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DIN 2304-1:2020-04

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Foreword

This document has been prepared by Working Committee NA 092-00-28 AA "Adhesive bonding (DVS AG V 8)" of *DIN-Normenausschuss Schweißen und verwandte Verfahren* (NAS) (DIN Standards Committee Welding and Allied Processes).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. DIN shall not be held responsible for identifying any or all such patent rights.

Amendments

This standard differs from DIN 2304-1:2016-03 as follows:

- a) normative references and the Bibliography have been updated;
- b) the structure has been improved;
- c) the text has been made more precise and redundancies have been deleted throughout the document.

Previous editions

DIN 2304-1: 2016-03

1 Scope

This document specifies requirements for the high-quality design and workmanship of structural, i.e. loadbearing, adhesive bonds, covering all steps of the adhesive bonding process chain, from design to manufacturing and maintenance. It also specifies safety classes into which the bonds covered in this standard are to be classified. The requirements of the standard are to be specified according to these safety classes. As adhesion is a special process, it is necessary to implement these requirements for the safety of the bonded components.

A structural bond within the meaning of this standard is a material compound produced using adhesive(s) and designed mainly to transmit mechanical loads. Its loadbearing function ensures its reliability and fitness for use throughout the life cycle of the product. As part of a technical unit the bond in this material compound contributes to the strength and stability of the unit as a whole, or of part of the unit, or of a component. It is intended, in accordance with its requirement profile, to resist all stresses involved irrespective of whether these are static, dynamic or a combination of both, and whether or not environmental effects are to be considered.

The main function of transmitting mechanical loads basically involves any adhesive and is regardless of:

- the strength and deformation characteristics of the adhesive used (i.e. it covers all types of adhesive, from low-modulus, highly resilient to high-modulus, very stiff adhesives);
- the curing/hardening mechanism of the adhesive used (e.g. chemically curing, physically hardening, combined curing mechanisms, or material pre-coated with an adhesive, such as adhesive tape) and
- the sector in or for which the bonded assembly is intended to be used.

This standard shall not be used for bonds whose manufacturing is otherwise covered in recognized or proven technical rules, existing approvals or other standards.

DIN 2304-1 specifies definitions and sets out general organizational, contractual and technical principles to be followed when manufacturing adhesive bonds.

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.

DIN SPEC 2305-3, Adhesive bonding technology — Quality requirements for adhesive bonding processes — Part 3: Requirements for the adhesive bonding personnel

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

DIN and DKE provide terminology databases for use in standardization at the following addresses:

- DIN-TERMinology portal: available at https://www.din.de/en/services/din-term
- DKE IEV: available at http://www.dke.de/DKE-IEV

3.1

(adhesive) bonding

joining adherends by means of adhesion (surface bonding) and cohesion (internal strength) using a non-metallic material (adhesive)

3.2

special process adhesive bonding

adhesive process whose result cannot be fully established non-destructively in any subsequent quality or product tests and for which any defects may possibly be apparent only when the product is being used

3.3

adhesive

non-metallic material capable of joining adherends by surface bonding (adhesion) and internal strength (cohesion)

3.4

adhesive bonding staff

persons who use adhesive bonding technology at the contract review, design, production, manufacture, quality assurance and maintenance stages

3.5

adhesive bonding coordinator

KAP

persons or organizational units responsible for the adhesive bonding technology used and for activities associated with bonding; their suitability and knowledge have been demonstrated, e.g. through training, education and/or suitable experience

Note 1 to entry: Further information on the adhesive bonding coordinator (tasks, responsibilities, deputy regulation, appointment, qualification, etc.) are described in DIN SPEC 2305-3.

3.6

quality requirements

requirements regarding the execution of adhesive bonds

3.7

surface treatment

surface preparation

pretreatment

physical and/or chemical treatment applied to the surface of a substrate (adherend, fibre) to render it suitable or more suitable for bonding

[SOURCE: DIN EN 923:2016-03, term 2.5.8]

3.8

maintenance

combination of all technical, administrative and managerial actions during the life cycle of an object intended to retain it in, or restore it to, a state in which it can perform the required function

[SOURCE: DIN EN 13306:2018-02, term 2.1, modified — Notes to entry deleted]

3.9

contractor

person or organization responsible for the bonding process

3.10

bonding system

mutually compatible and proven components whose use enables a bond to be made that meets the relevant requirements

Note 1 to entry: Components include cleaners, primers, activators, adhesives.

3.11

place of use

place where a processing step is to be performed

4 Selecting the bonding requirements

Requirements for the high-quality workmanship of structural, i.e. loadbearing adhesive bonds shall be established by classifying them into safety classes. Within the meaning of this standard, these classes relate solely to the effects of any possible failure of the bond in transmitting forces, that is, the expected consequences of mechanical failure of the bond, i.e. the main function of the bond being the transmission of mechanical loads referred to in Clause 1.

The safety classification of bonds in this standard does not cover/include aspects such as their suitability for use with food, their fire resistance and their compliance with emission control regulations and any stipulations regarding occupational safety or environmental protection, since these are covered in other standards, codes of practice or technical rules.

The designer or the person dealing with the component concerned shall classify the bond into one of the following safety classes, taking into consideration the potential effects of bond failure:

- S1: high-level safety requirements;
- S2: medium-level safety requirements;
- S3: low-level safety requirements;
- S4: no safety requirements.

The safety class of the relevant safety requirements to be met by a bond shall be specified prior to its execution at the latest, or specified and documented by the fabricator with the support of the adhesive bonding coordinator, where there is one.

The requirements given in Clause 5 only relate to safety classes S1, S2 and S3.

In particular applications, safety classes may already be specified in other existing standards, approvals or classifications. In cases of doubt, the highest required class shall be assumed.

A component can include different types of bond, which may be assigned to different safety classes, depending on the requirements specified.

Where a bond is not to meet at least a low-level safety requirement S3, this bond can be assigned to class S4 without safety requirements.

Table 1 illustrates the classification of bonds as a function of the relevant level of safety requirements.

Safety class	Level of safety requirement
S1	High level Failure of the bond — will directly or indirectly lead to an inevitable hazard to life or limb; — will result in a failure of the functionality, the effect of which will most likely lead to an inevitable hazard to life or limb.
S2	 Medium level Failure of the bond can lead to a hazard to life or limb; will result in a failure of the functionality, the effect of which will probably involve personal injury or result in major environmental damage.
S 3	 Low level Failure of the bond will result in a failure of the functionality, the effect of which will probably not involve personal injury or result in major environmental damage; will result in a failure of the functionality, the effect of which will at most affect comfort or performance.
S4	 No safety requirement Failure of the bond — will result in a failure of the functionality, the effect of which will not, under foreseeable circumstances, involve personal injury or result in environmental damage; — will result in a failure of the functionality, the effect of which will only affect comfort or performance.

Table 1 — Classification of bonds as a function of the level of safety requirements

A bond may be assigned to a higher safety class for environmental, economic, quality or functional reasons, for example.

5 Requirements to be met by the process chain for safety classes S1, S2 and S3

5.1 Infrastructure

5.1.1 Manufacturing environment

The manufacturing areas shall be designed to suit the bonding system used in terms of equipment, occupational safety and environmental protection. This includes ensuring the necessary ambient conditions, such as temperature, humidity, lighting, cleanliness, access restrictions, exclusion of any substances unduly affecting bonding, air quality, air flows. Areas shall be available where adherends, adhesives and auxiliary materials can be stored in a way consistent with the particular requirements. For the storage of hazardous materials, storage areas shall be provided that comply with the relevant regulations. Bonding areas shall be specified.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- any provisions for the work environment shall be documented;
- proof of compliance with the provisions shall be provided;
- in areas where bonding work is done, the use of substances unduly affecting adhesion (e.g. silicones, PTFE spray, etc.) is only permitted subject to the consent of the coordinator, who shall ensure that no carry-over occurs, e.g. through ventilation measures or use of the same tools;
- for any bonding tests to be carried out at the works, a suitable area shall be provided;
- bonding areas shall be identified.

5.1.2 Transportation

Supply, in-house transport and dispatch of adherends, adhesives and auxiliary materials, and bonded components shall be carried out in accordance with the relevant requirements, e.g. technical provisions (e.g. as set out in technical data sheets).

5.1.3 Infrastructure, maintenance and adaptation

Instructions shall be provided covering the servicing, maintenance and adaptation of the infrastructure to suit the current bonding requirements.

In addition, for safety class S1 and class S2 bonds, the following requirement shall be complied with:

— any servicing, maintenance and adaptation of the infrastructure shall be documented.

5.2 Staff

5.2.1 General

The contractor shall have sufficient qualified staff for the design, execution and supervision of the bonding process as a whole in accordance with the specified requirements.

NOTE Further information is given in DIN SPEC 2305-3.

5.2.2 Adhesive bonding coordinators

At least one person shall be designated as adhesive bonding coordinator. DIN SPEC 2305-3 specifies the relevant requirements, tasks and responsibilities of a coordinator. As a minimum, the adhesive bonding coordinator shall have proven basic bonding technology expertise in accordance with DIN SPEC 2305-3. Where a number of persons have been named coordinator, each person shall have the required competences.

The competences required for bonding work shall be specified in consultation with the coordinator.

The names of all persons involved in bonding work, together with their professional qualifications and any certificates, shall be documented.

In addition, for safety class S2 bonds, the following requirements shall be met:

- the coordinator shall have at least proven specific bonding expertise;
- persons designated as coordinator shall not also be charged with bonding work.

In addition to safety class S2 bonds, for safety class S1 bonds, the following requirement shall be met:

 the coordinator for the overall bonding process shall have proven comprehensive bonding technology expertise.

5.2.3 Bonding personnel

The persons carrying out bonding work shall have at least proven basic bonding expertise.

In exceptional cases, the coordinator may permit persons not having this qualification to make safety class S3 bonds. Such permission shall cover only individual bonds or operations. The staff members entrusted with the work shall be properly instructed by the coordinator or by staff authorized by the coordinator. It shall be the coordinator's responsibility to justify and document the reasons on which this permission is based.

The required specialist qualifications of the staff shall be specified for each bonding process. Prior to starting production, it is to be ensured that sufficient qualified staff is available for the bonding work to be done.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- at the time of bonding, it shall be possible to contact the coordinator who is empowered and authorized to specify necessary measures in the event of process deviations; alternatively, there shall be a process approved by the coordinator which regulates measures in the event of deviations;
- process deviations and any measures taken shall be documented.

5.2.4 Further training

Coordinators shall attend further training courses offered by a third party at least every two years.

The bonding personnel shall also attend training courses at least every two years. The content and duration of such training shall be specified in consultation with the coordinator.

Any further training shall be documented.

5.3 Checking the contractual provisions

It shall be the contractor's responsibility to check compliance of the contractual provisions with the provisions set down by the client and with any in-house guidelines set by the contractor themselves. It shall be ensured that any information required for carrying out the work is available prior to its commencement.

The contractor shall confirm to the client that all work will be done in compliance with the contractual provisions regarding bonding requirements.

NOTE See Annex A.5 for possible sources of contract review requirements.

The contractor, in their own interest, should ensure that any differences between the contractual provisions and any prior offer documents are verified, and that the client is informed about any modifications to the programme, costs and workmanship that may result from these differences. The client shall ensure that all relevant information is made available.

If, in the course of time, there are structural changes, for example, with respect to staff or equipment, it shall be checked whether these changes will affect quality. If so, any necessary measures are to be taken and are to be set down in the contract.

In addition, for safety class S1 and class S2 bonds, the following requirement shall be complied with:

 any contractual review by the contractor with regard to process steps that require special knowledge is to be documented.

5.4 Development and design

5.4.1 General

The functional capability of a bond shall be deemed to be achieved if all requirements specified are satisfied. This will be ensured only if all of the following aspects are coordinated and are adequately dealt with giving due considerations to the requirements.

5.4.2 Assignment to safety classes

Each bond shall be assigned to a safety class in accordance with Clause 4 on the basis of any potential consequences of failure in terms of safety. The safety class shall be specified and documented in consultation with the adhesive bonding coordinator.

5.4.3 Requirements to be met by the bonds

The requirements to be met by the bonds shall be established in consultation with the adhesive bonding coordinator.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- a procedure shall be developed and documented that ensures that the requirements from all relevant areas are established;
- the determined requirements shall be documented (e.g. in a list of requirements);
- proof is to be provided that the adhesive bonding coordinator has checked the requirements relating to the bond.

5.4.4 Design of bonds

The area of bonding surfaces, their location, the distribution and the dimensions of the adhesive between adherends after hardening shall be specified and documented.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- the bonded joint dimensions (joint width, length, thickness) shall be toleranced, and compliance with these tolerances shall be ensured; tolerances shall be specified as a function of the requirements to be met by the adhesive system and the overall structure;
- the relative position of adherends shall be clearly specified and shall be toleranced.

5.4.5 Adherends

The properties of adherends and their as-delivered condition shall be defined.

In addition, for safety class S1 and class S2 bonds, the following requirement shall be met:

— the design of adherends, in particular their behaviour under the expected stresses, shall be defined and documented so as to permit them to be reproducibly manufactured.

5.4.6 Adhesive

The type of adhesive, together with its components, its field of application and place of use shall be specified.

5.4.7 Surface treatment

The surface treatment, with all its stages, the materials used, the place of use and the working sequence shall be specified and defined.

5.4.8 Factors affecting the bonding process

All factors affecting the bonding process (e.g. ambient conditions, processing times, stresses involved in the manufacturing process) shall be assessed and defined in cooperation with the adhesive bonding coordinator and the process design department (see 5.6) and defined.

5.4.9 Verification

5.4.9.1 General

Verification is a procedure intended to provide evidence that the construction complies with the requirements.

For safety class S1 and class S2 bonds, at least one of the following types of verification shall be applied:

The verification process shall be documented. It shall be demonstrated that the assembly or component meets the requirements throughout its life cycle and intended service life.

Verification may be made using one of the following methods:

- 1) providing proof that stresses are lower than the stress resistance;
- 2) assembly/component testing;
- 3) documented experience;
- 4) combination of methods 1 to 3.

Verification shall cover not only the strength or stability under service conditions. It shall also include aspects such as adhesion, deformation behaviour, chemical resistance and stresses during manufacture, etc.

5.4.9.2 Method 1 — Stress < stress limit

5.4.9.2.1 General

A safety factor shall be specified based on the quality of information obtained regarding stresses and stress resistance; this is to be documented in a transparent way. Where laboratory values are used for assessing

the bond, proof is to be provided that these results were obtained under real manufacturing conditions (process validation).

In addition, for safety class S1 bonds, the following requirement shall be met:

Process validation shall be repeated throughout the period of manufacture at reasonable, specified intervals, using suitable methods. These measures and their scope shall be specified and documented by the adhesive bonding coordinator.

5.4.9.2.2 Stress

Stresses can be derived from the list of specifications. They shall be determined by testing or calculation, or taken from standards or empirical data, or using a combination of these. Stresses shall always take into consideration maximum values, exposure times, ambient conditions and any possible combination of these. Statistically substantiated information on the quality, intensity, duration and frequency of stresses throughout the life cycle shall be obtained. The method by which such information was obtained shall be transparent and shall be documented.

5.4.9.2.3 Stress limit

The stress limit of bonds can only be determined by testing. Tests can be performed using test pieces, test components or an actual component as in service. Unless otherwise explicitly specified in the requirements list, bonds should show cohesive failure in the case of destructive testing. Substrate failure shall be considered separately. If testing is not carried out on an actual component or is not performed under actual conditions, evidence shall be provided in a transparent way that deviations from the service conditions (e.g. accelerated ageing, testing agents used, combinations of agents) are suitable for qualifying the bond for the intended usage. Test results shall always be adequately evaluated statistically. The parameters determined shall be characteristic values with a specified survival probability. Data (e.g. test methods, results) shall be obtained in a transparent way and shall be documented.

5.4.9.3 Method 2 — Component testing

Component testing is understood to be testing the system as a whole or part of it under actual conditions or conditions reproducing the service conditions. Test conditions shall be adequately similar in terms of their effect on the bond, proof of which is to be provided. When testing partial systems, the interaction between these and the system as a whole shall be considered and verified so as to make sure that the interaction does not unduly affect the results. For evaluation purposes, a failure criterion shall be defined. Test results shall be adequately evaluated statistically. Depending on the knowledge regarding the bond, how far the test conditions are realistic and the statistical evaluation applied, a safety factor shall be integrated into the failure criterion or test conditions. The entire process shall be documented. Any decisions made and justifications for them shall be documented.

5.4.9.4 Method 3 — Documented experience

If verification is based on experience, plausible proof shall be provided that the construction has proven itself to be adequate. To this effect it shall be demonstrated that the behaviour of the bond under service conditions can be applied to the bond under consideration in terms of service life, loading conditions and bond properties. The procedure shall be documented in a transparent way.

5.4.9.5 Method 4 — Combination of method 1 to method 3

If the verification is performed by combining the above methods, it is to be ensured that this is suitable for adequately considering all requirements. Care shall also be taken to ensure that all parts of the verification process are mutually compatible (e.g. when comparing test results with the requirements). The procedure shall be documented in a transparent way.

5.5 Subcontracting the process to realize a bond

5.5.1 Principles

As a rule, all requirements specified for the final product are to be complied with, irrespective of who will provide which services.

It shall be ensured that all necessary documents and requirements have been made available to the subcontractor, who is to be in a position to satisfy these requirements, regardless of whether a service or bonded product is concerned.

Given the fact that the result of bonding work cannot be checked without destroying the bond, it shall be the customer's responsibility to ascertain that the processes at the subcontractor's works intended to ensure compliance with the requirements are effective. External subcontractors are also to meet the relevant requirements specified in this standard.

5.5.2 Deciding on subcontracting

The decision as to whether any work is to be subcontracted and as to the extent of any subcontracting shall be made in a transparent way.

In addition, for safety class S1 and class S2 bonds, the following requirement shall be met:

— the decision-making process shall involve the adhesive bonding coordinator.

5.5.3 Details and documentation of procurement

The scope of the service to be provided shall be described correctly, completely, clearly and so as to be easy to understand.

All requirements from the list of requirements that are to be satisfied within the scope of work or service shall be established. The above description and the requirements shall be documented.

5.5.4 Selection of suppliers and contracting

A suitable supplier shall be selected in accordance with the scope of work or service to be provided and the requirements to be satisfied.

Supplier and customer shall have reached agreement on a contract.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- any changes to the documentation shall be subject to agreement between both parties and be clearly identified;
- suppliers shall be selected with the involvement of the adhesive bonding coordinator.

5.5.5 Supplier management

For safety class S1 and class S2 bonds, the following requirements shall be met:

- measures for supplier monitoring (at product and process levels) shall be drawn up and implemented. Their planning and implementation shall be documented;
- design and implementation work shall involve the adhesive bonding coordinator.

5.6 Process planning

5.6.1 General

The process planning involves specifying the bonding process so as to ensure that the requirements to be met by the product and process are complied with in an economic and reproducible way.

The requirements derive from:

- provisions associated with the bonding technique;
- customer requirements (e.g. as regards certification, documentation);
- structural requirements;
- occupational safety, health and environmental protection;
- legal requirements;
- in-house guidelines.

The following shall be considered when planning a bonding process:

— the requirements to be met by the manufacturing process shall be established.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- the process planning shall be documented in a way that ensures all relevant areas are involved;
- the documentation shall be checked by the adhesive bonding coordinator.
- in the case of third-party designs, i.e. designs under the client's responsibility, these planning documents (e.g. drawings) shall be checked by the bond manufacturing plant to ensure that all the necessary information in accordance with this standard is available and has been released by the adhesive bonding coordinator for manufacture at this plant.

5.6.2 Bonding as part of the overall manufacturing process

The point in time in the overall manufacturing process at which bonding is to be carried out shall be specified and documented.

In addition, for safety class S1 and class S2 bonds, the following requirement shall be met:

moving the bonding process to a different point in time requires the adhesive bonding coordinator's consent.

5.6.3 Work sequence and manufacturing technology

The steps of the bonding process and their sequence are to be specified, as shall be the manufacturing technology used (e.g. tools, level of automation).

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- work sequence and manufacturing technology used and the relevant tests (process, product) shall be documented;
- proof of suitability of the manufacturing technology selected shall be provided. This proof can be based on experience (the transferability and applicability shall be demonstrated) or take the form of proof of capability (e.g. machine capability test, process capability test);
- the specified type, scope and time of the process validation shall be complied with and their performance documented.

5.6.4 Planning the use of production aids and tools

The use of any necessary production aids and tools is to be planned and their availability at the start of production shall be ensured (even after modifications to the process or product).

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- production aids and tools specific to bonding shall be documented for each particular bonding process;
- requirements for production aids and tools shall be specified and their suitability shall be demonstrated;
- their proper functioning throughout the manufacturing process, which also applies to automated manufacturing, shall be ensured.

5.6.5 Manufacturing documents

For each bonding process, documents (see Annex A, A.2) shall be prepared or be available which describe the details of work to the bonding staff. Design documents can also be used as manufacturing documents.

Manufacturing documents are to provide all information relevant to bonding work, as detailed above.

Manufacturing documents shall be up-to-date, correct, controlled, complete, clear and easy for the bonding staff to understand.

It shall be ensured that they contain all information necessary for the reproducible production of a bond that meets the requirements.

Manufacturing documents relating to bonding work shall be released by the coordinator.

For safety class S3 bonds, the scope of documentation shall be specified by the contractor. See Annex A, A.3 for information on documentation.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- where the manufacturing process is automated, the parameters of the equipment relevant to bonding shall be defined, complied with and documented;
- processes shall be documented in order to ensure traceability (see Annex A, A.3);

The documentation (bonding report) shall include at least the following:

- date and time;
- ambient conditions where relevant to bonding work;
- process parameters;
- bonding system: bonding products, batch numbers, expiry dates;
- identification of components and adherends;
- signature or identity of bonder;
- description of action taken in the case of process deviations (to be approved by the adhesive bonding coordinator).

5.6.6 Process release

For safety class S1 and class S2 bonds, the following requirements shall be met:

- the process design as completed shall be released by the adhesive bonding coordinator;
- the release can be effected by releasing the manufacturing documents;

In addition, for safety class S1 bonds, the following requirement shall be met:

— the release shall be documented in a transparent way.

5.7 Storage and logistics for adherends, adhesives and auxiliary materials

5.7.1 Incoming goods inspection

In the incoming goods inspection, goods are to be checked for correct marking and an adequate shelf-life, and their containers are to be visually inspected (e.g. for any damage). Where materials are subject to specific requirements (e.g. regarding the temperature), these shall be complied with.

In addition, for safety class S1 and class S2 bonds, the following requirement shall be met:

— quality-relevant transport conditions shall be specified in documentation.

In addition, for safety class S1 bonds, the following requirement shall be met:

— compliance with the quality-relevant transport conditions shall be checked and documented.

5.7.2 Storage

The quality-relevant storage conditions shall be defined and maintained. It is also to be ensured that no adhesive or auxiliary materials are used if their expiry date has expired and if they have not undergone any new check by the adhesive manufacturer with a view to extending their shelf-life. Such an extension shall be made in writing and be documented.

It is to be ensured that there is no contamination by substances which adversely affect adhesion and which are not safely removed by the cleaning step prior to bonding.

The storage conditions shall be known as regards any possible adverse effects, including those on components (e.g. contamination of bonding surfaces).

In addition, for safety class S1 and class S2 bonds, the following requirement shall be met:

a storage system shall be provided or there shall be documented instructions ensuring that no adhesives
or auxiliary materials in stock have exceeded their expiry date.

In addition, for safety class S1 bonds, the following requirement shall be met:

— the storage conditions shall be documented.

5.7.3 In-house transport

During in-house transport, materials shall not be unduly affected by adverse conditions (e.g. moisture, temperature, light).

5.7.4 Provision of materials

Materials and adherends needed for bonding shall be conditioned for an adequate period in compliance with the requirements specified.

The shelf-life of adhesives and auxiliary materials shall be recognizable at any time during manufacture. For traceability purposes (see Annex A, A.3), the date at which a container was opened for the first time shall be documented.

5.8 Manufacturing

5.8.1 Process validation

For safety class S1 and class S2 bonds, the following requirements shall be met:

- following the design stage it is to be checked that the procedure specified will fully comply with the technical requirements, i.e. it is to be verified that the process as designed is feasible in its entirety and that the product can be consistently manufactured in terms of quantity and quality as required by the client;
- there shall be a preliminary check of all individual steps of the manufacturing process;
- results shall be substantiated by preparing sample bonds and by test records;
- process data shall be determined and documented in accordance with the established procedure; in doing this, due consideration shall be given to the interfaces between process stages (storage, transport, effect of any downtimes on the upstream and downstream stages);
- the first bond shall be prepared with the assistance of the production planner and the coordinator, due consideration being given here that the entire manufacturing process reflects the conditions of the later series production. The assistance shall be documented.

In addition, for safety class S1 bonds, the following requirement shall be met:

at the start of production at the latest, proof shall be provided that the design parameters (strength, deformation characteristics) are complied with; this can also be done by component testing (see 5.4.9.3) or by testing work samples.

5.8.2 Periodic product validation

For safety class S1 and class S2 bonds, the following requirements shall be met:

- work samples (see Annex A, A.4) shall be prepared at specified intervals, in accordance with the
 procedure specified; for process assurance, at least sufficient adhesion and cohesion shall be
 qualitatively proven by the user company;
- conformity with the requirements shall be checked using specified methods. This is to be documented. The testing equipment and methods used shall be qualified.

5.8.3 Instruction of staff

Prior to and after the start of production and using the manufacturing documents, the staff involved in bonding work are to be instructed as to the individual processing steps and tests to be carried out. It shall be ascertained that:

- the staff have understood and accepted the instructions;
- the processing steps (sequence and duration of process stages) as designed are feasible;
- tolerances are realistic;
- production aids and tools fulfil the designated function;
- the staff are adequately qualified.

In addition, for safety class S1 and class S2 bonds, the following requirement shall be met:

 each staff member shall be instructed prior to the first bond they will make, and this shall be documented.

5.9 Maintenance

5.9.1 General

Generally, all requirements specified for new bonds also apply to maintenance processes. Below, only aspects specific to maintenance are dealt with.

5.9.2 Maintenance planning

Where a bond to be made as part of maintenance work has not been classified, the responsible designer, together with the adhesive bonding coordinator, shall assign a safety class (see Clause 4, particularly Table 1) to the bond.

The type of maintenance work concerned is to be defined prior to planning.

Prior to starting maintenance, it is to be checked whether the intended measures have already been planned. If not, the measures shall be planned first (see 5.6).

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- if a process to be used (using specified materials) has already been released, it is to be ensured that this process is applicable to the case in question;
- if a process (using materials still to be specified) is to be qualified for the first time with the support of the adhesive bonding coordinator, its suitability for the intended purpose is to be verified and documented (see 5.6);
- if a bond is made based on the parameters of a process already released, but with certain deviations for the new bond (e.g. bonding on an old bead using the same adhesive), any deviating stages shall first be approved;
- ideally, maintenance work is to be specified when qualifying a new design;
- given the fact that a bond mostly cannot be tested non-destructively, maintenance work shall be designed so that the serviceability of the bond is ensured;
- since the factual circumstances (e.g. bonding surfaces, adhesion, contamination) will become apparent only during maintenance work, any possible alternatives shall be considered already at the design stage, or a process is to be designed that ensures a reliable procedure at the time of work;
- in order to ensure a consistent quality of manufacture, accompanying testing is to be carried out as follows:
 - the type, scope and time of testing are to be specified;
 - the decision-making process shall be documented.

5.9.3 Maintenance instructions

Instructions shall be drawn up for maintenance work, specifying the necessary procedures to be followed by the bonder in bonding work.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- it shall be the designer's responsibility to release the design of maintenance work, in consultation with the adhesive bonding coordinator;
- the release shall be documented in a transparent way.

5.9.4 Performing maintenance work

Where maintenance work is done on sites outside the contractor's responsibility, the adhesive bonding coordinator of the company actually doing the work is to ensure that all necessary conditions are complied with prior to, during and after bonding work. If the responsibility is to be defined in a different way (e.g. in a client-contractor relationship), this is to be contractually agreed. The person responsible shall have the qualifications in accordance with the requirements specified in this standard for bonding work (see 5.2).

In addition, for safety class S1 and class S2 bonds, the following requirement shall be met:

— staff charged to carry out maintenance work shall have at least proven basic technical competence in bonding technology which allows them to identify any anomalies specific to the particular work (e.g. corrosion, voids, insufficient adhesion) and report these in accordance with the in-house procedures.

5.9.5 Documentation

For safety class S1 and class S2 bonds, the following requirement shall be met:

— the maintenance process shall be documented, at least reporting the data in the bonding report (see Annex A, A.3) and the area concerned.

5.10 Monitoring of measuring and test equipment and of production aids and tools

5.10.1 Monitoring measuring equipment

Any measuring equipment used in the bonding process shall be monitored. This applies, in particular, to instruments for measuring the ambient temperature, the component temperature and humidity, balances required when using two-component adhesives, and equipment for measuring the radiant intensity where light curing is involved.

In addition, for safety class S1 and class S2 bonds, the following requirement shall be met:

— measuring equipment is to be calibrated at specified intervals.

5.10.2 Monitoring bonding equipment

Bonding equipment shall be monitored with respect to its function and cleanliness. This applies, in particular, to application devices and equipment used for curing the adhesive. Where equipment requires maintenance, this shall be done by trained staff.

In addition, for safety class S1 and class S2 bonds, the following requirement shall be met:

— monitoring of the equipment and training of staff shall be documented.

5.10.3 Monitoring test equipment

Proof shall be provided that all test equipment used in the bonding process is monitored. This applies, in particular, to testing machines, surface measuring instruments and analytical equipment.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- test equipment is to be calibrated at specified intervals;
- proof shall be provided that the staff using the equipment have been trained.

5.11 Occupational health and safety and environmental protection

In addition to the requirements specified in this standard, all relevant legal requirements and regulations of the industrial employers' liability insurance associations shall be complied with.

5.12 Quality management

5.12.1 General

If a quality management system exists, the requirements of this standard can be integrated into it accordingly.

5.12.2 Control of planning and manufacturing documents

Planning and manufacturing documents shall be controlled. Information relevant to the bonding process shall be stored in such a way that it is available at any time when this information is needed in the company. In particular, it is to be ensured that at the time of bonding all current manufacturing documents have been made available to the staff member carrying out the bonding work.

5.12.3 Documentation, marking, traceability

All adhesives, auxiliary materials, adherends and production aids/tools shall be marked so as to permit easy identification with respect to the manufacturing documents.

5.12.4 Control of information

It shall be ensured that relevant information is transferred at the interfaces of the manufacturing process (e.g. process time after which further transport can only take place, internal transport of frost-sensitive substances).

The flow of information relevant to the bonding to the adhesive bonding coordinator shall be ensured.

5.12.5 Action in the case of deviations

Processes shall be established to control the flow of information, decision-making channels and the behaviour of staff involved in the bonding process in the case of process disruption and deviations.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- process disturbances which lead to the interruption of the bonding process shall be defined;
- it shall also be specified under which conditions the bonding process may be restarted;
- all staff involved in the bonding process shall be duly instructed in the procedures;
- the process and instructions shall be documented.

5.12.6 Control of faulty products

There shall be a process for controlling faulty products.

In addition, for safety class S1 and class S2 bonds, the following requirements shall be met:

- the handling of superimposed adhesives and auxiliary materials shall be regulated;
- the handling of superimposed adherends and components shall be regulated.

5.12.7 Preventive and corrective action

A process shall be established that governs any preventive or corrective actions (e.g. where the adhesive composition or the surface condition of bonding surfaces changes, etc.).

Annex A (informative)

Manufacturing documents

A.1 General

The following description of manufacturing documents is intended to illustrate the variety of their content. Not all items listed need to be applied and/or are applicable to a particular bond. On the other hand, additional points not listed here can be relevant. The list is intended to be used as a checklist facilitating the drawing up of manufacturing documents.

A.2 Working instructions

The working instructions are based on the following:

- standards, codes of practice, instruction sheets;
- bonding design documents (drawings, parts lists, proofs of suitability, bonding procedure plans);
- information specific to the products (e.g. technical data sheets, safety data sheets, any other product information);
- sector-specific information.

The working instructions should include the following:

- revision status and date of issue;
- adhesives, auxiliary materials, sealing materials (types and form supplied);
- any special tools and equipment;
- requirements regarding in-house conditions (e.g. qualifications of staff, working site conditions, ambient conditions such as temperature, humidity, lighting);
- mark of approval of adhesive bonding coordinator;
- detailed description of process, as regards, for example:
 - checking adhesives and auxiliary materials (types, required quantities, shelf-life, expiry date of adhesive in opened containers, any damage to containers, obvious deviations in colour or consistency);
 - checking adherends (types, any damage incurred, fitting accuracy, condition of bonding surfaces, required quantities);
 - conditioning of adherends, adhesives, primers and other agents at an appropriate site under suitable ambient conditions;
 - cleaning (cleaning agents, cleaning accessories, flash-off times, monitoring of baths, avoidance of recontamination);

- surface preparation (method used, parameters concerned, any checking of preparatory work, measures taken to avoid recontamination, specifying the maximum/minimum period until the start of the bonding process);
- preparation of adhesives (batching, mixing ratio, mixing tolerances, degree of blending);
- adhesive application (auxiliary materials, quantity, method of application, wetting, appearance);
- bonding (thickness of bond layer, width of adhesive layer, contact pressure, wetting);
- clamping (fixtures, pressure, duration);
- curing (duration, temperature, other relevant parameters).

Moreover, the following may also be included:

- information regarding quality assurance and process control;
- information regarding fault correction;
- requirement for a manufacturing documentation;
- information regarding occupational health and safety, environmental protection and waste management.

A.3 Traceability

The documentation should include the following information:

- revision status;
- date and time;
- details of ambient conditions;
- process parameters;
- bonding system: bonding products, batches, expiry dates;
- identification of components and adherends;
- signature or identity of person carrying out the bonding work;
- description of measures taken in the case of process deviations (to be taken only in consultation with the adhesive bonding coordinator (see 5.6.5.2), who is to give consent by signing);
- documenting or recording of bonding process (bonding records);
- notice of control by the adhesive bonding coordinator.

A.4 Process control during manufacture

If the quality of the bond cannot be established by component testing, work samples should be qualitatively checked at specified intervals for at least proper adhesion and cohesion for the bonding process specified.

The following details are to be specified:

The following details are to be specified:

- type and number of work samples;
- point in time of preparing the work samples during the component manufacturing process;
- frequencies;
- manufacture of work samples;
- curing conditions of work samples;
- testing and assessment of work samples.

A.5 Sources of contract review requirements

The contractual provisions can refer to:

- required application standards and any supplementary requirements;
- specifications for the bonding work to be done;
- details regarding the material and surface characteristics of the adherends;
- specifications regarding any surface treatment;
- quality documentation agreed with the client;
- specifications for the bonding technique to be used;
- specifications for testing and test methods;
- specifications for equipment to be used;
- approach regarding approval of the bonding technique to be used;
- recognition of staff qualifications;
- types, marking and/or traceability of adhesives and auxiliary materials, for example, and details of bonding work of the staff;
- provisions for quality control including any additional commissioning of an impartial testing house;
- any other bonding requirements, e.g. purity of abrasives, temperature and/or humidity;
- ambient conditions on site affecting bonding work, e.g. a very low ambient temperatures or any restrictions regarding surface treatment;
- any subcontracting permitted;
- measures to be taken in cases of non-conformity.

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¹ Obtainable from *Beuth Verlag GmbH* at http://www.beuth.de/en.