BS EN 61193-3:2013

BSI Standards Publication

Quality assessment systems

Part 3: Selection and use of sampling plans for printed board and laminate end-product and in-process auditing

National foreword

This British Standard is the UK implementation of EN 61193-3:2013. It is identical to IEC 61193-3:2013.

This edition includes information regarding sampling procedures for inspection by attributes. The international committee responsible for sampling procedures is ISO TC 69-5.

The user's attention is drawn to BS 6001-1 Sampling procedures for inspection by attributes for further information. Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection also provides useful information on sampling procedures.

The UK participation in its preparation was entrusted to Technical Committee EPL/501, Electronic Assembly Technology.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2013.

ISBN 978 0 580 62104 8

ICS 31.190

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 June 2013.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61193-3

April 2013

ICS 31.190

English version

Quality assessment systems -
Part 3: Selection and use of sampling plans for printed board and laminate end-product and in-process auditing
(IEC 61193-3:2013)

Système d'assurance de la qualité -
Partie 3: Choix et utilisation de plans d'échantillonnage pour cartes imprimées et produits finis stratifiés et audits en cours de fabrication
(CEI 61193-3:2013)

Qualitätsbewertungssysteme -
Teil 3: Auswahl und Anwendung von Stichprobenanweisungen für Endprodukte von Leiterplatten und Laminaten und fertigungsbegleitende Auditierung
(IEC 61193-3:2013)

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European Committee for Electrotechnical Standardization
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Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 61193-3:2013 E

Foreword

The text of document 91/1061/FDIS, future edition 1 of IEC 61193-3, prepared by IEC TC 91 "Electronics assembly technology" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61193-3:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2013-11-28
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-02-28

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The text of the International Standard IEC 61193-3:2013 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60068-2-20	NOTE Harmonized as EN 60068-2-20.
IEC 60068-2-38	NOTE Harmonized as EN 60068-2-38.
IEC 61189-2	NOTE Harmonized as EN 61189-2.
IEC 61189-3	NOTE Harmonized as EN 61189-3.
IEC 61193-1	NOTE Harmonized as EN 61193-1.
IEC 61193-2	NOTE Harmonized as EN 61193-2.
IEC 62326-1	NOTE Harmonized as EN 62326-1.
IEC 62326-4-1	NOTE Harmonized as EN 62326-4-1.
ISO 14001	NOTE Harmonized as EN ISO 14001.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60194	2006	Printed board design, manufacture and assembly - Terms and definitions	EN 60194	2006
IEC 62326-4	1996	Printed boards - Part 4: Rigid multilayer printed boards with interlayer connections - Sectional specification	EN 62326-4	1997
ISO 9000	2005	Quality management systems - Fundamentals and vocabulary	EN ISO 9000	2005
ISO 14560	2004	Acceptance sampling procedures by attributes - Specified quality levels in nonconforming items per million	-	-

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

QUALITY ASSESSMENT SYSTEMS –

Part 3: Selection and use of sampling plans for printed board and laminate end-product and in-process auditing

FOREWORD

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International Standard IEC 61193-3 has been prepared by IEC technical committee 91: Electronics assembly technology.

The text of this standard is based on the following documents:

FDIS	Report on voting
91/1061/FDIS	91/1080/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61193 series, under the general title *Quality assessment systems,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

A clear description in IEC standards and specifications and their reference to sampling plans in order to insure adherence to customer requirements is essential. All the details should be clear as to their implementation or adjustment for evaluation of the product to be shipped, the use of process control and SPC, or the applicability for using these principles in controlled experimentation. The general characteristics of these principles relate to a gradual reduction that might be needed in examining the product being manufactured. As such, they are sometimes referred to as the logical steps to process improvement. These steps are as follows.

a) STATISTICAL SAMPLING: where, when, and why

- To determine a proper amount of examples from a given lot of product and using statistics to evaluate the occurrence of anomalies.

b) ZERO DEFECT STANDARDS: role of specifications

- To adopt the role of attempting to achieve no defects in a production lot through the recommendations identified in standards or specifications that define the product requirements.

c) ECONOMICS: AQL versus cost of defects

- To establishing the highest level of non-conforming product characteristics, determining the cost that is incurred when these are discovered or delivered accidentally to the customer (cost of quality) and establishing an acceptable quality assessment methodology in order to reduce these occurrences.

d) SPC REDUCED INSPECTION: rules for use and control

- To create a process control program that is based on reject criteria, followed by controlled experimentation to improve the process and then using statistical analysis in order to determine that the process improvement has reduced the occurrences of these reject criteria.

The explosion of the electronics industry has led to a situation where the design of the printed board mounting structure or the material used to produce the product is so complex, that the quality level of these items delivered with known failures are no longer acceptable. The acceptable number of non-conforming products should be directed toward approaching zero in producer-customer contracts.

This has led to the development of new methods of quality assurance like the application of Statistical Process Control (SPC). The low number of permitted non-conforming product according to the AQL tables caused many to resort to 100 % testing or inspection.

At the same time the quality thinking has developed so that the idea to accept failures has become impossible, and the use of the AQL tables in the traditional way has been diminishing very rapidly.

QUALITY ASSESSMENT SYSTEMS –

Part 3: Selection and use of sampling plans for printed board and laminate end-product and in-process auditing

1 Scope

This part of IEC 61193 establishes sampling plans for inspection by attributes, including sample plan selection criteria and implementation procedures for printed board and laminate end-product and in-process auditing. The principles established herein permit the use of different sampling plans that may be applied to an individual attribute or set of attributes, according to classification of importance with regard to form, fit and function.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60194:2006, *Printed board design, manufacture and assembly – Terms and definitions*

IEC 62326-4:1996, *Printed boards – Part 4: Rigid multilayer printed boards with interlayer connections – Sectional specification*

ISO 9000:2005, *Quality management systems – Fundamentals and vocabulary*

ISO 14560:2004, *Acceptance sampling procedures by attributes – Specified quality levels in non-conforming items per million*

3 Terms and definitions

For purposes of this document, the terms and definitions given in IEC 60194:2006, ISO 9000:2005 and the following apply.

3.1
attribute
aspect or characteristic of a unit of a defined product in terms of actual requirement and allowable deviation

Note 1 to entry: An actual requirement signifies the following:

- a requirement that is stated as a measurement with an allowable more and/or less deviation;
- a requirement stated as an absolute desired condition with allowable anomalies;
- a requirement stated as an absolute without exception (go/ no-go).

3.1.1
critical attribute
attribute where a defect, that judgment and experience indicate, is likely to result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the product; or where a defect is likely to prevent performance or function of a major end item such as a ship, aircraft, computer, medical equipment, or telecommunication satellite

3.1.2
major attribute
attribute where a defect, other than critical, is likely to result in failure, or where a defect reduces the usability of the unit of a product for its intended purpose

3.1.3
minor attribute
attribute where a defect is not likely to reduce materially the usability of the unit of product for its intended purpose, or where a defect is a deviation from established standards having little bearing on the effective use or operation of the unit

3.2
acceptable quality level
DEPRECATED: AQL
maximum percent of defects that can be tolerated as a risk, stated for the purposes of sampling inspection

Note 1 to entry: Sample inspection with associated risk tolerance is employed only where all units of a product within an inspection lot is expected to completely conform to the specification requirements.

Note 2 to entry: See 3.3.

3.3
acceptance quality limit
lower than perfect quality level

Note 1 to entry: Revised term for AQL.

Note 2 to entry: The term is used to indicate a certain degree of risk in that some products may have non-conforming characteristics. However, they do not impact the final performance. These decisions are based on customer/supplier agreements.

Note 3 to entry: The use of the abbreviation AQL to mean “acceptable quality level” (refer to 3.2) is no longer recommended.

3.4
defective
unit of product that contains one or more defects

3.4.1
critical defective
unit of product that contains one or more defects of critical attributes, and that may also contain defects of major or minor attributes

3.4.2
major defective
unit of product that contains one or more defects of major attributes, and may also contain defects of minor attributes, but contains no defects of critical attributes

3.4.3
minor defective
unit of product that contains one or more defects of minor attributes, but contains no defects of major or critical attributes

3.5
inspection
process of measuring, examining, testing, or otherwise comparing the unit of product with the specified requirements

3.5.1
inspection by attributes
inspection of individual attributes (aspects or characteristics) of the unit of product per specified requirements, procedures, and/or instructions

3.5.2
inspection lot
collection of product units that are identified and treated as a unique entity from which a sample is drawn and inspected in order to determine conformance with acceptability criteria

3.5.3
inspection rate
number of features per unit of time that can be evaluated at specified false-alarm and escape-rate settings

3.6
risk management factor
RMF
maximum tolerable percentage of possible defects within a lot (group) of units, based on approximately 95 % confidence level

3.7
shipment-ready product
product shipped to the customer without having to meet any further acceptance criteria

3.8
unit of product
item(s) being inspected in order to determine conformance to specific requirements

Note 1 to entry: These requirements consist of the following:

- a single article, a pair, a set, a length, an area, an operation, a volume, a component of an end product, or the end product itself;
- may or may not be the same as the unit of purchase, supply, production or shipment.

4 Sampling methodologies

4.1 General

There is a considerable number of ISO standards on acceptance sampling (see Annex D for details). However, most of these standards contain plans that allow a lot to be accepted even when the sample from the lot contains one or more non-conforming items, although there are some exceptions (ISO 18414 and ISO 21247).

The zero acceptance number plans (c = 0) were originally designed and used to provide equal or greater consumer protection with less inspection than that required by corresponding sampling plans. The c = 0 plans are simple to use and administer since there is greater emphasis on zero defects and product liability prevention. The concepts stated herein provide a set of attribute plans for product lot inspection. The acceptance number in all cases is zero. This means that for some level of protection, a sample size is selected and if one or more non-conforming attributes are present, the lot will be withheld.

The terminology "withhold the lot" does not necessarily mean rejection. A lot is not automatically accepted or rejected if one or more non-conformances are found. It is only accepted if zero non-conformances are found in the sample.

Withholding the lot obliges engineering/management personnel to review the results and to withdraw the lot depending on the seriousness of the case. This relates to whether the attribute was critical, major, or minor, or whether identifying the non-conformance to the requirements was defined as a critical, major, or minor defect.

The word "defective" is commonly used in quality control to describe a part, component, item, or any other unit of product that contains one or more defects. The word "defect" is commonly used to describe a particular non-conforming characteristic on a unit of product.

4.2 Attribute sampling plans

4.2.1 General

The following subclauses provide an overview of lot size description attribute plans while relating them to other plans. Two broad categories of sampling exist and these are

a) continuous;

b) production lot.

4.2.2 Continuous sampling

Continuous sampling is often used when product units are submitted one at a time. This can apply to production processes where a product moves through various steps. Product moving along a conveyor can also be thought of as being a candidate for continuous sampling. Industry has moved away from inspecting quality at the end of the line; thus, in-process inspection or sampling is a way in which many companies maintain statistical process controls.

The continuous sampling plan may call for frequency checks, i.e. one unit out of five. Even if the products are good, this frequency check is maintained. If, however, a unit is non-conforming, 100 % inspection is reverted to until the specified number of consecutive conforming products result. At that point, the process returns to frequency inspection.

As an example, a quality decision for continuous sampling would be to examine five samples, within a particular hour, out of a total of thirty products passing through a process. Based on the characteristics being inspected (i.e., solder bridging on a particular part) nothing is observed in a certain number of hours, the time can be increased without changing the sample size. At this point, the sample taken represents a larger portion of an amount of products being processed. The samples are then monitored for a longer period of time before reducing to fewer samples again, or to increase the allotted time in which the samples are randomly selected.

4.2.3 Production lot attributes

Production lot size descriptions involve units of products that are presented in a group, batch, or lot for inspection, as opposed to being presented one at a time. In these cases, a sample of a specified quantity is drawn and compared with some acceptance criteria. In the past, sampling plans allowed a certain quantity of defectives in the sample; the c = 0 plan does not. In c = 0 plan, the attributes evaluated either conform or do not conform. Go/no go type gauges are often used in attribute plans.

4.2.4 Production lot variables

Another production lot sampling procedure involves the analysis of measured characteristics where the attributes vary with respect to their requirements. Variable sampling compared with attribute sampling essentially involves the inspection of a smaller sample size to obtain the same protection afforded by an attribute plan. The economics of these smaller sample sizes, however, are quite often offset by the calculation involved and the need to obtain and record measurements. In addition, the essential difference between variables and attributes sampling is not the relative sample sizes, but that variables sampling is based on measurements whereas attributes sampling is based on classifications.

Where variables' data is required from an inspection operation, variables' plans shall definitely be considered. The use of variable plans is necessary when the distribution of the variable data can significantly improve the process. It may also be important to establish an upper and lower characteristic so that the customer is aware of the changes that might be necessary to bring the two limits closer together in a manner that meets the customers' requirement (target). By the manufacturer retaining the records regarding meeting the target value of a particular requirement, the data can indicate when the process is starting to become out-of-control due to the distribution of measurements within the specified upper and lower acceptance limit. In variables' production lot sampling, the information is collected primarily to help assure the manufacturing of acceptable products by indicating the distance from the target that the lot inspection provides.

4.3 Non-statistical sampling plans

There are cases where zero defects can visually be assured, although the sample size cannot logically be defined in terms of statistical risks. Such sample sizes are generally exceptionally low for the more important attributes and, therefore, knowledge of the process and the control factors is essential. The drilling of printed circuit boards might use first article inspection as a methodology to determine that the automated tools creating the number of holes in the board meet the criteria of the requirements. No further inspection of the product is carried out. However, to ensure that the production process is still under control, a sampling may be made regarding the number of uses of a drill, any changes in speed or feed characteristics, or other features of the automated process that might impact the quality that was approved by the first article.

In order to avoid any confusion in justifying such sample sizes on inspection plans, specific notations should be used to avoid any tie-in with statistical risks. The reason for such a selection should be noted, either directly in the plan or in the quality engineering standards.

An example might be a sampling operation where just the first and last item from a lot, are inspected dimensionally. This is also accomplished where the first and last time a drill bit is used, it is drilled into an inspection coupon. This permits the first and last characteristics of the drilled hole to be examined and determined that all holes drilled in between are of a good quality. Another example might be evaluating a number of products during a particular time sequence. If the products are different, the technique can be normalized by evaluating the amount of unit area being processed along a conveyor over a particular time. In this case, a variety of products can be measured and evaluated. The system then would be judged in or out of control, depending on non-conformance per unit area over specific time sequences.

The higher index values in the $c = 0$ plans are also used where favourable process control has been demonstrated and just an audit is required. Although the statistical risks seem high, the risks from a practical standpoint would be exceptionally low.

4.4 Defining $c = 0$ plans

There are many plans that have used the $c \geq 0$ concepts. These plans are acceptable quality level (AQL) oriented. Essentially, the AQL is a specified percent that is considered to be good quality. In any sampling plan, an operating characteristic curve can be generated to define the risk of accepting lots with varying degrees of percent non-conforming or defective. These plans went out of favour in the late 1980's, due to the misunderstanding that it was good practice to release shipment-ready products with known, non-conforming attributes.

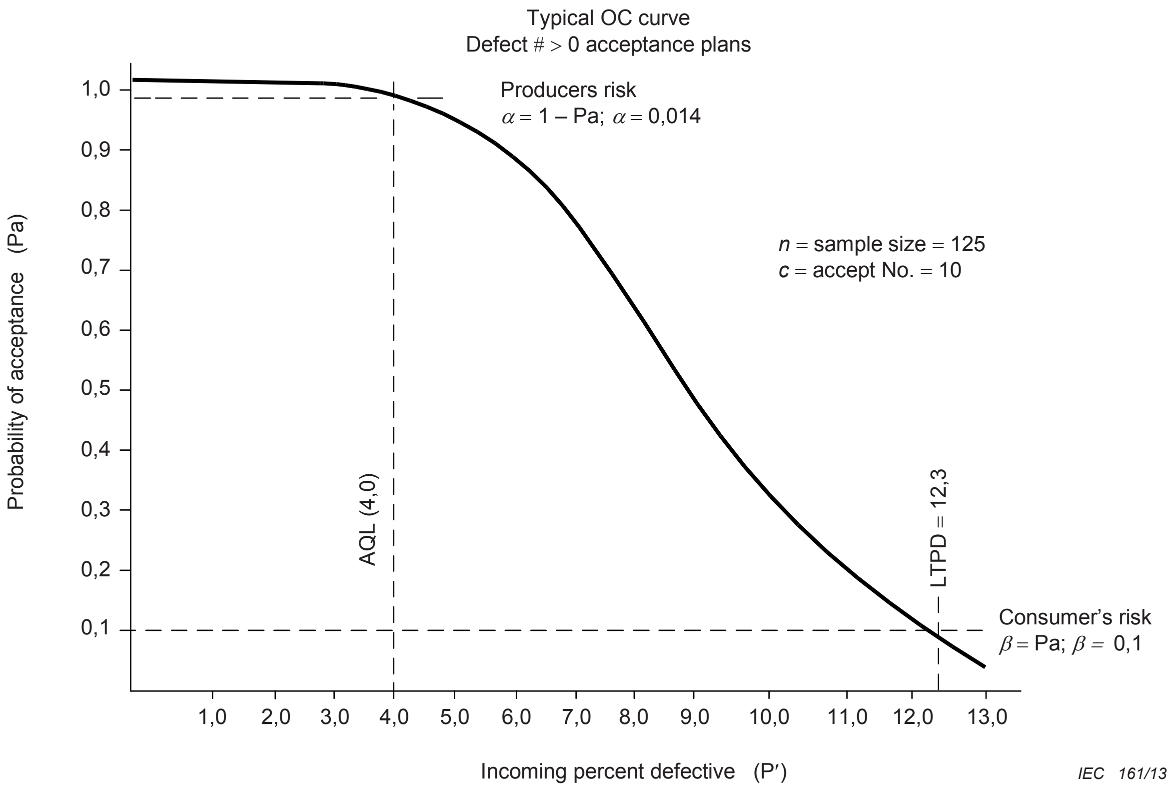
When the AQL concept is used, a high probability of acceptance associated with the AQL percentage exists. Normally, this is in the order of a 0,90 to 0,98 probability of acceptance level. The risk of rejecting this AQL percentage is in the order of 0,10 to 0,02 probability level. This rejection risk is called the "producer's risk."

The assumptions in employing the AQL concept, is that some agreement has been reached between the producer and the consumer. Although the term 'quality' is implied by the initials AQL, selecting this method is the worst tolerable quality level, since non-conforming products may be found in the sample size and yet the production lot is still delivered to the customer, see Table 1. Since sampling is used, the producer assumes a risk of having a lot rejected, although the actual percentage defective in the lot is equal to or less than specified in the AQL.

It is also important that a clear distinction be made by either the customer or the requirements of the specification regarding the characteristics of the non-conforming attribute. Many printed board or laminate standards identify some characteristics as a process indicator and allow these to be delivered since they do not impact the performance of the product. The sampling plan, therefore, allows a lower inspection number and uses the occurrences of the process indicators as something that needs to be improved. Scratches on copper conductors are an example of such an indicator. Other attributes are defined as defects since they do impact performance and, therefore, impact the entire production line.

If no prior AQL agreement exists, and sampling is to be performed simply because 100 % inspection is impractical, then over-inspection is usually the result. Also, when 100 % sampling is impractical, the producer is encouraged to inspect a small number of units of product on less critical attributes. To illustrate the concept, if the $c \geq 0$ plan were used, a 1,0 % AQL might be used for critical attributes and a 4,0 % AQL might be used for major attributes. The technique for sample selection under an Acceptable Quality Limit would correlate to a $c = 0$ plan which would allow no non-conforming product in the sample size.

It is a statistical fact that zero accept number ($c = 0$) plans provide equivalent statistical assurance than do plans associated with defect acceptance ($c \geq 0$). This can be verified by examining the operating characteristics (OC) curves, which should normally be provided with sampling plans. Figure 1 shows a typical OC curve from a $c \geq 0$ plan. There is a probability scale on the Y-axis and an incoming defective possibility scale on the X-axis. The curve is generated through probability calculations based on a sample size of 125 with an acceptable number of 10. Also shown is the producer's risk, which is a risk of rejecting a good lot of product and the associated consumer's risk, which is the risk of accepting a bad lot of product.



NOTE 1 Values come from Poisson distribution analysis. (α is 0,013 7 by Poisson distribution and is 0,011 9 by binomial distribution; β is 0,101 3 by Poisson distribution and is 0,086 8 by binomial distribution.)

NOTE 2 For typical OC curve refer to ISO 2859-1.

Figure 1 – Typical OC curve for $c \geq 0$ plan

In addition to the AQL and producer's risk, there is a parameter called the lot tolerance percent defectives (LTPD). This LTPD is considered poor quality, and is sometimes identified as consumer’s risk quality. Several sampling plans can have OC curves pass through the same AQL/producer's risk point. For each of these plans, however, there will be a different LTPD at some constant probability of acceptance level. This probability of acceptance level corresponding to the LTPD is usually low with a 0,10 being widely accepted. This probability level is called the "consumer's risk".

The user of sampling plans shall select the plan that will provide reasonably good protection against accepting lots with percent defectives not a lot greater than the AQL. With the AQL/producer's risk point fixed, the closer the LTPD gets to the AQL, the larger the sample size and the acceptance number becomes. Figure 2 is a comparison of the $c \geq 0$ OC curve and an equivalent OC curve from the zero defect $c = 0$ plan. This example illustrates that the $c = 0$ curve with a small sample of 18 and an accept number of 0 is equivalent or better than the $c = 0$ plan with a relatively large sample of 125 and an acceptance number of 10. The producer's risk probability may be greater at certain levels with the $c = 0$ plan.

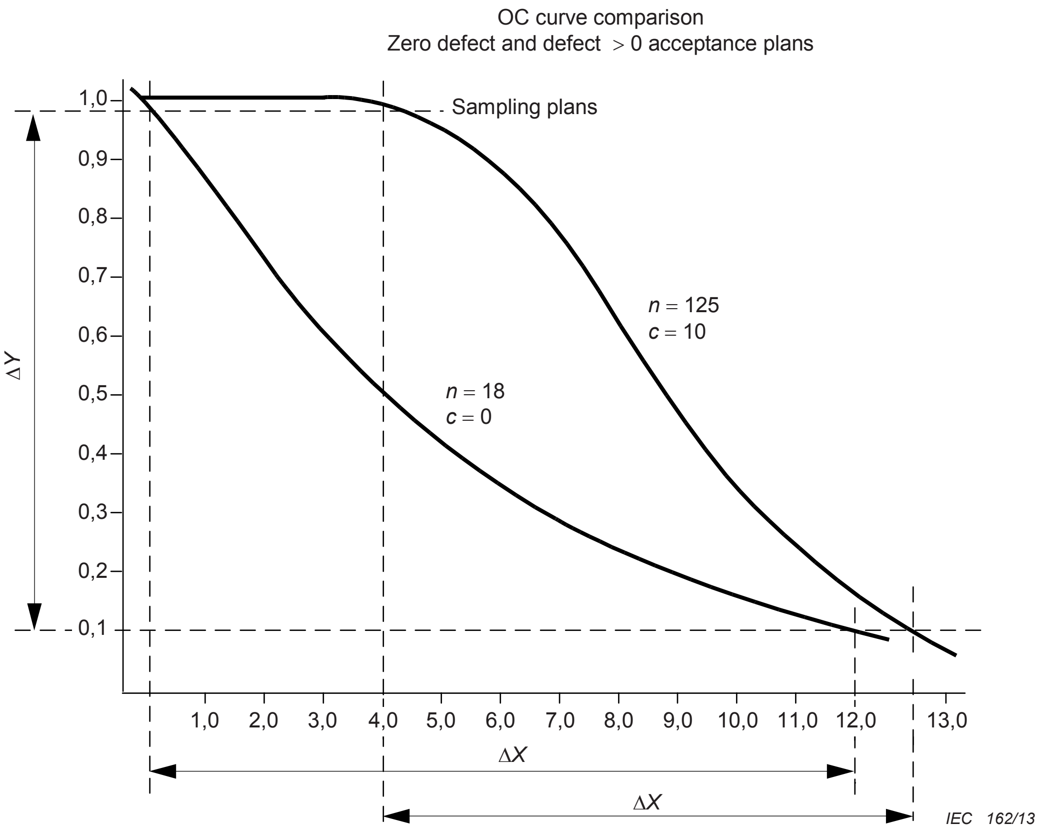


Figure 2 – OC curve comparisons between *c* ≥ 0 and *c* = 0 plans

What industry has tended to do, is to measure output, determine yields, and then resign to an acceptable level of defectives based on the information. These systems usually AQL-based, remove incentives to review the validity of specifications, investigate defect causes, or to improve overall product quality.

Table 1 shows a comparison of a set of $c = 0$ plans with previous plans of $c \geq 0$.

Table 1 – Inspection plan comparison

$c \geq 0$ Plan	**AQL**	**Sample size**	**Accept No.**
	1,0 %	125	3
	4,0 %	125	10
$c = 0$ Plan	**Associated AQL**	**Sample size**	**Accept No.**
	1,0 %	42	0
	4,0 %	18	0

The $c = 0$ plan provides equal to or greater LTPD protection at the 0,10 "consumer's risk" level. There is also less inspection performed on less critical characteristics or attributes.

All of the $c = 0$ characteristics are shown in Table 2. They are "associated" with the AQL's of the $c \geq 0$ plans (AQ level) by using the same percent probability columns to evaluate the number of samples to be taken. In the $c = 0$ AQ limit plans, the plans provide equal protection to the consumer. The method of developing the plans provides for simple conversion from past practices to the $c = 0$ plans. The table labels these associated AQ Limits as "risk management index values" because they are not AQ levels. They are an indication of the probability of some occurrences of non-conforming products in the production lot, even though the sample size does not show these anomalies.

Table 2 – Risk management index values (Associated AQ Limits)

Lot size	0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,5	10,0
	Sample size															
2 – 8	*	*	*	*	*	*	*	*	*	*	*	*	5	3	2	2
9 – 15	*	*	*	*	*	*	*	*	*	*	13	8	5	3	2	2
16 – 25	*	*	*	*	*	*	*	*	*	20	13	8	5	3	3	2
26 – 50	*	*	*	*	*	*	*	*	32	20	13	8	5	5	5	3
51 – 90	*	*	*	*	*	*	80	50	32	20	13	8	7	6	5	4
91 – 150	*	*	*	*	*	125	80	50	32	20	13	12	11	7	6	5
151 – 280	*	*	*	*	200	125	80	50	32	20	20	19	13	10	7	6
281 – 500	*	*	*	315	200	125	80	50	48	47	29	21	16	11	9	7
501 – 1 200	*	800	500	315	200	125	80	75	73	47	34	27	19	15	11	8
1 201 – 3,200	1 250	800	500	315	200	125	120	116	73	53	42	35	23	18	13	9
3 201 – 10 000	1 250	800	500	315	200	192	189	116	86	68	50	38	29	22	15	9
10 001 – 35 000	1 250	800	500	315	300	294	189	135	108	77	60	46	35	29	15	9
35 001 – 150 000	1 250	800	500	490	476	294	218	170	123	96	74	56	40	29	15	9
150 001 – 500 000	1 250	800	750	715	476	345	270	200	156	119	90	64	40	29	15	9
500 001 and over	1 250	1 200	1 112	715	556	435	303	244	189	143	102	64	40	29	15	9

Remarks:

a) The symbol * indicates "inspect the entire lot".

b) If the lot size is smaller than the sample size, the entire lot should be inspected.

c) If samples contain no defects, the entire lot is accepted. If the sample contains one or more defects, the entire lot is rejected.

Because of the zero accept number, the idea of combining lots under the $c = 0$ plans may arise because of the zero accept number. Aside from experience, which has shown that, in fact, considerable savings can be derived, one should consider the following:

- if the quality is very bad, acceptance numbers greater than zero will not be of much help;
- to allow acceptance numbers greater than zero in the plan, one is in effect authorizing an inspector to accept parts which may not be usable;
- the zero acceptance number forces a review of any defectives by quality assurance personnel in order to enable proper withdrawal of the defectives;
- if zero defects are to be achieved, it should be obvious that defectives should not knowingly allowed to be shipped.

The $c = 0$ plans were essentially designed to be equal or greater in consumer and average outgoing quality limit protection. Within a particular column of the details shown in Table 2 representing the index value, the operating characteristic curves actually differ for the most part between $c = 0$ and $c \geq 0$ plans, especially as the lot size increases. The reason for this common feature, in addition to satisfying the statistical relationship, is that it is generally considered more practical to obtain greater protection on larger lot sizes. Table 3 provides guidance to selection of sample sizes and comes from the standards developed for printed circuit board and laminate characteristic requirements. Table A.1 of Annex A provides a consensus sampling plan from IEC 62326-4 that identifies the different product characteristics, the number of samples that should be taken for performance levels A, B, and C, and the risk management index value to be used from Table 2.

Table 3 – Sample size selection guideline

Attributes	Defects		
	Critical	Major	Minor
Critical	0,1	1,0	2,5
Major	1,0	2,5	4,0
Minor	2,5	4,0	6,5

The use of constant sample sizes often results in a combination of over-inspection and under-inspection. For a broad range of lot sizes in general, however, in order to develop an inspection strategy, an evaluation should be made as to the attribute classification (critical, major, minor). This listing of comparisons should identify the risk management index value shown in the Table 2 and should allow the $c = 0$ plans to be used when

a) manufactured parts are expected to completely conform to specification requirements,
b) less inspection is desired on less critical characteristics,
c) sampling is performed because 100 % inspection on all attributes of all units of products is impractical,
d) inspections are not allowed to knowingly accept non-conforming products,
e) auditing is required for assurance of process validation, potential transit damage, certification of suppliers, or inventory verification.

5 Classification of attributes

5.1 General

Attributes are classified as part of the process for selection of sampling plans applied to individual and/or grouped attributes for inspection.

5.2 Classification assignment

Classification of individual attributes associated with specified requirements is assigned according to importance or seriousness. Any failure to conform to the ultimate form, fit, function, and intended use of the product unit is usually understood as being non-conforming to the requirements. Attributes are classified as one of the following:

a) critical;

b) major;

c) minor.

The market segment, or intended end use of a product unit will influence the attribute classification. Example: an identical attribute which may be considered as "critical" in the aircraft market segment may be considered "major" or even "minor" in the consumer market segment.

Table 4 shows basic "End use environments" as an aid for attribute classification.

Table 4 – Worst-case use environments

Use category	Temperature ranges			t_D h	Cycles/ year	Typical years of service	Approximate accept- acceptance failure risk %
	T_{min} °C	T_{max} °C	ΔT [b] °C				
1) Consumer	0	+60	35	12	365	1 to 3	1
2) Computers	+15	+60	20	2	1 460	5	0,1
3) Telecom	−40	+85	35	12	365	7 to 20	0,01
4) Commercial aircraft	−55	+95	20	12	365	20	0,001
5) Industrial Automotive passenger compartment	−55	+95	20 & 40 & 60 & 80	12 12 12 12	185 100 60 20	10	0,1
6) Military Ground &[a] ship	−55	+95	40 & 60	12 12	100 265	10	0,1
7) Space leo Geo	−55	+95	3 to 100	1 12	8 760 365	5 to 30	0,001
8) Military Avionics a b c	−55	+95	40 60 80 & 20	2 2 2 1	365 365 365 365	10	0,01
9) Automotive Under Hood	−55	+125	60 & 100 & 140	1 1 2	100 300 40	5	0,1

[a] & = in addition.

[b] ΔT represents the maximum temperature swing, but does not include power dissipation effects.

Sometimes the contractual agreements between consumer and producer indicate performance acceptance to an approved standard. IEC 62326-4 is an example of a standard that uses $c = 0$ sampling plans. This standard specifies performance requirements in a table for multilayer printed boards used in electronic equipment.

Table 1 in IEC 62326-4 has established the sampling criteria for each attribute or requirement stated in the standard. These are identified as a risk management factor (RMF) as opposed to the old AQL identifications. This was done to highlight the recommendation that certain sample sizes "based on the risk management factor" required that the number selected is sufficient to provide protection on critical attributes through using lower percentage non-conforming parts in the sample being evaluated (see Annex A).

Assignment of classification to individual attributes is the responsibility of the user/customer. Annex A shows an example of acceptance characteristics for three levels of product performance.

5.3 Classification and adjustment of sampling plan criteria

Selection of a sampling plan for an attribute should normally be based upon classification. However, manufacturing process and procedure variability which affects the conformance to the requirements of a particular attribute should be considered. If, a known process once set-up, produces consistent results, piece-to-piece within a lot or batch with little to no variability, it is logical and cost effective to deviate from the strict implementation of a given sampling plan. In this situation it is possible to apply a non-statistical audit by selecting a lesser RMF sampling plan.

5.4 Process control

Sampling plan application for the electronics industry is best utilized by the assignment of separate sampling decisions based on the critical impact for each characteristic specified. For different product categories, plans are applied to such products as shown, but not limited to:

a) electronic components IEC 61193-1
b) electromechanical parts IEC 61193-1
c) mechanical parts IEC 61193-1
d) product printed boards (printed circuits, printed wiring) IEC 61193-3
e) component printed boards (printed circuits, printed wiring) IEC 61193-2
f) hybrid circuits IEC 61193-2
g) electronic single-chip modules IEC 61193-2
h) electronic multi-chip modules IEC 61193-2
i) electronic assemblies IEC 61193-4[1]
j) electronic backplanes IEC 61193-3

The sampling risk levels would be applicable to the characteristics of units of a product category where the characteristics are critical to the reliability, customer satisfaction, or product liability potential. A more lenient plan can be applied to characteristics that are normally less critical to function or attributes that are identified as minor within a particular product category. In addition, the more lenient plans may also be appropriate where there is a known consistency of tooling and automatic processing.

1 Under consideration.

6 Defects and process deviation indicator (PDI) evaluation

6.1 General

Many performance standards list typical defects that are unacceptable and require disposition, e.g., rework, repair. The manufacturer is responsible for identifying other areas of risk and treating those additional concerns. Such items should be documented on the assembly drawing. Other than the unacceptable defects listed, anomalies and variances from within 'acceptable' limits are considered as process deviation indicators and shall be monitored when their occurrence is observed. Usually, disposition of process deviations revealed by PDIs is not required.

6.2 Process control and process improvement requirements

As the industry matures, inspection at the end of the process is not acceptable to many customers. They require the use of process control methodologies in the implementation and evaluation of processes used to produce electrical and electronic assemblies. Subject to agreement by the user, the manufacturer/assembler may be exempted from performing specific quality conformance inspection. Thus, sampling by attributes is not a desirable technique even with c = 0 inspection plans, since the practice implies that quality of the product is inspected at completion of all the work. Nevertheless, this practice helps the systematic process control of the path as shown in Figure 3.

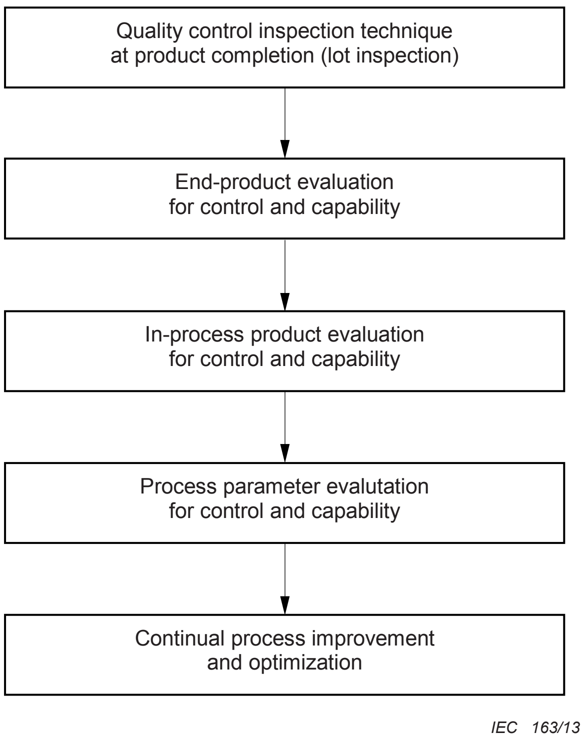


Figure 3 – Systematic path for implementing process control

7 Inspection plans

7.1 General

The following paragraphs define procedures for implementation and operation of inspection by attributes using c = 0 sampling plans.

7.2 Zero acceptance number-based sampling plans

There are still some areas, where the attribute sampling has its merits, for example:

- the producer of electronic components can control the occurrence of so called rogue lots (something totally wrong), by using sampling, and at the same time in the long run collect valuable information of the failures in his process and products. This information can also be used to calculate assessed process average (APA) figures, if they are needed;
- there are still some areas of failures, like some visual/mechanical failures in complicated electromechanical products, where AQLs in traditional form can be of use;
- in the qualification and periodical testing of the components a representative sample has to be selected, because all components cannot be tested.

It is possible to generate the acceptance/reject tables for attribute testing based on zero acceptance number. **It is very important that no matter what statistical levels are used, the acceptance number of failures shall be zero**. This has a strong psychological meaning, and it builds trust between the producer and the customer. This is true, although it has to be understood that the statistical probabilities to have failures are not different from zero and non-zero acceptance numbers, if the statistics used are the same.

The attribute testing can still be a viable tool in the quality assurance, when only the zero acceptance number of failures is used.

7.3 Responsible authority

When specified by a responsible authority, this standard shall be called up in the specification, contract, inspection instructions or other documents and the provisions set forth herein shall govern. The “responsible authority” shall be designated in one of the control documents listed. It should be noted that the responsible authority will normally be the customer.

7.4 Application

Sampling plans designated in this publication are applicable to, but not limited to, inspection of the following:

a) end items;
b) laminate materials;
c) printed board structures.

These plans are to be used primarily for lots or batches that are generally known to have been produced or manufactured under consistent and/or continuous conditions, from a single origination, and are expected to completely conform to specification requirements. The plans may also be used for inspection of isolated lots or batches, but in this latter case, the user may wish to consult the operating characteristics curves to find a plan that will yield the desired protection. These plans should normally only be used for completed items, such as out-going (at the supplier) and/or in-coming (at the customer). However, the sampling plans may be used in audit situations such as stock audit for assurance or potential transit damage, or used as part of a supplier certification procedure.

Statistical process control (SPC) methods and procedures should be used during the production/manufacturing steps in process.

7.5 Sampling plan specification

Normally an RMF and associated sample plan is generally specified by the user/customer for attributes in each classification, as influenced by market segment and variability factors. There is also a high impact derived from the technology sector for products in each market segment or the environment in which the product shall perform.

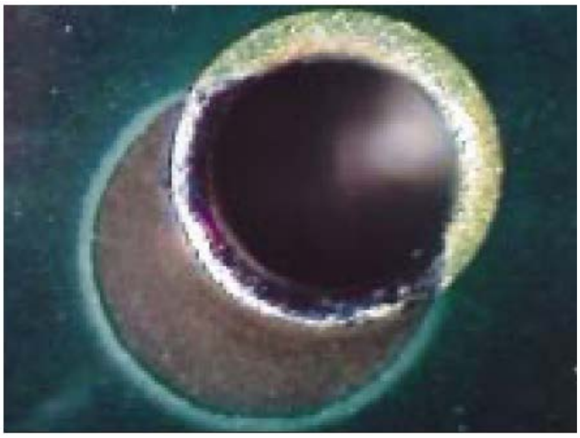
Table 5 is an example of how a user/customer might specify attribute sample plans for a particular market segment, for either internal or external contractual agreements. These are general categorizations and may be more stringent for critical attributes.

Table 5 – General sample plan criteria per industry markets/technology sectors

	High performance systems	Harsh environment systems	Handheld systems	Cost/ performance sensitive	Low cost/ high volume
Automotive	0,01	0,15	0,04	0,15	2,5
Military	0,01	0,15	0,04	0,25	2,5
Communication	0,015	0,025	0,065	0,25	4,0
Computer	0,025	0,4	0,10	0,25	4,0
Business	0,04	0,065	0,15	0,25	4,0
Instrumentation	0,065	0,10	0,15	0,40	6,5
Industrial	0,10	0,15	0,40	1,0	6,5
Consumer	0,40	0,65	2,5	6,5	10

7.6 Submission of product

Quality conformance evaluations are performed on products manufactured and intended to be delivered to the customer. When quality conformance evaluation is accomplished through sampling inspection techniques, sample size selection shall be taken from Table 2. For performance, the RMF for lot inspection is prescribed in the standard, customer specification, or derived from the example in Table 5. The lot inspection sample size prescribed is applicable, unless in-process controls have been established, with verifiable evidence of correlation to finished product requirements. For the purpose of the quality conformance inspection, products that are structurally similar may be aggregated into one inspection lot. Figure 4 shows some examples of different attributes that have been judged defective based on inspection criteria.

Non-conductive burrs	Board edges nicks
	
Foreign inclusions	**Solder mask registration**
	

IEC 164/13

Figure 4 – Non-conforming attributes with specification requirements

For a lot to be accepted, all test specimens of the sample shall conform to the requirements. If an inspection lot is rejected, the manufacturer may inspect 100 % of the lot and screen out the defective units for the defect(s) identified in the sample. The defective units may be reviewed and accepted by agreement between customer and manufacturer. To be accepted, the screened out inspection lot should be reinspected by selecting an additional sample in the sampling plan per the described RMF.

When lot inspection techniques are utilized for quality assessment, the manufacturer may reduce the sample size designated in Table 2 to the next less stringent RMF shown, as follows:

- five consecutive inspection lots, of similar size, have been accepted using the specified performance level and current assessment criteria;
- the time elapsed between the first and fifth inspection lots has been no longer than 12 months;
- the reduced assessment is applied to inspection lots of similar size or less;
- the certifying record shall indicate and verify changes in assessment levels.

This procedure can be undertaken twice, if the same criteria are met. Normal inspection shall be resumed if one inspection lot is rejected.

Lot inspections may be further reduced or discontinued, if process control techniques are established, with correlation to the finished product requirements.

Customers shall be made aware of the quality assessment procedures in operation, and shall be notified of reduced lot inspection or changes from lot inspection to in-process testing and control.

Annex A shows an example of the sampling requirements for multilayer boards; Annex B shows an example for the sampling and test method requirements for a copper clad laminate.

8 Classification of defects

8.1 General

An IEC standard will usually contain complete information on quality evaluation for any product to be fully compliant with the requirements for various performance levels. The sampling plan data shall specify the appropriate level of quality conformance inspection from Table 2, as well as the attributes (critical, major, minor), and defect characteristics (critical, major, minor).

Unless otherwise specified, specially designed test specimens may be used for carrying out tests for the lot inspection and the periodic inspection.

When specially designed test specimens are to be used, their description shall be included in the documentation. They may be based on the appropriate characteristics of the shipment-ready product. Consultation between manufacturer and customer is usually necessary.

8.2 Customers detail specification (CDS) data

A customer detail specification should also contain all information necessary to define the product clearly and completely. This includes the target acceptance conditions as well as what constitutes non-conformance.

Care shall be taken to avoid unnecessary requirements. Permissible deviations shall be stated where necessary and nominal values without tolerances or simple maxima or minima shall be given where sufficient. Where precise tolerances are necessary for certain products, they shall be applied and restricted to those products.

Lot 1 through lot *m* shall include all lots sampled from lot 1 through lot *m*.

9 Percent defectives per million opportunities

9.1 General

The objective of the defect per million opportunities (DPMOs) approach is to characterize the quality of shipment-ready lots of products. This assumes a uniform manufacturing process which has controls for eliminating non-representative lots.

Samples, which are drawn at random from the individual lots which comprise the population are assessed based on audits performed on shipment-ready products. See ISO 14560:2004.

The pass/fail result is used as final lot acceptance data. Lots/batches of products which fail acceptance inspection criteria are assumed to be either reprocessed 100 % with all non-conforming parts being removed from the lot/batch or the lot/batch is removed from consideration for shipment and discarded.

9.2 Classes of DPMO

9.2.1 General

Non-conformances shall be classified by the preparer of the IEC specification under one or more of the following classes (no device shall be counted more than once in any one of the five classes).

9.2.2 DPMO-1 – Functional non-conformances only

Those non-conforming devices which are inoperative.

9.2.3 DPMO-2 – Electrical non-conformances

Those devices non-conforming to specified parameters which define essential electrical characteristics of a product (includes DPMO-1 electrical).

9.2.4 DPMO-3 – Visual/mechanical non-conformances

Those devices non-conforming to specified parameters which define the essential visual/mechanical characteristics of a product (includes DPMO-1 visual/mechanical)

9.2.5 DPMO-4 – hermetic non-conformances

Those devices non-conforming to the hermetic requirements of a product (includes DPMO-1 hermetic).

9.2.6 DPMO-5 – all non-conformances

All devices non-conforming to any specification requirement of a product. This includes all of DPMO-2, DPMO-3, and DPMO-4, plus all other specification non-conformances.

9.3 Estimation of DPMO

9.3.1 General

Estimation of the non-conformance level in DPMO can be calculated using the assumption that attribute sample inspection is being conducted for a product which has completed all manufacturing processes to the criteria being reported. In addition, the manufacturing processes used to produce the product are maintained statistically in control.

Lots/batches of product which fail acceptance inspection are either reprocessed 100 % and all the non-conforming parts removed from the lots/batches or the lots/batches are removed from consideration for shipment and discarded.

All reprocessed lots/batches (second or other submissions) are segregated from non-sampled lots/batches. Data from these lots (i.e. other than first submission lots) will not be used in the compilation of DPMO.

9.3.2 DPMO reporting

For each DPMO value being reported, the manufacturer will specify what parameters were actually measured and used for that calculation. Non-conformities which are not related to parts, such as administrative errors, shall not be included in these calculations.

Since the plans are on a $c = 0$ basis, the sample size is based on the probability that some percentage (RMF) of non-conforming parts are included in the lot. The probable percentage number should be used in the calculation.

Data obtained from assumptions made on lots/batches that were not tested because of a skip lot sampling plan or a waiver of test requirements, cannot be used in any assessment of DPMO.

When products are manufactured at more than one location, data from these different locations may not be combined to form a composite DPMO value.

9.4 DPMO calculations

9.4.1 General

Estimation of the non-conformance level in DPMO is calculated as follows:

$$DPMO\ \# = \frac{0{,}7 + \sum\limits_{i=1}^{m} x_i}{\sum\limits_{i=1}^{m} n_i} \times 10^6$$

That is,

$$DPMO\ \# = \frac{0{,}7 + Total\ number\ nonconforming}{Total\ number\ inspected\ (tested)} \times 10^6$$

where

x_i is the number of non-conforming parts found in the actual inspection (testing of n_i parts from the I^{th} lot of m total lots; and

\# is the designated class of DPMO.

9.4.2 Sampling requirements

x_i and n_i are determined when performing the final audit or lot acceptance on a lot before it is shipped to a customer. The only requirement on the sampling procedure is that the parts shall be selected randomly.

Lot 1 through lot *m* shall include all lots sampled from lot 1 through lot *m*.

10 Use of sampling plans

10.1 General

There are many ways to apply the $c = 0$ sampling plan criteria. Each application has its merits and it is important to use the most reliable method which correlates to the products being manufactured.

10.2 Grouping of tests

Tests may be subdivided into categories in order to reflect various grouping of inspection.

The categories cover lot inspection and periodic tests. The tests may be destructive and may require the use of standard test specimens. The specimens may be included on the production lot or may be produced separately in conjunction with the production lot. Test specimens should be of the same materials and processes so as to be representative of the product and the process. If separate specimens are manufactured, they shall be spaced out in production in such quantities that a good average assessment can be made.

10.3 Categorization

Various techniques can be used to categorize the inspection and quality assessment of the attributes associated with shipment-ready products. Each category consists of sub-groupings depending on the products being assessed. Some of these are the following.

- Category V – Visual inspection
- Category D – Dimensional inspection
- Category S – Surface condition inspection
- Category E – Electrical inspection
- Category P – Physical inspection
- Category Y – Structure integrity inspection
- Category Z inspection – This category covers all tests which may be necessary in addition to tests of inspection categories V, D, S, E, P, and Y to complete an entire test program. Category Z tests are usually carried out at intervals of 12 months. They may be carried out progressively within a 12 month period.

10.4 In-process testing and control

In-process testing and control may be applied to any requirements listed in the standard, specification, or customer detail specification (CDS), and is required at some stages. In-process testing and control data shall be kept as verifiable evidence of conformance to requirements. Data shall be available which verifies correlation to finished product requirements. In process testing and control may be implemented for selected requirements while continuing lot inspection for other requirements. Depending upon the progress made in implementing in-process/process control the manufacturer may prove compliance to specifications with:

- quality conformance lot inspections;
- finished product control;
- in-process control;
- process parameter control.

A manufacturer may choose to use a combination of these techniques to prove conformances to requirements.

When agreement has been reached between customer and manufacturer, in-process testing and control may be substituted for the relevant test(s) and sampling prescribed in the quality conformance inspection schedule, provided that:

- the in-process testing and control is carried out under the authority of the appointed management representative (chief inspector);
- the process steps or storage periods between in-process testing and the completion of the units of product are not likely to affect the characteristics tested;
- the data provided by in-process testing is correlated to the finished product requirements and assures the same level of performance for characteristics as would be demonstrated in the prescribed finished product sampling plan and testing.

End-product statistical control should normally be established prior to implementation of in-process or process parameter control. However, some product requirements are preferably always evaluated in-process.

In process control requirements are indicated in Table 2 as risk management factors. The priority implementation code signifies how the sampling should be applied. The codes given in Table 6 can be used to communicate requirements between the user and the manufacturer.

Table 6 – Process control

Code	Priority implementation
C1	In-process and/or process parameter control, required implementation
C2	In-process and/or process parameter control, first priority implementation
C3	In-process and/or process parameter control, second priority implementation
C4	In-process and/or process parameter control, third priority implementation
C5	Periodic laboratory test (in conjunction with related in-process/process control for correlation to test criteria and product requirements)

10.5 Indirect measuring methods

Where appropriate, indirect measuring methods may be substituted for direct methods, provided the necessary accuracy and calibration are ensured.

EXAMPLE: Instead of directly measuring dimensions, a gauge of suitable characteristics may be used.

Where appropriate, control of a process parameter may be the most effective method of assuring product conformance to specification requirements. In this case, the process parameter control may be accepted as the primary quality assessment method for the affected characteristics, provided that a periodic product inspection for the relevant characteristic(s) is performed.

EXAMPLE: Process control of plating chemistry is the primary method of assuring adhesion of plated on component leads; maintaining process control coupled with periodic shipment-ready product inspection is preferred to lot inspection prescribed in a sampling plan.

Annex A
(informative)

Example of consensus sampling plan for three levels of conformance to requirements of IEC 62326-4 multilayer printed boards

Table A.1 indicates the perfomance requirements with respect to IEC 62326-4 multilayer printed boards. Note that in column "B" of "Specific requirements for perfomance level", "GR" is used to indicate that only the general requirements shall be met. For an explanation of the abbreviations and all the conditions of the sampling plan, see referenced IEC standards in Annex A.

Table A.1 – Performance requirements

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
V	VISUAL EXAMINATION								
V1	Conformity	Pattern, marking identification and material finishes shall comply with the CDS when viewed without magnification. There shall be no apparent defects.	As specified	– As specified	– As specified	6,5 4,0	Complete PB/DP	3V04	C4
V2	*Appearance and workmanship*	The boards shall appear to have been processed in a careful and workmanlike manner, in accordance with good current practice.	GR –	– GR	– GR	6,5 4,0	Complete PB/DP	3V01	C4
V3	*Plated-through holes as received*	Plated-through holes shall be clean and free from inclusions of any sort that could affect component insertion and solderability when viewed without magnification.	GR –	– GR	– GR	4,0 2,5	Complete PB	3V04	C4

Test code	Characteristics	General requirements	Specific requirements for performance level A	B	C	Assessment RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
		The number of holes with plating voids shall not exceed the specified percentage of the total number of plated-through holes when viewed without magnification.	5 % –	– 1 %	– None	4,0 2,5			C2
		The number of holes with plating voids shall not exceed the specified percentage of the total number of plated-through holes when viewed without magnification.	5 % –	– 1 %	– None	4,0 2,5			C2
	Holes showing plating voids	Total area of plating voids within a hole shall not exceed the specified percentage of the total area.	5 % –	– 2 %	– 2 %	4,0 2,5			C2
		The largest dimension of voids shall not exceed the specified percentage of the hole circumference in the horizontal plane or the same percentage of the board thickness in the vertical plane.	15 % –	– 10 %	– 5 %	4,0 2,5			C2
V4	*Plated-through holes after microsection*	Plated-through holes (levels B and C) shall be tested in as-received conditioning and after preconditioning according to test code Y4. Voids shall not coincide with internal or external copper layers. *Remarks* – All examinations execued at 100× magnification – Process control data may be used to supplement/ minimize this test	– –	GR –	– GR	1,5 1,0	A or B (3 holes)	3X09	C1

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
V4.1	Resin smear at interface	Resin smear between the edge of the inner layer copper and the continuous plating shall not interrupt electrical continuity or exceed the specified percentage of inner layer copper thickness at the interface (see IEC 62326-4: 1996, Figure 1)	≤30 % – –	– ≤15 % –	– – None	2,5 1,5 1,0			C1
V4.2	Circumferential cracks of copper plating	There shall be no circumferential cracks of the copper, or circumferential separation of the copper from the wall in the plated-through hole (see IEC 62326-4:1996, Figure 2)	GR – –	– GR –	– – GR	2,5 1,5 1,0			C1
V4.3	Copper barrel to hole separation	There shall be no separation of plating from the hole wall exceeding the specified percentage of the hole circumference (see IEC 62326-4: 1996, Figure 2). *Remark* Where necessary, this shall be verified by dimensional examination using test 3D01	≤50 % – –	– ≤40 % –	– – ≤30 %	2,5 1,5 1,0			C1
V4.4	Foil cracking	There shall be no foil cracking	GR – –	– GR –	– – GR	2,5 1,5 1,0			C1

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
V5	*Conductors*								
V5.1	External conductors	There shall be neither cracks nor breaks. Imperfections such as voids or edge defects are permissible provided that the conductor width or land area is not reduced by more than the specified percentage (see IEC 62326-4:1996, Figure 3). *Remarks* – Where necessary, this shall be verified by dimensional examination using test 3D01 – In the effective contact areas there shall be no imperfections – For test specimens supplied with solderable temporary protective coating the above requirement is not applicable	≤30 % (no occurrence >10 mm) –	– ≤20 % (no occurrence >5 mm)	– ≤10 % (no occurrence) >3 mm)	4,0 2,5	Complete PB	3V02	C3
		When specified, the conductors shall be covered with a smooth and bright solder coating with not more than 5 % of scattered imperfections, such as pinholes, unwetted or dewetted areas. The imperfections shall not be concentrated on one area.	GR – –	– GR –	– – GR	6,5 4,0 2,5	Complete PB	3V02	C1

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
V5.2	Internal conductors	There shall be neither cracks nor breaks. Imperfections such as voids or edge defects are permissible provided that the conductor width is not reduced by more than the specified percentage(see IEC 62326-4: 1996, Figure 3). *Remarks* – Where necessary, this shall be verified by dimensional examination using test 3D01. – This examination shall be in-process	≤30 % (no occurrence >10 mm) –	– ≤20 % (no occurrence >5 mm)	– ≤10 % (no occurrence >3 mm)	4,0	Complete PP	3V02	C3
V6	*Particles between conductors*								
V6.1	External conductors	Residual metallic particles are permissible provided that the leakage path is not reduced by more than the specified percentage or to less than the distance required for the circuit voltages in isolated areas discounting conductor undercut, edge roughness, spikes, etc. (see IEC 62326-4:1996, Figure 3). *Remark* Where necessary, this shall be verified by dimensional examination using test 3D01	≤30 % –	– ≤30 %	– ≤20 %	4,0 2,5	Complete PB	3V02	C3

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
V6.2	Internal conductors	Residual metallic particles are permissible provided that the leakage path is not reduced by more than the specified percentage or to less than the distance required for the circuit voltages in isolated areas discounting conductor undercut, edge roughness, spikes, etc. (see IEC 62326-4:1996, Figure 3). *Remarks* – Where necessary, this shall be verified by dimensional examination using test 3D01. – This examination shall be in-process	≤30 % –	– ≤20 %	– ≤10 %	4,0 2,5	Complete PP	3V02	C3
V7	*Permanent polymer coating* (including solder resist)	The polymer coating pattern shall comply with the CDS and the general requirements given below. There shall be no apparent defects. *Remark* When necessary this shall be verified by dimensional examination using test 3D01	As specified –	– As specified	– As specified	4,0 2,5	Complete PB/DP	3V01	C4
		When noted in the CDS that the polymer coating is used as an insulation all parts shall be completely covered.	As specified –	– As specified	– As specified	2,5 4,0			C3
		Imperfections in the polymer coating on the base material, such as pinholes, small uncovered areas, scratches, etc. are permitted.	GR –	– GR	– GR	4,0 2,5			C3

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
		Polymer coating used as solder resist shall cover the top surface of the conductor and shall be substantially free of pinholes. At least one or two adjacent conductor edges shall be covered.	GR –	– GR	– GR	4,0 2,5			C3
		Board edges and the areas near slots, notches, etc., shall be free from polymer coating (as specified on the master drawing when using a production board).	GR –	– GR	– GR	4,0 2,5			C3
		All metallic areas intended for solder attachment, electrical contact, or indexing marker shall be free from polymer coating residues.	GR –	– GR	– GR	4,0 2,5		3V02	C2
D	DIMENSIONAL EXAMINATION								
D1	*Board dimensions* (external boundary)	Dimensions including thickness shall comply with the CDS.	As specified –	– As specified	– As specified	4,0 2,5	Complete PB (3 places)	3D04	C4
D2	*Board thickness in the zone of edge board contacts*	The total board thickness over the edge board contacts shall comply with the CDS.	As specified B	B As specified	B As specified	4,0 2,5	Edge contact areas of PB	3D04	C4
D3	*Holes* (see also D8)								
D3.1	Diameter	Diameters of tooling holes, mounting holes and component holes shall comply with the CDS. *Remark* A recommended range of hole sizes and tolerances are given in IEC 61188-6 [a]	As specified –	– As specified	– As specified	4,0 2,5	Complete PB/DP (10 holes per size)	3D04	C2

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
D3.2	Plating thickness	The plating thickness shall comply with the CDS. *Remark* Examinations at 400× magnification.	As specified –	– As specified	– As specified	4,0 2,5	A or B (3 holes)	3X09	C1
D4	*Slots, cut-outs and notches*	The dimensions of applicable slots, cut-outs or notches shall comply with the CDS.	As specified –	– As specified	– As specified	4,0 2,5	Complete PB	3D04	C3
D5	*Conductor width*								
D5.1	External layer	The width shall comply with any specific dimensions given in the CDS. *Remarks* – To be measured together with V5.1 – If no tolerances are stated, the coarse deviations given in IEC 61188-6 [a] will apply	As specified –	– As specified	– As specified	4,0 2,5	Complete PB	3D01	C2
D5.2	Internal layer	The width shall comply with any specific dimensions given in the CDS. *Remarks* – To be measured together with V5.2 – If no tolerances are stated, the coarse deviations given in IEC 61188-6 [a] will apply – This measurement shall be in-process	As specified –	– As specified	– As specified	4,0 2,5	Complete PP	3D01	C2
D6	*Spacing between conductors*								

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
D6.1	External layer	The spacing shall comply with any specific dimension given in the CDS. *Remark* To be measured together with V6.1	As specified –	– As specified	– As specified	4,0 2,5	Complete PB	3D01	C3
D6.2	Internal layer	The spacing shall comply with any specific dimensions given in the CDS. *Remarks* – To be measured together with V6.2 – This measurement shall be in-process	As specified –	– As specified	– As specified	4,0 2,5	Complete PP	3D01	C3
D7	*Alignment of hole and conductive pattern*	There shall be no interruption of the conductive pattern and there shall be no hole break-out (land cut off) at the junction of the land and the conductor in excess of that specified below. This applies to both internal and external layers (see IEC 62326-4:1996, Figure 4, Figure 5 and Figure 6).					Complete PB (10 holes, random selection over total area)	3D01	
D7	*Alignment of hole and conductive pattern*	There shall be no interruption of the conductive pattern and there shall be no hole break-out (land cut off) at the junction of the land and the conductor in excess of that specified below. This applies to both internal and external layers (see IEC 62326-4:1996, Figure 4, Figure 5 and Figure 6).					Complete PB (10 holes, random selection over total area)	3D01	
D7.1	External pattern alignment to plated-through holes	The requirements shall be as specified.							

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
		Minimum annular width W_1 of external land at conductor junction (see IEC 62326-4:1996, Figure 4).	There shall be no defects at conductive pattern and through-hole plating –	– $W_1 \geq$ 0,03 mm	– $W_1 \geq$ 0,05 mm	4,0 2,5			C1
		Minimum annular width W_1 of external land at the other parts.	–	Break-out $\theta \leq 90°$ (see IEC 62326-4: 1996, Figure 6)	$W_1 \geq$ 0,05 mm (see IEC 62326-4: 1996, Figure 4)	2,5			
D7.2	External pattern alignment to plain holes holes	The requirements shall be as specified.	No breakout. No conductor junction reduction –	– No break-out. No conductor junction reduction	– No break-out. Minimum annular width 0,4 mm	4,0 2,5			C1
D7.3	Internal pattern alignment to plated-through holes	The requirements shall be as specified. Remarks – 100× magnification. – Any other adequate method may be used							

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
		Minimum annular width W_2 of internal land at conductor junction (see IEC 62326-4:1996, Figure 5).	$W_2 \geq$ 0,03 mm – –	– $W_2 \geq$ 0,03 mm –	– – $W_2 \geq 0,05$ mm	2,5 1,5 1,0	A or B (3 hole) and/or R for electrical continuity and/or F for process control	3X09	C1
		Minimum annular width W_2 of internal land at the other parts.	Break-out $\theta \leq 180°$ see IEC 62326-4: 1996, Figure 6) – –	– Break-out $\theta \leq 90°$ (see IEC 62326-4: 1996, Figure 6)	– – $W_2 \geq 0$ mm (see IEC 62326-4: 1996, Figure 5)	2,5 1,5 1,0			C1
D7.4	Landless holes	*Test under consideration*							
D8	*Positional accuracy*								
D8.1	Position of conductive pattern and holes relative to the position data	The position of all holes shall comply with any specific details given in the CDS. *Remark* When specially called for, the deviations given in IEC 61188-6 [a] will apply	As specified –	– As specified	– As specified	4,0 2,5	Complete PB (10 holes, random selection over total area)	3D04	C3

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
D8.2	Positional tolerance of hole centres with respect to the position data	The hole centres shall be within the specified tolerances in the CDS. *Remark* When specially called for, the deviation given in IEC 61188-6 [a] will apply	As specified –	– As specified	– As specified	4,0 2,5	Complete PB (10 holes, random selection over total area)	3D04	C2
D9	*Permanent polymer coating* (including solder resist)								
D9.1	Dimensions	The dimensions of the polymer coating pattern shall comply with the CDS.	As specified –	– As specified	– As specified	4,0 2,5	Complete PB/DP (10 places)	3D01	C3
D9.2	Thickness of polymer coating	The thickness shall comply with the CDS.	As specified –	– As specified	– As specified	4,0 2,5	Complete PB (3 places)	3D04 or	C3
		Remark The thickness shall be measured at the location stated in the CDS when using Test 3X09 with 400× magnification.	As specified –	– As specified	– As specified	4,0 2,5	1 time A or B (per panel)	3X09	C3
D10	*Flatness*	The allowable bow and twist shall not be more than the specified value for printed boards with a diagonal of ≥100 mm.	1,5 % of the diagonal –	– 1 % of the diagonal	– 0,5 % of the diagonal	4,0 2,5	Complete PB/DP	3M04	C3

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
S	SURFACE CONDITION TESTS								
S1	*Plating finishing*								
S1.1	Adhesion of plating, tape method *or*	There shall be no evidence of plating adhering to tape after removal from the conductor, other than permitted by the CDS. *Remark* Specimen N shall be tested prior to fusing	As specified – –	– As specified –	– – As specified	6,5 4,0 2,5	N	3X01	C3
	Adhesion of plating, burnish method	There shall be no evidence of blistering or detachment of the plating. *Remark* For contact finishes only	GR – –	– GR –	– – GR	6,5 4,0 2,5	Edge contact area of PB	3X02	C3
S1.2	Thickness of plating (contact area)	The thickness shall comply with the CDS.	As specified – –	– As specified –	– – As specified	6,5 4,0 2,5	Edge contact area of PB	3X06	C3
S1.3	Thickness of plating (other than contact area)	The thickness shall comply with the CDS.	As specified – –	As specified –	– – As specified	6,5 4,0 2,5	N	3X06	C3
S1.4	Porosity, gas exposure *or*	The total number of pores shall not be more than the number of the effective contact areas. The maximum number of pores per contact area shall be two. The percentage of contact areas with two pores shall not be more than specified.	– –	40 % –	– 20 %	4,0 2,5	N	3X03	C3

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
	Porosity, electrographic test	The total number of pores shall not be more than the number of the effective contact areas. The maximum number of pores per contact area shall be two. The percentage of contact areas with two pores shall not be more than specified.	– –	40 % –	– 20 %	4,0 2,5	N	3X04 or 3X05	C3
S2	*Adhesion of permanent polymer coating, tape method*	The loss of adhesion shall not be more than the specified allowable percentage of testing area. *Remark* Applicable to permanent polymer coating only					G	3X01	
		– on bare copper	10 % – –	– 5 % –	– – 0 %	6,5 4,0 2,5			C2
		– on gold or nickel	25 % – –	– 10 % –	– – 5 %	6,5 4,0 2,5			C2
		– on base laminate	10 % – –	– 5 % –	– – 0 %	6,5 4,0 2,5			C2
		– on melting metals (tin-lead plating, fused tin-lead, etc.)	50 % – –	– 25 % –	– – 10 %	6,5 4,0 2,5			C2

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
S3	*Solderability*	*Remark* When tested, the conductive surface of the board and the insides of the holes shall be properly wetted. When applied on production boards, only those holes having no connection with internal layers should be assessed to avoid "heat sink effect" affecting the interpretation of the results.							
S3.1	When the use of a non-activated flux is agreed between customer and supplier	*Remarks* – Non-activated flux, as specified in IEC 60068-2-20. – For both wetting and dewetting the holes shall comply with the well soldered holes of see IEC 62326-4: 1996, Figure 7.					M and S	3X07	
	As-received condition	Wetting: the specimen shall be wetted within 3 s. When temporarily protective coating intended to preserve the wettability is used, the specimen shall be wetted within 4 s.	–	–	GR	2,5			C1
		Dewetting: the specimen shall remain in contact with the molten solder for 5 s to 6 s and shall not be dewetted.	–	–	GR	2,5			C1
	After accelerated ageing	Wetting: the specimen shall be wetted within 4 s.	–	–	GR	2,5			C1
		Dewetting: the specimen shall remain in contact with the molten solder for 5 s to 6 s and shall not be dewetted.	–	–	GR	2,5			C1

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
S3.2	When the use of an activated flux is agreed between customer and supplier	*Remarks* – Activated flux (0,2 %) as specified in IEC 60068-2-20. – For both wetting and dewetting the holes shall comply with the well soldered holes in Figure 7 of IEC 62326-4:1996.					M and S	3X07	
	Condition as-received and after accelerated ageing	For boards with or without (solderable) temporary protective coating.							
		Wetting: the specimen shall be wetted within 3 s.	GR –	– GR	– –	6,5 4,0			General requirements
		Dewetting: the specimen shall remain in contact with the molten solder for 5 s to 6 s and shall not be dewetted.	GR –	– GR	– –	6,5 4,0			C1
S4	*Resistance to cleaning agents and flux*								
S4.1	Permanent polymer coating	No sign of: – blistering or delamination; – random removal of areas of permanent polymer coating or ink dissolving; – substantial change in colour.	– –	GR –	– GR	4,0 2,5	Complete PB	3C04	C4

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
S4.2	Marking legend	Accept: a) marking unaffected; b) marking reduced but legible. Reject: c) markings doubtfully legible, i.e. possible mistake between similar characters, such as R-P-B, E-F, C-G-O; d) marking illegible or destroyed	– –	GR –	– GR	4,0 2,5	Complete PB	3C041	C4
S5	*Land pattern topography*	*Test under consideration*							
S6	*Cleanliness*	*Test under consideration*							
E	ELECTRICAL TESTS								
E.1	*Electrical integrity*								
E1.1	Circuit continuity	The resistance of conductors and interconnections shall not be greater than specified in the CDS	As specified	As specified	As specified	All PBs	Complete PB	300	C4
E1.2	Circuit insulation	The requirements shall be as specified in the CDS. When applying 220 V minimum for 5 s (manual testing) or twice the rated voltage, the resistance between conductor patterns shall not exceed the specified value. Minimum allowable test current shall be 1 mA. *Remark* If the maximum voltage is not specified use 40 V minimum	As specified	As specified	As specified	All PBs	Complete PB	30	C4

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
E2	*Current proof*	At least five holes shall be tested. The plating within the holes shall withstand the appropriate current as specified in IEC 61189-3 without burnout (fusing) and without overheating as apparent by discoloration. The conductors shall not burn-out (fuse) and there shall be no overheating as apparent by discoloration.	– –	GR –	– GR	2 per quarter 2 per month	H	3E14 and 3E15	C5
E3	*Voltage proof*	There shall be no disruptive discharge.	– –	GR –	– GR	2 per quarter 2 per month	H	3E09	C5
E4	*Change in resistance of plated-through holes*	During conditioning the requirements shall be met. *Remark* Maximum permissible increase of resistance in percent during any immersion into the oil bath of 260 °C shall be specified	– –	10 cycles increase: ≥100 % –	– 30 cycles increase: ≤100 %	2 per quarter 2 per month	D	3E08	C5
E5	*Insulation resistance*	*Remark* Insulation resistance shall be measured before environmental conditioning, after environmental conditioning and at elevated temperature, as specified in the CDS							
E5.1	Measurement at standard atmospheric conditions	Preconditioning using test 1P01. The insulation resistance shall be as specified.							
	Surface layers		–	≥500 Ω	≥500 Ω	2 per month (level B)	E	3E03	C5

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
	Internal layers		–	≥500 Ω	≥500 Ω	2 per lot (level C)	E	3E04	
	Between layers		–	≥500 Ω	≥500 Ω		E	3E05	
E5.2	Measurement after conditioning	Conditioning, as specified in IEC 60068-2-3, Test Ca: Damp heat, steady state, or IEC 60068-2-38, Test Z/AD: Composite temperature/ humidity cyclic test. The insulation resistance shall be as specified. *Remark* Applicable conditioning to be specified in the CDS. Test Ca is the preferred conditioning test	–	10 days	21 days				
	Surface layers		–	≥500 Ω	≥500 Ω	2 per month (level B)	E	3E03	C5
	Internal layers		–	≥500 Ω	≥500 Ω	2 per lot (level C)		3E04	
	Between layers		–	≥500 Ω	≥500 Ω			3E05	
E5.3	Measurement at elevated temperature	*Remark* The temperature and the time in the chamber shall be specified in the CDS. The insulation resistance shall be specified							
	Surface layers		–	≥100 Ω	≥500 Ω	2 per month (level B)	E	3E03	C5

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
	Internal layers		–	≥100 Ω	≥500 Ω	2 per lot (level C)	E	3E04	
	Between layers		–	≥100 Ω	≥500 Ω		E	3E05	
E6	Characteristic impedance	Test under consideration							
P	PHYSICAL TESTS								
P1	Peel strength	Remark For foil lamination only							
P1.1	Measurement at standard atmospheric conditions	The peel strength shall not be less than the value specified in the CDS	–	–	≥22 N per 25 mm	4,0	N	3M01	C1
P1.2	Measurement at elevated temperature	Test under consideration							
P2	Pull-off strength of landless plated-through holes	The pull-off strength after five soldering operations shall not be less than the value specified in the CDS. *Remarks* – Preconditioning for 2 h – The thermal shock test 3N02 of IEC 61189-3 shall be applied for 10 s (B) and 20 s (C) – Microsection will be done only when required in the CDS	– –	≥16 N –	– ≥16 N	4,0 2,5	Complete PB/DP (3 holes)	3M03	C1

Test code	Characteristics	General requirements	Specific requirements for performance level			Assessment			
			A	B	C	RMF IEC 62326-1	Test specimen IEC 62326-4-1	Test no. IEC 61189-3	Process control code IEC 62326-1
P3	Pull-out strength of surface-mounted lands	Test under consideration							
P4	Permanent polymer coating hardness	The coating shall not be damaged when using a pencil hardness as specified	2B –	F –	– 2H	4,0 2,5	Complete PB	2	C2
Y	STRUCTURAL INTEGRITY TESTS								
Y1	Delamination, thermal shock	There shall be no apparent blistering or delamination. Remarks – Preconditioning for 2 h – The thermal shock test 3N02 of IEC 61189-3 shall be applied for 10 s (B) and 20 s (C) – Microsection will be done only when required in the CDS	– –	GR –	– GR	4,0 2,5	S	3X08	C5
Y2	Flammability	The materials used shall meet the flammability grade as given in the CDS	As specified	As specified	As specified	6,5	Complete PB	3C01	C5
Y3	Dielectric dissipation factor	Test under consideration							

[a] IEC 61188-6 is currently under consideration. The tests will apply as soon as this International Standard will be available.

Annex B
(informative)

Example of consensus sampling plan

NOTE For further information see also IEC 61249-2-34:2009, Clause 8 and Subclause 7.1.

B.1 Quality assurance

B.1.1 Quality system

The supplier shall maintain a quality system in compliance with ISO 9000 or similar to support quality conformance inspection. The supplier shall maintain a management system for environmental control in compliance with ISO 14001 or similar, to support environmental considerations.

B.1.2 Responsibility for inspection

The supplier is responsible for all inspections of the manufactured material. The purchaser or an appointed third party may audit these inspections.

B.1.3 Qualification inspection

Laminates furnished under this standard shall be qualified. Qualification testing shall be performed to demonstrate the manufacturer’s ability to meet the requirements of this specification sheet. Qualification testing shall be conducted at a laboratory in compliance with IEC laboratory requirements. A list of the normal qualification tests can be found in Table B.1. The manufacturer shall retain the data file which supports that the materials meet this standard and it shall be readily available for review upon request.

B.1.4 Quality conformance inspection

The supplier shall operate a quality plan to assure product conformance to this standard. This quality plan, when appropriate, shall utilize statistical methods rather than production lot inspection. It is the responsibility of the supplier, based on the quality plan, to determine the frequency of test to assure conforming products. In the absence of a quality plan or supporting data, the testing regime shall be as outlined in Table B.1.

A combination of the following techniques may be used to show compliance with the requirements which can be used to reduce the frequency of testing. The data supporting the reduction of testing frequency shall be available for review upon request.

– In process parameter control
– In process inspection
– Periodic final inspection
– Final lot inspection

B.1.5 Certificate of conformance

The supplier shall issue a certificate on request from the purchaser of conformance to this standard in electronic or paper format.

B.1.6 Safety data sheet

A safety data sheet in accordance with ISO 11014 shall be available for products manufactured and delivered in compliance with this standard.

Table B.1 – Guideline for qualification and conformance inspection

Property	Test method IEC 61189-2	Qualification testing	Conformance testing	Conformance frequency
Peel strength after thermal shock	2M14	Yes	Yes	Lot
Peel strength at 125 °C	2M15	Yes	Yes	Quarterly
Peel strength after solvent vapour	2M06	Yes	Yes	Quarterly
Peel strength after simulated plating	2M16	Yes	No	
Pull-off strength	2M05	Yes	No	
Dimensional stability	2X02	Yes	Yes	Monthly
Flexural strength	2M20	Yes	Yes	Annually
Flammability	2C06	Yes	Yes	Monthly
Thermal stress, unetched	2C05	Yes	Yes	Lot
Solderability	2MXX[a]	Yes	No	
Glass transition temperature	2M10 and 2M11[a]	Yes	Yes	Monthly
Cure factor	2M03	Yes	Yes	Monthly
Permittivity at 1 MHz, as received	2E10	Yes	Yes	Monthly
Dissipation factor at 1 MHz, as received	2E10	Yes	Yes	Monthly
Surface resistance after damp heat/recovery	2E03	Yes	Yes	Annually
Volume resistance after damp heat/recovery	2E04	Yes	Yes	Annually
Arc resistance	2E14	Yes	Yes	Annually
Dielectric breakdown	2E15	Yes	Yes	Quarterly
Electric strength	2E11	Yes	Yes	Quarterly
Water absorption	2N02	Yes	Yes	Quarterly
Bow and twist	2M01	Yes	Yes	Lot
Surface waviness	2M12	Yes	No	
Appearance of the dielectric base material	See Clause B.2	Yes	Yes	Lot

[a] Test methods 2MXX and 2M11 are not included in IEC 61189-2:2006. Consult a more recent edition of this International Standard as soon as it will be available.

B.2 Appearance of the dielectric base material

An etched specimen shall be inspected to verify that no surface or subsurface imperfections of the dielectric material exceed those given below. The panels shall be inspected using an optical aid apparatus which provides a minimum magnification of 4×.

Referee inspection shall be conducted at 10× magnification. Lighting conditions of inspection shall be appropriate to the material under inspection or as agreed upon between user and supplier.

Surface and subsurface imperfections (such as weave texture, resin starvation, voids, and foreign inclusions) shall be acceptable provided that the imperfections meet the following:

- the reinforcement fibres are not cut or exposed;

- the foreign inclusions are not conductive;
- the imperfections do not propagate as a result of thermal stress;
- the foreign inclusions are translucent;
- opaque foreign fibres are less than 15 mm in length, and an average number of no more than 1,0 per 300 mm × 300 mm area;
- opaque foreign inclusions other than fibres shall not exceed 0,50 mm. Opaque foreign inclusions less than 0,15 mm shall not be counted. The number of opaque foreign inclusions between 0,50 mm and 0,15 mm shall average no more than two spots per 300 mm × 300 mm area;
- voids (sealed voids or surface voids) have a longest dimension of less than 0,075 mm and there should not be more than three voids in a 3,5 mm diameter circle.

Annex C
(informative)

Operating characteristics curves and values

The following tables and graphs show the operating curves for single sampling plans with an acceptance number equal to zero. The sample size is indicated in each of the tables and relates to the following characteristics based on lot size submitted for inspection. These lot sizes are indicated in Table C.1.

Table C.1 – Lot sizes

a) Lot size 2 to 8	h) Lot size 281 to 500
b) Lot size 9 to 15	j) Lot size 501 to 1 200
c) Lot size 16 to 25	k) Lot size 1 201 to 3 200
d) Lot size 26 to 50	l) Lot size 3 201 to 10 000
e) Lot size 51 to 90	m) Lot size 10 001 to 35 000
f) Lot size 91 to 150	n) Lot size 35 001 to 150 000
g) Lot size 151 to 280	p) Lot size 150 001 to 500 000

In some instances, special sampling plan tables are desired for small lots when the associated AQL is 1,5 and below. Above 1,5 the main c = 0 tables are best used for small lot sizes. Any sampling plans developed for use with associated AQL less than 0,25 would generally not be valid.

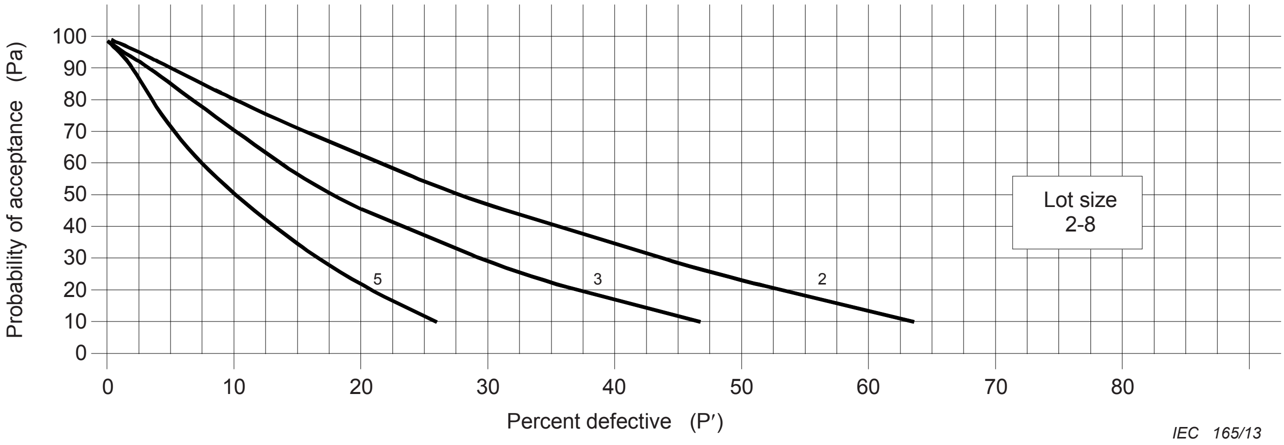
The LTPD for small lot sizes is targeted for the largest lot size range in which a constant sample size appears. For example (referring to a c = 0 table), for tables associated with an AQL of 1,0; 13 are used at the 91 to 150 lot size range for 0,65; 20 are used in the 151 to 280 range. In other words, the smaller lots shown in Table C.2 have essentially the same LTPD as the targeted LTPD.

Figures C.1 to C.14 show the acceptance characteristics and probability for various sample sizes.

Table C.2 – Small lot characteristics

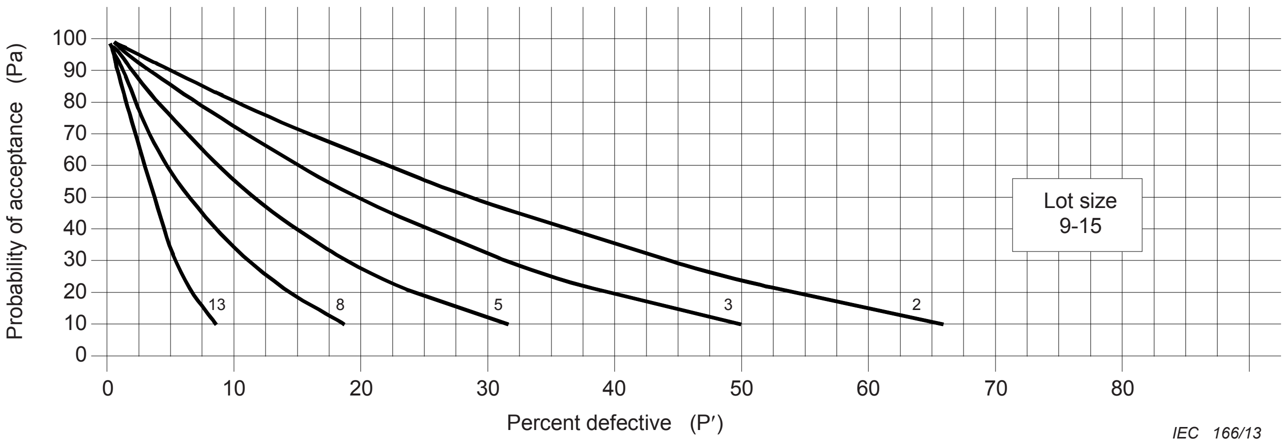
Lot size	0,25	0,4	0,65	1,0	1,5
5 to 10	[a]	[a]	[a]	8	5
11 to 15	[a]	[a]	11	8	5
16 to 20	[a]	16	12	9	6
21 to 25	22	17	13	10	6
26 to 30	25	17	13	10	6
31 to 35	28	23	18	12	8

[a] The entire lot size.



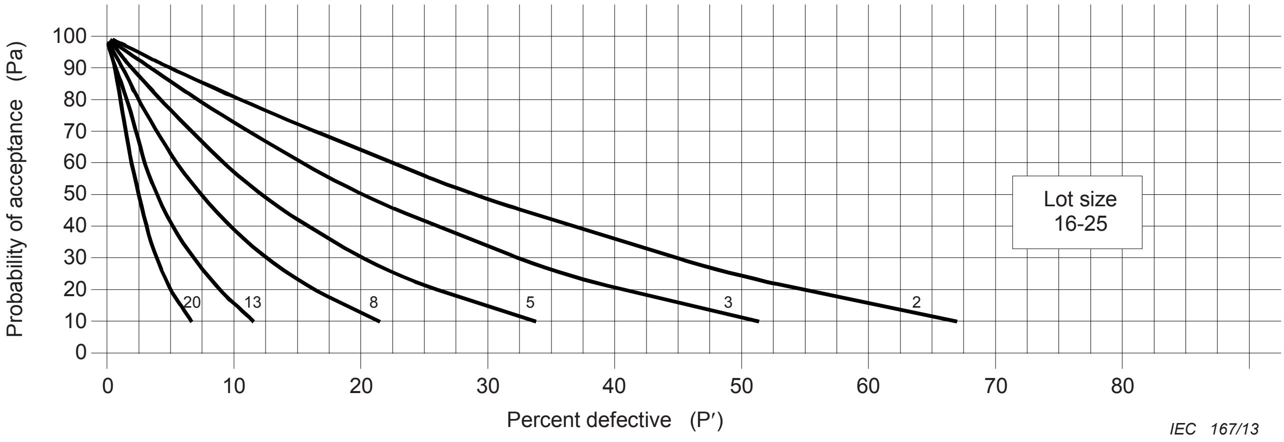
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
2	63,7	46,9	27,5	12,5	5,00	2,50	0,50
3	46,7	32,5	18,3	8,33	3,33	1,67	0,33
5	26,0	18,3	10,0	5,00	2,00	1,00	0,20

Figure C.1 – Lot size 2 to 8



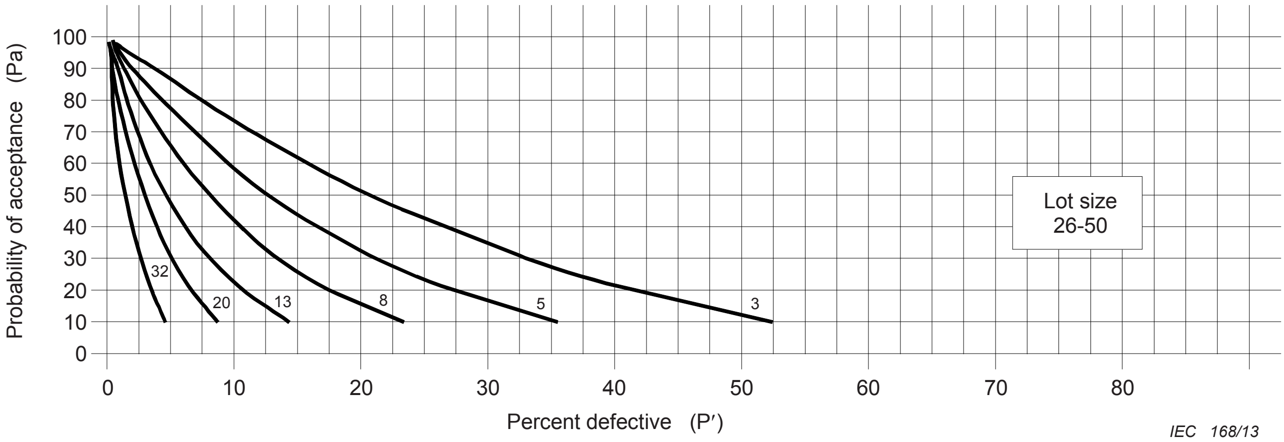
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
2	66,0	48,3	28,3	12,9	5,00	2,50	0,50
3	50,0	34,5	19,2	8,61	3,33	1,67	0,33
5	31,8	20,8	11,3	5,00	2,00	1,00	0,20
8	18,7	12,1	6,25	3,13	1,25	0,62	0,12
13	8,46	5,77	3,85	1,92	0,76	0,38	0,07

Figure C.2 – Lot size 9 to 15



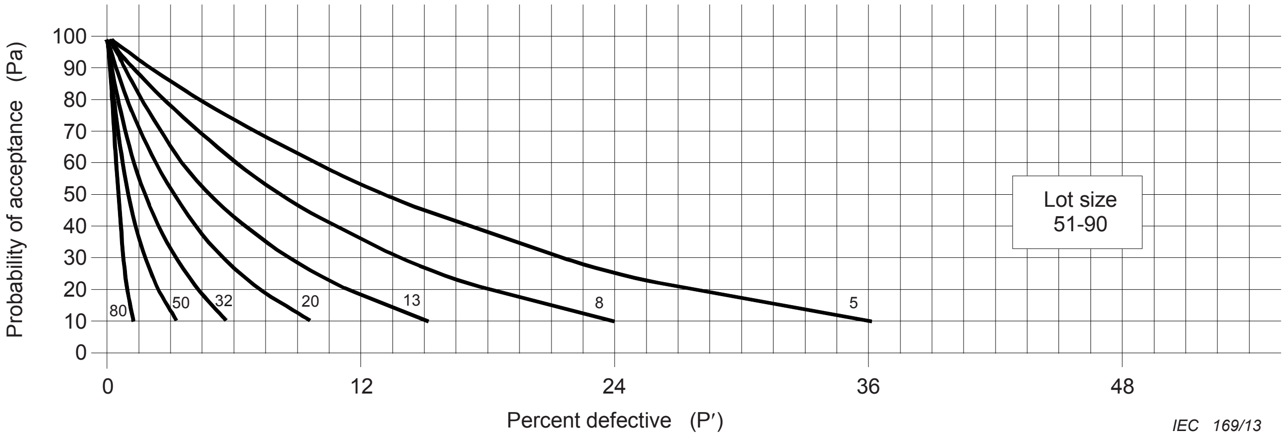
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
2	67,0	49,0	28,7	13,1	5,04	2,50	0,50
3	51,4	35,5	19,8	8,80	3,33	1,67	0,33
5	33,9	22,3	11,9	5,20	2,00	1,00	0,20
8	21,4	13,7	7,18	3,13	1,25	0,62	0,12
13	11,9	7,54	3,85	1,92	0,76	0,38	0,07
20	6,40	3,75	2,50	1,25	0,50	0,25	0,05

Figure C.3 – Lot size 16 to 25



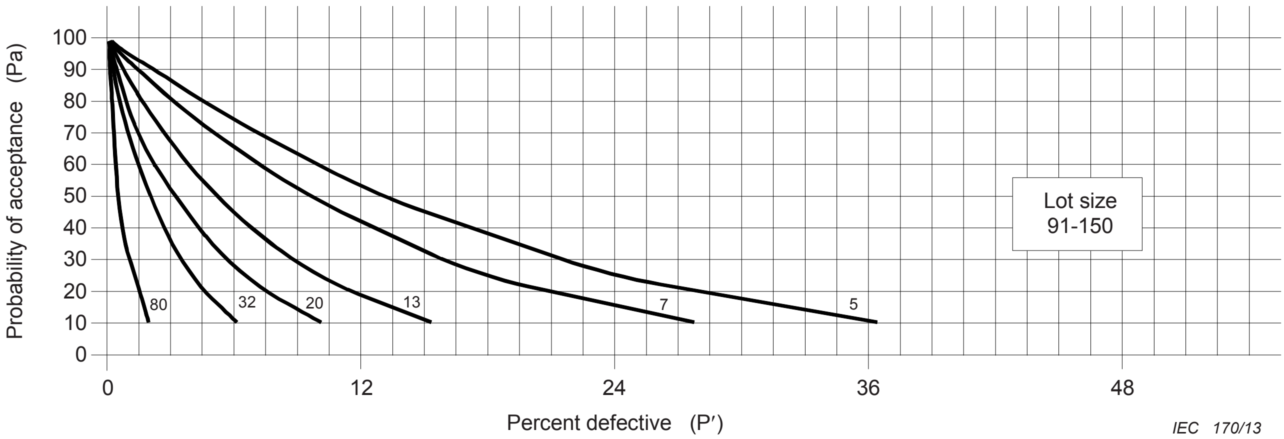
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
3	52,5	36,3	20,2	8,97	3,39	1,67	0,33
5	35,4	23,2	12,4	5,38	2,00	1,00	0,20
8	23,2	14,8	7,72	3,31	1,25	0,62	0,12
13	14,2	8,91	4,59	1,92	0,75	0,38	0,07
20	8,73	5,42	2,82	1,25	0,50	0,25	0,05
32	4,60	2,94	1,56	0,78	0,31	0,15	0,03

Figure C.4 – Lot size 26 to 50



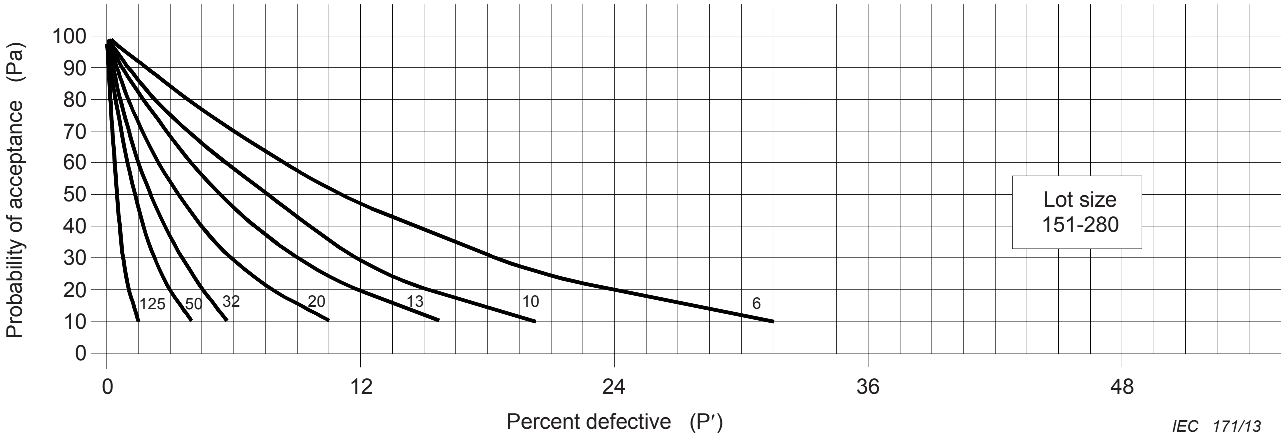
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
5	36,1	23,7	12,7	5,47	2,04	1,00	0,19
8	24,0	15,3	7,98	3,39	1,26	0,62	0,12
13	15,1	9,44	4,86	2,05	0,76	0,38	0,07
20	9,70	5,99	3,06	1,29	0,49	0,25	0,50
32	5,68	3,48	1,80	0,78	0,31	0,15	0,03
50	3,17	1,98	1,00	0,50	0,20	0,10	0,02
80	1,23	0,93	0,62	0,31	0,12	0,06	0,01

Figure C.5 – Lot size 51 to 90



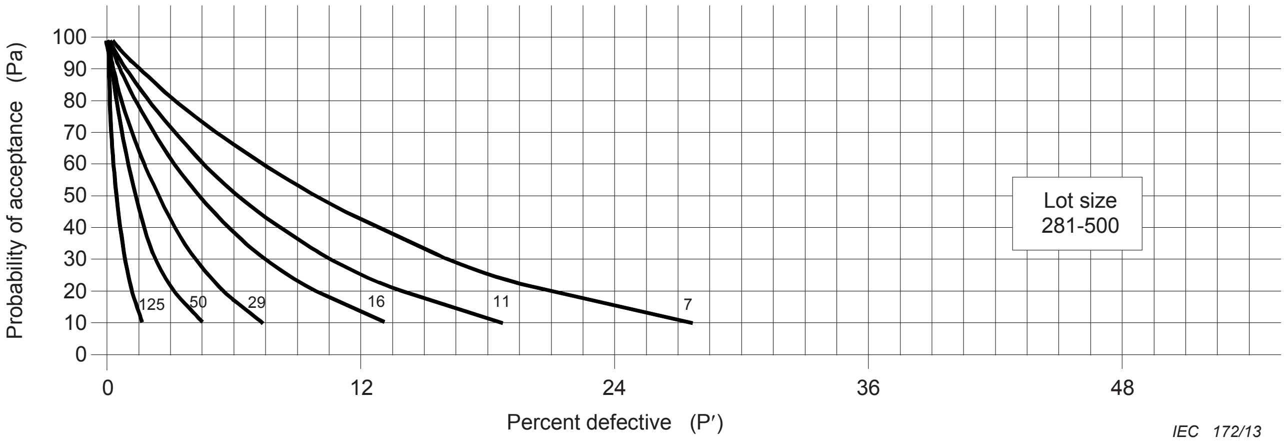
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
5	36,4	23,9	12,8	5,52	2,06	1,01	0,19
7	27,5	17,6	9,24	3,95	1,47	0,71	0,14
13	15,6	9,71	4,99	2,10	0,77	0,38	0,07
20	10,2	6,27	3,19	1,34	0,49	0,24	0,05
32	6,21	3,80	1,92	0,81	0,31	0,15	0,03
80	2,0	1,24	0,62	0,31	0,12	0,06	0,01

Figure C.6 – Lot size 91 to 150



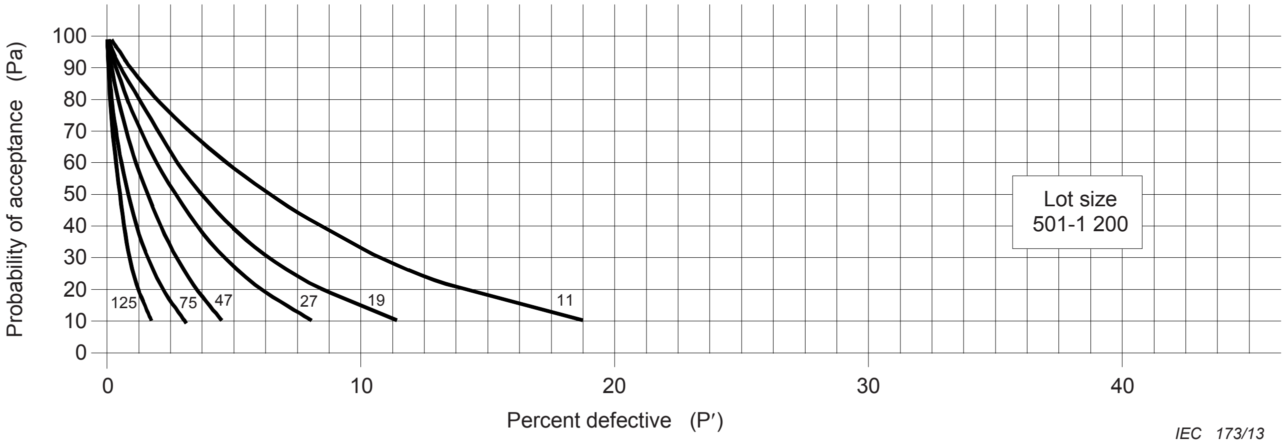
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
6	31,6	20,4	10,8	4,64	1,72	0,84	0,16
10	20,2	12,7	6,59	2,79	1,03	0,50	0,09
13	15,9	9,90	5,08	2,14	0,79	0,38	0,07
20	10,5	6,47	3,29	1,38	0,51	0,24	0,05
32	6,55	4,00	2,03	0,84	0,31	0,15	0,03
50	4,10	2,49	1,26	0,53	0,19	0,09	0,02
125	1,39	0,85	0,43	0,20	0,08	0,04	0,00

Figure C.7 – Lot size 151 to 280



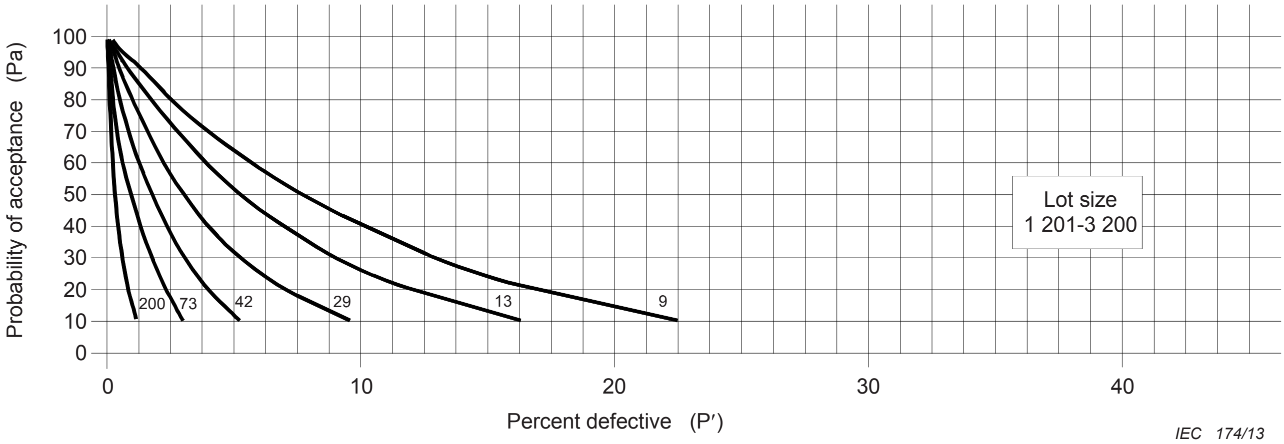
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
7	27,8	17,8	9,36	4,00	1,48	0,72	0,14
11	18,7	11,7	6,04	2,55	0,94	0,46	0,09
16	13,2	8,17	4,17	1,76	0,64	0,31	0,06
29	7,41	4,54	2,30	0,95	0,35	0,17	0,03
50	4,28	2,60	1,31	0,54	0,20	0,10	0,02
125	1,59	0,96	0,48	0,20	0,08	0,04	0,00

Figure C.8 – Lot size 281 to 500



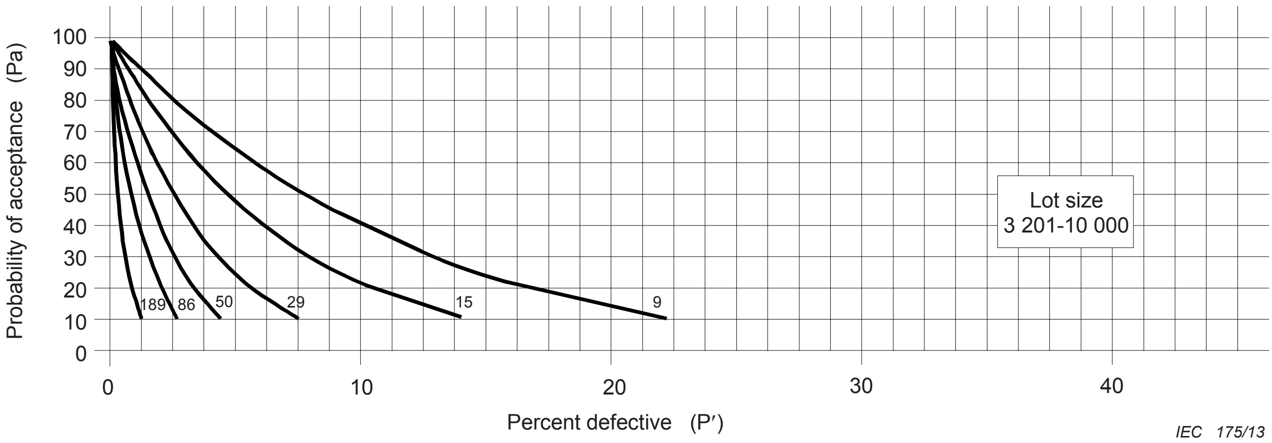
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
11	18,8	11,8	6,07	2,57	0,94	0,46	0,09
19	11,3	6,98	3,55	1,49	0,54	0,26	0,05
27	8,08	4,95	2,51	1,05	0,38	0,18	0,03
47	4,69	2,85	1,44	0,59	0,21	0,10	0,02
75	2,93	1,77	0,89	0,37	0,13	0,06	0,01
125	1,73	1,05	0,52	0,21	0,07	0,03	0,00

Figure C.9 – Lot size 501 to 1 200



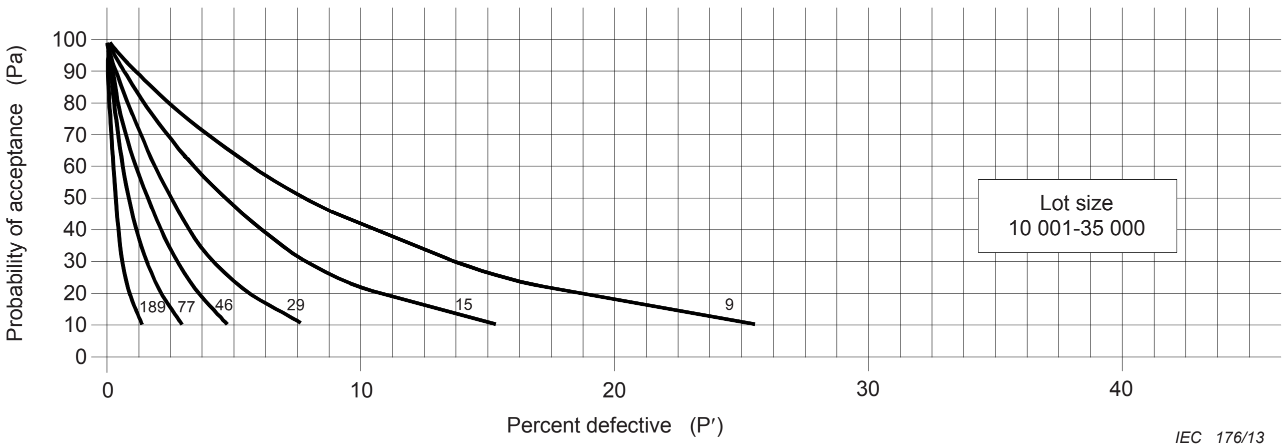
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
9	22,4	14,2	7,37	3,13	1,16	0,56	0,11
13	16,1	10,1	5,17	2,18	0,80	0,39	0,07
23	9,46	5,82	2,95	1,24	0,45	0,22	0,04
42	5,29	3,22	1,62	0,67	0,24	0,12	0,02
73	3,07	1,86	0,93	0,38	0,14	0,06	0,01
200	1,11	0,66	0,33	0,13	0,05	0,02	0,00

Figure C.10 – Lot size 1 201 to 3 200



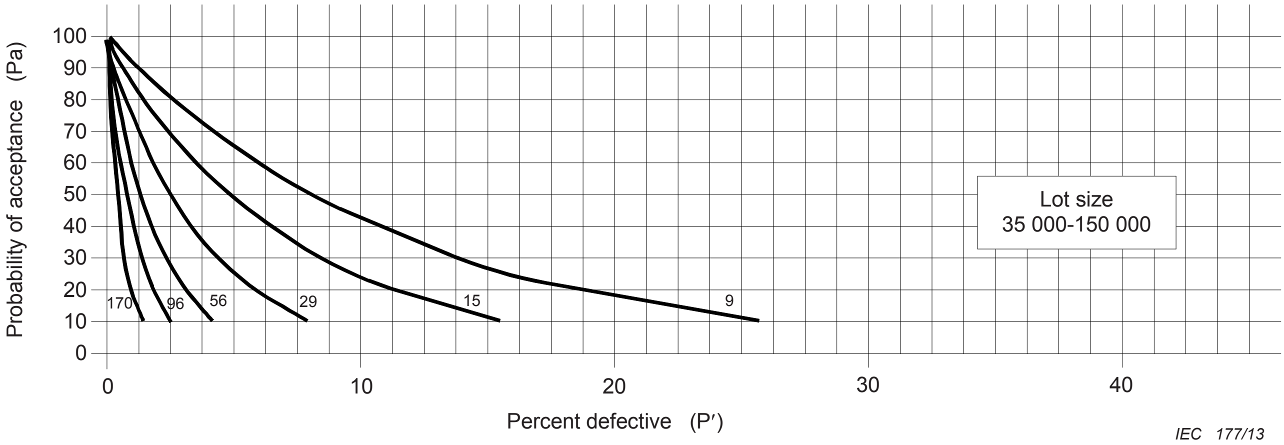
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
9	22,1	14,1	7,32	3,11	1,15	0,56	0,11
15	14,0	8,74	4,48	1,88	0,69	0,33	0,06
29	7,56	4,64	2,35	0,98	0,36	0,17	0,03
50	4,47	2,72	1,37	0,57	0,20	0,10	0,02
86	2,62	1,59	0,79	0,33	0,12	0,05	0,01
189	1,20	0,72	0,36	0,15	0,05	0,02	0,00

Figure C.11 – Lot size 3 201 to 10 000



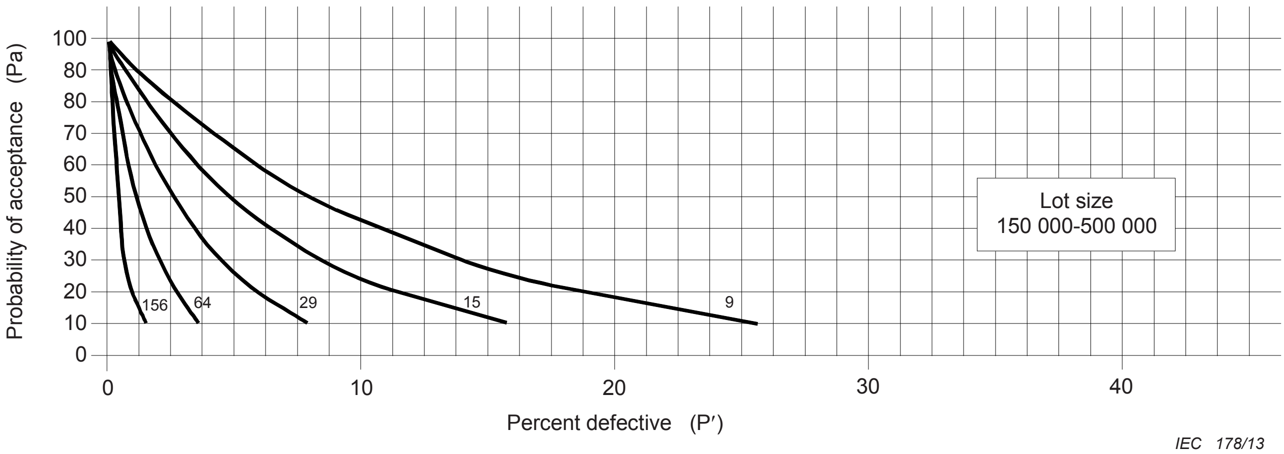
Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
9	25,6	15,4	7,38	3,02	1,14	0,55	0,10
15	15,4	8,54	4,40	1,85	0,68	0,33	0,06
29	7,61	4,58	2,33	0,97	0,35	0,17	0,03
46	4,80	2,93	1,48	0,61	0,22	0,11	0,02
77	2,91	1,77	0,89	0,37	0,13	0,06	0,01
189	1,20	0,72	0,36	0,15	0,05	0,02	0,00

Figure C.12 – Lot size 10 001 to 35 000



Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
9	25,6	15,4	7,70	3,20	1,14	0,55	0,10
15	15,4	9,24	4,62	1,92	0,69	0,33	0,06
29	7,94	4,78	2,39	0,98	0,36	0,17	0,03
56	4,11	2,48	1,24	0,51	0,18	0,09	0,01
96	2,40	1,44	0,71	0,29	0,10	0,05	0,01
170	1,35	0,81	0,40	0,16	0,06	0,03	0,00

Figure C.13 – Lot size 35 000 to 150 000



Sample size	Probability of acceptance						
	0,10	**0,25**	**0,50**	**0,75**	**0,90**	**0,95**	**0,99**
9	25,6	15,4	7,70	3,20	1,08	0,52	0,10
15	15,4	9,24	4,62	1,92	0,66	0,32	0,06
29	7,94	4,78	2,39	0,99	0,35	0,17	0,03
64	3,60	2,17	1,07	0,44	0,10	0,07	0,01
156	1,48	0,88	0,44	0,18	0,06	0,03	0,00

Figure C.14 – Lot size 150 001 to 500 000

Bibliography

Cited publications

NOTE These publications are referenced in informative Annexes A to C.

IEC 60068-2-3, *Basic environmental testing procedures – Part 2: Tests – Test Ca: Damp heat, steady state*[2]

IEC 60068-2-20, *Environmental testing – Part 2-20: Tests – Test T: Test method for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-38, *Environmental testing – Part 2-38: Tests – Test Z/AD: Composite temperature/ humidity cyclic test*

IEC 61188-6,— *Printed board and printed board assemblies – Design and use – Part 6: Design for manufacturing technology to achieve reliable product descriptions*[3]

IEC 61189-2, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 2: Test methods for materials for interconnection structures EN only*

IEC 61189-3, *Test methods for electrical materials, printed boards and other interconnection tructures and assemblies – Part 3: Test methods for interconnection structures (printed boards) EN only*

IEC 61193-1, *Quality assessment systems – Part 1: Registration and analysis of defects on printed board assemblies*

IEC 61193-2, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

IEC 61193-4,— *Quality assessment systems – Part 4: Selection and use of sampling plans for electronic modules and assemblies and end-products and in-process autiding* [4]

IEC 61249-2-34:2009, *Materials for printed boards and other interconnecting structures – Part 2-34: Reinforced base materials, clad and unclad – Non-halogenated modified or unmodified resin system, woven E-glass laminate sheets of defined relative permittivity (equal to or less than 3,7 at 1 GHz) and flammability (vertical burning test), copper-clad*

IEC 62326-1, *Printed boards – Part 1: Generic specification*

IEC 62326-4-1, *Printed boards – Part 4: Rigid multilayer printed boards with interlayer connections – Sectional specification – Section 1: Capability Detail Specification – Performance levels A, B and C*

ISO 11014, *Safety data sheet for chemical products – Content and order of sections*

ISO 14001, *Environmental management systems – Requirements with guidance for use*

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[2] Withdrawn.

[3] Under consideration.

[4] Under cosideration.

Other references

NOTE The following list of extant ISO standards on acceptance sampling is provided for information.

ISO 2859-1, *Sampling procedures for inspection by attributes – Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection*

ISO 2859-2, *Sampling procedures for inspection by attributes – Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection*

ISO 2859-3, *Sampling procedures for inspection by attributes – Part 3: Skip-lot sampling procedures*

ISO 2859-4, *Sampling procedures for inspection by attributes – Part 4: Declared quality levels*

ISO 2859-5, *Sampling procedures for inspection by attributes – Part 5: System of sequential sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 2859-10, *Sampling procedures for inspection by attributes – Part 10: Introduction to the ISO 2859 series of standards for sampling for inspection by attributes*

ISO 3951-1, *Sampling procedures for inspection by variables – Part 1: Specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection for a single quality characteristic and a single AQL*

ISO 3951-2, *Sampling procedures for inspection by variables – Part 2: General specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection of independent quality characteristics*

ISO 3951-3, *Sampling procedures for inspection by variables – Part 3: Double sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3951-5, *Sampling procedures for inspection by variables – Part 5: Sequential sampling plans indexed by acceptance quality limit (AQL) for inspection by variables (known standard deviation)*

ISO 8422, *Sequential sampling plans for inspection by attributes*

ISO 8423, *Sequential sampling plans for inspection by variables for percent nonconforming (known standard deviation)*

ISO 13448-1, *Acceptance sampling procedures based on the allocation of priorities principle (APP) – Part 1: Guidelines for the APP approach*

ISO 13448-2, *Acceptance sampling procedures based on the allocation of priorities principle (APP) – Part 2: Coordinated single sampling plans for acceptance sampling by attributes*

ISO 14560, *Acceptance sampling procedures by attributes – Specified quality levels in non-conforming items per million*

ISO 18414, *Acceptance sampling procedures by attributes – Accept-zero sampling system based on credit principle for controlling outgoing quality*

ISO 21247, *Combined accept-zero sampling systems and process control procedures for product acceptance*

ISO 24153, *Random sampling and randomization procedures*

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