THE NEW DIN 2304-1
A WAY TO INCREASE THE QUALITY OF BONDED JOINTS

CONSIDERATIONS NEEDED WHEN USING 2 PART ADHESIVES IN CARTRIDGES
**Introduction**

Multiple bonding applications both in industrial series production as well as in handicraft have proven that

- the adhesives available on the market are high-quality products which are manufactured in compliance with standards in „managed“ processes.
- a correct use of these adhesives – from the planning stage to the bonding process – generally leads to zero defect parts
# Introduction

Contradicting this statement is the fact that bonded joints unfortunately all too often do not meet the requirements placed on them, resulting in failure during the usage phase.

## Perspectives

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- ISO 9001 as base
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- Effect on using 2-k adhesives in cartridges

**Conclusion**

April 2010 | June 2010
---|---

Pictures: Sönke Lange
Introduction

Contradicting this statement is the fact that bonded joints unfortunately all too often do not meet the requirements placed on them, resulting in failure during the usage phase.

April 2011

Jan. 2012

Pictures: Sönke Lange
Introduction

Contradicting this statement is the fact that bonded joints unfortunately all too often do not meet the requirements placed on them, resulting in failure during the usage phase.

Solar panels bonded to a substructure became loose during a storm, not only damaging other panels but also becoming a risk for hurting passing by pedestrians.

Investigating the case led to the conclusion that, probably due to a lack of knowledge fatal mistakes have been made at several steps along the process chain.
A study recently published by the NMI* describes adhesive bonding as an established, environmentally compatible joining method having high scope for value creation and having clear competitive advantages over other joining techniques ...

... but also outlines, that
1. in many case the boning process is not planned end-to-end
2. the bonding process is not always fully controlled

*Source: University Tübingen: (Natural and Medical Sciences Institute at the University of Tübingen [http://www.nmi.de/nc/aktuell/aktuell/detailseite-download/artikel/2015-nmi-studie-sicheres-kleben/](http://www.nmi.de/nc/aktuell/aktuell/detailseite-download/artikel/2015-nmi-studie-sicheres-kleben/)
DIN 2304-1 – Introduction

**Objectives**

Adhesives are high-quality products allowing a zero-defect production

At least 90% of all observed bond failures are caused by application mistakes

... application processes have to be improved

A “managed” bonding process assures
- a “robust” (reproducible) process
- defect prevention

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of quality standards into application

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DIN EN ISO 9001 as base for DIN 2304-1

If a production step or a finished product cannot be tested by non-destructive means with 100% certainty for potential faults, namely when it concerns a so-called „special process“

all possible errors on the way to the finished product must be ruled out by “managing” the whole production process!

Based on the premises that the adhesive is a quality product which, if correctly used allows zero defect production, measures to rule out all errors all along the process chain are required.

Defect prevention is, in accordance to DIN EN ISO 9001 the magic formula for “special processes”

Note:
In welding technology this is already considered as state of the art
Limits of ISO 9001 and the need for DIN 2304-1

The ISO 9001 deals with

- the fundamentals of Quality Management Systems (QMS)

and

- defines the requirements that organizations need to fulfil to meet the customers’ and other stakeholders’ expectations related to the quality of products or services

ISO 9001 is the base for quality assurance in too many different businesses like

- manufacturing
- service industry
- health service
- ...

It can not be specific enough to cover all potential cases

- DIN 2304-1 fills the gaps by providing adhesive bonding specific organizational requirements to be met by a company using adhesives in production.
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DIN 2304-1:2016-03(E) – Adhesive bonding technology – Quality requirements for adhesive bonding processes

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# DIN 2304-1 – Adhesive bonding technology – Quality requirements for adhesive bonding processes

## Basics
- General organizational contractual production-oriented

## Development
- Construction
- Design
- Process planning
- QM planning

## Production
- Down-stream in-process up-stream
  - Part sourcing/ manufacturing
  - Sourcing, transport and storage of bought in components
  - Surface preparation
  - Adhesive dispensing
  - Joining, fixation
  - Curing process
  - Down-stream processes

## Rework/repair
- Work instruction for rework

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DIN 2304-1 – Adhesive bonding technology – Quality requirements for adhesive bonding processes

- applicable to all adhesive joints with load bearing as main function
- non regardless of the strength- and elastic properties of the adhesive in use
- of the type of finished product
- for all areas of application (industrial production as well as handicraft)
- does not replace existing well tried standards like series of EN

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©2016 KLEBTECHNIK Dr. Hartwig Lohse e.K. 12/42
1. **Classification** of bonded joints in accordance with safety requirements
   What are the consequences of a potential failure in load bearing capability of the bond?

2. **Work force qualification** with the assignment of supervisors in charge (SIC) of adhesive bonding work
   Providing qualified personnel (e.g. trained in accordance to EWF requirements, EAB, EAS, EAE)

3. **Verification** that during the whole life cycle of a bonded joint the loads/stresses to which a bonded joint is exposed are always smaller than the load/stress limit of that bonded joint
### DIN 2304-1 – Core Elements - 1. Classification

<table>
<thead>
<tr>
<th>Safety category</th>
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| S1 High safety requirements | Failure of the bond  
  • will directly or indirectly lead to an inevitable hazard to life and limb;  
  • will result in a loss of the function of which will most likely lead to an inevitable hazard to life and limb. |

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### DIN 2304-1 – Core Elements - 1. Classification

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<td>S2</td>
<td>Moderate safety requirements</td>
</tr>
<tr>
<td></td>
<td>Failure of the bond</td>
</tr>
<tr>
<td></td>
<td>• can lead to a hazard to life and limb;</td>
</tr>
<tr>
<td></td>
<td>• will result in a failure of the function, the effect of which will probably involve personal injury or result in a major environmental damage;</td>
</tr>
<tr>
<td></td>
<td>• will result in a failure of the function, the effect of which most likely involve major damage to property.</td>
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## DIN 2304-1 – Core Elements - 1. Classification

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<td><strong>Moderate safety requirements</strong></td>
</tr>
<tr>
<td>S3</td>
<td><strong>Low safety requirements</strong></td>
</tr>
</tbody>
</table>

- **Failure of the bond**
  - will result in a failure of the function, the effect of which will probably not involve personal injury or result in major environmental damage;
  - will result in a failure of the function, the effect of which will affect comfort or performance at the most;
  - will result in a failure of the function, the effect of which will probably not involve major damage to property
## DIN 2304-1 – Core Elements - 1. Classification

<table>
<thead>
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<th>Safety category</th>
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<td>S1</td>
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<td>Moderate safety requirements</td>
</tr>
<tr>
<td>S3</td>
<td>Low safety requirements</td>
</tr>
<tr>
<td>S4</td>
<td>No safety requirements</td>
</tr>
</tbody>
</table>

**Failure of the bond**

- will result in a failure of the function, the effect of which will not, under foreseeable circumstances, involve personal injury or result in environmental damage;
- will result in a failure of the function, the effect of which will only affect comfort or performance;
- will result in a failure of the function, the effect of which will not involve major damage to property
The classification of bonded joints defines the degree of the to be implemented organisational measures

The classification of a bonded joint into a safety class needs to be done carefully considering
• the severity of the resulting effect
• the probability of its occurrence
• the possibility for in time recognizing of the failure and by a fair degree of sure instinct.
DIN 2304-1 – Core Elements - 2. Work force qualification

„The organisation (user company doing adhesives bonding) must provide a sufficient number of trained personnel for all relevant tasks along the adhesive bonding process chain and has to document their appointment“

„A supervisor in charge (SIC) has to be assigned.“
(DIN 2304-1 Paragraph 5.)

Supervisor in charge (SIC):
The supervisor in charge (SIC) is the main contact person for all quality matters relating to the so-called "special process" of adhesive bonding - from the planning stage through to production and maintenance/repair.
The verification can be carried out in four ways and needs to be documented:

1. **Measurements**: Based on the specifications, the load/stress is determined from experiments, calculations, standards, real data or a combination of these and documented. The load/stress limit must be determined by experiment, with accompanying statistics, taking into account ageing, test media, combinations of effects, etc.
The verification of this can be carried out in four ways and needs to be documented:

1. **Measurements:**

2. **Component testing:** by testing a whole system or part of a system under real conditions or under conditions which mimic reality. When testing a part of a system, the mutual interaction between the part-system and whole-system must also be taken into account and it must be verified that this does not falsify the results in an impermissible way. A failure criterion for test evaluation, including an integrated safety factor, must be defined.
The verification of this can be carried out in four ways and needs to be documented:

1. **Measurements:**
2. **Component testing:**
3. **Documented experience:** The verification based on experience requires that the design of the bonded joint is already proven.
The verification of this can be carried out in four ways and needs to be documented:

1. **Measurements:**
2. **Component testing:**
3. **Documented experience:**
4. **Combination of 1. to 3.:** The verification of combinations of the aforementioned routes must ensure that all requirements are suitably evaluated and that the individual components are compatible with each other.
The New DIN 2304-1
A Way to Increase the Quality of Bonded Joints

**Perspective**

An English version has been approved by the DIN standards committee and is expected to be available soon.

Further concretion:
It is planned to further concretise the contents of DIN 2304-1 by providing additional information about

- the requirements for the bonding process (DINSpec 2305-1)
- the specifics if bonding fibre reinforced plastics (DINSpec 2305-2)
- the specifics of bonding by the use of adhesive tapes (DVS-Guideline)
- ...

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DIN 2304-1 allows user-companies the option of being certified in accordance with this standard.

In contrast to

- a company audit,
- a process review,

or

- an expert report

the certification of a company according to DIN 2304-1 gives customers the confidence that bonded joints are correctly manufactured in accordance with the state-of-the-art and can be considered as an advantage in competition.

In contrast to DIN 6701 there is (currently) no legal obligation for a certification.

A certification of adhesives according to DIN 2304-1 is not planned and also not suitable, as the adhesive is only one part of multiple influencing the bond quality.
**Considerations needed when using 2 part adhesives in cartridges**

The cartridge together with the dispense gun and the static mixer can be considered as the “application equipment” for the adhesive, which has to:

- assure the expected shelf life
- allow an air-bubble free dispense at an extrusion rate according to the process requirements
- dispense the adhesive at the correct mix ratio and an adequate mix quality
- allow to restart dispensing even after several days/weeks
- ...

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Considerations needed when using 2 part adhesives in cartridges

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- assure the expected shelf life
- allow an air-bubble free dispense at an extrusion rate according to the process requirements
- dispense the adhesive at the correct mix ratio and an adequate mix quality
- allow to restart dispensing even after several days/weeks
- ... and the requirements defined by DIN 2304-1, relevant to
  - process design
  - sourcing, storage and logistics of adhesives and accessories
  - manufacturing
  - monitoring of production aids

have to be observed

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Picture: Sulzer Mixpac
Considerations needed when using 2 part adhesives in cartridges

Although many of the to be considered details taken care about by the adhesive supplier, having identified the cartridges system and at least recommending a suitable mixer tip the adhesive user should be aware about the basics to allow for consideration during the adhesive selection process.

- Cartridge
- Mixer
- Cartridge filling
- Dispense gun
Considerations needed when using 2 part adhesives in cartridges

Cartridge system:

- Type of cartridge
- Mix ratio according to adhesive stoichiometry
- Cartridge material, sufficient stiffness, compatible to adhesive chemistry, providing a moisture barrier for 2-k-PU adhesives
- Size of cartridge, contend vs. ease of handling

Pictures: Sulzer Mixpac, KLEBTECHNIK Dr. Hartwig Lohse e.K.
Considerations needed when using 2 part adhesives in cartridges

Cartridge system:

• Mix ratio according to adhesive stoichiometry
• Type of cartridge (side-by-side, coaxial, “Peeler”, …)
• Cartridge material, sufficient stiffness, compatible to adhesive chemistry, providing a moisture barrier for 2-k-PU adhesives
• Size of cartridge, contend vs. ease of handling
• Piston
  • easy to insert, allowing all air between adhesive and piston face to escape

Picture: Sulzer Mixpac
Considerations needed when using 2 part adhesives in cartridges

Cartridge system:

• Mix ratio according to adhesive stoichiometry
• Type of cartridge (side-by-side, coaxial, “Peeler”, …)
• Cartridge material, sufficient stiffness, compatible to adhesive chemistry, providing a moisture barrier for 2-k-PU adhesives
• Size of cartridge, contend vs. ease of handling
• Piston
  • easy to insert, allowing all air between adhesive and piston face to escape
  • reliable seal to avoid leaking and to prevent adhesive from moisture (PU)

Picture: KLEBTECHNIK Dr. Hartwig Lohse e.K.
Considerations needed when using 2 part adhesives in cartridges

Mixer Tip:

• The mixer technology (Helix- vs. Quadro-Mixer) and the mixer dimensions (diameter, length, number of mixing elements) needs to be selected to deliver the best combination of
  • mix quality
  • pressure loss, flow rate
  • waste volume

Rule of thumb for checking mix quality: No visible colour difference after about 1/3 of the mixer length (→ to be included into work instructions)
Considerations needed when using 2 part adhesives in cartridges

Mixer Tip:

- The mixer technology (Helix- vs. Quadro-Mixer) and the mixer dimensions (diameter, length, number of mixing elements) needs to be selected to deliver the best combination of
  - mix quality
  - pressure loss, flow rate
  - waste volume
- Avoid in conjunction with the cartridge outlet cross contamination of the individual components

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Mixer Tip:

- The mixer technology (Helix- vs. Quadro-Mixer) and the mixer dimensions (diameter, length, number of mixing elements) needs to be selected to deliver the best combination of
  - mix quality
  - pressure loss, flow rate
  - waste volume
- Avoid in conjunction with the cartridge outlet cross contamination of the individual components
- Constant quality, especially a constant narrow gap between outer tube and the mixing elements (Warning: there are some cheap products on the market!)

Picture: ISF Aachen
Considerations needed when using 2 part adhesives in cartridges

Cartridge filling process:
The process needs to be designed

- to avoid entrapped air in order to assure a continuous correct ratio between the two parts and an uninterrupted bead.

  Note: Storing the cartridges upright allows, depending on the material’s viscosity the air to migrate to the top. Upon starting using a cartridge purging a small amount before assembling the mixer is removing the entrapped air.
Considerations needed when using 2 part adhesives in cartridges

Cartridge filling process:

The process needs to be designed

- to assure an equal filling level in both chambers. Otherwise the mix ratio is incorrect at the start of using a cartridge.

  Note: Upon starting using a cartridge purging a small amount bevor assembling the mixer will also level the pistons

A 100% equal filling level cannot be assured, therefore levelling the pistons should be included into the work instructions
The new DIN 2304-1
A way to increase the quality of bonded joints

Considerations needed when using 2 part adhesives in cartridges

Cartridge filling process:
Quality assurance offered by some cartridge filling companies
- 100% or at random X-raying of cartridges
- At random dispensing, e.g. using cartridge tester

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Dispense gun:
A wide variety of dispense tools, “guns” manually, pneumatic and electrically (battery) driven are available

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<tr>
<th>Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Manual</td>
<td>• unlimited leeway</td>
<td>• dispense interruption</td>
</tr>
<tr>
<td></td>
<td>• typically easy to clean</td>
<td>• physical fatigue of worker</td>
</tr>
<tr>
<td></td>
<td>• low cost</td>
<td></td>
</tr>
<tr>
<td>Pneumatic</td>
<td>• continuous dispense</td>
<td>• limited leeway due to pressured air hose required</td>
</tr>
<tr>
<td></td>
<td>• allows application of visually appealing beads</td>
<td>• difficult to clean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• more expensive</td>
</tr>
<tr>
<td>Electrically (battery)</td>
<td>• continuous dispense</td>
<td>• battery capacity limits</td>
</tr>
<tr>
<td></td>
<td>• unlimited leeway</td>
<td>• operating time</td>
</tr>
<tr>
<td></td>
<td>• allows application of visually appealing beads</td>
<td>• difficult to clean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• more expensive</td>
</tr>
</tbody>
</table>
Considerations needed when using 2 part adhesives in cartridges

Dispense gun:

None regardless of the type of dispense gun certain details need to be considered:

- The plungers need to be levelled otherwise dispensing will start off-ratio. (When inserting a side-by-side cartridge mark the chambers “left” and “right” to assure the same position upon next use with the same dispense gun

- Using a dispense gun not strong enough may result in twisted plungers with the effect of a partly off-ratio dispense or tilting of the pistons resulting in leaking pistons and off-ratio dispense
DIN 2304-1 – Conclusion

- Adhesive bonding becomes more and more an established joining technology
- The quality of modern adhesives allows zero defect production
- In part adhesive users suffer from a uncertainty about a sufficient process reliability, bonded parts fail.
- The quality of the adhesive application process must match the quality of the adhesive’s manufacturing process
- Adhesive bonding is a "special process"—not allowing a 100% non-destructive testing
- There is no alternative but to use a comprehensive QMS to avoid errors, as described in ISO 9001 and more specifically in DIN 2304-1
- Quality assurance for bonding processes minimizes faults, saves money, generates trust, promotes the wider use of adhesives, and sustainably improves the image of adhesive bonding.
- DIN 6701 has already demonstrated that.
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Conclusion
Experience on about 10 years with DIN 6701 (regulates, on the initiative of the “German Federal Railway Authority” adhesive bonding applications on parts intended for the use on the German railway system) shows that

• the number of adhesive related failures has been significantly reduced,
• failures are noticed predominantly while the part is still not delivered to the customer, and
• the number of bonding application has been increased
Adopting the principles and demands outlines in DIN 2304-1 will help that something like this will not happen again.

Many Thanks for your attention

Questions?

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www.how-do-you-glue.de

Picture: KLEBTECHNIK Dr. Hartwig Lohse e.K.