwise, "temperature" is considered "case temperature".

3.1.3
derating
intentional reduction in a parameter rating of a component in order to increase its useful life in terms of drift and reliability

3.1.4
junction temperature
temperature reached by a semiconductor within its active area during operation

3.1.5
life
period during which a specified performance is expected including ground and flight operation to the end of the mission

3.1.6
load ratio
permissible operating level after derating has been applied; given as a percentage of a parameter rating

3.1.7
operating conditions
parameter stress and environment (temperature, vibration, shock and radiation) in which components are expected to operate

3.1.8
performance
operation of a component or an equipment with respect to specified criteria

3.1.9
RadPack
package designed to provide some form of radiation protection

3.1.10
rating
maximum parameter value specified and guaranteed by the component manufacturer and component procurement specification

NOTE Rating is considered as a limit not to be exceeded during operation and constitutes in most cases the reference for derating.

3.2 Abbreviated terms

The following abbreviated terms are defined and used within this Standard:

Abbreviation	Meaning
AC	alternating current
A/D	analog to digital
AWG	American wire gauge
C	capacitance
DC	direct current
EMC	electro-magnetic compatibility
EPPL	European preferred parts list
EOL	end-of-life
ESCC	European Space Component Coordination
ESR	equivalent series resistance
f	frequency
FET	field effect transistor
GaAs	gallium arsenide
GEO	geostationary orbit
HBT	hetero-junction bipolar transistor
ISO	International Organization for Standardization
LED	light emitting diode
LEO	low Earth orbit
MEO	medium Earth orbit
MOS	metal on silicon
MIL (spec)	specification of the US Department of Defense
NASA	National Aeronautics and Space Administration
P	power
RadHard	radiation hardened
Ri	insulation resistance

SEBO	single event burn-out
SEGR	single event gate rupture
Si	silicon
SOA	safe operating area
T_j	junction temperature
T_{op}	operating temperature
V_{CE}	collector-emitter voltage

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User responsibility

a. The user of this Standard shall verify that the ordered assurance level of procured components is compatible with the intended application.

b. Derating shall not be a substitute for a screening or component selection programme.

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Derating

5.1 General

The term derating refers to the intentional reduction of electrical, thermal and mechanical stresses on components to levels below their specified rating. Derating is a means of extending component life, increasing reliability and enhancing the end-of-life performance of equipment. It provides a safety margin between the applied stress and the demonstrated limit of the component capabilities.

In addition, derating participates in the protection of components from unexpected application anomalies and board design variations.

The load ratios or limits given in clause 7 were derived from information available at the time of writing this Standard and do not preclude further derating for specific applications.

This Standard also defines how to handle transients.

a. Derating shall be applied in consideration of temperature limits recommended by manufacturers.

b. The derating requirements of this Standard shall not be applied to weak or immature components in order to enhance their quality and thus qualify them for use in space applications.

c. The derating requirements shall be taken into account at the beginning of the design cycle of equipment for any consequential design trade-off to be made. Specific attention shall be paid to, for example, breadboards and engineering models where parameter derating was not considered.

d. Component families and groups excluded in this Standard are due to lack of experimental data and failure history. For these components, the user shall consult a component design and reliability specialist to apply the requirements of this Standard.

5.2 Principles of derating

The component parameter strength defines the limits and the performance component technology in the particular application and varies from manufacturer to manufacturer, from type to type, and from lot to lot and can be represented by a statistical distribution. Likewise, component stress can be represented by a statistical distribution. Figure 1 illustrates the strength of a component and the stress applied at a given time, where each characteristics is represented by a probability density function.

A component operates in a reliable way if its parameter strength exceeds the parameter stress. The designer shall strive to make sure that the stress applied does not exceed the component parameter strength. This is represented by the intersection (shaded area) in Figure 1. The larger the shaded area, the higher the possibility of failure becomes.

There are two ways, which may be used simultaneously, in which the shaded area can be decreased:

- Decrease the stress applied (which moves the stress distribution to the left).
- Increase the component parameter strength (by selecting over-sized components) thereby moving the strength distribution to the right.

The goal is to minimize the stress-to-strength ratio of the component. Derating moves the parameter stress distribution to the left while the selection processes applied to the components for space applications contribute to moving the parameter strength distribution to the right. The selection processes also reduce the uncertainty associated with the component parameter strength.

Derating reduces the probability of failure, improves the end-of-life performance of components and provides additional design margins.

Another effect of derating is to provide a safety margin for design. It allows integrating parameter distribution from one component to another, and from one procurement to another.

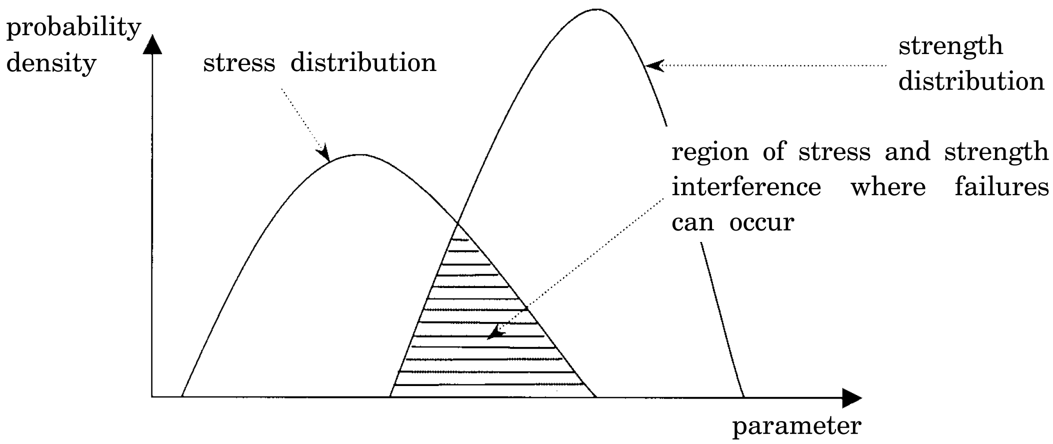

Figure 1: Parameter stress versus strength relationship

5.3 Applicability and component selection

This Standard applies to all components, selected for space applications, that are used for a significant duration. The meaning of “significant duration” is a period that contributes to the component life, for instance, one month (about 700 hours) is considered to be a significant duration. These requirements apply to screened components procured in accordance with approved space specifications (ESCC, NASA, MIL, National Space Agencies, customer or manufacturer).

This Standard also applies to any component, including those selected and evaluated in accordance with ECSS-Q-60.

Components may be excluded from this Standard if they are used for short durations of less than one month provided the device ratings are not exceeded; for example, components used in solar generator deployment systems, redundancy commutation and launchers (except in some specific cases, noted family by family). In these cases, the customer shall ensure that the design tolerance does not exceed the component rating. In the same way, during a test (e.g. qualification and EMC), derating requirements are applied on operating conditions and not on test conditions, even if during some periods, the temperature range reached is higher than the derated value. However, the specified ratings shall not be exceeded.

In general, derating is applied on normal operating conditions and not on the fault condition.

Where components are required to operate in a protection mode or in a fail-safe mode in order to prevent failure propagation (e.g. short-circuit protection), the components concerned shall meet the derating requirements and application rules under the worst-case failure conditions.

5.4 Derating parameters

Derating requirements are provided in clause 7 for each component family.

For each category and component type, the parameters to be derated are identified. The main parameters to be derated are:

- junction or case temperature at maximum operating conditions;
- power (rating, dissipation);
- voltage;
- current.

When available, load ratios or limits are given for different mission durations or different temperatures. A stress balancing concept offers flexibility between one stress versus another (voltage and temperature). In some cases, e.g. resistors, derating has a direct impact on component performance. This Standard also provides various load ratio figures or limits versus the end-of-life performance to be reached.

When the procurement specification includes parameter values for transients or surge conditions, the same load ratios or limits as for steady-state parameters shall be used.

When transient or surge conditions are present in the application, but no transient or surge rating values are specified in the procurement specification, the design transients or surges shall not exceed the maximum steady state rating given in procurement specifications.

Repetitive transients, e.g. in a switching DC/DC converter operation, and clock transmission lines, shall not exceed the specified steady state parameter load ratio or limits.

Radiation sensitive components are identified, and it is the user's responsibility that the chosen component technologies are suitable and that the mitigation factors, such as shielding, meet the customer's requirement. The electrical derating for radiation sensitive components shall be in accordance with this Standard.

5.5 Additional rules and recommendations

In addition to strict derating requirements, some application rules and recommendations are given in this Standard to achieve the suitable reliability.

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End-of-life parameter drift

6.1 General

This Standard provides the main parameter degradation figures to be used in worst-case circuit performance analysis. Worst-case analysis is performed to assess the performance of equipment at the end of its planned life.

6.2 Applicability

The parameter degradation figures provided in this Standard are applicable to all components procured in accordance with approved space specifications (ESCC, NASA, MIL, National Space Agencies, customer or manufacturer).

This Standard also applies to other components that have undergone rigorous selection testing in accordance with ECSS-Q-60.

6.3 Elements contributing to parameter drift

In general, parameter drift comprises the following, unless otherwise specified:

a. **Initial tolerance**

Parameter tolerance defined in the procurement specification.

b. **Component ageing and drifts (end-of-life factors)**

The ageing of a component is a continuous process of physico-chemical change. In most cases, the rate of change is an exponential function of temperature. The figures provided in this Standard take into account the most common degradation mechanisms.

c. **Temperature effects**

The junction or case temperature which affects the component's initial performance and contributes to the ageing mechanism.

d. **Voltage or current effects**

The parameter degradation resulting from the applied voltage or current shall be considered.

e. **Radiation effects**

Semiconductors are susceptible to degradation due to radiation. A great disparity of behaviour can appear under the influence of radiation which can be caused by:

- mission orbit (see Table 1) and duration,
- radiation types (such as protons, electrons and heavy ions),
- component technology, manufacturer, diffusion lot.

Identical components from different manufacturers can have a different radiation sensitivity.

Radiation sensitive components are identified, but the expected change is not quantified.

Table 1: Radiation effects versus orbit

Radiation effect	Orbit			
	GEO	LEO polar	LEO non-polar	MEO
Trapped electrons	+++	+	+	+
Trapped protons	-	++	++	++++
Total dose	+++	++	+	+++++
Heavy ions	+++	++	+	++
Solar flare protons	+++	+	-	++
- no effect	+ little effect		+++++ high effect	

f. **Component mounting**

The mounting on a printed circuit board or substrate of surface mount components induces a stress that can have an influence on the component performance. Components sensitive to mounting processes are identified, but the expected change is not quantified as this is considered to be part of the evaluation of the device.

g. **Mission duration**

Most parameter drifts are a function of time. The end-of-life parameter drift figures are valid for missions of up to 15 years provided the components are derated in accordance with this Standard.

7

Tables for load ratios or limits and end-of-life drift figures

7.1 General

This clause provides the load ratios or limits and end-of-life parameter drift figures.

They are also available on the World Wide Web at the following address:

https://escies.org/public/derating

Abbreviations used in the tables are explained in clause 3.

Annex A contains a complete listing of the family and group codes for parts that are referred to in this Standard.

7.2 Capacitors: ceramic — family-group code: 01-01 and 01-02

7.2.1 General

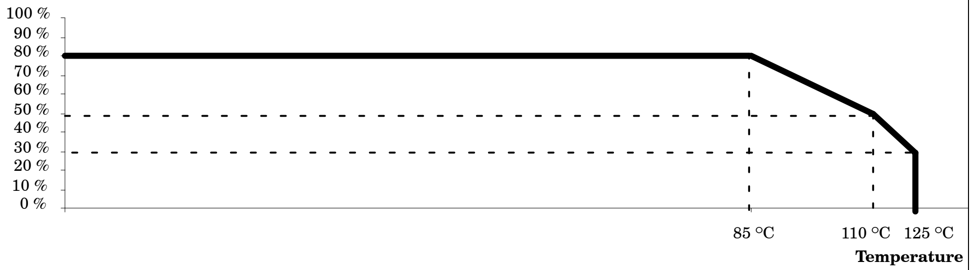
a. The capacitor stress sum value of steady state voltage, AC voltage and transients shall not exceed the load ratios specified hereunder.

b. Ceramic capacitors are sensitive to high surge currents. Manufacturer's surge current ratings shall never be exceeded. When no surge current is specified, the issue shall be recorded in the design file and the components selection shall be reviewed and approved as described in ECSS-Q-60 .

c. Multilayer capacitors with a voltage rating less than 100 V may be used in low voltage (less than 10 V) continuous applications provided they have been submitted to a low voltage (1,5 V) 85 % humidity at 85 °C screening test.

d. Physical limitation for type II**:** maximum surge dV/dt: 100 V/μs.

7.2.2 Derating

Parameters	**Load ratio or limit**
Voltage: rated voltage ≤ 500 V	
Voltage: rated voltage > 500 V	

7.2.3 End-of-life drifts

Parameters	**Drifts**
Type I: ΔC/C	±1,5 %
Type II: ΔC/C	±10 % This drift only covers ageing.
Type I and Type II: ΔRi/Ri	-50 %

7.3 Capacitors: solid tantalum — family-group code: 01-03

7.3.1 General

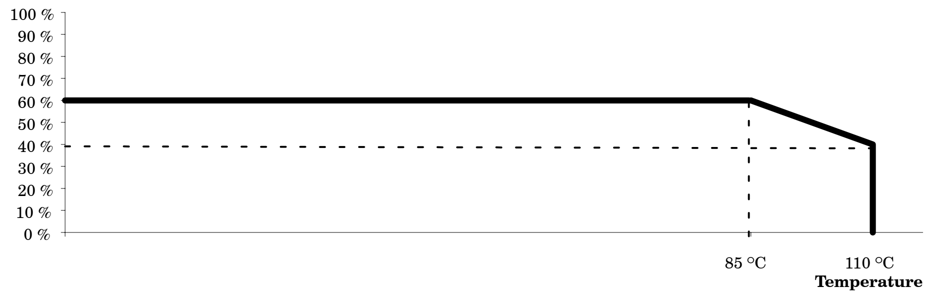
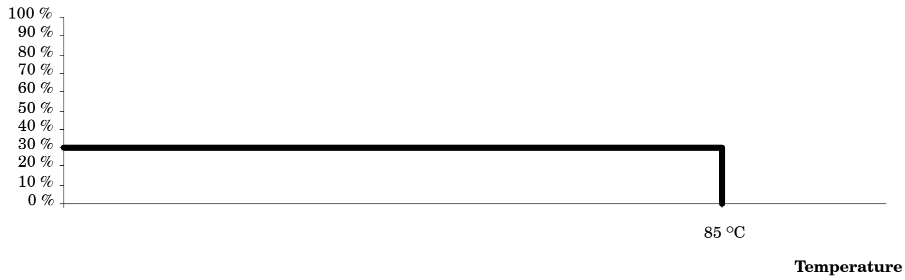
a. The use of surge current tested components is required for low series resistance circuits (current exceeding 10 A).

b. If the application surge current is limited, the customer organization shall approve the application of steady state voltage ratio where repetitive inrush currents do not exceed 10 A.

c. No reverse voltage shall be applied to these capacitors.

d. Manufacturer's ratings for ripple power or current shall never be exceeded.

7.3.2 Derating

Parameters	**Load ratio or limit**
Voltage: steady state and dynamic applications where current does not exceed 10 A.	
Voltage: dynamic applications where current exceeds 10 A.	

7.3.3 End-of-life drifts

Parameters	**Drifts**
ΔC/C	±5 %
$I_{leakage}$	Maximum specified limit.
Equivalent series resistance	No change.

7.4 Capacitors: non-solid tantalum — family-group code: 01-04

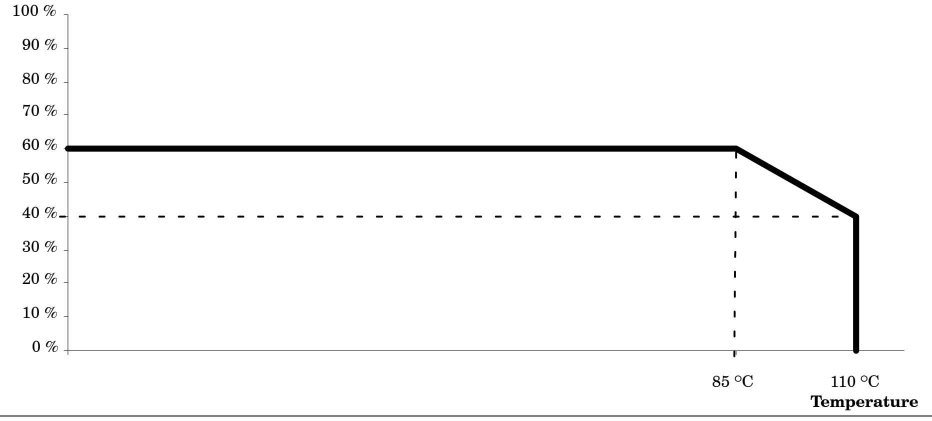
7.4.1 General

a. No reverse voltage shall be applied to these capacitors.

b. Manufacturer's ratings for ripple power or current shall never be exceeded.

c. Surge voltage shall never exceed 50 % of the specified value.

7.4.2 Derating

Parameters	Load ratio or limit
Voltage: voltage includes DC voltage and superimposed AC peak voltage.	

7.4.3 End-of-life drifts

Parameters	Drifts
$\Delta C/C$	±10 %
$I_{leakage}$	Maximum specified limit.

7.5 Capacitors: film — family-group code: 01-05

7.5.1 General

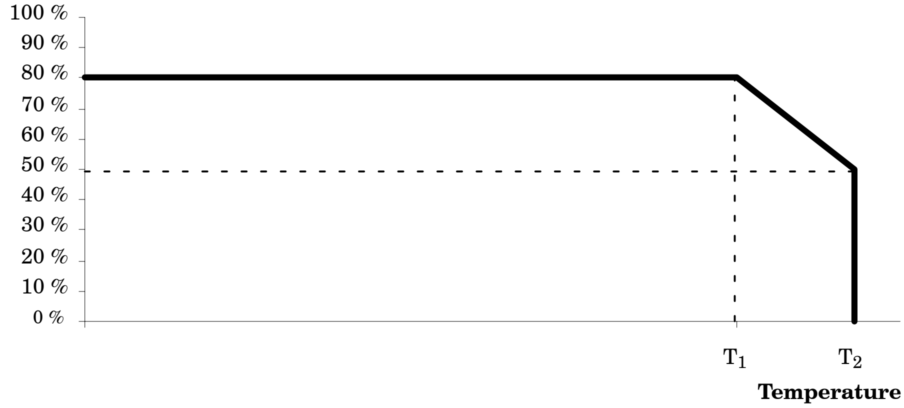
a. Self healing requirements for polyethylene terepthalate (PET, polyester) film:

1. To have a clearing process in any case, the minimum energy available shall be > 5 μJ.
2. To prevent any risk of destruction during self healing, capacitor banks shall not provide energy greater than 15 J.

b. For other films, clearing recommendations from manufacturers shall be followed.

c. Surge voltage shall never exceed 50 % of the specified value.

7.5.2 Derating

Parameters	Load ratio or limit
Voltage: voltage includes DC voltage and superimposed AC peak voltage.	 $T_1 = T_{max} - 40$ °C $T_2 = T_{max} - 25$ °C where T_{max} = rated maximum temperature.

7.5.3 End-of-life drifts

Parameters	Drifts
ΔC/C	±2 %
ΔRi/Ri (Insulation resistance)	-50 %

7.6 Capacitors: glass and porcelain — family–group code: 01-06

7.6.1 Derating

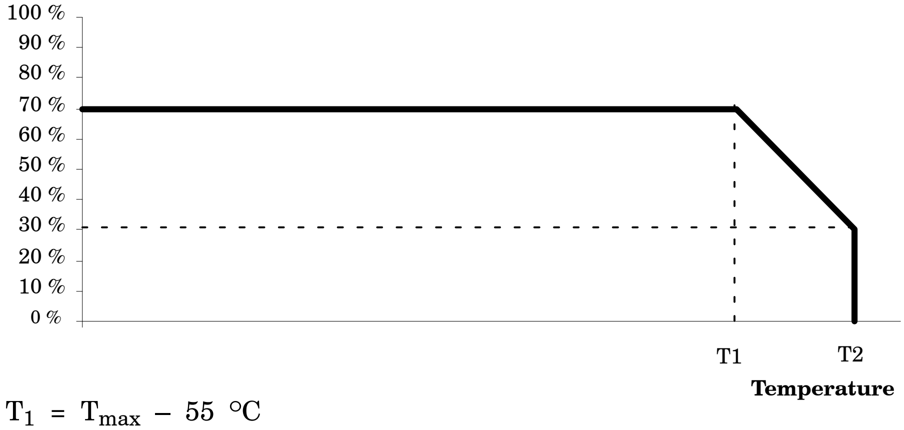
Parameters	Load ratio or limit
Voltage: voltage includes DC voltage and superimposed AC peak voltage.	

7.6.2 End-of-life drifts

Parameters	Drifts
ΔC/C	±0,2 % or ΔC ±0,5 pF, whichever is greater.

7.7 Capacitors: mica — family-group code: 01-07

7.7.1 Derating

Parameters	Load ratio or limit
Voltage	 $T_1 = T_{max} - 55$ °C $T_2 = T_{max} - 25$ °C where T_{max} = maximum operating temperature.

7.7.2 End-of-life drifts

Parameters	Drifts
ΔC/C	±0,5 %

7.8 Capacitors: aluminium solid — family-group code: 01-09

7.8.1 Derating

Parameters	Load ratio or limit
Voltage	

7.8.2 End-of-life drifts

Parameters	Drifts
ΔC/C	±10 %
Δtδ/tδ	±20 % of maximum limit.

7.9 Capacitors: feedthrough — family-group code: 01-10

7.9.1 Derating

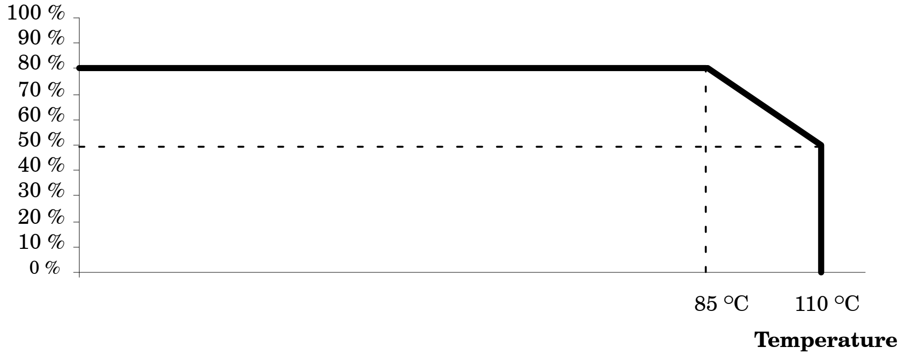
Parameters	Load ratio or limit
Voltage	

7.9.2 End-of-life drifts

Parameters	Drifts
Type I: ΔC/C	±1,5 %
Type II: ΔC/C	±10 % This drift only covers ageing.
Type I and Type II: ΔRi/Ri (Insulation resistance)	-50 %

7.10 Capacitors: semiconductor technology (MOS type) — family-group code: 01-11

7.10.1 Derating

Parameters	Load ratio or limit
Voltage	

7.10.2 End-of-life drifts

Parameters	Drifts
ΔC/C	±1,5 %
ΔRi/Ri (Insulation resistance)	-50 %

7.11 Connectors — family-group code: 02-01, 02-02, 02-03, 02-07 and 02-09

7.11.1 General

a. For power connectors, power and return lines shall be separated by at least one unassigned contact to reduce the short-circuit risk.

b. Connector savers shall be used during testing of equipment to minimize number of mating and demating cycles.

c. When multi-pin connectors are close to one another, they shall be configured such that mating with a wrong connector is not possible or the contact assignments shall be chosen such that mating with a wrong connector does not cause damage to the unit itself nor to any other element of the system.

d. The connector and its constituent parts shall be from the same manufacturer.

7.11.2 Derating

Parameters	**Load ratio or limit**
Working voltage	25 % of rated dielectric withstanding voltage (voltage proof) (contact to contact and contacts to shell).
Current	50 %
Maximum operating temperature	30 °C below maximum rated temperature.
Maximum mating and demating cycles	50

7.11.3 End-of-life drifts

No additional drift shall be considered.

7.12 Connectors RF — family-group code: 02-05

7.12.1 General

Connector savers shall be used during testing of equipment to minimize number of mating and demating cycles.

7.12.2 Derating

Parameters	**Load ratio or limit**
RF power	75 % and shall be limited such that a 6 dB margin exists before the onset of multipactor.
Working voltage	25 % of voltage proof (contact to shell).
Maximum operating temperature	30 °C below maximum rated temperature.
Maximum mating and demating cycles	50

7.12.3 End-of-life drifts

No additional drift shall be considered.

7.13 Piezo-electric devices: crystal resonator — family-group code: 03-01

7.13.1 Derating

Parameters	**Load ratio or limit**	**Special conditions**
Drive level	≤ Rated drive level.	If this condition is not met, the oscillators shall be characterized over the complete operating temperature range at the appropriate drive level, without exceeding the maximum rating.

7.13.2 End-of-life drifts

Parameters	**Drifts**	**Special conditions**
Δf/f	Ageing specified in the detail specification.	Unless otherwise specified, ageing includes the expected total drift (including life-time, vibration, shock, drive level). For hybrid oscillators, the variation applicable to the logic family inside the hybrid shall be added to ageing. Ageing shall be added to the frequency tolerance at T_0 and to the frequency variation with temperature.

7.14 Diodes — family-group code: 04-01, 04-02, 04-03, 04-04, 04-05, 04-08, 04-10 to 04-13, 04-14 and 04-15

7.14.1 General

Some diodes can be radiation sensitive: the issue shall be recorded in the design file and the components selection shall be reviewed and approved as described in ECSS-Q-60.

7.14.2 Derating

Parameters	**Load ratio or limit**		
	Signal, switching, rectifier, transient suppression and varactor diodes	**Schottky, step recovery diodes**	**Zener, reference diodes**
Forward surge current (I_{FSM}): • non-repetitive operation • repetitive operation	 80 % 50 %	 75 % 50 %	--
Zener surge current (I_{ZSM}): • non-repetitive operation • repetitive operation	--	--	 80 % 50 %
Reverse voltage (V_R)	80 %		--
Dissipated power (P_D)	80 %		
Maximum junction temperature (T_j)	125 °C or 40 °C below the maximum rating (whichever is lower).		

7.14.3 End-of-life drifts

Parameters	Drifts											
	Mission duration											
	5 years				10 years				15 years			
	Maximum junction temperature (°C)				Maximum junction temperature (°C)				Maximum junction temperature (°C)			
	55	85	110	125	55	85	110	125	55	85	110	125
Forward voltage (V_F): signal, switching, rectifier diodes.	0	+5 %	+5 %	+8 %	0	+5 %	+5 %	+8 %	0	+5 %	+5 %	+8 %
Forward voltage (V_F): Schottky and step recovery diodes.	0	+1 %	+5 %	+5 %	0	+1 %	+5 %	+5 %	0	+2 %	+5 %	+5 %
Zener voltage (V_Z): Zener and reference diodes.	0	-0,5 %	-2 %	-2 %	0	-0,5 %	-2 %	-2 %	0	-1 %	-2 %	-2 %
Zener voltage (V_Z): Compensated reference diodes	within initial limits											
Leakage Current (I_R): all diode families.	×1	×1,5	×2	×2,5	×1	×2	×2,5	×3	×1	×2	×3	×4

7.15 Diodes: RF — family-group code: 04-05, 04-06, 04-15, 04-16 and 04-17

7.15.1 General

Some diodes can be radiation sensitive: the issue shall be recorded in the design file and the components selection shall be reviewed and approved as described in ECSS-Q-60.

7.15.2 Derating

Parameters	**Load ratio or limit**
Reverse voltage (V_R)	75 %
Forward surge current	50 %
Dissipated power (P_D)	80 % or maximum derated operating temperature as above
Maximum operating temperature (T_{op}) or maximum junction temperature (T_j)	125 °C or $T_{j\ max}$ – 40 °C (whichever is lower)

7.15.3 End-of-life drifts

Parameters	**Drifts**
Forward voltage (V_F)	+10 % of the maximum rating.
Leakage current (I_R)	3× the maximum rating.

7.16 Feedthrough filters — family-group code: 05-01

7.16.1 Derating

<table>
<tr><th>Parameters</th><th>Load ratio or limit</th></tr>
<tr><td>Current (continuous and surge)</td><td>70 %</td></tr>
<tr><td>Voltage</td><td>
</td></tr>
</table>

7.16.2 End-of-life drifts

Parameters	Drifts
Attenuation	-2 dB in addition to the initial tolerance.
ΔRi/Ri	-50 %

7.17 Fuses: Cermet (metal film on ceramic) — family‐group code: 06‐01

7.17.1 General

a. Fuses shall be avoided whenever possible.

b. The largest fuse rating compatible with the source capability shall be used.

c. The power supply shall be capable of delivering four times the specified fuse rated current in order to obtain short fusing times.

7.17.2 Derating

Parameters	Load ratio or limit
Current	

7.17.3 End‐of‐life drifts

No additional drift shall be considered.

7.18 Inductors and transformers — family-group code: 07-01 – 07-03

7.18.1 General

For custom-made inductors and transformers, the maximum rated temperature shall be evaluated taking into consideration the temperature characteristics of the materials used.

7.18.2 Derating

Parameters	Load ratio or limit	Special conditions
Current (continuous and surge)	70 %	
Dielectric withstanding voltage (voltage proof)	50 %	Between winding-winding and between windings-case. For application voltages greater than 200 V, the maximum applied voltage (DC, AC peak or combined) shall be $< 0,5 \times$ VPD. The partial discharge voltage level (VPD) is defined as the component qualification test level where partial discharge activity is detected, and with a test equipment sensitivity > 1,0 pC (Pico-Coulomb).
Temperature	20 °C below maximum operating temperature.	Operating temperature = Board temperature + temperature rise +10 °C margin for hot spot.

7.18.3 End-of-life drifts

No additional drift shall be considered.

7.19 Integrated circuits: logic — family-group code: 08-10, 08-20, 08-21, 08-29 to 08-42, and 08-80

7.19.1 General

Some devices can be radiation sensitive: this shall be recorded and approved in accordance with ECSS-Q-60.

7.19.2 Derating

Parameters	Load ratio or limit	Special conditions
Supply voltage (V_{CC})	Manufacturer recommended value ±5 % for bi-polar devices 90 % of maximum rating for CMOS devices.	**Supply voltage** • Turn on transient peaks or other peaks shall not exceed the maximum rating. • The input voltage shall not exceed the supply voltage (unless otherwise stated in the device specification).
Output current (I_{out})	80 %	
Maximum junction temperature (T_j)	(T_j max) – 40 °C	**Junction temperature** If the maximum junction temperature is not specified, derate from the maximum operating temperature.

7.19.3 End-of-life drifts

No additional drift shall be considered.

7.20 Integrated circuits: non-volatile memories — family-group code: 08-22, 08-23 and 08-24

7.20.1 General

Some devices can be radiation sensitive: this shall be recorded and approved in accordance with ECSS-Q-60.

7.20.2 Derating

Parameters	**Load ratio or limit**	**Special conditions**
Supply voltage (V_{CC})	Manufacturer's recommended value ±5 % or 90 % of maximum rating.	**Supply voltage** • Turn on transient peaks or other peaks shall not exceed the maximum rating. • The input voltage shall not exceed the supply voltage (except adapted component design).
Output current (I_{out})	80 %	
Maximum junction temperature (T_j)	(T_j max) – 40 °C	**Junction temperature** If the maximum junction temperature is not specified, derate from the maximum operating temperature.
Endurance and data retention		**Endurance** The endurance (number of write and erase cycles) and the retention time-to-failure of EPROM, EEPROM and Flash devices can be derated from the manufacturer specification case by case. An acceleration model, such as Arrhenius's law with an activation energy of 0,6 eV, or lower, shall be used to determine the equivalent time for space flight.

7.20.3 End-of-life drifts

No additional drift shall be considered.

7.21 Integrated circuits: linear — family-group code: 08-50 to 08-60 and 08-69

7.21.1 General

Some linear circuits can be radiation sensitive: usage is application sensitive and requires justification at the appropriate design reviews.

7.21.2 Derating

Parameters	Load ratio or limit	Special conditions
Supply voltage (V_{CC})	90 %	Supply voltage shall include DC + AC ripple.
Input voltage (V_{IN})	70 % (or 50 % on the input current) for operational amplifiers. 100 % or derated circuit supply voltage, whichever is less, for comparators. 90 % for regulators.	In a radiation environment, 80 % for bi-polar technology and 50 % for MOSFET technology.
Output current (I_{out})	80 %	
Transients	Shall not exceed the specified maximum ratings.	
Maximum junction temperature (T_j)	110 °C or $T_{j\ max}$ − 40 °C, whichever is lower.	

7.21.3 End-of-life drifts

Parameters	Drifts								
	Mission duration								
	5 years			10 years			15 years		
	Maximum junction temperature (°C)			Maximum junction temperature (°C)			Maximum junction temperature (°C)		
Parameters	55	85	110	55	85	110	55	85	110
Input bias current (I_{bb}) Operational amplifiers and comparators	2 %(1)	6 %(1)	13 %(1)	3 %(1)	8 %(1)	18 %(1)	3 %(1)	10 %(1)	20 %(1)
Input offset voltage (V_{OS}) Operational amplifiers and comparators	20 % (1)								
Voltage gain (A_{vo}) Operational amplifiers	-25 %								
Output voltage (V_{out}) Regulators	Maximum specified voltage								
Load regulation ($V_{R\ load}$) Regulators	0,2 %								

(1) These drifts do not apply to offset voltage compensated components.

7.22 Integrated circuits: linear converters — family-group code: 08-61 and 08-62

7.22.1 General

Some linear circuits can be radiation sensitive: the choice of the component requires justification at the design review in accordance with ECSS-Q-60.

7.22.2 Derating

Parameters	**Load ratio or limit**	**Special conditions**
Maximum junction temperature (T_j)	110 °C or $T_{j\ max}$ − 40 °C, whichever is lower.	
Supply voltage (V_{CC})	90 %	Supply voltage shall include DC + AC ripple.
Input voltage (V_{IN})	100 % or derated circuit supply voltage, whichever is less.	
Output current (I_{out})	80 % (D/A converters only)	

7.22.3 End-of-life drifts

Parameters	**Drifts**
Supply current (I_{CC})	±5 %

7.23 Integrated circuits: MMICs — family-group code: 08-95

7.23.1 General

Some MMICs can be radiation sensitive: the choice of MMICs shall be based on suitability and application. Justification shall be in accordance with ECSS-Q-60 and provided in accordance with this Standard, and at the design reviews.

7.23.2 Derating

Each discrete cell (capacitors, resistors, diodes and transistors) constituting analogue custom MMICs shall be derated in accordance with this document's requirements for the applicable family. For digital cells, apply the derating rules applicable to integrated circuits.

When operational reliability data is available, the compression level shall be derated to 4 dB under the highest compression level showing no drift. MMICs having no compression data shall not be submitted to more than 0,5 dB of compression.

7.23.3 End-of-life drifts

Each discrete cell (capacitors, resistors, diodes and transistors) constituting analogue custom MMICs shall consider end-of-life drifts for the applicable family. For digital cells, end-of-life drifts shall be those applicable to integrated circuits.

7.24 Integrated circuits: miscellaneous — family-group code: 08-99

7.24.1 General

a. For all ICs not considered in the previous subgroups, the following derating rules shall be followed:
   - Manufacturer's derating values.
   - Maximum junction temperature: 110 °C or $T_{j\ max}$ – 40 °C, whichever is lower.
   - For the part of the IC similar to logic ICs, apply the derating rules for logic subgroups, for the part similar to linear ICs, apply the derating rules for linear subgroups and so forth.

b. Some integrated circuits can be radiation sensitive: this shall be recorded and approved in accordance with ECSS-Q-60.

7.24.2 End-of-life drifts

Parameters	**Drifts**
Supply current (I_{CC})	±5 %

7.25 Relays and switches — family-group code: 09-01, 09-02 and 16-01

7.25.1 General

a. The coil supply voltage shall be within the specified voltage range or between the specified rated and the maximum coil voltage.

b. The minimum coil pulse duration for latching relays shall be 10 times the sum of latch time (t_L) and bounce time (t_B) or 30 ms, whichever is greater.

c. Current derating does not apply to contacts that only carry current and do not switch it or to contacts that switch at zero current. In the latter case, the number of operations is limited to the qualified number of operations.

d. Rated contact load voltage should not be exceeded since it has a strong impact on the contact current: this shall be recorded and approved in accordance with ECSS-Q-60.

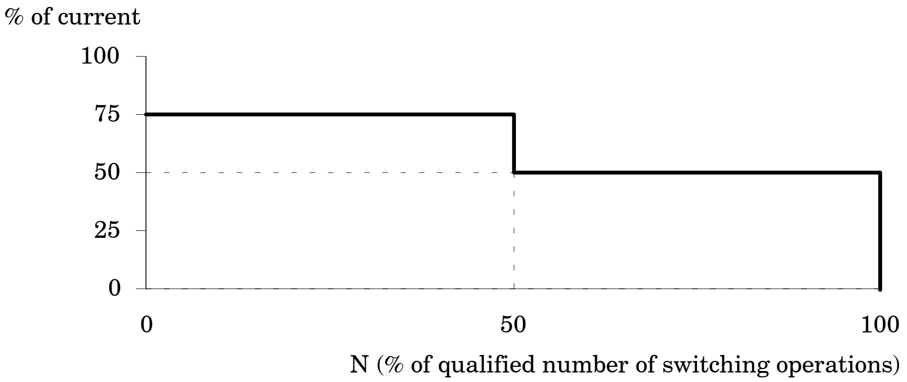
e. A double throw contact shall not be used to switch a load (movable contact) between a power supply and ground (stationary contacts). This type of configuration may be accepted in the following conditions:

- when switching off the power supply the other stationary contact is not connected to ground, or
- the potential difference between stationary contacts is less than 10 V and the switched current less than 0,1 A.

f. Parallelled relays shall not be used to increase current switching capabilities of contacts. When relays are parallelled for redundancy, in order to increase the system's reliability, the sum of the parallelled currents shall not exceed the contact current rating.

g. Suppression diodes shall not be used inside relays.

7.25.2 Derating

Parameters	Load ratio or limit
Contact current • Resistive load	 Number of operations less than 100 (including integration and testing • When the specified overload current is rated at twice the rated contact current, the rated contact current may be used. • When the specified overload current is rated at 4 times the rated contact current, twice the rated contact current may be used.
• Inductive load	50 % of inductive load if specified, or 40 % of resistive load otherwise. If an arc suppressor or snubber system is used, the load factor for resistive load may be applied.
• Motor load	50 % of motor load if specified, or 20 % of resistive load otherwise.
• Filament load.	10 % of resistive load.
Minimum contact current	• For rated contact current (I_{CR}) ≤ 1 A, no limit needs to be considered. • For 1 A < I_{CR} ≤ 5 A, the current shall be greater than 10 mA. • For I_{CR} > 5 A, the current shall be greater than 10 % of the rated current.
Surge contact current (I_{SCR})	When the surge duration ≤ 10 μs, the surge contact current shall not exceed 4 times the rated contact current.

7.25.3 End-of-life drifts

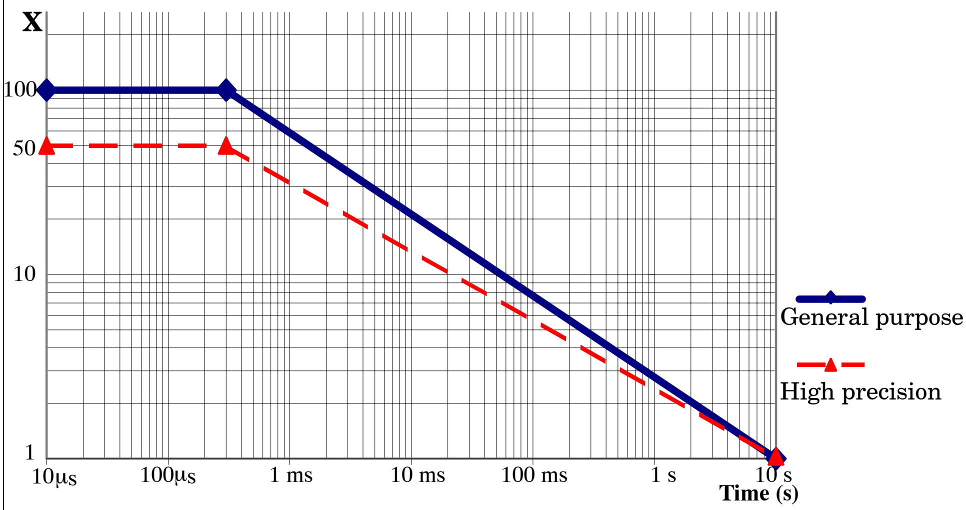
Parameters	Drifts
Contact resistance	Maximum limit (if N < 1000 operations). Maximum limit × 2 (if N > 1000 operations).
For thermal switches only: • Operating temperature (T_f) • Reset temperature (T_r)	 Initial tolerance + 1 °C Initial tolerance + 1 °C

7.26 Resistors — family-group code: 10-01 to 10-11

7.26.1 Derating (all resistors except heaters)

<table>
<tr><th>Parameters</th><th colspan="5">Load ratio or limit</th></tr>
<tr><td>Voltage</td><td colspan="5">80 %</td></tr>
<tr><td rowspan="11">Power</td><td colspan="5">
</td></tr>
<tr><th rowspan="2">Type</th><th colspan="2">P_1 @ T_1</th><th colspan="2">P_0 @ T_2</th></tr>
<tr><th>(%)</th><th>(°C)</th><th>(%)</th><th>(°C)</th></tr>
<tr><td>Metal film precision (type RNC except RNC90)</td><td>75</td><td>125</td><td>0</td><td>T_{max} - 25</td></tr>
<tr><td>Metal film semi-precision (type RLR)</td><td>75</td><td>70</td><td>0</td><td>T_{max} - 25</td></tr>
<tr><td>Foil (type RNC90)</td><td>75</td><td>70</td><td>35</td><td>125</td></tr>
<tr><td>Wire-wound high precision (type RBR 56)</td><td>75</td><td>125</td><td>0</td><td>130</td></tr>
<tr><td>Wire-wound power (types RWR, RER)</td><td>75</td><td>25</td><td>15</td><td>175</td></tr>
<tr><td>Film or foil chips</td><td>75</td><td>70</td><td>0</td><td>T_{max} - 25</td></tr>
<tr><td>Film network</td><td>75</td><td>70</td><td>0</td><td>T_{max} - 25</td></tr>
<tr><td colspan="5">Load ratios shall be read with end-of-life performance.</td></tr>
<tr><td>Pulse power rating — repetitive pulses</td><td colspan="5">Average power < 50 % of rating at corresponding temperature
$$P_{average} = \frac{V_p^{\ 2}}{R} \times \frac{t_p}{T}$$
Where:
V_p: pulse amplitude
R: resistance
t_p: pulse width
T: cycle duration in seconds</td></tr>
</table>

7.26.1 Derating (all resistors except heaters) *(continued)*

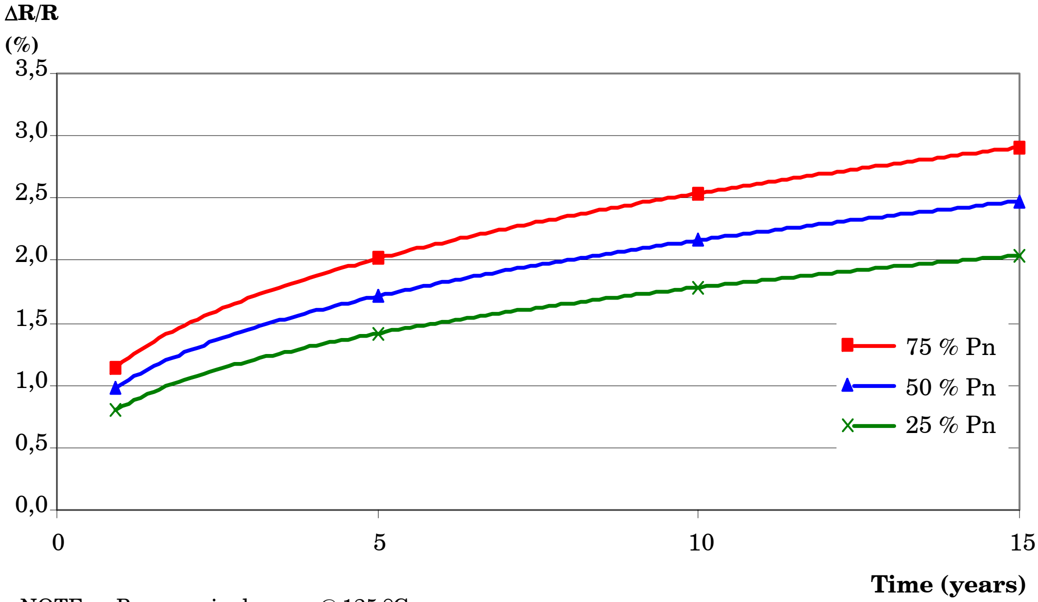
<table>
<tr><th>Parameters</th><th>Load ratio or limit</th></tr>
<tr><td>Pulse power rating — single pulses</td><td>

Single pulse (10 µs < t < 10 s): (except power wire-wound resistors).
$P_{max} = X \times P_{derated}$
Single pulse for power wire-wound resistors.
$P_{max} = \frac{18 \times P_{derated} \times 1s}{t_{pulse}}$
where:
$P_{derated}$ is the derated power in continuous conditions;
t_{pulse} is the pulse duration in seconds;
with voltage not exceeding 2,5 times the rated voltage.</td></tr>
</table>

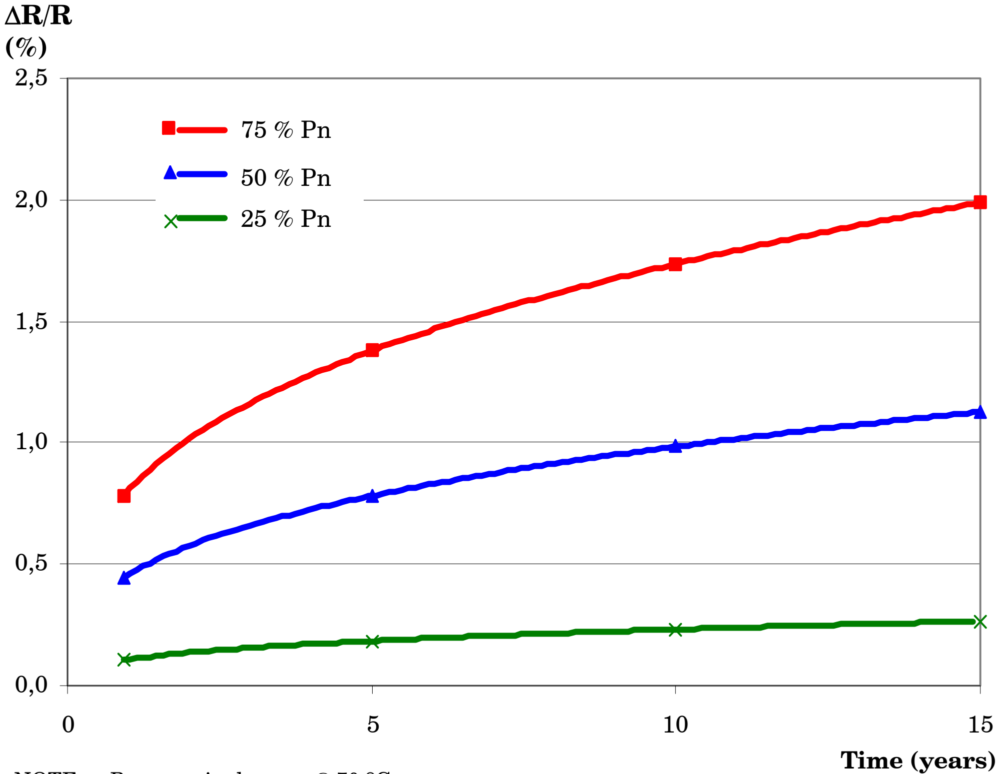
7.26.2 Derating for heaters

Parameters	Load ratio or limit
Power density with respect to heating area (W/cm^2)	50 %

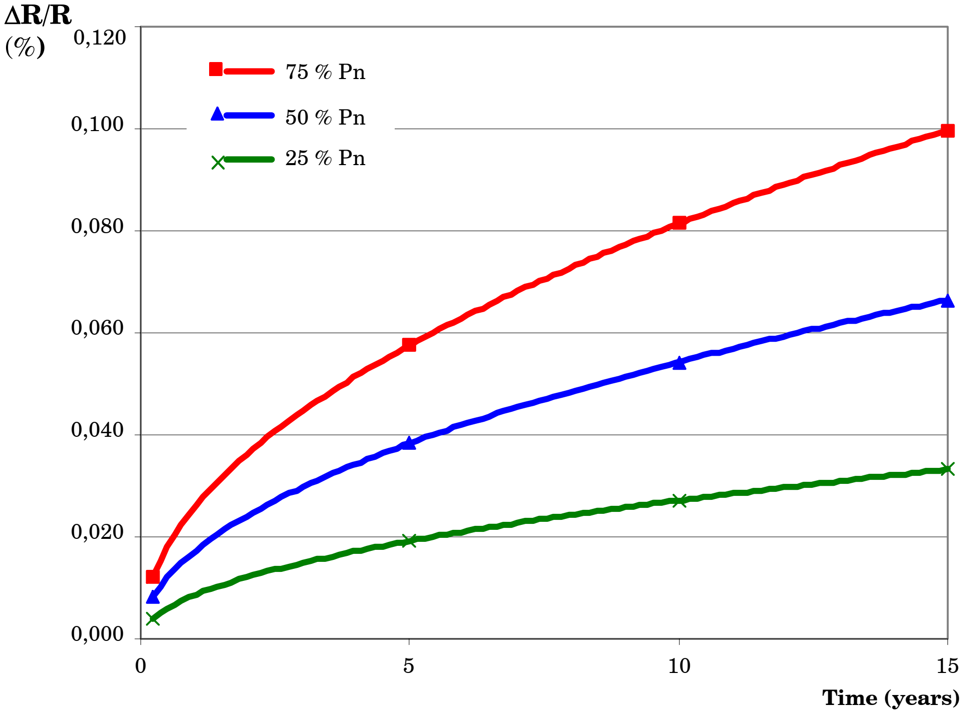
7.26.3 End-of-life drifts — metal film (RNC except 90)

Parameters	Drifts
ΔR/R @ 125 °C	 NOTE Pn = nominal power @ 125 °C

7.26.4 End-of-life drifts — metal film (RLR)

Parameters	Drifts
ΔR/R @ 70 °C	 NOTE Pn = nominal power @ 70 °C

7.26.5 End-of-life drifts — foil (RNC90)

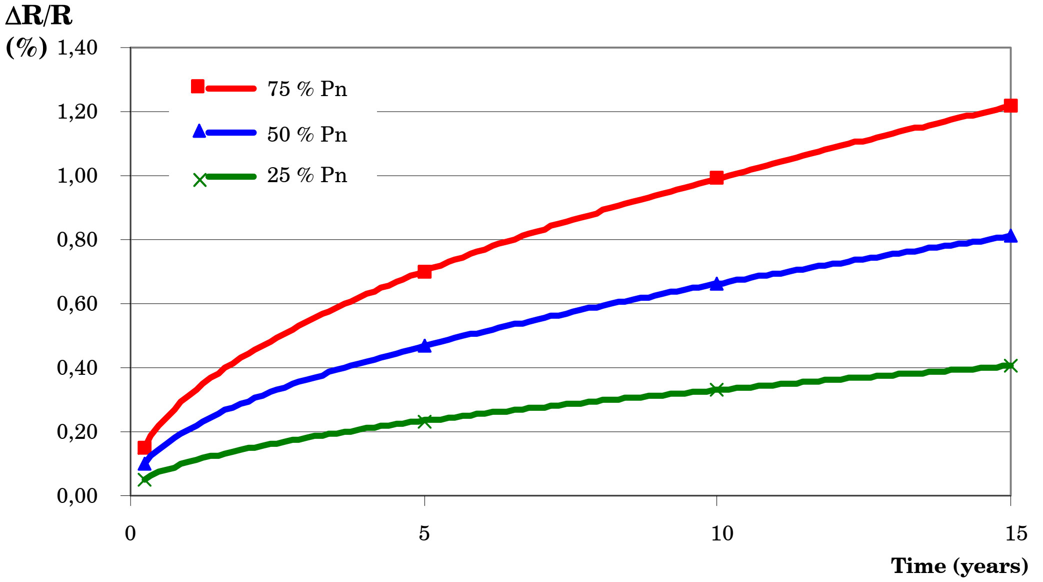
<table>
<tr><th>Parameters</th><th>Drifts</th></tr>
<tr><td>ΔR/R @ 70 °C</td><td>

NOTE Pn = nominal power @ 70 °C</td></tr>
</table>

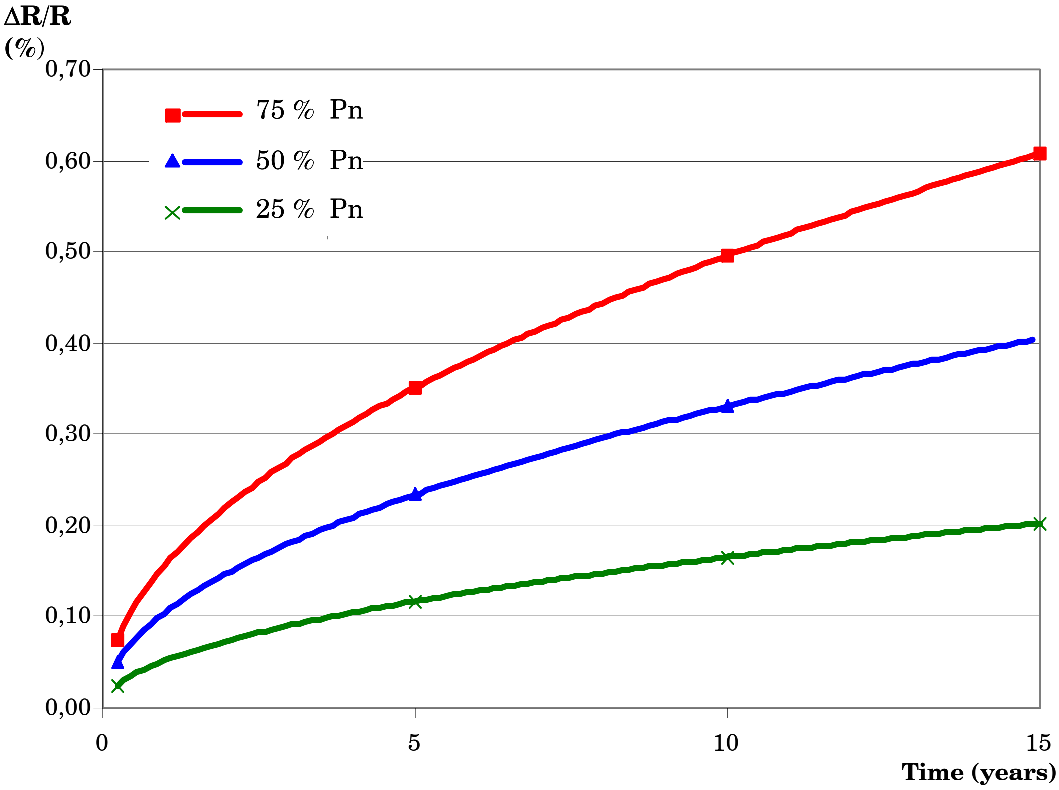
7.26.6 End-of-life drifts — wire-wound resistors

Parameters	Drifts		
	5 years	10 years	15 years
ΔR/R — wire-wound precision: type RBR	±0,4 %	±0,4 %	±0,4 %
ΔR/R — wire-wound power: types RWR, RER	±0,8 %	±1,2 %	±1,5 %

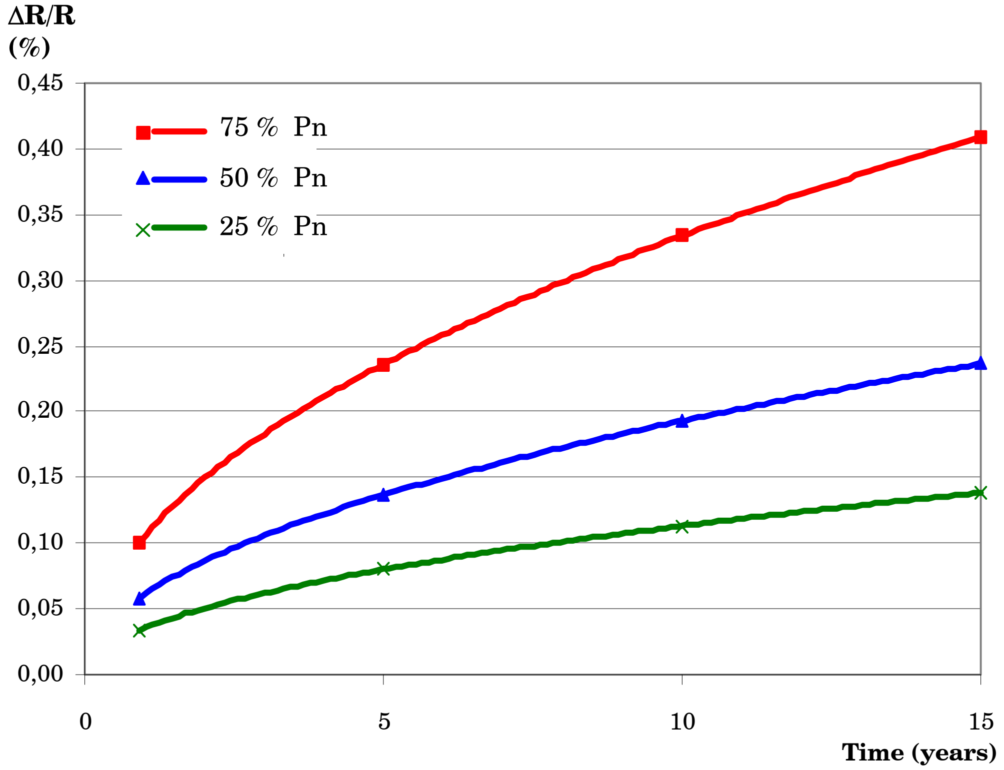
7.26.7 End-of-life drifts — chip, R < 100 Ω, type RM

Parameters	Drifts
ΔR/R @ 70 °C	 NOTE Pn = nominal power @ 70 °C

7.26.8 End-of-life drifts — chip, R ≥ 100 Ω, type RM

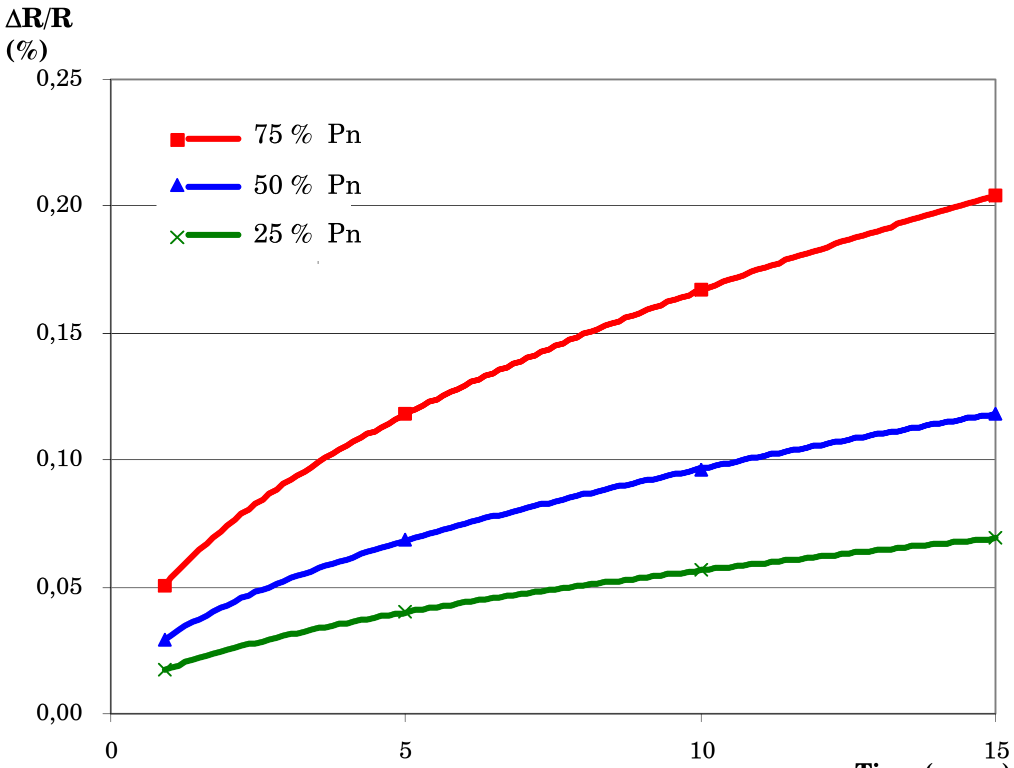
Parameters	Drifts
ΔR/R @ 70 °C	 NOTE Pn = nominal power @ 70 °C

7.26.9 End-of-life drifts — chip, precision, R < 100 Ω, types P, UMA

<table>
<tr><th>Parameters</th><th>Drifts</th></tr>
<tr><td>ΔR/R @ 70 °C</td><td>


NOTE Pn = nominal power @ 70 °C
</td></tr>
</table>

7.26.10 End-of-life drifts — chip, precision, R ≥100 Ω, types P, UMA

<table>
<tr><th>Parameters</th><th>Drifts</th></tr>
<tr><td>ΔR/R @ 70 °C</td><td>


NOTE Pn = nominal power @ 70 °C
</td></tr>
</table>

7.26.11 End-of-life drifts — networks and heaters

Parameters	Drifts		
	5 years	**10 years**	**15 years**
Network ΔR/R @ 70 °C	±0,9 %	±1,3 %	±1,6 %
Heaters ΔR/R	±0,6 %	±0,8 %	±1 %

7.27 Thermistors — family-group code: 11-01 to 11-03

7.27.1 Derating

Parameters	Load ratio or limit
Power	50 % (1)
(1) For positive temperature coefficient (PTC) and negative temperature coefficient (NTC) thermistors.	

7.27.2 End-of-life drifts

Parameters	Drifts			
	Time	Temperature		
		55 °C	85 °C	125 °C
Resistance NTC thermistor	5 years	Within initial tolerance	Within initial tolerance	Within initial tolerance
	10 years	Within initial tolerance	Within initial tolerance	Initial tolerance ±1 %
	15 years	Within initial tolerance	Initial tolerance ±1 %	Initial tolerance ±2 %
Resistance PTC thermistor	• Initial tolerance if sensor used between 0 °C and 100 °C. • Add ±0,5 % to the initial tolerance for other temperatures.			

7.28 Transistors: bipolar — family-group code: 12-01 to 12-04 and 12-09

7.28.1 General

Some transistors can be radiation sensitive: this shall be recorded and approved in accordance with ECSS-Q-60.

7.28.2 Derating

Parameters	**Load ratio or limit**	**Special conditions**
Collector-emitter voltage (V_{CE0})	80 %	
Collector-base voltage (V_{CB0})	80 %	
Emitter-base voltage (V_{EB0})	80 %	
Collector current (I_C max)	80 %	
Base current (I_B max)	80 %	
Safe Operating Area • $I_{C\ max}$ DC • $I_{C\ max}$ pulsed	 80 % of manufacturer's SOA curve. 80 % of manufacturer's SOA curve.	For power cycling application: • ΔT_j < 50 °C 50 000 cycles. • ΔT_j < 30 °C 100 000 cycles.
Maximum junction temperature (T_j)	110 °C for 10- or 15-year missions.	125 °C for 5-year missions.

7.28.3 End-of-life drifts

Parameters	**Drifts**	**Special conditions**
Collector-emitter voltage $V_{CE(sat)}$	Within maximum specified value.	
Base-emitter voltage $V_{BE(sat)}$	Within maximum specified value.	
Gain (h_{FE})	±25 %	In a radiation environment, the lower the collector current, the higher the gain degradation (hFE).
Collector-emitter current (I_{CES}/I_{CEX})	Within maximum specified value.	
Collector-base current (I_{CB0})	Within maximum specified value.	
Emitter-base current (I_{EBO})	Within maximum specified value.	

7.29 Transistors: FET — family-group code: 12-05 and 12-06

Transistor FETs - Power Mosfets are susceptible to single event burn-out (SEB) and single event gate rupture (SEGR) from heavy ions under certain conditions.
The requirements for derating are provided in ECSS-E-10-12.

7.30 Transistors: RF: bipolar — family-group code: 12-10, 12-11, 12-13, 12-15(HBT), 12-16(HBT)

7.30.1 General

Some transistors can be radiation sensitive: the issue shall be recorded in the design file and the components selection shall be reviewed and approved as described in ECSS-Q-60.

7.30.2 Derating

Parameters	**Load ratio or limit**
Collector-emitter voltage (V_{CE})	80 %
Collector-base voltage (V_{CB})	80 %
Emitter-base voltage (V_{EB})	80 %
Collector current (I_C)	80 %
Base current (I_B)	80 %
Power dissipation (P_D)	80 % or limited by the derating on operating temperature.
Maximum junction temperature (T_j)	110 °C or $T_{j\ max}$ – 40 °C (whichever is lower) for Si or GaAs bipolar transistors.

7.30.3 End-of-life drifts

Parameters	**Drifts**
Collector-base current (I_{CB})	Within maximum specified value.
Emitter-base current (I_{EB})	Within maximum specified value.
Gain (h_{FE})	±25 %

7.31 Transistors: RF: FET — family-group code: 12-12, 12-14, 12-15(FET), 12-16(FET)

7.31.1 General

Some transistors can be radiation sensitive: selection and approval shall be in accordance with ECSS-Q-60 and justification shall be provided at the appropriate project reviews.

7.31.2 Derating

Parameters	Load ratio or limit
Maximum channel temperature (T_{ch})	110 °C or $T_{j\ max}$ – 40 °C (whichever is lower) for Si FETs. 125 °C or $T_{j\ max}$ – 40 °C (whichever is lower) for GaAs FETs.
Drain to source voltage (V_{DS})	75 %
Gate to source voltage (V_{GS})	75 %
Gate to drain voltage (V_{DS})	75 %
Drain current	
• Normally "ON" technology (I_{DSS})	75 %
• Normally "OFF" technology ($I_{DS\ @}$ Vth)	75 %
Power dissipation (P_D)	80 % or limited by the derating on operating temperature.
NOTE When supported by reliability data, the compression level (including worst case modulation peak compression) is derated to 4 dB under the highest compression level showing no drift. No compression levels exceeding 1 dB are applied to FETs without compression data.	

7.31.3 End-of-life drifts

Parameters	Drifts
Threshold voltage (Vth)	±10 %
Gate leakage current (I_{GS})	5 × worst case operational value
Drain current for V_{GS} = 0 (I_{DSS})	Normally "ON": ±20 % Normally "OFF": 5 × initial value
Drain current for V_{GS} threshold ($I_{DS\ @}$ Vth)	Normally "ON": 5 × initial value Normally "OFF": ±20 %
Transconductance (g_m)	±25 %

7.32 Wires and cables — family-group code: 13-01 to 13 03

Derating

Parameters	Load ratio or limit														
Voltage	50 %														
Wire size (AWG)	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4
Maximum current (A)[(1)(2)]	1,2	1,3	1,5	2,5	3,5	5	7,5	10	13	17	25	32	45	60	81
Wire surface temperature	Manufacturer's maximum rating – 40 °C or 120 °C, whichever is lower.														

(1) Maximum applied current according to the wire size (AWG) resulting in a maximum temperature of 120 °C.

(2) The derating on current for bundles with N wires is calculated as follows
$I_{BW} = I_{SW} \times K$

Wires AWG 0 to AWG 12		Wires AWG 14 to AWG 32	
Number of wires (N)	**K**	**Number of wires (N)**	**K**
$1 < N \leq 3$	$1,1 - (0,1 \times N)$	$1 < N \leq 3$	$1,1 - (0,1 \times N)$
$3 < N \leq 7$	$1,01 - (0,07 \times N)$	$3 < N \leq 7$	$1,01 - (0,07 \times N)$
$7 < N \leq 19$	$0,81 - [0,15 \times \ln(N)]$	$7 < N \leq 52$	$0,81 - [0,15 \times \ln(N)]$
$19 < N \leq 331$	$0,59 - [0,076 \times \ln(N)]$	$52 < N \leq 331$	$0,467 - [0,0632 \times \ln(N)]$

I_{BW}: maximum current for an individual wire in a bundle.

I_{SW}: maximum current for a single wire as given in the derating table on preceding page.

ln: Natural log.

7.33 Opto-electronics — family-group code: 18-01 to 18-05

7.33.1 General

a. Light emitting diodes can be radiation sensitive, in particular, there is a high sensitivity to displacement damage. This shall be recorded and approved in accordance with ECSS-Q-60.

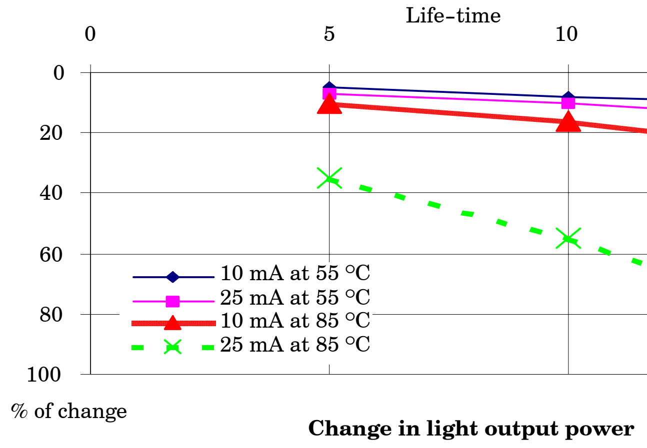
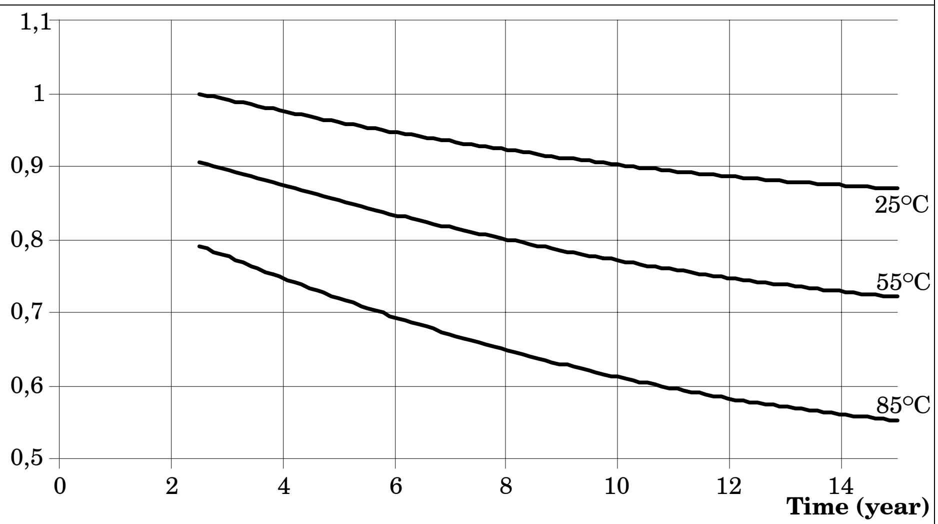
b. Opto-couplers can be radiation sensitive, in particular, operation at low diode currents increases radiation sensitivity. This shall be recorded and approved in accordance with ECSS-Q-60.

c. Photo-transistors can be radiation sensitive: this shall be recorded and approved in accordance with ECSS-Q-60.

7.33.2 Derating

Parameters	Load ratio or limit
Light emitting diodes and opto-couplers Power	
Photo-transistors and opto-couplers	
• V_{ceo}	80 %
• $I_{c\ max}$	80 %
• Maximum junction temperature	110 °C or $T_{j\ max}$ – 40 °C (whichever is lower).

7.33.3 End-of-life drifts

Parameters	Drifts
Light emitting diodes Light output power	
Opto-coupler Ageing coefficient for current transfer ratio $\left(\frac{\Delta CTR}{CTR}\right)$	
Photo-transistor Collector leakage current (I_{ceo})	0,25 µA × 2 $^{[(T-25)/10]}$ for V_{ce} ≤ 50 % of $V_{(br)ceo}$ 1 µA × 2 $^{[(T-25)/10]}$ for V_{ce} > 50 % of $V_{(br)ceo}$

7.34 RF passive components: family-group-code: 30-01, 30-07, 30-09, 30-10 and 30-99

7.34.1 General

For components with a connector, connector savers shall be used during testing of equipment to minimize number of mating and demating cycles.

7.34.2 Derating

Parameters	**Load ratio or limit**
RF power	75 % and shall be limited such that a 6 dB margin exists before the onset of multipaction.
Maximum operating temperature	30 °C below maximum rated temperature.
Maximum mating and demating cycles	50

7.35 Fibre optic components: fibre and cable: family-group-code: 27-01

7.35.1 Derating

Parameters	Load ratio or limit
Bend radius	200 % of the minimum value
Cable tension	50 % of the rated tensile strength
Fibre tension	20 % of the proof test

7.35.2 End-of-life drifts

Not applicable.

Annex A (informative)

Family and group codes

This annex contains an extract from the European preferred parts list (EPPL) and it lists all the parts referred to in this Standard providing their family and group codes.

Family code	Group code	Family	Group
01	01	Capacitors	Ceramic
01	02	Capacitors	Ceramic Chip
01	03	Capacitors	Tantalum solid
01	04	Capacitors	Tantalum non-solid
01	05	Capacitors	Plastic metallized
01	06	Capacitors	Glass
01	07	Capacitors	Mica
01	09	Capacitors	Aluminium solid
01	10	Capacitors	Feedthrough
01	11	Capacitors	Semiconductor
02	01	Connectors	Circular
02	02	Connectors	Rectangular
02	03	Connectors	Printed circuit board
02	07	Connectors	Microminiature
02	09	Connectors	Rack and panel
03	01	Piezo-electric devices	Crystal resonator
04	01	Diodes	Switching
04	02	Diodes	Rectifier
04	03	Diodes	Voltage regulator
04	04	Diodes	Voltage reference/zener
04	05	Diodes	RF/microwave Schottky - Si
04	06	Diodes	Pin

Family code	Group code	Family	Group
04	08	Diodes	Transient suppression
04	10	Diodes	High voltage rectifier
04	11	Diodes	Microwave varactor – GaAs
04	12	Diodes	Step recovery
04	13	Diodes	Microwave varactor – Si
04	14	Diodes	Current regulator
04	15	Diodes	Microwave Schottky – GaAs
04	16	Diodes	RF/microwave – PIN
04	17	Diodes	Microwave GUNN – GaAs
05	01	Filters	Feedthrough
06	01	Fuses	All
07	01	Inductors	RF coil
07	02	Inductors	Cores
07	03	Inductors	Chip
08	10	Microcircuits	Microprocessors/microcontrollers/ peripherals
08	20	Microcircuits	Memory SRAM
08	21	Microcircuits	Memory DRAM
08	22	Microcircuits	Memory PROM
08	23	Microcircuits	Memory EPROM
08	24	Microcircuits	Memory EEPROM
08	29	Microcircuits	Memory others
08	30	Microcircuits	Programmable logic
08	40	Microcircuits	ASIC technologies digital
08	41	Microcircuits	ASIC technologies linear
08	42	Microcircuits	ASIC technologies mixed analogue/digital
08	50	Microcircuits	Linear operational amplifier
08	51	Microcircuits	Linear sample and hold amplifier
08	52	Microcircuits	Linear voltage regulator
08	53	Microcircuits	Linear voltage comparator
08	54	Microcircuits	Linear switching regulator
08	55	Microcircuits	Linear line driver
08	56	Microcircuits	Linear line receiver
08	57	Microcircuits	Linear timer
08	58	Microcircuits	Linear multiplier
08	59	Microcircuits	Linear switches
08	60	Microcircuits	Linear multiplexer/demultiplexer
08	61	Microcircuits	Linear analog to digital converter
08	62	Microcircuits	Linear digital to analogue converter
08	69	Microcircuits	Linear other functions
08	80	Microcircuits	Logic families

Family code	Group code	Family	Group
08	99	Microcircuits	Miscellaneous

09	01	Relays	Non-latching
09	02	Relays	Latching

10	01	Resistors	Metal oxide
10	02	Resistors	Wire-wound precision - including surface mount
10	03	Resistors	Wire-wound chassis mounted
10	04	Resistors	Variable trimmers
10	05	Resistors	Composition
10	07	Resistors	Shunt
10	08	Resistors	Metal film
10	09	Resistors	Chip - all
10	10	Resistors	Network - all
10	11	Resistors	Heaters, flexible

11	01	Thermistors	Temperature compensating
11	02	Thermistors	Temperature measuring
11	03	Thermistors	Temperature sensor

12	01	Transistors	Low power, NPN - < 2 W
12	02	Transistors	Low power, PNP - < 2 W
12	03	Transistors	High power, NPN - > 2 W
12	04	Transistors	High power, PNP - > 2 W
12	05	Transistors	FET N channel
12	06	Transistors	FET P channel
12	09	Transistors	Switching
12	10	Transistors	RF/microwave NPN low power/low noise
12	11	Transistors	RF/microwave PNP low power/low noise
12	12	Transistors	RF/microwave FET N-channel/P-channel
12	13	Transistors	RF/microwave bipolar power
12	14	Transistors	RF/microwave FET power - Si
12	15	Transistors	Microwave power - GaAs
12	16	Transistors	Microwave low noise - GaAs

13	01	Wires and cables	Low frequency
13	02	Wires and cables	Coaxial
13	03	Wires and cables	Fibre optic

16	01	Switches	Standard DC/AC power toggle

Family code	Group code	Family	Group
18	01	Opto electronics	Optocoupler
18	02	Opto electronics	LED
18	03	Opto electronics	Phototransistor
18	04	Opto electronics	Photo diode/sensor
18	05	Opto electronics	Laser diode
27	01	Fibreoptic components	Fibre/cable
30	01	RF passive devices	Coaxial couplers
30	07	RF passive devices	Isolator/circulator
30	09	RF passive devices	Coaxial power dividers
30	10	RF passive devices	Coaxial attenuators/loads
30	99	RF passive devices	Miscellaneous

Bibliography

ECSS-E-10-12 [1)]	Space engineering — Method for calculation of radiation dose and margin policy
ECSS-Q-30	Space product assurance — Dependability

1) To be published.

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ECSS Document Improvement Proposal

1. Document I.D.	2. Document date	3. Document title
ECSS-Q-60-11A	7 September 2004	Derating and end-of-life parameter drifts — EEE components
4. Recommended improvement (identify clauses, subclauses and include modified text or graphic, attach pages as necessary)		
5. Reason for recommendation		
6. Originator of recommendation		
Name:	Organization:	
Address:	Phone: Fax: e-mail:	**7. Date of submission:**
8. Send to ECSS Secretariat		
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