

Why you need quality assurance in adhesive bonding technology

Overview:

- **Quality assurance is absolutely vital in adhesive bonding technology; tapes are no exception**
- **Tape manufacturers are responsible for making their customers aware of critical quality control principles and measures during the design, production and sales processes**
- **85% of cases of delamination of the adhesive joint are rooted not in the quality of the tape used but in the quality of the production process of the item incorporating tape**
- **Tape is a sophisticated, high-quality product requiring high-quality conditions of production by tape users**
- **In terms of product design incorporating adhesive joints, the real load should always be lower compared with the maximum load limit (actual load/stress + safety factor < load/stress limit)**
- **DIN 6701, which applies to the rail vehicle construction industry, is a model which should be used for all other areas where adhesives and tapes are used.**

[View the complete slide presentation](#)

4th article in Afera's Sicily conference presentation series

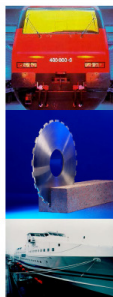
Andreas Gross' presentation "Do we need quality assurance in adhesive bonding technology?" provided Afera's recent Conference attendees with a view into the most important issues and principles driving quality assurance in adhesive bonding, including tapes. Currently Head of Training and Technology Transfer at Germany's prestigious Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Prof. Gross created the Centre for Adhesive Bonding Technology and the Plastics Competence Centre Bremen, and he is also active in several German and European technical working groups.

Quality assurance measures in the bonding process

Concept: Split the bonding process into individual process steps.

Assure quality by:

- Carrying out all the required steps
- Observing the correct sequence of steps
- Verification of each step by carrying out suitable QA measures
- Additional supra-process QA measures
- Controlled information flows (in the process direction and backwards)



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The bottom line: Quality assurance is absolutely vital in adhesive bonding technology. Tapes are no exception. Tape producers must make their tape-using customers aware of their critical responsibility in managing the quality of products made using adhesive joints. In 85% of cases of delamination of the adhesive joint made with tapes, the tape manufacturer is not at fault. The quality of the tape is usually satisfactory. The issue lies with the production of the item incorporating the tape. Prof. Gross asserts that tape is a sophisticated, high-quality product requiring high-quality conditions of production by tape users.

Prof. Gross makes his case with the assumption that the tape producer is responsible for the quality of their tape, which is understood to be satisfactory. Secondly, the tape producer's customer is responsible for the quality of tape used in their final product. The quality of an adhesively bonded structure through the use of tape is ruled by a few different issues, such as environmental conditions, surface quality, employee qualifications, etc. The tape producer must make the tape utiliser aware of this varied responsibility.

Absence of quality assurance has had tragic consequences

The 2003 case of a collapsing domestic front door illustrates that the designers, producers and sales managers involved in generating and placing the final product had no basic knowledge of adhesive bonding technology. An aluminium frame was adhesively bonded to a 75-kg steel plate door, and after a prolonged period of high summer temperatures, the steel plate collapsed out of the frame, killing a two-year-old child.

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IFAM, which was tasked with investigating this deramination, found that the adhesive joint was not constructed with a minimum thickness in order to avoid deraminations, i.e. to ensure that the adhesive could balance out all possible thermal expansions. The 200% adhesional fracture was evident: the adhesive didn't show any adhesion to the aluminium frame or the steel plate. No calculations were made regarding the necessary strengths of the loads. Furthermore, in production, no primer was used for increasing adhesional interactions.

Development process: The importance of optimising the adhesive joint

In order to put quality assurance into place properly, tape producers should split the bonding process into individual steps for their customers, including the product's specifications (materials utilised, the best types of adhesive and surface treatments, etc.). In terms of design, in every case the real load must be lower compared with the maximum load limit. Prof. Gross demonstrates in the cases of the adhesive-bonded door and in ferry windows that getting this right could mean the difference between life and death. Furthermore, you must ensure reproducibility in production. This is not simple. Each step must be verified by work samples. This may sound over the top, but work samples produced under real conditions greatly help in detecting failures in production.

Production process: Making your tape customer aware of his responsibilities

Quality assurance for existing production processes

Objectives:

- ◆ Zero-fault production (prevent faults rather than have to rectify faults!)
- ◆ Customer satisfaction
- ◆ Quality statements to the marketplace
- ◆ Deliberate and controlled actions of employees
- ◆ Traceability / fault analysis



first-out principle is not at work in every company. The customer must prohibit any sources of contamination during these processes. In all cases, contaminants disturb the adhesion properties of tapes.

3. **Work environment and conditions:** The production environment must be carefully monitored by the user, i.e. the tape customer. He is responsible for ensuring that environmental conditions are compatible with the use of tapes.
4. **Preparation of substrate materials:** It is the responsibility of tape manufacturer to make the customer aware of the importance of acclimatisation, inspection, accuracy of fit, and surface treatment.
5. **Preparation of the adhesive and primer**

Quality management for the development of bonded products

1. Determine the actual loads/stresses
2. Draw up a list of requirements (specifications)
3. Preselect the adhesive + surface treatment
4. Determine the load/stress limit of the joint
5. **Optimize the joint until it is demonstrated that: Actual load/stress + safety factor < load/stress limit**
6. Monitoring of subcontractors
7. Production planning, preparation of work instructions
8. Demonstrate the feasibility of the process
9. Production process + accompanying tests
10. After-sales management



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6. **Tape application:** The tape manufacturer delivers application aids. He must ensure that the customer is aware that they must be used. In order to verify the production quality of bonded products, the tape user must utilise work or production samples produced under real (workshop floor) conditions.
7. **Joining and positioning/securing:** The tape manufacturer must provide detailed specifications regarding joining pressure, monitoring, devices used, etc. The customer must be made aware that these must be followed.
8. **Final quality inspection of bonded joints:** Samples taken during production should be tested for strength and fracture behaviour through the current available destructive test methods. Prof. Gross is currently involved in researching non-destructive test methods for measuring strength and fracture behaviour.
9. **Maintenance and repairs**
10. **Final product inspection.**

Supra-company quality measures: The importance of controlled information flow

Some of the overriding issues in quality management production processes include:

1. **Workforce training:** As they have existed for the welding industry for the last 50 years, qualifications should be set for working with adhesive bonding technology (see below).
2. **Documentation of quality-related data and processes and their relevance to a particular product:** This is essential for ensuring that bonded products are zero-fault products.
3. **Inspection of tools and test equipment**
4. **Management of defective products**
5. **Communication:** All areas and positions in the line of production must know what has been done with the product beforehand and what will be done next. Barrier-free communication is required between all involved parties.
6. **Specification of areas of responsibility**
7. **Work organisation.**

Adhesive tape bonding as a “special process”: DIN EN ISO 9001

Workforce training system for adhesive bonding technology



DVS®-EWF European Adhesive Bonder - EAB

Duration: 40 hours
Target group: Technical employees (production level)
Objectives: To understand and properly carry out work instructions

DVS®-EWF European Adhesive Specialist - EAS

Duration: 120 hours
Target group: Technical managers, supervisors
Objectives: To prepare and explain work instructions, to instruct and supervise employees



DVS®-EWF European Adhesive Engineer - EAE

Duration: 320 hours
Target group: Technical decision-makers
Objectives: Interdisciplinary thinking, decision-making, and actions for effective use of adhesive bonding technology



ISO 9001 addresses quality management as it applies to adhesive bonding technology. The standard uses the term “special processes” to describe adhesive bonding “processes requiring validation”, i.e. outputs which cannot be tested non-destructively to be fully verified. Therefore process errors will only be discovered during product usage.

The technical term “special processes” was originally developed for welding technology. Prof. Gross emphasises that the use of tapes by tape manufacturers’ customers is much more of a “special process” than welding because of the more sensitive nature of the quality-influencing factors in the case of adhesive bonding

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technology. Under the terms of ISO 9001, the high production quality of outputs made with tapes must simply be produced; they cannot be tested. This is the reason quality management is essential when using tapes.

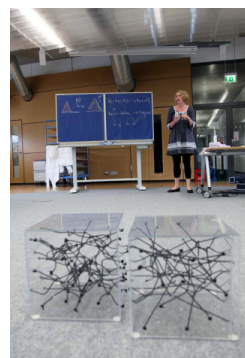
New demands on employees: International certified workforce qualification system

With companies putting comprehensive quality management systems into place, qualified personnel are needed. Along these lines, Fraunhofer IFAM has developed an internationally certified workforce qualification system for production-level technicians (DVS®-EWF European Adhesive Bonder), technical managers and supervisors (DVS®-EWF European Adhesive Specialist), and technical decision-makers (DVS®-EWF European Adhesive Engineer).

4,500 people worldwide have received one of Fraunhofer IFAM's qualifications to date. The current industry of focus is the rail vehicle construction industry. Fraunhofer IFAM coordinates its international programmes with neutral, independent partners in Europe, the U.S. and China, who work to the same standards of quality. Course venues include Europe, U.S., South Africa, Russia, China and Korea.

DIN 6701 as a model for tapes

The German Welding Society (DVS) guideline 3310 forms the basis of quality management in adhesive bonding technology (which includes tapes). This is in the process of incorporation as a standard by the German Institute for Standardisation (DIN). DIN 6701 is the first national series of standards which cover the requirements for special processes of adhesive bonding technology, including tapes, in a distinct area: the rail vehicle construction industry. These standards apply for manufacturing bonded joints for the production and maintenance of rail vehicles and their parts.



International partners

Partners abroad:

- BeNeLux-Area: makiba b.v.
Contact person: Arnold Knottnerus
+31 6 4977 3178 / knottnerus@makiba.nl
- USA: The ChemQuest Group
Contact person: Daniel S. Murad
+ 513 469 7555 / dmurad@chemquest.com
- China: Shanghai Yifa Bonding
Technology Co. Ltd
Contact person: YuXiang Zhang
+86 15821221503 / buddy.zhang@yifabond.com



The German railway authority initiated DIN 6701, which is valid not only for polyurethanes, but epoxies and acrylates. Its objectives are to make adhesive bonding for rail vehicle construction more efficient; to adapt bonding processes at companies to technological needs; to enable companies to utilise better the full potential of adhesive bonding technology; and to give companies which comply with DIN 6701 a competitive advantage.

Part 2 is the most essential part of the series of standards, as it covers the evaluation of the compliance of parts/products. Class A, for example, denotes bonded joints with a high relevance for safety. So, if failures occur with these bonds, they pose a risk to life and limb or to safe operation. For example, the front window of the ICE, the German high speed train, is a Class A1 bonded window, because if the joint delaminates, there is great risk of personal injury.

DIN 6701: Adhesive bonds on rail vehicles and parts of rail vehicles

Class	Description	Definition Safety requirement
A1	Bonded joints of high relevance for safety	Failure poses a risk to life and limb or a risk to safe operation
A2	Bonded joints of average relevance for safety	Failure may pose a risk to operation, with injury to people, or to impairment of the overall functioning
A3	Bonded joints of low relevance for safety	Failure leads at most to reduced comfort / personal injury unlikely
A4	No own use of adhesives in production, no bonded parts/components are constructed, sold, or assembled	As A1 and A2

Most importantly, due to this guideline, a bonded joint must be sized such that the load it bears is smaller than the load limit of the joint. It is the responsibility of the supervisor in charge (SIC) to ensure that this is the case. The SIC is a highly qualified professional possessing an overview of the comprehensive bonding process, from the development of the part/product to its maintenance. Prof. Gross explains that they are adopting the successful model of DIN 6701, which was developed for bonding for rail vehicle construction, for all adhesive bonding technology.



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About Andreas Gross

Currently Head of Training and Technology Transfer, Prof. Dr. Andreas Gross has been working at Germany's prestigious Fraunhofer Institute IFAM since 1987. He created the Centre for Adhesive Bonding Technology and the Plastics Competence Centre Bremen, which are acknowledged training units for adhesive bonding and fibre reinforced technology. Within the DVS, Prof. Gross leads the working group "Adhesive Bonding Technology and represents the DVS within the European Federation for Welding, Joining and Cutting (EWF) regarding adhesive bonding technology. He is also a member of the Technical Committee and several working groups of the German Adhesives Association (IVK).

Questions and Comments?

Prof. Dr. Andreas Gross
Training & Technology Transfer
Fraunhofer-Institut für Fertigungstechnik und angewandte Materialforschung - IFAM
- Adhesive Bonding and Surfaces -
andreas.gross@ifam.fraunhofer.de
www.ifam.fraunhofer.de
www.kleben-in-bremen.de
www.kunststoff-in-bremen.de
Wiener Strasse 12 | 28359 Bremen
Germany
Phone +49 421 2246-437 | Fax -605
Mobile +49 171 1257084

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