SIKA MARINE APPLICATION GUIDE

SEALING AND BONDING TECHNOLOGY

Version 2/2017

BUILDING TRUST

CONTENT

03 Preface

05 Explanation of Different Fixing Methods

07 Difference Between Rigid and Elastic Adhesives

10 Bonding Construction Design

13 Cost Advantage of Elastic Bonding

14 Tips and Tricks

18 Product Selector, Calculation Tools

19 Adhesive Primer Consumption

20 Conversions and Calculations

21 Quality Assurance

24 Product Datasheets and Safety Datasheets

PREFACE

INTRODUCTION

Since the middle of the 17th century, when the industrial revolution began, the process of manufacture has changed dramatically, in methods and materials. At the time, it was state-of-the-art to assemble boats and ships using traditional methods like wood jointing, nailing and screwing. Riveting and welding followed in later years, but today, we are aware of the limitations of these old methods compared to what is currently available. New lightweight materials as well as sandwich structures need smooth, stress concentration free assembly. Today, time, weight, cost, design freedom and reliability are all greatly enhanced by using chemical bonding, sealing and damping products.

BONDING, SEALING AND DAMPING

Sealants and adhesives share a similar technology. Their functions overlap to a large extent, but as they also have a range of other benefits, the role of elastic bonding is not only to join, but also to waterproof, dampen sound, insulate and prevent galvanic corrosion; all needed to overcome the daily problems in the marine environment. Some products are specifically for bonding as they exhibit high mechanical strength (commonly known as rigid adhesives) and feature variable open time to accommodate everything from quick production rates, to the much slower large structural component assembly. Much of their usefulness in absorbing forces and shock stems from the toughness of the cured bond and this, in turn, is a major factor in the durability and reliability of the bond.

FLEXIBLE BONDING AND SEALING

Flexible bonding and sealing is distinct from bonding with high modulus adhesives. They are applied in a bondline thickness of some millimetres. These products have the high elastic characteristics of both adhesives and sealants. While it does not have the high mechanical strength of rigid bonding adhesives, it has far greater flexibility, which helps to reduce fatigue in the bonded components.

FLOORING AND ACOUSTIC DAMPING

Sub decks are not always smooth and level and besides being generally unattractive, they are responsible for the transmission of most of the noise in cabins and compartments.

Modern flooring has elements that improve the marine environment:

- The deck is levelled and smoothed
- The noise level transmitted through it is reduced
- The cosmetic finish improves the appearance
- Various systems can be used that amplify one or more of these.

Sika works closely with suppliers, universities, research institutions, certification societies but primarily with our customers, to maintain the most relevant level of expertise in bonding sealing and damping. We are continuously developing the product range as new methods, materials and designs emerge or are needed. All processes concerning application of our products are fully tested and choreographed to ensure 100% reliability.

This manual explains the processes and describes the procedures necessary to achieve the highest standards. It is therefore essential that the appropriate section is consulted and adhered to for every process undertaken.

From long experience in marine applications, it is highly recommended that Sika (Corporate or local Technical Service) is consulted at the outset of any new projects.

EXPLANATION OF DIFFERENT FIXING METHODS

SOME HISTORICAL FACTS

Traditional fixing methods are mechanical fixations. Adhesives have still the nimbus of a low seriousness due to less and / or negative experiences, Adhesive technologies are not accepted voluntary. The bonded result cannot visually be detected. The resulting prudence is also called Icarus effect. From this story from the greek mythology only the crash of Ikarus is known where Daidalos his succeeding father is less known. Nevertheless Daidalos, a blacksmith, is the “historical father” of the bonding technology as the wings he produced to escape from his prison have been feathers bonded with an adhesive (light weight construction).

Nowadays aircrafts like the Boeing 787 Dreamliner are made out of synthetic carbon fibres. Only the bonding technology can be used for joining such substrates. The bonding technology is state of the art in multiple areas including the naval industry.

Sealing on the other hand has been one of the oldest technologies in the shipbuilding. Caulking boats with cotton robs impregnated with bitumen is one of the used technologies. Nowadays modern products replace this demanding working procedure.

The differences between some mechanical fixations and the bonding technologies outline some advantages of each method.

Fig. 1 Ikarus and Daidalos. Painting from Carlo Saraceni 1580-1620

Fig. 2 Boing 787 Dreamliner

PRINCIPAL DIFFERENCES OF THE FIXING METHODS

Production	Riveting / srewing	Spot weld	Rigid bonding	Elastic bonding
Process speed	Fast	Fast	Medium to fast	Medium
Substrate preparation	Low	Low	Medium to important	Medium to important
Substrate deformation (heatprocess)	Low	High	Low	None
Tolerance gapping	Low	Low	Low	Very good
Calculation of the bondline	Yes	Yes	Possible	Possible
Industrial hygiene	Low	Low	Medium	Medium
Noise emission during manufactoring	High to low	Medium	Low	Low
Quality control	Easy	Easy	Needs QC	Needs QC

Obtained characteristics	Riveting / srewing	Spot weld	Rigid bonding	Elastic bonding
Joining different materials	Possible / limited	Not possible	Possible	Possible
Sealing	Separate operation	Separate operation	Yes	Very good
Acoustical improvements	No	No	Limited	Yes
Joining of thin substrates	Not recommended	No	Possible	Ideal method
Durability	Danger of corrosion	Danger of corrosion	Good	Good

Adhesive bonding is a modern and highly effective joining technique with a number of innovative performance characteristics, which forms a welcome addition to the standard repertoire of rigid fastening technologies. Through the selective use of these adhesives and careful attention to the specific application techniques associated with them, engineers and designers are now able to design technically sophisticated products that can be manufactured economically.

The use of this bonding technology permits to use all kind of substrates permitting an optimised construction. Just to mention some advantages:

- Freedom of styling (use of GRP / plastics / metals to optimise material cost)
- Weight savings (thinner substrates / plastics)
- Sound reduction (especially with elastic adhesives)
- Corrosion resistance (bonding on anti-corrosive paints, no injury of the anti-corrosive layer)

The highest economic and technical benefit of the bonding technology is based on these multiple advantage which is achieved in a single operation.

The bonding technology is a new tool for engineers and designer to realise modern and innovative solutions in the Marine Industry.

DIFFERENCE BETWEEN RIGID AND ELASTIC ADHESIVES

Elastic adhesives differ in their functionality to the rigid systems. Rigid (high modulus) adhesives are normally used in thin layers of about some hundred microns. In contrast elastic adhesives are used in a thickness of some millimeters. Therefore the expression of thick layer bonding has been created for such application types.

The function of these systems differs in their way to transmit forces. Rigid adhesives transmit forces directly without noticeable deformation. Elastic adhesives lower the forces by bond line deformation and uniform stress distribution over the whole bonding surface.

Both of these systems have their advantages as well as their limitation. The following article describes the principal characteristics, knowing that this classification is not complete as semi flexible products may be situated somewhere in between.

To show the difference, studies have been done at the University of Munich to demonstrate this difference. Tensile lap shear samples of PMMA (Polymethylmetacrylate, ex. Plexiglas) have been bonded and stressed. By using polarized light, lines of different colours (stress levels) could be visualized.

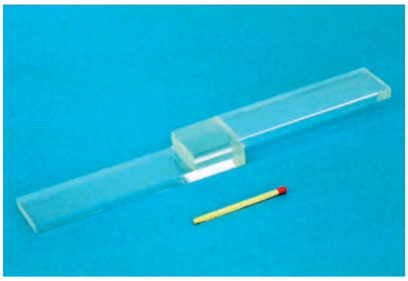


Fig. 3 Test sample. Lap shear test with PMMA substrate bonded with different adhesives. One sample has been screwed

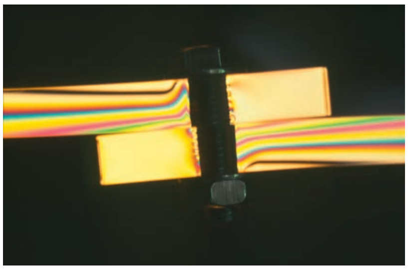


Fig. 4 Screwed sample. The force line indicate a direct transmission of the forces from one part of the sample through the screw to the other part of the sample

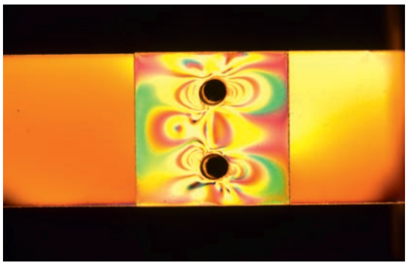


Fig. 5 Same sample plan view. Here stress concentration around the bolts is visible (stress peaks around the screw).

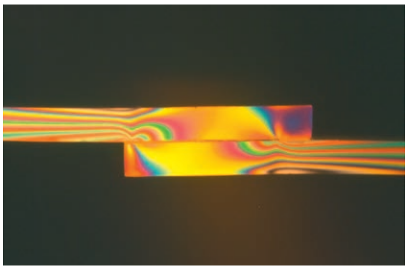


Fig. 6 Thin layer bonded sample with a rigid adhesive. The stress concentration is visible at both ends of the sample.

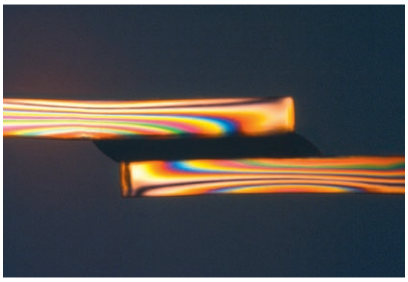


Fig. 7 Thick layer elastic bonded sample. The stress transmission is uniform over the hole bonding area (no stress peaks). The adhesive is not easily visible as it is not transparent.

The uniform stress distribution of the elastic adhesive permits to utilize the whole bonding surface for the force transmission.

Elastic thick layer bonding permits therefore to use thinner substrates, or just to bond directly on painted surfaces for better corrosion resistance, just to mention two of the multiple advantages by using this fixation method.

One of the most contradictory discussion concerns the definition of "Structural bonding" Many authors use this expression in connection with a high strength or modulus of an adhesive. A more practice related definition uses this expression for bonding assemblies which are essential for the functioning to the assembled part. This seams for us a better definition as it will also take in consideration the durability aspects.

Elastic adhesive bonding is a joining technique with a number of innovative performance characteristics, which forms a welcome addition to the standard repertoire of rigid fastening technologies. Through the selective use of these adhesives and attention to the specific application techniques associated with them, engineers and designers are now able to design technically sophisticated products that can be manufactured economically.

Differences between elastic thick layer bonding and rigid thin layer bonding

General Characteristics	Rigid (high modulus) adhesives	Elastic adhesives
Bondline dimension	Thin adhesive layer, small overlapping	Thick layer of at least 2 mm. Higher force transmission may be achieved by increasing the overlap (bonding area)
Temperatur dependency	Glass transition temperature has to be observed. If the bonded object is used over this temperature, mechanical resistance drops and may lead to failures	Elastic adhesives have a glass transition temperature at about minus 50 °C. The dependency of the mechanical strength in the normal application range is minim. However the temperature resistance is limited to approx. 90 °C for elastic Polyurethanes and approx. 120 °C for Silicones
Force transmission	Forces resulted by mechanical stress or differences in thermal expansion coefficient have to be transmitted and result directly from the chosen parameters. In some cases parts may deform during temperature change due to a "Bimetal effect"	Forces applied on an elastic bond line provoke a deformation of the bondline, thus lowering the stress on the substrates
Shock resistance	Normally the shock resistance of a rigid bond line is not very high, especially in the range of the Glass Transition Temperature. However some special formulations have an excellent choc resistance	The shock resistance of elastic bond lines is excellent. The mechanical resistance increases with the applied speed. Under choc resistance, the mechanical resistance is high
Adhesion on painted substrates	The paint adhesion on a substrate is about 7N / mm^2. High modulus adhesive may lead to stress peaks and cause a break between paint and substrate	The modulus of elastic adhesives is lower than the one of the paint. Therefore application on painted substrate is possible. Thereby the corrosion resistance is not impaired
High strength bonding	Good solution. Rigid adhesives may be combined with mechanical fixation methods	Only possible with larger bonding area

Differences elastic thick layer bonding / rigid thin layer bonding

	Rigid thin layer bonding	Elastic thick layer bonding
Bonding of different metals	Perfect in case of metals with low differences in thermal behavior, good for applications where bondline dimension (thickness /surface) is restricted	Good compensation of thermal movements, good protection against galvanic corrosion, good tolerance gapping
Bonding of metals with plastic	Usable for bonding smaller parts, good for applications where bondline dimension (thickness /surface) is restricted.	Ideal for bonding of GRP with important tolerances, good for shock resistence and acoustical damping
Bonding plastic to plastic	Normally good technique with low surface preparation, ideal for sandwich construction with low modulus core materials	Less interresting solution. ESC has to be taken in consideration. Ideal for bonding duromers (glass reinforced plastics) with important tolerances

Fig. 8 Bonded windows on cruise vessel

Fig. 9 GRP parts and windows bonded on high speed ferry

Fig. 10 Luxury megayacht glazing

BONDING CONSTRUCTION DESIGN

PRINCIPALS

Joining of two materials means to connect them to a unit which is capable to transmit forces resulting from dynamic, static or other stress during the use of the subject. Normal joint technologies are mechanical joining methods which are known since long times.

Glues however have been reported to be used about 3000 years before JC. Asphalt and natural resins have been used to tighten up ships and clay has been used to build houses.

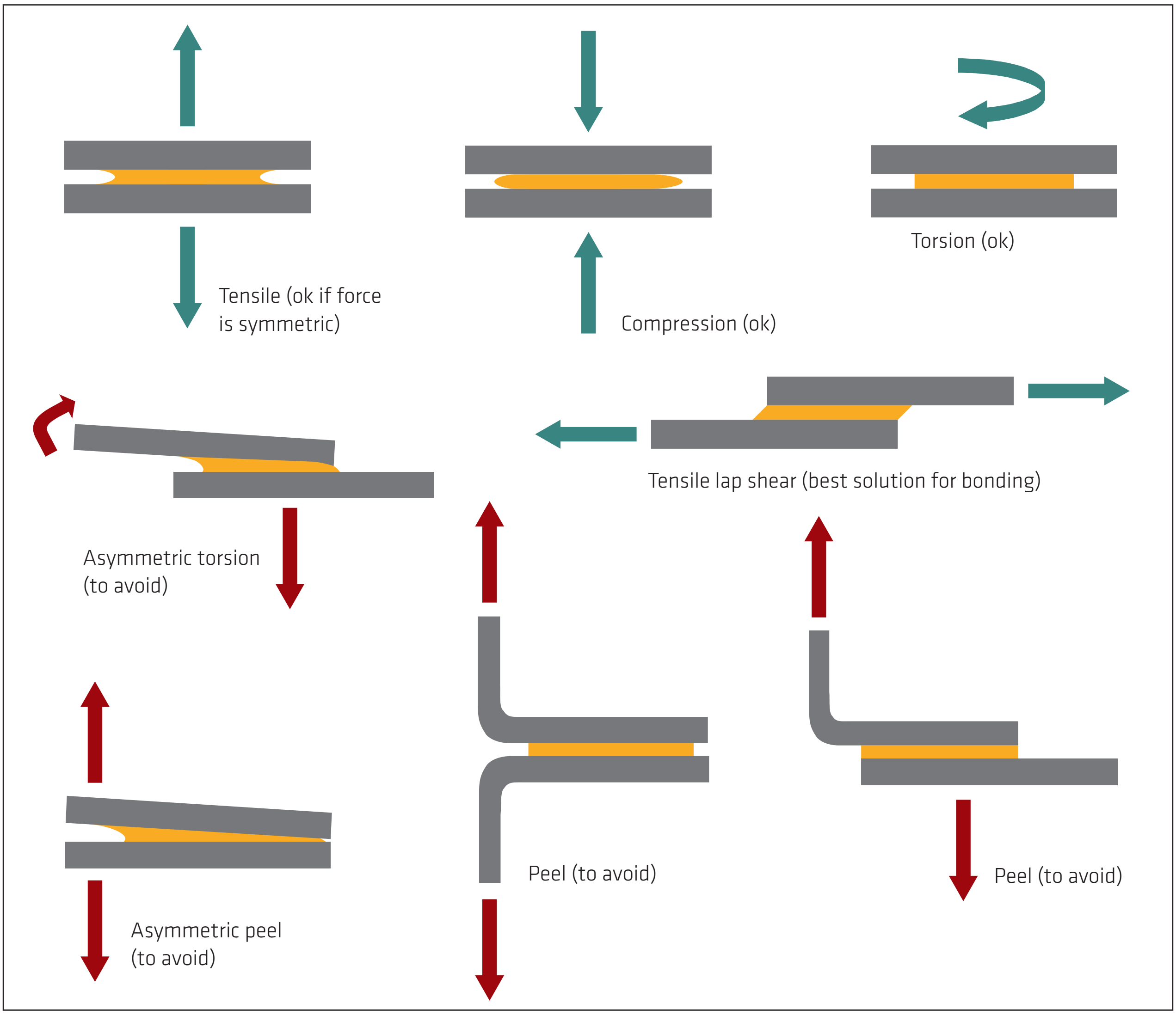
However structural bonding started in the 30ties of this century. One of them is unsaturated polyester which are still in use today. The development of epoxy resins opened up a vast area of bonding applications

Elastic adhesives or sealants started in 1964 in the USA using an elastic adhesive for windscreen bonding. This technology is state of the art in all type of windscreen bonding in all market fields.

In the 80ties elastic bonding was used in busses followed by trains and trams in 1992. Structural bonding in Marine started at the beginning of the 90ties. In the meantime, elastic bonding technology was established in other sectors of the manufacturing industry, such as for containers, refrigerators and washing machines, facades, floors, windows and many applications.

The following chapter will help to understand the bonding technology and how to design an adhesive joining case.

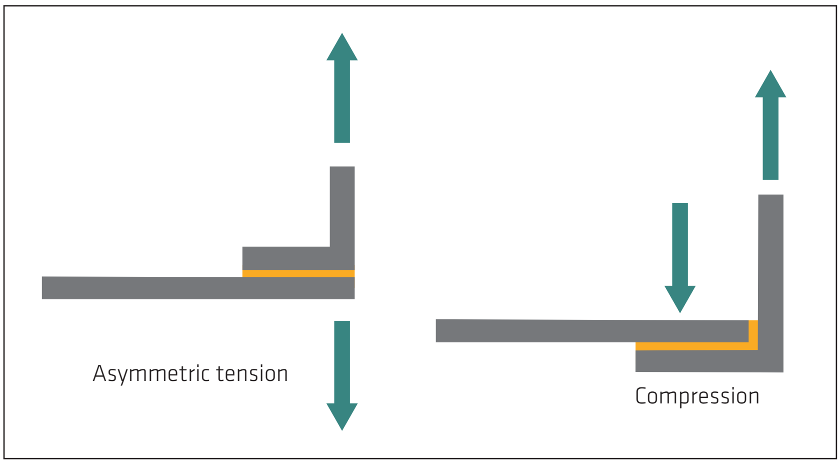
Generally forces which in praxis occur are the following:



The strength of a joint is basically determined by the area of the bond, the inherent strength of the adhesive or the substrate and the stress distribution within the joint. A poorly designed joint can lead to high stress concentrations in the joint itself and / or in the substrates connected, which in turn can lead to premature failure. Good joint design, which takes into account the practicalities of application as well as the geometry of the joint, is essential for a long service life in a demanding Marine environment.

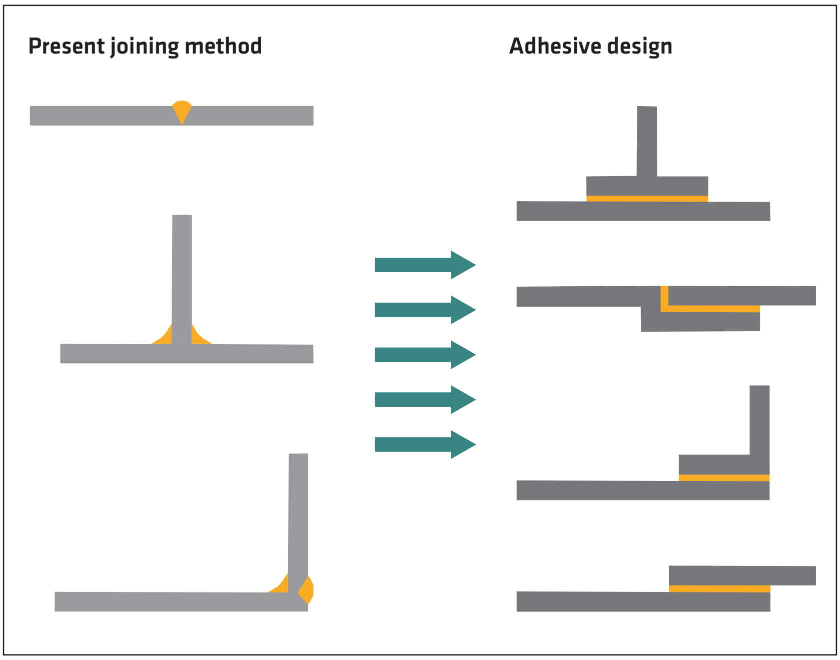
Peel forces are the most difficult to counter and must be avoided by changing the design of the joint.

Here an example: by changing the construction the risk of peel forces could be minimised



Traditional mechanical joint design has to cope with the inherent strength of an adhesive.

The following examples show some of an adhesive alternative to welding.



CALCULATION OF THE BONDING AREA

The dimensioning of a bond line depends mainly of the forces to be transmitted, and the mechanical resistance of the substrates and adhesives.

One of the most common errors is to calculate the bond line on the bases of the data's in the Product Datasheets. These data's are based on static tests. In praxis a lot of factors have to be considered. Temperature influence, type and frequency of the stress, aging etc. are factors on which the bond line is subjected.

Detailed calculation procedures can be ordered from your local Sika Industry branch or in appropriated literature (Example: "Elastic bonding, the principles of adhesive technology and a guide to its cost effective use in Industry" Verlag Moderne Industrie)

In praxis a rule of thumb can be used as a first approximation. The lap shear strength has to be reduced to 3% of the Product Datasheet value.

Example:
Tensile lap shear force needed is 200 kg equal to 2000 Newton.
The Product Datasheet value of a particular adhesive is 2 N / mm^2

The calculation value for the applicable tensile lap shear strength is only 3 % of this Product Datasheet value: 2 N / mm^2 x 0.03 = 0.06 N / mm^2

The required bond surface is therefore: 2000 N / 0.06 N / mm^2 = 33'000 mm^2 = 330 cm^2

Considering a bond line width of 15 mm, the required length of the joint is:
330 cm^2 / 1.5 cm = 220 cm or <u>2.2 m</u>

Note:
For exact calculation with the FEM-Methods we recommend to consult the Technical Service Sika Industry

COST ADVANTAGE OF ELASTIC BONDING

COST COMPENSATION

Adhesives compared to riveting or spot welding result in an advantage of the mechanical fixations.

However, a cost comparison has to be done taking all factors of the realisation in consideration. As an example spot welding may increase the expenditure of the filling of a surface prior to painting, thus increasing the overall costs.

The following list gives thought-provoking impulse to realise a correct cost comparison.

Properties	Benefits (manufacturing)
Bond / seal simultaneously	Reduction of process steps / No additional sealant costs
Compensates for tolerances	Less work to prepare substrate
Application at room temperature (no thermal deformation)	Less spatula work / Low energy costs
Curing at room temperature	Lower energy costs
Bonding different substrates	Optimised choice of materials / lightweight construction / No bimetallic plates necessary
No sink marks on thin sheets	Thinner sheets / savings
Less tools	Lower investment costs

Properties	Benefits (enduser)
Not corrosion-prone fixing	Longer life expectancy
Reduced maintenance	Lower costs
Weight-reduction	Lower fuel consumption
No built-in tensions	Increased longevity
Design with low cw (drag coeff.)	Lower fuel consumption
Application and curing at room temperature	Simple repair
Even surfaces	Easy to clean
Noise reduction	Increased comfort
Freedom of design	Increased brand awareness

TIPS AND TRICKS

SURFACE PREPARATION

GENERAL REMARKS

The surface preparation is beside the material choice and the joint dimensioning the key for a long lasting bond. Therefore it is essential to execute the surface preparation very accurately.

SURFACE CLEANING

Dirty surfaces have to be pre cleaned. For oily or fatty surfaces, steam cleaning with detergents and consecutive rinsing with clean water are recommended for large areas. Smaller areas may be pre cleaned with solvents such as Sika® Remover-208.

Dust on surfaces is best removed with a vacuum cleaner. Compressed air as alternative can be used if it is deoiled.

Rust, other oxydes or loose paints have to be eliminated mechanically. Methods are sandblasting, and grinding. In case of sandblasting the type of blasting material has to be chosen according to substrate to clean. If necessary contact an abrasive producer.

Grinding with sand paper may be done with belt grinder, excentric grinder, rotation grinder or manually. The grit to choose depends on the material to eliminate. Usually grit 40-80 is used.

After grinding the dust has to be eliminated with a vacuum cleaner.

Fig. 11 Sandblasting

Fig. 12 Steam cleaner

Fig. 13 Deoiler for compressed air

Fig. 14 Excenter grinder

Fig. 15 Rotative grinder

Fig. 16 Belt grinder

SURFACE TREATMENT

The additional surface treatment may be the use of an activator or/and a primer. Detailed informations are given on the Marine Pre-Treatment Chart.

STORAGE OF THE PRODUCTS

STORAGE UNOPENED CARTRIDGE OR UNIPACK

Sikaflex® and Sikasil® products should be stored at a temperature below 25°C.
The product shelf life is indicated on each packaging unit.

If the product is stored at higher temperature, viscosity of Sikaflex® rises up to a moment where it is hard to extrude and shows a slight elastic behavior. In this case do not use it as the wetting of the substrate is not ensured anymore.

Sikasil® reacts differently. After the expiry date the reactivity slows down and the physical strength is lower than indicated in the Product Datasheet. The viscosity (extrusion behavior) of the product is not changing.

STORAGE OF AN OPENED CARTRIDGE

If a cartridge is opened and not used for some days, the nozzle has to remain on the cartridge and just changed with a new one before reuse of the cartridge.

If the product will not be used for a longer period, we recommend removing the nozzle and covering the cartridge opening with an aluminum foil. Screw a new nozzle over this foil. When reused after elimination of the foil, the beginning of the extrusion needs a high force. Once the plunger starts to move, the extrusion force drops down to a normal level.

STORAGE OF ACTIVATORS AND PRIMERS

These products should be stored at lower temperatures than 25°C. Once opened bottles should be closed immediately after use. Maximum storage life after opening is 3 months.

PRODUCT APPLICATION

GENERAL ADVICE

Respect the recommendation in the actual Product Safety Sheet concerning collective and personal protection.
Use only products within the best before date. Never use thinners or solvents to dilute Activators or Primers.

Fig. 17 Best before date cartridge

Fig. 18 Best before date unipac

APPLICATION OF ACTIVATORS AND PRIMERS

Activators should be applied like a solvent. It is applied on non-porous substrates only! Wet a paper tissue sparingly with the corresponding Activator and wipe the surface in one direction. Turn the tissue to a proper side and continue cleaning. Dry the area with a dry tissue (wipe on / wipe off method) Discard the tissues when dirty according to legal legislation.

Close Activator bottles immediately after use.

Fig. 19 Outer and inner cap

Fig. 20 Close inner cap immediately after use

If you transfer the Activator in a separate can, discard the rest at the end of the day according to legal legislation to prevent inactivation of it.

Do not use an Activator which is cloudy or which show an unusual aspect.

Respect the minimum and maximum waiting time until the adhesive or sealant is applied. Consult the Pre-Treatment Chart Marine.

Primers are applied like paint. Use a clean dry brush, a felt or dauber to apply a Primer.

Sika® MultiPrimer Marine may also be applied with a paper tissue.

Pigmented primer like Sika® Primer-206 G+P or Sika® Primer-209 D have to be shaken until the metal ball in the can be heard. Shake for another minute until the primer is completely homogen.

Fig. 21 Shake

Fig. 22 Outer and inner cap

Fig. 23 Close inner cap immediately after use

If you transfer the primer for use in a separate can, discard the rest of it at the end of the day according to national legislation. With this action inactivation or jellification will be prevented.

Respect the minimum and maximum waiting time until the adhesive or sealant is applied.

APPLICATION OF ADHESIVES AND SEALANTS

The application is done with a good quality type of gun. Cheap guns may fail especially with higher viscous adhesives such as Sikaflex®-292i or -296.
Apply the product with a triangle shaped nozzle of the appropriate dimension, holding the gun in a vertical position.

Fig. 24 Adhesive application

Insert spacers (see page 17) beside the adhesive bead

Join the parts together, applying a uniform pressure until the final position of the parts is reached. Use a flat rod to press flexible parts uniformly to the desired thickness.

In case of vertical application use distance blocks or adhesive tapes to hold the part in position until the adhesive get sufficient strength.

For additional sealing operation, protect the sides with adhesive tapes. Apply the sealant watching a complete filling of the space to prevent air inclusions between adhesive and sealant. Tool the sealant with a flexible spatula. Remove the adhesive tapes as soon as the tooling has been done before skinning of the sealant occurs.

REMOVAL OF ADHESIVES AND SEALANTS

FRESH UNCURED PRODUCTS
On non-porous substrate, remove the sealant or adhesive with a spatula. Clean the left over with a tissue or rag and Sika® Remover-208.

Do not use other solvents as they can react with Sikaflex® forming a permanently sticky surface

On porous substrate it is best to let the product cure and remove it after hardening with mechanical means.

CURED PRODUCT
Cured Sikaflex® can only be eliminated with mechanical means. Solvents do not dissolve the hardened Sikaflex® but may soften it for easier removal (use acetone or isopropyl alcohol)

Note: Never use Sika® Aktivator for cleaning

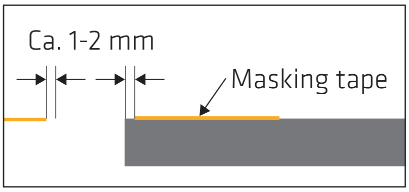
CLEANING OF HANDS AND SKIN
Contact with Sikaflex® should be avoided. Use personal and collective protection means, such as gloves etc.

Never use solvents to clean the skin. Best is Sika® Handclean towel or other water based cleaning pastes.

Detailed information's about the physiology of the products are available in the national Safety Datasheet, available on the Internet. www.sika.com

AUXILIARY MATERIALS

MASKING TAPE
Masking tapes are to be used to protect the substrate against soiling. Apply the masking tape about 1 mm away from the joint area (see illustration). After application and tooling of the adhesives, the masking tape should be eliminated as soon as possible before skinning of the adhesive or sealant occurs.



SPACERS
Spacers are used to assure a defined thickness of the bond line. They should be softer (shore hardness) than the cured adhesive.

Suitable materials are self-adhesive bumpers. Other possibility is to produce a small bead or sheet of the Sikaflex® adhesive in the desired thickness. After curing cut it in small parts of approx. 5x10 mm.

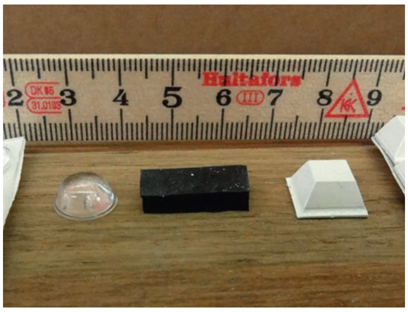


Fig. 25 Example of spacers

Fix the spacer on the substrate. If an adhesive is needed we recommend to use a small dot of Sikaflex®. Never use superglue as they exhale vapors which impair a good adhesion of the Sikaflex® adhesive on the substrate.

DISTANCE BLOCKS
Distance blocks are used to temporarily fix vertically bonded parts to prevent sliding.

They are best made of plastics or wood. Never use metals! After sufficient curing of the adhesive. They can be removed to permit the consecutive sealing (backfill) of the remaining joint.

Fig. 26 Distance block

HOW TO AVOID CORROSION

The best corrosion resistance is achieved with suitable paint systems which are designed for the marine conditions.

- Aluminum and ordinary steel have to be protected with such systems. (ISO 12499-3)
- In addition enclosed air pockets or other closed areas (example between adhesive and backfill sealant) have to be avoided. In case of cold application temperature, the viscosity can be decreased warming up the adhesive or sealant in a water bath. (Up to about 40°C)
- Interrupt the bead to allow occasionally entered water (condensed water).

Note: Sika primers give a very limited corrosion resistance and should be used only for adhesion purposes.

PRODUCT SELECTOR, CALCULATION TOOLS

Adhesives / sealants APPLICATIONS	Sikaflex®-290 DC PRO	Sikaflex®-291i	Sikaflex®-292i	Sikaflex®-295 UV	Sikaflex®-296	Sikaflex®-298	Sikasil® WS-605 S	Sika Firesil® Marine N	Sikasil® N-Plus	SikaTransfloor®-352 ST and SL
General sealing overpaintable	-	● ● ●	● ●	-	-	-	-	-	-	-
General sealing, weathering resistant	-	-	-	● ● ●	● ●	-	● ● ●	-	-	-
Fire retardent sealing	-	-	-	-	-	-	-	● ● ●	-	-
Organic glass bonding	-	-	-	● ● ●	●	-	-	-	-	-
Mineral glass bonding	-	-	-	-	● ● ●	-	-	-	-	-
Deck levelling	-	-	-	-	-	-	-	-	-	● ● ●
Wodden deck bonding	-	● ●	-	-	-	● ● ●	-	-	-	-
Caulking	● ● ●	-	-	-	-	-	-	-	-	-
Bonding of coverings	-	● ●	-	-	-	● ● ●	-	-	-	-
Sanitary sealing	-	●	-	-	-	-	-	-	● ● ●	-
SERVICE CONDITIONS										
High temperature > -40 °C to 150 °C	-	-	-	-	-	-	-	● ● ●	● ●	-
Normal temperature -40 °C to 90 °C	-	● ● ●	● ● ●	● ● ●	● ● ●	● ● ●	● ● ●	-	-	● ● ●

See also Pre-Treatment Chart for Marine Applications

KEY TO SYMBOLS

● ● ●	Best solution
● ●	Good solution
●	Possible solution

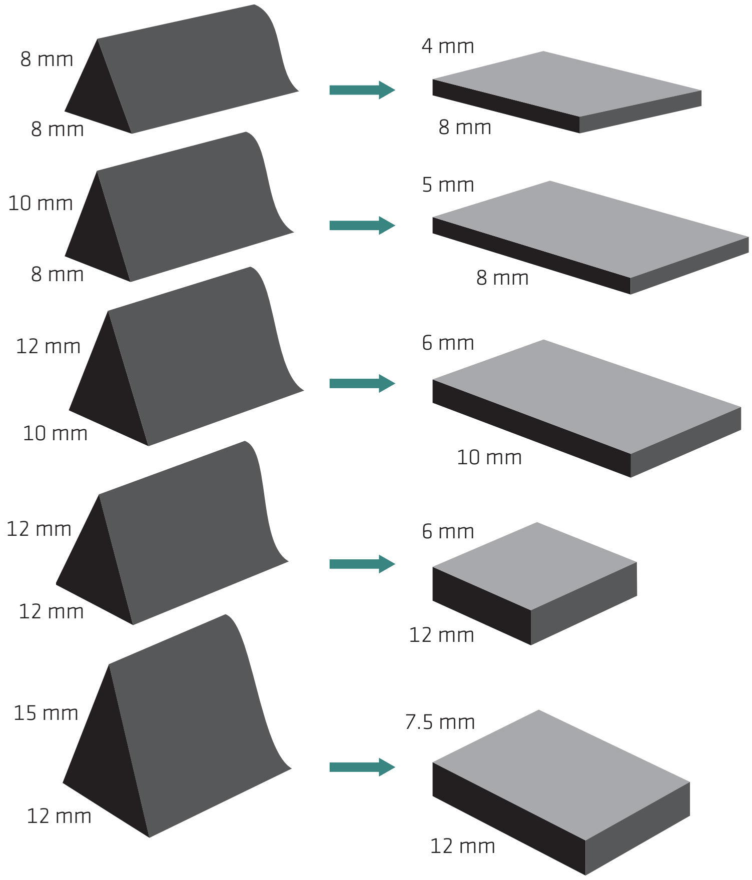
ADHESIVE PRIMER CONSUMPTION

DESIGN OF ADHESIVE LAYER GEOMETRY

The elastic adhesive can only fully develop its positive properties (movement compensation, peeling and impact resistance) if the adhesive layer geometry is correct.

Above all, this means keeping to a minimum layer thickness that must be individually suited to the bond. A layer thickness of 2-3 mm has proved best for most applications. Thicker layers may be required where considerable movement is expected.

Depths over 20 mm should be avoided with standard Sikaflex® grades because the adhesive would take too long to harden.



	NO. OF METRES PER 300 ML CARTRIDGE			NO. OF METRES PER 100 ML TUBE		
JOINT WIDTH	5	10	15	5	10	15
DEPTH / LAYER THICKNESS OF BOND (MM) 1	62.00	31.00	20.60	20.00	10.00	6.60
2	31.00	15.50	10.30	10.00	5.00	3.30
3	20.60	10.30	6.88	6.60	3.30	2.20
4	15.50	7.75	5.15	5.00	2.50	1.60
5	12.40	6.20	4.10	4.00	2.00	1.30
6	10.30	5.16	3.44	3.30	1.60	1.10
7	8.85	4.40	2.95	2.80	1.40	0.90
8	7.75	3.90	2.60	2.50	1.20	0.80
9	6.90	3.50	2.30	2.20	1.10	0.70
10	6.20	3.10	2.00	2.00	1.00	0.60

PRIMER AND CLEANER CONSUMPTION

PRODUCT	YIELD PER 100 ML AT 20 MM WIDTH (m)	BRUSH APPLICATION TISSUE APPLICATION* (l / m²)
Sika® Aktivator / Sika® Aktivator-205	25-30	0.04*
Sika® Primer-206 G+P	17-22	0.1-0.15
Sika® Primer-209 D	12-15	0.15-0.2
Sika® MultiPrimer Marine	12-15	0.15-0.2

Make sure that:

- The primed areas coincide with the bonding areas
- The right primer for the material surface is used
- The primer is completely dry and cured before bonding i.e. watch the evaporation time
- Primers are shaken if necessary

CONVERSIONS AND CALCULATIONS

FORMULAE

TO ESTIMATE THE NUMBER OF LITRES REQUIRED

Normal bead application;

$$\text{Quantity in litres} = \frac{\text{bead width (mm) x bead thickness (mm) x joint length (metres)}}{1000}$$

(Dimensions are for wet adhesive in rectangular cross section)

Large area bonding and laminating;

Quantity in litres = width (metres) x length (metres) x wet film adhesive thickness (mm).

TO DETERMINE THE VOLUME OF A SEMI-CIRCULAR BEAD

$$\text{Quantity in litres} = \frac{\text{3.142 x diameter (mm) x diameter (mm) x length (metres)}}{8000}$$

TO DETERMINE THE VOLUME OF A TRIANGULAR BEAD

$$\text{Quantity in litres} = \frac{\text{width (mm) x height (mm) x length (metres)}}{2000}$$

TO CONVERT KILOGRAMS TO LITRES

$$\text{Quantity in litres} = \frac{\text{weight in kilograms}}{\text{density (grams / ml or kg / l)}}$$

TO CONVERT BETWEEN TEMPERATURE SCALES

$$\text{Fahrenheit} = \frac{\text{(degrees celsius (°C) x 5)}}{9} - 32$$

$$\text{Celsius} = \frac{\text{(degrees fahrenheit (°F) x 9)}}{5} + 32$$

WEIGHT	
1 ounce =	28.3495 g
1 pound =	0.45359 kg
1 hundredweight =	50.8023 kg

AREA	
1 inch^2 =	645.16 mm^2
1 foot^2 =	0.0929 m^2
1 yard^2 =	0.8361 m^2
1 acre =	4046.86 m^2
1 mile^2 =	2.59 km^2

VOLUME	
1 pint (UK) =	0.5683 l
1 pint (USA) =	0.4732 l
1 gallon (UK) =	4.5461 l
1 gallon (USA) =	3.7854 l

LENGTH	
1 inch =	25.4 mm
1 foot =	0.3048 m
1 yard =	0.9144 m
1 furlong =	201.17 m
1 mile =	1.6093 km

PRESSURE	
1 bar =	0.1 MPa
1 Pascal =	1 N / m^2
1 kgf / cm^2 =	0.09807 MPa
1 psi =	6894.76 Pa

SI PREFIXES

NAME	SYMBOL	FACTOR
giga	G	109
mega	M	106
kilo	k	103
hecto	h	102
deca	da	101
deci	d	10-1
centi	c	10-2
milli	m	10-3
micro	µ	10-6
nano	n	10-9

TEMPERATURE SCALES

°C	°F
100	212
80	176
60	140
40	104
35	95
30	86
25	77
20	68
15	59
10	50
5	41
0	32

The information, and, in particular, the recommendations relating to the application and end-use of Sika products, are given in good faith based on Sika's current knowledge and experience of the products when properly stored, handled and applied under normal conditions. In practice, the differences in materials, substrates and actual site conditions are such that no warranty in respect of merchantability or of fitness for a particular purpose, nor any liability arising out of any legal relationship whatsoever, can be inferred either from this information, or from any written recommendations, or from any other advice offered.

The proprietary rights of third parties must be observed. All orders are accepted subject to our current terms of sale and delivery. Users should always refer to the most recent issue of the Sika Product Datasheet for the product concerned, copies of which will be supplied on request.

QUALITY ASSURANCE

PRACTICAL HINTS

This chapter examines the practical issues of quality assurance for elastic adhesive and sealant applications

The proposals outlined here should be viewed as a general checklist to be adapted to the specific requirements of each marine manufacturing environment.

Particular attention needs to be paid to establishing an effective system of quality assurance for adhesive connections.

Testing of the adhesion, and therefore the reliability, is only possible by destructive means.

Visible inspection is only effective to a limited degree, so the quality of the bond line has to be assured by the following:

- Ensure the constance of the surface quality of the substrates to be bonded
- Correctly prepare the surfaces to be bonded
- Select the correct adhesive (as specified by the manufacturer)
- Apply (and cure) the adhesives correctly
- Respect engineering rules such as joint dimensions, etc.

If these parameters are maintained within the prescribed limits, then the quality, strength and durability of the adhesive bond is ensured.

In addition, there is little or no need to supplement these measures with time-consuming and costly destructive testing.

The following table (Quality Assurance Programme) shows that quality assurance begins at the project stage and continues throughout construction, right up to the final rollout of the product. It outlines a typical quality management programme for adhesive applications. This model has been adopted with very satisfactory results in many areas of OEM ship building and in the subcontractor segment of the marine industry.

QUALITY ASSURANCE PROGRAMME

PROJECT STUDY	CONSTRUCTION OF PROTOTYPE	END OF TEST PHASE	SERIAL PRODUCTION
Design and construction adapted to adhesive technology and assembly methods	Checking and specifying correct method of substrate preparation in consultation with adhesive and paint suppliers	Evaluation of test phase, making any design changes that may be indicated	Implementation of a quality assurance system
Dimensioning and configuration of adhesive joints based on existing codes of practice and design data	Construction of prototype based on design criteria for adhesive bonding. Adhesive supplier (applications engineer) to advise where necessary	Preparation of a production and quality assurance manual for adhesive bonding applications, taking into account the key application parameters of temperature and humidity	Periodic refresher courses and further training for personnel
Appointment of an in-house adhesives specialist to liaise between departments on all aspects of adhesive usage	Specifying type and scope of repair works	Training of assembly personnel in the use of adhesives	Introduction of activities aimed at raising quality standards (e.g. quality awareness groups)

In commercial enterprises that use adhesives in serial production, the sound working knowledge of adhesive technology needed is generally confined to a few individuals in technical departments. The policy of training one technician as an in-house adhesives specialist has proven to be an effective solution to making this information available on the production floor.

The trained person is also able to coordinate all aspects of adhesive usage for marine projects as a whole and acts as a neutral adviser to the individual departments concerned.

The following table highlights the main issues that need to be addressed.

MAIN POINTS OF CONSIDERATION FOR THE INTRODUCTION OF ADHESIVE TECHNOLOGY

ADHESIVE	Selected to suit the requirements of the production cycle and the service stresses to which the finished assembly will be subjected
SUBSTRATE	Consistent and sound composition and surface condition
SURFACE PREPARATION	Selected to suit the requirements of the production cycle and the service stresses to which the finished assembly will be subjected and to accommodate variances in unstable substrates (mould release in GRP, wood)
APPLICATION PARAMETERS	Working within the specified time limits (open time), taking account of temperature and relative humidity levels
JOINT DESIGN	Adhesive-friendly joint design, dimensioning of joints to suit functional requirements of finished assembly in accordance with manufacturers engineering rules. Think about a possible repair solution
STAFF TRAINING	External or internal training courses organized in conjunction with adhesive suppliers

The following table is a guide to the preparation of a quality assurance concept. The scope and frequency of the test regime will need to be adjusted to the scale of the project and to the availability of technical and manpower resources.

A GUIDE TO THE PREPARATION OF A QUALITY ASSURANCE CONCEPT

AREA OF RESPONSIBILITY	CHECKS AND CONTROLS	DEPARTMENT / PERSON RESPONSIBLE
ENSURING CONSISTENT QUALITY OF SUBSTRATE	Specification (name, brand, grade, supplier, chemical composition, manufacturing processes, details on mould release systems used, etc.) Release system (open mould, infusion)	Design and engineering
	Contractual agreements specifying quality and condition of substrate (duty to inform in event of changes)	Purchasing
	Checks on incoming deliveries (name, brand, grade, product characteristics) with adhesion tests (see Pre-Treatment Chart)	Quality assurance
	Correct storage (temperature, humidity, prevention of soiling, first-in first-out stock rotation)	Quality assurance / Logistics
PREPARATION OF SUBSTRATE	Specification (mechanical surface preparation, chemical products, type of application, processing schedule)	Design and engineering / Adhesives technician / Adhesive supplier
	Checks on incoming deliveries (name, brand, grade, visual inspection of packaging, labelling, product characteristics)	Quality assurance
	Correct storage (temperature, humidity, prevention of soiling, use of stock by expiry date)	Quality assurance / Logistics
	Subjective checks for visible defects in primers, etc. (E.g. cloudiness, sedimentation, thickening, smell), plus checks on expiry date	Quality assurance / Foreman
	Periodic checks on the correct application procedures (method of application, observation of recommended drying times, correct handling of primed components prior to assembly, etc.)	Quality assurance / Adhesive technician Adhesive specialist
APPLICATION OF ADHESIVE	Checks on incoming deliveries (name, brand, grade product characteristics, visual inspection of packaging, labelling, periodic adhesion tests[1])	Quality assurance
	Correct storage (temperature, humidity, conditioning of stock to room temperature, use of stock by expiry date)	Quality assurance / Logistics
	Subjective checks for visible defects in adhesives (changes in consistency, flow behaviour, etc.), plus checks on expiry date	Quality assurance / Foreman
	Periodic checks on correct application procedures (method of application, observance of specified open times, correct joint assembly sequence, waiting times prior to further processing, etc.)	Quality assurance/ Adhesive technician Adhesive specialist

[1] Adhesion tests are based on DIN 54457

Nowadays, bonding technology is a well accepted and proven practical assembly method. However if the correct application procedures are neglected, the bonded or sealed object will not comply with expectations. In fact the correct use of adhesives and sealants in marine applications should not be regarded any differently from other traditional industrial skills such as welding or painting. The only real difference is that applications use a wide range of different materials and subsequently this requires personnel with specialist skills and training.

This manual supplies all of the information necessary for the correct application of adhesives and sealants. However, should there be any doubt regarding materials, methods or applications, support and advice can be obtained from the Marine expert at the nearest Sika Industry organisation.

PRODUCT DATASHEETS AND SAFETY DATASHEETS

PRODUCT DATASHEETS (PDS)

The Product Datasheet describes the product characteristics as well as information about the area of application, advantages and application descriptions.

Before using Sikaflex® or other Marine products we recommend to download the actual Product Datasheets from the Internet.

As the legal part depends on the country of application, the Product Datasheet has to be downloaded from the national internet site. Choose worldwide and click on the respective country.

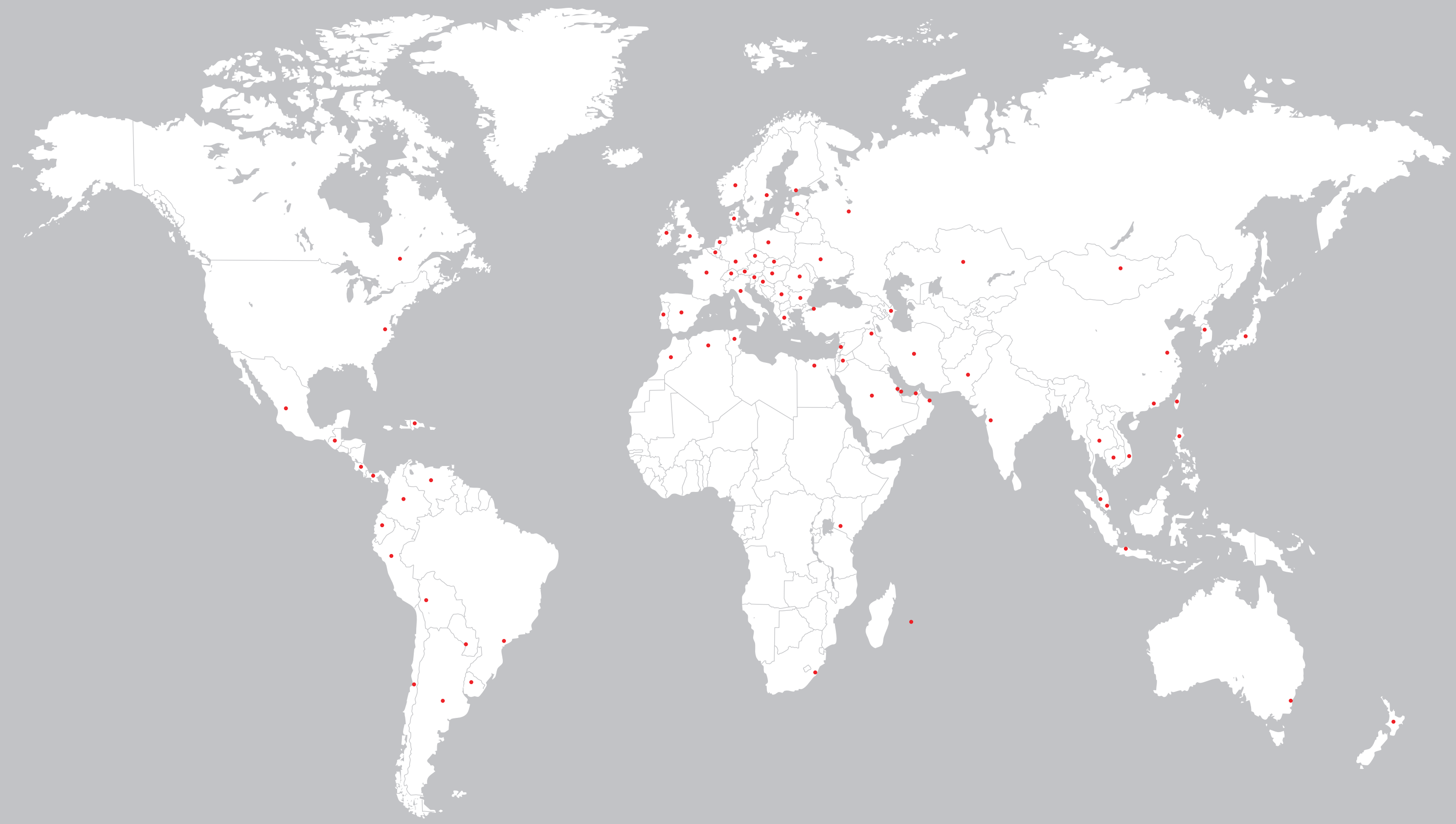
SAFETY DATASHEETS (SDS)

The Safety Datasheet helps to work safely with chemical products. This document has to be available to everyone which is in direct and indirect contact with chemical products.

The content of the SDS
- Identification
- Composition
- Hazards
- First-aid measures
- Fire-fighting measures
- Accidental release measures
- Handling and storage
- Exposure controls
- Personal protection
- Physical / chemical properties
- Stability and reactivity
- Toxicological information
- Ecological information
- Disposal considerations
- Transport regulatory information

Most up-to-date Safety Datasheet are available through the local sales organisation, or on www.sika.com.

GLOBAL BUT LOCAL PARTNERSHIP



FOR MORE MARINE INFORMATION:

www.sika.com/marine

WHO WE ARE
Sika is a specialty chemicals company with a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing and protecting in the building sector and the motor vehicle industry. Sika has subsidiaries in 94 countries around the world and manufactures in over 170 factories. Its more than 17,000 employees generated annual sales of CHF 5.49 billion in 2015.

Our most current General Sales Conditions shall apply.
Please consult the Data Sheet prior to any use and processing.

SIKA SERVICES AG
Tueffenwies 16
8048 Zurich
Switzerland

Contact:
Phone: +41 58 436 40 40
Fax: +41 58 436 45 30
www.sika.com/marine

BUILDING TRUST