

JEDEC STANDARD

Assessment of Average Outgoing Quality Levels in Parts Per Million (PPM)

JESD16B

(Revision of JESD16A, April 1995, Reaffirmed September 2008)

NOVEMBER 2017

JEDEC SOLID STATE TECHNOLOGY ASSOCIATION



NOTICE

JEDEC standards and publications contain material that has been prepared, reviewed, and approved through the JEDEC Board of Directors level and subsequently reviewed and approved by the JEDEC legal counsel.

JEDEC standards and publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for use by those other than JEDEC members, whether the standard is to be used either domestically or internationally.

JEDEC standards and publications are adopted without regard to whether or not their adoption may involve patents or articles, materials, or processes. By such action JEDEC does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the JEDEC standards or publications.

The information included in JEDEC standards and publications represents a sound approach to product specification and application, principally from the solid state device manufacturer viewpoint. Within the JEDEC organization there are procedures whereby a JEDEC standard or publication may be further processed and ultimately become an ANSI standard.

No claims to be in conformance with this standard may be made unless all requirements stated in the standard are met.

Inquiries, comments, and suggestions relative to the content of this JEDEC standard or publication should be addressed to JEDEC at the address below, or refer to www.jedec.org under Standards and Documents for alternative contact information.

Published by
©JEDEC Solid State Technology Association 2017
3103 North 10th Street
Suite 240 South
Arlington, VA 22201-2107

This document may be downloaded free of charge; however JEDEC retains the copyright on this material. By downloading this file the individual agrees not to charge for or resell the resulting material.

PRICE: Contact JEDEC

Printed in the U.S.A.
All rights reserved

PLEASE!

DON'T VIOLATE
THE
LAW!

This document is copyrighted by JEDEC and may not be
reproduced without permission.

For information, contact:

JEDEC Solid State Technology Association
3103 North 10th Street
Suite 240 South
Arlington, VA 22201-2107

or refer to www.jedec.org under Standards-Documents/Copyright Information.

sobco

ASSESSMENT OF AVERAGE OUTGOING QUALITY LEVELS IN PARTS PER MILLION (PPM)

Contents

	Page
Introduction	ii
1 Scope	1
2 Application	1
3 Reference publications	1
4 Definitions	1
5 Symbols	3
6 Assumptions	4
7 Procedures	5
7.1 Data accumulation for a single inspection	6
7.2 Computing AOQ and variance for a single inspection	6
7.3 Combining inspections within a group	7
7.4 Combining groups within a class	7
7.5 Combining classes	8
7.6 Data exclusion	8
7.7 Minimum total sample size	8
7.7.1 Minimum total sample size criterion (graphic method)	9
7.7.2 Minimum total sample size criterion (numeric method)	10
8 Reporting	10
Annexes	
A Examples	12
B Derivation of the minimum sample size criterion	16
C Derivation of the standard deviation of AOQ	20
D References	30
E Differences between JESD16B and JESD16A	31

ASSESSMENT OF AVERAGE OUTGOING QUALITY LEVELS IN PARTS PER MILLION (PPM)

Introduction

Improvements in manufacturing technology and methodology have resulted in corresponding quality improvements for electronic devices. As a result, the traditional measure for reporting average quality levels in percent nonconforming needs to be replaced with a quantity more in line with the quality levels of today. That measure is parts-per-million or ppm. It is simply clearer to report estimated average device quality as 10 ppm, rather than the more cumbersome 0.001%. The ppm terminology applies to estimating the average outgoing quality (AOQ) level of a device, from lot acceptance results.

This standard was developed to provide a uniform method of measurement and calculation of average outgoing quality levels. Minimum sample sizes and a method for aggregating data are provided.

ASSESSMENT OF AVERAGE OUTGOING QUALITY LEVELS IN PARTS PER MILLION (PPM)

(From JEDEC Board Ballot JCB-17-18 formulated under the cognizance of JC-13 Committee on Government Liaison.)

1 Scope

This standard is intended to provide a uniform method of determining fraction nonconforming in finished devices and to provide a standardized definition of the quality index referred to as Average Outgoing Quality (AOQ). The method used here is primarily directed at devices whose production or procured volume is large enough, during some predefined sampling period, to give statistically meaningful information.

2 Application

This standard is intended to provide a method for the derivation and reporting of fraction nonconforming. The AOQ philosophy applies to the estimation of the average quality level of a product, not to lot acceptance plans. Since it is necessary to focus on accumulated lots to generate sufficient data for device quality characterization, the method in this standard should not be used to establish ppm levels for individual lots or to form the basis for determining acceptability of product on a lot-by-lot or batch-by-batch basis.

3 Reference publications

Publications referenced by this document are listed in Annex D.

4 Terms and definitions

For the purpose of this standard the following terms and definitions shall be used:

acceptance inspection: A sampling inspection or series of sampling inspections used to determine the suitability of a lot of material for shipment.

NOTE The accumulation of acceptance inspection data is used to determine average outgoing quality (AOQ).

accept number (c): The maximum number of nonconforming devices in the sample for which acceptance of the lot is allowed under the sampling plan.

average outgoing quality (AOQ): The expected population average nonconforming, in parts per million, estimated from a series of lots.

4 Terms and definitions (cont'd)

class: A categorization of similar characteristics for the purpose of reporting parts-per-million (ppm) nonconforming.

NOTE Examples of classes include functional (ppm1), electrical (ppm2), visual/mechanical (ppm3), hermetic (ppm4).

fraction nonconforming: The unknown nonconforming proportion of the total population of devices.

NOTE Estimates of fraction nonconforming are derived from samples.

group: A subdivision of a class based on inspection conditions or criteria, e.g., device type, product family, test temperature, sample size.

NOTE Lots that are members of the same group receive the same set of inspections in that group.

inspection: The assessment of a characteristic and its comparison to a standard.

NOTE Examples of inspections include low-temperature electrical test, room-temperature test, and visual inspection.

lot: An aggregate of devices from which the sample is selected.

lot acceptance rate (LAR): The ratio of lots inspected over a sample period.

nonconformance: A device characteristic that does not conform to an individual specified criterion.

nonconformity: A single device that has one or more nonconformances.

NOTE These nonconformities may be placed into classes for reporting purposes.

parts per million (ppm): The unit of measurement used to describe Average Outgoing Quality giving the number of nonconformities for each million units.

sample period: The period of time selected by the manufacturer to accumulate data for the calculation and reporting of average outgoing quality (AOQ) or lot acceptance rate (LAR).

5 Symbols

The following symbols are used in this standard:

<u>Symbol</u>	<u>Formula</u>	<u>Definition</u>
AOQ'		True value of the average outgoing quality.
AOQ		Estimate of AOQ'.
c		Sample plan acceptance number.
L		Total number of lots inspected.
LR		Total number of lots rejected.
LAR	$1-(LR/L)$	Lot acceptance rate.
m	S/L	Average sample size per lot
N		Total number of devices in lots inspected.
D		Total number of nonconforming devices found from all samples.
S	mxL	Total number of devices sampled.
p	D/S	Fraction of nonconforming devices found in all samples.
UB ₁		Upper bound of a one-sided confidence interval for AOQ'.
LB ₂		Lower bound of a two-sided confidence interval for AOQ'.
UB ₂		Upper bound of a two-sided confidence interval for AOQ'.
σ^2		Variance of AOQ.
σ	σ^2	Standard deviation of AOQ.

6 Assumptions

The following assumptions are used by this standard. Users should confirm that these assumptions are met for the device whose quality is to be reported.

6.1 Attribute sampling inspection is being conducted on devices that have completed manufacturing processes affecting the criteria being reported.

6.2 Equipment must be calibrated according to ISO 10012-1, ANSI/NCCL Z540.1, ANSI/NCCL Z540.3, or ANSI/ASQC-M1. Accuracy and precision must be in accordance with manufacturer's internal documents or applicable procurement requirements. Statistical controls for the test process shall be in accordance with JESD557. For the purpose of estimating AOQ, test equipment can be used interchangeably provided the requirements of this paragraph are satisfied.

6.3 Lots of devices that fail acceptance inspection are reprocessed 100%, and all nonconforming devices are removed from the lot or the lot is removed from consideration for shipment and discarded. The nonconforming devices that were removed may or may not be replaced by conforming devices. In the case of $c > 0$ sampling schemes, nonconforming devices found in the sample of accepted lots are removed from the sample and may or may not be replaced by conforming devices before the sample is returned to the lot for shipment.

6.4 All confirmed nonconforming devices observed during the first submission to acceptance inspection are included in the calculation of the total number of nonconforming devices found in samples (D) unless excluded according to 7.6. Data from resubmitted lots are not used in the calculation of AOQ.

6.5 Single, multiple or skip lot sampling may be used if appropriate (e.g., multiple temperature or hermeticity inspecting). Double counting of nonconforming devices is not allowed.

6.6 The total number of devices sampled (S) shall include only devices actually inspected.

6.7 AOQ values shall be reported for inspected characteristics only. Characteristics actually inspected and accompanying inspection results comprising the data for AOQ calculations shall be included in the manufacturing internal documentation and shall be available for review upon request.

6.8 Nonconformities that are not device-related shall not be included in the calculation of AOQ.

6.9 A single device with nonconformities in more than one class should be included only in the class that would have the most severe impact.

6.10 The estimator of AOQ given in equation (1) of 7.2 is appropriate if, for each lot, the sample size for the lot does not exceed 10% of the lot size.

6.11 The estimates of p and LAR shall be determined using the same samples.

6.12 All devices selected for acceptance inspection are assumed to be randomly sampled from the population being analyzed. (see Hahn and Meeker (1991) P10ff).

7 Procedures

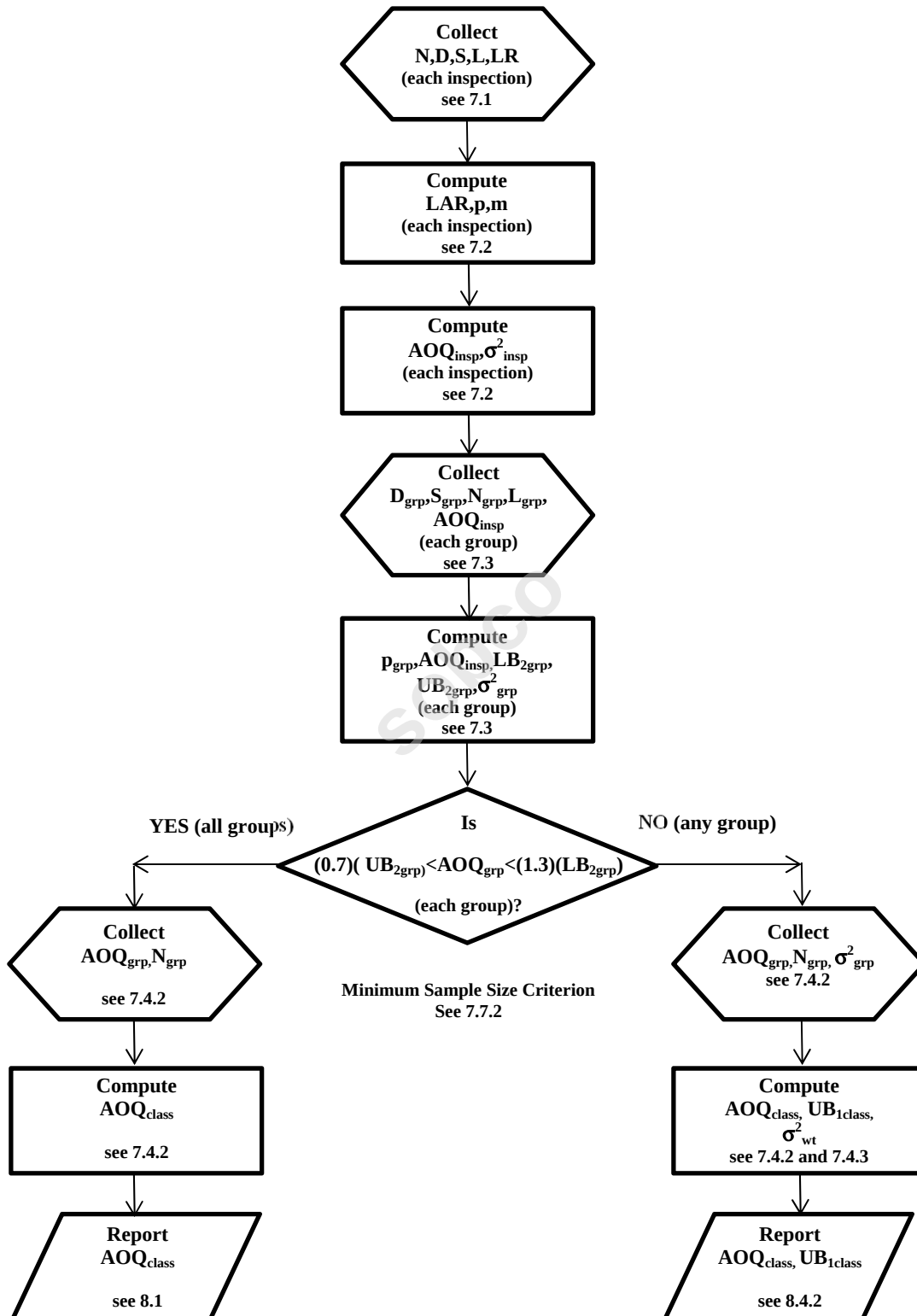


Figure 1 — Procedure Flow Chart

7 Procedures (cont'd)

7.1 Data accumulation for a single inspection

For all acceptance inspections during the sample period, sum each of the following independently and record for subsequent calculation:

- the number of observed nonconforming devices (D),
- the number of sampled devices (S),
- the number of devices in lots inspected (N), and
- the number of lots rejected (LR) and the number of lots inspected (L).

The sample period shall not exceed one year.

7.2 Computing AOQ and variance for a single inspection

7.2.1 Using the data totals from 7.1, the single inspection AOQ ($AOQ_{\text{inspection}}$) given by Schilling (1982) is:

$$AOQ_{\text{inspection}} = p \times LAR \times 10^6 \quad (1)$$

7.2.2 When $c = 0$, an approximation of the variance σ^2 for AOQ, as defined in equation (1) is given in Annex C as:

$$\sigma^2 \approx \frac{(L-1)p}{mL^3} \{L - 1 + 2mp(3 - 2L)\} \quad (2)$$

If this approximation yields a negative result, then use the exact formula in Annex C.

7.2.3 If the sample size for any lot exceeds 10% of the lot size, then AOQ defined in equation (1) should be multiplied by $1 - \frac{S}{N}$. Equation (1) then becomes:

$$AOQ_{\text{inspection}} = p \times LAR \times \left\{1 - \frac{S}{N}\right\} \times 10^6 \quad (1')$$

Similarly, equation (2) becomes:

$$\sigma^2 \approx \frac{(L-1)p}{mL^2} \{L - 1 + 2mp(3 - 2L)\} \left\{1 - \frac{S}{N}\right\} \times 10^{12} \quad (2')$$