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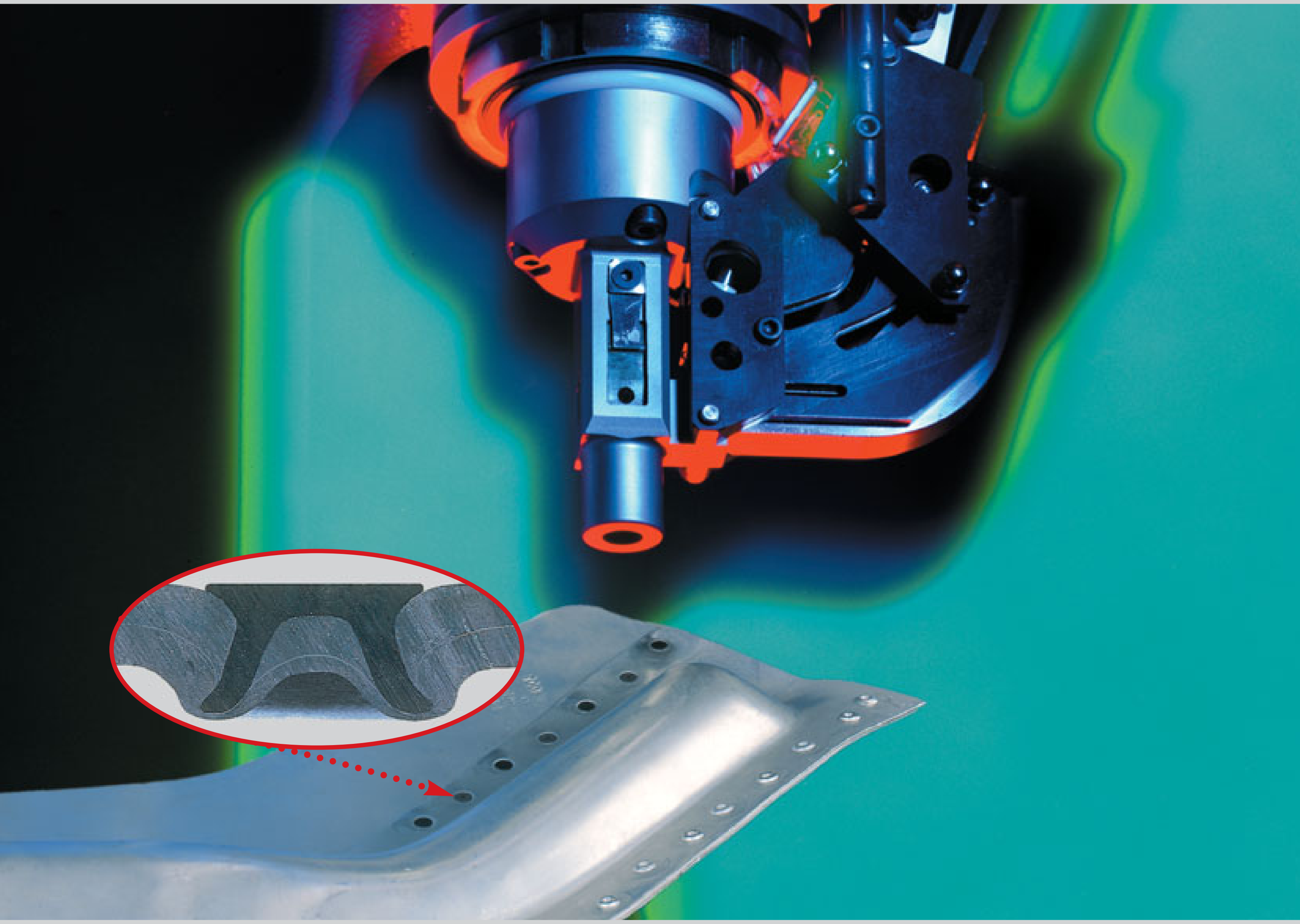
General Principles

RIVSET®



Self-Pierce Riveting

BÖLLHOFF

The Concept

All manufacturing industry has to join materials together. The importance and use of mechanical joining methods has increased significantly in recent years.
The need to accommodate changes in environmental legislation has lead to the use of new design concepts and materials. Development programmes have improved mechanical joining into a highly cost effective method of construction and assembly.
The trend is towards the use of lightweight assemblies, galvanised and coated steels, high strength steels, aluminium and plastics and combinations of these materials. As an example, in the sheet metalworking industry the use of the self-pierce rivet mechanical joining technique is found to be a cost effective alternative to conventional joining processes.
Self-pierce riveting is a process for a high strength mechanical joining of similar or combinations of materials whereby several layers can be joined without problem.

The Advantages of Self-Pierce Riveting at a Glance

The joint

- High strength
- Visual checks possible
- Reproducible
- No pre-drilling
- Impervious to liquids and gas
- For various metal and non-metallic materials
- For various material thickness
- For various material strengths

The system

- Safe, always correctly located supply
- Rapid automatic processing
- Simple, comfortable, operator friendly operation
- Automated process monitoring possible (as an option)

→

- Economical
- Reliable
- Flexible
- Environmentally safe

Advantages as compared with more traditional joining methods e.g. spot welding and blind riveting:

Material mix
- Many material combination options are possible (type of material and thickness).
- Coated metallic materials can be joined (using metallic, organic or inorganic coatings).
- Interim layers e.g. plastic or adhesive, are process-compatible.

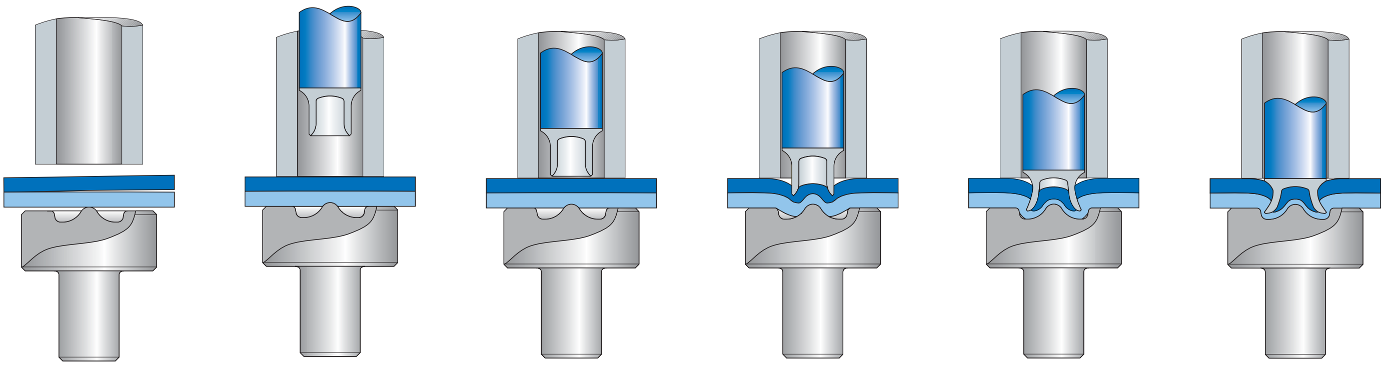
Process reliability
- Controllable process.
- Joint can be checked without damage, (NDT).
- No thermal load on joining zone.
- Simple to operate.
- No pre/post-treatment required e.g. no pre-cleaning or subsequent removal of spray deposits from the area around the joint.
- Does not damage or overheat alloy materials.

Environmental sustainability
- No harmful fumes or gases produced during production process.
- Low noise.
- Low energy consumption.
- No waste (e.g. splash, filling).

Functionality
- The process is ideal for automation and integration into other production operations (e.g. assembly processes).
- Rivet elements can assume other functions depending on design.
- Short set-up times.

The Process

Material layers are joined by a hardened semi-tubular rivet in a single step with no pre-drilling, little noise and no emissions, producing an interlocked friction joint. The rivet is designed to penetrate through the top material and is spread under the influence of a die positioned below the lower material. As this lower material is not pierced the resulting joint is localised and impervious to gas and liquid. Note that depending upon the overall thickness, more than two material layers can be joined using this technique.
The materials to be joined are placed between the setting head and the die. A force is then applied to a punch which then causes the self-pierce rivet to pierce the upper workpiece and forms the "button” in the lower workpiece under the influence of the die.
The return stroke is triggered once the pre-set pressure is reached and if required a specified distance of rivet penetration has been reached.
The result is a high strength, impervious joint.
The self-pierce rivets are made of carbon steel, stainless steel or aluminium and can be provided with various hardness levels and surface finishes designed to achieve maximum corrosion resistance. They can also be supplied painted in different colours.

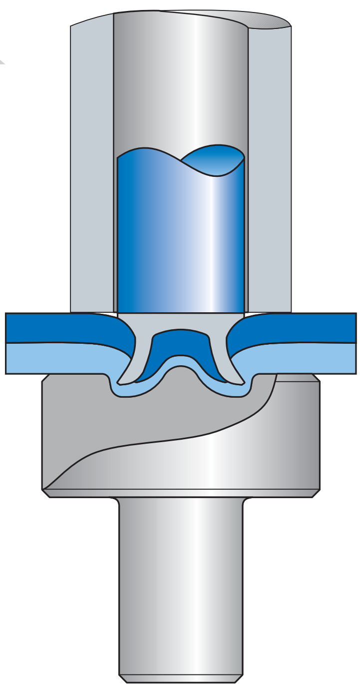


A simple and rapid operation enables materials with similar or different properties to be joined in an environmentally sustainable technique.

Variables that influence the Quality of a Self-Pierce Rivet

Joining equipment
- Design of the joining equipment
- Type of power production
- Static deformation behaviour
- Dynamic deformation behaviour
- Kinematics
- Control means

Joining parts
- Number
- Materials
- Material thickness
- Surface condition
- Geometry
- Accessibility

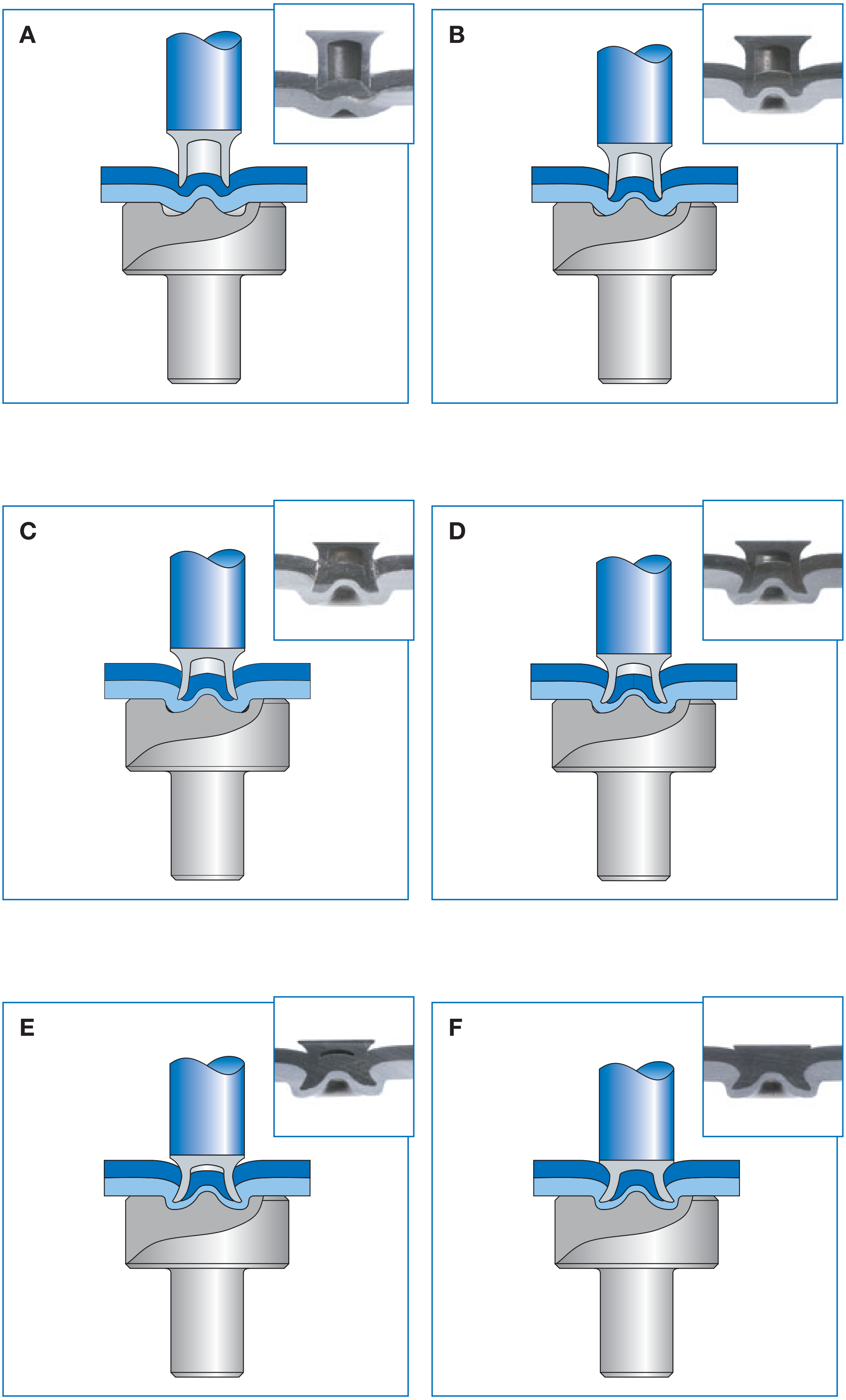


Joining tool
- Die geometry
- Joining forces

Auxiliary joining part
- Rivet material
- Self-pierce rivet geometry
- Hardness of the rivet

Joining process
- Spatial orientation
- Cycle times
- Ambient influences

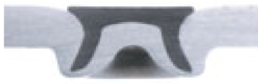
The Self-Pierce Rivet Process in Detail



What Materials can be joined?

- Steel (total thickness of the joint between 1.2 mm to 6.5 mm)
- Aluminium (total thickness of joint between 1.8 mm to 11 mm)
- Non-ferrous metals such as copper
- Castings of various materials
- Plastics
- GFK/CFK
- Wood
- Various combinations of material mix is possible

Aluminium 1.3 mm
Aluminium 1.3 mm



Aluminium 1.2 mm
Aluminium 1.2 mm

Steel 0.9 mm
Aluminium 2.0 mm

Plastic 2.0 mm
Aluminium 2.0 mm

Aluminium 1.6 mm
Steel 1.5 mm
Aluminium 1.6 mm

Steel 0.7 mm
Steel 0.9 mm
Steel 0.7 mm
Steel 2.2 mm

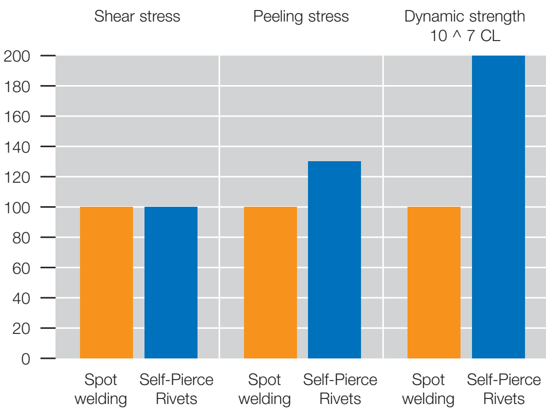
Shearing and Peeling Tensile Forces of a RIVSET® *Self-Pierce Rivet Joint*

Material	Sheet thickness punch side [mm]	Sheet thickness die side [mm]	Rivet dimensions (Ø)	Shear tensile strength [kN]	Peeling tensile strength [kN]
St 1203	0.75	0.75	3	2.29	0.87
St 1203	1.00	1.00	3	3.10	1.12
St 1203	1.00	1.00	5	3.75	1.89
St 1203	1.20	1.20	3	3.89	1.78
St 1203	1.20	1.20	5	4.45	2.23
St 1203	1.50	1.50	3	4.37	2.45
St 1203	1.50	1.50	5	5.99	3.26
ZStE 340	1.00	1.00	3	3.72	1.15
AlMg3	0.80	0.80	3	1.70	0.25
AlMg3	1.00	1.00	3	2.19	0.58
AlMg3	1.20	1.20	3	2.48	0.93
AlMg3	1.20	1.20	5	3.17	0.98
AlMg3	1.50	1.50	5	4.38	1.73
AlMg3	2.00	2.00	5	4.94	2.87

The given strength value are guideline values.

Shearing and Peeling Tensile Strengths and Vibration Strengths of Self-Pierce Rivet and Spot Weld Joints

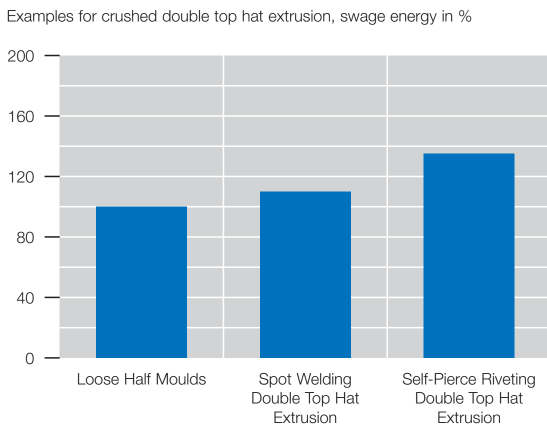
Strength values in %



Self-pierce rivet, diameter: 5 mm / source VAW

Energy absorption capacity

Examples for crushed double top hat extrusion, swage energy in %



Economic Benefits of Self-Pierce Riveting

The primary aim of the self-pierce riveting, besides being a modern, innovative joining system, is to save production costs.
These cost savings comprise of various factors:

Low investment costs

- No extraction equipment required (no dangerous fumes as from spot welding)
- No cooling water and therefore no costly installation required
- No expensive electrical installations for welding transformers
- High costs are associated in particular with the welding of galvanised steel plate and aluminium
- No time consuming or expensive set up

Low operating costs

- Lower energy consumption when operating the tools
- Low wear and tear costs thanks to long service life of tool kits
- No added electrical costs required by extraction equipment
- No cooling water required

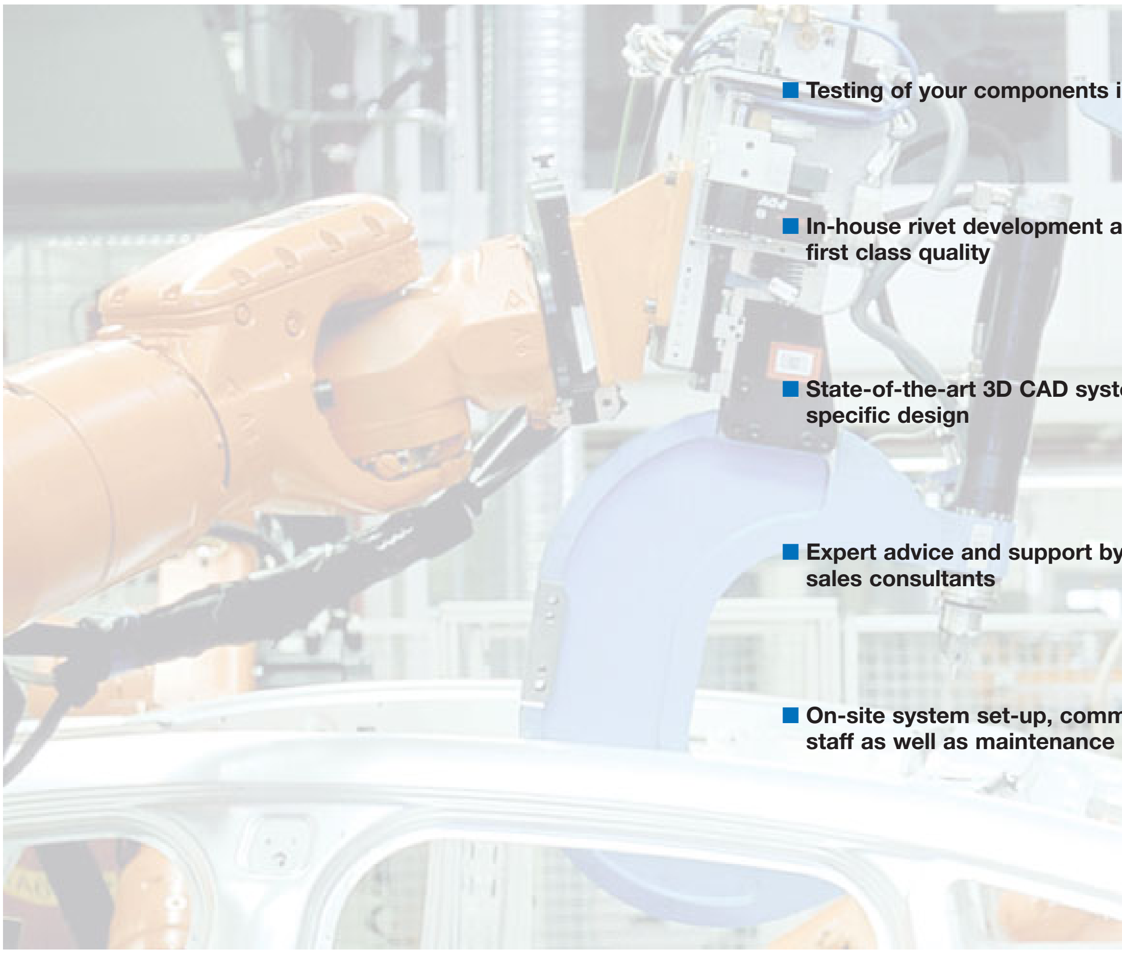
No post-processing costs

- Surface finishes, e.g. galvanising, are undamaged
- No "burn off" as with spot welding or the resulting costly and time consuming re-galvanising to prevent undesirable corrosion
- No re-sealing because there is no warping due to heat

Short production times

- Faster joining process (setting time depends on supply stroke and design of system used)
- Greater degree of automation possible –> higher unit quantities with fewer personnel!

We will be available to help with your project from the first step to completion

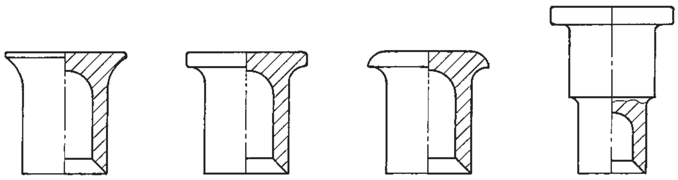


- **Testing of your components in the application system**
- **In-house rivet development and production guarantee first class quality**
- **State-of-the-art 3D CAD systems support our customer-specific design**
- **Expert advice and support by our project managers and sales consultants**
- **On-site system set-up, commissioning, training of your staff as well as maintenance and service support**

System Components of the RIVSET® *Self-Pierce Riveting System*

The Self-Pierce Rivet

Special care is taken in the development and design of the self-pierce rivet. We carry out a series of tests with an application system similar to the final design, using your material combinations, or matching, to determine the precise geometry of the self-pierce rivet. The resulting optimised self-pierce rivet is then manufactured in our own production centre. In this way you benefit from our continuous improvements on the basis of our in-house development and test programme. The variety of potential applications for self-pierce riveting is apparent from the range of different rivet designs available. The self-pierce rivet geometry, the hardness, the surface finish and the head shape can all be varied and each one is tailored to suit the particular application. Standard rivets are also available, in different lengths with shank diameters of 3 mm and/or 5 mm.



Countersunk head rivet | Flat head rivet | Flat round head rivet | T-pin

All self-pierce rivets are produced with various surface finishes according to customer specifications, e.g. mechanical zinc, ALMAC or lacquered head.

The Die

The die serves to produce the optimum form for the underside "button". It is designed so that the self-pierce rivet deforms in the bottom material and guarantees a corresponding "spread".
The parameters of the die are determined through trials with the customer's sample parts. The result in every case is a guaranteed optimum joint tailored to the actual application.

The Setting Head (Nose piece)

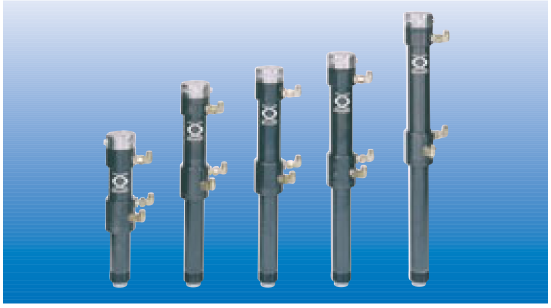
As well as guiding the rivet to the workpiece, the nose piece also serves to transfer the pre-clamping force. Various shapes can be selected to optimise access to the joining point.

System Components of the RIVSET® *Self-Pierce Riveting System*

The Setting Cylinder

There are two types available:

- Dual action cylinder for mobile and static use.
- Dual action cylinder with hydraulic pre-clamp for flexible and static use, especially designed for processing thin sheet, aluminium etc.

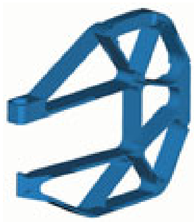


The C-Frame

As a possible joining force of up to 50 kN may be required, a stable mounting for the setting head and die is the guarantee of a good joint. The C-frame is designed to take into account the elastic deformation and the permanent strength requirements. The expected performance of each individual frame is calculated via FEA. Only in this way can the requirements of accessibility into the smallest of spaces be combined with the requirements for strength of the C-frame. Manufacture is carried out with extreme care. The C-frames are constructed in several distinct steps to the tightest tolerances. A comprehensive record is kept of each C-frame made so that our designs can be monitored throughout their productive life. As well as solid C-frames, weight or (wide) opening requirements may necessitate further modifications. Lightweight and articulated C-frames are available, with "open frame" types to meet specific applications. For optimum accessibility to the workpiece, on automatic blowfeed systems the rivet supply can be integrated into the frame itself.

C-frame for optimum accessibility

C-frame articulated

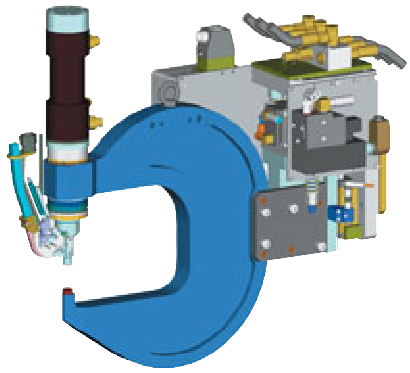


Weight-optimised C-frame

Standard C-frame

Axis Compensator

The axis compensator serves for the mounting-dependant weight compensation of the setting tool and compensates for the elastic C-frame deformation during the setting process. In addition the die can be reset to its starting position immediately after setting the rivet.



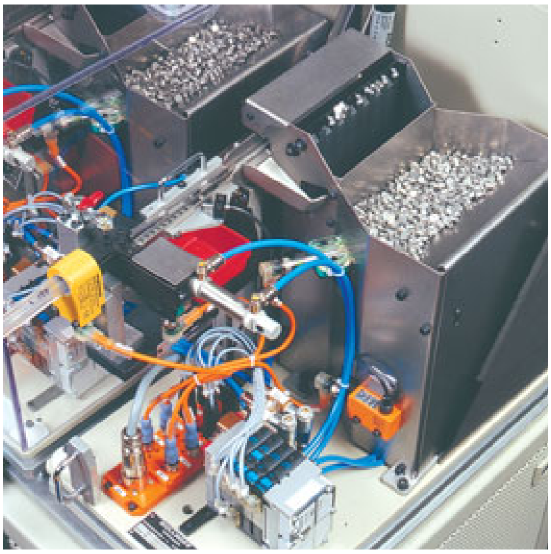
Supply System

There are two basic options for the supply of self-pierce rivets either as loose rivets or in a tapefeed spool/cassette. The chosen depends to a great extent on the application and volume to be used. Tapefeed spool/cassette supply systems are advantageous where different self-pierce rivets are to be processed in small or medium-sized runs.
They are particularly suitable for manual applications but can, if necessary, be used in robot systems.

System Components of the RIVSET® Self-Pierce Riveting System

The Self-Pierce Riveting System

Supply System



Loose self-pierce rivets in compact system
This system handles rivets in loose form, which are fed in bulk into a stepfeeder. They are then separated very gently and the rivet is then automatically blown to the setting tool.
The whole rivet feeding process is monitored. This ensures a rapid, continuous and reliable supply to the self-pierce rivet tool.
The use of loose self-pierce rivets, with an initially higher system investment cost makes sense, above all, for large production runs, as it reduces the rivet price. This method allows a continuous and reliable rivet feeding without tape changes, reduces transport and handling cost considerably and produces no waste (tapefeed belt) for disposal.

The Power Unit

The self-pierce rivet tool is hydraulically actuated.
The following power units are provided:

Integrated power unit for dual action cylinder
The power unit for the dual action cylinder is fitted with a high lift and low lift pump. This pump combination is actuated by a 1.5 kW electric motor with the hydraulic unit tank holding 6.0 litres hydraulic oil. The unit can be connected to a riveting tool for static or mobile use, thereby allowing rapid and continuous processing of the self-pierce rivets.

System Components of the RIVSET® *Self-Pierce Riveting System*

Power unit for dual action cylinder with hydraulic pre-clamping.
The power unit of the dual action cylinder with hydraulic pre-clamping is fitted with a 7.5 kW electric motor (setting and pre-clamping pressures can be adjusted separately). This drives a low-noise, internally geared pump with an oil feed rate of 23.0 l /min. It is designed for use with a PLC controlled self-pierce rivet system, which can be stand alone or integrated into a custom built machine or robot system. Further power units for specific applications are available on request.

Electrical power unit

The electrical power unit is another practical drive variant which is aimed at the car manufacturing industry. An electrically actuated spindle enables path and power-controlled rivet setting. A clever piece of engineering enables, here as with the other power units, the setting force and the holding down force to be set for each individual rivet point.
In development great value was placed on the compatibility of the systems. As a result all mechanical interfaces are identical. That means that e.g. the C-frames can be used with no modification for hydraulically or electrically actuated systems. Rivet supply and process monitoring are also identical. This has enabled us to keep all spare parts largely identical for those using both systems.

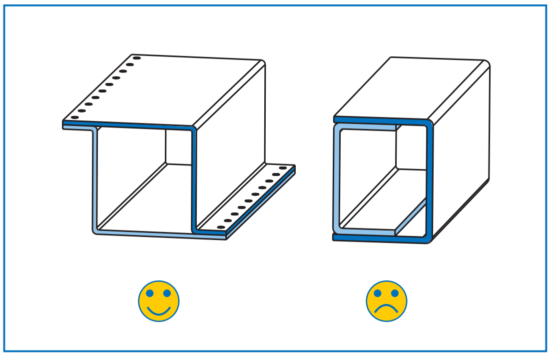
Process Monitoring

Quality monitoring of automatic self-pierce riveting is becoming increasingly important. Safety critical components, for example in the automotive industry, as well as parts subject to documentation in all branches of industry, necessitate the monitoring of the joint quality and the joining system itself.
The RIVSET® self-pierce riveting system offers the facility for controlling and recording the quality of the self-pierce riveting process via force/distance monitoring.

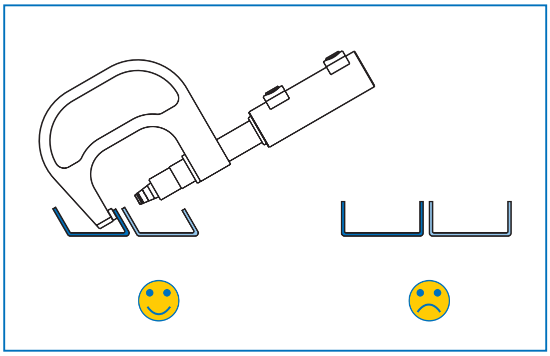
Böllhoff offers a number of process monitoring options:
Simple in operation via a menu system, highly flexible in the adaptation to customer specific joining tasks plus the ability to communicate with high level controllers via defined interfaces, are only a few of the outstanding system features.
Dedicated sensors measure the progress of the riveting force (via the hydraulic pressure) and the punch movement. The resulting generated curve is compared with a reference curve implemented via a teaching process.
If the actual process curve is within the pre-specified tolerance range it is recorded as OK. If not, an error signal is given and the process is halted. Whilst the reference curve can be ‘taught’, a certain number of reference curves are also available for standard applications.
The tolerance range can envelop the reference curve in a linear form or be defined in sections. The reference limits for the joining force and the punch movement are described and monitored within an individually defined window. If the process curve reaches this window without an error signal, the riveting process is recorded as OK.
The systems are very flexible and can be adjusted optimally and with ease to the actual application.

Workpiece Design – Advice for Designers

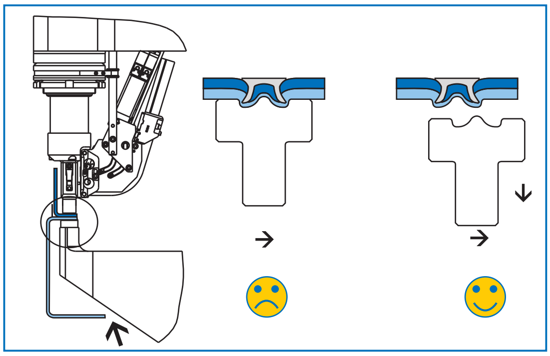
1. Avoid closed extrusions.



2. Allow access for the setting tool, avoid vertical flanges.

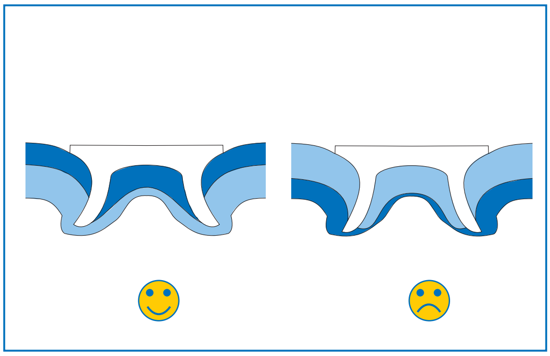


3. Leave sufficient clearance for the die and the C-frame. C-frames must be lowered before the tool can be moved out of the component.



4. Note rivet direction in the case of varying individual sheet thickness.

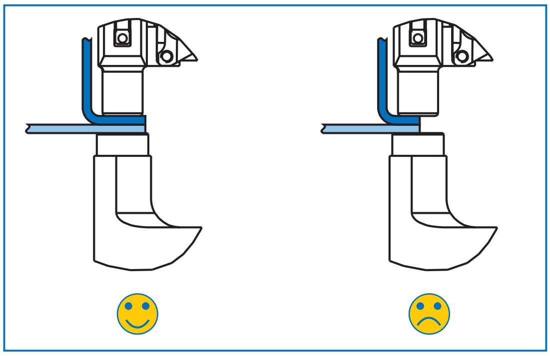
- Thin to thick
- Hard to soft



5. Provide sufficient flange width.

Rivet-Ø	
Ø 3 mm	16 mm
Ø 5 mm	18 mm

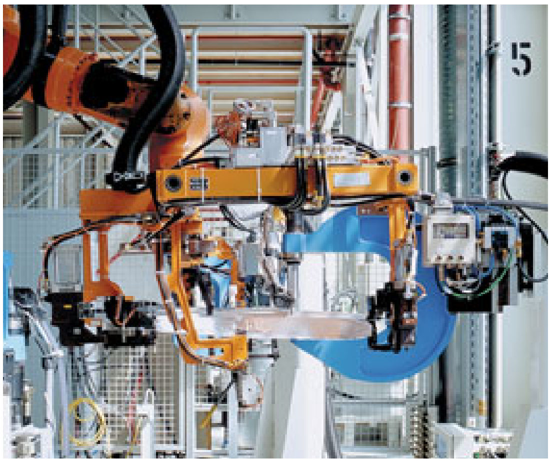
(without bending radius)



Handling Options

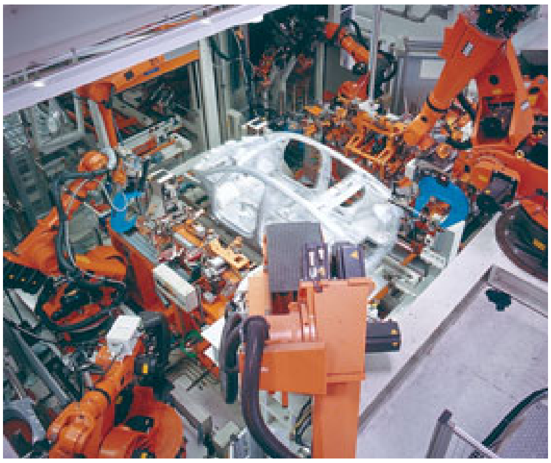
Manual component handling at static self-pierce riveting system.

Automatic handling between robot-fed components and self-pierce riveting system.



Manual handling of self-pierce riveting system at static (fixed) component.

Automatic handling between robot-fed self-pierce riveting system in a fully-automated production line.



Joining Techniques at a Glance

	Clinching	Self-pierce riveting	Blind riveting	Screw fastening	Spot welding	Bonding
Corrosion of coated material	Little	Little	Little	Little	High	None
Joint and strength	None	None	None	None	Yes	None
Dynamic load resistance	Very good	Very good	Less good	Less good	Less good	Good
Crush load resistance	Less good	Very good	Less good	Less good	Less good	Good
Static load resistance: 1. Shearing 2. Head stress	 Good Good	 Very good Very good	 Very good Very good	 Very good Very good	 Very good Very good	 Good Good
Process combined with bonding	Optimum	Optimum	Possible	Possible	Poor	–
Edges - Burring - Splinters	None	None	None	Edges	None	None
Joining elements required	None	Self-Pierced Rivet	Rivet	Nuts, Bolts, Washers Tap	None	Glue
Additional working processes	None	Supply	Drilling, Supply, Caulking	Drilling, Supply, Screwing	Post retreat-ment of treated surfaces	Supply, Pressing, Hardening
Cost per joint	Very little	Little	Very high	Very high	High	High
Energy consumption	Little	Little	High	High	Very high	Very high
Economy	Very good	Good	Poor	Poor	Less good	Less good
Environmentally friendly workplace	Very good	Very good	Good	Good	Poor	Very poor
Handling	Very simple	Simple	Simple	Simple	Simple	Time consuming
Reproducibility	Very good	Very good	Good	Good	Satisfactory	Good
Dependence of joint result on surface quality	Little	None	None	Little	High	Very high
Pre-processing	None	None	Drilling	Drilling	Washing, Etching	Washing, Etching

Self-Pierce Rivet system comparison

Equipment	Features	ABF	EBF	MBF	MTF	CTF	ABF-E
System integration							
Automatic system	Robot communication	●					●
Manual system	Two handed solution	●	●	●	●	●	●
	Foot switch solution	●	●	●	●	●	●
Rivet processing							
Magazine rivet feed	Conveyor belt transport				●	●	
Loose rivet separation	Step feeder with linear feed path with rivet length check	●					●
	Drum feeder		●	●			
Feed	Pneumatic	●	●	●			●
	Mechanical				●	●	
Hydraulic unit	Compact and modular	●	●	●	●	●	
	Separate	●					
Prop. Valve system	Variable setting pressure per rivet point	●		●	●		
	Variable hold-down pressure per rivet point	program-mable	manual	manual	manual		
Control	Siemens Type „S7“	●	●	●	●	Relay	●
Display		Touch Screen	Text Display	Operator Panel	Operator Panel		Touch Screen
IPC		●					●
Cylinder, joining power, max. 50 kN Joining pressure max. 250 bar	ZH 50 mm, 100 mm, 150 mm (infeed stroke-hydr. cylinder) SH 30 mm, 58 mm (punch stroke-hydr. cylinder)	●		●	●	ZH 50 mm, 120 mm, SH 30 mm	ZH 100 mm, SH 30 mm, spindle: max. 55 kN incl. hold down force
Cylinder, joining power, max. 50 kN Joining pressure max. 425 bar	ZH 50 mm, 100 mm (feed stroke-hydr. cylinder) SH 30 mm (punch stroke-hydr. cylinder)		●				ZH 100 mm, SH 58 mm, spindle: max. 55 kN incl. hold down force
	Interim stroke - stepless	●		●	●		●
	Hold down function	●	● (up to 3.1 kN)	●	●		●
	Stroke measurement system	●		●	●		●
	Partial return stroke	●		●	●		●
Rivet centring	Ball/shell centring	●	●	●	●	●	●
	Vacuum	●		●			●
C-frame	ABF standard	●	●	●	●		●
	EBF standard		●				
	CTF standard					●	
	Connect above and behind	●	optional	●	●	optional	●
	Through-grab option	optional	optional	optional	optional		optional
Axle load adjustment cradle		●					
Coupling module		●					
Joint quality	Eccentric sleeve for cylinder	●		●	●	optional	●
Process control	Pressure measurement	●		●	●		● force measurement
	Path measurement	●		●	●		● Resolver
	Enveloping curve monitoring	●					●
	Limit value monitoring	●		●	●		●
	Visualisation and storage of curves	●					●
Expandability	Use of two feeders	optional		optional			optional
	Use of two tools (alternating)	optional	optional	optional	optional	optional	optional

Application examples of RIVSET® *Self-Pierce Riveting Systems*

Motor Vehicle Industry

More examples:

- Wings
- Window apertures
- Front walls
- Door aperture
- Front/rear bonnets
- Floor subassembly
- Suspension strut brackets

Audi A2 body in white, aluminium

Motor Vehicle Supply Industry

More examples:

- Battery holders
- Heat shield panel
- Vehicle seats
- Wheel housing supports
- Sunroof

Flywheel/ steel

Heating, Air Conditioning and Ventilation

More examples:

- Vent pipes
- Air ducts
- Air vents
- Heat exchangers

Ventilation pipe/ steel

Sheet-Metalworking Industry

More examples:

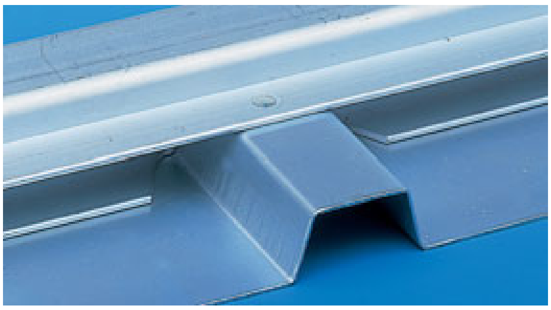
- Corner braces
- Escalators
- Protective covers
- Housings
- Garage doors
- Container constructions

Corner bracing for transport container/ aluminium

Building and Building Supplies Industry

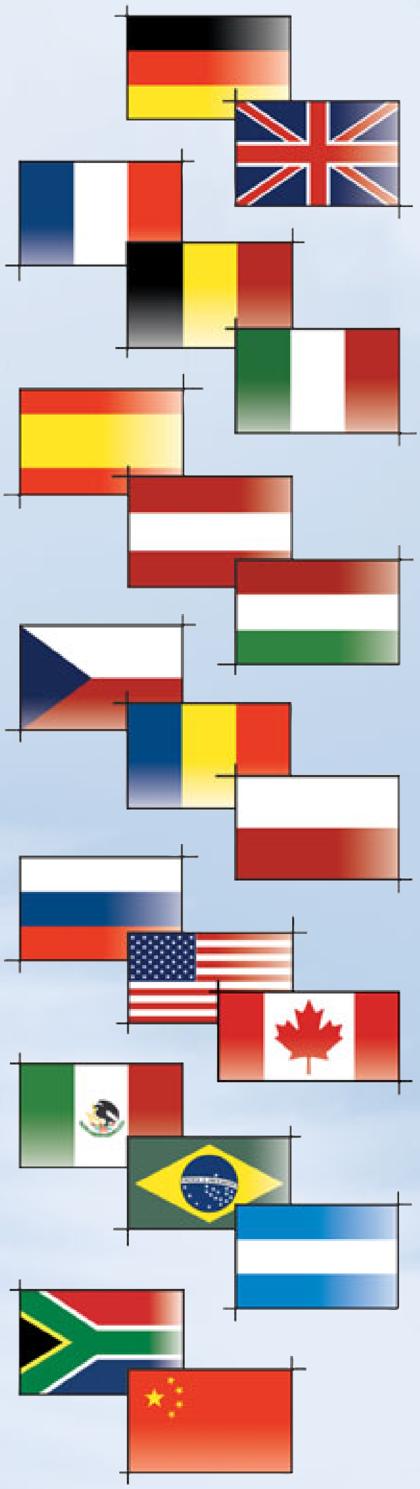
More examples:

- Wall cladding
- Structural components
- Prefabricated house constructions
- Silo constructions



Wall cladding/ aluminium

Böllhoff International



North Europe
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