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Space product assurance

Derating - 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.

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 (NSAs) and the European space industry, reviewed by the ECSS Product Assurance Panel and approved by the ECSS Steering Board.

The end-of-life parameter drifts are not covered by this Standard.

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Introduction

This Standard specifies derating requirements applicable to electronic, electrical and electromechanical components.

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.

1 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;
- Application rules and recommendations.

This standard may be tailored for the specific characteristics and constraints of a space project, in accordance with ECSS-S-ST-00.

2
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-S-ST-00-01	ECSS system – Glossary of terms
ECSS-Q-ST-60	Space product assurance – Electrical, electronic and electromechanical (EEE) components

3 Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this Standard, the terms and definitions from ECSS-ST-00-01 apply.

3.2 Terms specific to the present standard

3.2.1 ambient temperature

temperature surrounding a component

3.2.2 case temperature

temperature on the component package surface

3.2.3 derating

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

3.2.4 hot spot temperature

highest measured or predicted temperature within any component

3.2.5 junction temperature

highest measured or predicted temperature at the junction within a semiconductor or micro-electronic device

NOTE Predicted temperature can be taken as T_{case} + thermal resistance between junction and case times actual power (Watt) of the device.

3.2.6 load ratio

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

3.2.7 operating conditions

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

3.2.8 performance

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

3.2.9 RadPack

package designed to provide some form of radiation protection

3.2.10 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.

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
AC	alternating current
A/D	analog to digital
AWG	American wire gauge
C	capacitance
DC	direct current
EMC	electromagnetic 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
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
SEE	single event effect
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

4
User responsibility

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

5 Derating

5.1 Overview

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.

Derating participates in the protection of components from unexpected application anomalies and board design variations.

The load ratios or limits given in clause 6 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.

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 5-1 illustrates the strength of a component and the stress applied at a given time, where each characteristic is represented by a probability density function.

A component operates in a reliable way if its parameter strength exceeds the parameter stress. The designer should ensure that the stress applied does not exceed the component parameter strength. This is represented by the intersection (shaded area) in Figure 5-1. 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.

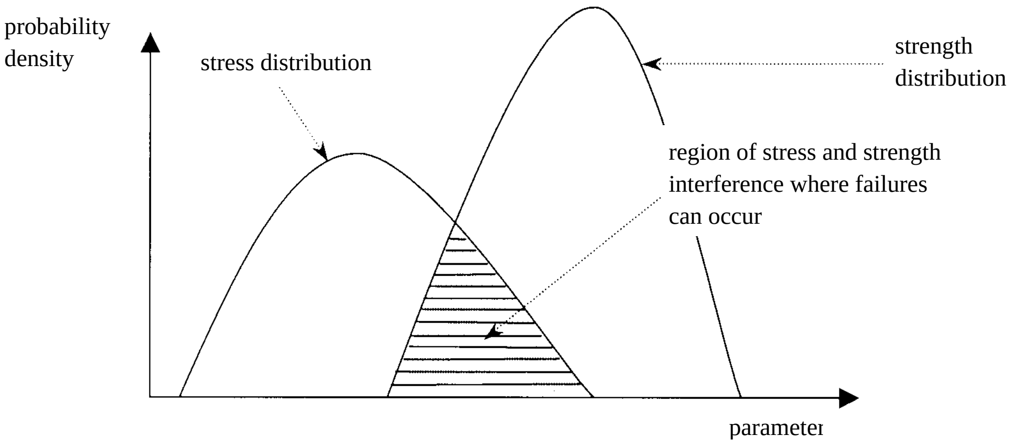


Figure 5-1: Parameter stress versus strength relationship

5.3 Applicability and component selection

5.3.1 Overview

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 is considered to be a significant duration. These requirements apply to screened components procured in accordance with approved space specifications.

This Standard only applies to approved components for which quality was proven after rigorous testing in accordance with ECSS-Q-ST-60.

5.3.2 Requirements

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

b. The derating requirements of this Standard shall not be used as a justification to upgrade the quality level of components.

c. The derating requirements shall be taken into account at the beginning of the design cycle of an 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 the 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.

e. 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 designer shall ensure that the applied stress level does not exceed the component maximum rating.

f. 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 maximum ratings shall not be exceeded.

g. Derating shall be applied on normal operating conditions and not on the fault condition.

h. Where components are required to operate in protection mode or in 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 when performing the protection or fail-safe function under the worst failure case (i.e. highest stress applied to the components that can last throughout the mission).

5.4 Derating parameters

5.4.1 Overview

Derating requirements are provided in clause 6 for each component family.

For each category, 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.

The parameters to be derated depend on component type.

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.

5.4.2 Requirements

a. If ratings are provided for transients or surge conditions, the same derating figures as for steady-state equivalent parameters shall be used.

b. If ratings are not provided for transient or surge conditions, then it shall be assured that the transient or surge values are below the steady-state specified maximum ratings.

c. Repetitive transients, e.g. in a switching DC/DC converter operation, and clock transmission lines, shall not exceed the derated steady-state values, superseded by no more than 90 % of the rated manufacturer values if not compatible.

d. Where radiation sensitive components are identified, 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 shall be in accordance with this Standard.

5.5 Additional rules and recommendations

5.5.1 Overview

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

5.5.2 Requirements

a. For hybrids, individual components shall be in conformance with their respective derating rules.

6 Tables for load ratios or limits

6.1 Overview

This clause provides the load ratios or limits.

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

https://escies.org

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.

6.2 Capacitors: ceramic – family-group code: 01-01 and 01-02

6.2.1 General

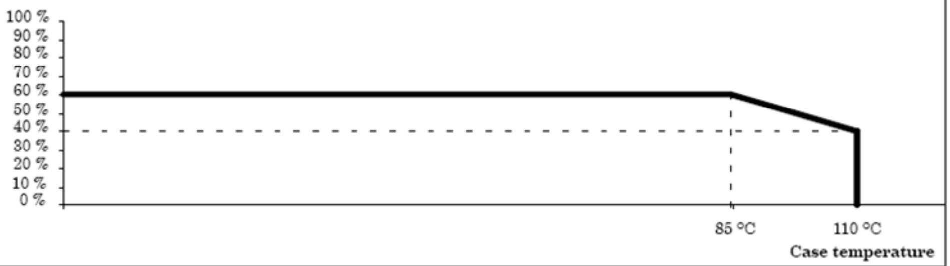
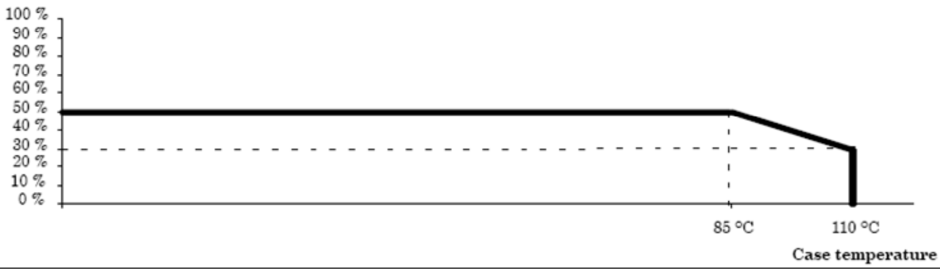
a. The capacitor stress sum value of steady-state voltage, AC voltage shall not exceed the load ratios specified hereunder. For transients refer to clause 5.4.

b. Multilayer capacitors with a DC 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 test or other approved method.

c. Physical limitation for type II**:** maximum surge dV/dt approximate to 100 V/µs. This should be verified with the manufacturer.

d. Internal heating due to ESR can increase ageing and should be taken into account by applying a margin in temperature. Where ESR is not known at the frequency of a ripple current, an extrapolation of the ESR value and resonance (from manufacturer's or test data) should be made where possible.

6.2.2 Derating

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

6.3 Capacitors: solid tantalum – family-group code: 01-03

6.3.1 General

a. The capacitor stress sum value of steady-state voltage and AC voltage shall not exceed the load ratio specified hereunder. For transients refer to clause 5.4.

b. 100 % surge current screening shall be applied for all surface mounted capacitors types.

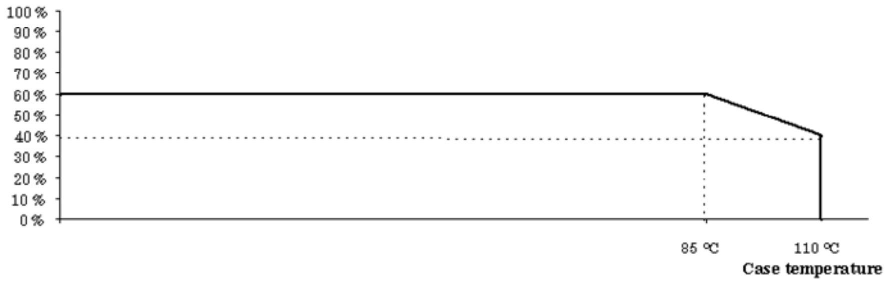
c. Surge current shall be derated to 75 % of the Isurge max. Isurge max is defined as Vrated/(ESR+Rs). Vrated is the maximum rated voltage, ESR is the maximum specified value and Rs is the value of series resistance specified in the circuit for surge current testing as defined in the applicable procurement specification.

d. Reverse voltage shall not exceed 75 % of the manufacturer's specified maximum value for the reverse voltage.

e. Ripple power shall never exceed 50 % of the manufacturer's specified maximum value.

f. Internal heating due to ESR can increase ageing and should be taken into account by applying a margin in temperature. Where ESR is not known at the frequency of a ripple current, an extrapolation of the ESR value and resonance (from manufacturer's or test data) should be made where possible.

6.3.2 Derating

Parameters	Load ratio or limit
Voltage	

6.4 Capacitors: non-solid tantalum – family-group code: 01-04

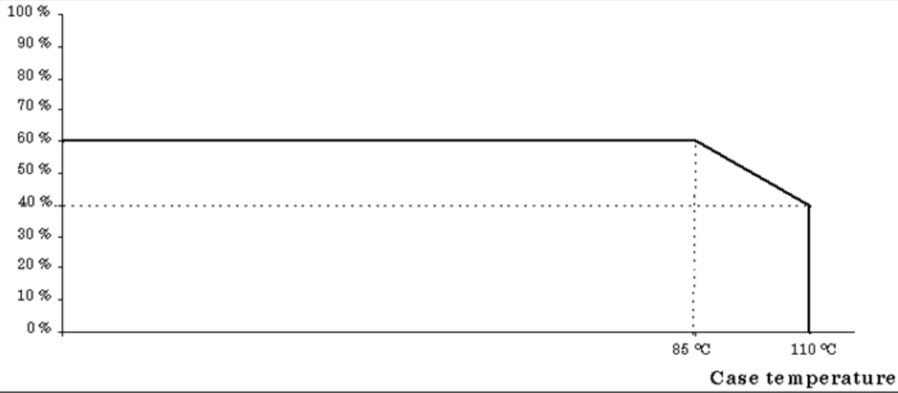
6.4.1 General

a. Reverse voltage shall not exceed 75 % of the manufacturer's specified maximum value for the reverse voltage.

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

c. Internal heating due to ESR can increase ageing and should be taken into account by applying a margin in temperature. Where ESR is not known at the frequency of a ripple current, an extrapolation of the ESR value and resonance (from manufacturer's or test data) should be made where possible.

6.4.2 Derating

Parameters	Load ratio or limit
Voltage: voltage includes DC voltage and super-imposed AC voltage or surge voltage.	

6.5 Capacitors: film – family-group code: 01-05

6.5.1 General

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

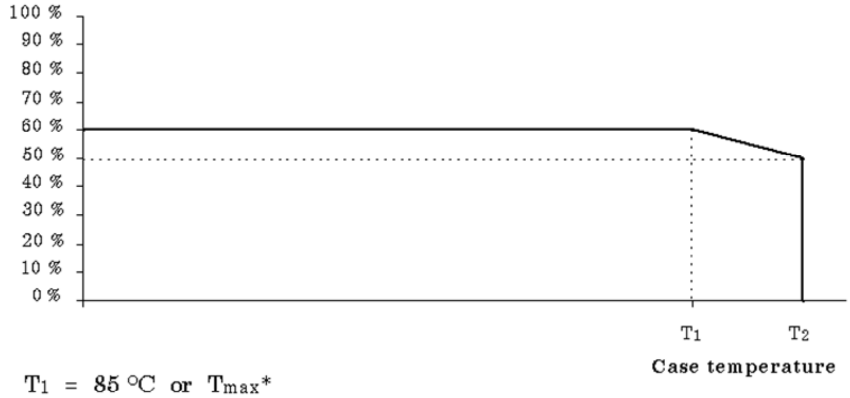
   1. To have a clearing process in any case, the minimum energy available shall be greater than the manufacturer's specified value (typical self healing energy is 5 μJ minimum).

   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. Internal heating due to ESR can increase ageing and should be taken into account by applying a margin in temperature. Where ESR is not known at the frequency of a ripple current, an extrapolation of the ESR value and resonance (from manufacturer's or test data) should be made where possible.

6.5.2 Derating

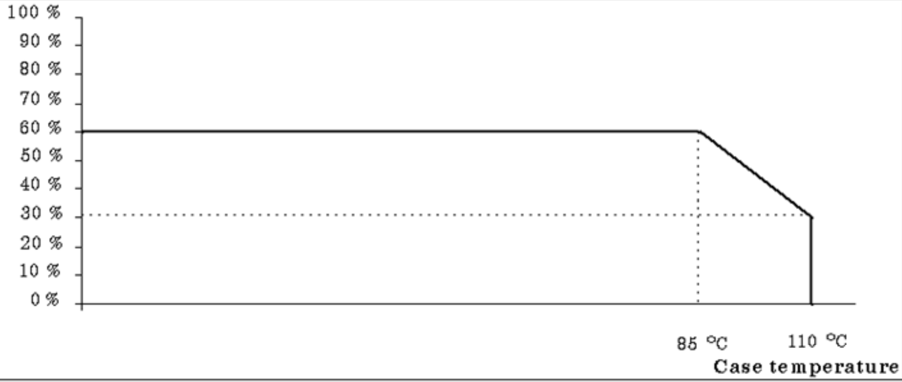
Parameters	Load ratio or limit
Voltage: voltage includes DC voltage and superimposed AC peak voltage.	 T_1 = 85 °C or T_{max}* T_2 = 100 °C or T_{max}* whichever is lower * For capacitors rated 100 °C, the general rule is superseded by the application of a voltage derating of 60 % up to a temperature of 85 °C

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

6.6.1 General

a. Internal heating due to ESR can increase ageing and should be taken into account by applying a margin in temperature. Where ESR is not known at the frequency of a ripple current, an extrapolation of the ESR value and resonance (from manufacturer's or test data) should be made where possible.

6.6.2 Derating

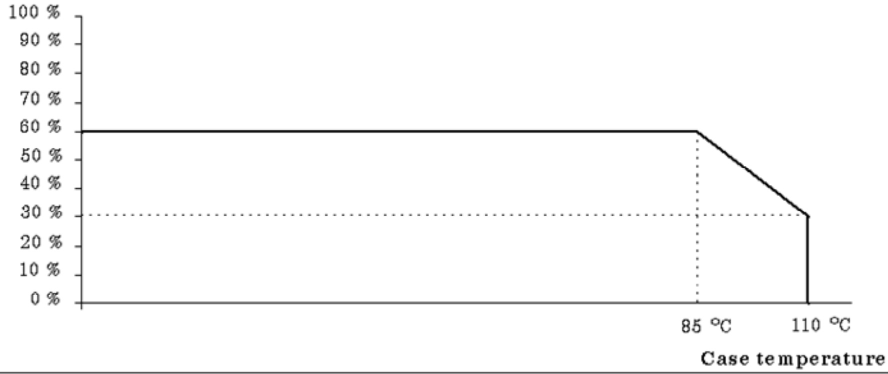
Parameters	Load ratio or limit
Voltage: voltage includes DC voltage and super-imposed AC peak voltage.	

6.7 Capacitors: mica and reconstituted mica – family-group code: 01-07

6.7.1 General

a. Internal heating due to ESR can increase ageing and should be taken into account by applying a margin in temperature. Where ESR is not known at the frequency of a ripple current, an extrapolation of the ESR value and resonance (from manufacturer's or test data) should be made where possible.

6.7.2 Derating

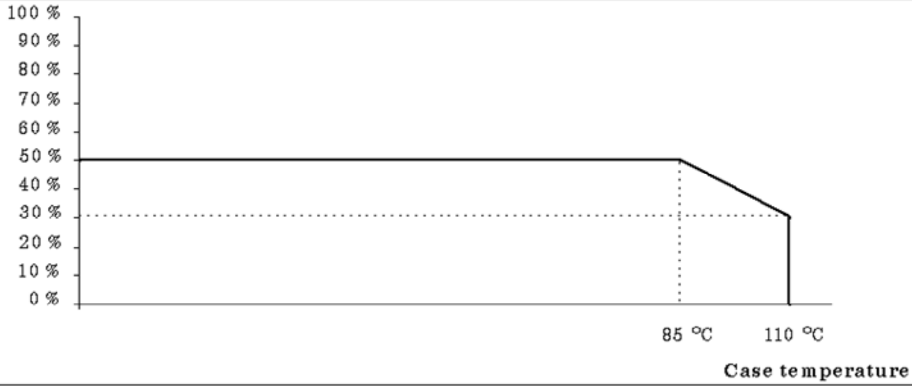
Parameters	Load ratio or limit
Voltage: voltage includes DC voltage and super-imposed AC peak voltage.	

6.8 Capacitors: feedthrough – family-group code: 01-10

6.8.1 General

a. Internal heating due to ESR can increase ageing and should be taken into account by applying a margin in temperature. Where ESR is not known at the frequency of a ripple current, an extrapolation of the ESR value and resonance (from manufacturer's or test data) should be made where possible.

6.8.2 Derating

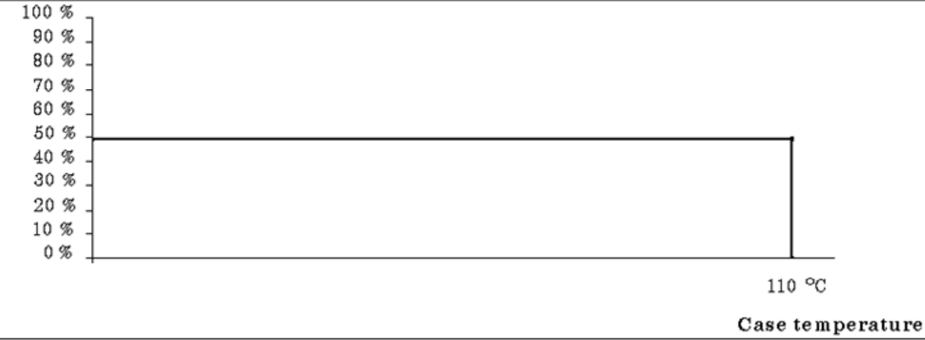
Parameters	Load ratio or limit
Voltage	

6.9 Capacitors: semiconductor technology (MOS type) – family-group code: 01-11

6.9.1 General

a. Internal heating due to ESR can increase ageing and should be taken into account by applying a margin in temperature. Where ESR is not known at the frequency of a ripple current, an extrapolation of the ESR value and resonance (from manufacturer's or test data) should be made where possible.

6.9.2 Derating

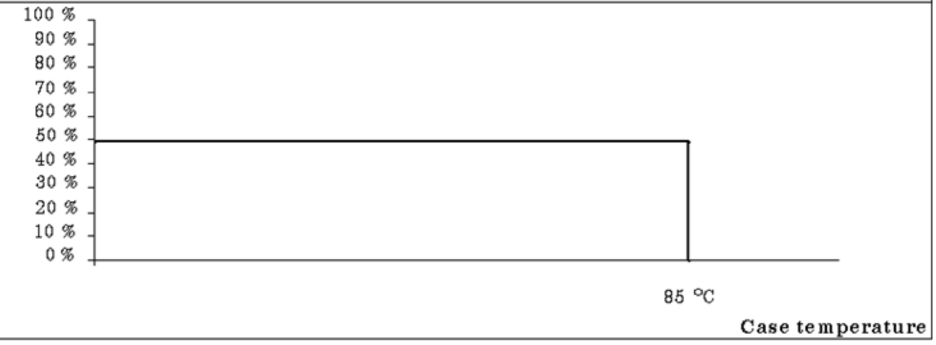
Parameters	Load ratio or limit
Voltage	

6.10 Capacitors: miscellaneous (variable capacitors) – family-group code: 01-99

6.10.1 General

a. Internal heating due to ESR can increase ageing and should be taken into account by applying a margin in temperature. Where ESR is not known at the frequency of a ripple current, an extrapolation of the ESR value and resonance (from manufacturer's or test data) should be made where possible.

6.10.2 Derating

Parameters	Load ratio or limit
Voltage	

6.11 Connectors – family-group code: 02-01, 02-02, 02-03, 02-07 and 02-09

6.11.1 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.

6.11.2 Derating

Parameters	Load ratio or limit
Working voltage	50 % of specified voltage at any altitude (pin-to-pin and pin-to-shell).
Current	50 %
Maximum operating temperature	30 °C below maximum rated temperature.
Maximum mating and demating cycles	50

6.12 Connectors RF – family-group code: 02-05

6.12.1 General

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

6.12.2 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	50 % of specified voltage at any altitude (pin-to-pin and pin-to-shell).
Maximum operating temperature	30 °C below maximum rated temperature.
Maximum mating and demating cycles	50

6.13 Piezo-electric devices: crystal resonator – family-group code: 03-01

6.13.1 Derating

Part type	Derating
Drive level	25 % power rated drive level (superseded by manufacturer required minimum drive level if not compatible).

6.14 Diodes – family-group code: 04-01, 04-02, 04-03, 04-04, 04-06, 04-08, 04-10 to 04-13 and 04-14

6.14.1 General

a. 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-ST-60. Where power cycling is critical this should be considered.

6.14.2 Derating

6.14.2.1 Diode (signal/switching, rectifier, transient suppression, varactor, pin, Schottky, step recovery) derating table

Part type	**Derating**
Forward surge current (I_{FSM}): - non-repetitive operation - repetitive operation	 80 % 60 %
Reverse voltage (V_R)	75 %
Dissipated power (P_D)	50 % (only if dissipated power is defined by the manufacturer)
Maximum junction temperature ($T_{j\,max}$)	110 °C or $T_{j\,max}$ – 40 °C (whichever is lower).

6.14.2.2 Diode (Zener, reference) derating table

Part type	**Derating**
Zener surge current (IZSM): - non-repetitive operation - repetitive operation	 80 % 60 %
Dissipated power (P_D)	65 %
Maximum junction temperature ($T_{j\,max}$)	110 °C or Tj max – 40 °C (whichever is lower)

6.15 Diodes: RF/microwave-PIN – family-group code: 04-05, 04-15, 04-16 and 04-17

6.15.1 General

a. 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-ST-60.

6.15.2 Derating

Part type	**Derating**
Forward surge current	50 %
Reverse voltage (V_R)	75 %
Dissipated power (P_D)	65 %
Maximum junction temperature ($T_{j\,max}$)	110 °C or $T_{j\,max}$ – 40 °C (whichever is lower)
NOTE 1: Forward current is not applicable to varactors. NOTE 2: Reverse voltage is not applicable to Gunn diodes.	

6.16 Feedthrough filters – family-group code: 05-01

6.16.1 Derating

Parameters	Load ratio or limit
Current (continuous and surge)	70 %
Voltage	

6.17 Fuses: Cermet (metal film on ceramic) – family-group code: 06-01

6.17.1 General

a. Fuses shall be avoided whenever possible. The derating requirements in 6.17.2 (below) are only applicable to Cermet types. The application and the deratings of other fuse technologies shall be justified.

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

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

6.17.2 Derating

Parameters	Load ratio or limit
Current	

6.18 Inductors and transformers – family-group code: 07-01 to 07-03

6.18.1 General

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

6.18.2 Derating

Parameters	Load ratio or limit	Special conditions
Maximum operating voltage (1)	50 % of the applied insulation test voltage (2)	(1) Between winding-winding and between windings-case. The maximum operating voltage shall include DC, AC peak or combined. (2) Unless specified in the procurement specification, the minimum insulation test voltage applied shall be 500 V. For operating voltages greater than 200 V the insulation test voltage is equal to the partial discharge voltage (V_{PD}), defined as the component qualification test level, where the partial discharge activity is detected, and with a test equipment sensitivity of no less than 1 pC.
Hot spot temperature	20 °C below maximum rated temperature of any material used.	

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

6.19.1 General

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

6.19.2 Derating

Parameters	**Load ratio or limit**	**Special conditions**
Supply voltage (V_{CC})	Manufacturer 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 (unless otherwise stated in the device specification).
Output current (I_{out})	80 %	
Maximum junction temperature ($T_{j\ max}$)	110 °C or $T_{j\ max}$ – 40 °C (whichever is lower)	**Junction temperature** If the maximum junction temperature is not specified, derate from the maximum operating temperature.

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

6.20.1 General

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

6.20.2 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 ($T_{j\,max}$)	110 °C or $T_{j\,max}$ – 40 °C (whichever is lower)	**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.

6.21 Integrated circuits: linear – family-group code: 08-50 to 08-60 and 08-69

6.21.1 General

a. Some linear circuits 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-ST-60.

b. Additional margins can be applied for radiation effects.

6.21.2 Derating

Parameters	**Load ratio or limit**	**Special conditions**
Supply voltage (V_{CC})	90 % of the maximum rated value	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.	
Output current (I_{out})	80 %	
Transients	Shall not exceed the specified maximum ratings.	
Maximum junction temperature ($T_{j\,max}$)	110 °C or $T_{j\,max}$ – 40 °C, whichever is lower.	

6.22 Integrated circuits: linear converters – family-group code: 08-61 and 08-62

6.22.1 General

a. Some linear circuits 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-ST-60.

6.22.2 Derating

Parameters	Load ratio or limit	Special conditions
Maximum junction temperature ($T_{j\,max}$)	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)	

6.23 Integrated circuits: MMICs – family-group code: 08-95

6.23.1 General

a. 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-ST-60 and provided in accordance with this Standard, and at the design reviews.

6.23.2 Derating

a. 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.

b. When operational reliability data is available, the compression level shall be derated to 2 dB under the highest compression level showing no drift. MMICs having no compression data shall not be submitted to more than 1 dB of compression.

6.24 Integrated circuits: miscellaneous – family-group code: 08-99

6.24.1 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-ST-60.

6.25 Relays and switches – family-group code: 09-01, 09-02 and 16-01

6.25.1 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-ST-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:

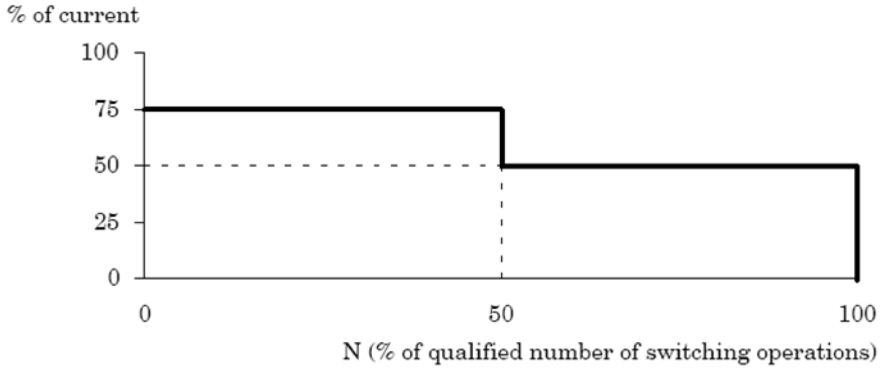
— when switching off the power supply the other stationary contact is not connected to ground, or

— the potential difference between stationary contacts is less than 10 V and the switched current less than 0,1 A.

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

g. Suppression diodes shall not be used inside relays.

6.25.2 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.

6.26 Resistors – family-group code: 10-01 to 10-11

6.26.1 Derating (all resistors except heaters)

6.26.1.1 General

a. The mentioned temperatures cited below refer to case temperatures.

6.26.1.2 Metal film precision resistor (type RNC, except RNC 90) derating table

Part type	Derating
Voltage	80 %
Power	50 % up to 125 °C and further decreasing to 0 % at 150 °C

6.26.1.3 Metal film semi-precision resistor (type RLR) derating table

Part type	Derating
Voltage	80 %
Power	50 % up to 70 °C and further decreasing to 0 % at 125 °C

6.26.1.4 Foil resistor (type RNC 90) derating table

Part type	Derating
Voltage	80 %
Power	50 % up to 70 °C and further decreasing to 0 % at 125 °C

6.26.1.5 Wire-wound high precision resistor (type RBR 56) derating table

Part type	Derating
Voltage	80 %
Power (type RBR 56)	Wire-wound for all tolerances: 50 % up to 115 °C, decreasing to 0 % at 130 °C

6.26.1.6 Wire-wound power resistor (type RWR, RER) derating table

Part type	Derating
Voltage	80 %
Power	60 % up to 25 °C, decreasing to 0 % at 175 °C

6.26.1.7 Chip resistor (RM), network resistor derating table

Part type	Derating
Voltage	80 %
Power	50 % up to 85 °C, decreasing to 0 % at 125 °C

6.26.1.8 Microwave load resistor derating table

Part type	Derating
Voltage	80 %
Power	50 %

6.26.1.9 Pulse power rating - repetitive pulses

a. Average power < 50 % of nominal rating

$$P_{average} = \frac{V_p^2}{R} \times \frac{t_p}{T}$$

where

Vp is the pulse amplitude

R is the resistance

t_p is the pulse width

T is the cycle duration

6.26.1.10 Pulse power rating (single pulse)

a. If ratings are provided for transient or surge condition, the same derating figures as for steady-state equivalent parameters shall be used.

b. If ratings are not provided for transient or surge condition, then it shall be assured that the transient or surge values are below the steady-state specified ratings.

6.26.2 Derating for heaters

Parameters	Load ratio or limit
Actual rated power (W)	50 %

a. Actual rated power shall be specified in the applicable heater design drawing. It shall be determined from the specified heating area (s) in cm^2 taking into account the thermal properties of the mounted heater in the application.

6.27 Thermistors – family-group code: 11-01 to 11-03

6.27.1 Derating

Parameters	Load ratio or limit
Power	50 % of the maximum power

6.28 Transistors: bipolar – family-group code: 12-01 to 12-04 and 12-09

6.28.1 General

a. 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-ST-60.

6.28.2 Derating

Part type	Derating
Collector-emitter voltage (V_{CE0})	75 %
Collector-base voltage (V_{CB0})	75 %
Emitter-base voltage (V_{EB0})	75 %
Collector current (I_C max)	75 %
Base current (I_B max), if specified	75 %
Power (P_D)	65 % of maximum power. [a] [b]
Maximum junction temperature ($T_{j\,max}$)	110 °C or $T_{j\,max}$ - 40 °C (whichever is lower).

[a] The designer should refer to the SOA.

[b] Where power cycling is critical this should be considered.

6.29 Transistors: FET – family-group code: 12-05 and 12-06

6.29.1 General

a. Only SEE radiation characterized MOSFETs shall be used in space applications.

b. The user shall consider power cycling when this is critical to his application.

6.29.2 Derating

Parameters	**Load ratio or limit**
Drain to source voltage (V_{DS})	80 % of rated, or the SEE safe operating area (VDS versus VGS), whichever is lower
Gate to source voltage (V_{GS})	75 %, taking into account the SEE Safe Operating Area
Drain current (I_{DS})	75 %
Power dissipation (P_D) max	65 % max
Maximum junction temperature ($T_{j\,max}$)	110 °C or $T_{j\,max}$ - 40 °C (whichever is lower)

6.30 Transistors: RF: bipolar – family-group code: 12-10 and 12-13

6.30.1 General

a. 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-ST-60.

6.30.2 Derating

Part type	Derating
Collector-emitter voltage (V_{CE})	75 %
Collector-base voltage (V_{CB})	75 %
Emitter-base voltage (V_{EB})	75 %
Collector current (I_C)	75 %
Base current (I_B), if specified	75 %
Power dissipation (P_D)	65 % or limited by the derating on operating temperature.
Maximum junction temperature ($T_{j\,max}$)	110 °C or $T_{j\,max}$ – 40 °C (whichever is lower) for Si bipolar transistors.

6.31 Transistors: RF: FET – family-group code: 12-12, 12-14, 12-15(FET) and 12-16(FET)

6.31.1 General

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

6.31.2 Derating

Part type	Derating
Drain to source voltage (V_{DS})	75 %
Gate to source voltage (V_{GS})	75 %
Gate to drain voltage (V_{DS})	75 %
Drain current (I_{DS})	75 %
Power dissipation (P_D)	80 % or limited by the derating on operating temperature.
Maximum junction temperature ($T_{j\,max}$)	110 °C or $T_{j\,max}$ – 40 °C (whichever is lower) for Si. 115 °C or $T_{j\,max}$ – 40 °C (whichever is lower) for GaAs.
NOTE When supported by reliability data, the compression level (including worst case modulation peak compression) is derated to 2 dB under the highest compression level showing no drift. No compression levels exceeding 1 dB are applied to FETs without compression data.	

6.32 Wires and cables – family-group code: 13-01 to 13 03

6.32.1 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 Cu (I) (A) [a b]	1,2	1,3	1,5	2,5	3,5	5	7,5	10	13	17	25	32	45	60	81
Maximum current Al (I) (A) [a b]						4	6	8	10,4	13,6	18,4	25,6	36		
Wire surface temperature	Manufacturer's maximum rating – 40 °C or 120 °C, whichever is lower.														

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

[b] The derating on current for bundles with N wires is calculated as follows IBW = ISW × 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 ≤ 3	1,1 – (0,1 × N)	1 < N ≤ 3	1,1 – (0,1 × N)
3 < N ≤ 7	1,01 – (0,07 × N)	3 < N ≤ 7	1,01 – (0,07 × N)
7 < N ≤ 19	0,81 – [0,15 × ln(N)]	7 < N ≤ 52	0,81 – [0,15 × ln(N)]
19 < N ≤ 331	0,59 – [0,076 × ln(N)]	52 < N ≤ 331	0,467 – [0,0632 × ln(N)]

IBW: maximum current for an individual wire in a bundle.
ISW: maximum current for a single wire as given in the derating table above.
ln: Natural log.

6.33 Opto-electronics – family-group code: 18-01 to 18-05

6.33.1 General

a. Light emitting diodes can be radiation sensitive, in particular, there is a high sensitivity to proton displacement damage: this issue shall be recorded in the design file and the components selection shall be reviewed and approved as described in ECSS-Q-ST-60.

b. Opto-couplers can be radiation sensitive, in particular, operation at low diode currents increases radiation sensitivity: this issue shall be recorded in the design file and the components selection shall be reviewed and approved as described in ECSS-Q-ST-60.

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

6.33.2 Derating

Parameters	**Load ratio or limit**
Light emitting diode:	
Forward current	Manufacturer recommended value, or derate to 50 % if not available
Reverse voltage	Derate to 75 %
Photo transistor:	
Maximum collector current	Derate to 80 %
Maximum collector-emitter voltage	Derate to 75 %
Light emitting diode and photo transistor:	
Maximum junction temperature ($T_{j\,max}$)	110 °C or $T_{j\,max}$-40 °C (whichever is lower)

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

6.34.1 General

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

6.34.2 Derating

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

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

6.35.1 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

6.36 Hybrids

a. For hybrids, individual components shall be in conformance with their respective derating rules.

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 and reconstituted mica
01	10	Capacitors	Feedthrough
01	11	Capacitors	Semiconductor
01	99	Capacitors	Miscellaneous
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

Family code	Group code	Family	Group
04	06	Diodes	Pin
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

Family code	Group code	Family	Group
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
08	95	Microcircuits	MMIC
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

Family code	Group code	Family	Group
12	06	Transistors	FET P channel
12	09	Transistors	Switching
12	10	Transistors	RF/microwave NPN 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
18	01	Opto-electronics	Opto-coupler
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-S-ST-00	ECSS system - Description and implementation and general requirements