NobelClad™

February 2019

# DISSIMILAR METAL WELDING



A DMC Company

# Dissimilar Metal Welding = Explosion Welding

# LIGHTWEIGHT PLATFORM DESIGN – ALL ALUMINUM

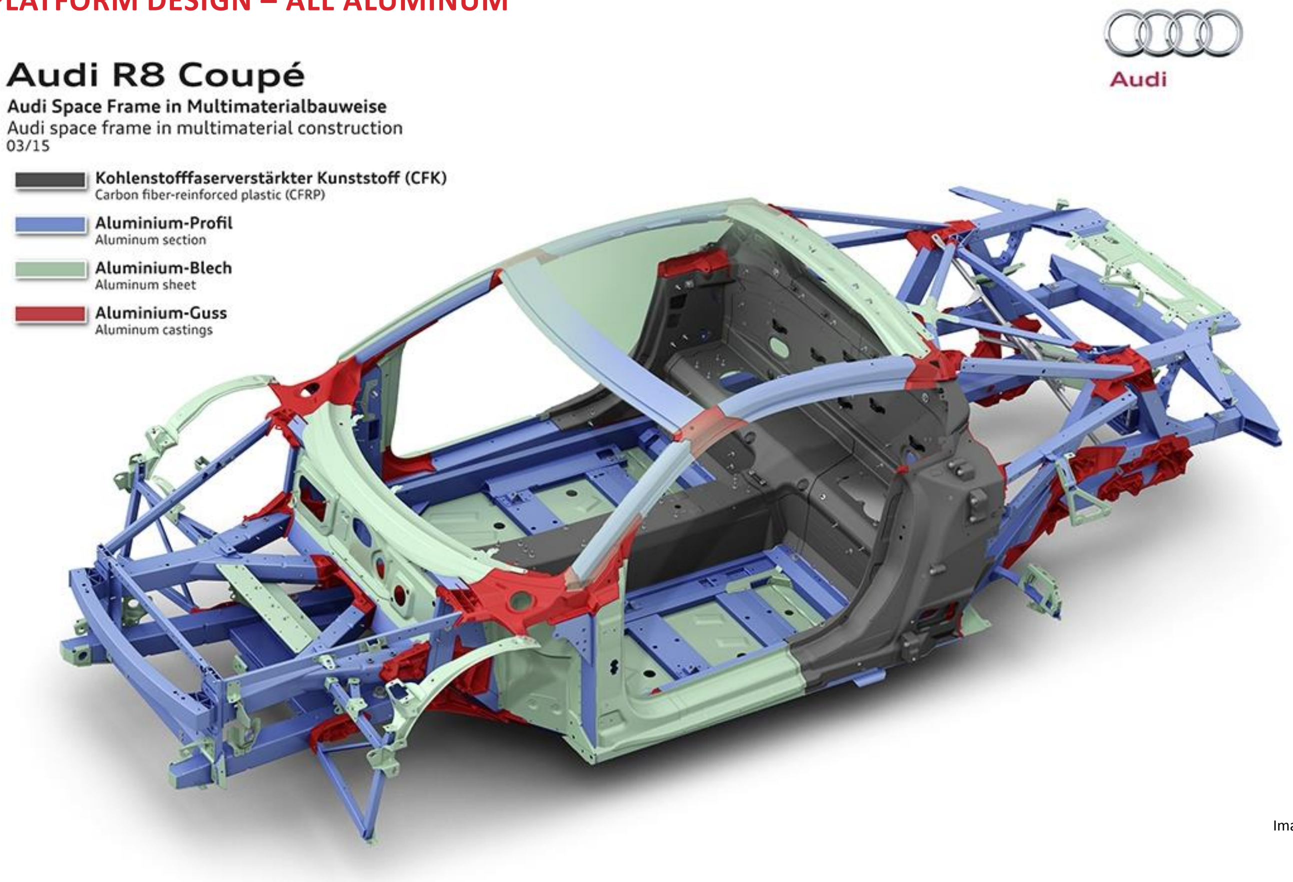



Image courtesy of Audi AG

## GM Truck Platform

- Mostly steel

## Weight Savings

- HSS – welded
- Aluminum - fasteners

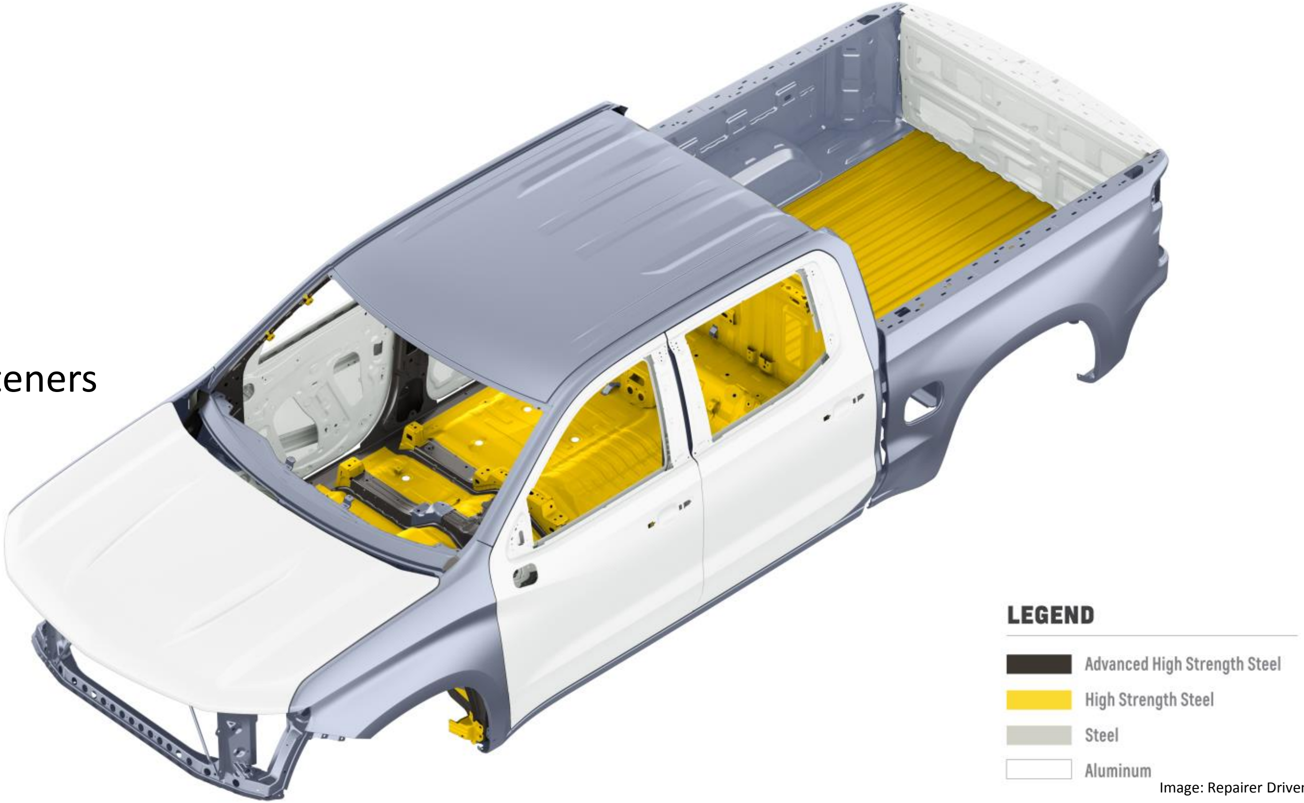
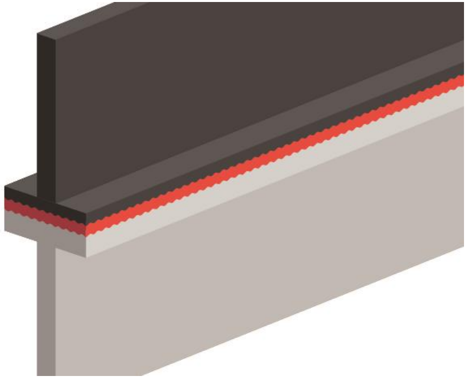
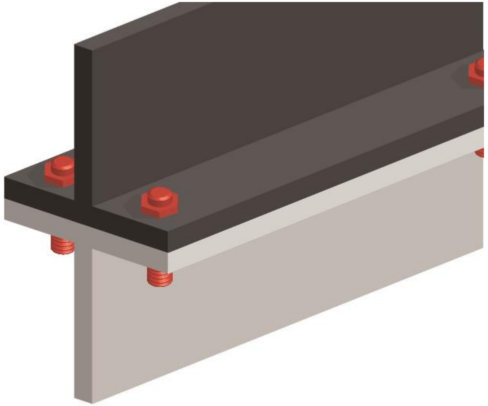



Image: Repairer Driven News

## CONSIDER HYBRID METALS?

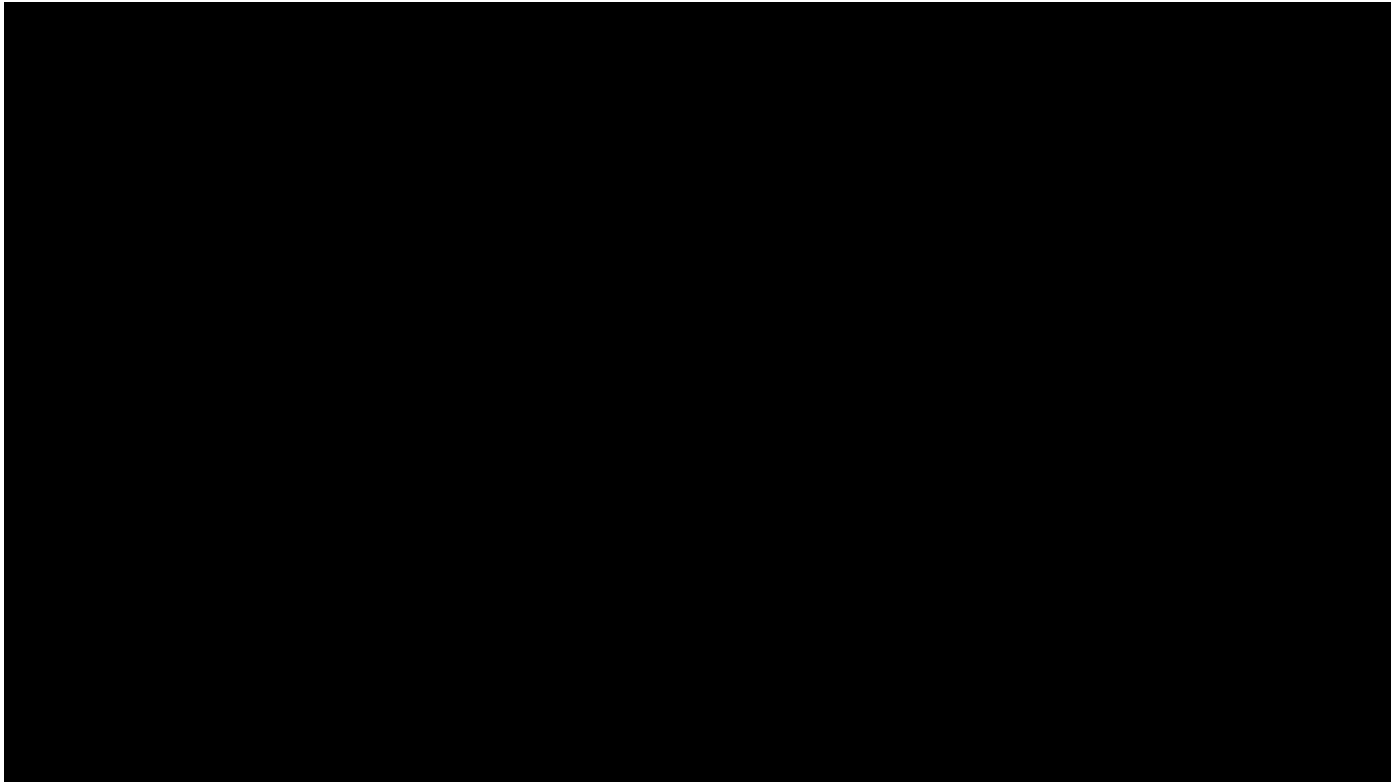
- Reducing weight
  - Enable lightweight materials
  - Use of Bi-metal Transition Joints allows structural welds between traditionally non-weldable materials:   Steel to Al, Ti to Al, Steel to Ti, Cu to Al etc.
- Welding electrical connections
  - Bi-metal from explosion cladding are better conductors than bolts or mechanical contacts
- Fighting corrosion and wear
  - A thin corrosion barrier can be cladded on some pieces to solve galvanic or corrosion issues
  - Welded structures are water tight solutions (no crevice corrosion)
- Reducing total costs
  - Faster and cheaper than machining, riveting, bolting
  - Eliminates galvanic corrosion protection requirements





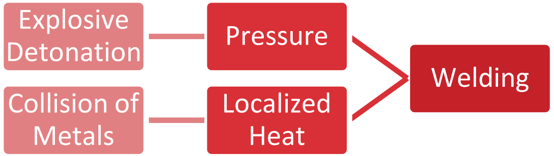
# NobelClad Process

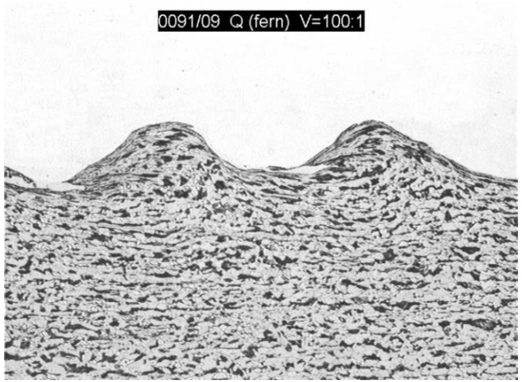
# INTRODUCTION TO EXPLOSION WELDING

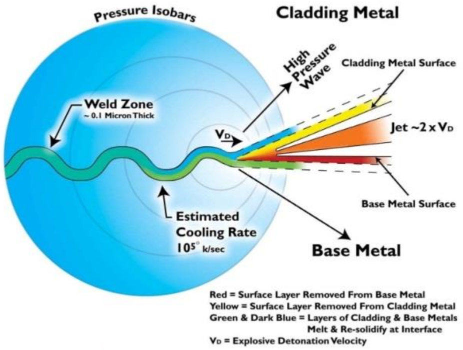


## EXPLOSION WELDED INTERFACE

- Interface achieved by combination of:
  - Very high pressure ⟷ Explosive detonation
  - Very localized heat ⟷ Collision of metals
- Wavy bond on a macro scale
- Jet assures pure and clean surfaces for the welding
- Possible to weld similar and dissimilar metals



## EXPLOSION WELDING CLASSIFICATION

- Process developed, commercialized and standardized in the 1960's
  - Process classified in EN 14610, EN ISO 4063 and American Welding Society (AWS)

**3.1.6.5**
**explosive welding (441)**
shock welding in which the workpieces are welded when impacted together by the detonation of an explosive charge

**SOLID-STATE WELDING (SSW)**

| | |
|---|---|
| coextrusion welding | CEW |
| cold welding | CW |
| diffusion welding | DFW |
| explosion welding | EXW |
| forge welding | FOW |
| friction welding | FRW |
| hot pressure welding | HPW |
| roll welding | ROW |
| ultrasonic welding | USW |

EN 14610:2004 (E/F/D)

**3.1.6.4**
**shock welding**
welding with pressure in which the workpieces are welded by the application of a striking force. The heat generated by the sudden collision contributes to the welding

**3.1.6.5**
**explosive welding (441)**
shock welding in which the workpieces are welded when impacted together by the detonation of an explosive charge

see Figure 11

**3.1.6.4**
**soudage par choc**
soudage avec pression dans lequel les pièces sont soudées par l'application d'un effort violent, la chaleur produite par la collision brutale permettant de réaliser la soudure

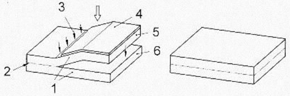
**3.1.6.5**
**soudage par explosion (441)**
soudage par choc dans lequel les pièces sont soudées lorsqu'elles sont plaquées l'une contre l'autre par la détonation d'une charge explosive

voir Figure 11

**3.1.6.4**
**Schockschweißen**
Pressschweißen, wobei die Werkstücke durch Aufwenden schlagartiger Kraft geschweißt werden. Die bei dem plötzlichen Zusammenprallen entstehende Wärme trägt zum Schweißen bei

3.1.6.5
**Sprengschweißen (441)**
Schockschweißen, wobei die Werkstücke geschweißt werden, indem sie durch die Detonation einer Sprengladung aneinandergeschleudert werden

Siehe Bild 11




**Key**
1 Workpieces
2 Weld and buffer
3 Detonation front
4 Explosive charge
5 Flyer plate
6 Parent plate

**Légende**
1 Pièces
2 Soudure
3 Front de la détonation
4 Charge explosive
5 Tôle volante
6 Tôle de base

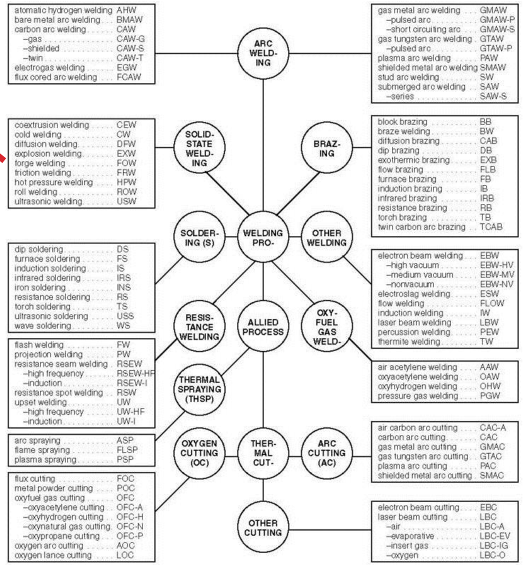
**Legende**
1 Werkstück
2 Schweißnaht
3 Detonations-druckwelle
4 Sprengladung und Speichermedium
5 Plattierungsblech
6 Grundblech

**a) Explosive welding for cladding**

**a) Soudage par explosion utilisé pour le placage**

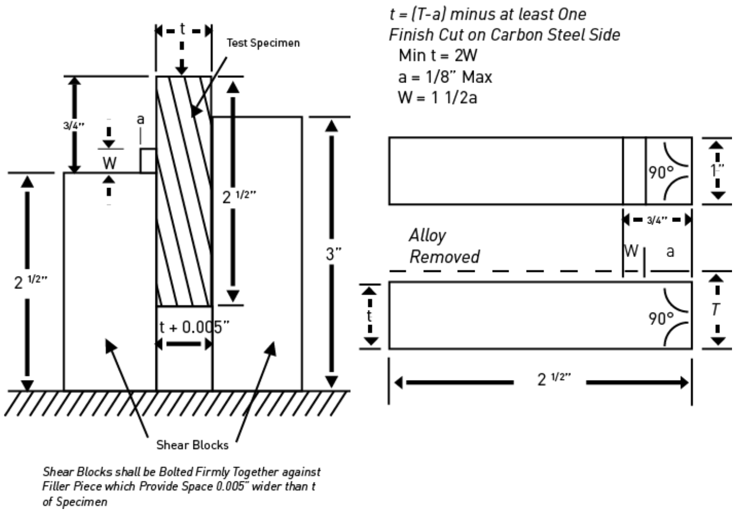
**a) Sprengschweißen zum Beschichten**

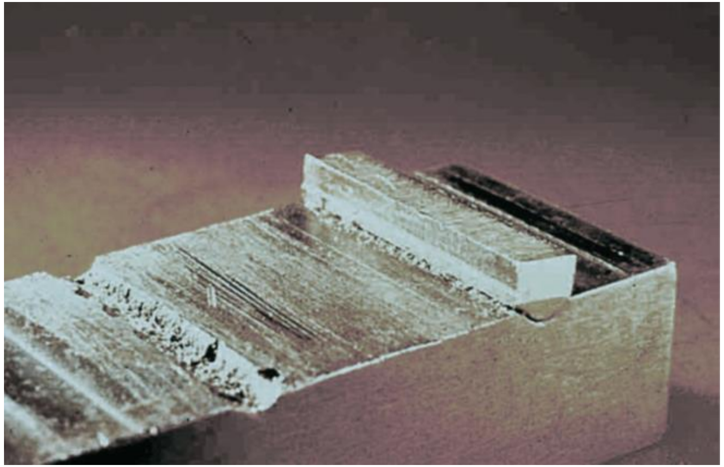
**Master Chart of Welding and Joining Processes**



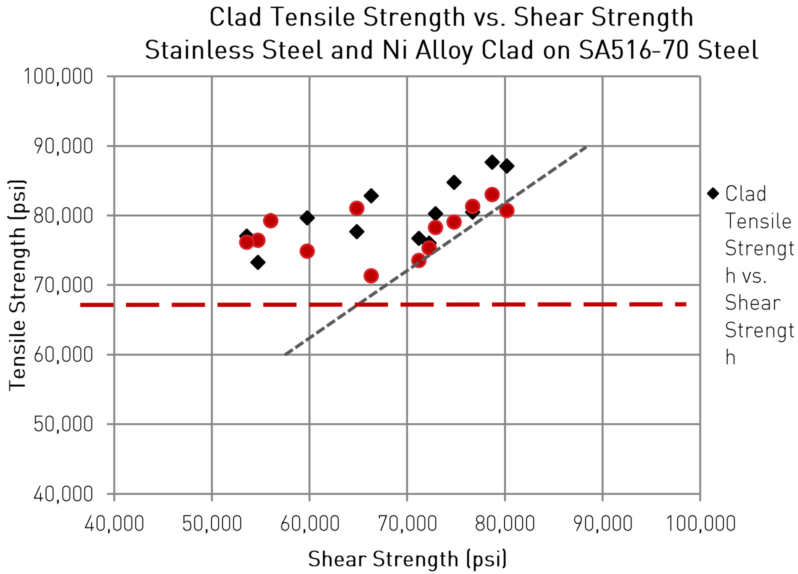
## INTERFACE SHEAR PROPERTIES

- ASME code and EU codes require shear tests
- Bond quality and forming capacity
- Design with direct attachments to the clad



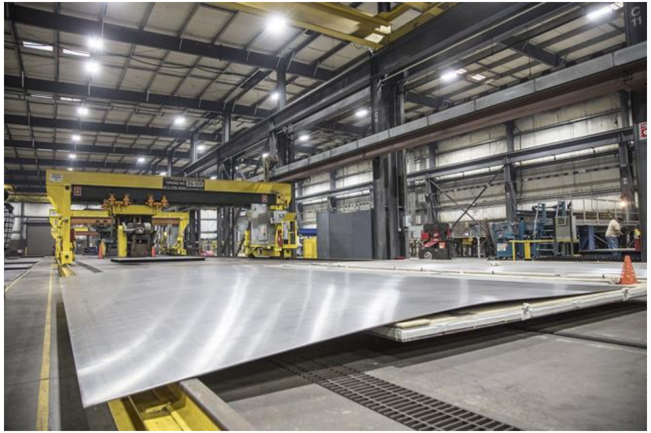
- 1st R&D Project: Comparison of tensile vs. shear strength
- Initial test program and paper published in 2005
- Tensile Strength of NobelClad EXW Bond
  > Shear Strength



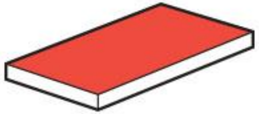

# NobelClad Plants and Manufacturing

## NOBELCLAD SHOOTING FACILITIES

- USA – Dunbar mine and Coolspring mine
  - Underground chambers
  - 35,000 – 50,000 sq. m
- Germany – Königzug mine and Höchen site
  - Underground chambers
  - 20,000 – 30,000 sq. m
- Total Production volume
  - 55,000 – 80,000 sq. m or 10,000 plates per year

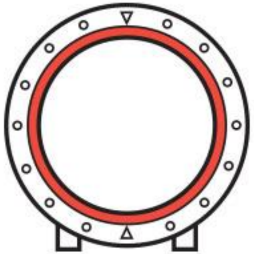


# Plate Products

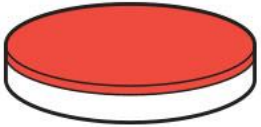


PLATES

HEADS

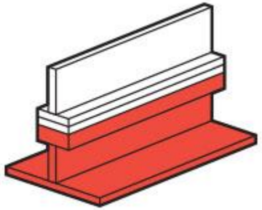


SHELLS

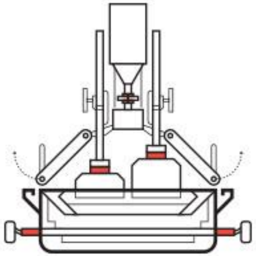


TUBESHEETS

# Transition Joints



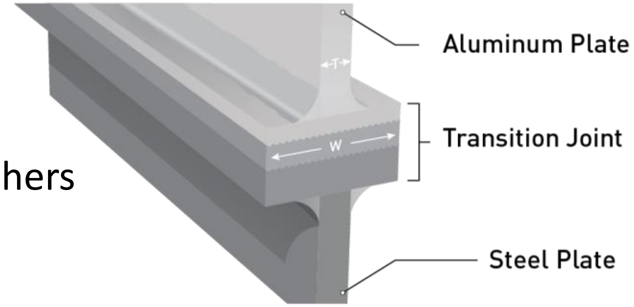
STRUCTURAL



ELECTRICAL

## FROM CLAD PLATE TO TRANSITION JOINT

- A transition joint is a bi-metal product used as an intermediate piece to weld 'non-weldable' structures
- Bi-metal transition joints are cut from the mother plate by water jet and or sawing
- Different shapes are possible (round, cylinders, beams, square)
- Long profiles are possible up to 12 m
- Large & small quantities
- Very efficient and cost effective
- Repeatability from 1 piece to the others




# Transportation Applications and Solutions Examples

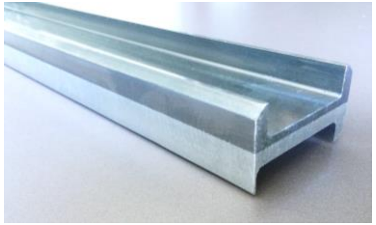
# RAILCLAD™ STRUCTURAL TRANSITION JOINTS FOR THE TRAIN INDUSTRY

- RailClad™ transition joints
  - Welded and maintenance free connection between aluminum components and steel structures in the train industry.
- Design Goals
  - Alternate solution to bolting and riveting
- Qualification
  - EN 3834-2:2005 and to EN 15085 – Certification Level CL1 (welding of railway vehicles and components).


ALSTOM CHOSE RAILCLAD TO BENEFIT FROM THE TECHNICAL AND ECONOMIC ADVANTAGES IT OFFERS

## STRUCTURAL TRANSITION JOINTS - TRAIN

- RailClad™ allows welding the Aluminum floor on the steel frame of the carbody structure, in lieu of bolts and rivets.
- Key Details
  - Combination
    - Steel + Al1050 + Al5XXX (18+3+18mm)
  - Typical test values
    - RAM tensile: 152MPa
    - Shear: 92MPa
- Certified by Alstom transport
    - Used for 10 years on more than 1,000 rail vehicles

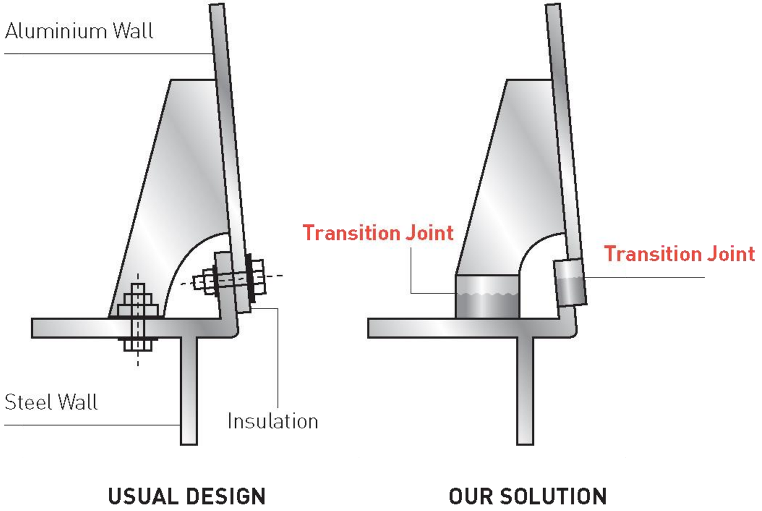


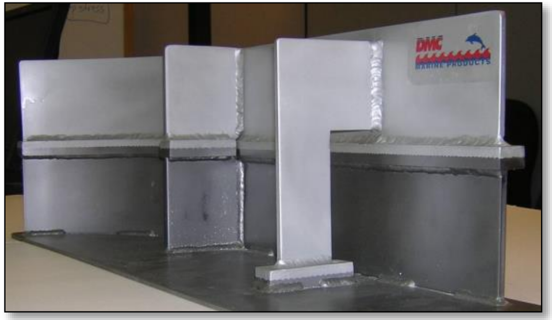

*Before: Hybrid bars*


*After: Aluminum alloy panel welded on the steel structure*

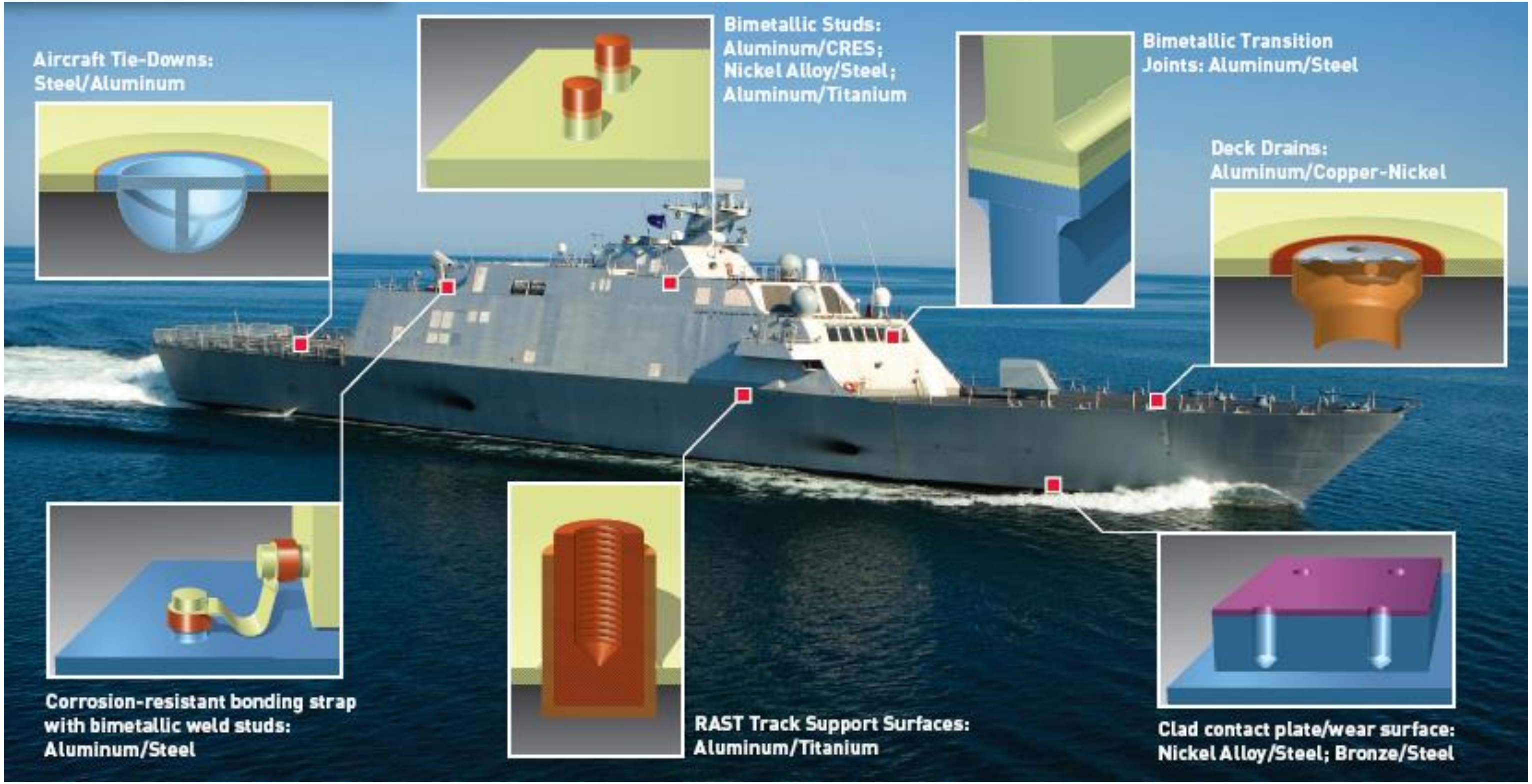
## STRUCTURAL TRANSITION JOINTS - MARINE

- For 50 years, NobelClad has made the welding of Aluminium superstructures on steel decks possible.
- Benefits include:
    - Low cost
    - Low maintenance
    - Easy installation
    - Reduced vessel weight
    - Superior corrosion control
    - Universally approved by maritime authorities

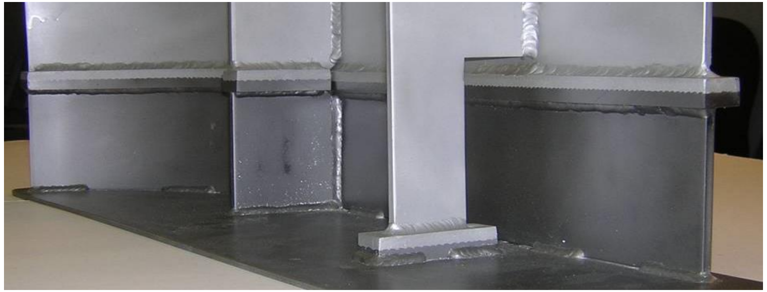


## SHIP APPLICATIONS



## SHIP APPLICATIONS



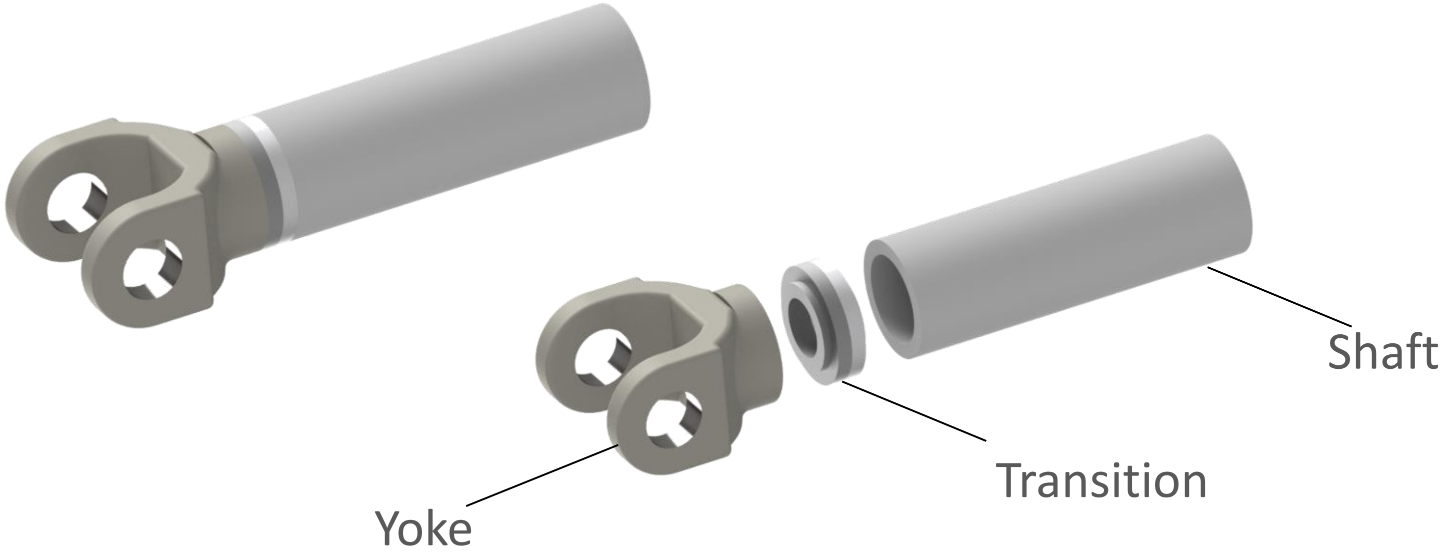
Structural transition joints

Titanium Light Assembly mounted to Steel deck with Titanium-Steel bimetal flange.

Titanium studs are welded to Aluminum hulls and decks

Steel-Aluminum bimetal tie-down point for welding to Aluminum decks.

- Transitions
  - Aluminum crossmembers welded to steel frames
  - Steel weld attach points for aluminum sheetmetal
  - Driveshaft transitions (steel u-joint to aluminum shaft)
  - Others


Shaft
Transition
Yoke

# AUTOMOTIVE – APPLICATIONS (CONTINUED)

# *What would you do if you could simply weld aluminum to steel?*

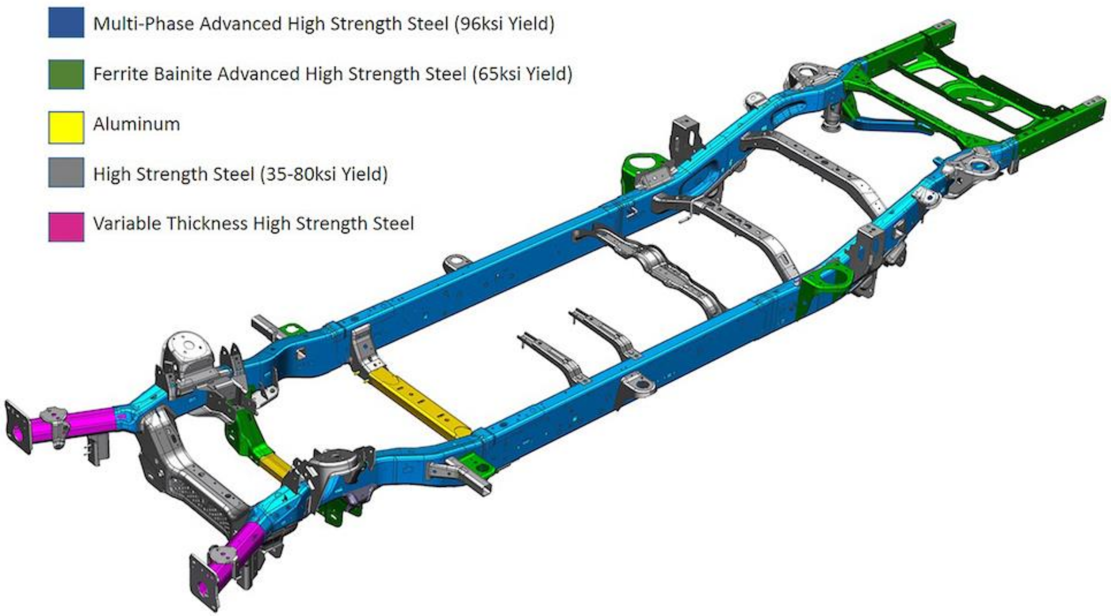



Image: FCA LLC US

## QUESTIONS

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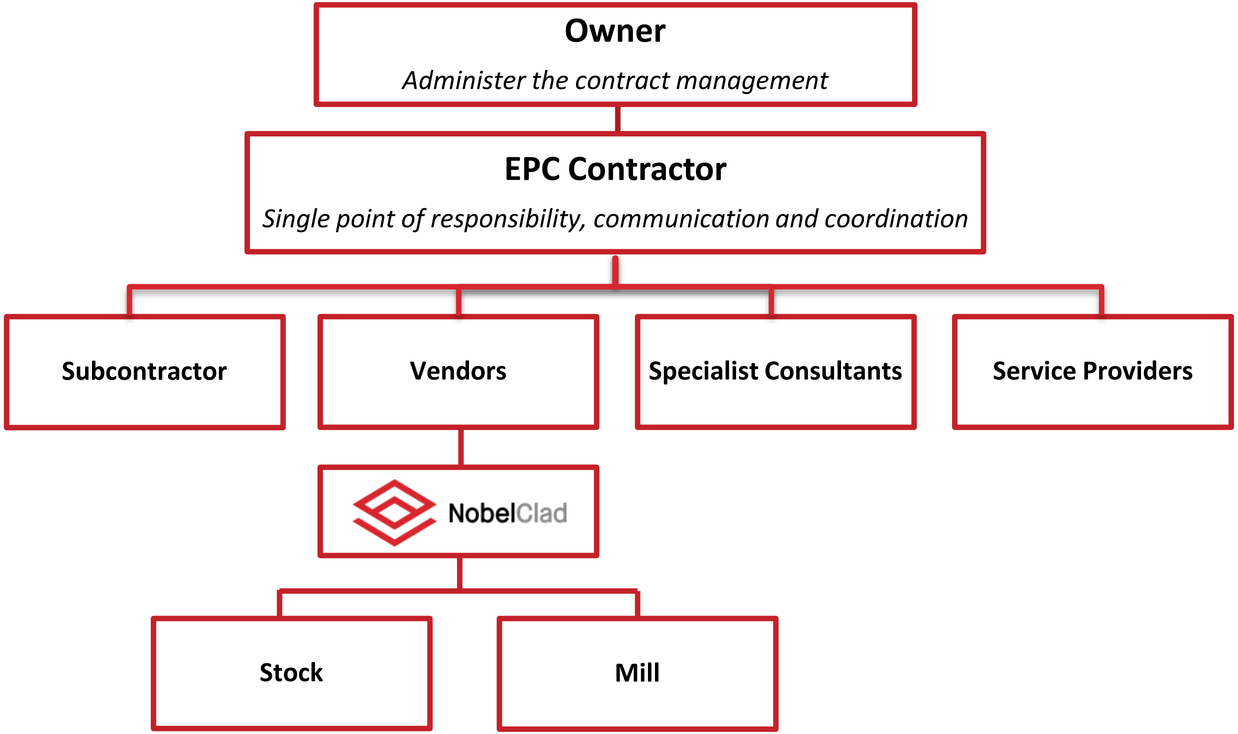
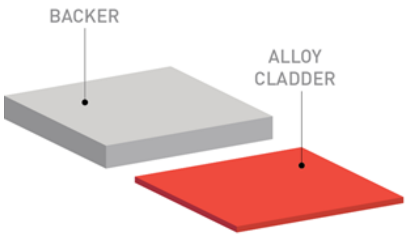
# Appendix

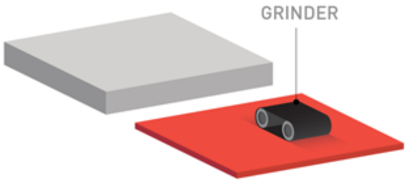
# LARGE OIL & GAS PROJECT STRUCTURE



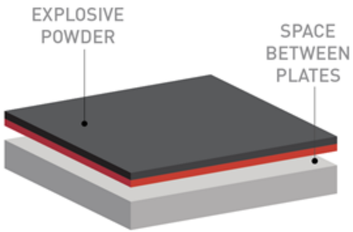
# EXPLOSION WELDING PROCESS



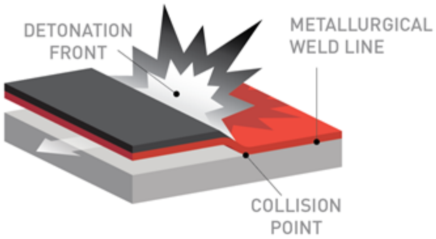

1. PLAIN MATERIAL INSPECTION



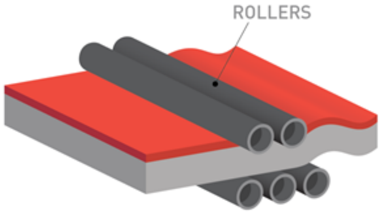

2. GRIND MATING SURFACES



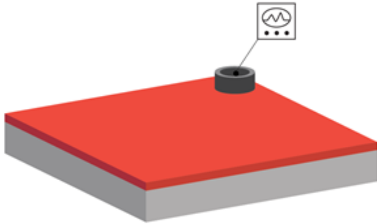

3. ASSEMBLE BACKER, CLADDER & EXPLOSIVE




4. EXPLOSION




5. FLATTENING & CUTTING



6. TESTING & INSPECTION

## PRE WELDING GRINDING

- The proprietary DetaClad Explosion Welding process begins with a thorough inspection of the materials.
- Then, grinding the surface of each metal ensures that they are free from any debris, oxides and surface flaws.

- Explosion Bonding Parameters
  - Standoff distance
  - Explosive load
  - Explosive burn rate
- Key Process Parameters
  - Input material meets specifications
  - Careful preparation and assembly
  - Final inspection

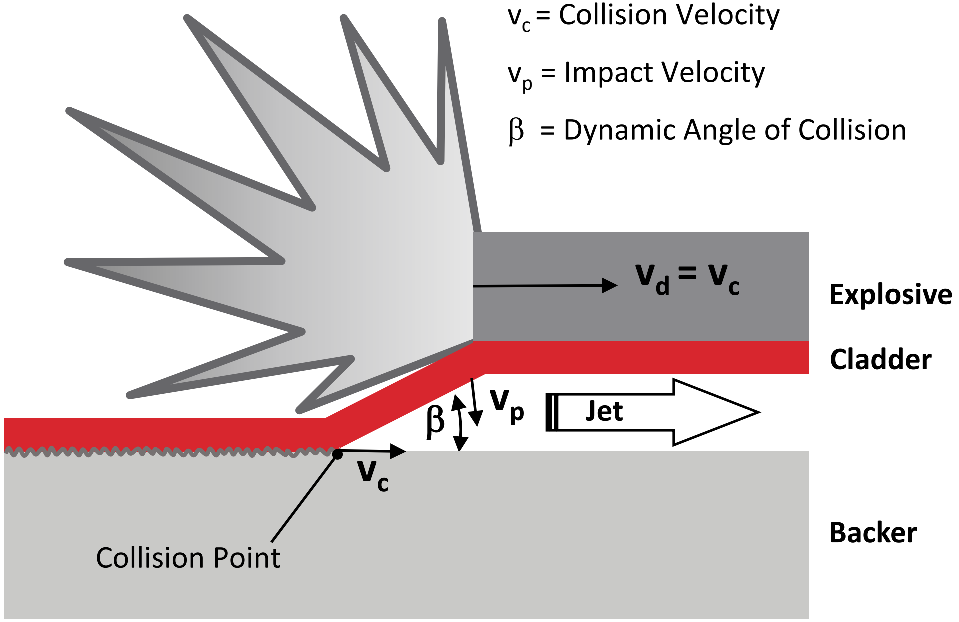
**KEY**

$v_d$ = Detonation Velocity

$v_c$ = Collision Velocity

$v_p$ = Impact Velocity

$\beta$ = Dynamic Angle of Collision



- Cladding and base metal plates are positioned parallel with a preset separation distance
- Explosive is placed on top
- Explosive detonation sweeps across the plate at ~2000 m/sec pushing the cladder onto the backer under high pressures (β,Vp)
- The collision between metals generates the jet and creates the wavy interface

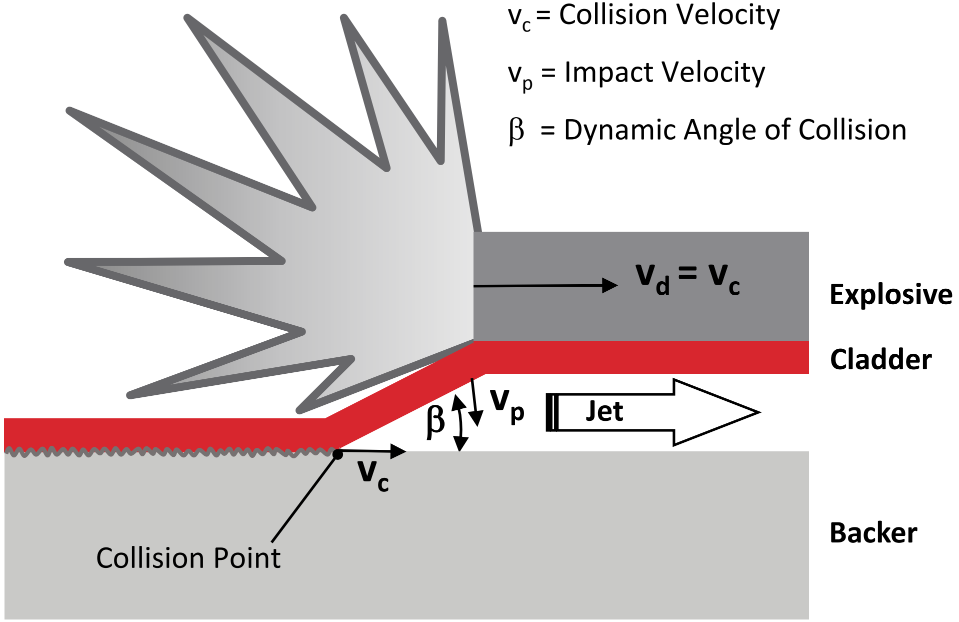
**KEY**

$v_d$ = Detonation Velocity

$v_c$ = Collision Velocity

$v_p$ = Impact Velocity

$\beta$ = Dynamic Angle of Collision



## POST WELDING PROCESS

- In preparation for delivery, the explosion welded clad plates undergo a finishing process that can include heating, cutting, or flattening.
- All clad undergoes stringent testing and qualification to ensure it meets industrial and project specifications.

## AUTOMATIC ULTRASONIC SCANNING

- Capacity
  - L=12 m & W=4.2 m up to 500 mm
  - Weight=50 t
  - Plate or tubesheets
- Scanning speed: 500 mm/s
- Permanent coupling with water layer
- 3 multitransducer heads adaptable vs specification
- Applicable specifications:
- B898 / SA578 / EN 10160 & SA577

# POST WELDING PICTURES