

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)



BSI Standards Publication

Printed board assemblies

Part 7: Technical cleanliness of components and printed board assemblies

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)

National foreword

This Published Document is the UK implementation of IEC TR 61191-7:2020.

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.

© The British Standards Institution 2020
Published by BSI Standards Limited 2020

ISBN 978 0 539 05118 6

ICS 31.180; 31.190

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 March 2020.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)



Edition 1.0 2020-03

TECHNICAL REPORT



Printed board assemblies – Part 7: Technical cleanliness of components and printed board assemblies

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.180; 31.190

ISBN 978-2-8322-7901-4

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

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)

CONTENTS

FOREWORD.....	8
INTRODUCTION.....	10
1 Scope.....	11
2 Normative references	11
3 Terms and definitions	11
4 Technical cleanliness	11
4.1 What is technical cleanliness?	11
4.2 History – standardisation of technical cleanliness	12
4.3 Technical cleanliness in the electronics industry	12
4.4 Potential particle-related malfunctions	12
5 Technical cleanliness as a challenge for the supply chain.....	13
5.1 General.....	13
5.2 Contamination.....	14
5.2.1 Definition of particles	14
5.2.2 Definition of fibres	14
5.3 Test procedure to determine technical cleanliness	15
5.3.1 Fundamentals.....	15
5.3.2 Clarification form	16
5.3.3 System technology	18
5.3.4 Process parameters for pressure rinsing extraction	19
5.3.5 Pressure rinsing process	19
5.3.6 Preparing membrane filters for measurement analysis.....	20
5.4 Measurement analysis	22
5.5 Evaluating the results of cleanliness analyses.....	22
5.5.1 Overview	22
5.5.2 Particle count relative to component surface.....	23
5.5.3 Procedure for violation of action control limits.....	24
5.6 Extended risk assessment	25
5.6.1 General	25
5.6.2 Example	25
5.7 Component cleanliness – Data management and visualization.....	27
5.7.1 Component cleanliness analysis – flow diagram	27
5.7.2 Explanation of SCI (Surface Cleanliness Index).....	28
5.7.3 Creating a database	31
5.7.4 Summary	34
6 State of the art – Technical cleanliness in the electronics industry.....	35
6.1 Process flow (per cluster)	35
6.1.1 General	35
6.1.2 Electronics manufacturing cluster	35
6.1.3 Passive components cluster (e.g. for inductors and aluminium electrolytic capacitors).....	36
6.1.4 Electromechanical components cluster	37
6.1.5 PCB cluster	39
6.2 Technical cleanliness in the electronics industry – current situation	39
6.2.1 General	39
6.2.2 Electronics manufacturing.....	40

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)

6.2.3	Electronic components.....	41
6.2.4	Electromechanical components.....	44
6.2.5	Metal housings	48
6.2.6	Packaging.....	49
6.2.7	Printed circuit boards (PCBs).....	49
6.3	Determining potential particle sources in production areas.....	52
6.3.1	General	52
6.3.2	Particle generation	52
6.3.3	Electronics manufacturing cluster	52
6.3.4	Passive components cluster	53
6.3.5	Electromechanical components cluster	59
6.3.6	PCB cluster	63
6.4	Cleanliness-controlled design and process selection.....	72
6.4.1	Aspects of cleanliness-controlled design/production with regard to metallic particles.....	72
6.4.2	Environmental cleanliness and internal production processes	74
6.5	Environmental cleanliness analysis and visualisation	76
6.5.1	General	76
6.5.2	Procedure for environmental analysis	76
6.5.3	Conclusions:.....	80
6.6	Cleaning tips.....	81
6.6.1	General	81
6.6.2	Washing	81
6.6.3	Brushing	81
6.6.4	Suction-cleaning	82
6.6.5	Blowing.....	83
6.6.6	Reducing carry-over and controlling cleanliness in workplace design.....	83
6.6.7	Adhesive methods	84
6.7	Packaging and logistics requirements	84
7	Why do metallic particles in assemblies so rarely cause short circuits?	84
7.1	General.....	84
7.2	Probability of contact	85
7.2.1	Introduction and theory	85
7.2.2	Testing the probability of contact	88
7.2.3	Results	90
7.3	Rinsing extraction versus actual mobility.....	92
7.4	Particle sinks	92
7.5	Effect of short circuits on ICs	93
7.6	Tool for estimating the risk of short circuit.....	93
7.6.1	Overview	93
7.6.2	Model hypotheses.....	94
7.6.3	Calculation methods	95
7.6.4	Orientation factor.....	95
7.6.5	Critical area.....	96
7.6.6	Number of particles per size class	97
7.6.7	Weighting factors.....	98
7.7	Example use of the risk assessment tool.....	99
7.7.1	Example use of the risk assessment tool for calculating failure rate.....	99
7.7.2	Example use of the risk assessment tool for design changes	100

This is a preview of "PD IEC TR 61191-7:20...". Click here to purchase the full version from the ANSI store.

7.7.3	Example use of the risk assessment tool for specification violations	101
8	Summary	102
9	Outlook.....	102
10	Related topics	103
10.1	Filmic contamination	103
10.1.1	General	103
10.1.2	Biological films	103
10.1.3	Chemical films	103
10.2	Whiskers.....	103
Annex A (informative)	Determining the surface area of components and assembled circuit boards.....	106
Annex B (informative)	Examples of cleanliness clarification forms.....	109
Bibliography.....		114
Figure 1	– Test method as per VDA 19 Part 1	16
Figure 2	– Examples of extraction systems	18
Figure 3	– Component holder during manual pressure rinsing	20
Figure 4	– Examples of different options for drying membrane filters	21
Figure 5	– Slide frame with membrane filter	21
Figure 6	– Example procedure if specifications are exceeded	24
Figure 7	– Particle size distribution and corresponding process capability.....	26
Figure 8	– Flow diagram for component cleanliness analysis	27
Figure 9	– Scope of analytical report.....	27
Figure 10	– Derivation of Illig value.....	28
Figure 11	– Derivation of SCI.....	29
Figure 12	– Evaluation of 7-pin HV strip connector.....	30
Figure 13	– Graph showing cleaning effect based on SCIs.....	30
Figure 14	– Comparison of the three largest particles	31
Figure 15	– Structural levels of a database	32
Figure 16	– Option A – Evaluation of the largest particles by length and width	32
Figure 17	– Option B – Extension to include the degree of contamination – SCI.....	33
Figure 18	– Option C – Extension to include a separate data sheet "direct comparison of test series".....	33
Figure 19	– Option D – Extension of the database "to include 'comparison with customer standards'"	34
Figure 20	– Flexible circuit board	49
Figure 21	– Rigid circuit board	50
Figure 22	– Burr formation on copper wire ($D = 2,25$ mm) after use of wire-cutter	54
Figure 23	– Particles generated by wire cutting $D = 1,8$ mm (tinned copper)	54
Figure 24	– Particles generated by wire cutting $D = 1,8$ mm (tinned copper)	55
Figure 25	– Particle (tin) adhering to a tinned copper wire $D = 2,25$ mm.....	55
Figure 26	– Hair-like particle (tin whiskers) chipped off a tinned wire (655 μ m long).....	56
Figure 27	– Milled enamel wires.....	56
Figure 28	– Molten solder balls fused to plastic housings.....	57
Figure 29	– Ferrite particle, identified as metallic (419 μ m).....	58

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)

Figure 30 – Ferrite particle, identified as non-metallic (558 µm)	58
Figure 31 – Non-metallic particle, probably burr or plastic residue (217 µm)	59
Figure 32 – Non-metallic particle, probably pink polystyrene packaging material.....	59
Figure 33 – Shielding plate	60
Figure 34 – Stamped contacts	61
Figure 35 – Connector pin.....	61
Figure 36 – Connector housing	62
Figure 37 – 58-pin connector housing	62
Figure 38 – 12-pin connector with bridged contacts	63
Figure 39 – Plastic particles + fibres	64
Figure 40 – Plastic particles.....	64
Figure 41 – Metallic particle	64
Figure 42 – Milling crosses V-scoring line	65
Figure 43 – V-scoring line on milling edge	66
Figure 44 – Chip formation in milled hole	66
Figure 45 – Edge plating.....	67
Figure 46 – Connections for electroplated gold areas	67
Figure 47 – Deep milling	68
Figure 48 – Chip formation caused by stamping.....	68
Figure 49 – Flexible circuit board with undercut	69
Figure 50 – Punching burr in hole	69
Figure 51 – Punching burr.....	70
Figure 52 – Damaged metallic stiffener	70
Figure 53 – Stamping residue along stamped edge.....	71
Figure 54 – Stamping residue loosened by pickling bath.....	71
Figure 55 – Plastic element with burr	72
Figure 56 – Particles on externally supplied plastic elements	72
Figure 57 – Process chain analysis as per VDA 19 Part 2.....	75
Figure 58 – Cleanroom production	76
Figure 59 – Example particle trap	77
Figure 60 – Position of particle trap	77
Figure 61 – Database – Visualisation.....	78
Figure 62 – Illustration of the Illig value with max. three particles.....	78
Figure 63 – Airborne dispersion diagram.....	79
Figure 64 – Analysis results in the cleanroom	79
Figure 65 – Analysis results in the area not governed by VDA 19.....	80
Figure 66 – Weighting of factors influencing technical cleanliness	80
Figure 67 – Manual cleaning with brush and illuminated magnifier	82
Figure 68 – ESD brush.....	82
Figure 69 – Workstations designed for cleanliness control	83
Figure 70 – Adhesive roller system for PCB contact cleaning.....	84
Figure 71 – Diagram showing failure risks based on metallic particles on assemblies	85

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)

Figure 72 – Sketch of electrical arrangement (particle forming "bridge" between two conductors).....	86
Figure 73 – Diagram showing contact point of a particle on a conductor – nickel-gold conductor and copper particle	87
Figure 74 – SIR test circuit boards (interleaving comb pattern layout)	89
Figure 75 – Voltage source that measures current with an analogue picoamperemeter	89
Figure 76 – Automated current measurement with software	90
Figure 77 – Comparison of CU particles in three conditions on SAC305 PCBs	91
Figure 78 – Overview of all metals in the voltage classes, rounded	91
Figure 79 – Functional structure of risk assessment tool	94
Figure 80 – Geometric constraints at a contact pair	96
Figure 81 – Clearance areas up to 400 µm (in white)	97
Figure 82 – Clearance areas up to 600 µm (in white)	97
Figure 83 – Clearance areas up to 1000 µm (in white)	97
Figure 84 – Example calculation 1 – Calculating an absolute probability of failure	99
Figure 85 – Example calculation 2 – Calculating probabilities of failure for layout changes e.g. for a new generation component	100
Figure 86 – Example calculation 3 – Optimising the main variables.....	101
Figure 87 – Example calculation 3 – Calculating the changed probability of failure in the event of specification violation	101
Figure 88 – Whiskers growth of > 8 mm over a period of 10 years	104
Figure 89 – Whiskers growth of > 2 mm over a period of 6 months	105
Figure A.1 – Dimensions of cuboid components	106
Figure A.2 – Dimensions of cylindrical components.....	107
Figure B.1 – Ambient cleanliness clarification form	109
Figure B.2 – Ambient cleanliness clarification form	110
Figure B.3 – Component cleanliness clarification form	111
Figure B.4 – Component cleanliness clarification form	112
Figure B.5 – Component cleanliness clarification form	113
Table 1 – Influence of the blank value on the measurement results for different material surfaces (examples for a blank value fraction of 2,2 % and above).....	24
Table 2 – Electronics manufacturing cluster process flow	35
Table 3 – Process flow for inductors	36
Table 4 – Aluminium electrolytic capacitors.....	37
Table 5 – Stamped contact production/plastic production (housing) process flow	38
Table 6 – Housing assembly process flow.....	38
Table 7 – PCB cluster process flow.....	39
Table 8 – Empirical data from electronics manufacturing cluster	40
Table 9 – Empirical data from inductors	41
Table 10 – Empirical data from aluminium electrolytic capacitors	41
Table 11 – Empirical data from tantalum capacitors	42
Table 12 – Empirical data from chip components	42
Table 13 – Empirical data from shunts	43
Table 14 – Empirical data from quartz.....	43

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)

Table 15 – Empirical data from semiconductors	44
Table 16 – Empirical data from metallic components – stamping from pre-treated strip stock.....	44
Table 17 – Empirical data from metallic components – stamping of contact from untreated strip stock and subsequent electroplating process.....	45
Table 18 – Empirical data from metallic components – turning of pins and subsequent electroplating process.....	45
Table 19 – Empirical data from pure plastic parts.....	46
Table 20 – Empirical data from joined strip connectors	46
Table 21 – Empirical data from high-voltage connectors (typically shielded)	47
Table 22 – Empirical data from the assembly process of non-metallic components	47
Table 23 – Empirical data from die-cast aluminium housing	48
Table 24 – Empirical data from deep-drawn trays (new).....	49
Table 25 – Empirical data from flexible PCBs without cleaning step.....	50
Table 26 – Empirical data from bare, flexible PCBs with cleaning step.....	51
Table 27 – Empirical data from bare, rigid PCBs	51
Table 28 – List of materials used in the test.....	88
Table A.1 – Sample values of standard components to determine the component surface area	108

This is a preview of "PD IEC TR 61191-7:20...". Click here to purchase the full version from the ANSI store.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRINTED BOARD ASSEMBLIES –

**Part 7: Technical cleanliness of components
and printed board 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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a Technical Report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC/TR 61191-7, which is a technical report, has been prepared by IEC technical committee 91: Electronics assembly technology.

The text of this Technical Report is based on the following documents –

Draft TR	Report on voting
91/1583/DTR	91/1595/RVDTR

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

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://www.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.

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.

This is a preview of "PD IEC TR 61191-7:20...". [Click here to purchase the full version from the ANSI store.](#)

INTRODUCTION

The Technical Report applies to electric, electronic and electromechanical components, circuit boards and electronic assemblies and describes the resulting level of technical cleanliness that can be expected for products that are manufactured with state-of-the-art standard production methods and processes.

The Technical Report is an informative document which serves to illustrate the technically feasible options and provide a basis for customer and supplier agreements. It is not intended to be regarded as a specification or standard. It does not cover the production of electric motors, batteries, cable harnesses and relays.

Its primary focus is on loose or easily detachable particles (labile particles). Film residues, chemical and biological contamination are also briefly covered. It does not deal with the cleanliness of functional fluids and/or gases.

This Technical Report provides information, how the requirements put down in VDA 19.1 and VDA 19.2 could become reasonably applied in electronic industry. It provides information about particle generation considering processes and materials, illustrates their impact on performance and reliability and describes suitable countermeasures as well as procedures for risk assessments.

Related standards issued by the automotive industry and the electronic industry are gathered in the bibliography.

The Technical Report has been prepared based on material provided by the working group on component cleanliness of the ZVEI (Zentralverband Elektrotechnik- und Elektronikindustrie e.V., Germany).

This is a preview of "PD IEC TR 61191-7:20...". Click here to purchase the full version from the ANSI store.

PRINTED BOARD ASSEMBLIES –

Part 7: Technical cleanliness of components and printed board assemblies

1 Scope

This part of IEC 61191 serves as a Technical Report and provides information, how technical cleanliness can be assessed within the electronics assembly industry. Technical cleanliness concerns sources, analysis, reduction and control as well as associated risks of particulate matter, so-called foreign-object debris, on components and electronic assemblies in the electronics industry.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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 Technical cleanliness

4.1 What is technical cleanliness?

The term 'technical cleanliness' was coined by the automotive industry to address particle-related system interruptions in the automotive industry. In contrast to 'optical cleanliness', which relates to the cosmetic or visual appearance, e.g. vehicle coating, technical cleanliness always refers to the performance of components, assemblies and systems.

Particulate contamination in the automotive industry is often not limited to a certain area but may migrate from a previously non-critical to a sensitive location and hence impair performance. For instance, a particle on the lens of a traffic sign detection camera may cause it to malfunction. Similarly, a conductive particle from the aluminum cover of an electronic control unit may cause a short circuit on the circuit board and undermine its performance. This is why the cleanliness requirements of the automotive industry often apply to complete systems, whereby the most particle-sensitive component (weakest link in the chain) determines the cleanliness level and admissible limiting values for the entire system and all components within it. With regard to components, technical cleanliness refers to the specification, observance and verification of limiting values, e.g. according to weight of residual contamination, particle count, type and size. At the same time, the automotive industry tolerates failures only in the ppm range. New stipulations are continuously being added to the existing specifications. These are often tailored to suit the specific requirements of a company or component and its performance. Their scope of application is limited, i.e. they are valid in-house and/or for suppliers.