TALAT Lecture 4104

Application Characteristics

15 pages, 18 figures

Basic Level

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Objectives:

– to describe the parameters governing performance of rivet and clinch joints

Prerequisites:

– General mechanical engineering background
– TALAT lectures 4101, 4102, 4103

Date of Issue: 1994

4104 Application Characteristics

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- Recommendations for rivet diameters
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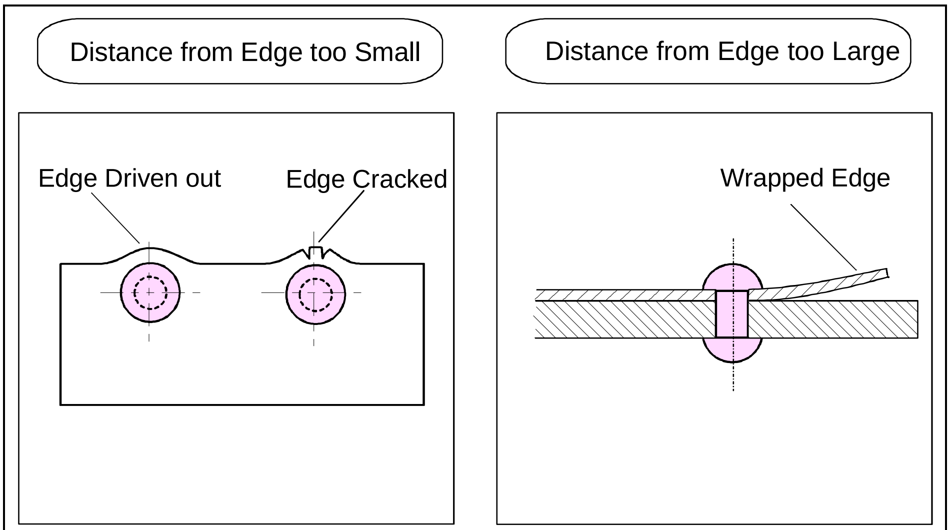
Choosing the Distance from Edges for Riveting

Riveting was the first universally applied mechanical fastening method to have a major influence on the aluminium manufacturing industry. It still has a large field of application, although clinching, for example, is nowadays a viable alternative fastening method which has made rapid progress. Improvements and further developments in the general riveting technology - for example, punch riveting - and particularly tooling technology have made it possible to apply this fastening technology rationally (**Figure 4104.01.01**).

For roughly cut edges (sheared sheets, sawed sections, etc.), the distance from the edges should chosen so that the edge is neither driven outwards (distance from edge too small) nor does it tend to warp or spring up (distance from edge too large).

Rivets can be placed singly, in rows or in fields. Depending on the arrangement, one obtains rivets which are staggered or parallel or in rows. The joints can be constructed as overlapped or strapped rivet fastenings.



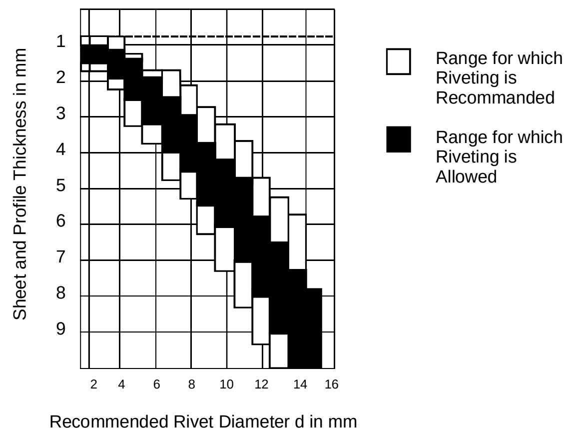
Source: Company Documents of ALUSINGEN

TALAT	Choosing the Distance from Edges for Riveting	4104.01.01

Recommendations for Rivet Diameters

The forces acting on the riveted joint are transmitted to the cold worked rivet mainly as bearing pressure (clamping force) or as shear and bending forces.

The number of rivets and the diameter of the rivets to be used depends mainly on the design of the aluminium construction. The general aim is to choose such a relationship between the rivet diameter and sheet thickness so that both the shear force acting on the rivet as well as the bearing pressure (clamping force) on the joint materials do not exceed the allowable maximum (**Figure 4104.01.02**).



Source: Company Documents of Alusingen

TALAT	Recommendation for Rivet Diameters	4104.01.02

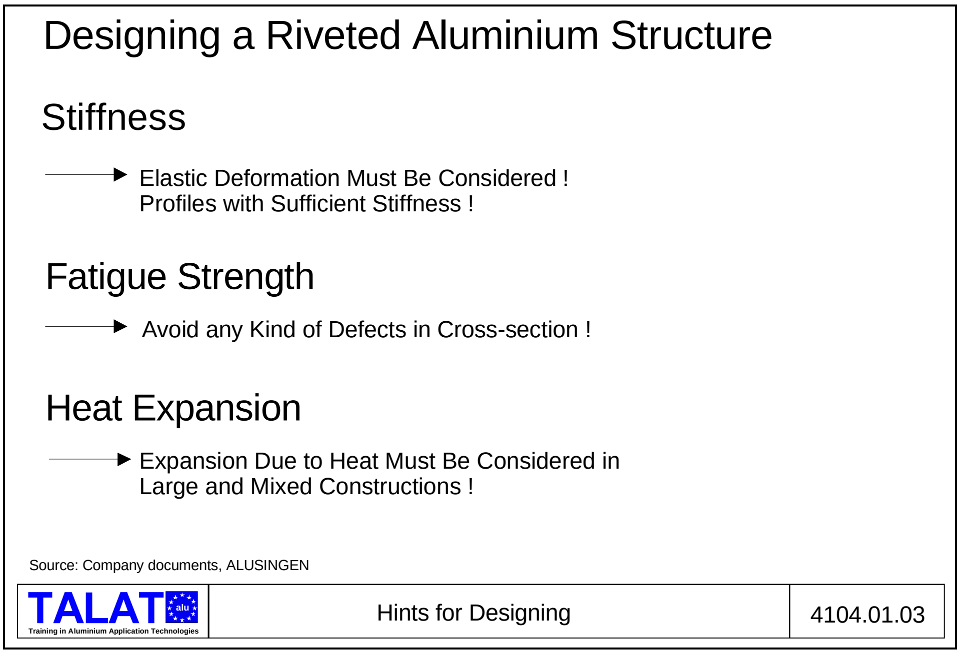
Hints for Designing

The unique properties of aluminium should be considered while designing riveted joints. As far as the design principles are concerned, one cannot simply transfer the guidelines used in designing for steel.

The modulus of elasticity of aluminium is about a third that of steel so that a corresponding allowance for elastic deformation has to be incorporated in the design.

Imperfections in the cross-section like those caused, for example, by holes and surface defects, tend to reduce the fatigue strength.

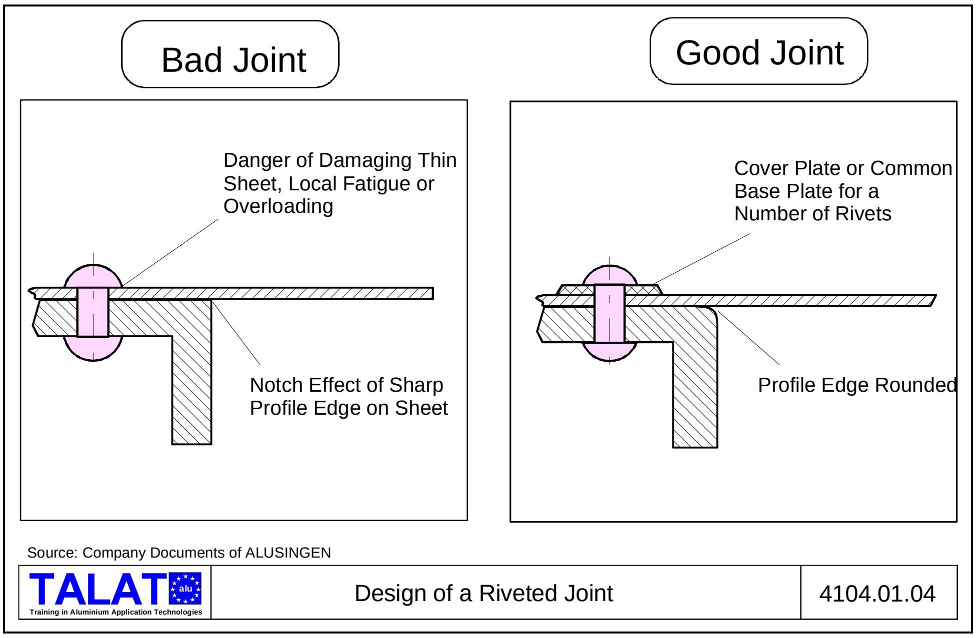
In large as well as composite constructions, the thermal expansion must be taken into account, especially since the coefficient of thermal expansion of aluminium is about twice as large as that for steel (see **Figure 4104.01.03**).



Design of a Riveted Joint

Fatigue cracks on the joint parts start mostly from the contour of the rivet head.

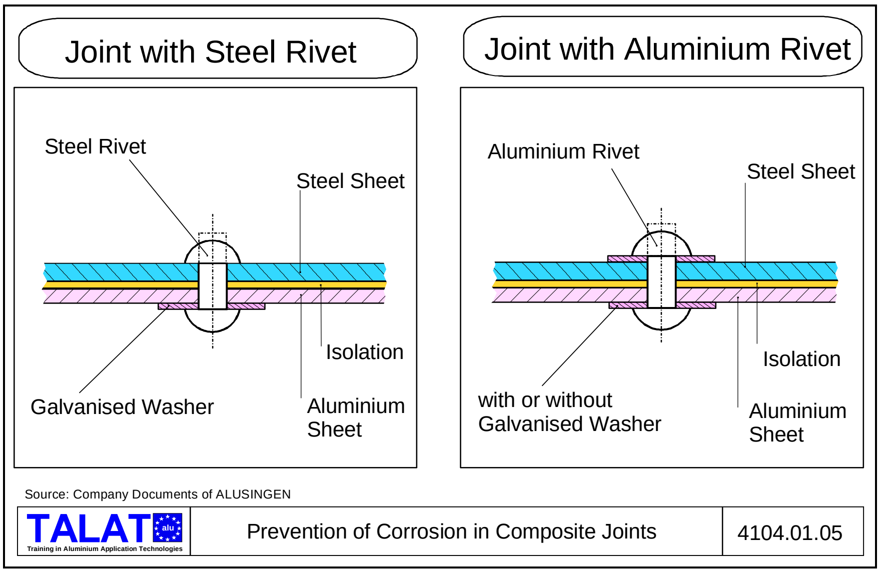
This danger can be reduced by using a support plate, this being especially helpful when thin sheets are to be joint (**Figure 4104.01.04**).



Prevention of Corrosion in Composite Joints

Galvanic (contact) corrosion can occur when composite joints of aluminium with a much nobler metal like copper, for example, are exposed to humidity.

Contact corrosion can be prevented by coating all surfaces which come into contact with each other with a zinc chromate primer.
For joints consisting of aluminium with other metals - like for example aluminium with steel - these precautionary measures suffice only in exceptional cases. Generally, the different metals should be isolated (**Figure 4104.01.05**).



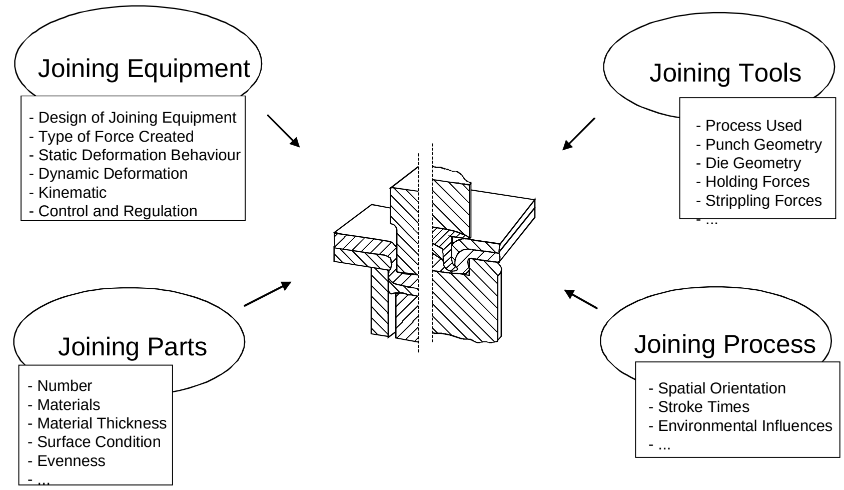
4104.02Material and Tooling Parameters

- Factors influencing the quality of mechanical fastenings
- Improving the operational life of clinching tools
- Clinching of composite joints
- Strength behaviour of clinch joints
- The influence of material surface on the joint strength of clinch fastenings

Factors Influencing the Quality of Mechanical Fastenings

A number of factors must be considered while deciding whether or not a mechanical fastening method is suitable. In principle, one can differentiate among the influences of material, the semi product, the fastening machines and the fastening tools. Within each of these groups are a number of parameters which influence the design of the joint and consequently the load carrying capacity of a mechanical fastening (**Figure 4104.02.01**).

Particularly in the case of the "new" mechanical fastening technologies - like clinching or punch riveting - the numerous influencing parameters are a problem, since the experience and knowledge available is not sufficient.

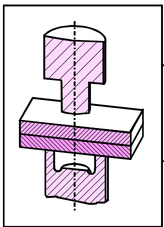


Source: Budde, Klemens

TALAT | Factors Influencing the Quality of Mechanical Fastenings | 4104.02.01

Improving the Operational Life of Clinching Tools

The operational life of the fastening tools is an important criterion for the economy for light constructions. The operational life of clinching tools can be improved by a number of means, the most important of which are: modifying the tool geometry and/or the material, surface treatment of the fastening tool (**Figure 4104.02.02**). Current innovations in process technology have made it possible to achieve operational lives of 200,000 points or more during clinching of sheet shaped products.



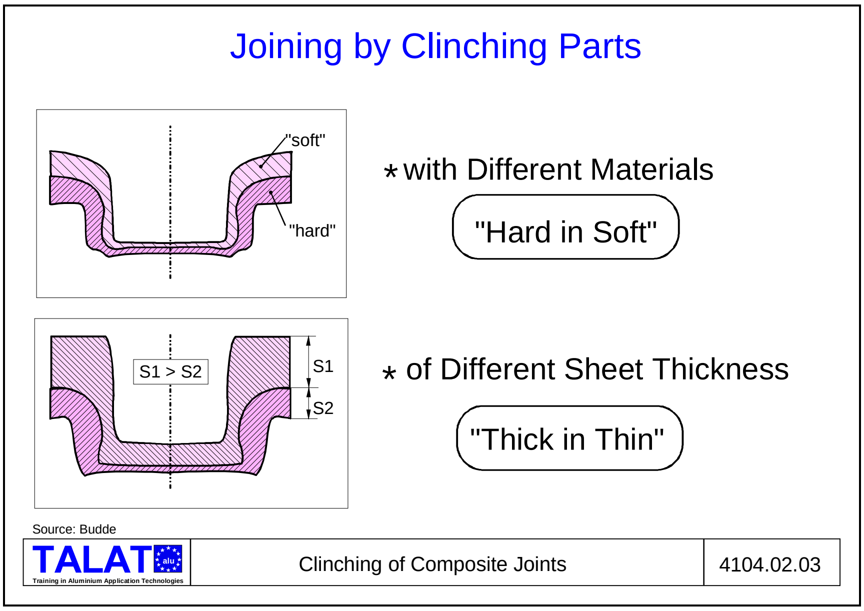
	Operational Life	Reasons for Stoppage
Die Boron Coated	800-9000 Points	Die Breaks or Die Smeared up
Die Made of Old Material and Plasma Nitrided	1000-15000 Points	Die Breaks
Die Titanium Nitrided	3800-9300 Points	Die Breaks or Deforms
Die Made of Modified Material and Plasma Nitrided	120000 Points	Die Removed as a Precaution!

Source: Reuter

TALAT | Improving the Operational Life of Clinching Tools | 4104.02.02

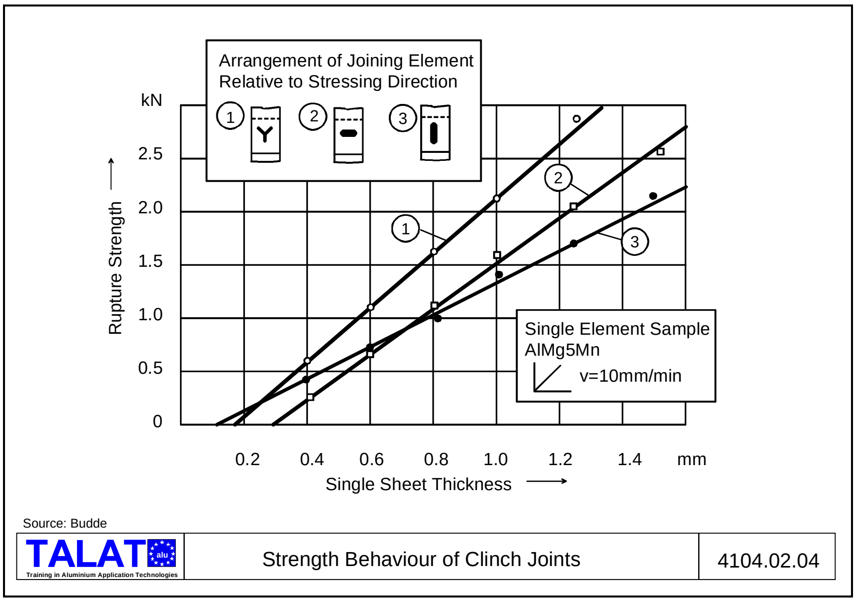
Clinching of Composite Joints

Mechanical fastening techniques, like clinching without local incision, can be used to join different sheet and profile parts as well as metal sheets of varying thicknesses (**Figure 4104.02.03)**.



Strength Behaviour of Clinch Joints

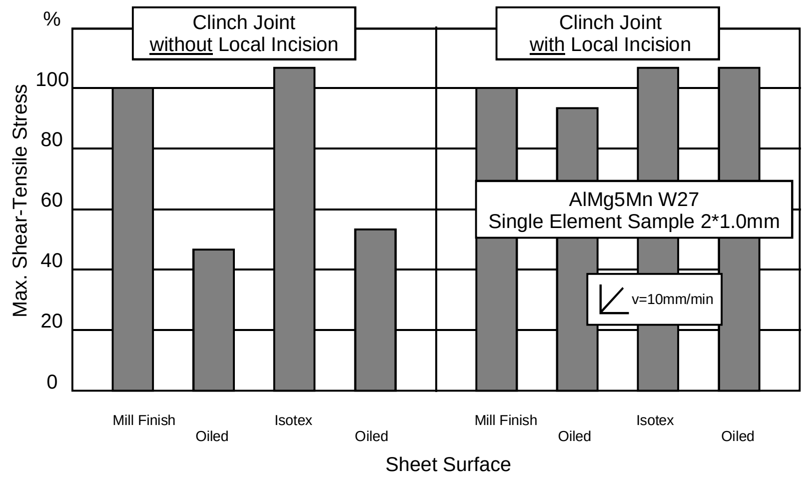
Depending on the joint geometry, it is possible to have clinch joints with anisotropic (rod form), nearly isotropic (cross and star form) and isotropic (round form) properties. The properties of the joints depend more or less on the alignment of the joint to the loading direction (see **Figure 4104.02.04**).



The Influence of Material Surface on the Joint Strength of Clinch Fastenings

The surface finish of the parts to be joint is an important parameter which governs the load carrying capacity as well as the consistency of mechanical fastenings of aluminium sheet shaped and profile parts. Thus, the influence of organic and metallic surface treatments or the presence of oil or grease on the surface has a significant effect on the joint quality (see **Figure 4104.02.05**).

As in the case of adhesive joining, a high quality can be obtained only with a well defined surface. Under conditions which guarantee a uniform flow of material in the joining region, rough starting surfaces are advantageous, since these lead to an increase in the interlocked elastic load-carrying parts.



Source: Steimmel

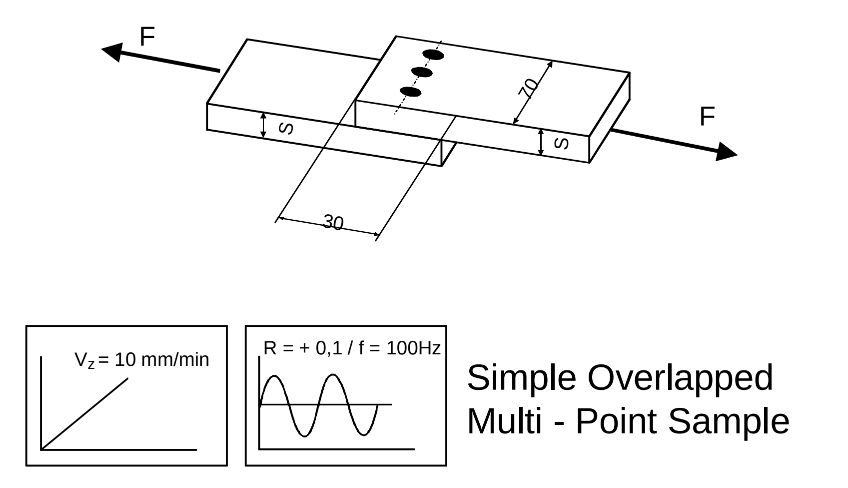
TALAT	The Influence of Material Surface on the Joint Strength of Clinch Fastenings	4104.02.05

4104.03Testing of Mechanical Joints

- Geometry of samples for shear-tensile testing under dynamic reversed loading
- Results using quasi statically loaded shear-tensile samples with different multiple-point joints
- Results of fatigue tests on different multiple-point joints
- Geometry of samples for impact testing
- Results of impact tests using flanged double-C-channels with different joints

Geometry of Samples for Shear-Tensile Testing under Dynamic Reversed Loading

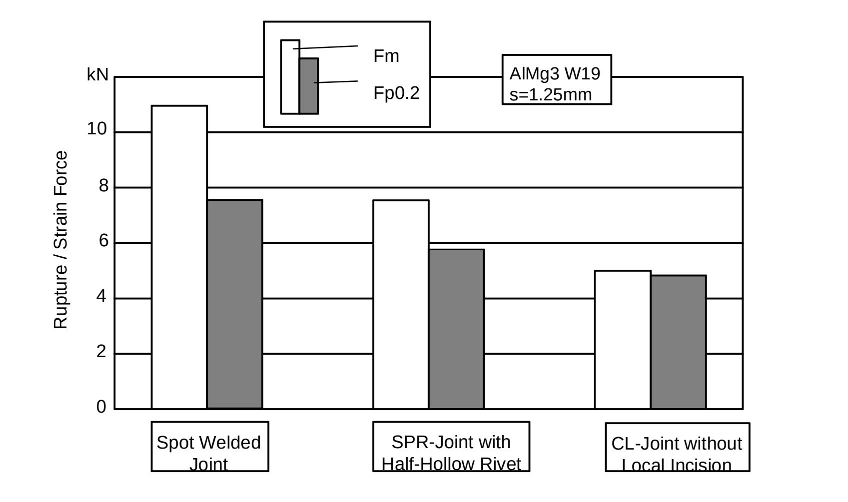
The function of a mechanical fastening element which governs the joint strength of aluminium construction parts depends on the flow characteristics at the interface of the joint parts and to a large extent on the type of loading. The strength of mechanical fastenings is measured by loading simple multiple-point lapped-joint samples statically or dynamically (**Figure 4104.03.01**).



TALAT — Geometry of Samples for Shear - Tensile Testing under Dynamic Reversed Loading — 4104.03.01

Results Using Quasi-Statically Loaded Shear-Tensile Samples with Different Multiple-Point Joints

Just like experiments with single-element joints have shown, even multiple-point mechanical fastenings do not attain the strength of spot-welded joints under static loading (**Figure 4104.03.02**).

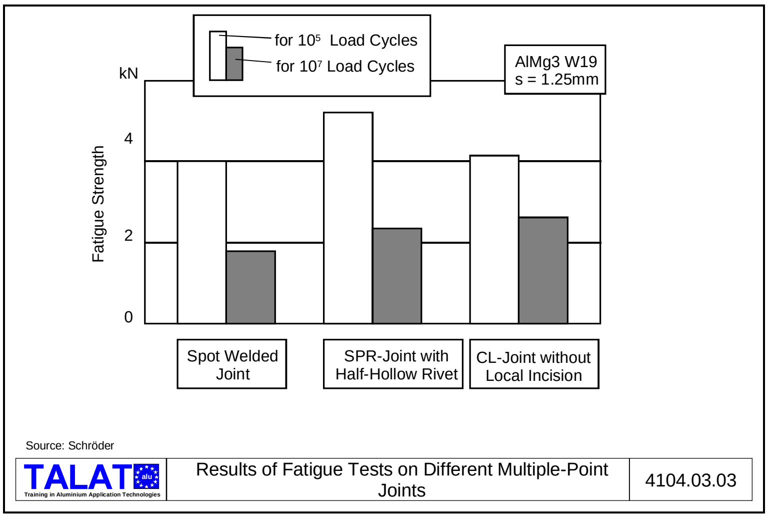


Source: Schröder

TALAT — Results Using Quasi Statically Loaded Shear-Tensile Samples with Different Multiple-Point Joints — 4104.03.02

Results of Fatigue Tests on Different Multiple-Point Joints

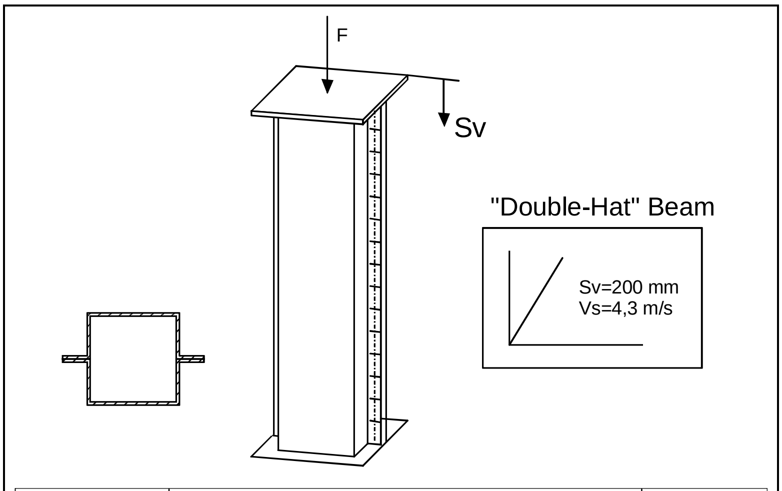
Experiments with multiple-point samples of aluminium sheets under dynamic loading have shown that both punch riveted as well as clinched joints deliver strengths similar to those reached with spot welding (**Figure 4104.03.03**). The above mentioned statement is only valid for joints in sheets which are not too oily and for which the joining parameters and the joint distances have been optimised.



Results of Fatigue Tests on Different Multiple-Point Joints 4104.03.03

Geometry of Samples for Impact Testing

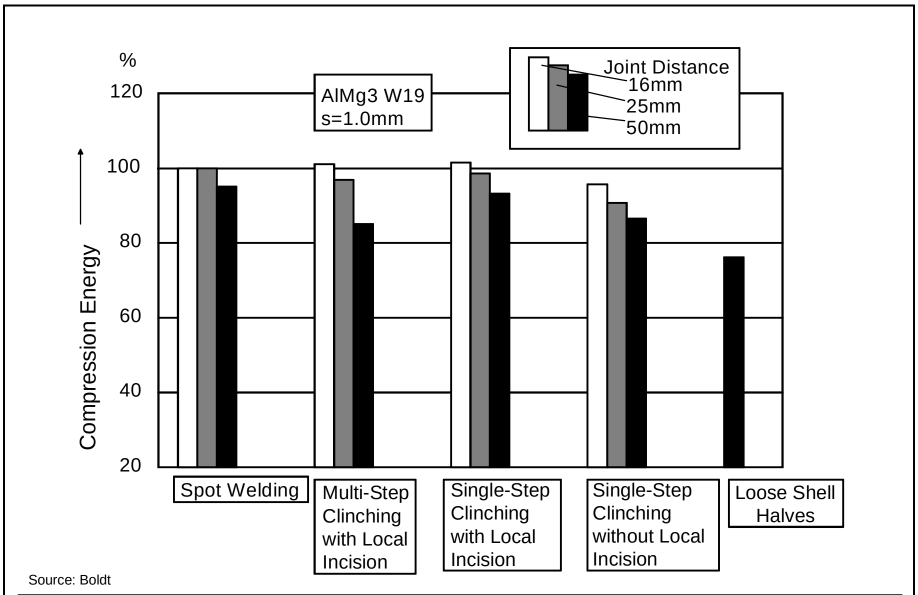
While evaluating the results presented here, it must be remembered that the experiments for measuring strength were conducted on single-element and multiple-point samples. In order to be able to transfer these results to practical situations, the experiments must be conducted under conditions closely resembling the expected operational conditions and using mechanical joints which have been optimised as far as the geometry and testing technique is concerned. The flanged double-C-Channels for impact tests is such an example (**Figure 4104.03.04**).



TALAT | Geometry of Samples for Impact Testing | 4104.03.04

Results of Impact Tests Using Flanged Double-C-Channels with Different Joints

Impact tests on mechanical fastenings lead to the conclusion that, in principle, mechanical fastenings are better than spot-welded joints for applications in which low forces act on the joints causing large deformations.
Thus, one concludes that mechanical fastenings can be used effectively for joining aluminium sheet shaped products and profile parts used primarily for "soft" constructions, i.e. large-surfaced (flat) covering panels (**Figure 4104.03.05**).



TALAT | Results of Impact Tests Using Flanged Double-C-Channels with Different Joints | 4104.03.05

4104.04Cost Considerations

- Comparitive costs of joining technologies
- Cost comparison of joining technologies for steel and aluminium
- Cost comparison of different joining methods for aluminium sheets

Comparative Costs of Joining Technologies

When choosing the right joining technology, all factors which may be relevant must be considered rationally and comprehensively.

The economy of a joining technology is one of the decisive factors in choosing a particular fastening method for constructions. Mechanical fastening methods have indisputable economical advantages over "classical" joining techniques (**Figure 4104.04.01**).

Characteristics \ Joining Technology	Adhesive Joining	Spot Welding	Clinching	Riveting
Investment Cost	Low to Very High	Very High	Low to Middle	Low to Middle
Joining Cost	Low to High	High	High	Low to High

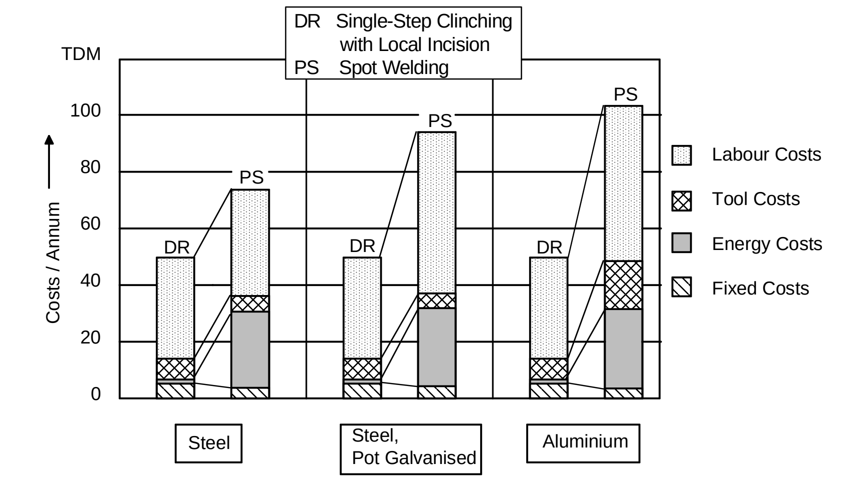
Source: Budde

TALAT Training in Aluminium Application Technologies | Comparative Costs of Joining Technologies | 4104.04.01

Cost Comparison of Joining Technologies for Steel and Aluminium

A comparison of costs of clinching with local incision and spot welding shows that under certain circumstances, joining by clinching can be cheaper than spot welding (see **Figure 4104.04.02**).

The economic advantage is all the more obvious, if one considers that by using the appropriate press arrangements, different types of joints, i.e. clinching and punch riveting can be made simultaneously.

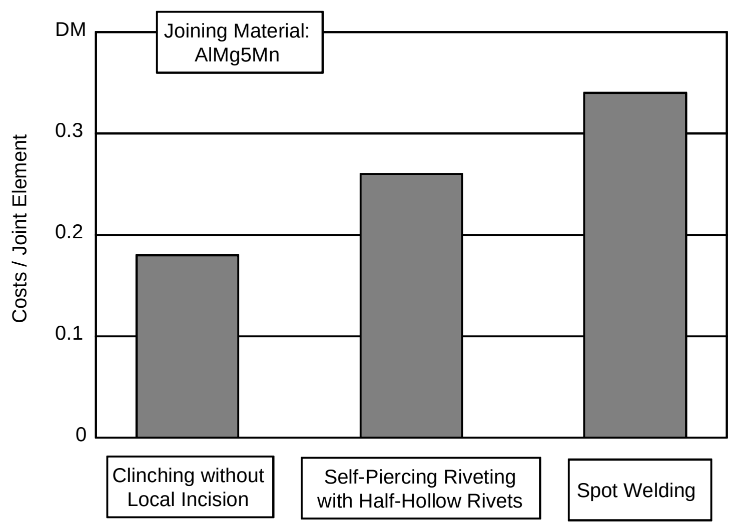


Source: Beyer

TALAT Training in Aluminium Application Technologies | Cost Comparison of Joining Technologies for Steel and Aluminium | 4104.04.02

Cost Comparison of Different Joining Methods for Aluminium Sheets

When joining aluminium constructions, self-piercing riveting with half hollow rivets has an economical advantage over spot welding due to the fact that the former delivers joints with a higher strength under dynamic loading and that the operational life of equipment for spot welding aluminium is lower (**Figure 4104.04.03**). The cost advantage is further enhanced by the fact that non-destructive testing can be used for quality assurance of mechanical fastenings.



Source: Budde

TALAT Training in Aluminium Application Technologies | Cost Comparison of Different Joining Methods for Aluminium Sheets | 4104.04.03

4104.05 Literature/References

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