
**Adhesives — Guidelines for the
fabrication of adhesively bonded
structures and reporting procedures
suitable for the risk evaluation of such
structures**

*Adhésifs — Lignes directrices pour la fabrication des structures
collées par adhésifs et procédures pour l'établissement de rapports
pour l'évaluation des risques liés à ces structures*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 11, *Products*.

This second edition cancels and replaces the first edition (ISO 21368:2005), which has been technically revised.

The main changes compared to the previous edition are as follows:

- broadening of the terms and definitions to include relevant processing and manufacturing terms;
- classification of adhesively bonded joints according to safety requirements;
- clarification of the competences, knowledge and experience of adhesive bonding personnel;
- comprehensive explanation the design of adhesively bonded joints;
- thorough description of surface treatment procedures;
- extensive account of how to assemble/manufacture of adhesively bonded joints.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Adhesive bonding technology is used widely internationally to fabricate many of the structures in the adhesive-using industry. In some companies, it is the key feature to production. Such structures range from microelectronic encapsulation to the structure and reinforcement of aircraft wings and bridges. Adhesive bonding technology appeals to industry across sectors and applications because it allows flexibility in the selection of materials, product design and product manufacture up to the final assembly. As such, adhesive bonding technology exerts a profound influence on the cost of fabrication and the quality of the product, thus allowing significant production savings and a competitive advantage in comparison with traditional methods of manufacture. It is important, therefore, to ensure that adhesive bonding technology is carried out in the most effective way and that appropriate control is exercised over all aspects of the operation. If used properly and professionally, the adhesive bonding technology is undoubtedly able to meet the requirements of circular economy and eco-design.

Within the ISO 9000 series of standards for quality systems, adhesive bonding technology is to be treated as a “special process” since adhesively bonded joints cannot be fully verified by subsequent inspection and testing of the product to ensure the required quality standards have been met.

As per today’s knowledge, adhesively bonded joints cannot be inspected into a product. The task is to install them faultlessly from the outset. Even the most extensive and sophisticated non-destructive testing does not improve the quality of adhesively bonded joints.

For adhesively bonded structures to be effective and fit for purpose in service, there is a need to provide controls from the design stage through material selection to manufacture and subsequent inspection. Poor design for adhesive bonding creates serious risks and costly difficulties in the workshop, on site or in service. Inadequate consideration of the materials to be adhesively bonded and the choice of adhesive may result in adhesive bonding problems such as lack of adhesion or inadequate gap-filling of the structure. It is therefore essential for adhesive bonding procedures to be correctly formulated and approved to avoid imperfections. Comprehensive and qualified supervision ensures that the specified quality is achieved.

To ensure the quality of adhesively bonded structures on an international level and to make the quality of adhesively bonded structures internationally comparable, the task of management is to:

- identify possible sources of error;
- create organizational structures that prevent these sources of error from the outset; and
- introduce suitable quality procedures.

For these reasons, this document represents the state of the art for the professional organization of adhesive bonding processes in all areas of industry and trade in a holistic and international view. It also applies analogously to sealing processes if the function of the seal is only to secure and support adhesively bonded joints. The consideration of adhesive bonding technology according to this document comprises, starting with the first idea, the development of adhesively bonded joints (pre-production), continues through production, i.e. the manufacture of adhesively bonded joints (in-production), to the finished adhesively bonded product including its maintenance, repair and disposal (post-production).

This holistic approach also includes the quality assurance of production, inspection and maintenance, including the repair and disposal of adhesively bonded joints. The approach according to this document is, without exception and in any case, independent of the lot size as well as the respective area of application.

This document establishes definitions and sets out organizational, management technical, contractual and technical principles to be followed when manufacturing adhesively bonded joints. This is achieved by defining three essential core elements:

- Core element 1: the classification of each adhesive bond according to safety requirements (see [Clause 4](#));

- Core element 2: the appointment of supervisory personnel [Adhesive Bonding Coordinators (ABCs)] and execution personnel (Adhesive Bonding Operators) who are both capable of objectively verifying the necessary and required adhesive bonding competence, knowledge and experience in each case (see [Clause 5](#));
- Core element 3: the verification that the real load of the respective adhesive bond in the use and application of the adhesively bonded product is in any case less than the maximum load bearing capacity (see [Clause 6](#)).

The above-mentioned, necessary worldwide comparability in quality and implementation is achieved through a uniform implementation of these three core elements at the international level.

Since the all numerical values described in this document are reference values, it is advisable for the practitioners to decide on their own when implementing them.

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Adhesives — Guidelines for the fabrication of adhesively bonded structures and reporting procedures suitable for the risk evaluation of such structures

1 Scope

This document provides guidelines describing the adhesive bonding quality requirements suitable for use by adhesive user-companies utilizing adhesive bonding as a means of fabrication. In particular, the guidelines define various approaches to meeting quality requirements for fabrication and reporting procedures, both in workshops and on site. These guidelines aim to convey the importance of maintaining quality standards in fabrication and reporting procedures, keeping records and thus enabling documentation to provide the basis for risk evaluation of adhesively bonded structures in service and in use.

These guidelines have been prepared such that:

- a) they are independent of the type of adhesively bonded structure;
- b) they are independent of adhesive user-companies' and suppliers' product recommendations;
- c) they define the quality requirements for adhesive bonding in terms of fabrication and reporting procedures, both in workshops and on site;
- d) they can be used as the basis for risk evaluation of adhesively bonded structures in service and in use;
- e) they can be used as a basis for assessing a fabricator's capability to produce adhesively bonded structures fulfilling specified quality requirements when they are detailed in one or more of the following:
 - a contract between the parties involved;
 - an application standard;
 - a regulatory statement.

The guidelines contained within this document can be adopted in full or selectively chosen by the adhesive user to suit the structure concerned. The guidelines provide a flexible framework for the control of adhesive bonding activities in the following cases.

Case 1

The provision of specific requirements for adhesive bonding in contracts that require the adhesive user to have a quality system other than ISO 9001.

Case 2

The provision of specific requirements for adhesive bonding as guidance to an adhesive user developing a quality system.

Case 3

The provision of specific requirements for references in application standards that uses adhesive bonding as part of its requirements or in a contract between relevant parties.

Case 4

The provision of a framework for fabrication and reporting procedures to a quality standard, suitable in particular as a basis for the risk evaluation of adhesively bonded structures.

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.

ISO 472, *Plastics — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472 and the following apply.

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

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

3.1 adherend substrate

object or semi-finished product (for example, sheet metal, wires, metal extruded, moulded plastic, fabrics, glass, etc.) on which an adhesive is applied

Note 1 to entry: In adhesive bonding processes, the term adherend is often used as a synonym for substrate.

3.2 adhesion

interaction between the adhesive and the *adherend/substrate* (3.1) surface

Note 1 to entry: The interactions that make up adhesion are based on forces between the surface of the adherend/substrate and the adhesive film and include physical interactions, chemical bonds and micromechanical interlocking.

Note 2 to entry: Adhesion occurs in nm-dimensions.

3.3 adhesion promotor primer

liquid used in surface treatment to improve the adhesion of the adhesive to the *substrate/adherend* (3.1)

Note 1 to entry: Adhesion promoters often are named as primers, accelerators or activators.

3.4 adhesive

non-metallic material, which joins two *adherends/substrates* (3.1) together via adhesion and cohesion

3.5 adhesive bonding

special process for joining of *adherends/substrates* (3.1) by using an adhesive

Note 1 to entry: The adherends/substrates can be made of the same as well as of different materials and can have different surface characteristics.

3.6**adhesive bonding area**

area used to join two *adherends/substrates* (3.1) using an adhesive

Note 1 to entry: Usually the product of the overlap length and overlap width of the adherends/substrates.

3.7**adhesive bonding coordinator****ABC****responsible adhesive bonding coordinator****rABC**

competent person with proven professional skills in adhesive bonding technology responsible for the supervision and release of the adhesive bonding processes and for all activities associated with it including the release

Note 1 to entry: The responsible adhesive coordinator (rABC) is the appointed head of all adhesive bonding processes including their release and with the appropriate decision-making managerial authority concerning the adhesive technology within the company.

3.8**adhesive bonding operator****ABO**

execution personnel with proven corresponding knowledge applying or executing independently the adhesive bonding process to manufacture, maintain or repair components according to approved work instructions

3.9**adhesive bonding personnel****ABP**

people involved in the design, planning, manufacturing, quality assurance and maintenance/repair related to the adhesive bonding process

Note 1 to entry: As a rule, this employee group consists of ABCs (3.7) and ABOs (3.8).

3.10**adhesive bonding procedure**

all processes concerned with adhesive bonding such as surface treatment, processing the adhesive, application of the adhesive, joining the *adherends/substrates* (3.1), and solidification (curing/hardening)

3.11**adhesive bonding surface**

area prepared for adhesive bonding, or on which the adhesive is applied, or the surface of the part to be adhesively bonded with adhesive between two parts to be adhesively bonded [length of overlap × width of overlap mm]

3.12**adhesively bonded joint**

connection of two or more substrates (*adherends*) from the same material or different materials with the use of an adhesive

Note 1 to entry: An adhesively bonded joint can be defined as rigid coupling, flexible coupling or joint sealing. All three types of junction are based on the same principles of operation.

3.13**adhesively bonded structure
structure**

structure used for a partially or fully finished constituent or any other form of adhesively bonded item and designed mainly to transmit mechanical loads

Note 1 to entry: The loadbearing function is the main role of the adhesively bonded item ensuring reliability and fitness-for-purpose throughout the life cycle of the finished product.

3.14

adhesive tape

flexible backing or carrier coated with a pressure-sensitive, moisture- or heat-activated adhesive

3.15

ageing

entirety of all irreversible chemical and physical processes occurring in a material in the course of time

Note 1 to entry: This can relate to:

- evolution of the properties of adhesively bonded joints with time;
- reproduction of the real operating life through accelerating (reduce time) test of ageing in appropriated environment (chemical and mechanical).

3.16

application

placement of the adhesive during the adhesive bonding procedure

3.17

assembly

group of parts that has been placed together for adhesive bonding or has been adhesively bonded

3.18

clamping

holding of an adhesively bonded joint under pressure with clamps during solidification of the adhesive between the adherends

3.19

cohesion

internal strength that, for example, keep the molecules of an adhesive together

Note 1 to entry: These forces are based on attractive physical forces between the polymer chains, entanglement of the polymer chains, and chemical bonds inside and between the adhesive polymer chains.

3.20

component

one part of an adhesive system

Note 1 to entry: In adhesive bonding technology, the parts of an adhesive system (resin and hardener) are called components (component A and component B).

3.21

conditioning

exposure of *components* (3.20) and joining parts required for the adhesive bonding process for a reasonable period in compliance with the specified requirements

3.22

curing

chemical solidification of the adhesive

Note 1 to entry: Chemical reactions leading to solidification of the adhesive in the form of thermoplastic, elastomeric or thermoset polymers.

Note 2 to entry: This refers to chemically curing adhesives.

3.23

curing time

period of time required to solidify an adhesive *curing* (3.22) by chemical reactions

3.24**destructive testing**

analyses, tests and surveys carried out for the definition of information of qualitative/quantitative about specific properties of the analysed system, obtained following the destruction of the system itself

Note 1 to entry: The test specimen will be destroyed during the test and cannot be used afterwards.

3.25**exposure time**

length of time for which adhesively bonded joints are exposed under specified conditions

3.26**fabricator**

adhesive bonding workshops and/or sites under the same technical and quality management

Note 1 to entry: See *user-company* (3.59).

3.27**flash off-time**

minimum waiting time when using cleaners, activators or primers until the solvent has completely evaporated

3.28**high-modulus adhesive****load-bearing adhesive****structural adhesive**

adhesive where strength and stiffness are the most important properties after solidification

Note 1 to entry: In contrast, there are low-modulus adhesives.

Note 2 to entry: After solidification, high-modulus adhesives concentrate on their strength and stiffness, and less on their formability.

Note 3 to entry: The property transitions between high and low-modulus adhesives are fluid and not precisely defined [see *low-modulus adhesive* (3.37)].

Note 4 to entry: The term "structural adhesives" is often used for high-modulus adhesives. For the purposes of this document, the term "structural adhesives" is replaced by "load-bearing adhesives" (analogous: "load-bearing adhesive bonds" instead of "structural bonds").

3.29**hot spot**

small region or area with a high value of a quantity

EXAMPLE Stress, strain, energy.

Note 1 to entry: A hot spot can be calculated with FEM.

3.30**joining**

assembling of *components* (3.20) to become a whole

EXAMPLE Adhesive bonding is just one joining method. Other examples are welding, screwing and riveting.

3.31**influence**

non-mechanical parameters that are applied to a material which changes its properties

Note 1 to entry: The nature of the non-mechanical parameters influences the material behaviour (loading) and the load capacity to be selected.

Note 2 to entry: Further influences can have an impact on the adhesive selection.

3.32

in-production

all adhesive bonding activities after preparation, which are connected with the execution of the respective adhesively bonded joint/component until its completion

Note 1 to entry: See *pre-production* (3.42).

3.33

load

mechanical parameters that are applied to a material and lead to stresses and strains (deformations) in the material

Note 1 to entry: The type of mechanical parameters influence the material behaviour (stress, strain and/or strain energy) and the *load capacity* (3.34) to be selected.

3.34

load capacity

limit of the adhesively bonded joint to withstand stress, strain and strain energy

Note 1 to entry: The load capacity can be a permissible value.

3.35

load case

combination of loads and influences applied to an adhesively bonded joint at the same time

Note 1 to entry: Usually there are several load cases which describe different states in vehicle operation as well as in the manufacturing/repair process. Manufacturing/repair load cases are always to be evaluated in combination with the solidification state of the adhesive in the adhesively bonded joint and are basis for the determination of handling strength and commissioning times.

3.36

loading

physical results in the adhesively bonded joint due to the load and influence combinations defined in the *load case* (3.35)

Note 1 to entry: Physical results of the calculation can be e.g. stress, strain and/or strain energy.

3.37

low-modulus adhesive

adhesives that show an elongation at break of at least 100 % and a modulus of elasticity of at most 10 MPa after solidification

Note 1 to entry: This definition is adapted from ISO 21194. There is no scientifically exact definition. In these adhesives, the deformation properties are the dominant and less their strength and stiffness. Their opposites are the high-modulus adhesives. These adhesives concentrate on their strength and stiffness after solidification. The deformation properties take a back seat. The property transitions between high and low modulus adhesives are fluid.

3.38

mechanical properties

features relating to the behaviour of an adhesive or adhesively bonded joint when subjected to external physical forces (tensile forces, shear forces, abrasive forces, compressive forces, torsional forces, lap shear forces, etc.)

3.39

non-destructive testing

analyses, tests and measurements performed using methods that do not change the material and do not require the destruction or removal of samples of the test system, aimed at the investigation and identification of defects of the structure itself

Note 1 to entry: Each test specimen can be used afterwards without compromising the functioning of the product.

3.40**post-production**

all adhesive bonding activities after the execution of the adhesive bonding

Note 1 to entry: These activities include, among other things, the testing and evaluation of work samples during production, the adaptation of the adhesive bonding process, if necessary, the non-destructive testing (e.g. visual) of the manufactured adhesive bonds, the execution of repairs and repair work as well as disposal.

Note 2 to entry: See *in-production* (3.32).

3.41**pot life**

period of time during which a reactive adhesive shall be applied after mixing (the maximum processing time)

Note 1 to entry: This time depends on the speed of the chemical reactions responsible for polymer formation (curing speed) and also on the external boundary conditions (temperature, amount of mixture prepared). In order to create high-quality adhesive bonds, the pot life is strictly adhered to. Chemically curing adhesives that have exceeded their pot life are to be treated as waste and are unsuitable for application to joining surfaces. The pot life varies with the volume and temperature of the mixed adhesive and the environment.

3.42**pre-production**

all adhesive bonding activities prior to execution of the adhesive bonding

Note 1 to entry: These activities include the development and planning (including work preparation and workplace preparation) of the respective adhesive bonding and the respective adhesive bonding processes. In addition, verification that the real load of the adhesively bonded joint is always smaller than the maximum load capacity in the application (see [Clause 6](#)). After that, the adhesive bonding process can also be implemented in the respective production in the planned manner.

Note 2 to entry: See *in-production* (3.32).

3.43**pressure-sensitive adhesive**

adhesive that, in a dry state, is permanently tacky at room temperature and adheres readily to surfaces under light and brief pressure

Note 1 to entry: Pressure-sensitive adhesives are used, for instance, for the manufacture of pressure-sensitive tape.

3.44**qualification of the adhesive**

process for proving that the adhesive meets the requirements placed on it

3.45**competent personnel**

employees who have the required competences, knowledge and experience in adhesive bonding technology, who have acquired this through further training with a recognised credential, vocational training or comparable adhesive bonding technology activities and who can objectively verify this through recognised documents and unequivocally prove it

3.46**quality plan**

plan to define and document how customer requirements are to be met

3.47**reproducibility**

correspondence between the individual results obtained by the same procedure on identical tests

Note 1 to entry: This applies here to bonds produced under different conditions (different operators, different instruments, different laboratories, different laboratories) and/or at different times.