

# INTERNATIONAL STANDARD



---

**Printed board assemblies –  
Part 2: Sectional specification – Requirements for surface mount soldered  
assemblies**





## **THIS PUBLICATION IS COPYRIGHT PROTECTED**

**Copyright © 2017 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### **About the IEC**

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### **About IEC publications**

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

#### **IEC Catalogue - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)**

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

#### **IEC publications search - [www.iec.ch/searchpub](http://www.iec.ch/searchpub)**

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

#### **IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)**

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

#### **Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### **IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)**

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

#### **IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)**

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [csc@iec.ch](mailto:csc@iec.ch).



# INTERNATIONAL STANDARD



---

**Printed board assemblies –  
Part 2: Sectional specification – Requirements for surface mount soldered  
assemblies**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 31.190; 31.240

ISBN 978-2-8322-4322-0

**Warning! Make sure that you obtained this publication from an authorized distributor.**



## CONTENTS

FOREWORD.....	5
1 Scope .....	7
2 Normative references .....	7
3 Terms and definitions .....	7
4 General requirements .....	7
5 Surface mounting of components.....	7
5.1 General.....	7
5.2 Alignment requirements .....	8
5.3 Process control .....	8
5.4 Surface mounted component requirements .....	8
5.5 Flatpack lead forming.....	8
5.5.1 General .....	8
5.5.2 Surface mounted device lead bends .....	8
5.5.3 Surface mounted device lead deformation .....	9
5.5.4 Flattened leads.....	9
5.5.5 Dual-in-line packages (DIPs) .....	9
5.5.6 Parts not configured for surface mounting.....	9
5.6 Small devices with two terminations .....	9
5.6.1 General .....	9
5.6.2 Stack mounting.....	9
5.6.3 Devices with external deposited elements.....	9
5.7 Lead component body positioning .....	10
5.7.1 General .....	10
5.7.2 Axial-leaded components.....	10
5.7.3 Other components .....	10
5.8 Parts configured for butt lead mounting.....	10
5.9 Non-conductive adhesive coverage limits.....	10
6 Acceptance requirements .....	10
6.1 General.....	10
6.2 Control and corrective actions.....	10
6.3 Surface soldering of leads and terminations.....	11
6.3.1 General .....	11
6.3.2 Solder fillet height and heel fillets .....	11
6.3.3 Flat ribbon L and gull-wing leads .....	12
6.3.4 Round or flattened (coined) leads .....	13
6.3.5 J leads.....	14
6.3.6 Rectangular or square end component .....	15
6.3.7 Cylindrical end-cap terminations .....	16
6.3.8 Bottom only terminations .....	17
6.3.9 Castellated terminations .....	18
6.3.10 Butt joints .....	19
6.3.11 Inward L-shaped ribbon leads.....	20
6.3.12 Flat lug leads.....	21
6.3.13 Ball grid array.....	22
6.3.14 Column grid array .....	23
6.3.15 Bottom termination components.....	24



6.3.16	Components with bottom thermal plane terminations (D-Pak) .....	24
6.3.17	P-style terminations .....	26
6.4	General post-soldering requirements applicable to all surface-mounted assemblies.....	26
6.4.1	Dewetting .....	26
6.4.2	Leaching.....	26
6.4.3	Pits, voids, blowholes, and cavities.....	26
6.4.4	Solder wicking .....	27
6.4.5	Solder webs and skins .....	27
6.4.6	Bridging .....	27
6.4.7	Degradation of marking .....	27
6.4.8	Solder spikes.....	27
6.4.9	Disturbed joint .....	27
6.4.10	Component damage.....	27
6.4.11	Open circuit, non-wetting .....	27
6.4.12	Component tilting.....	27
6.4.13	Non-conducting adhesive encroachment.....	28
6.4.14	Open circuit, no solder available .....	28
6.4.15	Component on edge .....	28
7	Rework and repair .....	28
Annex A (normative)	Placement requirements for surface mounted devices .....	30
A.1	General.....	30
A.2	Component positioning .....	30
A.3	Small devices incorporating two terminations.....	30
A.3.1	Metallization coverage over the land (side-to-side) .....	30
A.3.2	Metallization coverage over the land (end).....	30
A.4	Mounting of cylindrical end-cap devices (MELFs).....	30
A.5	Registration of castellated chip carriers .....	30
A.6	Surface mounted device lead and land contact .....	30
A.7	Surface mounted device lead side overhang .....	30
A.8	Surface mounted device lead toe overhang.....	31
A.9	Surface mounted device lead height off land (prior to soldering) .....	31
A.10	Positioning of J lead devices.....	31
A.11	Positioning gull-wing lead devices.....	31
A.12	External connections to packaging and interconnect structures.....	31
Bibliography	.....	32
Figure 1	– Lead formation for surface mounted device .....	8
Figure 2	– Fillet height .....	12
Figure 3	– Flat ribbon and gull-wing leads.....	13
Figure 4	– Round or flattened (coined) lead joint.....	14
Figure 5	– J lead joint .....	15
Figure 6	– Rectangular or square end components .....	16
Figure 7	– Cylindrical end-cap terminations .....	17
Figure 8	– Bottom only terminations.....	18
Figure 9	– Leadless chip carriers with castellated terminations .....	19
Figure 10	– Butt joints.....	20



Figure 11 – Inward L-shaped ribbon leads .....	21
Figure 12 – Flat lug leads .....	22
Figure 13 – BGA with collapsing balls .....	23
Figure 14 – Bottom termination components .....	24
Figure 15 – Bottom thermal plane terminations .....	25
Figure 16 – P-style terminations .....	26
Table 1 – BGA with non-collapsing balls .....	23
Table 2 – Column grid array.....	23
Table 3 – Reworkable defects .....	29



## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**PRINTED BOARD ASSEMBLIES –****Part 2: Sectional specification –  
Requirements for surface mount soldered assemblies****FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61191-2 has been prepared by IEC technical committee 91: Electronics assembly technology.

This third edition cancels and replaces the second edition published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) the requirements have been updated to be compliant with the acceptance criteria in IPC-A-610F;
- b) some of the terminology used in the document has been updated;
- c) references to IEC standards have been corrected;
- d) five termination styles have been added.



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

CDV	Report on voting
91/1386/CDV	91/1429/RVC

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

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

A list of all parts of IEC 61191 under the general title *Printed board assemblies* can be found in the IEC website.

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

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

A bilingual version of this publication may be issued at a later date.

**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.**



## PRINTED BOARD ASSEMBLIES –

### Part 2: Sectional specification – Requirements for surface mount soldered assemblies

#### 1 Scope

This part of IEC 61191 gives the requirements for surface mount solder connections. The requirements pertain to those assemblies that are totally surface mounted or to the surface mounted portions of those assemblies that include other related technologies (e.g. through-hole, chip mounting, terminal mounting, etc.).

#### 2 Normative references

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

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

IEC 61191-1, *Printed board assemblies – Part 1: Generic specification – Requirements for soldered electrical and electronic assemblies using surface mount and related assembly technologies*

IPC-A-610, *Acceptability of Electronic Assemblies*

#### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60194 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

#### 4 General requirements

The requirements of IEC 61191-1 are a mandatory part of this specification.

Workmanship shall meet the requirements of IPC-A-610 in accordance with the classification requirements of this document.

#### 5 Surface mounting of components

##### 5.1 General

This clause covers assembly of components that are placed on the surface to be manually or machine soldered and includes components designed for surface mounting as well as through-hole components that have been adapted for surface mounting technology.



## 5.2 Alignment requirements

Sufficient process control at all stages of design and assembly shall be in place to enable the post-soldering alignments and solder joint fillet controls specified in 6.3 to be achieved.

Relevant factors affecting the requirements include land and conductor design, component proximities, component and land solderability, solder paste/adhesive quantity and alignment and component placement accuracy.

## 5.3 Process control

If suitable process controls are not in place to ensure compliance with 5.2 and the intent of Annex A, the detailed requirements of Annex A shall be mandatory.

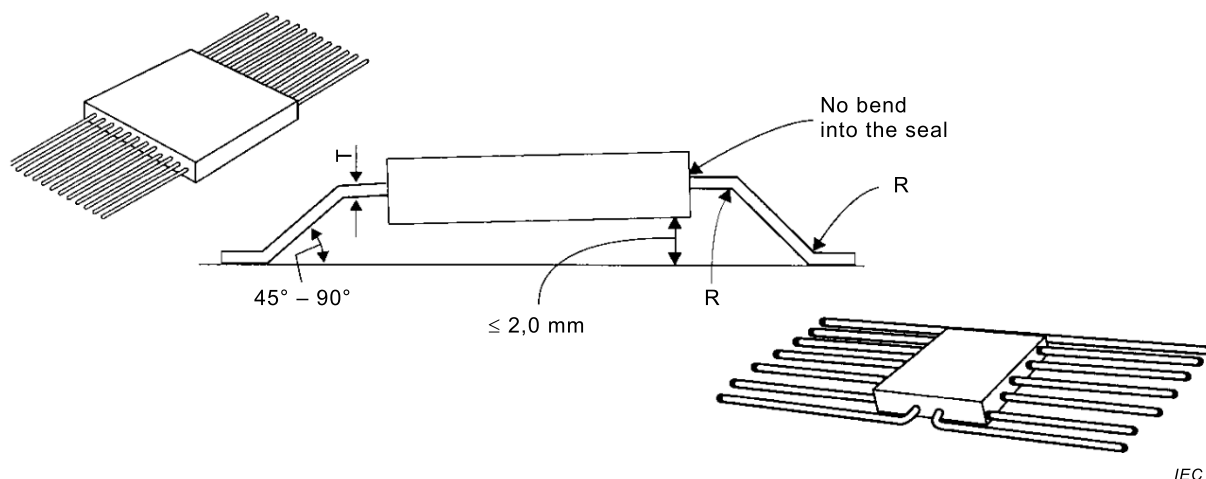
## 5.4 Surface mounted component requirements

The leads of lead surface mounted components shall be formed to their final configuration prior to mounting. Leads shall be formed in such a manner that the lead-to-body seal is not damaged or degraded and that they may be soldered into place by subsequent processes which do not result in residual stresses decreasing reliability. When the leads of dual-in-line packages, flatpacks, and other multilead devices become misaligned during processing or handling, they may be straightened to ensure parallelism and alignment prior to mounting, while maintaining the lead-to-body seal integrity.

## 5.5 Flatpack lead forming

### 5.5.1 General

Leads on opposite sides of surface mounted flatpacks shall be formed such that the non-parallelism between the base surface of the component and the surface of the printed board (i.e. component cant) is minimal. Component cant is permissible provided the final configuration does not exceed the maximum spacing limit of 2,0 mm (see Figure 1).



#### Key

- R lead-bend radius
- T nominal lead thickness

**Figure 1 – Lead formation for surface mounted device**

### 5.5.2 Surface mounted device lead bends

Leads shall be supported during forming to protect the lead-to-body seal. Bends shall not extend into the seal (see Figure 1). The lead-bend radius (R) shall be  $> 1 T$  (T = nominal lead



thickness). The angle of that part of the lead between the upper and lower bends in relation to the mounting land shall be 45° minimum and 90° maximum.

### **5.5.3 Surface mounted device lead deformation**

Lead deformation (unintentional bending) may be allowed when

- a) no evidence of a short circuit or potential short circuit exists,
- b) lead-to-body seal or weld is not damaged by the deformation,
- c) does not violate minimum electrical spacing requirement,
- d) top of lead does not extend beyond the top of body; preformed stress loops may extend above the top of the body; however, stand-off height limit shall not be exceeded,
- e) toe curl, if present on bends, shall not exceed two times the thickness of the lead (2 T),
- f) coplanarity limits are not exceeded.

### **5.5.4 Flattened leads**

Components with axial leads of round cross-section may be flattened (coined) for positive seating in surface mounting. If flattening is used, the flattened thickness shall be not less than 40 % of the original diameter. Flattened areas of leads shall be excluded from the 10 % deformation requirement in 6.5.3 of IEC 61191-1:2013.

Flattened leads on opposite sides of a surface mount part shall be formed such that the non-parallelism between the base surface of the component and the surface of the printed board (e.g. component cant) is minimal.

### **5.5.5 Dual-in-line packages (DIPs)**

Dual-in-line packages may be surface mounted provided the leads are configured to meet the mounting requirements for surface mounted loaded parts. The lead preparation operation shall be performed using die forming/cutting systems. Hand forming and trimming of leads are prohibited.

### **5.5.6 Parts not configured for surface mounting**

Flatpacks of the through-hole configuration, transistors, metal power packages, and other non-axial lead components shall not be surface mounted unless the leads are formed to meet the surface mounted device lead forming requirements. Such applications shall be agreed on between user and manufacturer.

## **5.6 Small devices with two terminations**

### **5.6.1 General**

The detailed requirements for mounting of small devices with two lead terminations are defined in 5.6.2 and 5.6.3.

### **5.6.2 Stack mounting**

When part stacking is permitted by the assembly drawing, parts shall not bridge spacing between other parts or components such as terminals or other chip components.

### **5.6.3 Devices with external deposited elements**

Components with electrical elements deposited on an external surface (such as chip resistors) shall be mounted with that surface facing away from the printed board or substrate.



## **5.7 Lead component body positioning**

### **5.7.1 General**

Parts mounted over protected surfaces and insulated parts that are positioned over circuitry or parts mounted over surfaces without exposed circuitry may be flush mounted (i.e. no stand-off height). Parts mounted over exposed circuitry shall have their leads formed to provide a minimum of 0,25 mm between the bottom of the component body and the exposed circuitry. The maximum clearance between the bottom of the leaded component body and the printed wiring surface shall not exceed 2,0 mm.

### **5.7.2 Axial-leaded components**

The body of a surface-mounted axial-leaded component shall be spaced from the surface of the printed board at a maximum of 2,0 mm unless the component is mechanically attached to the substrate by adhesive or other means. Leads on opposite sides of surface mounted axial-leaded components shall be formed such that component cant (non-parallelism between the base surface of the mounted component and the surface of the printed board) is minimal and in no instance shall body cant result in non-conformance with maximum spacing limits.

### **5.7.3 Other components**

TO-can devices, tall profile components (i.e. over 15 mm), transformers, and metal power packages may be surface mounted provided the parts are bonded or otherwise secured to the board in a manner which enables the part to withstand the end-item shock, vibration and environmental stresses.

## **5.8 Parts configured for butt lead mounting**

Components designed for through hole (pin-in-hole) applications and modified for butt joint attachment, or stiff leaded dual-in-line packages may be butt mounted on level A and B products. Butt mounting is not permitted on level C products unless the component is designed for surface mounting. Components with solder-charged terminations designed for butt mounting may be acceptable for all classes. For other butt-mounted termination components acceptance criteria have to be agreed between the manufacturer and the user.

## **5.9 Non-conductive adhesive coverage limits**

Non-conductive adhesive materials, when used for component mounting, shall not flow onto, or obscure, areas to be soldered or into vias or plated-through holes.

## **6 Acceptance requirements**

### **6.1 General**

Materials, processes, and procedures described and specified in IEC 61191-1 provide for soldered interconnections that are better than the minimum surface mount acceptance requirements in this clause. Processes and their control should be capable of producing product meeting or exceeding the acceptance criteria for defined product levels.

### **6.2 Control and corrective actions**

The detailed requirements for acceptance, corrective action limits, control limit determination, and general assembly criteria described in IEC 61191-1 are a mandatory part of this standard. In addition 6.3 shall be met for all surface mount assembly and for connection acceptability.



### **6.3 Surface soldering of leads and terminations**

#### **6.3.1 General**

Solder joints or terminations on components designed for surface mounting shall exhibit solder joints that meet the general descriptions of Clause 10 of IEC 61191-1:2013 with the specific measurements defined in 6.3.3 to 6.3.17 of this document. Some surface-mounted components will self-align during reflow soldering but a degree of misalignment is permitted to the extent specified. However, minimum design conductor spacing shall not be violated.

In 6.3.3 to 6.3.17, certain joint features are unspecified in size and the only requirement is that a properly wetted fillet to both lead/termination and lands be visible. Geometric dimensions not called out with any requirements are considered non-critical to the performance of the interconnection.

Surface-mounted joints formed to connector, socket, and other leads or terminations without mechanical support, subjected to stress from insertion and withdrawal of components or printed boards, shall meet the requirements of level C.

#### **6.3.2 Solder fillet height and heel fillets**

##### **6.3.2.1 General**

The height  $F$  of solder fillets, including heel fillets, as required in the following subclauses shall be judged by the distance the applied solder has risen up the joined surface. Figure 2 illustrates this measurement for joints of equal height but having different solder volume. In 6.3.3 to 6.3.12, for some lead configurations, the minimum acceptable fillet height criterion is referenced to the lead thickness  $T$ , or one half the thickness ( $0,5 T$ ). When referenced to  $T$ , the height of the heel fillet to a formed lead shall be measured at the lowest point of the inside bend radius of the lead, as indicated by point A of Figure 2b (e.g. level C in Figures 3 to 5). When referenced to  $0,5 T$ , the fillet may be  $0,5 T$  lower (e.g. level B in Figures 3 to 5).

NOTE Subclause 6.3.3 provides an organization that combines the requirement paragraph, the appropriate figure and a dimensional table that describes the specific details.

##### **6.3.2.2 Solder connection contours**

A mounting technique shall be used to compensate for the coefficient of thermal expansion (CTE) mismatch of the part and board. This mounting technique shall be limited to part leads, specialized mounting devices, and normal solder connections. The use of specialized stand-offs mounted between the part and the land is permissible. Leadless components shall not be soldered into place using redundant interconnect wiring between the component castellation and the land.

Designs that use special solder connection contours as part of a CTE mismatch compensation system shall be identified on the approval assembly drawing. The mounting technique shall be capable of performing with a solder connection which meets the requirements of this document.

##### **6.3.2.3 Surface mount device lead heel position**

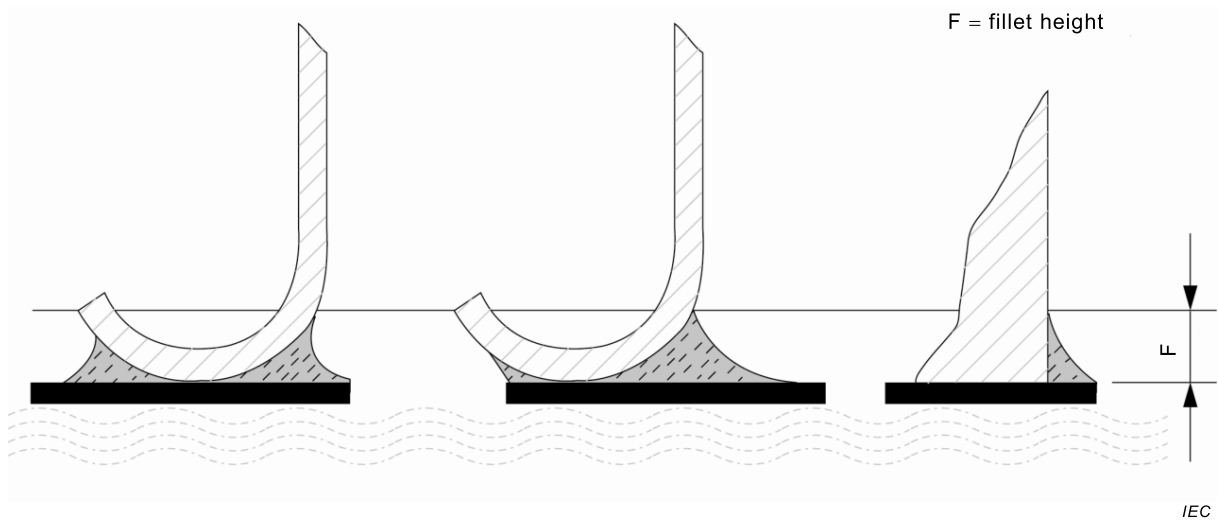
The heel of a leaded component shall not overhang the land.

NOTE The heel begins where the lead starts to curve at the lead bend.

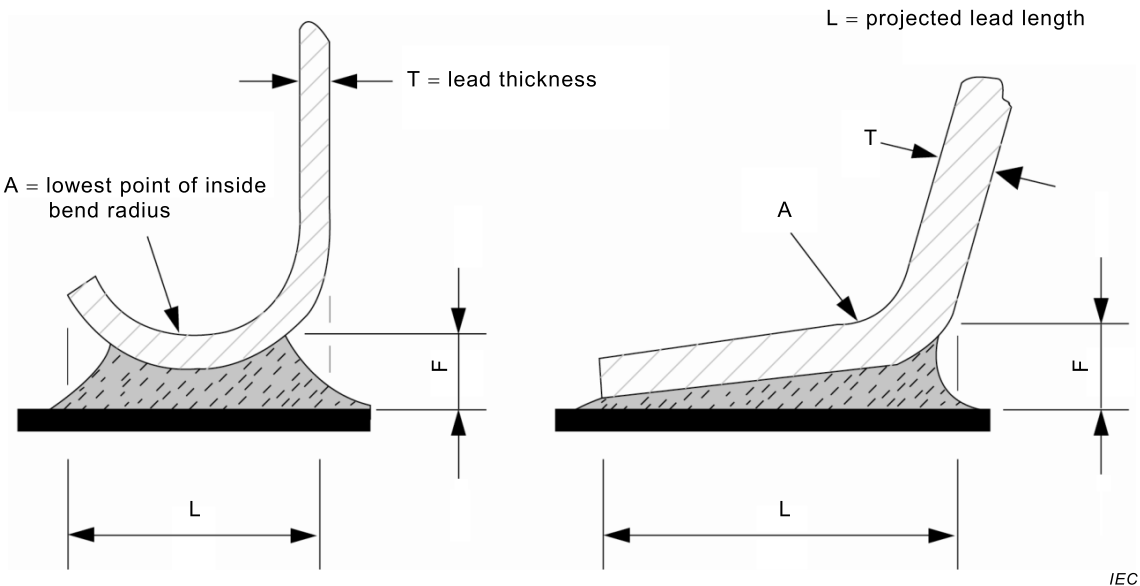
##### **6.3.2.4 Break-away tie bars**

Components (e.g. connectors and flexible circuits) which incorporate break-away tie bars in their design may be installed or soldered in place prior to removal of the tie bar. Exposed basis metal resulting from tie bar removal is permissible.





a) Fillet height



b) Fillet height referenced to lead thickness

**Key**

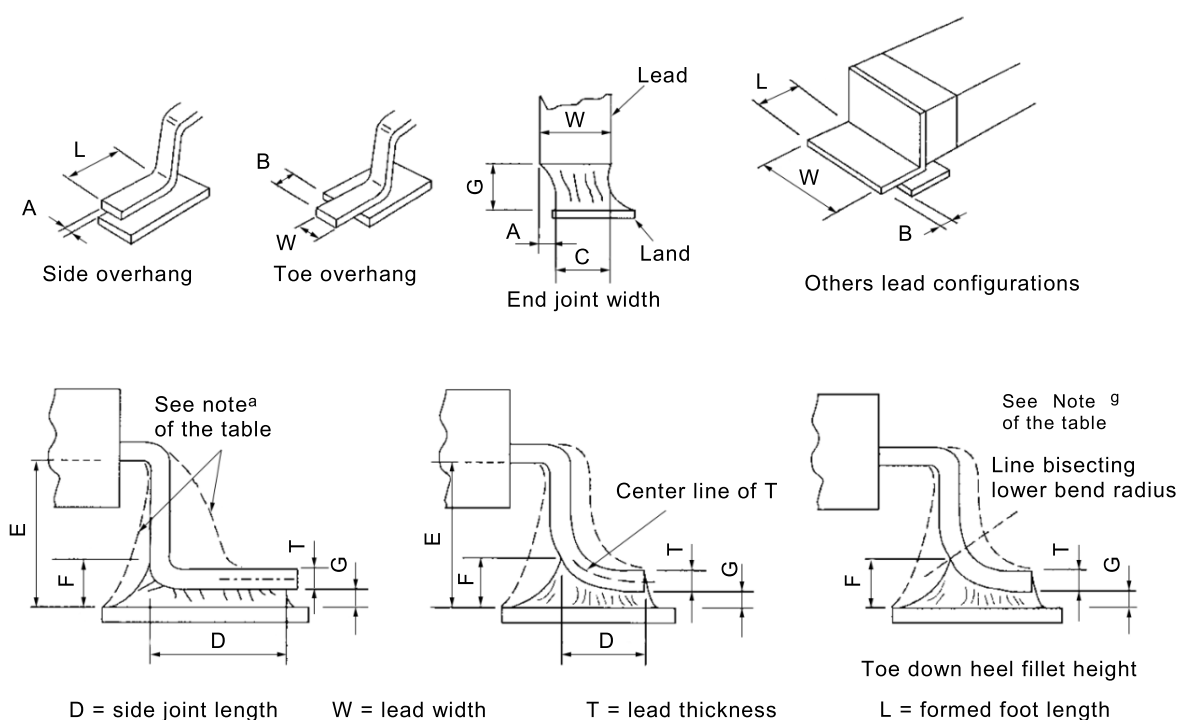
- A lowest point of inside bend radius
- F fillet height
- L projected lead length
- T lead thickness

**Figure 2 – Fillet height**

**6.3.3 Flat ribbon L and gull-wing leads**

Solder joints between substrate lands and flat ribbon leads formed into an L, and gull-wing shaped component leads of either stiff or flexible materials shall meet the alignment and solder fillet requirements of Figure 3 for each product level.





IEC

Dimensions in millimetres

Feature		Dimension	Level A	Level B	Level C
Maximum side overhang		A	$\frac{1}{2}W$ or 0,5 mm, <sup>d</sup> whichever is less	$\frac{1}{2}W$ or 0,5 mm, <sup>d</sup> whichever is less	$\frac{1}{4}W$ or 0,5 mm, <sup>d</sup> whichever is less
Maximum toe overhang		B	d	Not permitted when L < 3W <sup>d</sup>	Not permitted when L < 3W <sup>d</sup>
Minimum end joint width <sup>c</sup>		C	$\frac{1}{2}W$	$\frac{1}{2}W$	$\frac{3}{4}W$
Minimum side joint length <sup>b</sup>	When L ≥ 3W	D	W or 0,5mm, whichever is less	3W or $\frac{3}{4}L$ , whichever is longer	
	L				
When L < 3W					
Maximum heel fillet height		E	f		
Minimum heel fillet height	T ≤ 0,4 mm	F	e	G + T	G + T <sup>f</sup>
	T > 0,4 mm			G + $\frac{1}{2}T$	
Minimum solder thickness		G	e	e	e

<sup>a</sup> Solder fillets for levels A and B may extend through the top bend.

<sup>b</sup> Leads not having wettable sides or ends by design (such as leads stamped or sheared from prepared stock) are not required to have side or end fillets, but side overhang is not permitted (all levels).

<sup>c, d</sup> Shall not violate minimum design conductor spacing.

<sup>e</sup> Properly wetted fillet evident.

<sup>f</sup> Solder does not touch body or end seal.

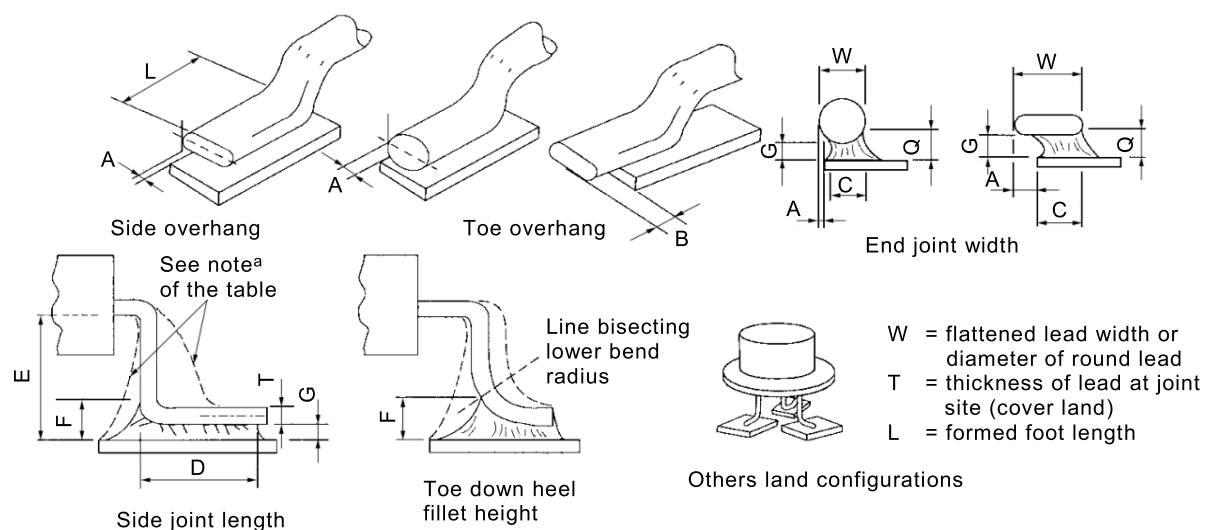
<sup>g</sup> In case of toe down configuration, minimum fillet height F extends at least to the mid-point of the outside lead bend.

**Figure 3 – Flat ribbon and gull-wing leads**

#### 6.3.4 Round or flattened (coined) leads

Joints formed to round or flattened (coined) leads shall meet the dimensional and fillet requirements of Figure 4 for each product level.





IEC

Dimensions in millimetres

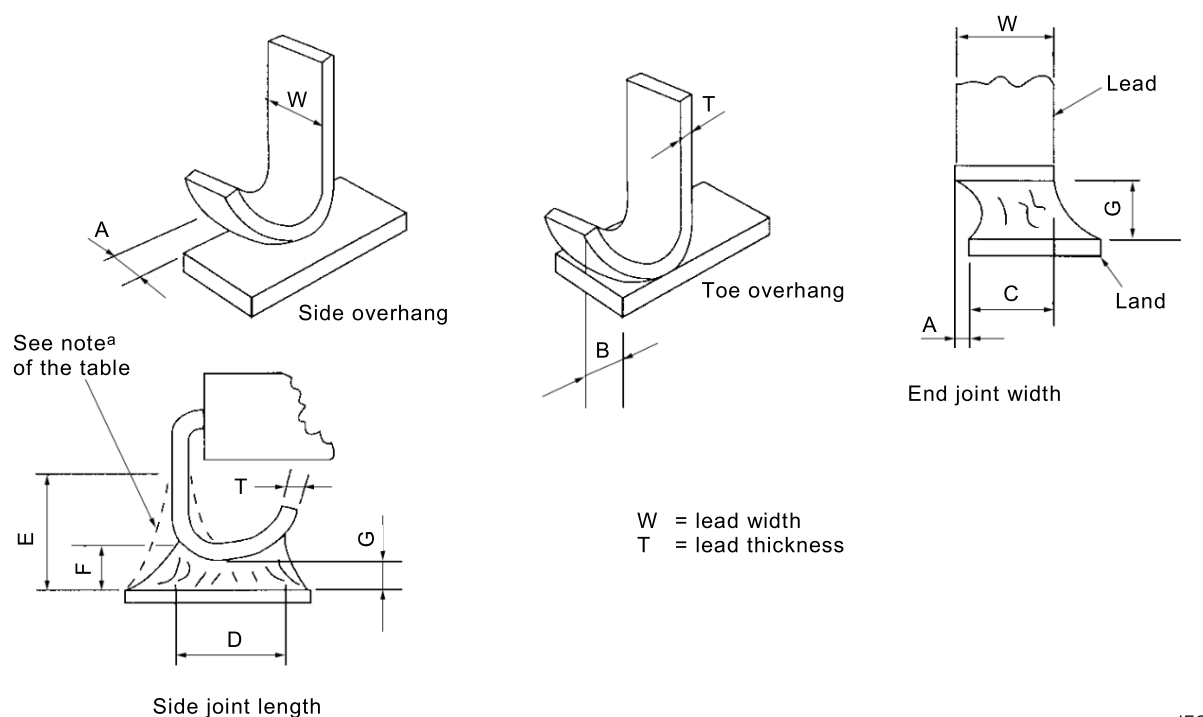
Feature	Dimension	Level A	Level B	Level C
Maximum side overhang	A	$\frac{1}{2}W$ or 0,5 mm, whichever is less <sup>b</sup>		$\frac{1}{4}W$ or 0,5 mm, whichever is less <sup>b</sup>
Maximum toe overhang	B	b	b	b
Minimum end joint width	C	c	c	$\frac{3}{4}W$
Minimum side joint length	D	W		$1\frac{1}{2}W$
Maximum heel fillet height	E	a	a	a
Minimum heel fillet height	F	c	$G + \frac{1}{2}T$ <sup>d</sup>	$G + T$ <sup>d</sup>
Minimum solder thickness	G	c	c	c
Minimum side joint height	Q	c	$G + \frac{1}{2}T$	$G + \frac{1}{2}T$
<sup>a</sup> Solder does not touch package body or seal. <sup>b</sup> Shall not violate minimum design conductor spacing. <sup>c</sup> Properly wetted fillet evident. <sup>d</sup> In case of toe down configuration, minimum heel fillet height F extends at least to the mid-point of the outside lead bend				

**Figure 4 – Round or flattened (coined) lead joint**

### 6.3.5 J leads

Joints formed to leads having a J shape at the joint site shall meet the dimensional and fillet requirements of Figure 5 for each product level.





IEC

Dimensions in millimetres

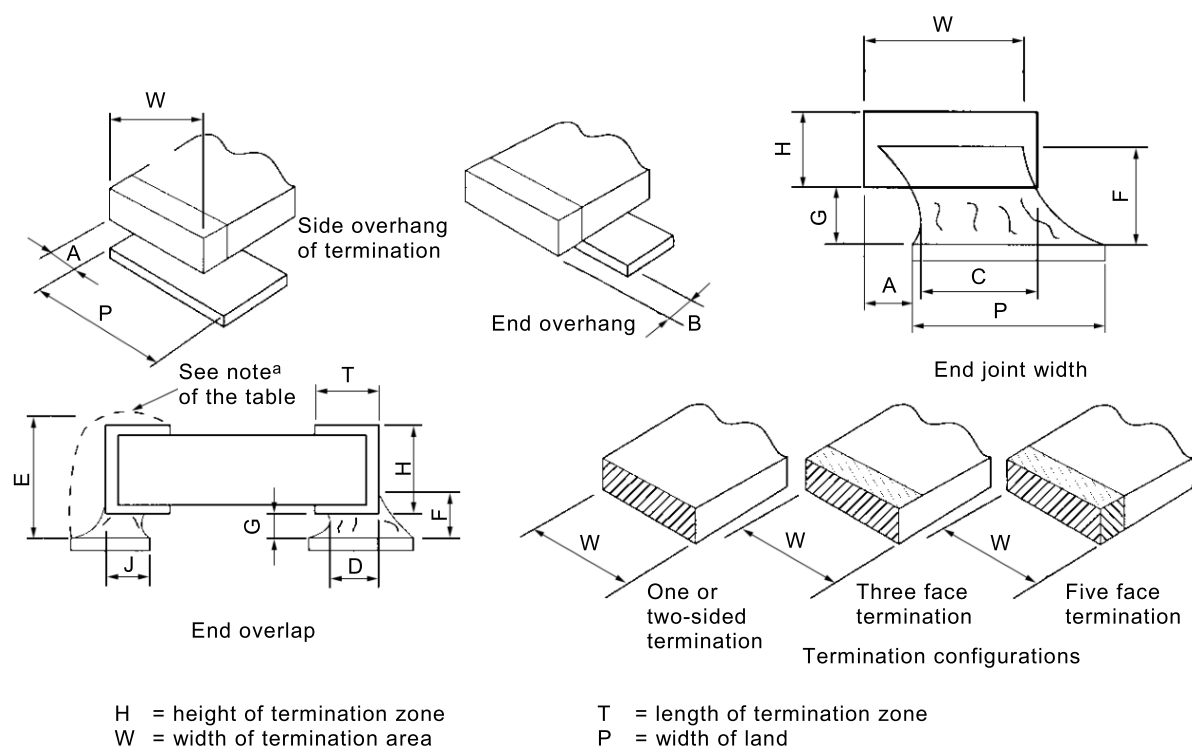
Feature	Dimension	Level A	Level B	Level C
Maximum side overhang <sup>f</sup>	A	$\frac{1}{2}W$	$\frac{1}{2}W$	$\frac{1}{4}W$
Maximum toe overhang	B	b d	b d	b d
Minimum end joint width	C	$\frac{1}{2}W$		$\frac{3}{4}W$
Minimum side joint length <sup>e</sup>	D	c	$1\frac{1}{2}W$	$1\frac{1}{2}W$
Maximum fillet height	E	a	a	a
Minimum fillet height	F	$G + \frac{1}{2}T$		$G + T$
Minimum solder thickness	G	c	c	c
<sup>a</sup> Maximum solder fillet does not touch package body or end seal. <sup>b</sup> Unspecified parameter. <sup>c</sup> Properly wetted fillet evident. <sup>d</sup> Shall not violate minimum design conductor spacing.				

Figure 5 – J lead joint

### 6.3.6 Rectangular or square end component

Solder joints to components having terminations of a square or rectangular configuration shall meet the dimensional and solder fillet requirements of Figure 6 for each product level.





IEC

Dimensions in millimetres

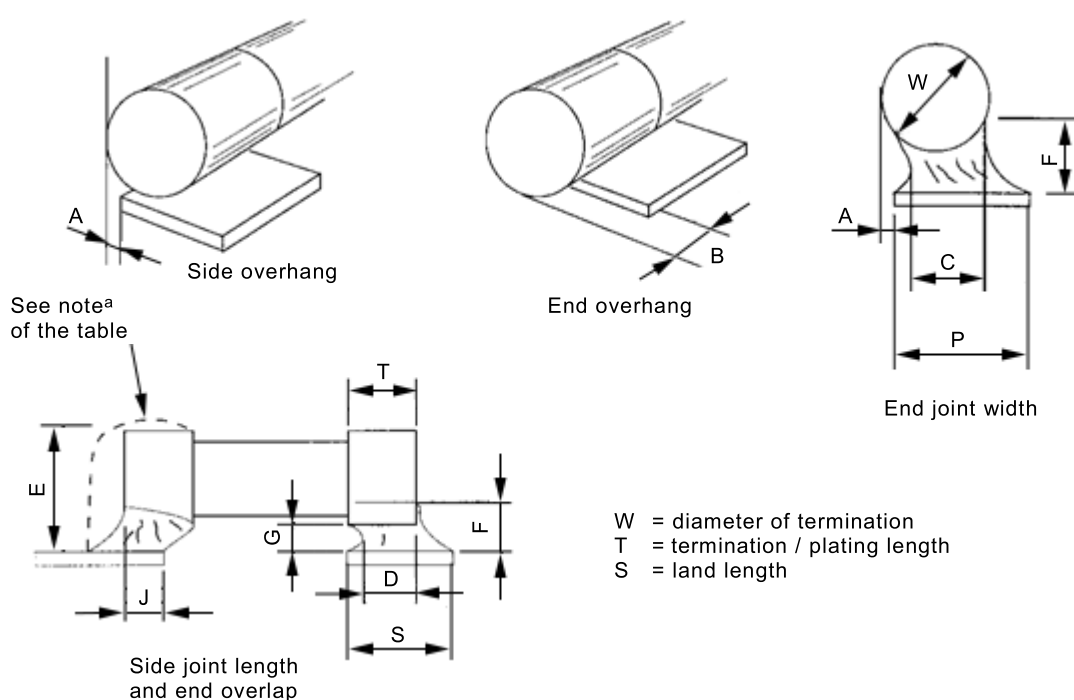
Feature	Dimension	Level A	Level B	Level C
Maximum side overhang <sup>e</sup>	A	½W or P, whichever is less		¼W or P, whichever is less
End overhang	B	Not permitted		
Minimum end joint width	C	½W or P, whichever is less		¾W or P, whichever is less
Minimum side joint length <sup>c</sup>	D	d		
Maximum fillet height <sup>a</sup>	E	a		
Minimum fillet height	F	d		G + ¼H or G + 0,5, whichever is less
Minimum solder thickness <sup>b</sup>	G	d		
Minimum end overlap <sup>c</sup>	J	required		¼T
<sup>a</sup> The maximum fillet may overhang the land or extend onto the top of the end-cap metallization; however, the solder shall not extend further onto the component body.				
<sup>b</sup> Unless satisfactory cleaning can be demonstrated with reduced clearance. G is not specified when cleaning is not required.				
<sup>c</sup> Not required for one face only termination type components.				
<sup>d</sup> Properly wetted fillet evident.				
<sup>e</sup> Shall not violate minimum design conductor spacing.				

**Figure 6 – Rectangular or square end components**

### 6.3.7 Cylindrical end-cap terminations

Solder joints to components having cylindrical end-cap terminations (e.g. MELFs) shall meet the dimensional and solder fillet requirements of Figure 7 for each product level.





IEC

Dimensions in millimetres

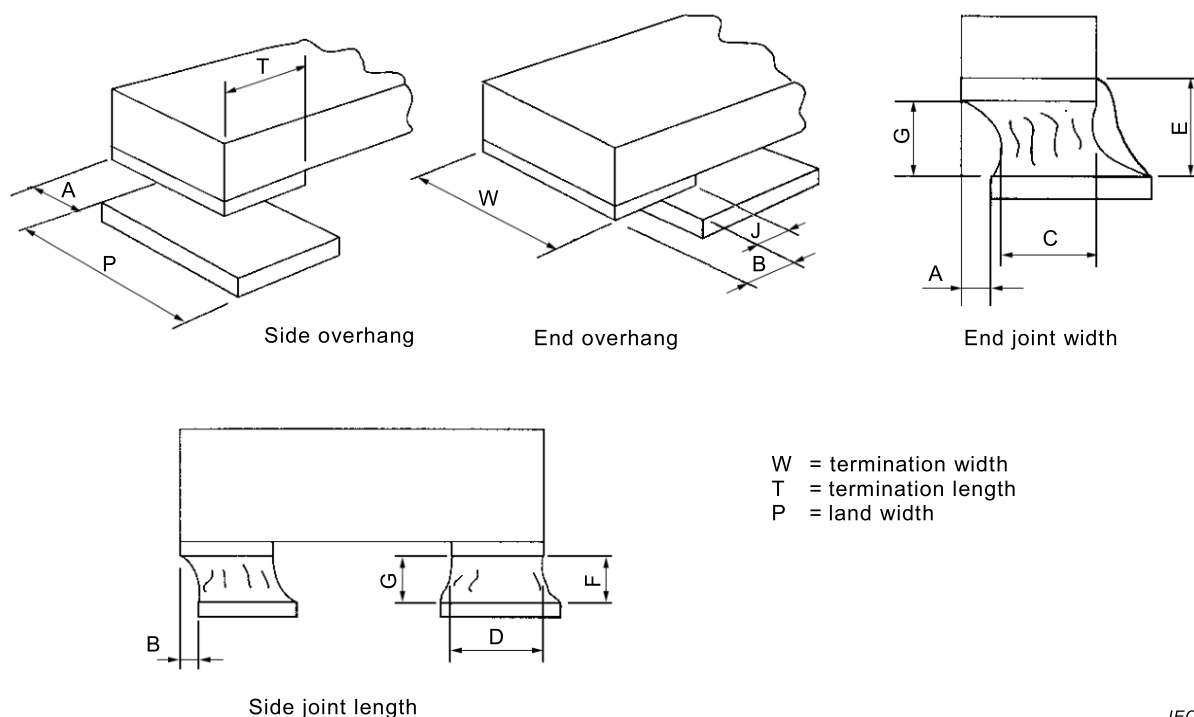
Feature	Dimension	Level A	Level B	Level C
Maximum side overhang <sup>c</sup>	A	$\frac{1}{4}W$ or P, whichever is less		
End overhang	B	Not permitted		
Minimum end joint width	C	<sup>b</sup>	$\frac{1}{2}W$ or P, whichever is less	
Minimum side joint length	D	<sup>b</sup>	$\frac{1}{2}T$ or S, whichever is less	$\frac{3}{4}T$ or S, whichever is less
Maximum fillet height (end and side)	E	<sup>a</sup>		
Minimum fillet height (end and side)	F	<sup>b</sup>		G + $\frac{1}{4}W$ or G + 1,0 mm, whichever is less
Minimum solder thickness	G	<sup>b</sup>		
Minimum end overlap	J	<sup>b</sup>	$\frac{1}{4}T$	$\frac{3}{4}T$
<sup>a</sup> The maximum fillet may overhang the land or extend onto the top of the end-cap metallization; however, the solder shall not extend further onto the component body. <sup>b</sup> Properly wetted fillet evident. <sup>c</sup> Shall not violate minimum design conductor spacing.				

Figure 7 – Cylindrical end-cap terminations

### 6.3.8 Bottom only terminations

Discrete chip components, leadless chip carriers, and other devices having metallized terminations on the bottom side only shall meet the dimensional and solder fillet requirements of Figure 8 for each product level.





Dimensions in millimetres

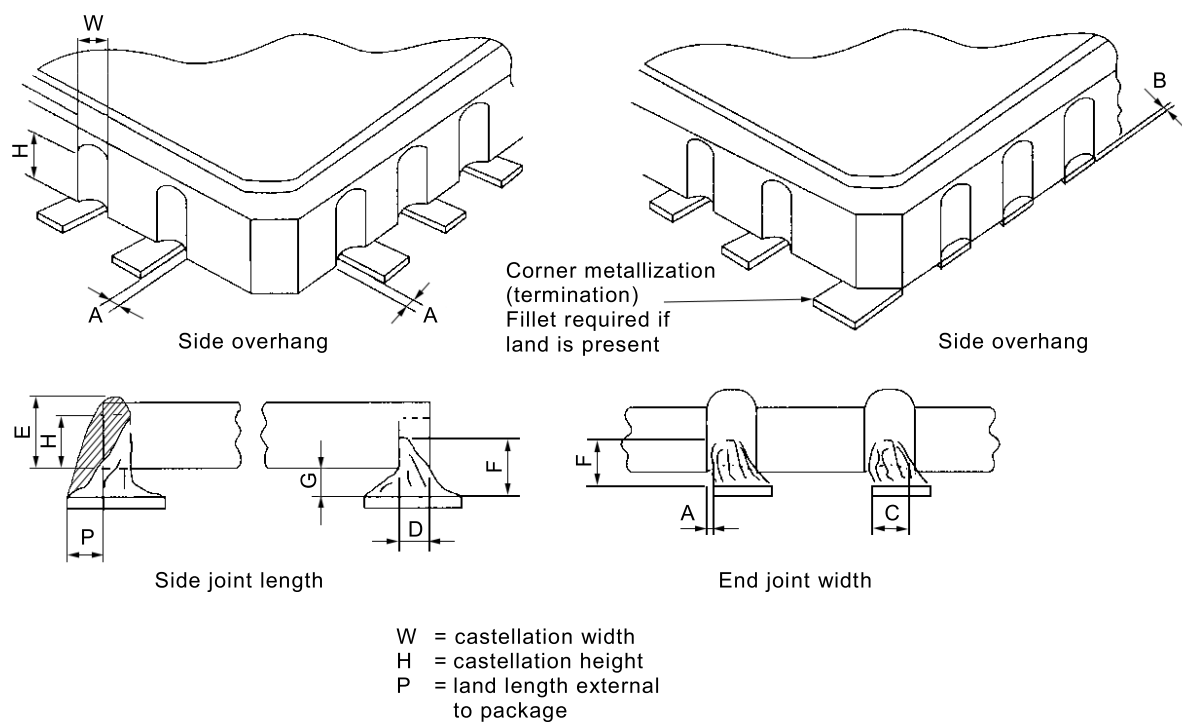
Feature	Dimension	Level A	Level B	Level C
Maximum side overhang	A	$\frac{1}{2}W$ or P, whichever is less <sup>d</sup>		$\frac{1}{4}W$ or P, whichever is less <sup>d</sup>
End overhang	B	Not permitted		
Minimum end joint width	C	$\frac{1}{2}W$ or P, whichever is less		$\frac{3}{4}W$ or P, whichever is less
Minimum side joint length	D	a	a	a
Maximum fillet height	E	a	a	a
Minimum fillet height	F	a	a	a
Minimum solder thickness <sup>c</sup>	G	b	b	b
Minimum end overlap	J	b	$\frac{1}{2}T$	$\frac{3}{4}T$
<sup>a</sup> Unspecified parameter. <sup>b</sup> Properly wetted fillet evident. <sup>c</sup> If cleaning is required, G is not specific as long as satisfactory cleaning can be demonstrated with reduced clearance. <sup>d</sup> Shall not violate minimum design conductor spacing.				

**Figure 8 – Bottom only terminations**

### 6.3.9 Castellated terminations

Joints formed to castellated terminations of leadless chip carriers shall meet the dimensional and solder fillet requirements of Figure 9 for each product level.





IEC

Dimensions in millimetres

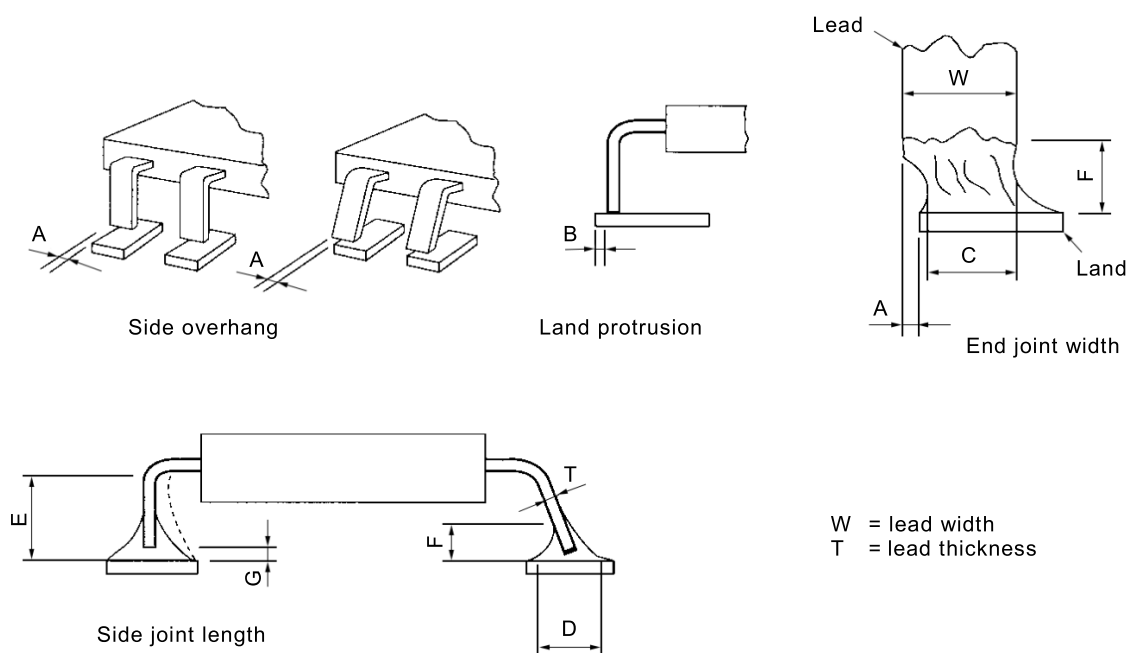
Feature	Dimension	Level A	Level B	Level C
Maximum side overhang <sup>d</sup>	A	½W	½W	¼W
End overhang	B	Not permitted	Not permitted	Not permitted
Minimum end joint width	C	½W	½W	¾W
Minimum side joint length <sup>a</sup>	D	<sup>c</sup>	Depth of castellation	
Maximum fillet height	E	<sup>a d</sup>		
Minimum fillet height	F	<sup>c</sup>	G + ¼H	G + ½H
Minimum solder thickness <sup>b</sup>	G	<sup>c</sup>		
<sup>a</sup> The maximum fillet may extend beyond the top of castellation provided it does not contact the body				
<sup>b</sup> If cleaning is required, G is not specific as long as satisfactory cleaning can be demonstrated with reduced clearance.				
<sup>c</sup> Properly wetted fillet evident.				
<sup>d</sup> Shall not violate minimum design conductor spacing.				

Figure 9 – Leadless chip carriers with castellated terminations

### 6.3.10 Butt joints

Joints formed to leads positioned perpendicular to a circuit land in a butt configuration shall meet the dimensional and solder fillet requirements of Figure 10 for each product level. For level A and B products, leads not having wettable sides by design (such as leads stamped or sheared from preplated stock) are not required to have side fillets; however the design should permit easy inspection of wetting to the wettable surfaces.





See note<sup>a</sup>  
of the table

IEC

Dimensions in millimetres

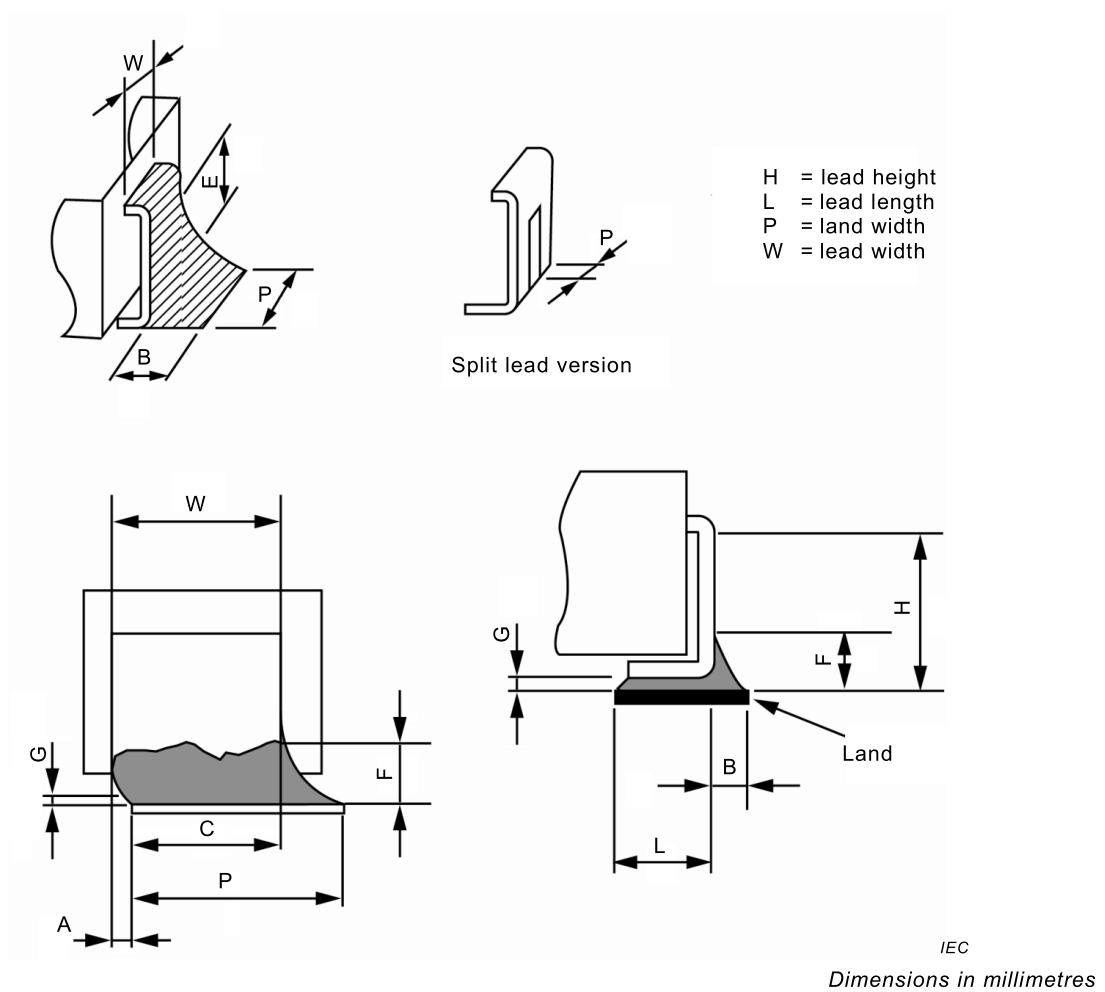
Feature	Dimension	Level A	Level B
Maximum side overhang <sup>c</sup>	A	$\frac{1}{4}W$	Not permitted
Toe overhang	B	Not permitted	
Minimum end joint width	C	$\frac{3}{4}W$	$\frac{3}{4}W$
Minimum side joint length <sup>a</sup>	D	b	b
Maximum fillet height	E	a	a
Minimum fillet height	F	0,5 mm	0,5 mm
Solder thickness	G	b	b
<sup>a</sup> Maximum fillet may extend into the bend radius. Solder does not touch package body or end seal. <sup>b</sup> Properly wetted fillet evident. <sup>c</sup> Shall not violate minimum design conductor spacing.			

**Figure 10 – Butt joints**

### 6.3.11 Inward L-shaped ribbon leads

Solder joints to components having inward L-shaped ribbon lead terminations shall meet the dimensional and solder fillet requirement of Figure 11.





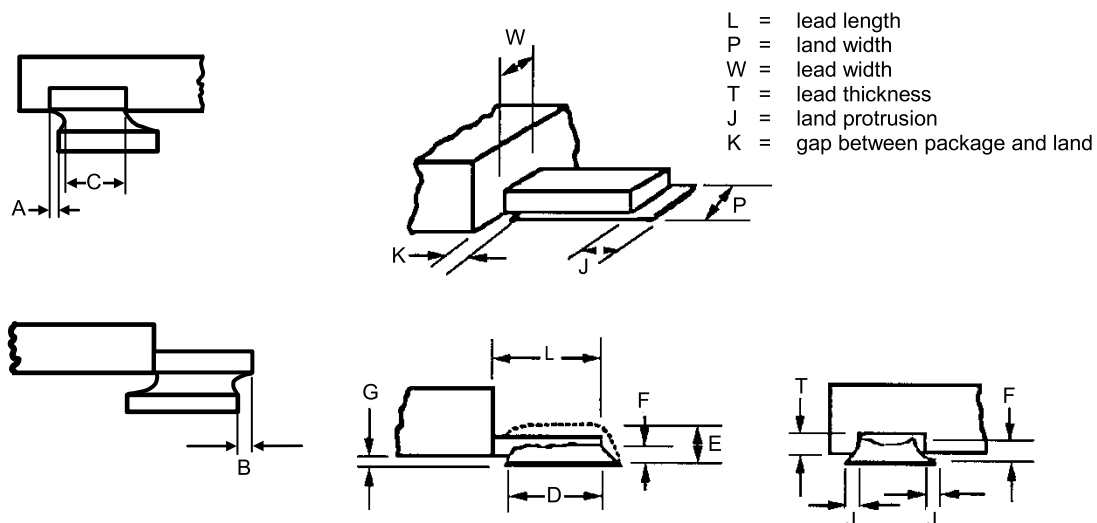
Feature	Dimension	Level A	Level B	Level C
Maximum side overhang <sup>a</sup>	A	½W	½W	¼W or ¼P, whichever is less
Maximum toe overhang	B	a		
Minimum end joint width	C	½W	½W	¾W or ¾P, whichever is less
Maximum fillet height	E	H + G <sup>b</sup>		
Minimum fillet height	F	Wetting is evident on the vertical termination surfaces	G + ¼H or G + 0,5, whichever is less	G + ¼H or G + 0,5, whichever is less
Solder thickness	G	c		
<sup>a</sup> Shall not violate minimum design conductor spacing.				
<sup>b</sup> Solder does not contact component body.				
<sup>c</sup> Wetting is evident.				

Figure 11 – Inward L-shaped ribbon leads

### 6.3.12 Flat lug leads

Solder joints to power dissipating components with flat lug leads terminations shall meet the dimensional requirements of Figure 12 for each product level.





SOURCE: IPC. Figure reprinted with permission.

*Dimensions in millimetres*

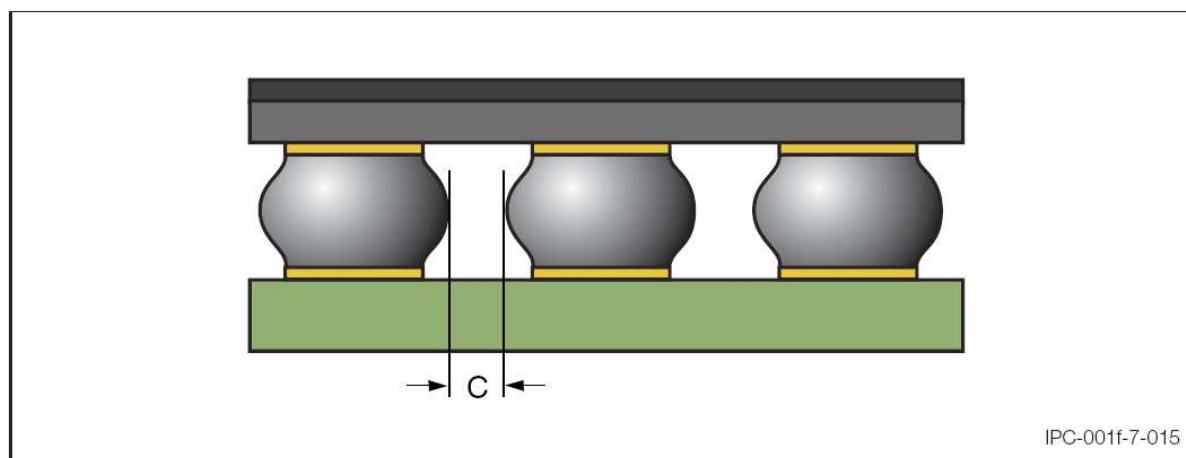
Feature	Dimension	Level A	Level B	Level C
Side overhang	A	$\frac{1}{2}W^c$	$\frac{1}{4}W^c$	Not permitted
Toe overhang	B	$c$	Not permitted	Not permitted
Minimum end joint width	C	$\frac{1}{2}W$	$\frac{3}{4}W$	W
Minimum side joint length	D		$L - K^a$	$L - K^a$
Maximum fillet height	E	$b$	$b$	$G + T + 1,0$
Minimum fillet height	F	$d$	$d$	$G + T$
Solder thickness	G	$d$	$d$	$d$
<sup>a</sup> Where the lug is intended to be soldered beneath the component body and the land is designed for this purpose, the lead shall show evidence of wetting in the gap K. <sup>b</sup> Unspecified parameter. <sup>c</sup> Shall not violate minimum design conductor spacing. <sup>d</sup> Wetting is evident.				

**Figure 12 – Flat lug leads**

### 6.3.13 Ball grid array

Solder joints of ball grid array (BGA) shall meet the dimensional requirements of Figure 13 or Table 1 for each product level. Whether the BGA balls are collapsing or non-collapsing depends on the soldering temperature.





SOURCE: IPC. Figure reprinted with permission.

Feature	Level A, B, C
Alignment	Solder ball offset does not void minimal electrical clearance
Clearance C	Solder ball offset does not void minimal electrical clearance
Soldered connection	Solder balls contact the land and form a continuous elliptical, round or pillar connection
Voids	Level of voiding shall be agreed between user and supplier <sup>a b c</sup>
Underfill or staking material	Present and completely cured if required
<sup>a</sup> Design-induced voids by microvias, etc. are excluded. In such cases, acceptance criteria have to be established between user and supplier. <sup>b</sup> Manufacturer may use test or analysis to develop alternative voids criteria under consideration of end use environment. <sup>c</sup> Plating process induced voids, e.g. micro-voids/champagne voids, are excluded. In such cases, acceptance criteria have to be established between user and supplier.	

**Figure 13 – BGA with collapsing balls**

**Table 1 – BGA with non-collapsing balls**

Feature	Level A, B, C
Alignment	Solder ball offset does not void minimal electrical clearance
Soldered connection	Solder is wetted to the solder ball and land
Underfill or staking material	Present and completely cured if required

#### 6.3.14 Column grid array

Solder joints of column grid arrays with round, square and rectangle profile shall meet the dimensional requirements of Table 2 for each product level.

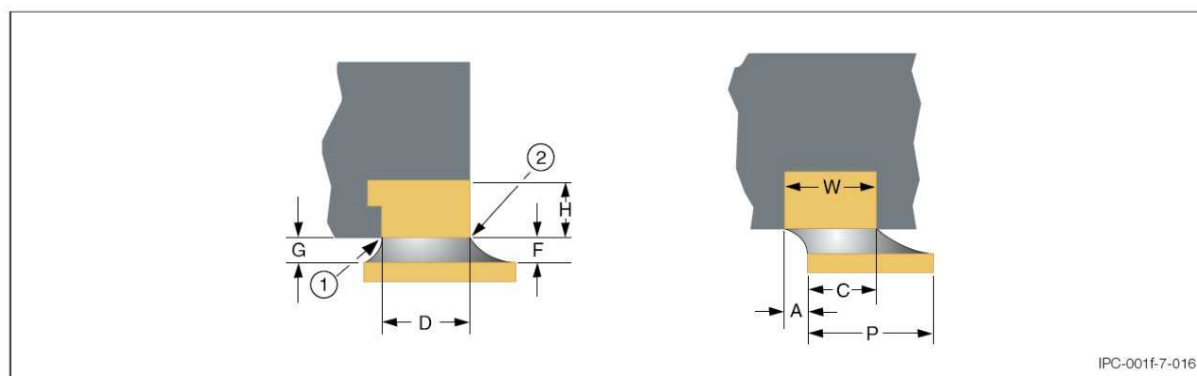
**Table 2 – Column grid array**

Feature	Level A	Level B, C
Alignment	Column offset does not void minimal electrical clearance	Column perimeter does not extend perimeter of the land
Soldered connection	270° circumferential wetting	270° circumferential wetting
Underfill or staking material	Present and completely cured if required	



### 6.3.15 Bottom termination components

Solder joints of bottom termination components shall meet the dimensional requirements of Figure 14 for each product level.



SOURCE: IPC. Figure reprinted with permission.

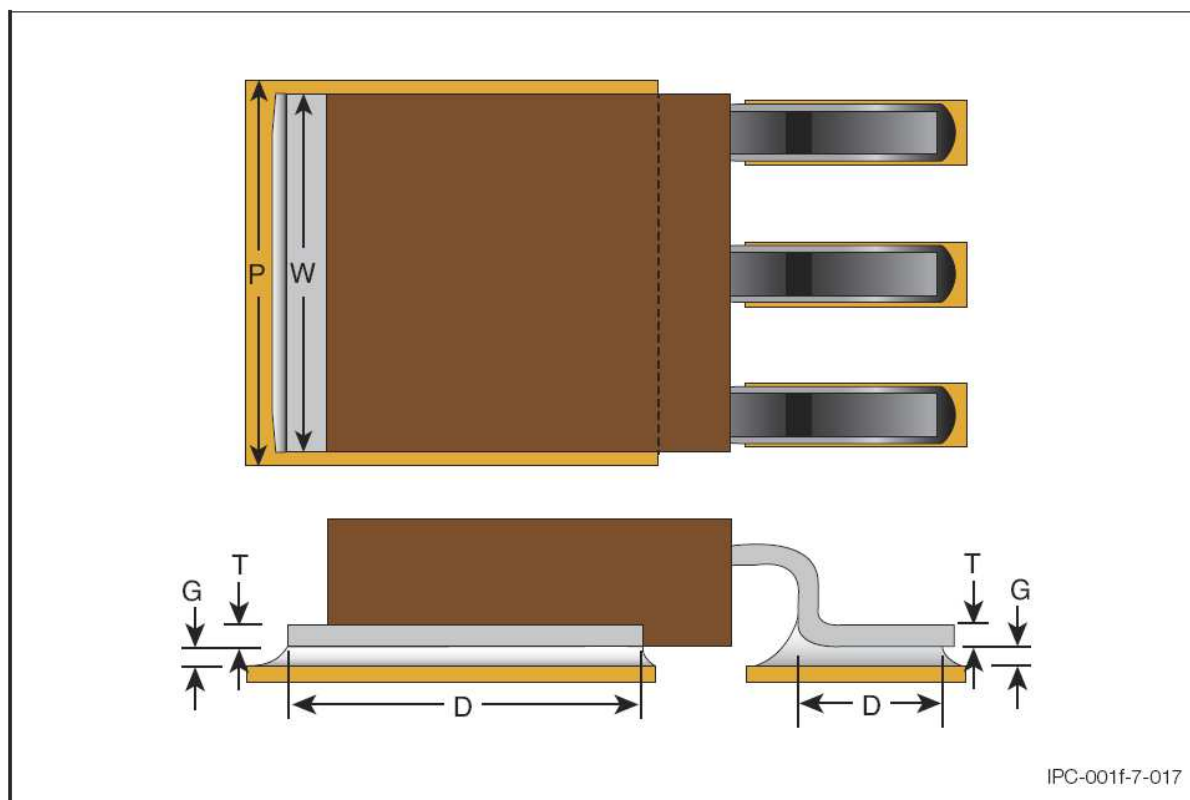
Feature	Dimension	Level A	Level B	Level C
Side overhang	A	$\frac{1}{2}W^a$	$\frac{1}{4}W^a$	$\frac{1}{4}W^a$
Toe overhang	B	Not permitted	Not permitted	Not permitted
Minimum end joint width	C	$\frac{1}{2}W$	$\frac{3}{4}W$	$\frac{3}{4}W$
Minimum side joint length	D	d	d	d
Solder fillet thickness	G	c	c	c
Minimum toe fillet height	F	b <sup>e</sup>	b <sup>e</sup>	b <sup>e</sup>
Termination height	H	e	e	e
Land width	P	b	b	b
Termination width	W	b	b	b
<sup>a</sup> Does not violate minimum electrical clearance. <sup>b</sup> Unspecified parameter. <sup>c</sup> Wetting is evident. <sup>d</sup> No visual inspectable attribute. <sup>e</sup> H = height of wettable side surface if present. Some packages do not have wettable surface on sides and do not require a side fillet.				

**Figure 14 – Bottom termination components**

### 6.3.16 Components with bottom thermal plane terminations (D-Pak)

Solder joints of components with bottom thermal planes shall meet the dimensional requirements of Figure 15 for each product level.





SOURCE: IPC. Figure reprinted with permission.

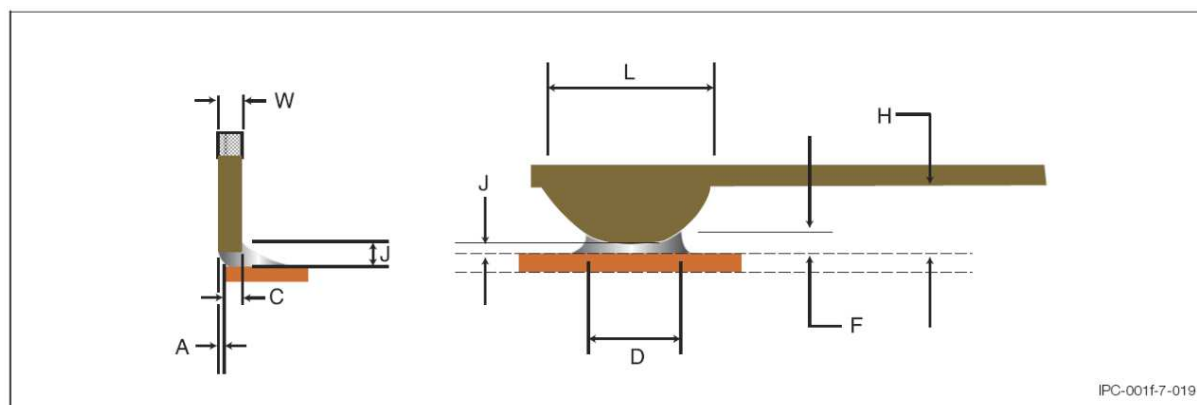
Feature	Dimension	Level A	Level B	Level C
Side overhang	A <sup>a</sup>	Criteria for the type of lead termination being used		
Toe overhang	B <sup>a</sup>			
Minimum end joint width	C <sup>a</sup>			
Minimum side joint length	D <sup>a</sup>			
Maximum heel fillet height	E <sup>a</sup>			
Minimum heel fillet height	F <sup>a</sup>			
Solder fillet thickness	G			
Lead thickness	T			
Feature (only thermal plane connection)	Dimension	Level A	Level B	Level C
Thermal plane side overhang		¼W		
Thermal plane end overhang		Not permitted		
Thermal plane end joint width		100 % wetting in contact area <sup>b</sup>		
Thermal plane side joint length	D <sup>a</sup>	c		
Thermal plane solder fillet thickness	G	Wetting is evident when a fillet is present		
Thermal plane void criteria		c		
Thermal plane termination width	W	b		
Thermal plane land width	P	d		
<sup>a</sup> See 6.3.3.				
<sup>b</sup> Solder wetting is not required on trimmed edges of the thermal plane if that exposes not wettable surfaces.				
<sup>c</sup> Acceptance criteria have to be established between the user and the supplier.				
<sup>d</sup> Not specified or design determined variable in size.				

**Figure 15 – Bottom thermal plane terminations**



### 6.3.17 P-style terminations

Solder joints of components with P-style terminations shall meet the dimensional requirements of Figure 16 for each product level.



SOURCE: IPC. Figure reprinted with permission.

Feature	Dimension	Level A	Level B	Level C
Side overhang	A	$\frac{1}{2}W$	$\frac{1}{4}W$	Not permitted
Toe overhang	B	a	a	a
Minimum end joint width	C	$\frac{1}{2}W$	$\frac{3}{4}W$	W
Minimum side joint length	D	W	$1\frac{1}{2}W$	$1\frac{1}{2}W$
Minimum fillet height – toe and heel	F	b	$\frac{1}{4}H$	$\frac{1}{4}H$
Termination height	H	c	c	c
Minimum side fillet height	J	b	b	b
Termination length	L	c	c	c
Termination width	W	c	c	c
<sup>a</sup> No part of the L portion of the termination extends beyond the land. <sup>b</sup> Wetting is evident. <sup>c</sup> Not specified or design determined variable in size.				

Figure 16 – P-style terminations

## 6.4 General post-soldering requirements applicable to all surface-mounted assemblies

### 6.4.1 Dewetting

Non-conforming, defect level A, B, C: dewetting at any termination if it reduces the wetted area of any termination or land by more than 5 % of the maximum.

### 6.4.2 Leaching

Non-conforming, defect level A, B, C: leaching at any termination if it causes more than 5 % of the visible part of any termination wetted area to become unwetted.

### 6.4.3 Pits, voids, blowholes, and cavities

Non-conforming, defect level A, B, C: when the wetted areas or wetted perimeters of a solder joint are reduced below the specified minimum for the relevant joint type.



#### **6.4.4 Solder wicking**

Non-conforming, defect level A, B, C: wicking prevents the specified minimum wetting requirements for the relevant joint type from being met, or it causes excessive stiffness in a lead.

#### **6.4.5 Solder webs and skins**

Non-conforming, defect level A, B, C: any solder web or skin present.

#### **6.4.6 Bridging**

Non-conforming, defect level A, B, C: any unwanted bridging joining normally isolated conducting surfaces.

Non-conforming, defect level B, C: where excess solder causes a large rigid connection between two or more component terminations that are intended to be electrically connected but physically apart, this may also be non-conforming. Defect due to stress risks from CTE mismatch.

#### **6.4.7 Degradation of marking**

Non-conforming, defect level A, B, C: loss of identity data or parametric value marking through degradation of characters or colours on components, parts, printed boards.

#### **6.4.8 Solder spikes**

Acceptable, level A, B, C: spikes that have rounded tips or are less than 0,5 mm high and appear in circuits that operate below 250 V AC or DC.

Non-conforming, defect level A, B, C: any spike that violates minimum design spacing.

#### **6.4.9 Disturbed joint**

Acceptable, level A, B, C: a joint with surface roughness (grainy or dull finish).

Non-conforming, defect level A, B, C: any joint exhibiting a crack, fillet lifting, or a surface exhibiting visible contamination.

#### **6.4.10 Component damage**

Non-conforming, defect level A, B, C: any damage to a component, part, or board that may

- a) cause loss of functionality, reduction in reliability, or
- b) result in failures to meet relevant IEC or user's specifications, or
- c) be a rejection criterion for quality inspections.

#### **6.4.11 Open circuit, non-wetting**

Non-conforming, defect level A, B, C: any solder joint where solder was available but there has been failure to wet any surface specified as being part of the minimum joint, for example due to solder balling, poor solderability, surface tension effect (tombstoning).

#### **6.4.12 Component tilting**

Acceptable, level A, B, C: a component or part that exhibits tilt in any direction, but meets the relevant specified requirements for all its soldered joints.



Non-conforming, defect level A, B, C: any component or part whose tilt causes it to fail to meet the specified minimum requirements.

#### **6.4.13 Non-conducting adhesive encroachment**

Acceptable, level A, B, C: adhesive encroachment into a solder joint that does not prevent it from meeting the relevant specified minimum wetting and alignment requirements.

Non-conforming, defect level A, B, C: adhesive encroachment into a solder joint that will cause it to fail to meet the relevant specified minimum requirements for the joint or prevent reliable rework.

#### **6.4.14 Open circuit, no solder available**

Non-conforming, defect level A, B, C: any failure to make a solder joint due to local non-availability of solder prior to or during soldering, for example arising from a stencil defect, shadowing, solder balling.

#### **6.4.15 Component on edge**

Acceptable, level A, B, C: provided component body length is less than 3,2 mm, width is less than 1,6 mm and thickness greater than 1,0 mm and all solder joint and alignment requirements for the relevant level are met.

### **7 Rework and repair**

Rework shall only be undertaken with prior permission of the user. The maximum number of rework actions on an individual board or unit shall be agreed on with the user.

All rework activities on a product shall be recorded in the manufacturer's quality system. This data shall be used for continual improvement and corrective action by the supplier.

When rework is performed, each reworked or reflowed connection shall be inspected to the requirements of 6.3. See Table 3 for re-workable defects.



**Table 3 – Reworkable defects**

No.	Defects
1	Defects identified in Table 2 of IEC 61191-1:2013
2	Flat, ribbon L, or gull-wing lead solder connections that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.3
3	Round or flattened (coined) lead solder connections that do not meet the requirements of 6.3, 6.3.2 or 6.3.4.
4	J lead solder connections that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.5
5	Rectangular or square end component solder connections that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.6
6	Cylindrical end-cap termination (MELF) solder connections that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.7
7	Bottom only termination solder connections that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.8
8	Leadless chip carrier with castellated termination solder connections that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.9
9	Butt joint solder connections that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.10
10	Inward L-shaped lead connections that do not meet the requirements of 6.3, 6.3.2 or 6.3.11
11	Flat lug leads on power dissipating components that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.12
12	Ball grid arrays that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.13
13	Column grid arrays that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.14
14	Bottom termination components that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.15
15	Components with bottom thermal plane terminations (D-Pak) that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.16
16	P-style terminations that do not meet the requirements of 6.3.1, 6.3.2 or 6.3.17



## **Annex A**

### **(normative)**

## **Placement requirements for surface mounted devices**

### **A.1 General**

The following placement requirements for surface mount devices shall be imposed only if process controls are not sufficiently in place to ensure compliance with 5.3.

### **A.2 Component positioning**

Misregistration of components shall not reduce the spacing to adjacent printed wiring or other metallized elements by more than the minimum electrical spacing.

### **A.3 Small devices incorporating two terminations**

#### **A.3.1 Metallization coverage over the land (side-to-side)**

At least 75 % of the component metallization width on each end of the component shall overlap the land area. If land metallization width is less than 75 % of the component metallization, the component metallization shall cover the entire width of the land (see Figure 6).

#### **A.3.2 Metallization coverage over the land (end)**

At least two-thirds of the length of the end metallization shall overlap the land area. Minimum conductor spacing shall be maintained (see Figure 6).

### **A.4 Mounting of cylindrical end-cap devices (MELFs)**

MELF devices shall be mounted such that the side overhang does not exceed 25 % of the diameter of the metallized face (end cap). At least two-thirds of the thickness of the metallized face (end cap) shall be on the land (see Figure 7). Use of lands with cut-outs (e.g. U-shaped lands) to aid in component positioning is permissible provided that an adequate solder fillet is formed.

### **A.5 Registration of castellated chip carriers**

At least 75 % of the cross-section of each metallized castellation of a leadless chip carrier shall be over the land to which the chip carrier is registered (see Figure 9).

### **A.6 Surface mounted device lead and land contact**

Minimum contact length (D) shall be equal to 75 % of the foot length (L) for flat ribbon leads, round leads and flattened round leads. Refer to Figures 3 to 4.

### **A.7 Surface mounted device lead side overhang**

Leads may have side overhang, provided the overhang does not exceed 25 % of the lead width or 0,5 mm, whichever is less, and minimum conductor spacing is maintained.



### **A.8 Surface mounted device lead toe overhang**

Toe ends of leads of the following surface mounted devices may overhang the land, provided the minimum electrical spacing and contact length is maintained:

- flat ribbon L and gull-wing leads;
- round or flattened (coined) leads;
- J leads.

### **A.9 Surface mounted device lead height off land (prior to soldering)**

Round or flattened leads may be raised off the land surface a maximum of one-half the original lead diameter. Flat or ribbon leads may be raised off the land surface a maximum of two times the lead thickness or 0,5 mm, whichever is less. Toe up or toe down on flat and round leads shall be permissible provided that separation between leads and termination area does not exceed 2T and 50 % of D limits, respectively.

### **A.10 Positioning of J lead devices**

J lead devices shall be mounted so that the side overhang is less than 25 % of the lead width. The part shall be positioned so that a minimum solder fillet of one-and-a-half lead widths can be formed.

### **A.11 Positioning gull-wing lead devices**

It is preferred that leads be seated such that the full length of the foot is within the land area (no overhang).

### **A.12 External connections to packaging and interconnect structures**

Where packaging and interconnect structures (P&I) are used to provide controlled thermal expansion, they shall not be connected to external system elements (i.e. chassis or heat sinks) that will degrade the thermal expansion control below design limits.



## Bibliography

### IEC and ISO references

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

IEC 60068-2-58, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 61188-5-1, *Printed boards and printed board assemblies – Design and use – Part 5-1: Attachment (land/joint) considerations – Generic requirements*

IEC 61188-5-2, *Printed boards and printed board assemblies – Design and use – Part 5-2: Attachment (land/joint) considerations – Discrete components*

IEC 61188-5-3, *Printed boards and printed board assemblies – Design and use – Part 5-3: Attachment (land/joint) considerations – Components with gull-wing leads on two sides*

IEC 61188-5-4, *Printed boards and printed board assemblies – Design and use – Part 5-4: Attachment (land/joint) considerations – Components with J leads on two sides*

IEC 61188-5-5, *Printed boards and printed board assemblies – Design and use – Part 5-5: Attachment (land/joint) considerations – Components with gull-wing leads on four sides*

IEC 61188-5-6, *Printed boards and printed board assemblies – Design and use – Part 5-6: Attachment (land/joint) considerations – Chip carriers with J-leads on four sides*

IEC 61188-7, *Printed boards and printed board assemblies – Design and use – Part 7: Electronic component zero orientation for CAD library construction*

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*

IEC 61190-1-2, *Attachment materials for electronic assembly – Part 1-2: Requirements for soldering pastes for high-quality interconnects in electronics assembly*

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

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

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

IEC 62326-4, *Printed boards – Part 4: Rigid multilayer printed boards with interlayer connections – Sectional 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 9001, *Quality management systems – Requirements*



**Other references**

IPC-TM-650, *Test Methods Manual*

- 2.3.25 Detection and measurement of ionizable surface contaminants by resistivity of solvent extract
- 2.3.25.1 Ionic cleanliness testing of bare PWBs
- 2.3.27 Cleanliness test – residual rosin
- 2.3.38 Surface organic contamination detection test
- 2.4.22 Bow and twist (percentage)
- 2.6.3.3 Surface insulation resistance, fluxes

IPC-9191, *General Guidelines for Implementation of Statistical Process Control (SPC)*

IPC-OI-645, *Standard for Visual Optical Inspection Aids*

IPC-SM-817, *General Requirements for Dielectric Surface Mount Adhesives*

IPC-A-610, *Acceptability of Electronic Assemblies*

J-STD-001, *Requirements for Soldered Electrical and Electronic Assemblies*

J-STD-002, *Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires*

J-STD-003, *Solderability Tests for Printed Boards*

J-STD-004, *Requirements for Soldering Fluxes*

J-STD-005, *Requirements for Soldering Pastes*

J-STD-006, *Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Solder Applications*

J-STD-020, *Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices*

---











INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

3, rue de Varembé  
PO Box 131  
CH-1211 Geneva 20  
Switzerland

Tel: + 41 22 919 02 11  
Fax: + 41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)