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INTERNATIONAL STANDARD

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Semiconductor devices – Guidelines for reliability qualification plans – Part 2: Concept of mission profile

Dispositifs à semiconducteurs – Lignes directrices concernant les plans de qualification de la fiabilité – Partie 2: Concept de profil de mission

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Semiconductor devices – Guidelines for reliability qualification plans – Part 2: Concept of mission profile

Dispositifs à semiconducteurs – Lignes directrices concernant les plans de qualification de la fiabilité – Partie 2: Concept de profil de mission

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SEMICONDUCTOR DEVICES – GUIDELINES FOR RELIABILITY QUALIFICATION PLANS –

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FOREWORD

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The text of this International Standard is based on the following documents:

Draft	Report on voting
47/2796/FDIS	47/2803/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

This International Standard is to be read in conjunction with IEC 63287-1.

A list of all parts in the IEC 63287 series, published under the general title *Semiconductor devices*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- amended.

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SEMICONDUCTOR DEVICES – GUIDELINES FOR RELIABILITY QUALIFICATION PLANS –

Part 2: Concept of mission profile

1 Scope

This part of IEC 63287 gives guidelines for the development of reliability qualification plans using the concept of mission profile, based on the environmental conditioning and proposed usage of the product. This document is not intended for military- and space-related applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 63287-1:2021, *Semiconductor devices – Generic semiconductor qualification guidelines – Part 1: Guidelines for IC reliability qualification*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
failure mode
style classification of a fault phenomenon which causes product failure

Note 1 to entry: Disconnection, a short circuit, occasional loss, abrasion, characteristic deterioration, etc. are typical items considered as failure modes.

4 Mission profile

4.1 Concept of mission profile

In designing the reliability test plan, the test plan greatly changes depending on how the environmental conditions of the LSI is assumed. For example, in the case of electronic units for automotive application installed in the vicinity of the engine, operational temperature gradually rises by the heat generated by the engine but the temperature decreases after the engine stops, meaning that the unit is not always subjected to sever temperature conditions. The set of changing environmental temperature conditions and their time ratio is called the “mission profile”. Because mission profile depends on multiple factors such as operational duty of LSI, installation environment, generation of heat by peripheral parts, etc., it cannot be unconditionally standardized. Therefore, it is important to agree the mission profile between the LSI vendor and the user and decide on accurate test conditions.

Figure 1 shows an example of mission profile, with the ambient temperature and the estimated hours of operation at that temperature differing between installation around the engine and around the cabin for cases of automotive application with an estimated lifetime of 15 years (7 500 operational hours). A design method for the reliability test plan using the mission profile shown in Figure 1 is given in 4.2. For comparison, as an example of change in the test plan content due to the difference of mission profile, a design method for lifetime of 15 years (12 000 operational hours) as application for engine peripherals is given in 4.3

Trial calculation procedures of test time and number of test samples are based on JEITA ED-4701/002.

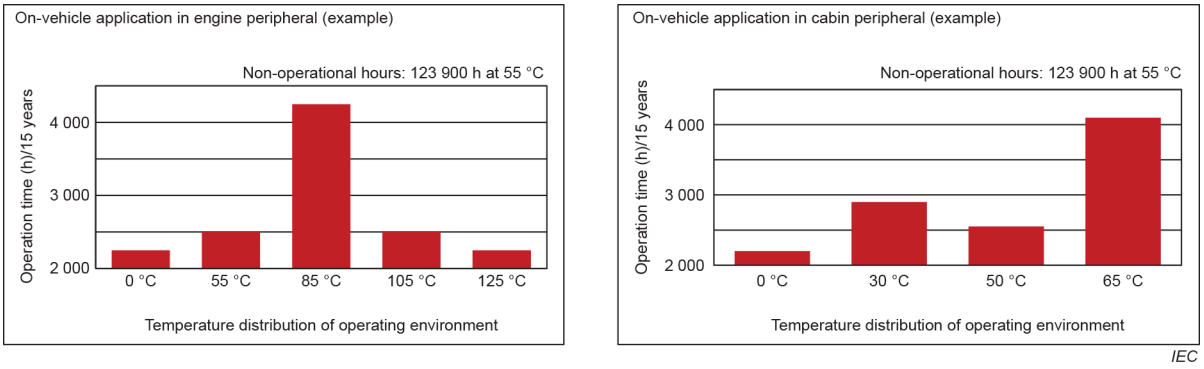

Figure 1 – Example of mission profile for automotive application

4.2 Example of reliability test plan considering the mission profile of automotive engine peripherals application (1)

Table 1 below shows the trial calculation of the reliability test plan (number of samples and time for the reliability test), based on the mission profile of on-vehicle application in the engine peripheral shown in Figure 1, taking the operating life test as an example. Table 1 is an example assuming general automotive applications in Japan with a presupposition of 500 annual operational hours.

In designing a test plan for the operating life test, only the hours of operation in the mission profile shall be regarded as the stress time in the LSI use environment. In this example, the rise in junction temperature (ΔTj) during operation is assumed as 20 °C and the test temperature is set as Ta = 125 °C. As shown in Table 1, conducting about 279 hours of operating life test at 125 °C gives stress equivalent to 15 years of actual use.

Table 1 – Trial calculation example of equivalent time under operating life test based on consideration of the mission profile (automotive application in the engine peripheral)

Mission profile (environment of actual use)			Test conditions	Convert hours of operation to equivalent time under acceleration condition	
Ta	Tj [a]	Hours of operation		125 °C temperature acceleration only[b]	125 °C temperature acceleration[b] + 3,96 V voltage acceleration [c]
0 °C	20 °C	500 h	125 °C 3,96 V (Voltage in actual use 3,3 V)	0,3 h	0,02 h
55 °C	75 °C	1 000 h		53 h	4 h
85 °C	105 °C	4 500 h		1 530 h	109 h
105 °C	125 °C	1 000 h		1 000 h	71 h
125 °C	145 °C	500 h		1 327 h	95 h
Total		7 500 h		3 910 h	279 h

[a] Tj = Ta + 20 °C (Assumption)

[b] Ea = 0,7 eV (Formula (1))

[c] β = 4 (Formula (2))

Table 2 uses the reliability test plan of IEC 63287-1. It shows the calculated values based on the number of samples and test time of operating life test in the case of 90 % confidence level and less than 0,1 % total of confirmation level of wear-out failure in the above mission profile (15 years of actual use).

NOTE The reliability tests of IEC 63287-1 are conducted by accelerating voltage, temperature, humidity, etc. of the actual use environment.

Table 2 – Trial calculation example of number of samples/test time of operating life test with consideration of the mission profile (Automotive application in the engine peripheral)

Test items	Assumed failure mode	Failure distribution	Acceleration parameter	Test conditions	Reliability test scale to confirm the life of 15 years/0,1 % (Confidence level 90 %)			Reference: AEC-Q100
High temperature operating life test	TDDB	Weibull distribution m = 3	Ea = 0,7 eV (Formula (1)) voltage acceleration *β* = 4 (Formula (2))	125 °C 3,96 V (Voltage in actual use 3,3 V)	Number of test samples	45 pcs	231 pcs	231 pcs
					Test time	1 037 h	601 h	1 000 h

TDDB = time-dependent dielectric breakdown

As shown above, designing test plan with consideration of the mission profile is effective in the case of application with large temperature change in environment of actual use. Therefore, use of mission profile in conducting efficient test is recommended.

4.3 Example of reliability test plan considering the mission profile of automotive engine peripherals application (2)

Table 3 shows an example of change in the test plan content due to the difference of mission profile. Table 3 is an example assuming general automotive applications in North America and Europe with a presupposition of 800 hours (12 000 hours/15 years) of annual operational hours, intended by AEC-Q100.

Similarly to the design of the test plan of the operating life test in 4.2, only the hours of operation in the mission profile shall be regarded as the stress time in the LSI use environment. The rise in junction temperature (ΔTj) during operation is assumed as 20 °C and the test temperature was set as Ta = 125 °C. Table 3 shows the trial calculation example of conversion of operational hours to equivalent time under operating life test. Here, the assumed failure mode is time-dependent dielectric breakdown (TDDB). The temperature acceleration is estimated as Ea = 0,7 eV (Formula (1)) and the voltage acceleration as β = 4 (Formula (2)) for the trial calculation. As shown in Table 3, conducting about 528 hours of operating life test at 125 °C gives stress equivalent to 15 years of actual use.

Table 3 – Trial calculation example of equivalent time under operating life test with consideration of the mission profile (automotive application in the engine peripheral)

Mission profile (environmental conditions of actual use)			Test conditions	Convert hours of operation to equivalent time under acceleration condition	
Ta	Tj [a]	Hours of operation		125 °C temperature acceleration only [b]	125 °C temperature acceleration [b] + 3.96 V voltage acceleration [c]
0 °C	20 °C	500 h	125° C 3,96 V (Voltage in actual use 3,3 V)	0,3 h	0,02 h
55 °C	75 °C	500 h		27h	2 h
85 °C	105 °C	8 000 h		2 719h	194 h
105 °C	125 °C	2 000 h		2 000h	143 h
125 °C	145 °C	1 000 h		2 654 h	189 h
Total		12 000 h		7 400 h	528 h

[a] Tj = Ta + 20 °C (Assumption)

[b] Ea = 0,7 eV (Formula [a])

[c] β = 4 (Formula [b])

Table 4 shows the calculated values based on the reliability test plan of IEC 63287-1. It shows the calculated values based on the number of samples and test time of operating life test in the case of 90 % confidence level and 0,1 % or less total of confirmation level of wear-out failures in the above mission profile (15 years of actual use).

NOTE The reliability tests of IEC 63287-1 are conducted by accelerating voltage, temperature, humidity, etc. of the actual use environment.

Table 4 – Trial calculation example of equivalent time under operating life test with consideration of the mission profile (Automotive application in the engine peripheral)

Test items	Assumed failure mode	Failure distribution	Acceleration parameter	Test conditions	Reliability test scale to confirm the life of 15 years/0.1 % (Confidence level 90 %)			Reference: AEC-Q100
High temperature operating life test	TDDB	Weibull distribution m = 3	Ea = 0,7 eV (Formula (1)) voltage acceleration β = 4 (Formula (2))	125 °C 3,96 V (Voltage in actual use 3,3 V)	Number of test samples	45 pcs	231 pcs	231 pcs
					Test time	1 961 h	1 137 h	1 000 h

As shown above, the difference in mission profile changes the reliability test plan (number of samples and time for the reliability test), even if it is under the same test conditions. The concept of mission profile allows the development of a suitable test plan for individual applications.

4.4 Example of reliability test plan considering the mission profile of automotive cabin peripherals application

The mission profile below shows the design procedure of a reliability test plan (number of samples and time for the reliability test) for automotive application in the cabin peripheral of Figure 1.

In designing a test plan for the operating life test, only the hours of operation in the mission profile shall be regarded as the stress time in the LSI use environment. In this example, the trial calculation example of conversion of operational hours to equivalent time under operating life test is shown in Table 6 for the case where rise in junction temperature (ΔTj) during operation is assumed as 20 °C and the test temperature is set as Ta = 125 °C. Here, the assumed failure mode is TDDB. The temperature acceleration is estimated as Ea = 0,7 eV (Formula (1)) and the voltage acceleration as β = 4 (Formula (2)) for the trial calculation. As shown in Table 5, conducting about 130 hours of operating life test at 125 °C gives stress equivalent to 15 years of actual use.

Table 5 – Trial calculation example of equivalent time under operating life test with consideration of the mission profile (automotive application in the cabin peripheral)

Mission profile (environmental conditions of actual use)			Test conditions	Convert hours of operation to equivalent time under acceleration condition	
Ta	Tj [a]	Hours of operation		125 °C temperature acceleration only [b]	125 °C temperature acceleration [b] + 3,63 V voltage acceleration [c]
0 °C	20 °C	400 h	125 °C 3,63 V (Voltage in actual use 3,3 V)	0,3 h	0,1 h
30 °C	50 °C	1 800 h		15,8 h	4,2 h
50 °C	75 °C	1 100 h		41,8 h	11,2 h
65 °C	85 °C	4 200 h		430,1 h	114,9 h
Total		7 500 h		488h	130,4 h

[a] Tj = Ta + 20 °C (Assumption)

[b] Ea = 0,7 eV (Formula [a])

[c] β = 4 (Formula [b])

Table 6 shows the calculated values based on the reliability test plan of IEC 63287-1. It shows the calculated values based on the number of samples and test time of operating life test in the case of 90 % confidence level and 0,1 % or less total of confirmation level of wear-out failures in the above mission profile (15 years of actual use).

NOTE The reliability tests of IEC 63287-1 are conducted by accelerating voltage, temperature, humidity, etc. of the actual use environment.

Table 6 – Trial calculation example of number of samples/test time of high temperature operating life test with consideration of the mission profile (Automotive application in the cabin peripheral)

Test items	Assumed failure mode	Failure distribution	Acceleration parameter	Test conditions	Reliability test scale to confirm the life of 15 years/0,1 % (Confidence level 90 %)			Reference: AEC-Q100
High temperature operating life test	TDDB	Weibull distribution m = 3	Ea = 0,7 eV (Formula (1)) voltage acceleration β = 4 (Formula (2))	125 °C 3,63 V (Voltage in actual use 3,3 V)	Number of test samples	45 pcs	231 pcs	231 pcs
					Test time	484 h	281 h	1 000 h

As shown above, consideration of the concept of mission profile is effective in the case of applications with a large temperature change in the environment of actual use. Therefore, use of mission profile in conducting efficient test is recommended. As a calculation, an example of mission profile, in comparison with the example of AEC-Q100 is shown in Clause 5.

5 Calculation examples of mission profiles (Calculation of sample and test time of life tests)

Table 7 and Table 8 show examples of trial calculations substituting acceleration conditions and acceleration model used in JEITA EDR-4708B by the mission profile of AEC-Q100, and comparing the sample size and time. AEC Q100 only provides an example.