

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

CONSIDERATIONS NEEDED WHEN USING 2 PART ADHESIVES IN CARTRIDGES







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

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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



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Zürich, September 28. to 29.

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





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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.





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Introduction

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/



Zürich, September 28, to 29.







DIN EN ISO 9001 as base for DIN 2304-1

If a production step or a finished product cannot be tested by nondestructive 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

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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 – Core Elements

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

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DIN 2304-1 – Core Elements **1.** Classification -**Definition of safety requirements** Safety category Introduction **S1 High safety requirements** DIN 2304-1 Failure of the bond objectives will directly or indirectly lead to an inevitable hazard ISO 9001 as base to life and limb; Limits of ISO 9001 will result in a loss of the function of which will most ٠ likely lead to an inevitable hazard to life and limb. DIN 2304-1 contents • core elements Perspective Effect on using 2-k adhesives in cartridges Conclusion





DIN 2304-1 – Core Elements 1. Classification -Safety category **Definition of safety requirements** Introduction **High safety requirements S1** DIN 2304-1 S2 Moderate safety requirements objectives ISO 9001 as base Failure of the bond can lead to a hazard to life and limb; Limits of ISO 9001 will result in a failure of the function, the effect of • which will probably involve personal injury or result DIN 2304-1 contents in a major environmental damage; core elements will result in a failure of the function, the effect of ٠ which most likely involve major damage to property. Perspective Effect on using 2-k adhesives in cartridges Conclusion MIXPACTh





DIN 2304-1 – Core Elements - 1. Classification

Safety category	Definition of safety requirements	Introduction
S1	High safety requirements	DIN 2204 1
S2	Moderate safety requirements	objectives
S3	Low safety requirementsFailure of the bondwill result in a failure of the function, the effect of	ISO 9001 as base Limits of ISO 9001
	which will probably not involve personal injury or result in major opvironmental damage:	DIN 2304-1 contents
	 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 	core elements
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DIN 2304-1 – Core Elements 1. Classification -Safety category **Definition of safety requirements** Introduction **S1 High safety requirements** DIN 2304-1 S2 Moderate safety requirements objectives ISO 9001 as base **S**3 Low safety requirements **S**4 No safety requirements Limits of ISO 9001 Failure of the bond DIN 2304-1 will result in a failure of the function, the effect of contents which will not, under foreseeable circumstances, core elements involve personal injury or result in environmental damage; Perspective will result in a failure of the function, the effect of Effect on using which will only affect comfort or performance; 2-k adhesives in will result in a failure of the function, the effect of cartridges which will not involve major damage to property Conclusion





DIN 2304-1 – Core Elements - 1. Classification

Safety category	Safety requirements	Organisational requirements	Introduction
S1	High Safety requirements	high	DIN 2304-1 objectives
S2	Moderate safety requirements		ISO 9001 as
S3	Low safety requirements		Limits of ISO
S4	No safety requirements	Low	DIN 2304-1

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.

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 DIN 2304-1 - Core Elements
 3. Verification

 Load/stress limit
 >
 Load/stresses the

 of the bond
 >
 Load/stresses the

 bond is exposed to
 >

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..

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 DIN 2304-1 - Core Elements
 3. Verification

 Load/stress limit of the bond
 >
 Load/stresses the bond is exposed to
 Introduction

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.

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 3. Verification

 Load/stress limit
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 of the bond
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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.







Perspective Introduction An English version has been approved by the DIN standards committee and is expected to be available soon. DIN 2304-1 objectives ISO 9001 as base Further concretion: It is planned to further concretise the contents of DIN 2304-1 by providing Limits of ISO 9001 additional information about DIN 2304-1 the requirements for the bonding process contents • (DINSpec 2305-1) core elements the specifics if bonding fibre reinforced plastics Perspective (DINSpec 2305-2) Effect on using the specifics of bonding by the use of adhesive tapes 2-k adhesives in (DVS-Guideline) cartridges • ... Conclusion





Perspective

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.



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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



Picture: Sulzer Mixpac

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... 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



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

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Pictures: Sulzer Mixpac







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

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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.

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Considerations needed when using 2 part adhesives in cartridges **Mixer Tip:** Introduction The mixer technology (Helix- vs. Quadro-Mixer) and the mixer dimensions (diameter, length, number of mixing elements) needs to be DIN 2304-1 selected to deliver the best combination of objectives ISO 9001 as base mix quality pressure loss, flow rate Limits of ISO 9001 waste volume DIN 2304-1 Rule of thumb for checking mix quality: No visible colour difference after contents about 1/3 of the mixer length (\rightarrow to be included into work instructions) core elements Perspective

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Pictures: KLEBTECHNIK Dr. Hartwig Lohse e.K.



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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Picture: Sulzer Mixpac .





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!)



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Picture: ISF Aachen





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 bevor assembling the mixer is removing the entrapped air.















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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Picture: Lohnpack GmbH.





<u>Consideratio</u>	ns needed when using 2 part adhesiv	ves in cartridges
Dispense gur	:	
A wide variet electrically (b	y of dispense tools, "guns" manually, attery) driven are available	pneumatic and Introduction
Туре	Advantages Disadva	ntages objectives
Manual Pneumatic	 unlimited leeway typically easy to clean low cost continuous dispense allows application of visually appealing beads more 	ense interruption ical fatigue of workerISO 9001 as base Limits of ISO 9001ed leeway due to sured air hose required ult to clean e expensiveDIN 2304-1 • contents • core elements
Electrically (battery)	 continuous dispense unlimited leeway allows application of visually appealing beads 	ery capacity limits ating time ult to clean e expensive Effect on using 2-k adhesives in cartridges Conclusion





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 offratio. (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 % nondestructive 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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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



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



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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Picture: KLEBTECHNIK Dr. Hartwig Lohse e.K.