

# Implementation of Ultrasonic Metal Welding on an Aluminium Vehicle Structure

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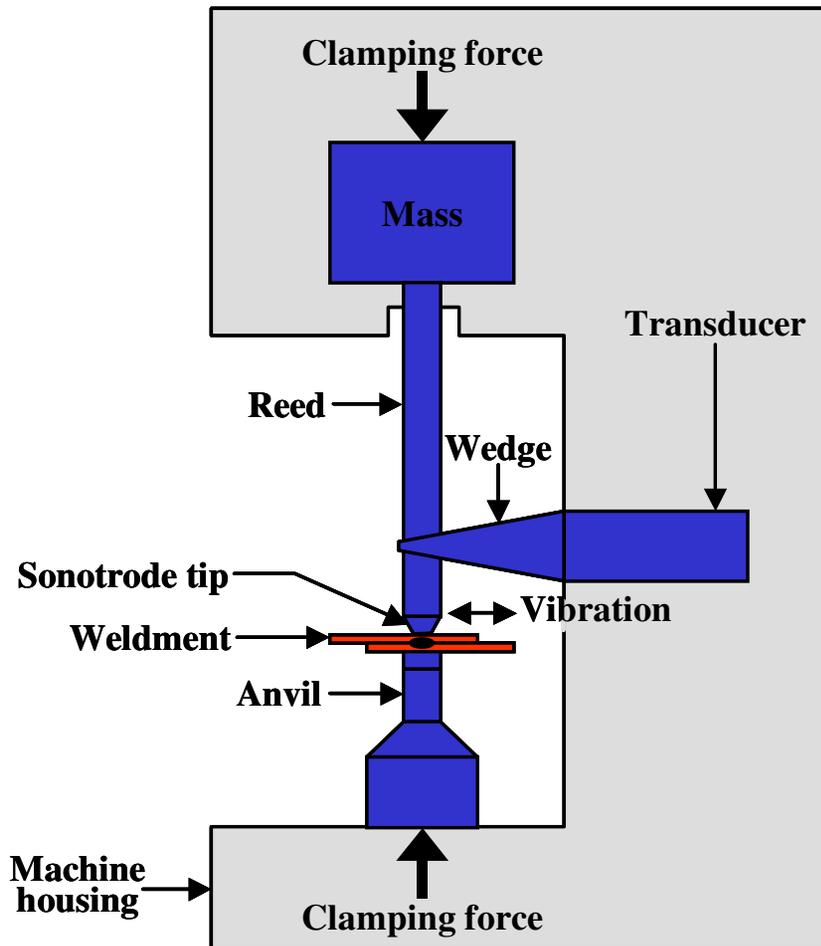
Ford Motor Company

Janet Devine and Joe Walsh

Sonobond Ultrasonics



# What is Ultrasonic Welding?



**Ultrasonic metal welding is a solid-state welding process that produces coalescence through the simultaneous application of localized high-frequency (20 kHz) vibratory energy and moderate clamping forces achieved via plant air at pressures up to 7 Bar.**

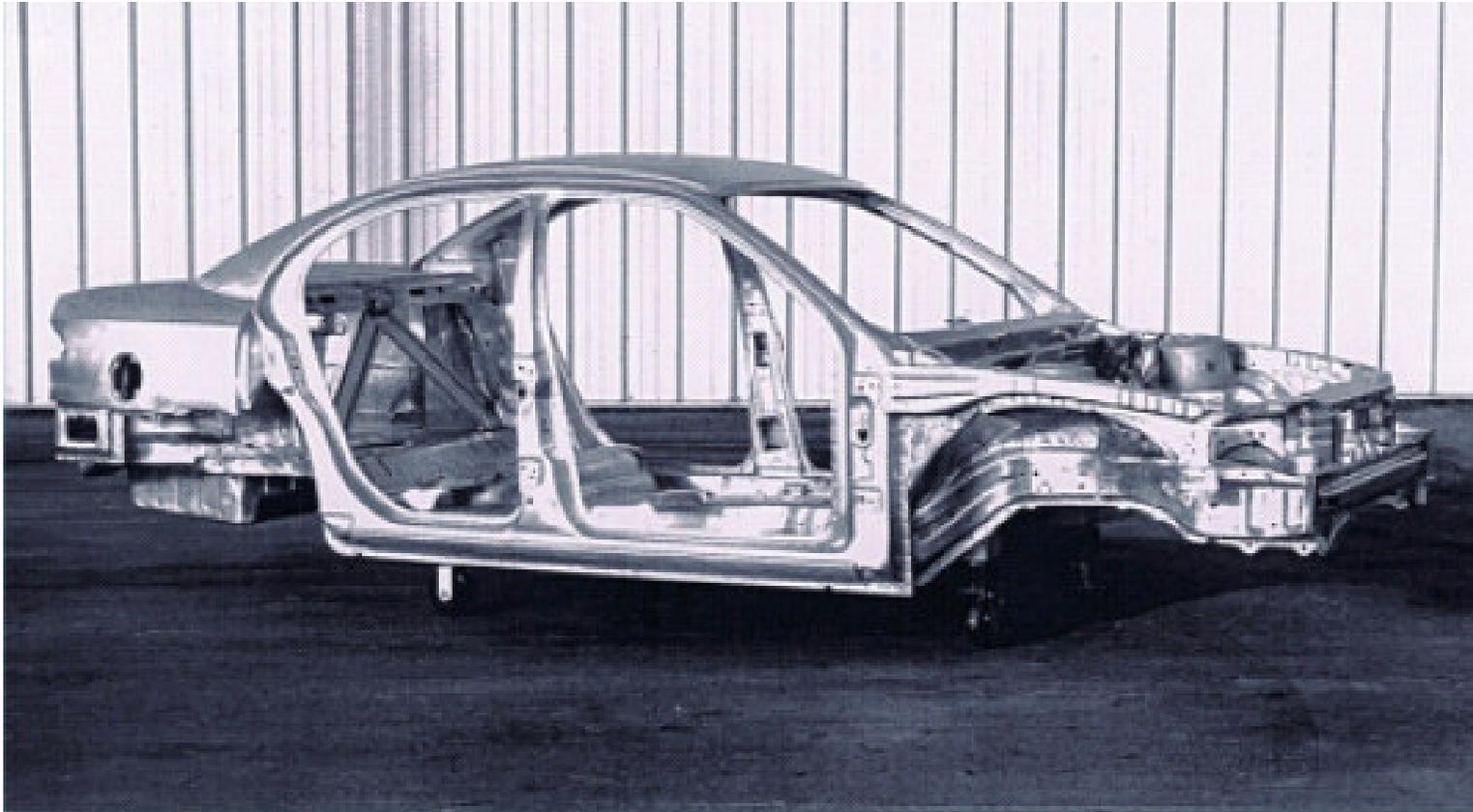


# Why Join Aluminium Sheet with Ultrasonic Welding?

- Less energy required than for resistance spot welding
- Lower cost than riveting
- No heat affected zone
- Relatively insensitive to range of lubricant types and levels
- Works on pretreated aluminum



# Typical Aluminium Vehicle



**Ford P2000 Body-in-White**

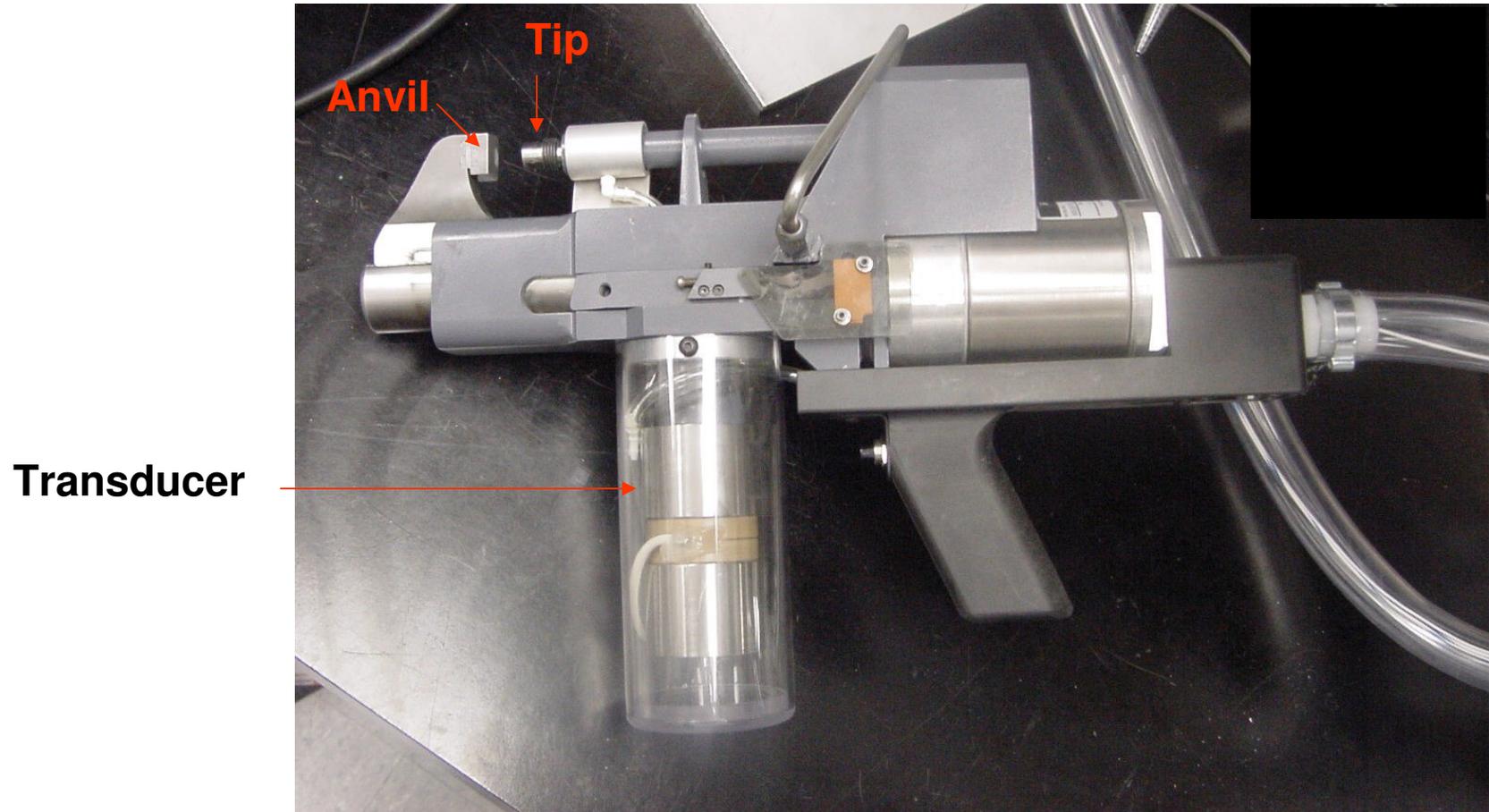


# Typical Aluminium Sheet Alloys for Automotive Vehicles

Alloy	Typical Gauges
<b>AA5182-O</b>	0.9 mm- 3 mm
<b>AA5754-H111</b>	1-3 mm
<b>AA6016-T4</b>	1-1.5 mm
<b>AA6111-T4</b>	0.9 – 2 mm



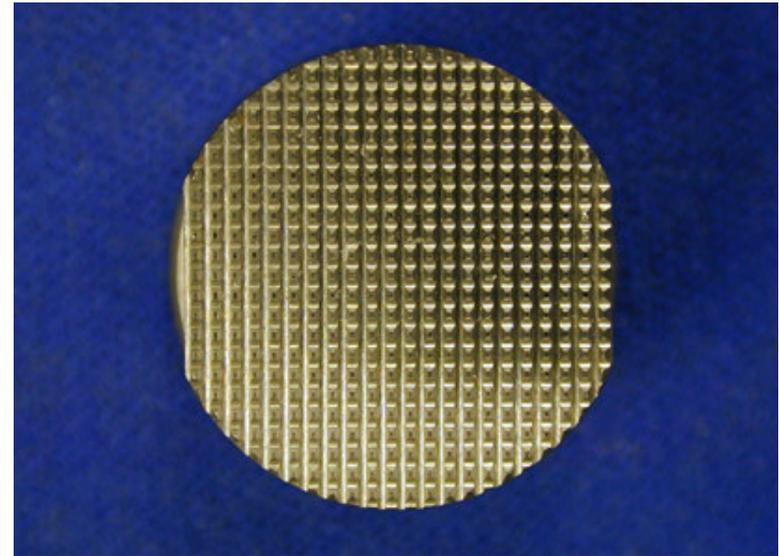
# Manual Ultrasonic Weld Gun



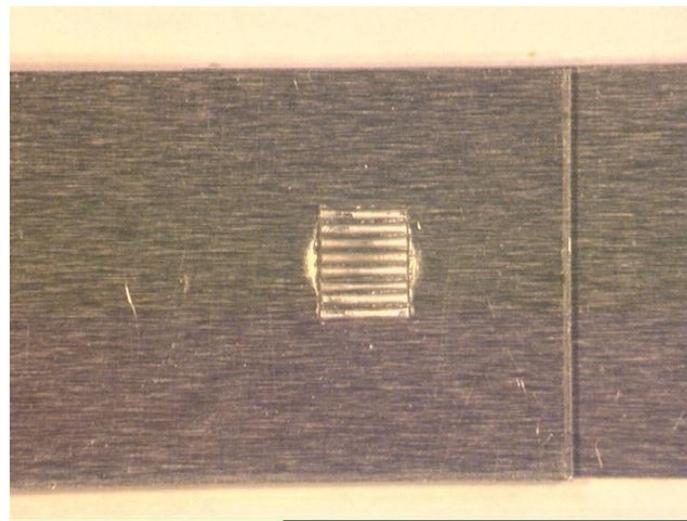
# Sheet Metal Welding Tip and Anvil



*Tip Gripping Surface*



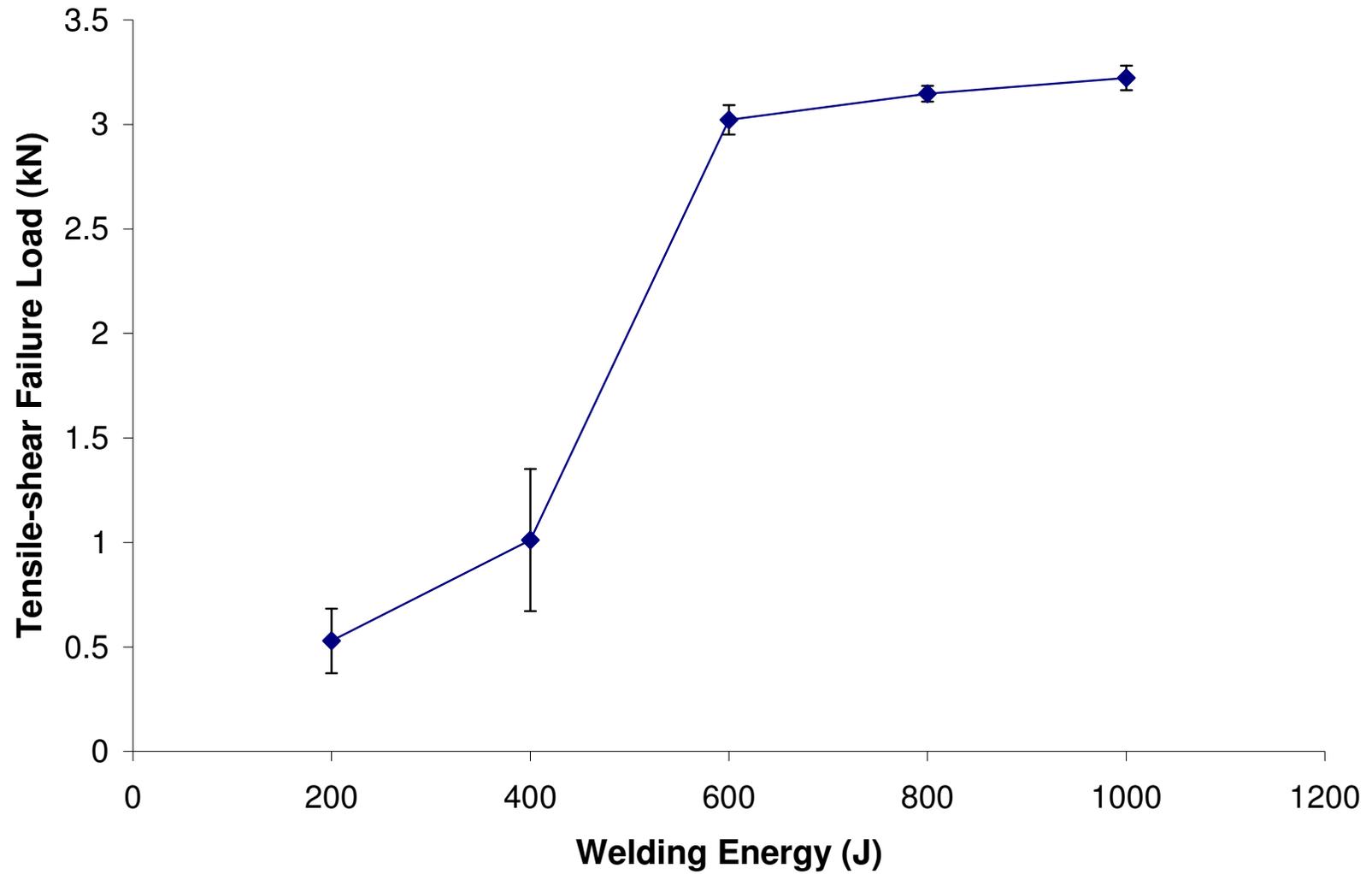
*Anvil Gripping Surface*



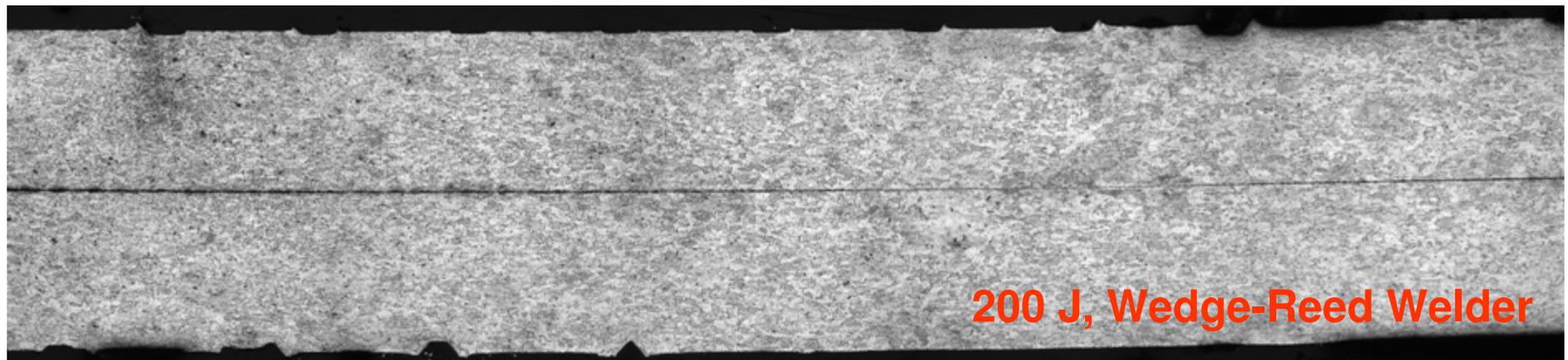
Tip Side of Welded Coupon



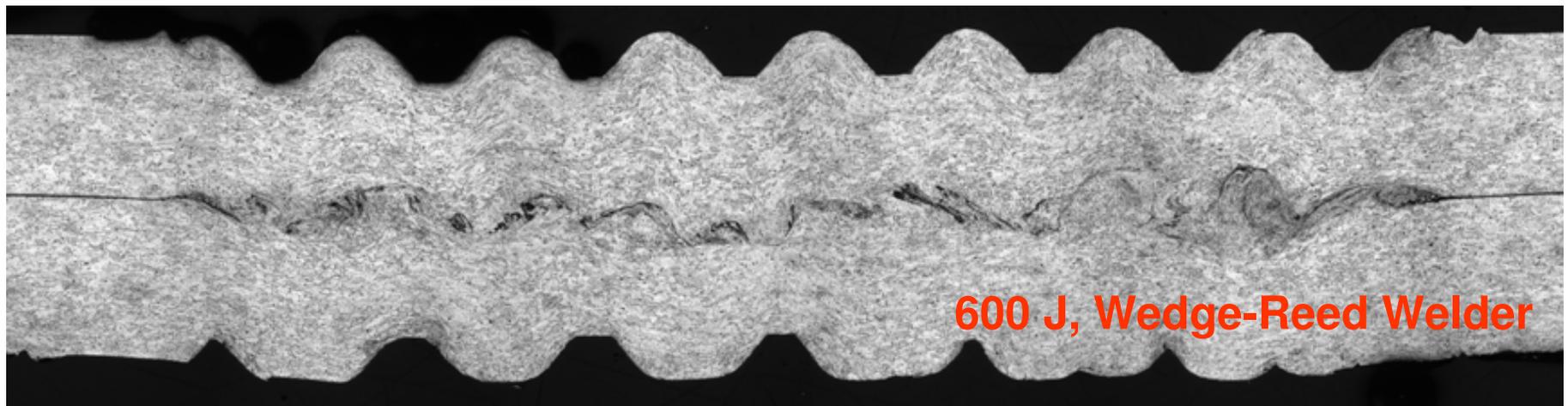
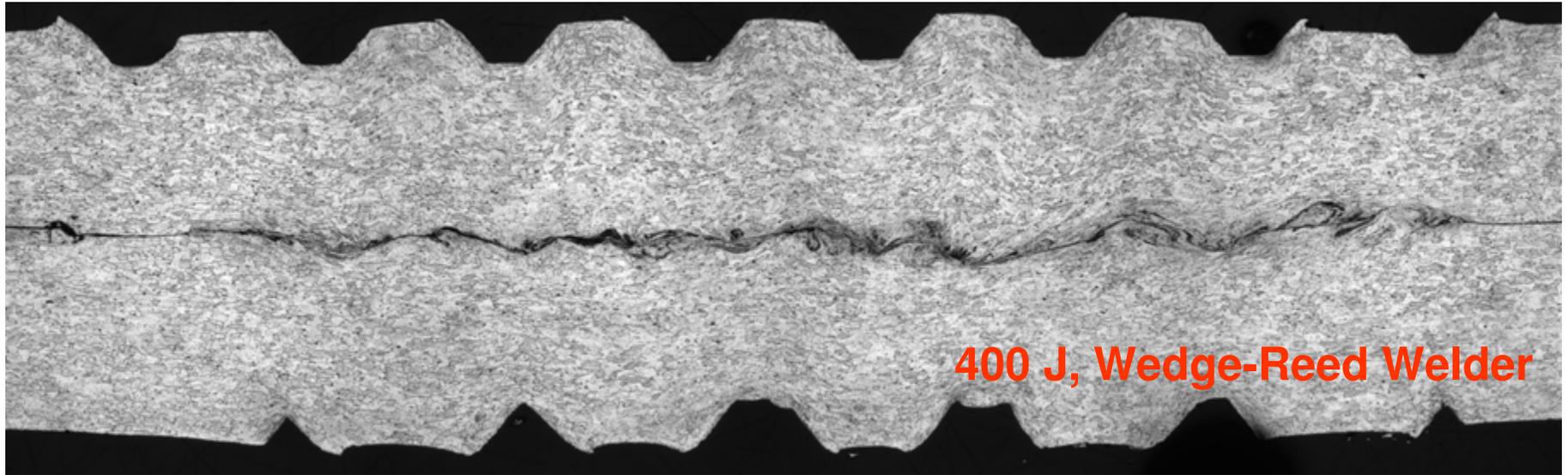
# How Does the Weld Develop?



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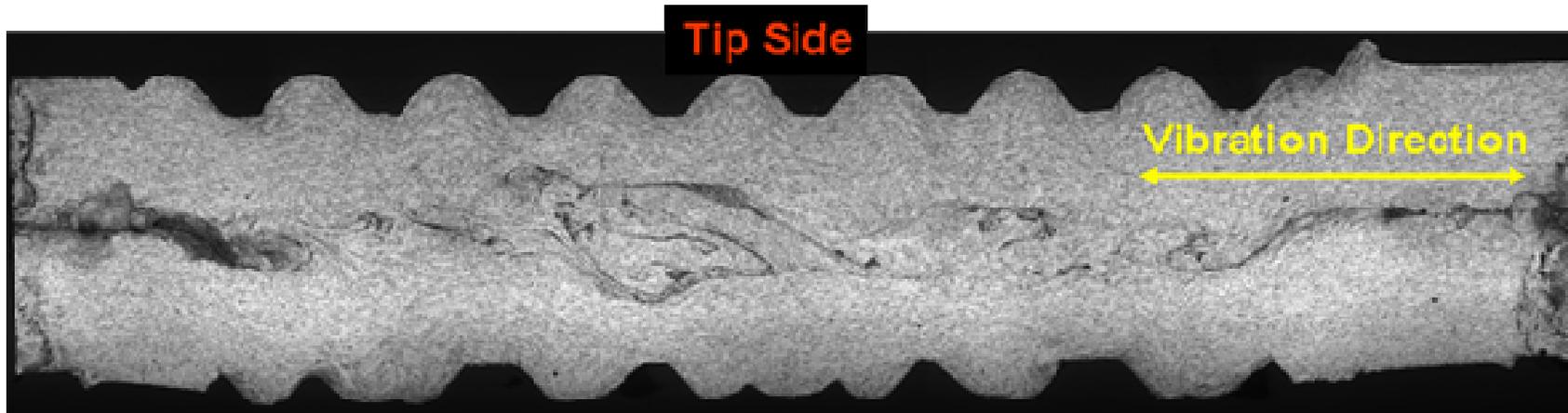


# Weld Formation Summary

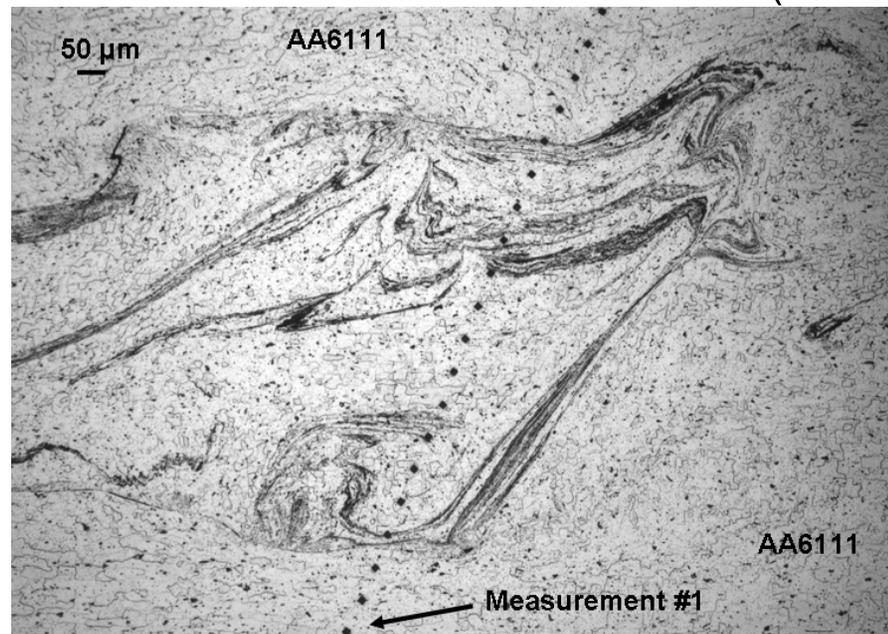
- Physical deformation at weld interface and at tip and anvil interfaces occurs concurrently.
- Mechanical mixing occurs at the interface.
- Some deformation of grains occurs at the interfaces of the tip and anvil with the weldments.
- There is no evidence of melting.



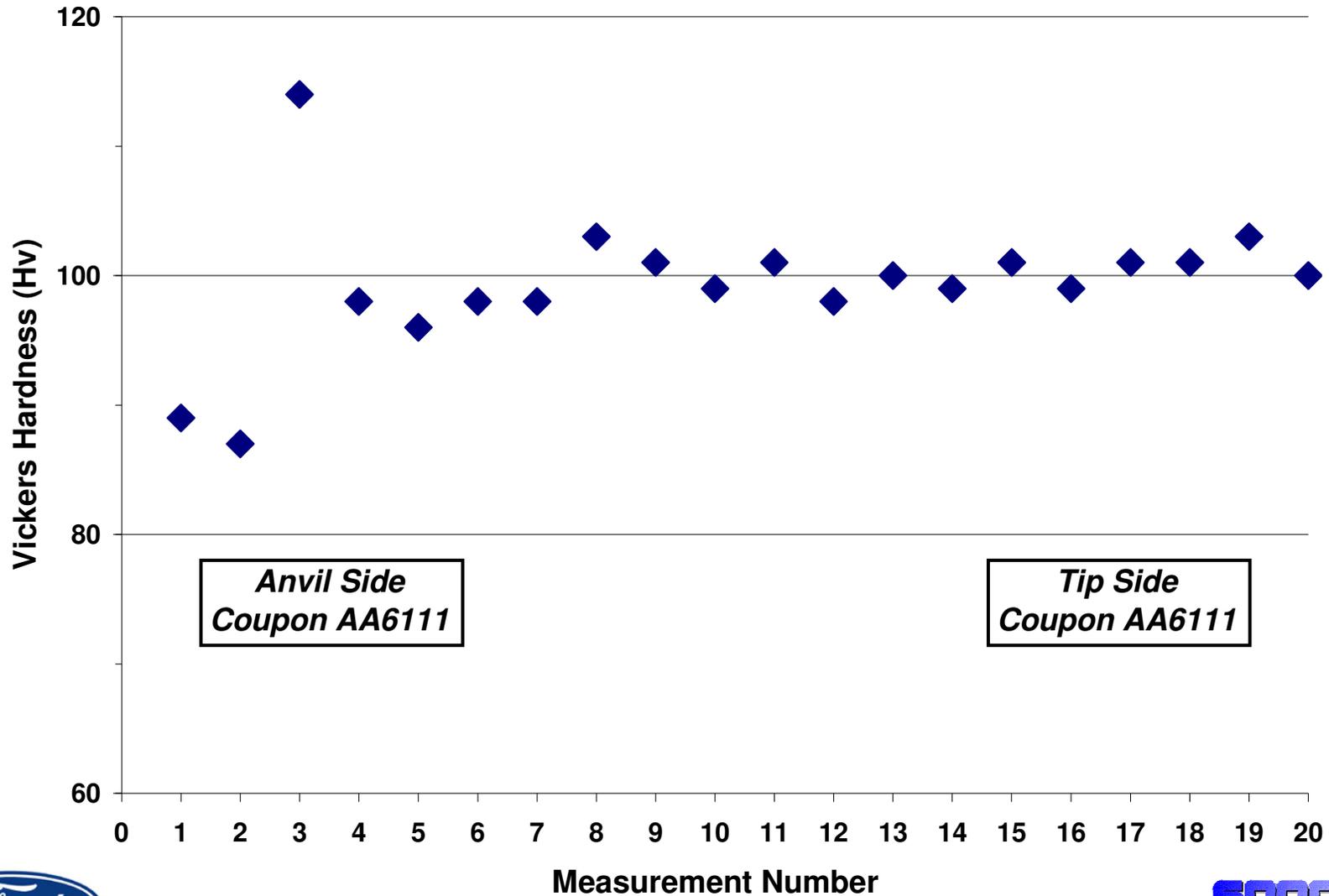
# AA6111-AA6111



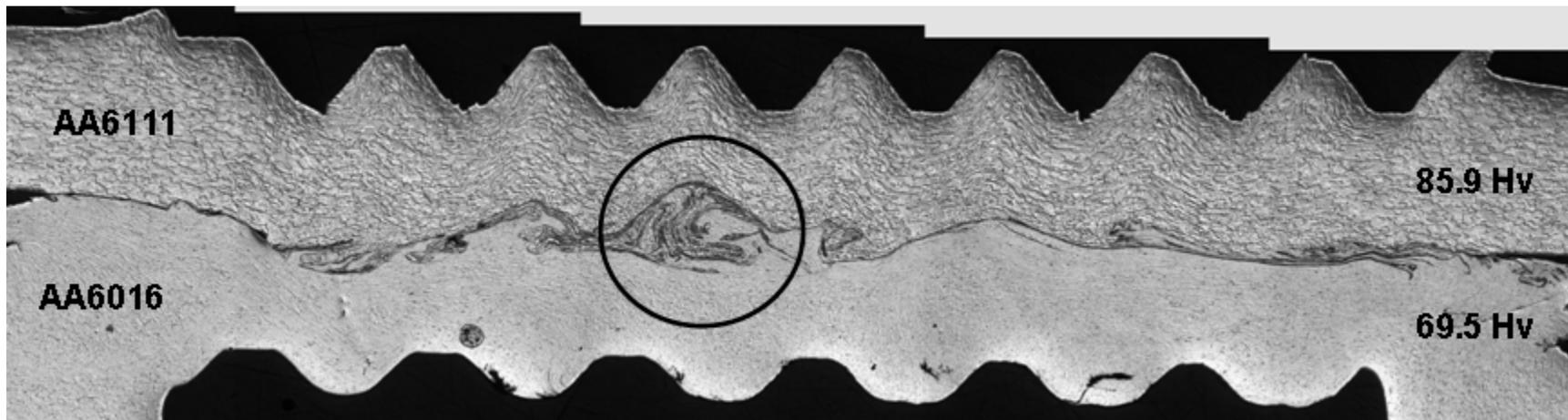
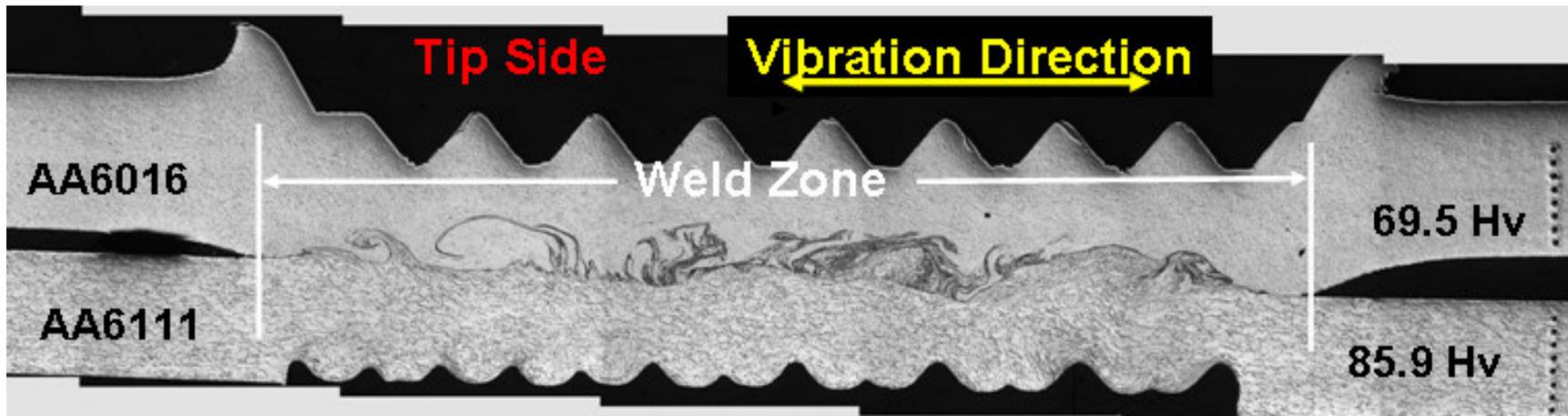
Cross-section of Welded AA6111-T4 (0.9 mm)



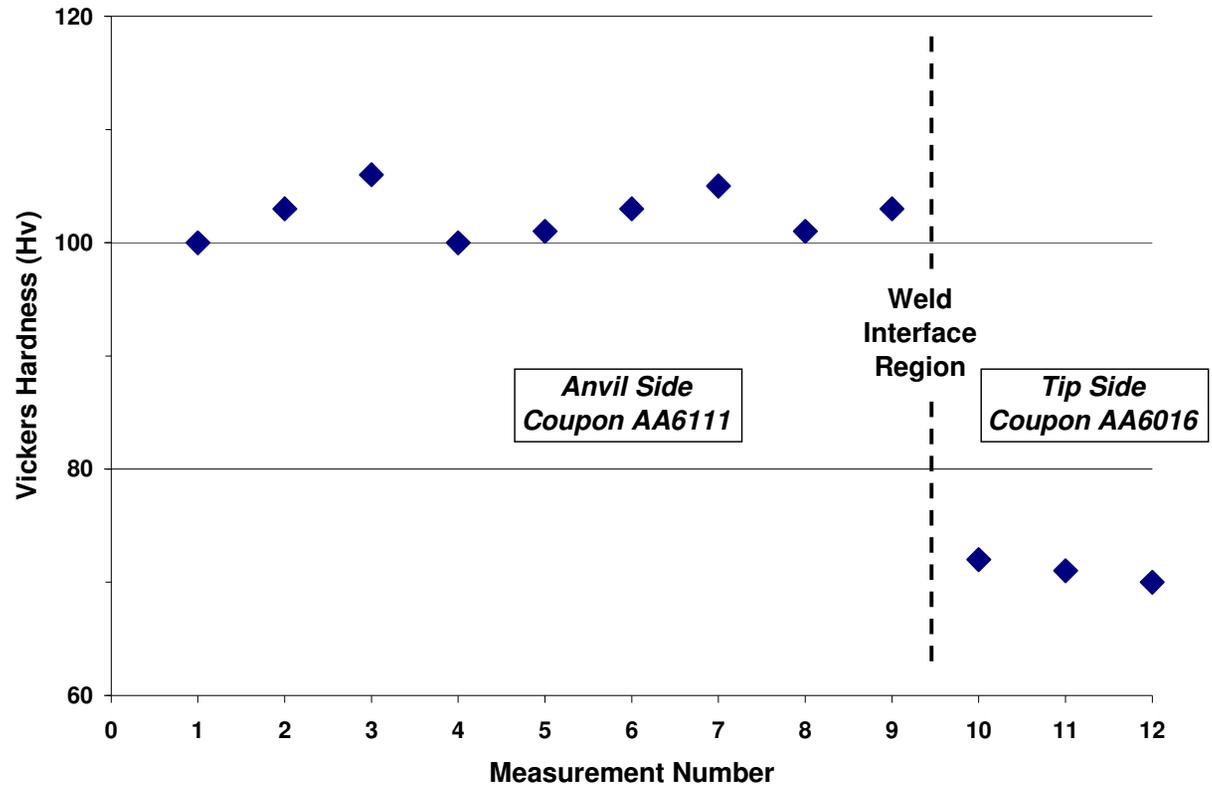
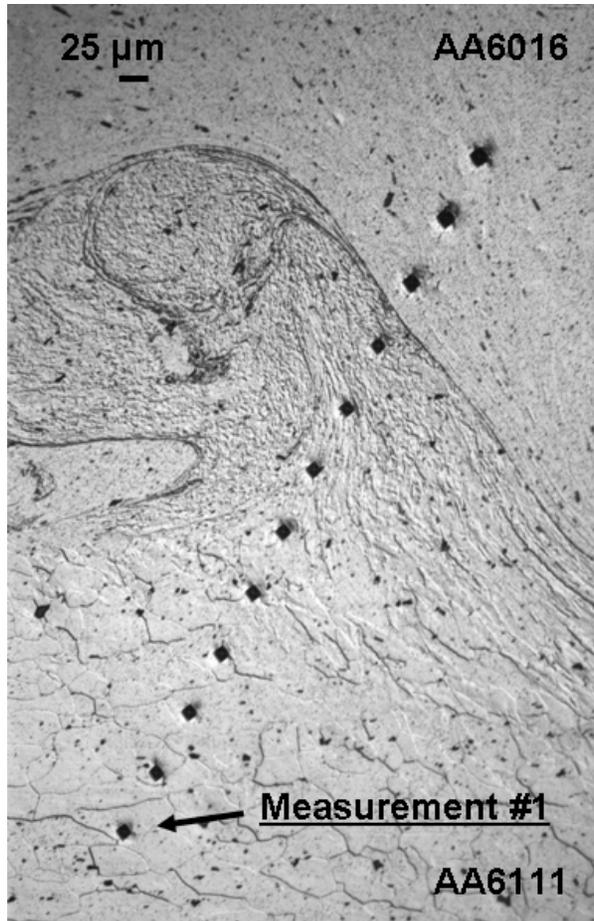
# Hardness Across Weld AA6111-AA6111



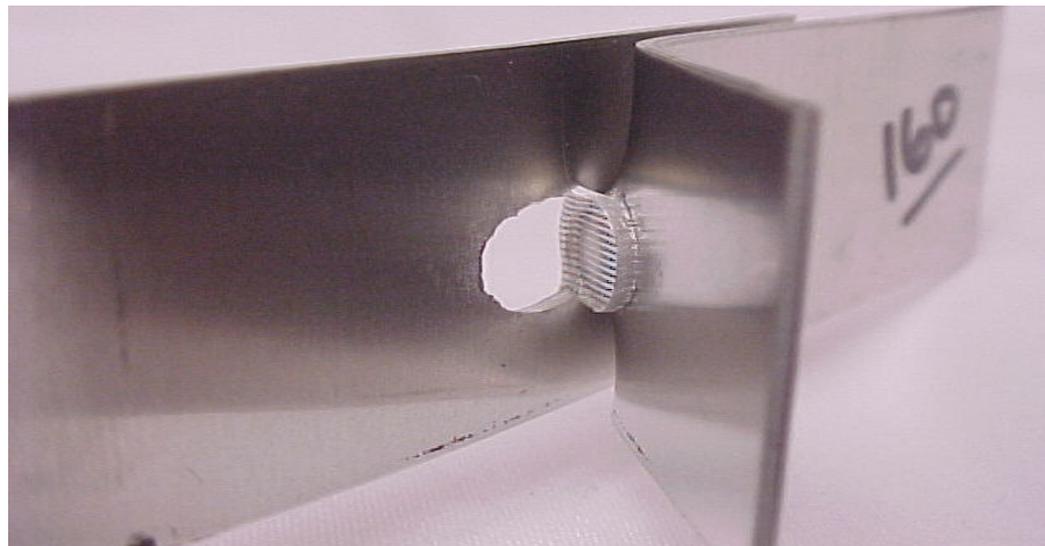
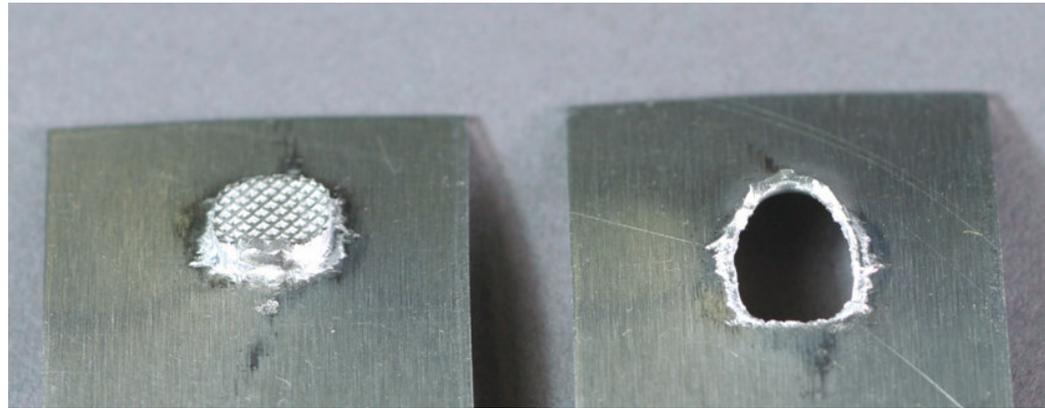
# Cross-section of AA6016-AA6111 Weld



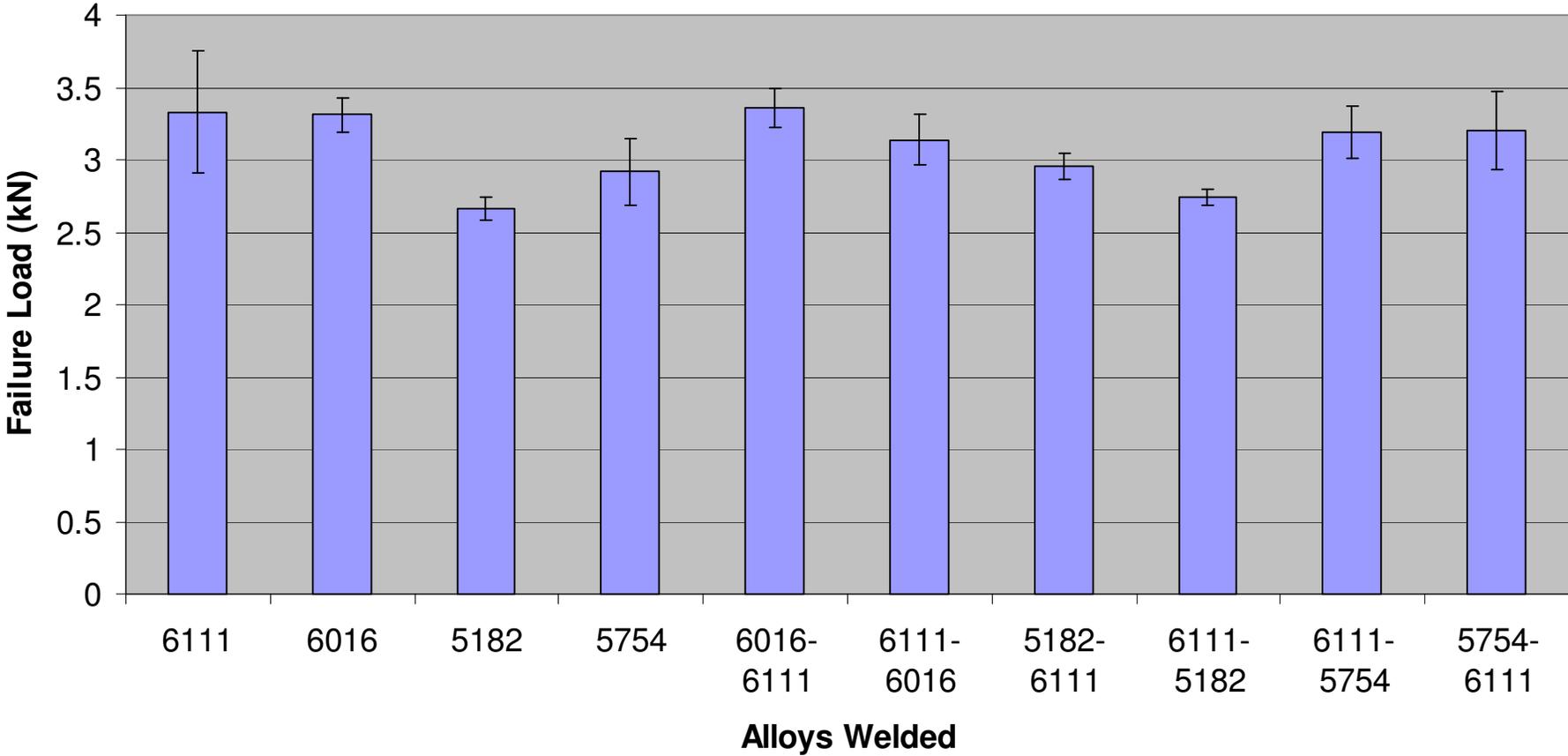
# Hardness Across AA6016-AA6111 Weld



# Example of Tensile-Pulled Lap-Shear Coupon



# Lap-Shear Failure Loads



0.9 mm AA6111-T4

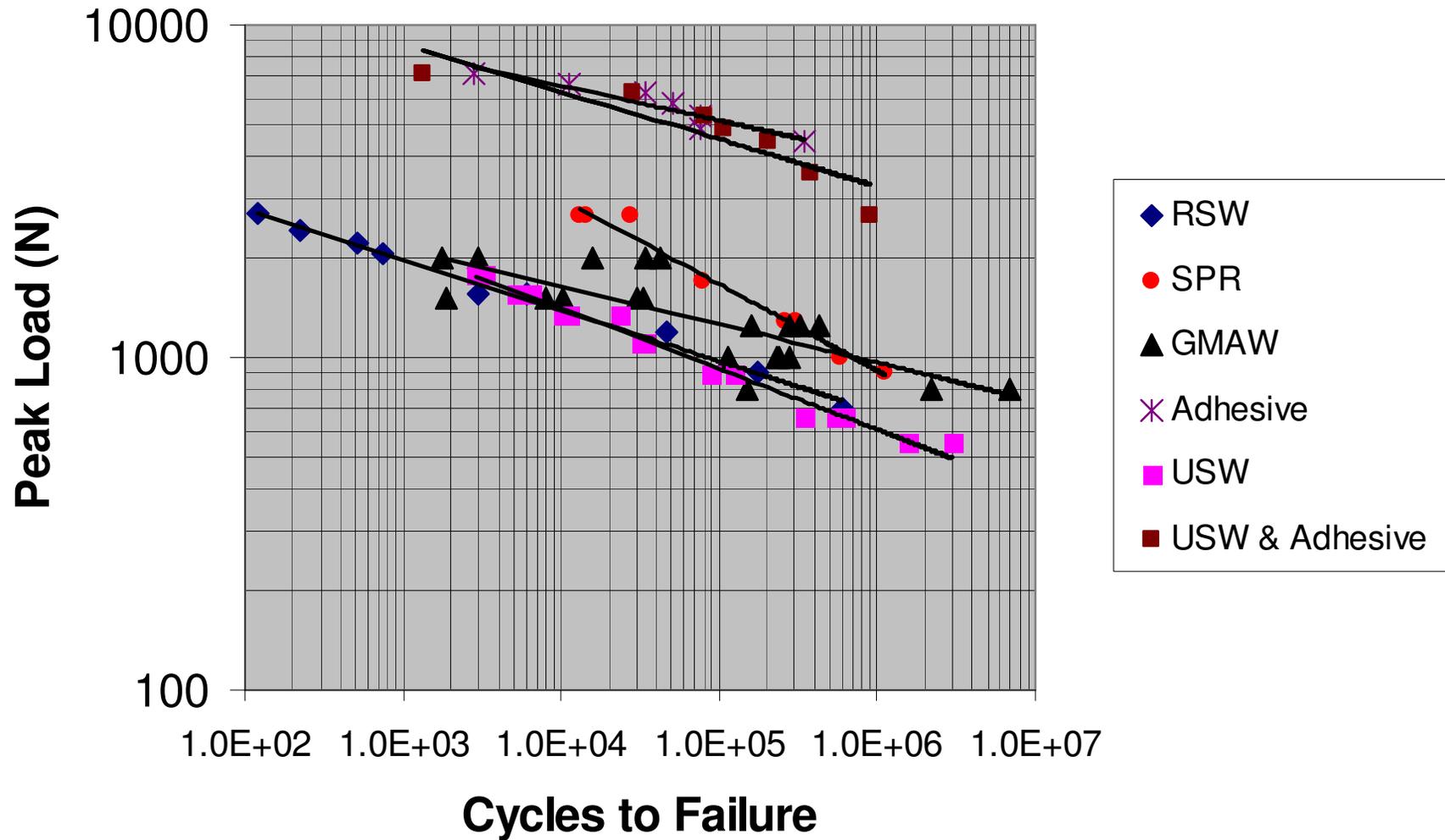
1.2 mm AA6016-T4

1.0 mm AA5182-O

1.0 mm AA5754-H111



# Fatigue Life of Joined 0.9 mm AA6111, R=0.1



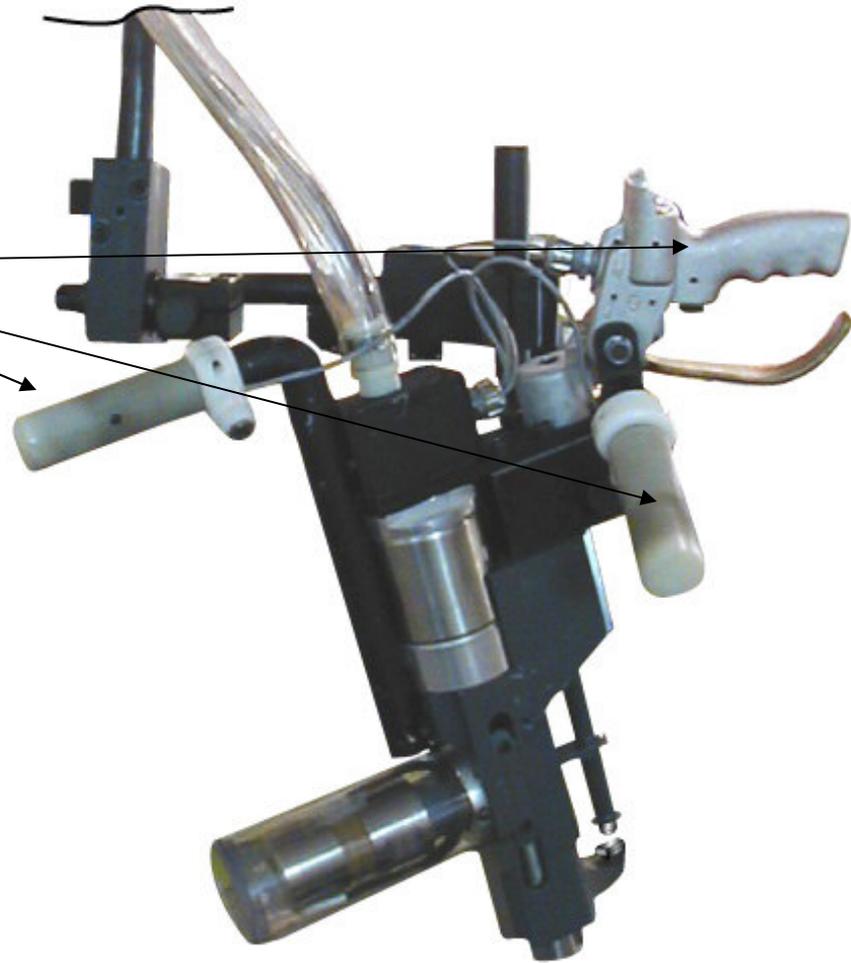
# Welding Structures

- Access to weld location
- Cycle Time
  - 0.4 s for 1 mm to 1 mm sheet
  - 2.0 s for 3 mm to 3 mm sheet
- Manual and Robotic Weld Applications



# Manual Ultrasonic Weld Gun for Aluminium Vehicle Structure Welding

**Multiple Handles  
Accommodate  
Welds Made at  
Several Orientations**



# Robotic Ultrasonic Welding Gun for Aluminium Vehicle Structure



**C-Frame Robotic  
Weld Gun with  
Clamping System**

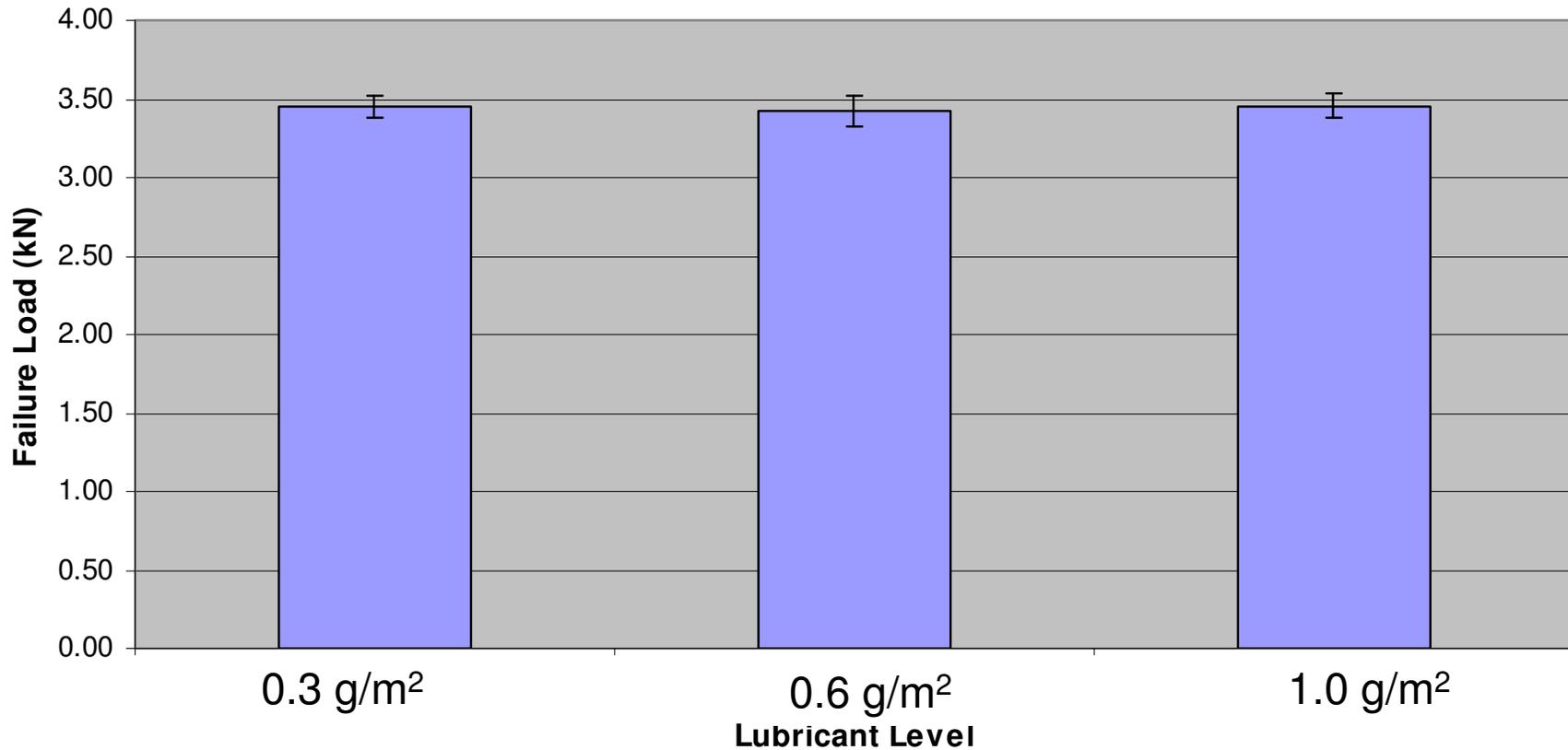


# Process Robustness

- Alloy Combinations
  - 5XXX
  - 6XXX
- Lubricant
  - Liquid
  - Dry Film
- Gauges
  - 0.9 to 3 mm



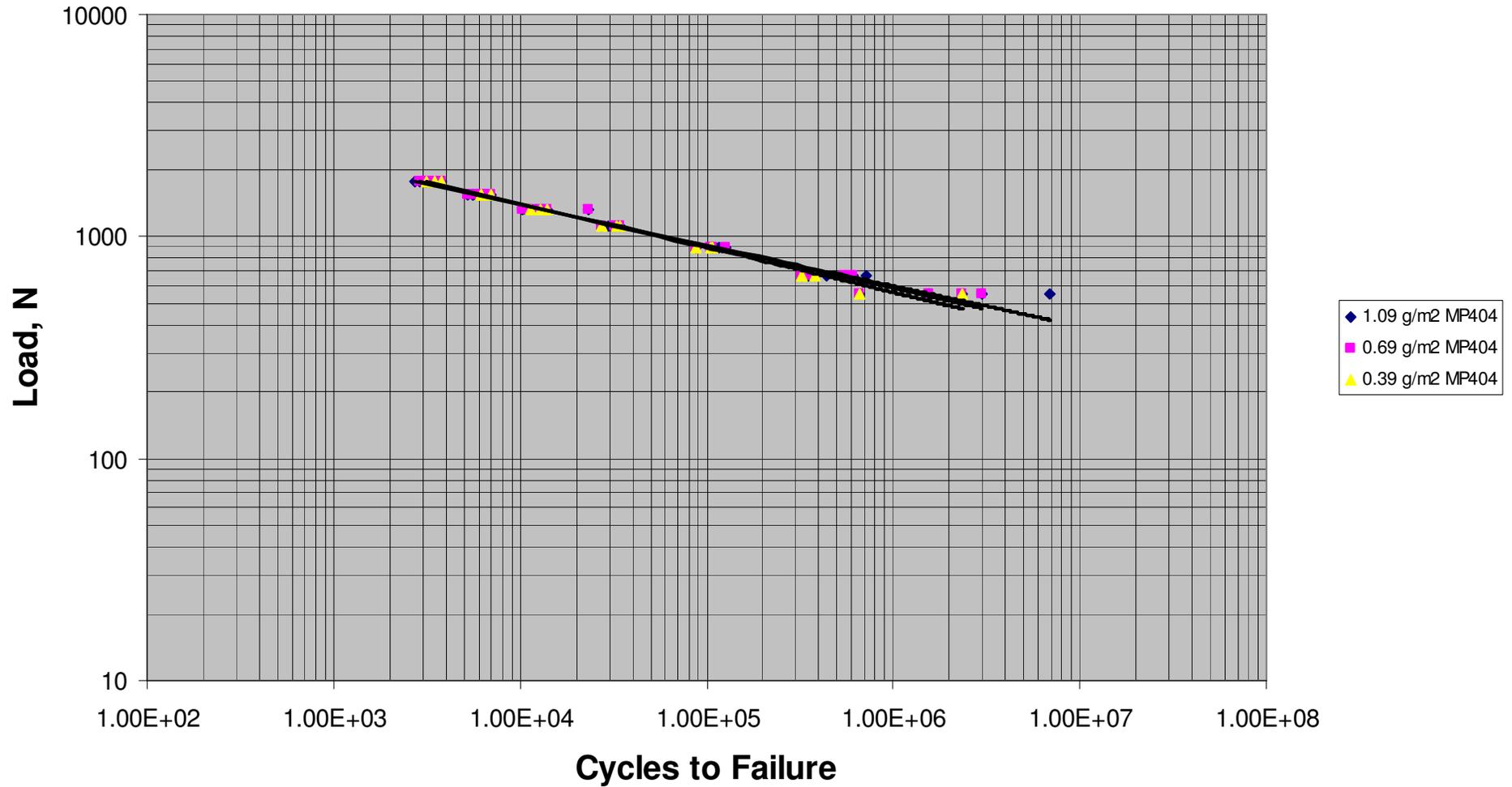
# Effect of Stamping Lubricant on Weldability of Aluminium



0.9 mm AA6111-T4 to AA6111-T4 Welds  
Lap-Shear Failure Loads



# Fatigue Life of Welded AA6111 with Various Lubricant Levels



# Typical Lap-shear Failure Loads of Different Aluminium Gauges

1 mm 5754 to 1mm 5754	2 mm 5754 to 2 mm 5754	3 mm 5754 to 3 mm 5754
2.8-3.0 kN	5.0-5.5 kN	7.5-8.5 kN



# Application Challenges

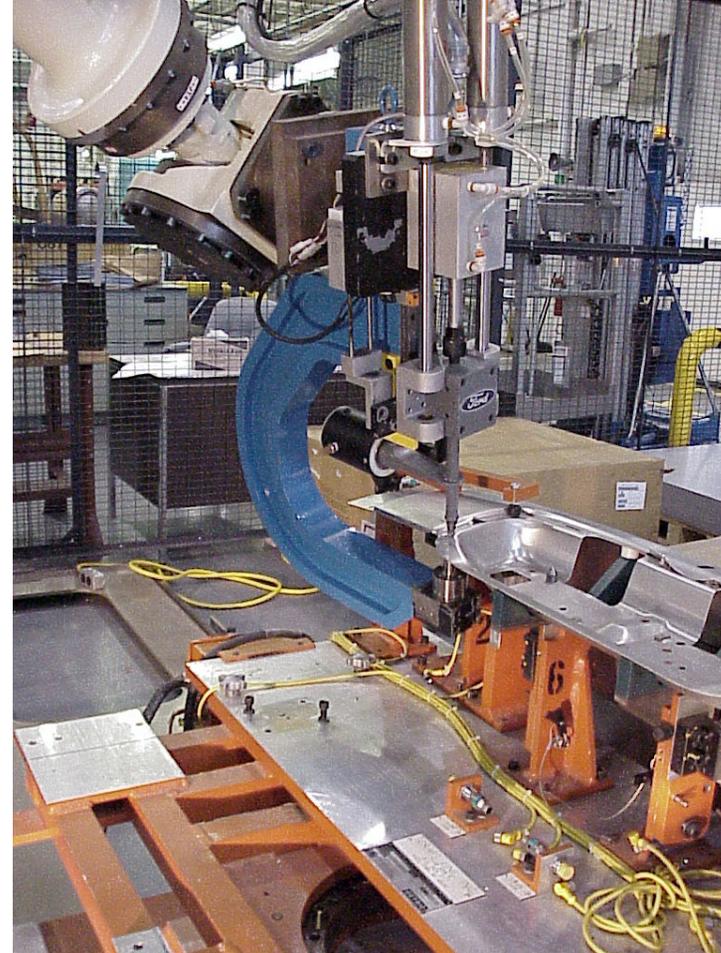
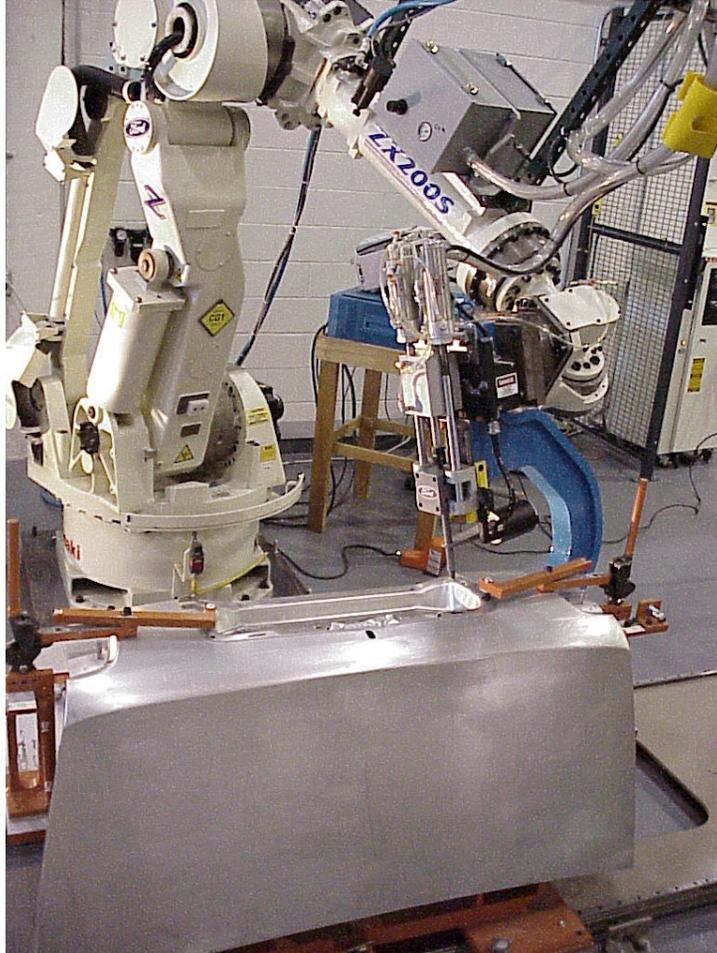
- Presence of adhesive
- Cleaned Samples (no lubricant)
- Clamping weldments



# USW Manual Gun for Automotive Assembly Fixture



# Robotic USW Gun for Automotive Closure Panels



# Conclusions

- USW is a good, economical joining method for aluminium vehicle construction
- Utilization of USW joining technology is appropriate for a range of aluminium gauges, lubricant levels and aluminium alloys.



# Acknowledgements

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