Australian/New Zealand Standard™

Electric components — Reliability — Reference conditions for failure rates and stress models for conversion





### AS/NZS IEC 61709:2019

This Joint Australian/New Zealand Standard<sup>™</sup> was prepared by Joint Technical Committee QR-005, Dependability. It was approved on behalf of the Council of Standards Australia on 5 April 2019 and by the New Zealand Standards Approval Board on 7 May 2019.

This Standard was published on 20 May 2019.

University of Western Australia University of Wollongong

The following are represented on Committee QR-005:

Asset Management Council
Australian Industry Group
Department of Defence (Australian Government)
Engineering New Zealand
Engineers Australia
Independent Transport Safety and Reliability Regulator (NSW)
Institution of Occupational Safety and Health
National Road Carriers Association (NZ)
New Zealand Institute of Safety Management
Professionals Australia
Risk Engineering Society
Risk Management Institute of Australasia
RiskNZ
University of New South Wales

This Standard was issued in draft form for comment as DR AS/NZS IEC 61709:2019.

### **Keeping Standards up-to-date**

Ensure you have the latest versions of our publications and keep up-to-date about Amendments, Rulings, Withdrawals, and new projects by visiting:

www.standards.org.au www.standards.govt.nz

ISBN 978 1 76072 474 0

This is a preview. Click here to purchase the full publication.

# Australian/New Zealand Standard™

# Electric components — Reliability — Reference conditions for failure rates and stress models for conversion

First published as AS/NZS IEC 61709:2019.

### **COPYRIGHT**

- © IEC 2019 All rights reserved
- © Standards Australia Limited/the Crown in right of New Zealand, administered by the New Zealand Standards Executive 2019

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher, unless otherwise permitted under the Copyright Act 1968 (Cth) or the Copyright Act 1994 (New Zealand).

## **Preface**

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee QR-005, Dependability.

The objective of this Standard is to give guidance on the use of failure rate data for reliability prediction of electric components used in equipment. The method presented in this document uses the concept of reference conditions which are the typical values of stresses that are observed by components in the majority of applications. Reference conditions are useful since they provide a known standard basis from which failure rates can be modified to account for differences in environment from the environments taken as reference conditions.

This Standard is identical with, and has been reproduced from, IEC 61709:2017, *Electric components* — *Reliability* — *Reference conditions for failure rates and stress models for conversion.* 

As this document has been reproduced from an International Standard, a full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms "normative" and "informative" are used in Standards to define the application of the appendices or annexes to which they apply. A "normative" appendix or annex is an integral part of a Standard, whereas an "informative" appendix or annex is only for information and guidance.

# **CONTENTS**

F	OREWOR	RD	9
IN	TRODUC	CTION	11
1	Scope		12
2	Norma	ative references	12
3	Terms	, definitions and symbols	12
		Terms and definitions	
	3.2	Symbols	16
4	Conte	xt and conditions	17
	4.1 I	Failure modes and mechanisms	17
	4.2	Thermal modelling	18
	4.3 I	Mission profile consideration	18
	4.3.1	General	18
	4.3.2	Operating and non-operating conditions	
	4.3.3	Dormancy	
	4.3.4	Storage	
		Environmental conditions	
		Components choice	
		Reliability growth during the deployment phase of new equipment  How to use this document	
5		ic reference conditions and stress models	
J		Recommended generic reference conditions	
		Generic stress models	
	5.2.1	General	
	5.2.2	Stress factor for voltage dependence, $\pi_{\sf U}$	
	5.2.3	Stress factor for current dependence, $\pi_1$	
	5.2.4	Stress factor for temperature dependence, $\pi_{T}$	
	5.2.5	Environmental application factor, $\pi_{E}$	28
	5.2.6	Dependence on switching rate, $\pi_{S}$	28
	5.2.7	Dependence on electrical stress, $\pi_{ES}$	29
	5.2.8	Other factors of influence	29
6	Integr	ated semiconductor circuits	29
	6.1	Specific reference conditions	29
	6.2	Specific stress models	31
	6.2.1	General	31
	6.2.2	Voltage dependence, factor $\pi_{\sf U}$	32
	6.2.3	Temperature dependence, factor $\pi_{T}$	32
7	Discre	te semiconductors	35
	7.1	Specific reference conditions	35
		Specific stress models	
	7.2.1	General	36
	7.2.2	Voltage dependence for transistors, factor $\pi_{U}$	37
	7.2.3	Temperature dependence, factor $\pi_{T}$	37
8	Optoe	lectronic components	39
	•		

	8.1 8.2		ons	
	8.2.1	General	4	ŀ1
	8.2.2	Voltage dependence,	, factor $\pi_{\sf U}$ 4	ŀ1
	8.2.3	Current dependence,	factor $\pi_{\parallel}$ 4	ŀ1
	8.2.4	Temperature depend	ence, factor $\pi_{T}$ 4	12
9	Сара	citors	4	14
	9.1		ons4	
	9.2	Specific stress model	4	14
	9.2.1	General	4	14
	9.2.2	Voltage dependence,	, factor $\pi_{U}$ 4	14
	9.2.3	Temperature depend	ence, factor $\pi_{T}$ 4	16
10	Resis	tors and resistor networks	34	7
	10.1	Specific reference condition	ons4	17
	10.2	•	4	
	10.2.		4	
	10.2.	2 Temperature depend	ence, factor $\pi_{T}$ 4	3
11	Induc	tors, transformers and coi	ls4	16
	11.1		4	
	11.2	•	4	
	11.2.		4	
	11.2.		ence, factor $\pi_{T}$ 4	
12			5	
	12.1	·	ons5	
40	12.2	•	5	
13		·	5	
	13.1 13.2	•	ons5	
14	-	•	5	
• •	14.1		ons5	
	14.2	•		
15		•	5	
	15.1		5	
	15.2		5	
16	Relay	/S	5	52
	16.1	Reference conditions	5	52
	16.2	Specific stress models	5	;3
	16.2.		5	
	16.2.	2 Dependence on switch	ching rate, factor $\pi_{S}$ 5	;3
	16.2.	3 Dependence on elect	trical stress, factor $\pi_{ES}$ 5	54
	16.2.	4 Temperature depend	ence, factor $\pi_{T}$ 5	55
17	Switc	hes and push-buttons	5	55
	17.1	Specific reference condition	ons5	55
	17.2	Specific stress model	5	56
	17.2.	1 General	5	56

17.2.2	Dependence on electrical stress, factor $\pi_{ES}$	56
18 Signal a	nd pilot lamps	57
18.1 Sp	ecific reference conditions	57
18.2 Sp	ecific stress model	57
18.2.1	General	57
18.2.2	Voltage dependence, factor $\pi_{U}$	58
19 Printed of	circuit boards (PCB)	58
20 Hybrid c	ircuits	58
Annex A (nor	mative) Failure modes of components	59
Annex B (info	ormative) Thermal model for semiconductors	62
B.1 The	ermal model	62
B.2 Jur	nction temperature calculation	63
B.3 The	ermal resistance evaluation	64
B.4 Po	wer dissipation of an integrated circuit P	65
Annex C (info	ormative) Failure rate prediction	68
C.1 Ge	neral	68
C.2 Fa	ilure rate prediction for assemblies	68
C.2.1	General	68
C.2.2	Assumptions and limitations	69
C.2.3	Process for failure rate prediction	
C.2.4	Prediction models	70
C.2.5	Other methods of reliability prediction	71
C.2.6	Validity considerations of reliability models and predictions	72
C.3 Co	mponent considerations	73
C.3.1	Component model	
C.3.2	Components classification	73
C.4 Ge	neral consideration about failure rate	73
C.4.1	General	73
C.4.2	General behaviour of the failure rate of components	74
C.4.3	Expected values of failure rate	75
C.4.4	Sources of variation in failure rates	
Annex D (info	ormative) Considerations on mission profile	77
D.1 Ge	neral	77
D.2 Do	rmancy	77
D.3 Mis	ssion profile	78
D.4 Ex	ample of mission profile	79
Annex E (info	ormative) Useful life models	80
E.1 Ge	neral	80
E.2 Po	wer transistors	80
E.3 Op	tocouplers	80
E.3.1	Useful life L	
E.3.2	Factor $L_0$	81
E.3.3	Factor κ <sub>0</sub>	81
E.3.4	Factor κ <sub>1</sub>	82
E.3.5	Factor $\kappa_2$	82
E.3.6	Factor $\kappa_3$	82
E/ IE	D and LED modules	83

E.4.1	Useful life L	83
E.4.2	Factor <i>L</i> <sub>0</sub>	83
E.4.3	Factor κ <sub>0</sub>	84
E.4.4	Factor κ <sub>1</sub>	84
E.4.5	Factor $\kappa_2$	85
E.4.6	Factor $\kappa_3$	85
E.5	Aluminium, non-solid electrolyte capacitors	
E.6	Relays	86
E.7	Switches and keyboards	86
E.8	Connectors	86
Annex F (	informative) Physics of failure	87
F.1	General	87
F.2	Failure mechanisms of integrated circuits	8
Annex G	(informative) Considerations for the design of a data base on failure rates	
G.1	General	89
G.2	Data collection acquisition – collection process	
G.3	Which data to collect and how to collect it	
G.4	Calculation and decision making	
G.5	Data descriptions	
G.6	Identification of components	
G.6.	·	
G.6.2		
G.6.3	·	
G.7	Specification of components	91
G.7.′	General	91
G.7.2	Electrical specification of components	91
G.7.3	B Environmental specification of components	92
G.8	Field related issues data	92
G.8.′	General	92
G.8.2	2 Actual field conditions	92
G.8.3	B Data on field failures	92
G.9	Test related issues data	93
G.9.	General	93
G.9.2	2 Actual test conditions	93
G.9.3	B Data on test failures	93
G.10	Failure rate database attributes	94
Annex H	informative) Potential sources of failure rate data and methods of selection	96
H.1	General	96
H.2	Data source selection	96
H.3	User data	97
H.4	Manufacturer's data	97
H.5	Handbook reliability data	98
H.5.1	General	98
H.5.2	Using handbook data with this document	98
H.5.3	List of available handbooks	99
Annex I (i	nformative) Overview of component classification	102
l.1	General	102
1.2	The IEC 61360 system	102

1.3	Other systems	110
1.3.1	General	110
1.3.2	NATO stock numbers	110
1.3.3	UNSPSC codes	110
1.3.4	STEP/EXPRESS	110
1.3.5	IECQ	110
1.3.6	ECALS	111
1.3.7	ISO 13584	111
1.3.8	MIL specifications	111
Annex J (	informative) Presentation of component reliability data	112
J.1	General	112
J.2	Identification of components	112
J.2.1	General	112
J.2.2	Component identification	113
J.2.3	Component technology	113
J.3	Specification of components	113
J.3.1	General	113
J.3.2	Electrical specification of components	113
J.3.3	Environmental specification of components	113
J.4	Test related issues data	113
J.4.1	General	113
J.4.2	Actual test conditions	114
J.5	Data on test failures	114
Annex K (	informative) Examples	116
K.1	Integrated circuit	116
K.2	Transistor	116
K.3	Capacitor	116
K.4	Relay	117
Bibliograp	hy	118
Figure 1 -	- Comparison of the temperature dependence of $\pi_{T}$ for CMOS IC	24
•	- Selection of stress regions in accordance with current and voltage-operating	
	3	54
•	- Selection of stress regions in accordance with current and voltage-operating	
	S	
•	1 – Temperatures inside equipment	
Figure B.2	2 – Thermal resistance model	64
Figure D.	1 — Mission profile	79
	Basic environments	
Table 2 –	Values of environmental parameters for basic environments	21
	Recommended reference conditions for environmental and mechanical	25
	Environmental application factor, $\pi_{E}$	
Table 5 –	Memory	30
Table 6 –	Microprocessors and peripherals, microcontrollers and signal processors	30
Table 7	Digital logic families and bus interfaces, bus driver and receiver circuits	30

Table 8 – Analog ICs	31
Table 9 – Application-specific ICs (ASICs)	31
Table 10 – Constants for voltage dependence	32
Table 11 – Factor $\pi_{\sf U}$ for digital CMOS-family ICs	32
Table 12 – Factor $\pi_{\sf U}$ for bipolar analog ICs	32
Table 13 – Constants for temperature dependence	32
Table 14 – Factor $\pi_{T}$ for ICs (without EPROM; FLASH-EPROM; OTPROM; EEPROM;	
EAROM)	34
Table 15 – Factor $\pi_{T}$ for EPROM; FLASH-EPROM; OTPROM; EEPROM; EAROM	34
Table 16 – Transistors common, low frequency	35
Table 17 – Transistors, microwave, (e.g. RF > 800 MHz)	35
Table 18 – Diodes	36
Table 19 – Power semiconductors	36
Table 20 – Constants for voltage dependence of transistors	37
Table 21 – Factor $\pi_{\sf U}$ for transistors	37
Table 22 – Constants for temperature dependence of discrete semiconductors	37
Table 23 – Factor $\pi_{T}$ for transistors, reference and microwave diodes	38
Table 24 – Factor $\pi_{T}$ for diodes (without reference and microwave diodes) and power	
semiconductors	38
Table 25 – Optoelectronic semiconductor signal receivers	39
Table 26 – LEDs, IREDs, laser diodes and transmitter components	39
Table 27 – Optocouplers and light barriers	40
Table 28 – Passive optical components	40
Table 29 – Transceiver, transponder and optical sub-equipment	40
Table 30 – Constants for voltage dependence of phototransistors	41
Table 31 – Factor $\pi_{\sf U}$ for phototransistors	41
Table 32 – Constants for current dependence of LEDs and IREDs	42
Table 33 – Factor $\pi_{ m l}$ for LEDs and IREDs	42
Table 34 – Constants for temperature dependence of optoelectronic components	42
Table 35 – Factor $\pi_{T}$ for optical components	43
Table 36 – Capacitors	44
Table 37 – Constants for voltage dependence of capacitors	
Table 38 – Factor $\pi_{\sf U}$ for capacitors	
Table 39 – Constants for temperature dependence of capacitors	46
Table 40 – Factor $\pi_{T}$ for capacitors	47
Table 41 – Resistors and resistor networks	48
Table 42 – Constants for temperature dependence of resistors	
Table 43 – Factor $\pi_{T}$ for resistors	
Table 44 – Inductors, transformers and coils	
Table 45 – Constants for temperature dependence of inductors, transformers and coils .	49
Table 46 – Factor $\pi_{T}$ for inductors, transformers and coils	50