

sapa:

F S W

Friction Stir Welding



- I. Welding Method Overview**
- II. Friction Stir Welding Process**
- III. Examples of FSW**
- IV. Current R & D Projects**

Common methods:

- Metal Inert Gas [MIG]
- Tungsten Inert Gas [TIG]
- Friction Stir Welding [FSW]

Less common methods:

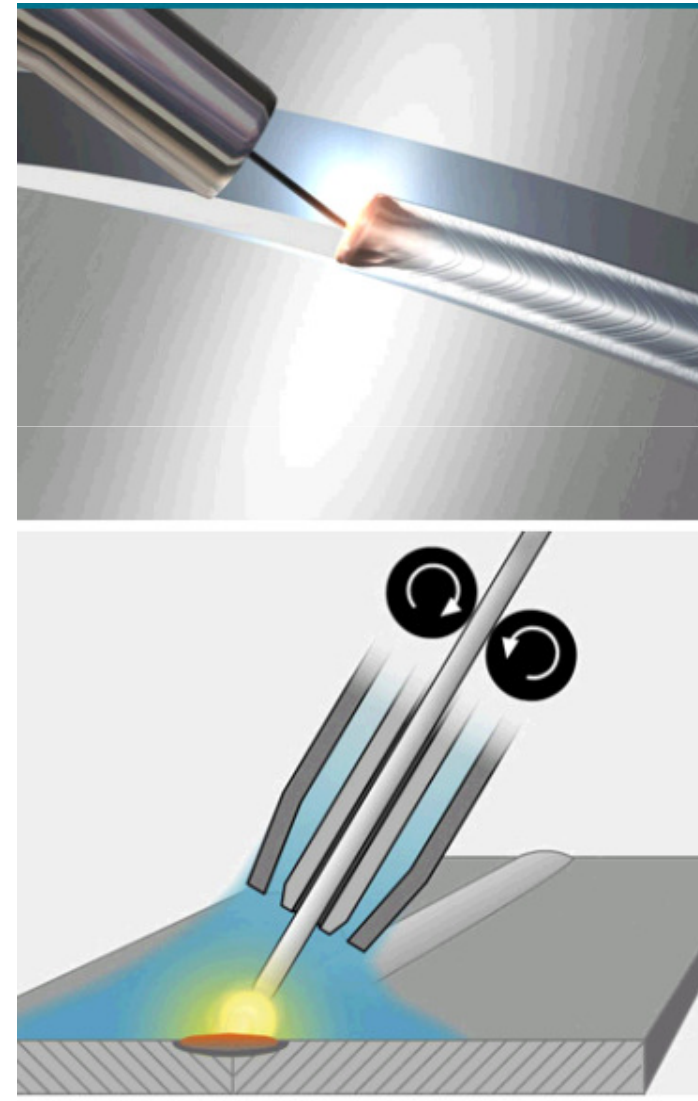
- Laser welding
- Hybrid methods
- Explosive welding
- Magnetic pulse welding
- Friction Welding
- Resistive spot welding
- Friction Stir Spot Welding
- Plasma welding



MIG Welding Method

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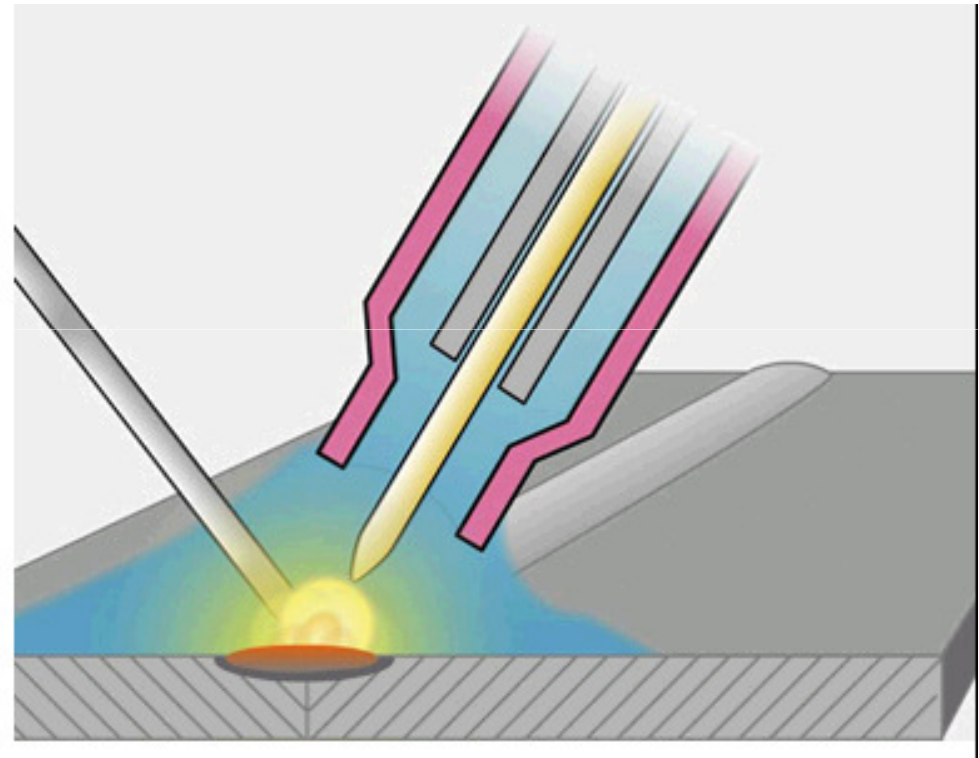
- High production method
- Continuous feeding of fill material.
- Manual or automatic.
- Most used in thicker goods (>2 mm)
- Somewhat operator dependent



TIG Welding Method

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- Low productivity
- High quality
- Fillet material can be used
- Manual or mechanized
- Application mostly in thinner goods (<3 mm)
- Highly operator dependent



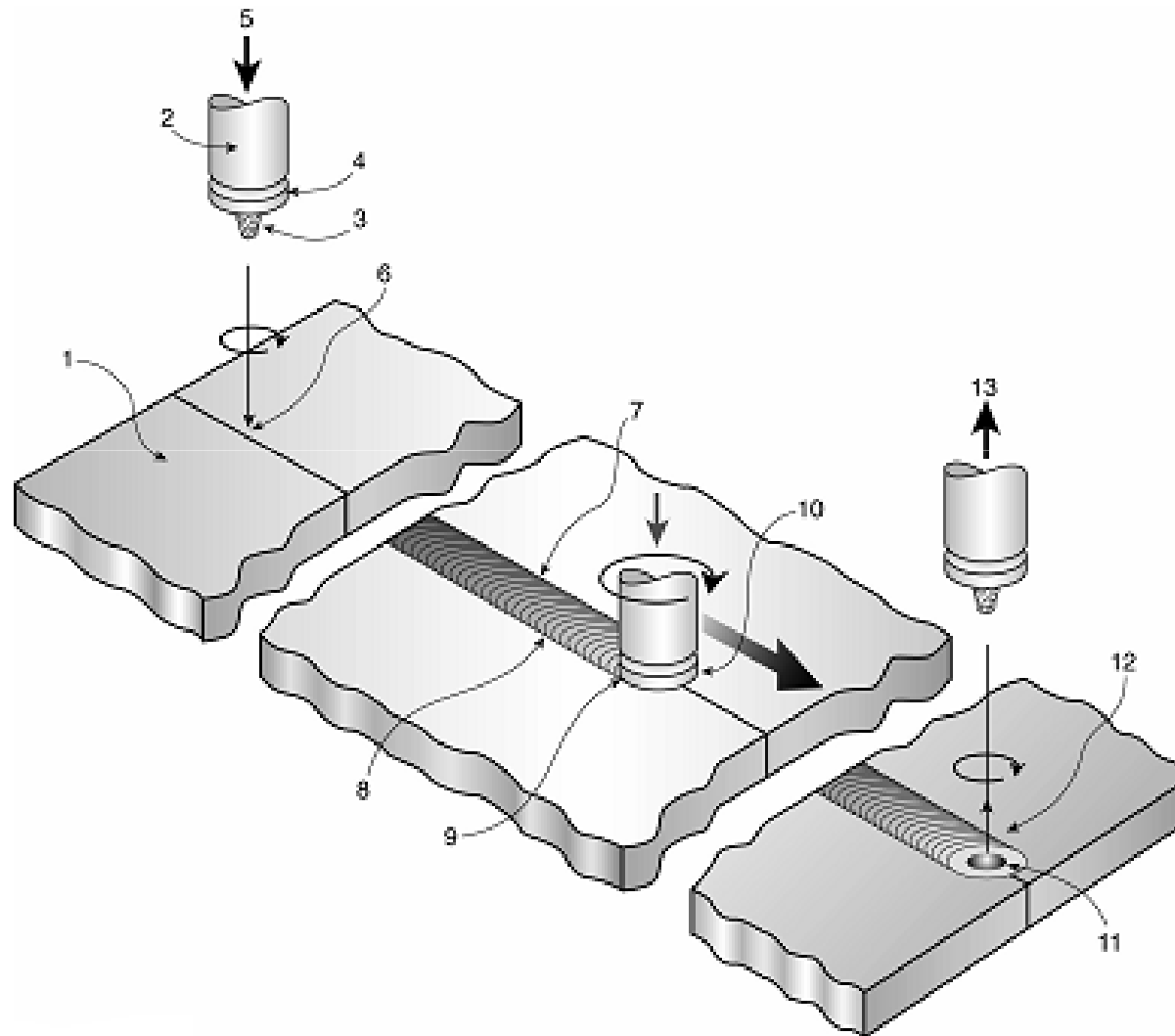
FSW

Friction Stir Welding

- **1990 First FSW trials at TWI**
- **1991 First patent application from TWI**
- **1993 GSP formed**
- **1994 First FSW weld at Sapa**
- **1995 First order! “Freezing plate”**
- **1997 First FSW-machine to Sapa**
- **1997 First order in the new machine. Ericsson**
- **1999 Second FSW-machine. ABB Power Systems**
- **1999 Third FSW-machine. Autoliv**
- **1999 Long-length machine installed**
- **2000 Industrial production long-length FSW**
- **2003 FSW-machine in Holland**
- **2005 FSW-machine in Shanghai**
- **2005 Approximately 1000 m/day being welded**
- **2008 Approximately 2000 m/day being welded**

Friction Stir Welding Method

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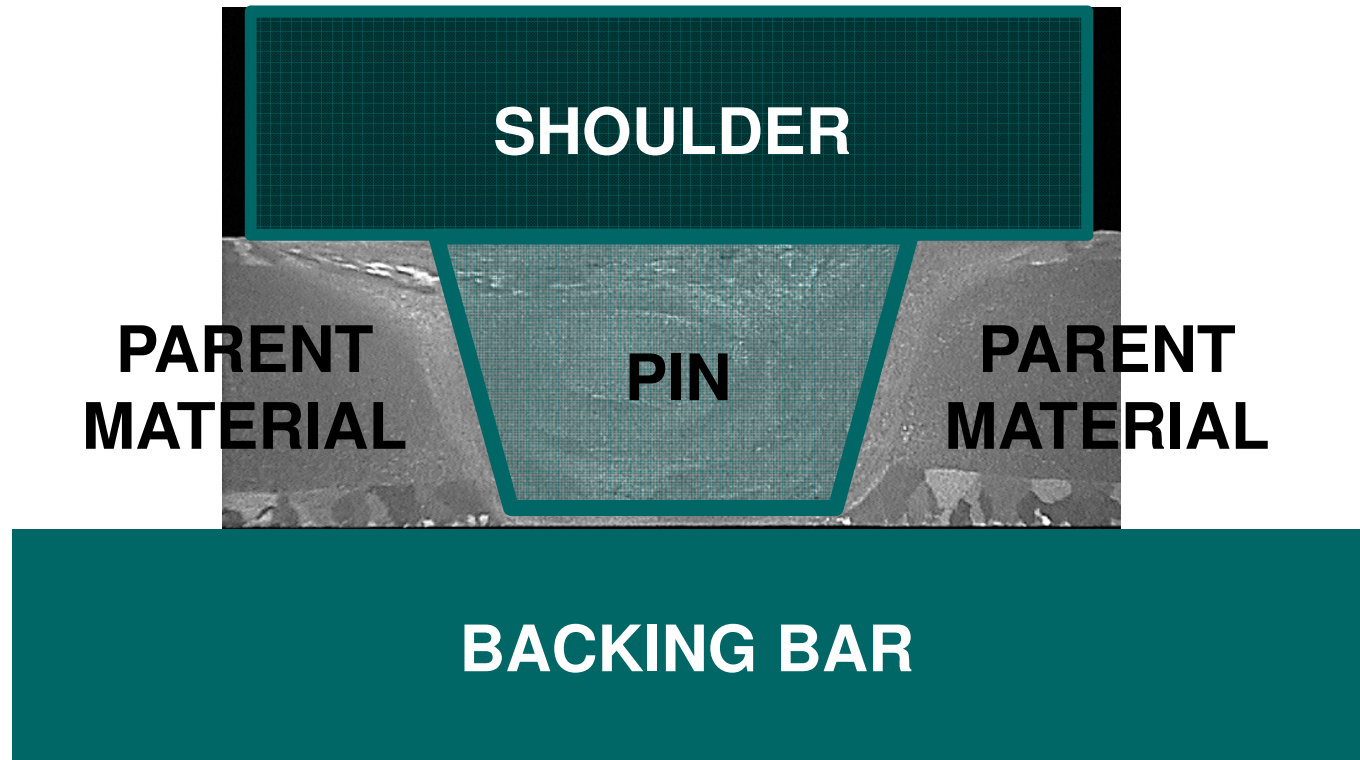


- Strong backing
- High demand of fixation (tolerances, handling)
- Rigid machine
- Solid state process
- No Melting

- 1 Workpiece
- 2 Tool
- 3 Probe
- 4 Tool shoulder
- 5 Start rotation
- 6 Touchdown and commence travel
- 7 Advancing side of weld
- 8 Retreating side of weld
- 9 Trailing edge of tool shoulder
- 10 Leading edge of tool shoulder
- 11 Exit hole
- 12 Finish
- 13 Withdraw, stop rotation

Need to contain the softened material

- Softened material must be contained by parent material, FSW tool shoulder or backing bar (anvil):



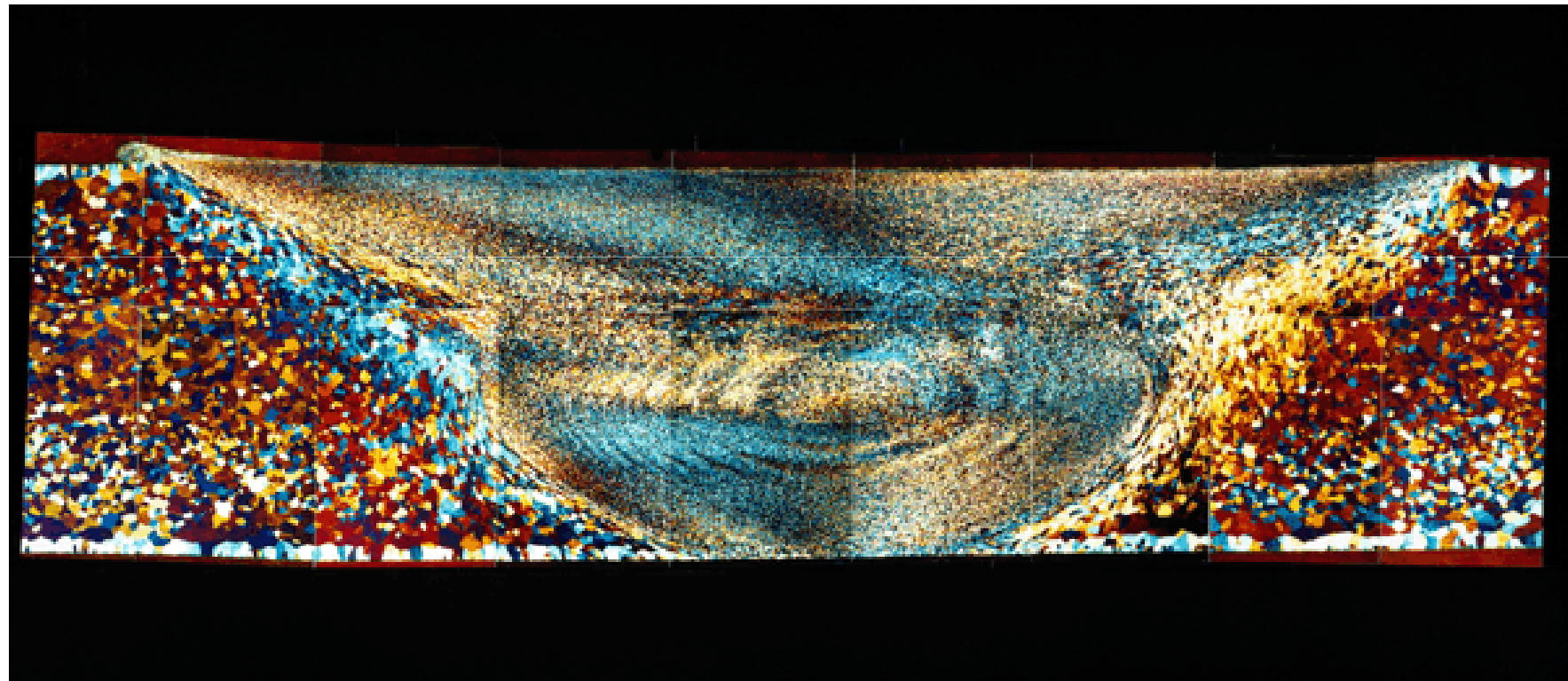
Typical top face of the weld

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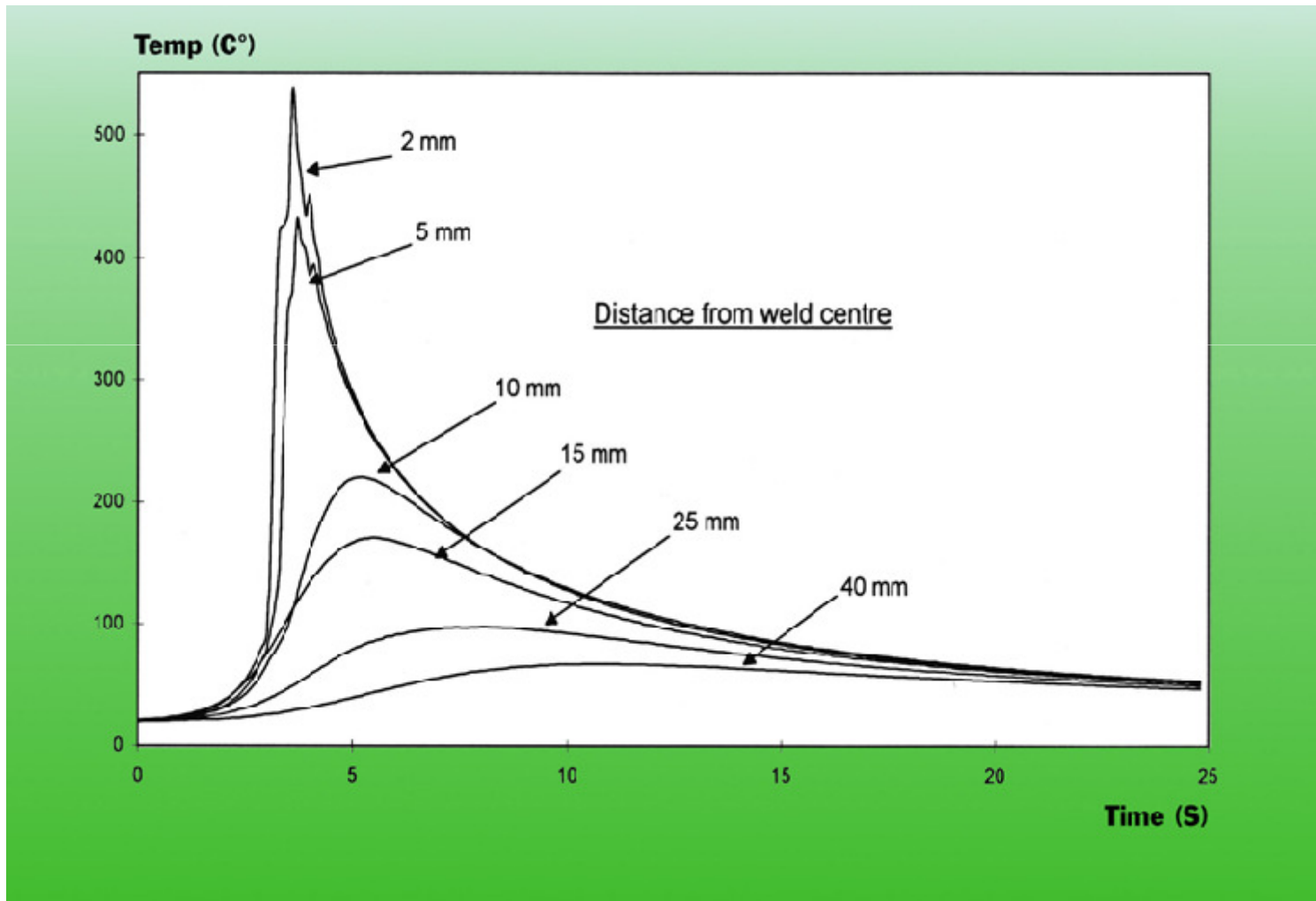


FSW – Weld Structure

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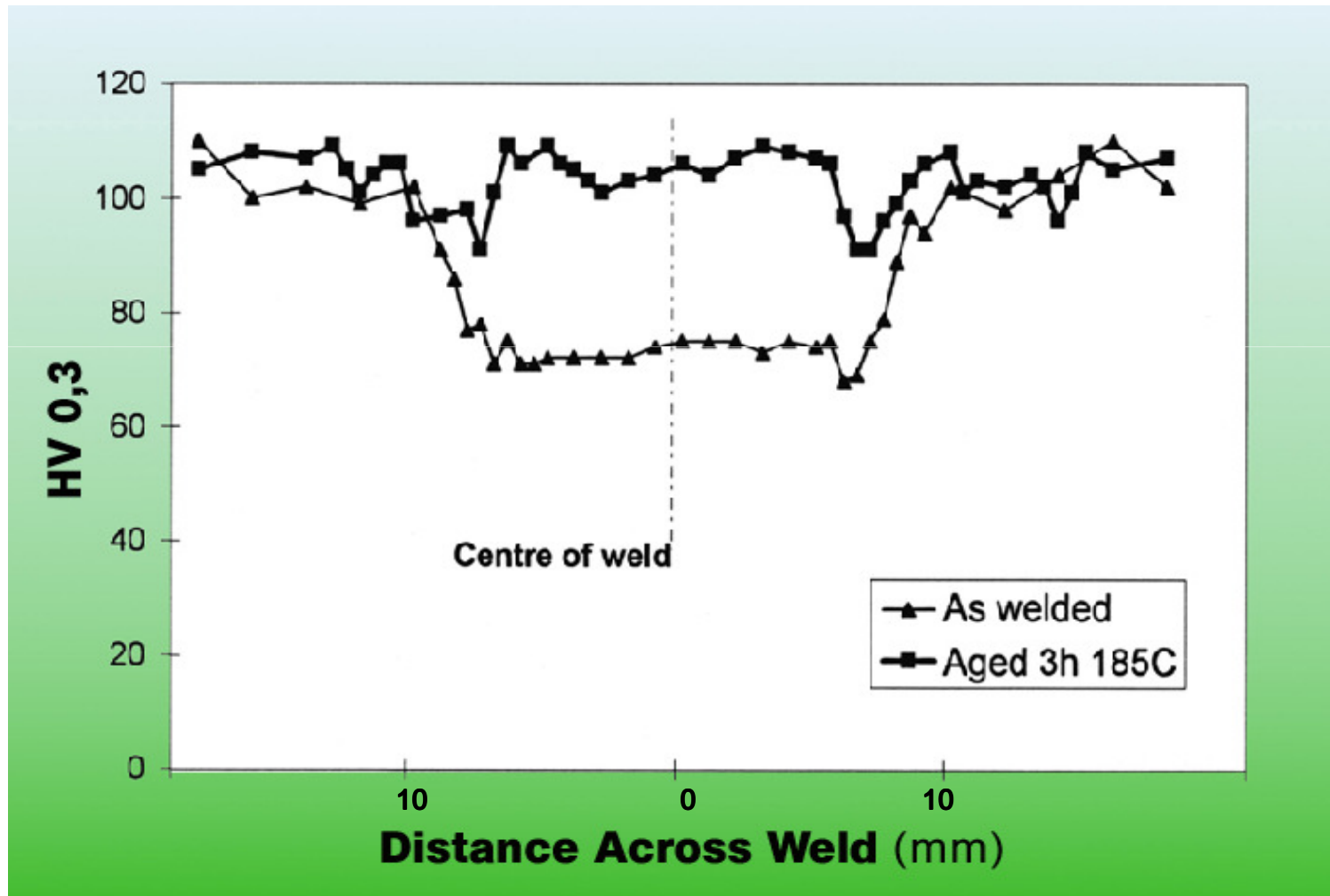
FSW – Temperature Cycle During Welding **sapa:**



EN-AW 6063-T6 (Material thickness 4 mm)

FSW – Hardness Profile Across Weld

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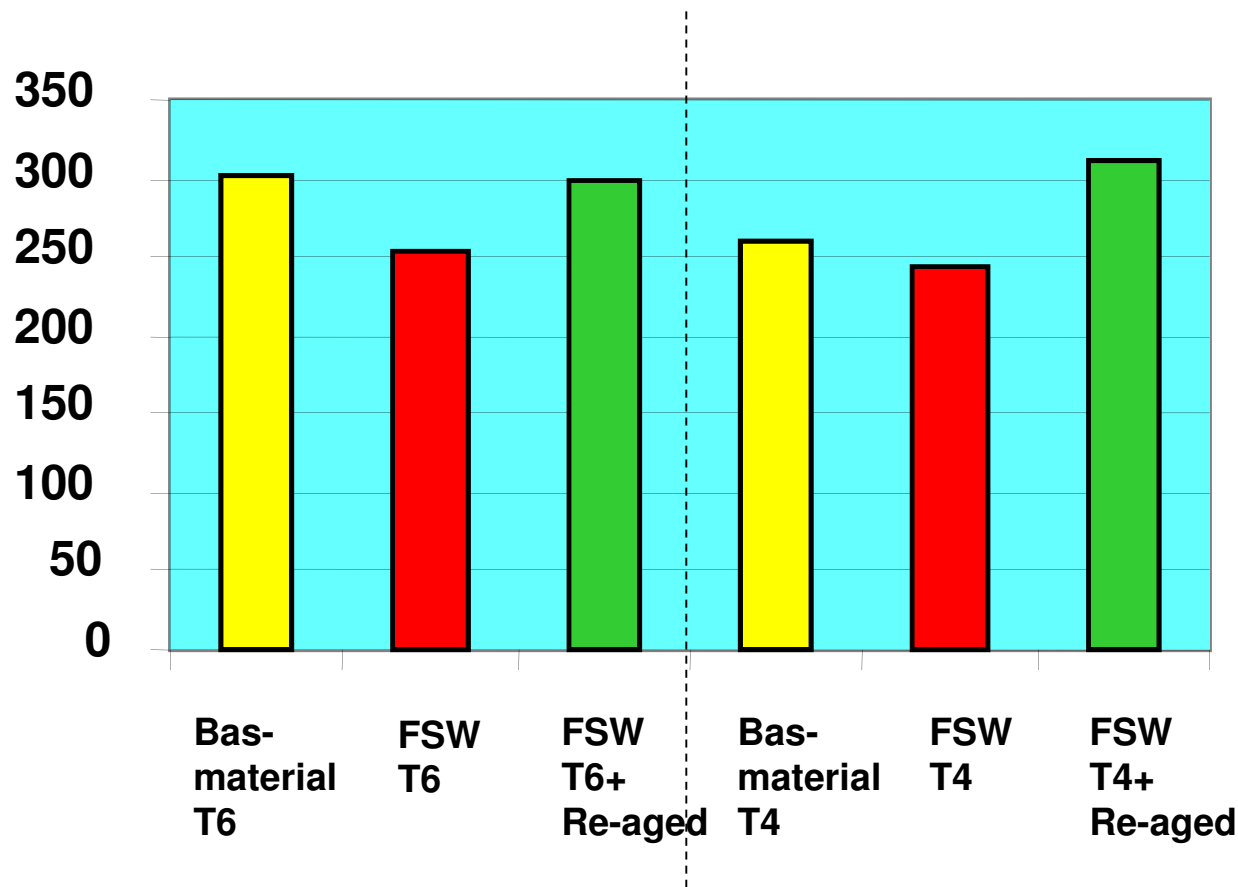


UTS - EN-AW 6082

Different combinations of welding and ageing

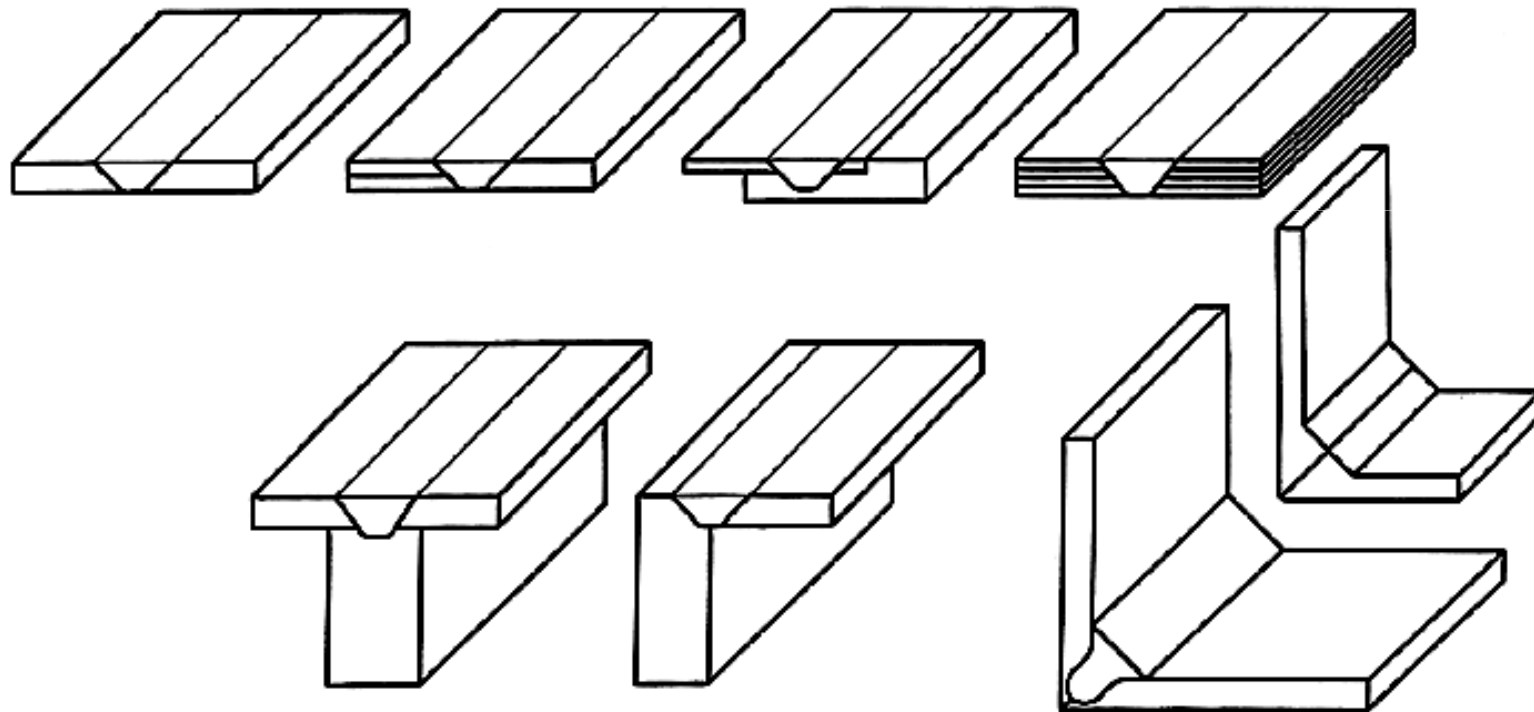
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Stress [Mpa]



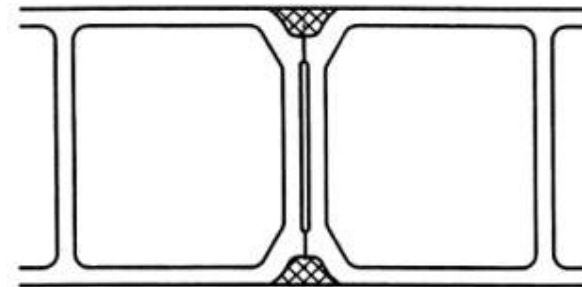
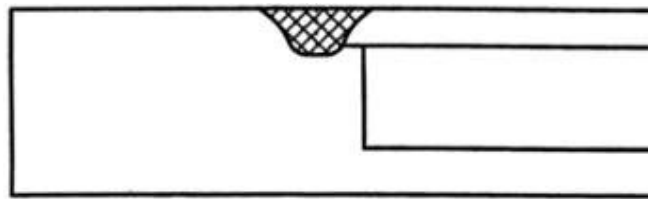
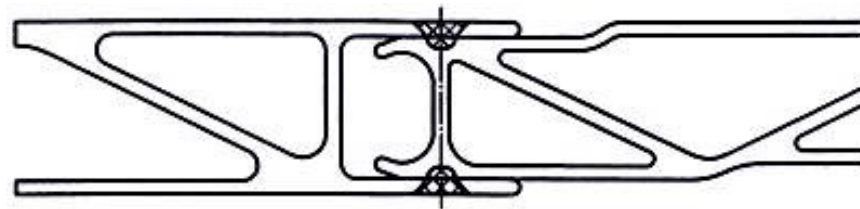
Typical FSW Joint Geometries

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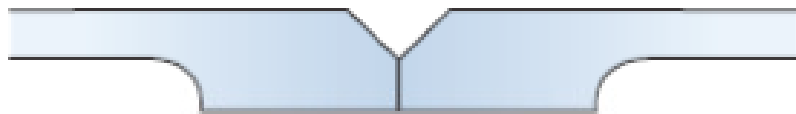
Typical FSW Joint Geometries

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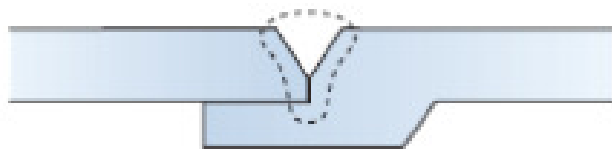


Design The Profile

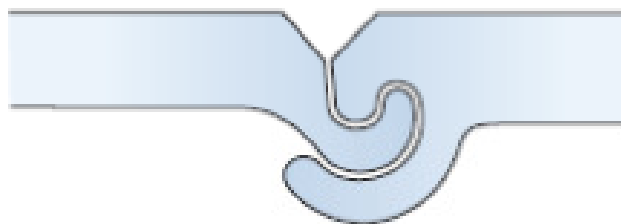
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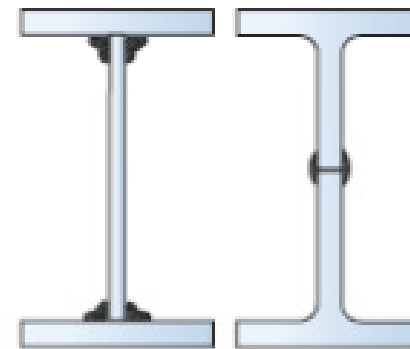
Edge preparation integrated into profile design
– the illustration also features material compensation for strength reduction in the weld zone.



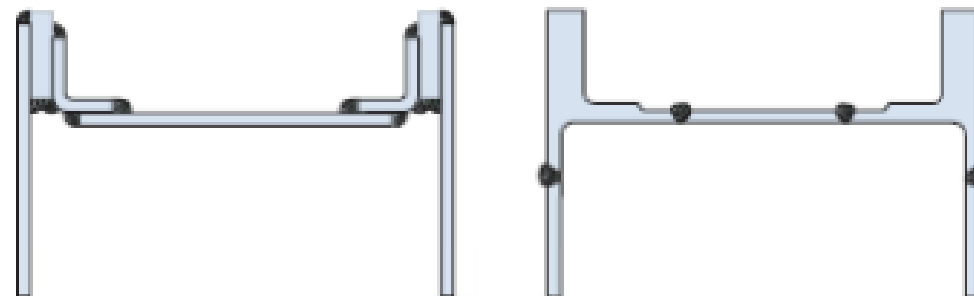
Permanent root backing.



In-built fastening – used in dry environments.



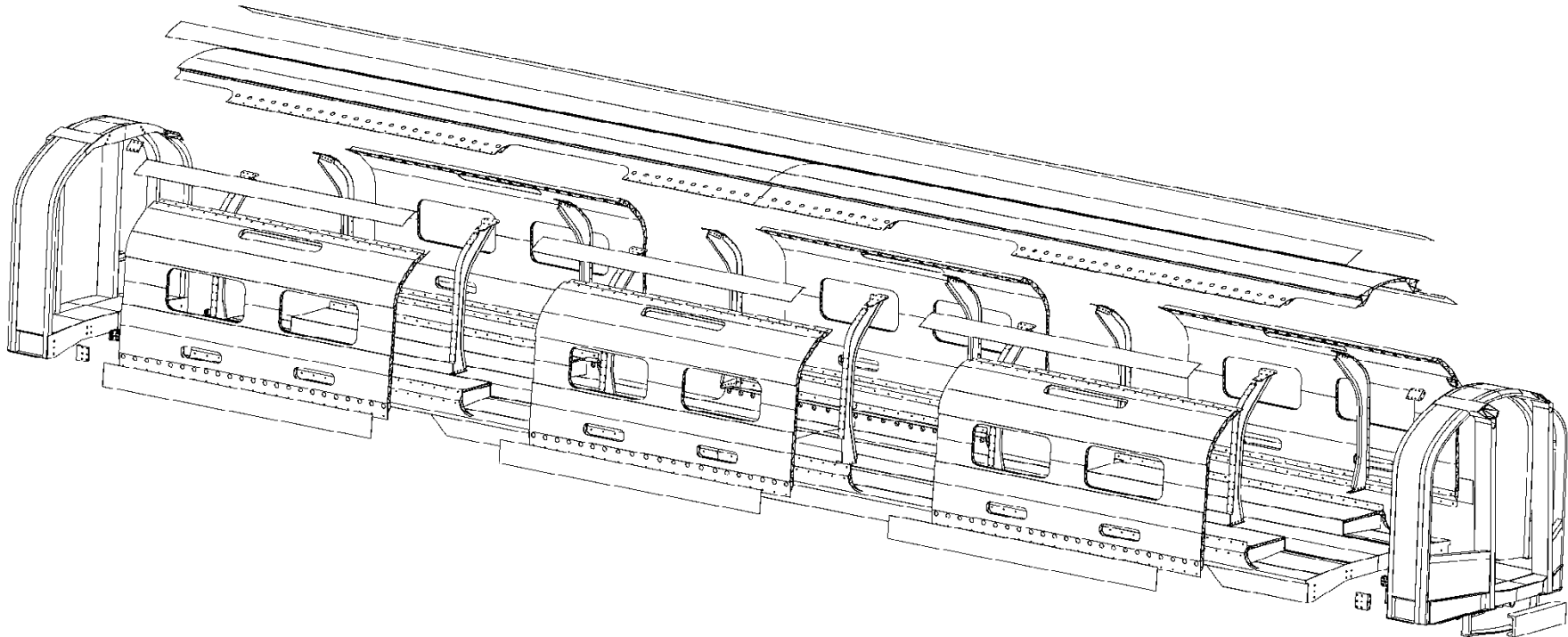
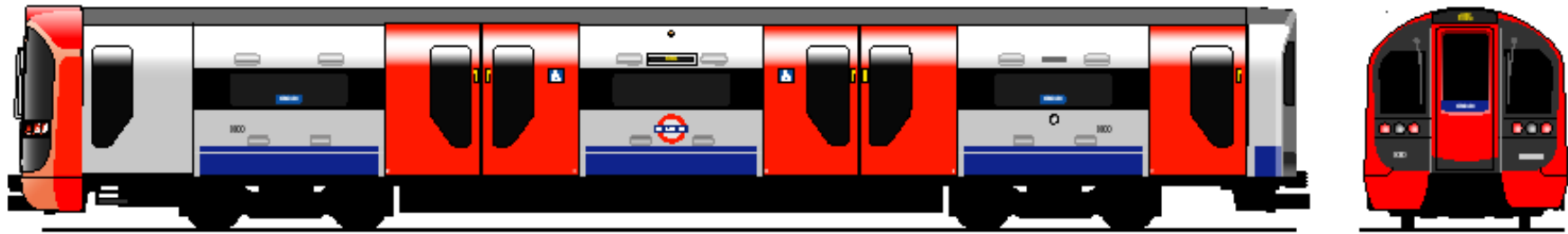
Placing of welds in lower stress sections of the cross sectional area. This results in fewer welds, and butt rather than fillet welds.



Number of welds reduced from 12 to 4 – butt welds rather than the weaker fillet welds (which are also harder to x-ray). Fewer components, reduced welding (consequently fewer heat-affected zones) and straightening minimised.

Bombardier "VLU"

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Transit Car Assemblies

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Alstom LHB GmbH

sapa:



Marine Applications

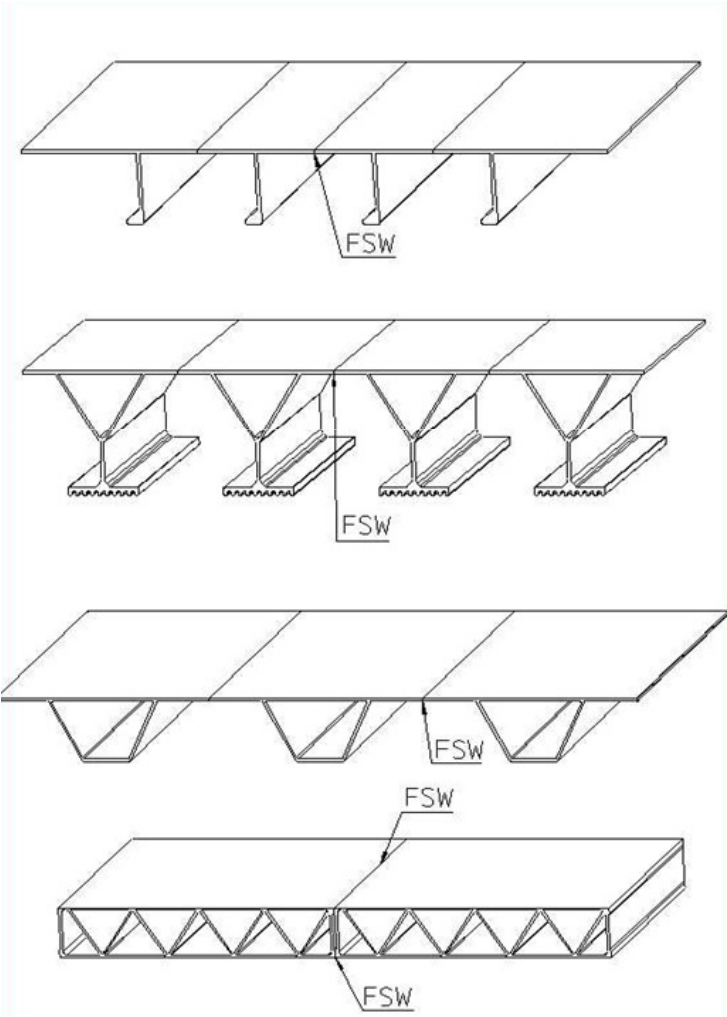
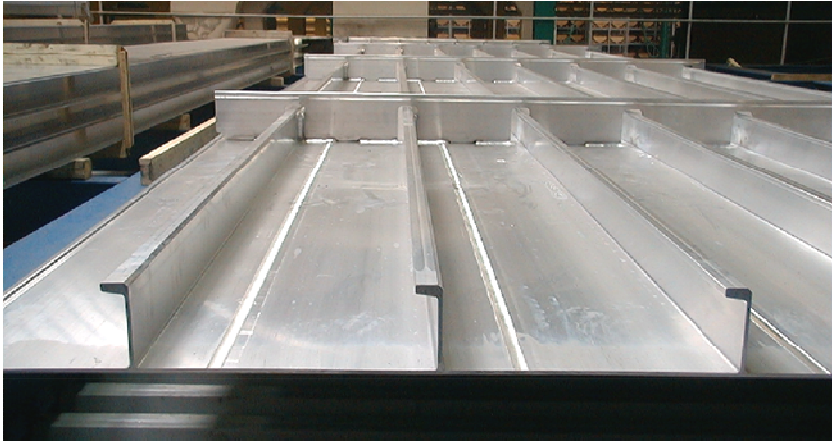
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Aluminium panels for ship decks, hulls, bulkheads, balconies, roofs, etc. in:

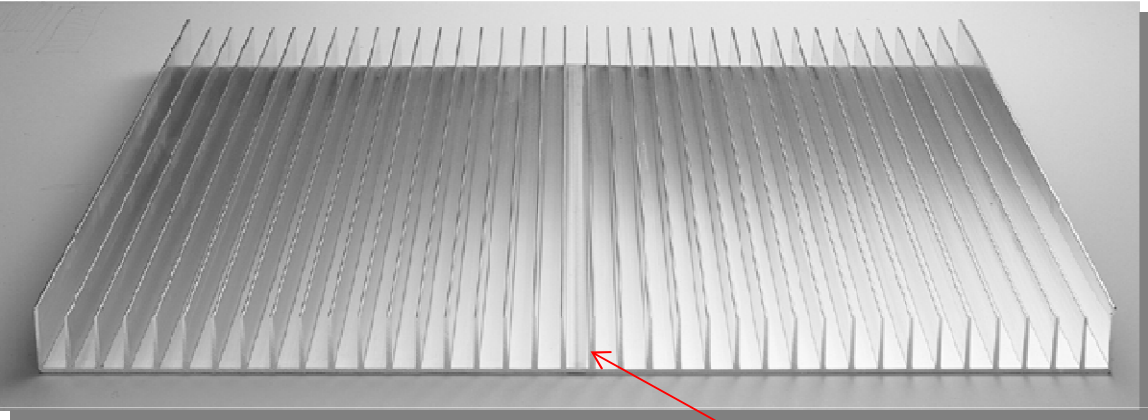
- Mega yachts
- Cruise ships
- High speed ferries
- Military vessels



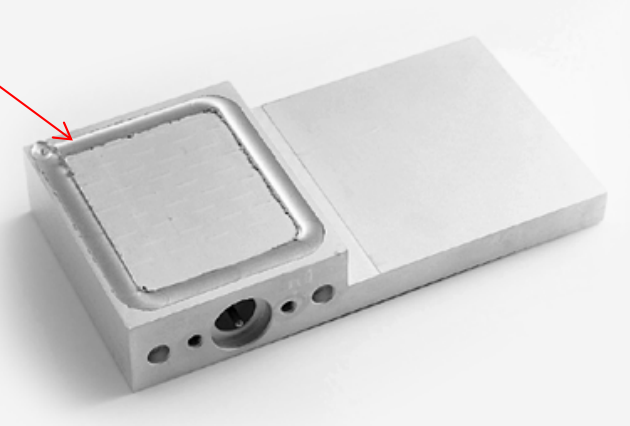
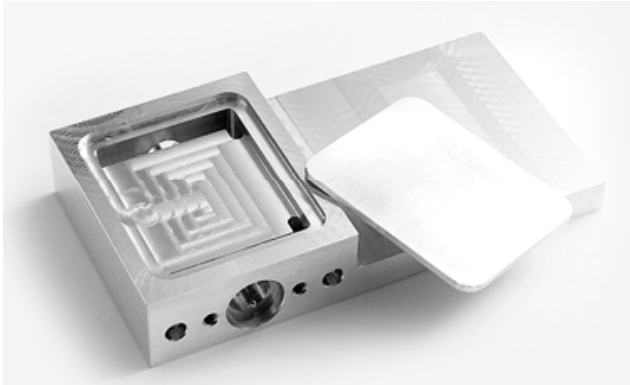
Marine Applications - Examples



Telecom Applications - Heat Sinks



Liquid cooler:
body and lid before and
after FSW



FSW

Aluminium bridge decks

Accelerated Bridge Construction

Sapa's time-proven technology offers unmatched advantages over traditional steel and concrete construction:

- Accelerated construction saves significant time and money in both A+B and A+B+C bid evaluations.
- Reduced lifecycle costs from initial installation throughout the life of the bridge.
- Lightweight (Up to 75% lighter than steel with concrete) decreases dead load, allowing for widening of functionally obsolete bridges using the existing structure.
- "Deployment Ready" technology can be preassembled for rapid bridge deck or whole bridge replacement.

Sapa offers the advantage of proven aluminum isotropic deck technology with 43 years of experience.

Designed around infinite fatigue life using AASHTO Specifications for aluminum bridges.

Sapa Industrial Extrusions
Cressona Sales Office:
Phone: 800-233-3165 FAX: 800-252-4646
www.sapagroup.com/us/industrialextrusions



- **Simple Answer –**
 - **It Depends**
- **Longer Answer – Factors to Consider**
 - **Design Changes**
 - **Cost of Consumables**
 - **Post Weld Clean-Up**
 - **Quality Issues**
 - **Appearance**

- **Solid state**
- **Reliable method**
- **No added material**
- **No shielding gas**
- **Low heat input**
- **Low thermal distortion of joints**
- **High tensile properties in heat treatable alloys**
- **Suitable for automation**
- **Cost effective**
- **Sapa has FSW experience since 1996**

- **Place to find further information:**
<http://www.eaa.net/eea/education/talat/>
- **Sapa:s Design Manual, Chapter 10.**
- **Sapa Technology / www.sapagroup.com**
- **The Aluminium Association (AA) aluminum.org**
- **Sasak.dk (Danish project – joining of large aluminium constructions)**
- **Goda råd vid aluminiumsvetsning, Svetskommissionen (svets.se) (in Swedish)**



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Questions?

The logo for Sapa, featuring the word "sapa" in a bold, teal, lowercase sans-serif font. To the right of the word are two brown dots stacked vertically, resembling a colon.

sapa:

Shaping the future

**For More Information – Contact Randy Thomure
Email: randy.thomure@sapagroup.com**

Sapa is environmentally conscious with regenerative equipment and reduced solvent and waste components. Sapa products meet or exceed AAMA specifications.
