Gluing technology and technique

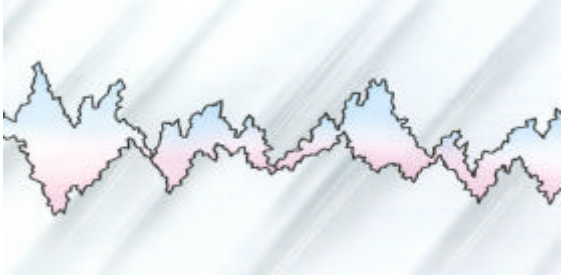
1 Theories of gluing

1.1 Introduction

Modern gluing technology is a broad and interesting world. It grows as the manufacturing industry is coming up with new advanced constructions in combination of materials

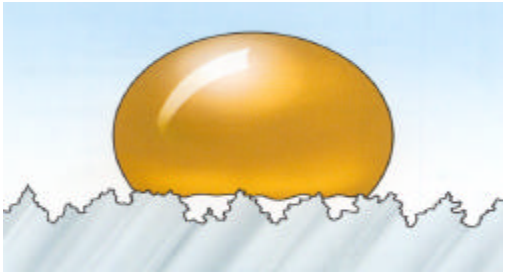
1.2 What is glue?

Gluing is defined as combining two components using a third, the glue. The difference between welding and gluing is that the third unit is made by plastic instead of metal. The bonding is made possible while using either cohesion(inner bond) or adhesion(attraction in the surface). The Q-Bond® gluing technology uses “mechanic adhesion”, which means that the glue uses the texture of the cloth to get a grip of it. Adhesion is an acting force between two molecules that are close enough to each

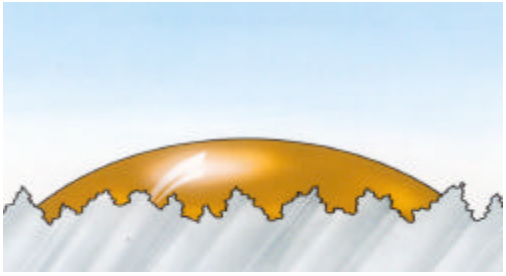


Picture N0.1: Even The most smooth surface has asperity that is several hundred Angstroms (1 Å = 10^{-10} m) deep. The picture shows two

other. The distance between the molecules needed for the force to arise, must be not less than 5 Å = 5 x 10^{-10} m. The glue must wet the surface to enable a contact this close, and the surface will only get wet if the surface tension of the glue is lower than that of the surface. What is surface tension then? Surface tension, or the difference in surface tension, is what enables the water bug to run on water, and what makes the water run off a tent even if you can see the sun shining through the cloth.



Picture No. 2: When the surface tension of the glue is higher than of the material there is no adhesion since the surface is not wet.



Picture No. 3: When the surface tension of the glue is lower than the surface tension of the material, the surface is wet, and adhesion can take place.

Glue can be categorised based on how it solidifies, i.e. transforms from fluid to solid form:

- *Drying*, solvent or water evaporates.
- *Cooling* of hot melting glue.
- *Hardening,* Chemical reaction that produce larger molecules.

If the glue has wet the materials, which is necessary, the bond between glue and material is stronger than the weakest component.

1.3 How does it work?

If you understand how glue works, how it wets the material, and how it solidifies, you can also understand why the glue is not working. Seen in this perspective the understanding of gluing technology is even more important for the quality of the product.

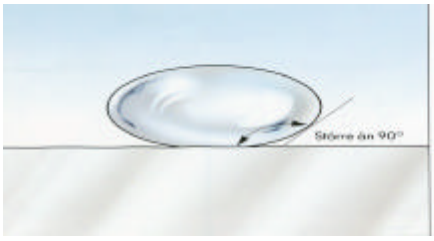
Several theories has evolved during the years, trying to describe what happens between the glue and material. The present theory, the *thermodynamic adsorption theory* states that:

- If two components are close enough they will combine with each other .
- The compound between these two components will be stronger than the weakest component.

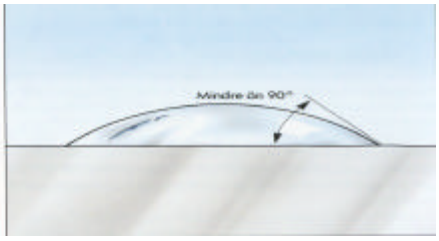
Good adhesive capability will be the result if:

- Glue that has a lower surface tension than the material that is being glued is used.
- The surface of the cloth is not completely even.
- The glue solidifies after contact with the surface has been made

To obtain enough closeness, 5 Å = 5 x 10^{-10} m at the most, is it necessary for one of the materials to deform /adjust. In the same way as the soldering tin melts and deforms to adjust to the texture of the material to be soldered, the glue melts into the material. This is only made if the surface tension is lower than the surface tension of the material. This can be compared to a drop of water on a piece of fabric. Water can not wet fabrics treated with silicone or Teflon, and the drop will not flow into the fabric. The Q-Bond® glue works in the same way, it does not work very well on water repellent cloths, and especially not on Teflon and silicone coated fabrics. By dripping some glue on the cloth you can easily determine the adhesive ability of it, by reading the angle between drop and fabric. Compare picture No. 4 and 5.

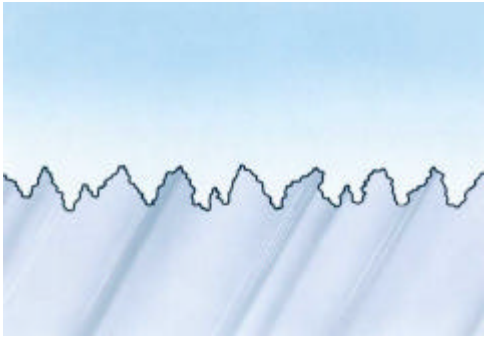


Picture No. 4: Angles of between 90º or more will result in bad adhesive ability



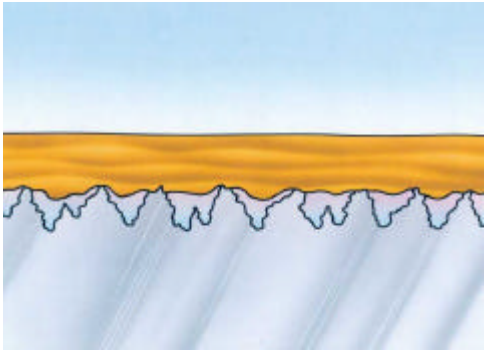
Picture No.5: The smaller the angle the more power transmission in the bond, and because of that a better adhesive ability.

Since glue does not stick on every material, is it important that you try out the materials that you intend to use. Please read the report *Strength analysis of Q-Bond® tape in sail bonding* for reference.

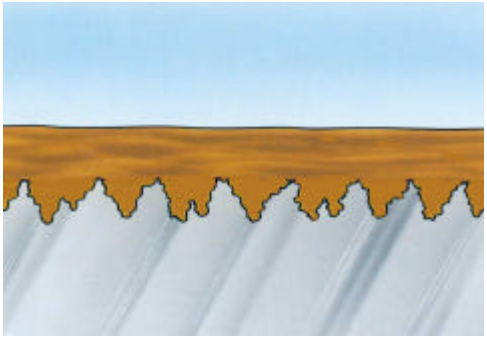


Picture No. 6: There is no surface without asperity.

Almost every material has asperity, though they may look and feel smooth. The strong grip of the bond comes with the glues ability to flow into the asperity of the surfaces. Compare with picture No. 7 and 8. It is also important to avoid weakening oxidation in the joint. Oxidation is caused by air pockets between glue and cloth.



Picture No.7: incorrect. The glue has not flown into the material and does thereby not have a good grip of the asperity. Oxidative and corrosive air pockets between glue and material are formed. These air pockets will make the joint weaker and give the sail shorter life span.



Picture No. 8: Correct. The glue has moistened the contact surfaces and has a good grip of both materials. The asperity is full of glue, and there are no air pockets. A strong joint that is going to last.

2

The Q-Bond® system gluing technique

2.1 Introduction

The Q-Bond® activating machine uses ultra sound to bond sails. This chapter describes the theories behind the ultra sound, and how it is used to melt Q-Bond® tape.

As With everything new you will need a certain period of learning before you can take advantage of the Q-Bond® technology. You will have to learn the method properly before you can begin delivering Q-Bond® made sails to your customers.

Used the right way, the system will give you impeccable joints that are stronger and longer lasting than traditional seams. However, if the method is carried out the wrong way, broken joints and displeased customers will be the case.

To obtain the right knowledge, you will need to do several trial bonds. Through trying out different settings and cloths, you will get a picture of what a good result should be like and what adjustments that needs to be made to get a proper result.

We highly recommend that you take notes of your different settings and write them down in the enclosed data-sheet.

2.2 Q-Bond® tape

Warning note

Picture No.9: Q-Bond® Tape is delivered in an airtight plastic bag. It is packed with vacuum to last longer. Please note that the tape is a perishable and should be used before the date written on the bag.

Picture NO.10: Each bag contains a roll of tape and a moisture bag. The moisture bag is used to absorb possible moist in the bag.

2.3 The Q-Bond® activating machine

The Q-Bond® machine is built up with components from Rinco® Ultrasonics. The manual for these components is enclosed, and can be read for further information.

A transducer is the core of ultra sound technology. The machines Piezoelectric transducers are made of ceramic plates that changes in size when exposed to electricity. A fluctuating current with a frequency of 35kHz works the transducers and makes them vibrate with the same frequency. As the vibrations are not powerful enough (the amplitude is too low) they must be amplified before they can reach the hammer. The Hammer is the machine part that transfers the vibrations from the transducer to the joint.

2.4 Why the Q-Bond® glue melts when activated

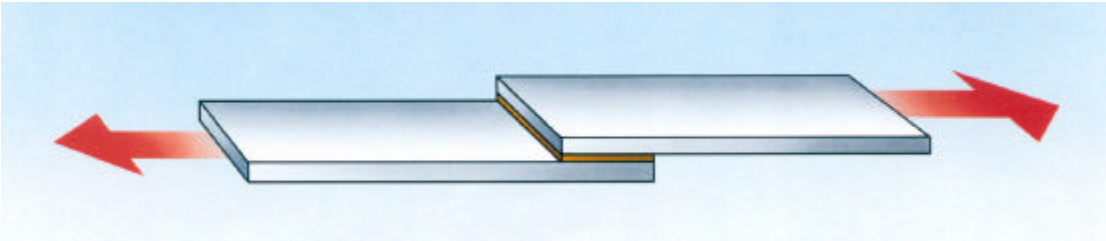
Activating a joint means that the vibrations from the hammer makes the glue melt inside the joint. When melted, the glue flows into the texture of the fabric and gets a good grip of it. After the activation begins the solidifying and hardening process, that gives the joint its strong bond between the materials. To make the bond as strong as possible is it important that the glue has melted enough to flow out properly into the texture.

Q-Bond® tape is based on soft and sticky melting glue. When not yet hardened the molecular bindings in the glue are weak, and the bindings in the cloth strong. This is why only the glue is effected when the vibration from the hammer transfers into the joint. When the hammer vibrates, the glue molecules starts to vibrate and the weak bindings in the glue dissolves, -the glue melts. Since only the glue is effected by the vibrations and the sailcloth remains intact, you can easily bond spinnaker cloth without risk of burning hole into the fabric.

If the machine is used in the wrong way and the hammer is allowed to work the same piece of the joint too long, this can eventually cause the sailcloth to melt. This because of the friction between the two pieces of fabric will generate too much heat.

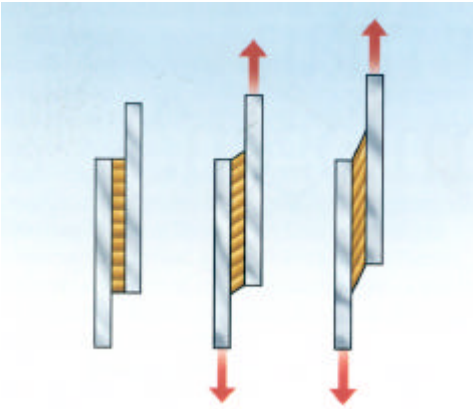
A thick Mylar cloth absorbs more of the vibrations than an ordinary Dacron cloth does. This means that you will have to adjust the parameters (V, P, A), to the current cloth to avoid that either the glue does not melt enough, or that the glue flows out too much and “bleeds” through the cloth.

Design of the joint

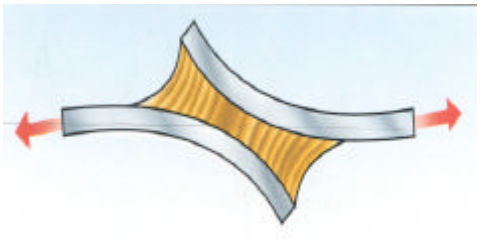


Picture NO.11: The overlap joint

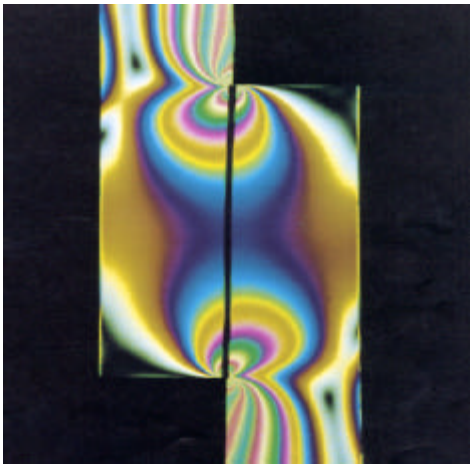
There are several ways to design a glue joint. The most common is the overlap joint. This joint is the one used both in traditional seams and in the Q-Bond® system. When a joint is exposed to load comes first the shove tension, followed by an adjustment to the load direction that curves the joint a bit.



Picture No.12: The glued materials are stretched when exposed to load. The picture shows that too thick joint may increases the risk for the joint to deform instead of making it stronger. Is the joint too thin on the other hand, is there a risk of not having enough adhesive ability in the joint. Tests have shown that the joint should be about 0,2-0,4mm depending on the type of cloth.



Picture No.13: A curving moment arises when the joint adjusts to the load direction. Compare chapter 3.4 in the *Strength analysis of Q-Bond® tape in sail bonding* paper to see how a traditionally sewn joint adjusts to the load direction.



Picture No.14: The picture shows that a joint that has been exposed to load has got the most strains in the joints edges. This means that depending on how much the glue flows out to the edges, the joint will take load differently.