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# **Weld & Rivet Reduction Through Structural Metal Bonding**

***Originally presented at:  
Assembly Tech Expo  
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**Assembly Solutions: Advantages of Adhesive Fasteners to Replace  
Mechanical Joining Methods in Automated Assembly**

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# Agenda/Outline



- **Challenges of metal production/bonding**
- **Structural adhesives and how they work**
- **Benefits & limitations of structural adhesives for metal assembly**
- **Adhesive strength and performance properties**
- **Effect of metal treatment and paint processes**
- **Typical applications**

# Challenges of metal production/assembly



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METHOD	Speed of Assembly?	Stress on Assembly?	Disassembly Method?	Quality & Reliability
Welding, Brazing, Solder	Instant	Heat	None	Good
Rivets, Screws, Nut/Bolt	Instant	Holes	Unscrew	Better
Structural Adhesive Bonding	Minutes	Reduced	Heat + Force	Best



# Structural adhesives and how they work



- **Two-part Acrylics (or Epoxies)**
  - **Mix thoroughly, then apply to surfaces**
    - Typically moderate to high viscosity
    - Variety of fixture speeds possible
- **Activator Cure Acrylics**
  - Easy to use, limited gap cure capability
- **Traditional Heat Cure Epoxies**
  - **Single component**
    - Typically High Viscosity - Thick Paste

# Benefits (and limitations) of structural adhesives for metal assembly

- **Weight Reduction**
- **Cost Reduction**
  - Parts, Labor, Energy
- **Improved Appearance**
- **Bond dissimilar substrates**
- **Improved durability...**
  - **Shock, impact, vibration**
  - **Corrosion protection**
  - **Thermal cycling**
    - (Temp range) - Epoxy vs. Acrylic

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Lower Costs



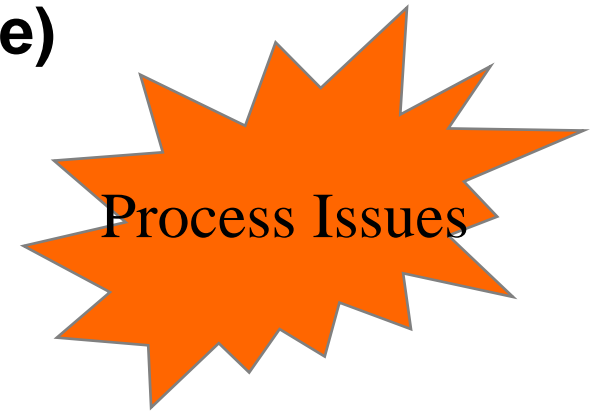
Higher Quality

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# Benefits (and limitations) of structural adhesives for metal assembly



- Adhesive Application Method
  - (and Part Assembly Technique)
- Fixture Speed of Adhesive
  - (*combined with...*)
- Wet Process Resistance
  - (Paste vs. Liquid)



# Adhesive strength and performance properties



- **Bond Strength on Metals**
  - Shear typically 3,000 to 4,000 psi
  - Impact range 10-40 kJ/m<sup>2</sup>
- **Durability Performance**
  - Humidity and Salt Fog Resistance
  - Thermal Cycling Resistance - '85/85'
  - Hot Strength @ 100°C, 125°C, and 150°C



# Effects of metal treatment and paint processes [on Steel]

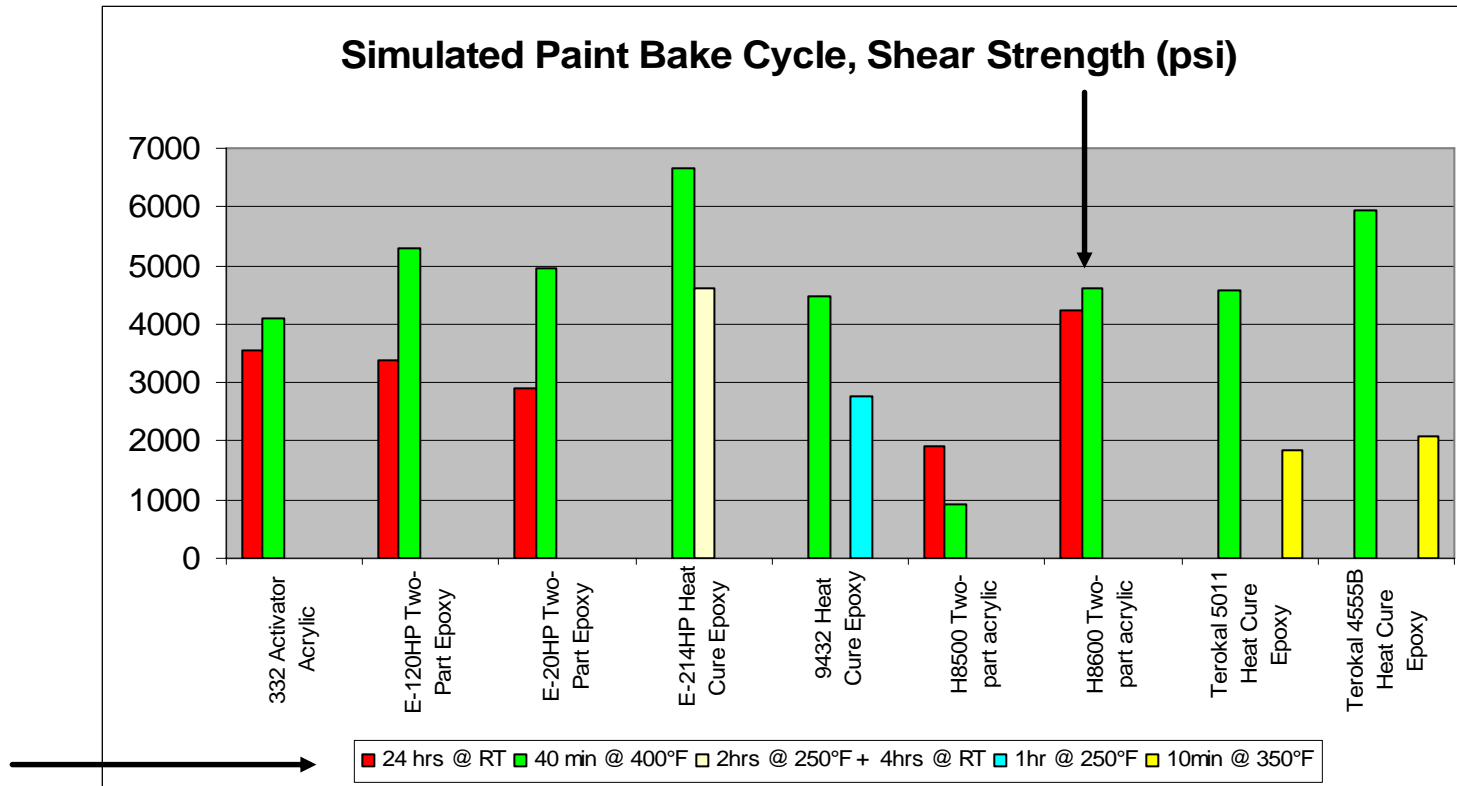


- Simulated Paint Bake Cycle
- Phosphate & Autophoretic Metal Treatments
  - Various wet process immersions, plus E-coat Paint
- Effect of Spot Welding
  - *“The assembly must be held together.”*
- Effect of Lubricant Residues
  - Oil based vs. Synthetic
- Combined Process Effects

# Simulated Paint Bake Cycle

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**Shear Strength Testing, ½" overlap, standard spring clamped assembly**

# Simulated Paint Bake Cycle – Results Summary



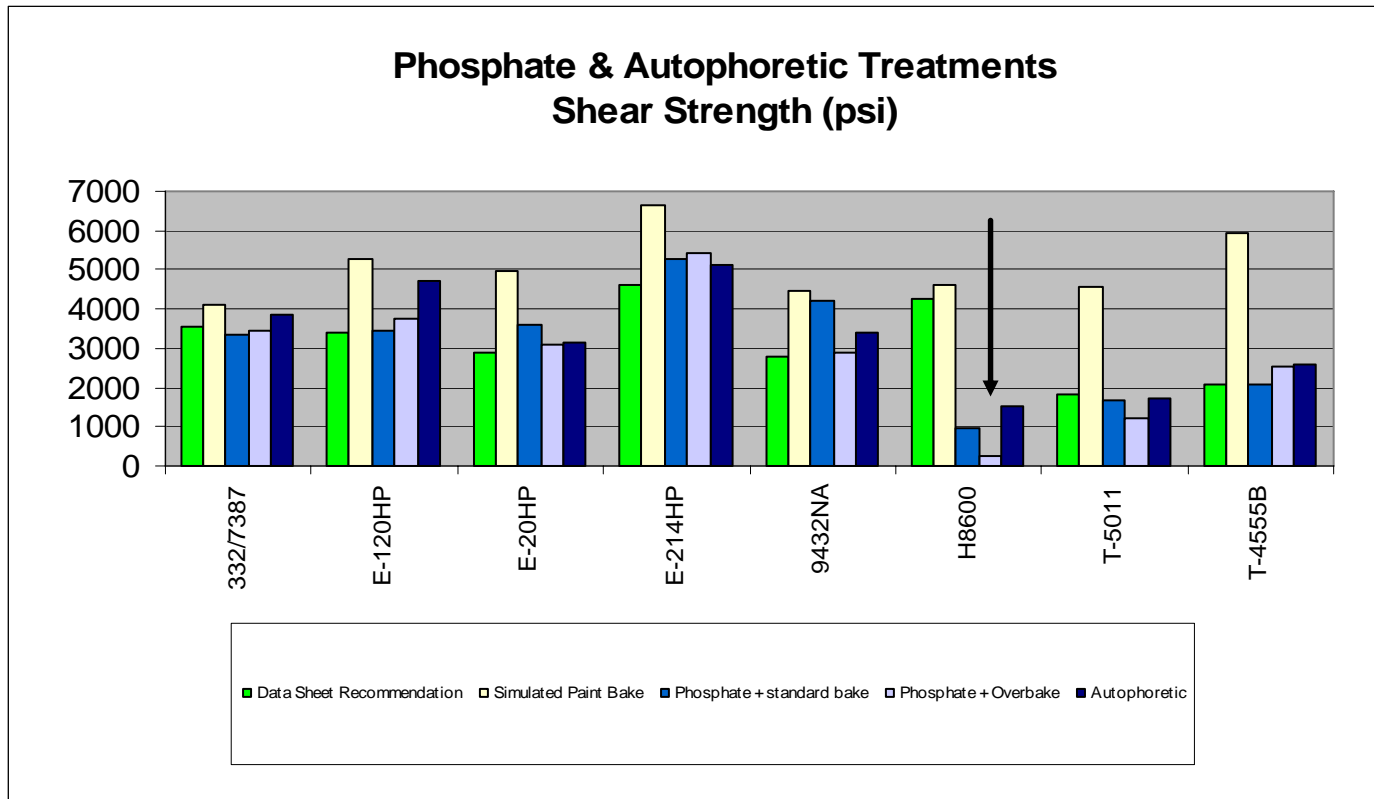
- Moderate Strength Improvement *typically* observed with two-part and activator cure structural acrylics
- **Two-part epoxies ~50% better**
- **Heat cure epoxies 1-2X stronger!**

# Phosphate & Autophoretic Metal Treatment Processes



- a) 3% alkaline cleaner rinse for 5 minutes + city water rinse for 5 minutes
- b) 30% Phosphoric Acid Pickle solution at 90°F for 2 minutes.
- c) Ambient city water rinse for 5 minutes.
- d) Activator application (for Zinc Phosphate).
- e) Zinc Phosphate pre-treatment at 120 degrees F for 2 minutes.
- f) Ambient city water rinse for 5 minutes.
- g) Parcolene 99X sealer exposure (polymer based) for 2 minutes.
- h) Dionized water rinse for 5 minutes.
- i) Ekote bath exposure at 100 degrees F for 5 minutes.
- j) Ecoat bake at 400-450 degrees oven temp for 40 minutes
- k) Polyester powder coat at 400 degrees F for 40 minutes

# Phosphate & Autophoretic Metal Treatments



**Shear Strength Testing, ½" overlap,  
standard spring clamped assembly**

# Phosphate & Autophoretic – Results Summary



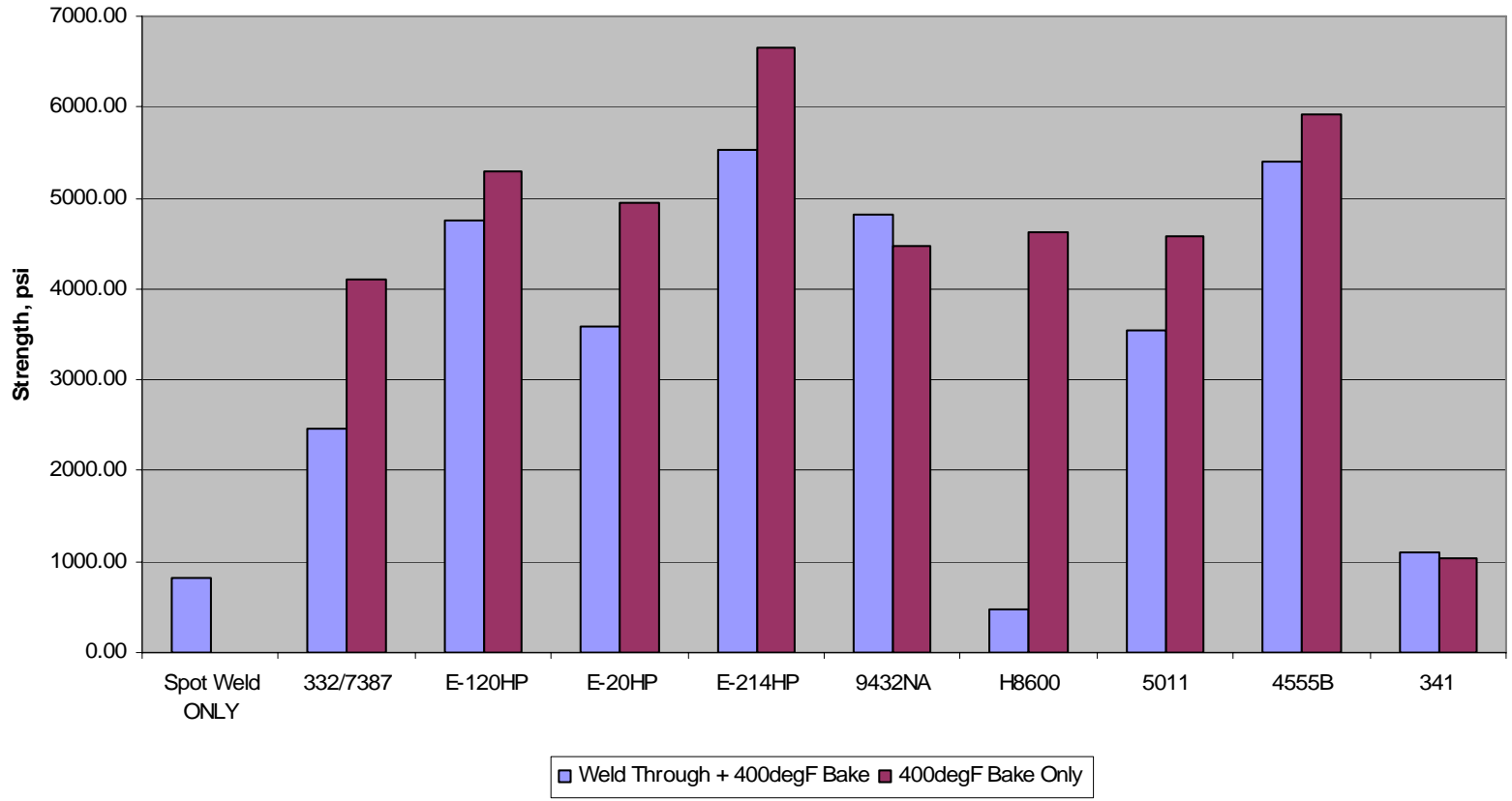
- Strength of activator cure structural acrylic unaffected
- **ALL\* epoxies show high resistance!**
- Negative effect on Two-part acrylic
  - Wash out from immersion process + heat cycle

# Effect of Weld Through



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Weld Through + Oven Bake vs. Oven Bake Only  
Shear Strength (psi)



**Shear Strength Testing, 1/2" overlap,  
1 sec spot welded assembly**



# Weld Through – Results Summary

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- Bond area (and strength) typically reduced @ spot weld location
- **ALL adhesives stronger than spot weld only!**
- Severe discoloration of Two-part acrylic
  - Refer to photo

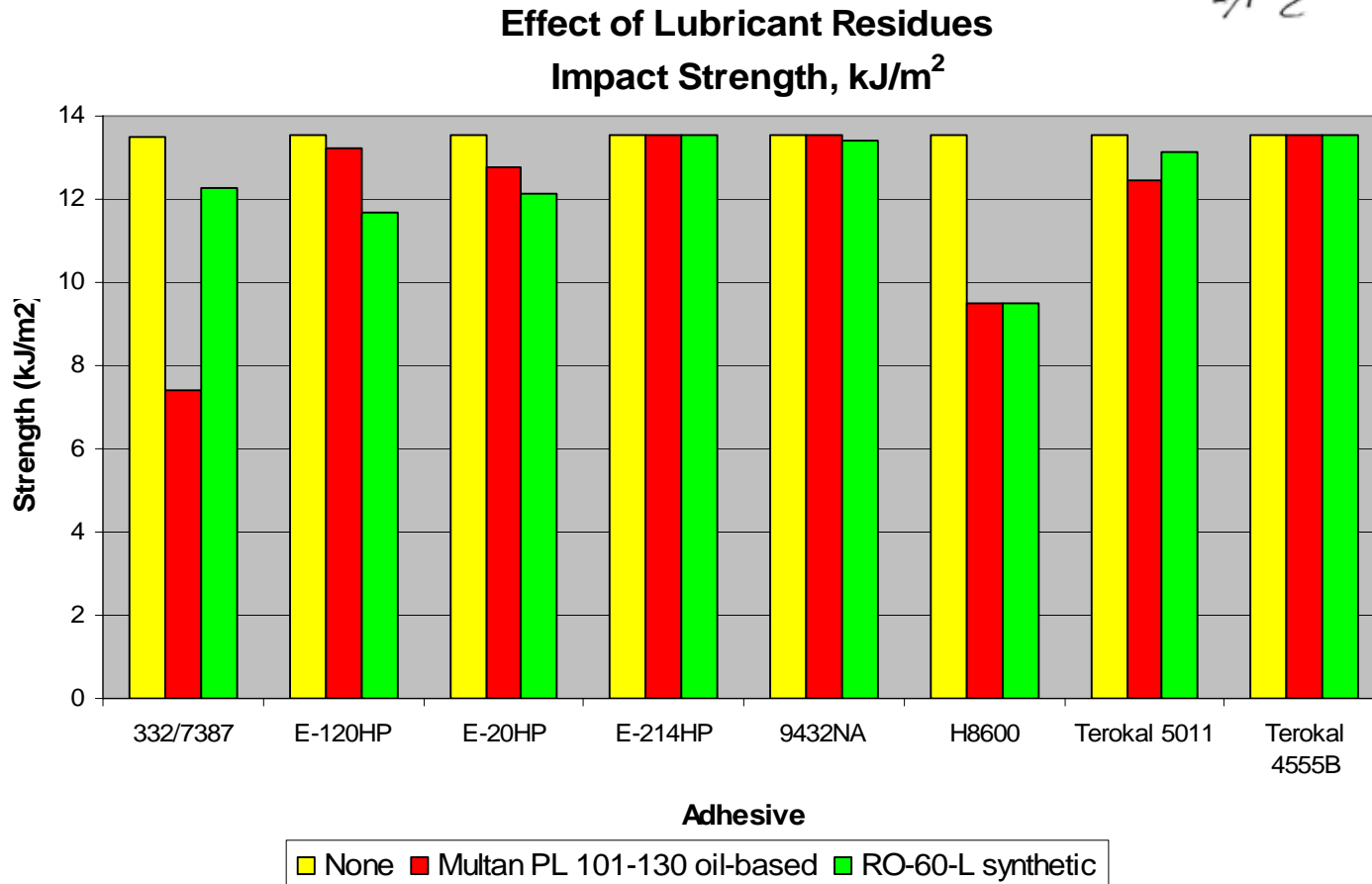




# Effect of Lubricant Residues

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***Shear Strength Testing, 1" overlap,  
standard spring clamped assembly***

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# Lubricants - Results Summary

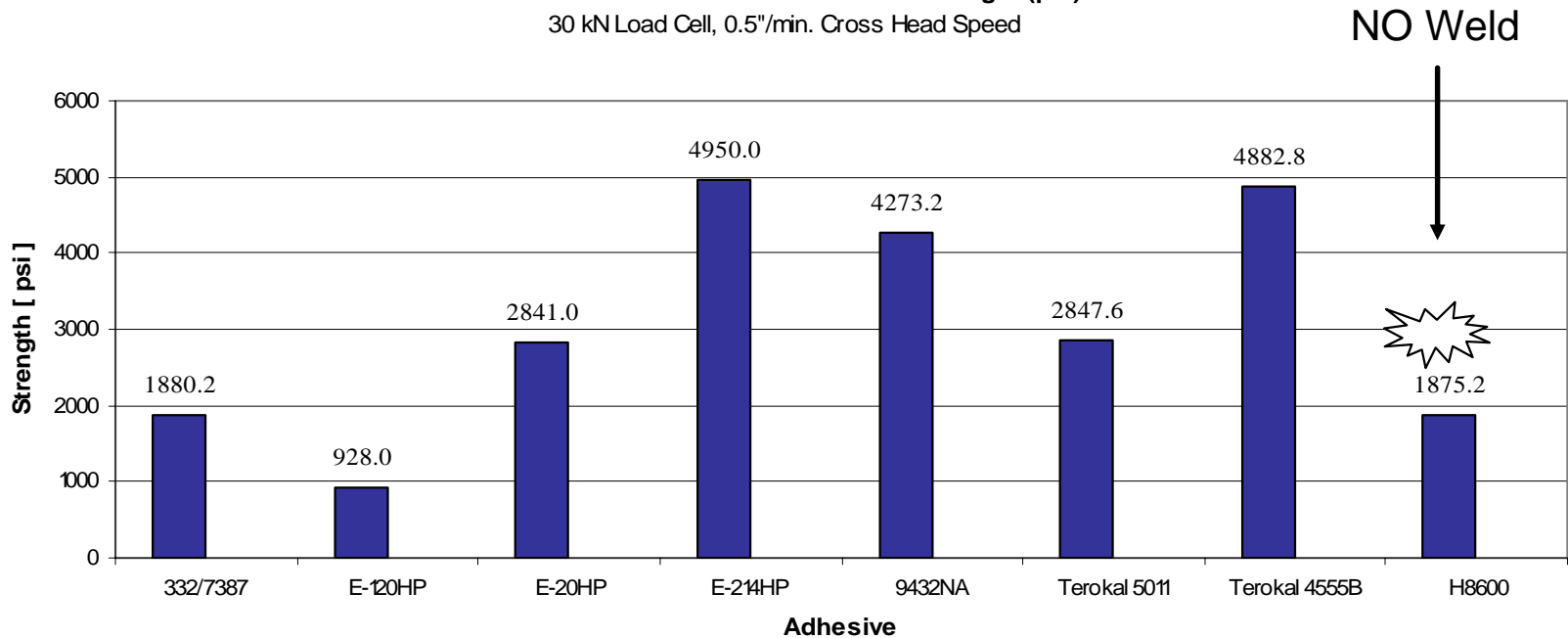


- Although activator cure acrylic was negatively effected by oil-based residue, it was unaffected by synthetic.
- **ALL\* epoxies show high resistance!**
- Slight decrease on Two-part acrylic
- Failure Mode of epoxies is adhesive failure
- Failure Mode of acrylics is cohesive failure

# Combined Process Effects - Shear Strength, psi

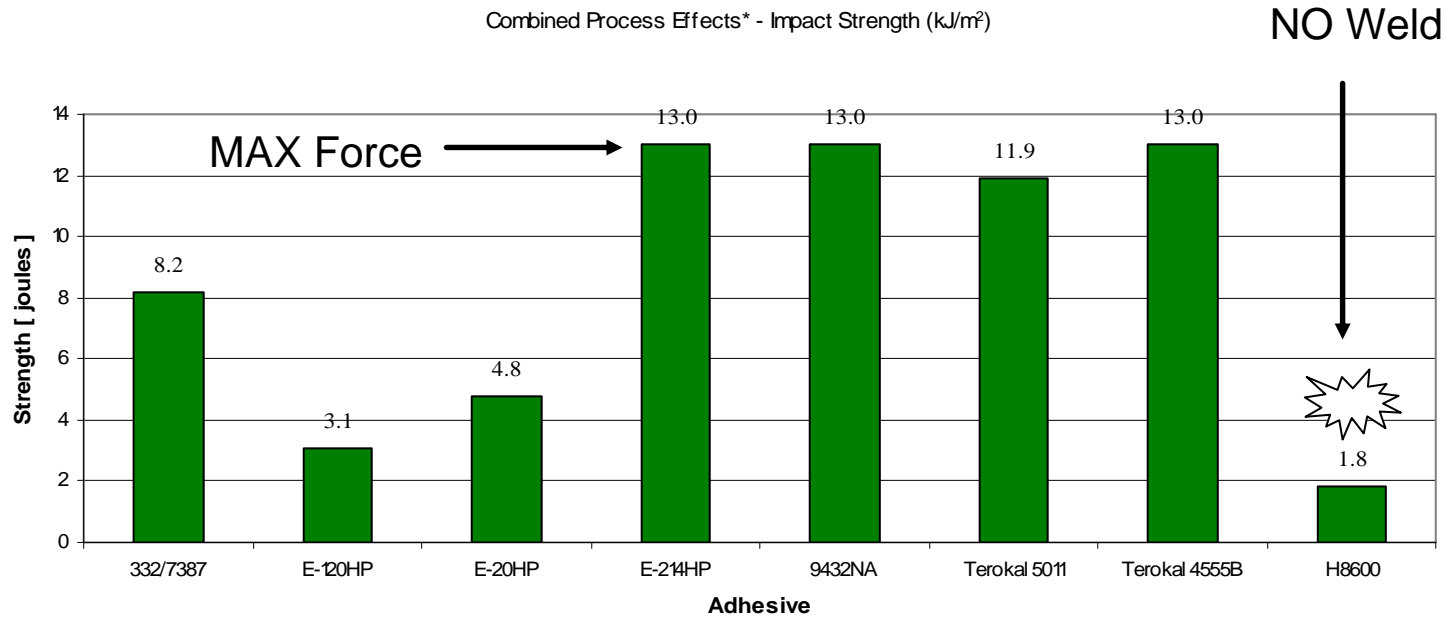


Combined Process Effects\* - Shear Strength (psi)  
30 kN Load Cell, 0.5"/min. Cross Head Speed



**Shear Strength Testing, ½" overlap,  
Spot Welded assemblies!**

# Combined Process Effects - Impact Strength, kJ/m<sup>2</sup>



**Impact Strength Testing, ½" overlap,  
Spot Welded assemblies!**



# Combined Process Effects – Results Summary

- The activator cure structural acrylic exhibited good process resistance (shear and impact bond strength.)
- **The high viscosity (paste) epoxies demonstrate the highest resistance to the various wash / immersion processes and heat exposure.**
- The two-part, lower viscosity epoxies exhibited moderate wet process resistance.
- The wet process and heat exposure resistance of the two-part acrylic was lower than the other candidates.
  - **Need more set-time prior to immersion + lower heat cure**
- **Testing always recommended**

# Typical applications – for structural adhesive bonding



- Metals, Plastics/Composites, Glass/Ceramics, Wood
  - Not rubber or elastomers (use CA's, urethanes, silicones)
- We're not limited to metal substrates!

Markets:

- Agriculture/Construction  
/Specialty Vehicles
- Enclosures
- Furniture
- Signs + Displays
- Tubs/Spas
- Machinery

# For more information...



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