

**Studies and Analyses** DIN Standards Become International **Applications** A Suitable Mixing Technology for Every Application **Plant and Processing Equipment** Solutions for the Mobility of Tomorrow

# Adhesives for Renewable Energies Next-Generation Adhesives for Wind Turbine Blades

# DIN Standards Become International

Standards-based quality assurance in adhesive bonding technology is progressing. The starting point was the publication of the world's first series of standards in 2006, DIN 6701 "Adhesive bonding of railway vehicles and components". In 2016, this was followed by DIN 2304-1 for all other areas of adhesive bonding technology applications outside of rail vehicle construction. With the now worldwide application of national DIN 6701 and DIN 2304, these are currently being transferred to international standards.

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Adhesive bonding is one of the "special processes" that cannot be tested and verified one hundred percent non-destructively. In accordance with the Product Safety Act (PSG), adhesive bonding technology and adhesively bonded products must also be carried out in accordance with the state of the art. In order to realise this legally binding requirement, special processes for prophylactic error prevention require the implementation of a quality management system (QMS), for example in accordance with ISO 9001. This existing QMS is concretised adhesive bonding-specifically on the basis of the QA standards. Therefore, for the special process of adhesive bonding and for adhesively bonded products, the legally required state of the art consists of the inseparable linking of PSA, QMS and QA standards.

Standard-based quality assurance in adhesive bonding technology began in 2006 with the publication of DIN 6701 – "Adhesive bonding of rail vehicles and parts", the world's first series of standards to regulate the organisation and implementation of adhesive bonding technology processes for this area of application. The series of standards DIN 6700 and EN 15085, which were successful for the equally special process of welding in rail vehicle construction, served as a model for this (*Figure 1*). Their basic structure with the core elements "classification according to

safety requirements", " assignment of verifiably qualified personnel" and "verification of the safety of the respective joint" was adopted and adapted to adhesive bonding technology.

In 2016, DIN 2304-1 – "Adhesive bonding technology – Quality requirements for adhesive bonding processes/Part 1: Process chain for adhesive bonding" followed with the same basic structure of the above-mentioned core elements. Following the example of the DIN 6701 series of standards, it regulates the adhesive bonding technology process organisation and implementation for all other areas of adhesive bonding technology applications outside of rail vehicle construction.

With DIN 6701 and DIN 2304, there is now a comprehensive quality assurance concept for adhesive bonding technology processes that is normatively anchored in all areas of application. [1]

### "State of the art" for adhesive bonding

In order to be able to use a material, a product made from it or a process safely, work must be carried out according to the "state of the art", especially in the case of safety-relevant products [2]. This is legally binding across materials, applications and technologies and is based on the Product Safety Act [3] (PSA), according to which a product - consequently also an adhesively bonded product - may only be placed on the market "if it does not endanger the safety and health of persons when used as intended or in a foreseeable manner". If this verification for processes and products cannot be carried out with non-destructive methods and one hundred per cent certainty, then according to ISO 9001 there are "special processes" in the underlying manufacturing procedures [4] [5]. For these, ISO 9001 requires the introduction of a Quality Management System (QMS) for the comprehensive prevention of process and product errors that cannot be verified one hundred per cent non-destructively, in order to avoid these errors from the outset [6].

For special processes and products manufactured with these processes, the Product Safety Act links its legally binding requirement of safety verification with the avoidance of defects without exception. This covers the entirety of the period from the beginning of a product development phase to the end of product use.

In this context, the adhesive bonding QA standards take on the main function of concretising the ISO 9001 core idea of error prevention for adhesive bonding processes and products in an adhesive bond-ing-specific way on the basis of an existing QMS [7], so that this helps the user companies to achieve safe adhesive bonding. [8]

# Welding/adhesive bonding technology: some examples of quality standards



Figure 1 Quality-assuring welding standards and adhesive bonding standards – transfer of a success story

The necessary basis for this is given, because today's adhesives and sealants are high-tech products and their production can be described as a "mastered process" [9] in the context of standards. Under the premise of professional use, they generally enable zero error production.

Occurring adhesive bonding errors are therefore mostly due to adhesive using errors and not to adhesive manufacturing errors [10]. For this reason, the QA standards pursue the goal of designing adhesive bonding application processes in such a way that the entirety of the adhesive bonding process, that is the adhesive production and at the same time the adhesive application, is mastered [11]. They define both the requirements for quality-appropriate development and execution of adhesive bonding joints and the general organisational, contractual and manufacturing fundamentals for the development and manufacture of adhesively bonded joints [12]. Therefore, the quality standards support the state of the art for the professional, error-avoiding organisation and implementation of adhesive bonding technology processes in all areas of industry and

handicraft, from the product life phase of planning and development, through manufacture and utilisation, to end-of-life. For adhesive bonding technology, the legally required and thus legally binding state of the art is therefore the inseparable link between the legally binding EU product safety law, QMS, for example in accordance with ISO 9001 and the QA adhesive bonding standards (Figure 2) [13]. By implementing the adhesive bonding technology QA standards, the user designs the entirety of the adhesive bonding process and all product life cycle phases of adhesively bonded products to be robust and reproducible, which is "mastered" in the standards sense.

# Company certifications according to DIN 6701 and DIN 2304

Companies using adhesive bonding technology can be certified according to the DIN standards mentioned. Certification bodies have been set up and approved for this purpose. These are accredited by the German Accreditation Body – DAkkS according to DIN EN ISO/IEC 17065 and officially approved for company certifications according to DIN 6701 and DIN 2304. In this context, the working groups "adhesive bonding DIN 6701" and "adhesive bonding DIN 2304" were founded [16]. In accordance with their respective rules of procedure, their tasks are, among other things, to approve certification bodies and their auditors, to control the certification bodies and to harmonise the respective certification activities in such a way that the equivalence of the company certificates valid for three years is given. Furthermore, the working groups adopt resolutions on how to interpret and implement the standards in specific cases where the standards contain interpretable requirements. The resolutions binding on the certification bodies are documented and published in an A-Z Guideline. This A-Z Guideline is also a basis for upcoming revisions of standards.

# Effect of QA standards using the example of rail vehicle construction

*Figure 3* illustrates the success of the introduction and implementation of QA stand-



Figure 2 State of the art: Product Safety Act (PSA), QMS (ISO 9001) and QA adhesive bonding standards



Figure 3 Long-term study DIN 6701 [17]

ards using the example of DIN 6701 in rail vehicle construction [17]. The development of adhesive bonding technology was investigated in a long-term study over 15 years [18]. As *Figure 3* shows, the number of significant, that are load-transmitting adhesively bonded joints, was low before the introduction of the standard (left beam). In addition, adhesive bonding errors were predominantly only noticed in the product life cycle phase of utilisation by the customer. This did not change in the five subsequent years (middle bar). A change only occurred with the introduction and implementation of the standard. The introduction of the QS standard was the decisive change parameter. Ten years after the introduction of the standard (right bar), the number of load-transmitting, design-relevant adhesively bonded joints increased by 300 % compared to the initial situation. Despite a significant increase in the number of load-transmitting adhesive bondings compared to the time before the introduction of the standard (left bar), 80 % fewer adhesive bonding errors occurred. In addition, the few adhesive bonding errors that occur are now for the most part already identified and corrected by the manufacturer.

# Dissemination of DIN 6701 and DIN 2304

After the first company was officially certified according to DIN 6701 in 2007, the national DIN standards are now also used internationally. Worldwide, more than 1,150 user companies have been certified according to DIN 6701 and DIN 2304 (as of 31.07.2023). The number of active certificates is currently just under 1,100 [19] [20]. More than 60 % of the certified companies are located outside Germany on all five continents (*Figure 4* and *Figure 5*).

# Transition of the DIN standards into EN 17460 and EN ISO 21368

Against the background of the international application of national standards, work began in 2014 on the transition of DIN 6701 (rail vehicle construction) to the new EN 17460 and in 2017 on the transition of DIN 2304-1 (general industry) to the revised ISO 21368. Both transitions were successfully completed in 2022. In March 2022, the revised ISO 21368 (*Figure 6*) was published (EN ISO 21368 (*Figure 6*) was published (EN ISO 21368: 03/2023 / DIN EN ISO 21368 probably 10/2023), in July 2022 EN 17460 (DIN EN 17460: 10/2022). This means that all standards at DIN, CEN and ISO level are compatible with each other in terms of content and structure.

For both standards (EN 17460 and EN ISO 21368), there is a three-year transition period for the coexistence of the respective DIN and EN or EN ISO standard. This is necessary to give user companies already certified according to the DIN standards the opportunity to change their certification to EN 17460 and EN ISO 21368. The compatibility of the standards simplifies the changeover.

In analogy to the working groups "Adhesive bonding DIN 6701" and "Adhesive bonding DIN 2304", the "European Committee for Adhesive Bonding of Railway Vehicles – ECARV" (*Figure 7*) was founded in June 2022 for the implementation of EN 17460 at a European level with the same tasks as the national working



Figure 4 Implementation of DIN 2304/DIN 6701: Distribution of certified companies worldwide



Figure 5 Adhesive bonding QA standards "It's around the world"

groups. Preparations for the establishment of the analogous working group for EN ISO 21368 have begun.

After the end of the coexistence phases, the national DIN standards will be withdrawn. EN 17460 (Railway Vehicles) and EN ISO 21368 (General Industry) will then apply nationally and internationally as the generally recognised regulations for adhesive bonding. They complete the state of the art for all areas of adhesive bonding applications.

### Summary and perspectives

The further development of adhesive bonding technology applications is well on its way. Adhesives, adhesive tapes and sealants are innovative high-tech products whose production must be evaluated as mastered processes and whose professional use should lead to zero error production. By linking the Product Safety Act (PSA) with the existing quality management system (QMS) in the user company and the implementation of the QA standards for adhesive bonding technology specification of the existing QMS, the adhesive applications also become mastered processes. The product- and company-neutral personnel qualification system of DVS [21] and EWF [22], which certifies personnel, supports the transfer of adhesive bonding technology applications into mastered processes, since the complexity and interdisciplinarity of adhesive bonding technology requires the use of verifia-



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# 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



Figure 6 ISO 21368



Figure 7 European Committee for Adhesive Bonding of Railway Vehicles - ECARV

bly qualified personnel from a technological point of view and is therefore stipulated in standards worldwide [23]. With these steps, the goal is achieved of creating even more confidence in adhesive applications and thus a successful basis for innovation. //

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