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Weld & Rivet Reduction Through Structural Metal Bonding

ATEXpo – September 27, 2006

**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



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

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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



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- **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

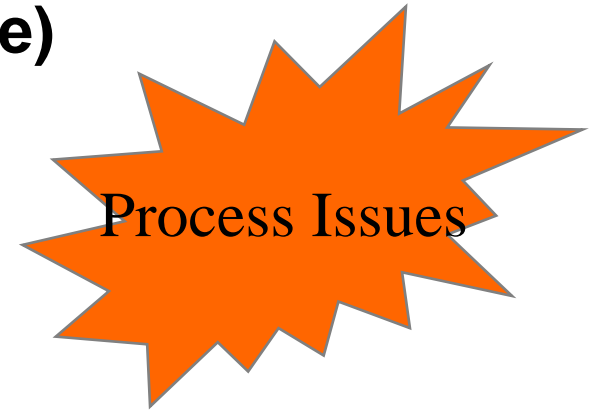


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Benefits (and limitations) of structural adhesives for metal assembly



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



Adhesive strength and performance properties



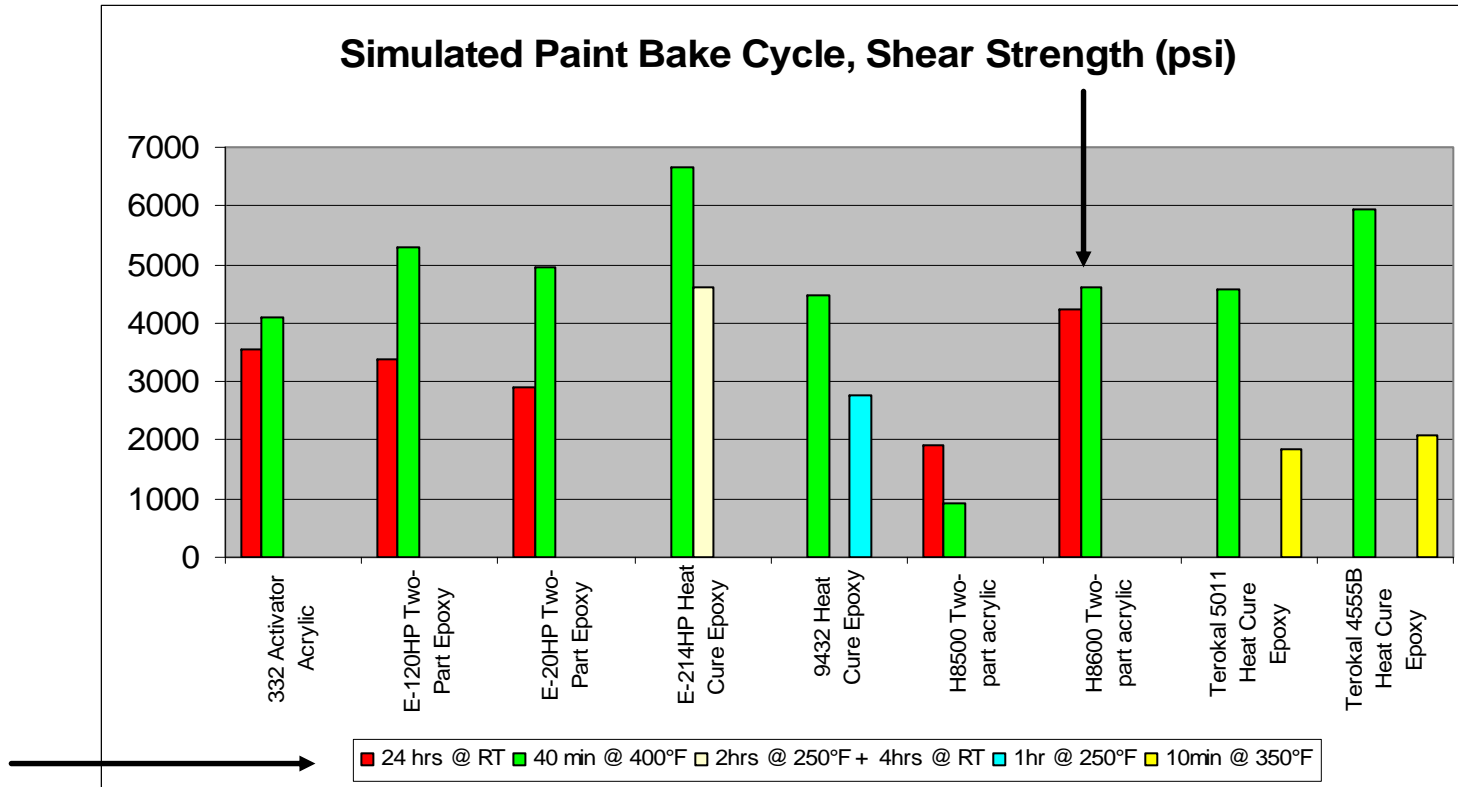
- **Bond Strength on Metals**
 - Shear typically 3,000 to 4,000 psi
 - Impact range 10-40 kJ/m²
- **Durability Performance**
 - Humidity and Salt Fog Resistance
 - Thermal Cycling Resistance - '85/85'
 - Hot Strength @ 100°C, 125°C, and 150°C

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



Shear Strength Testing, 1/2" overlap, standard spring clamped assembly

Simulated Paint Bake Cycle – Results Summary



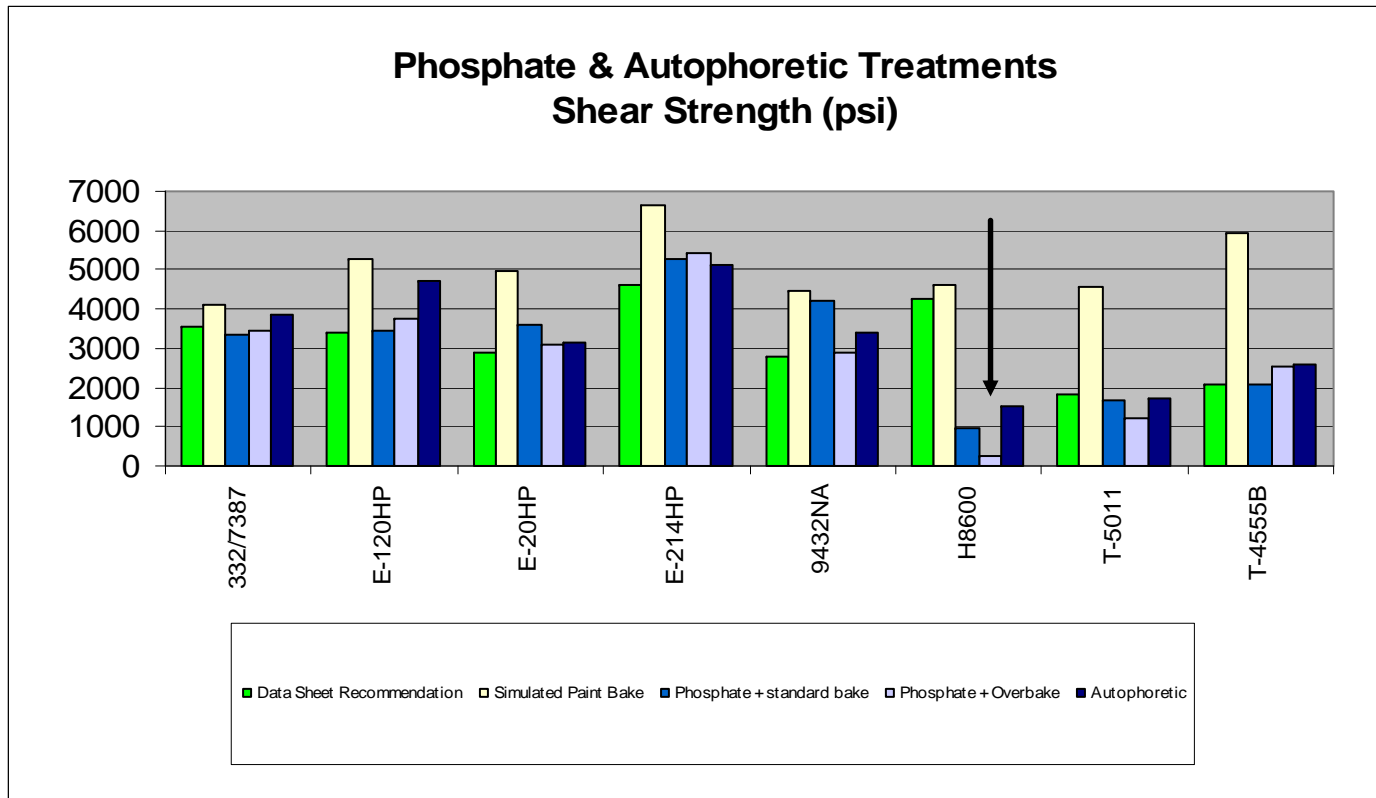
- Moderate Strength Improvement *typically* observed with two-part and activator cure structural acrylics
- **Two-part epoxies ~50% better**
- **Heat cure epoxies 1-2X stronger!**

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, 1/2" overlap,
standard spring clamped assembly**

Phosphate & Autophoretic – Results Summary



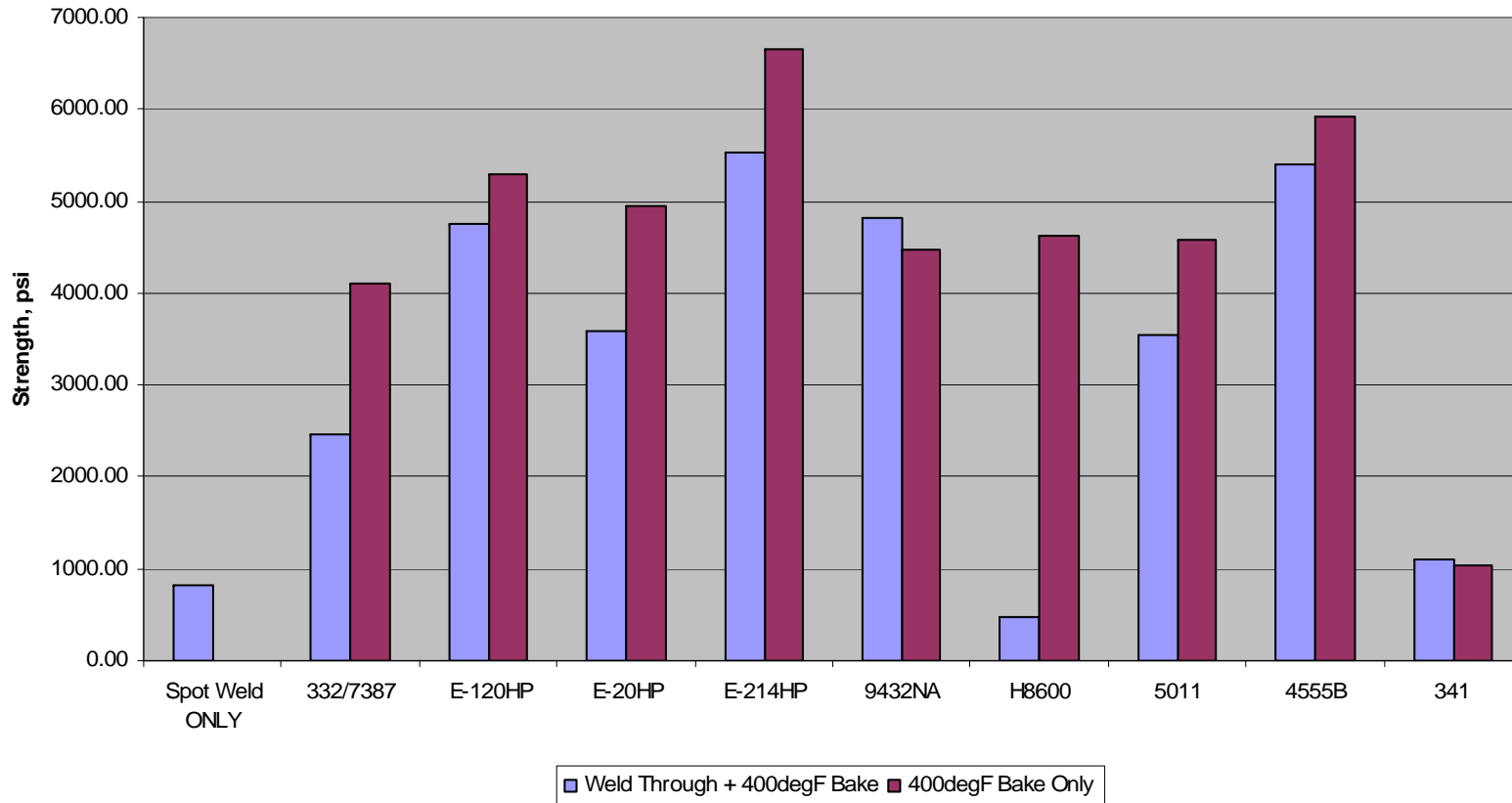
- Strength of activator cure structural acrylic unaffected
- **ALL* epoxies show high resistance!**
- Negative effect on Two-part acrylic
 - Wash out from immersion process + heat cycle

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 →

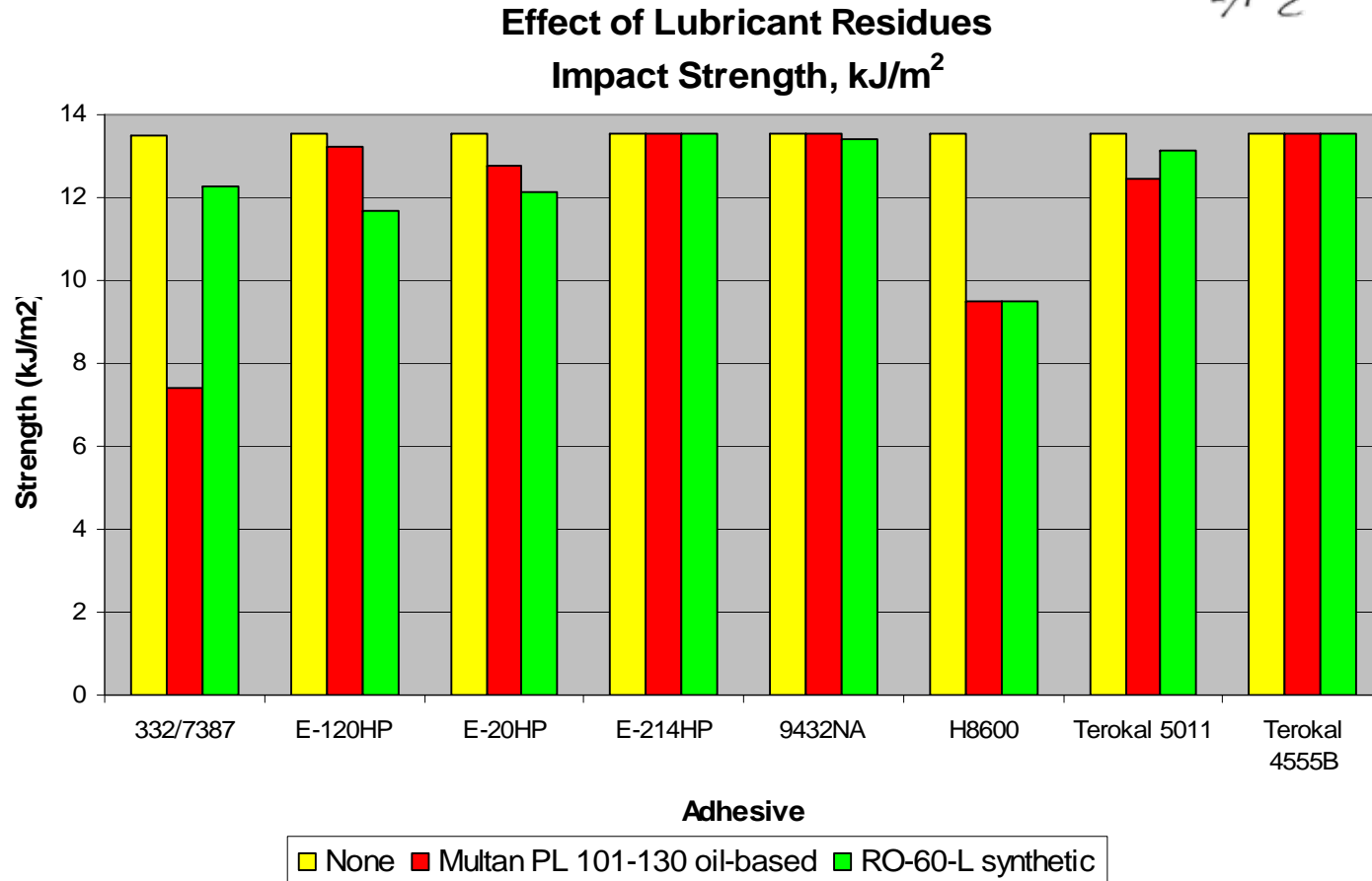


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Effect of Lubricant Residues



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

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Lubricants - Results Summary

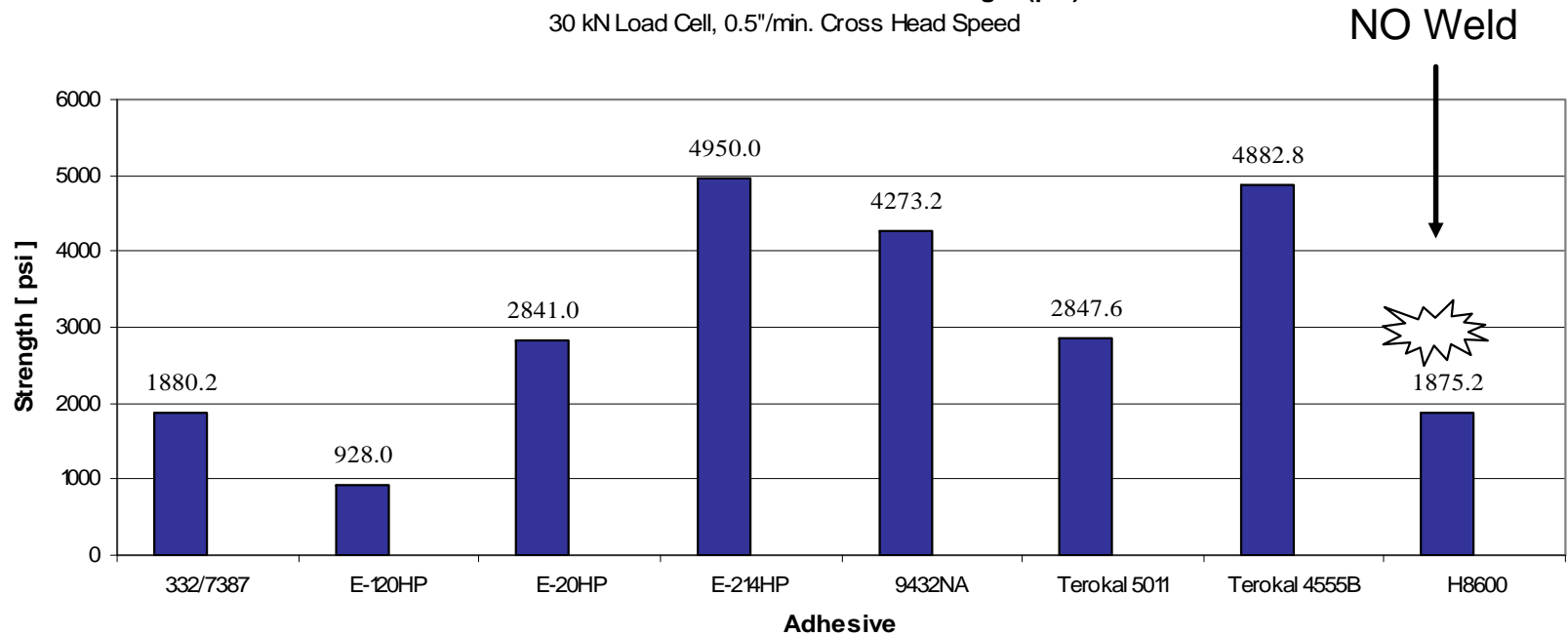


- Although activator cure acrylic was negatively effected by oil-based residue, it was unaffected by synthetic.
- **ALL* epoxies show high resistance!**
- Slight decrease on Two-part acrylic
- Failure Mode of epoxies is adhesive failure
- Failure Mode of acrylics is cohesive failure

Combined Process Effects - Shear Strength, psi



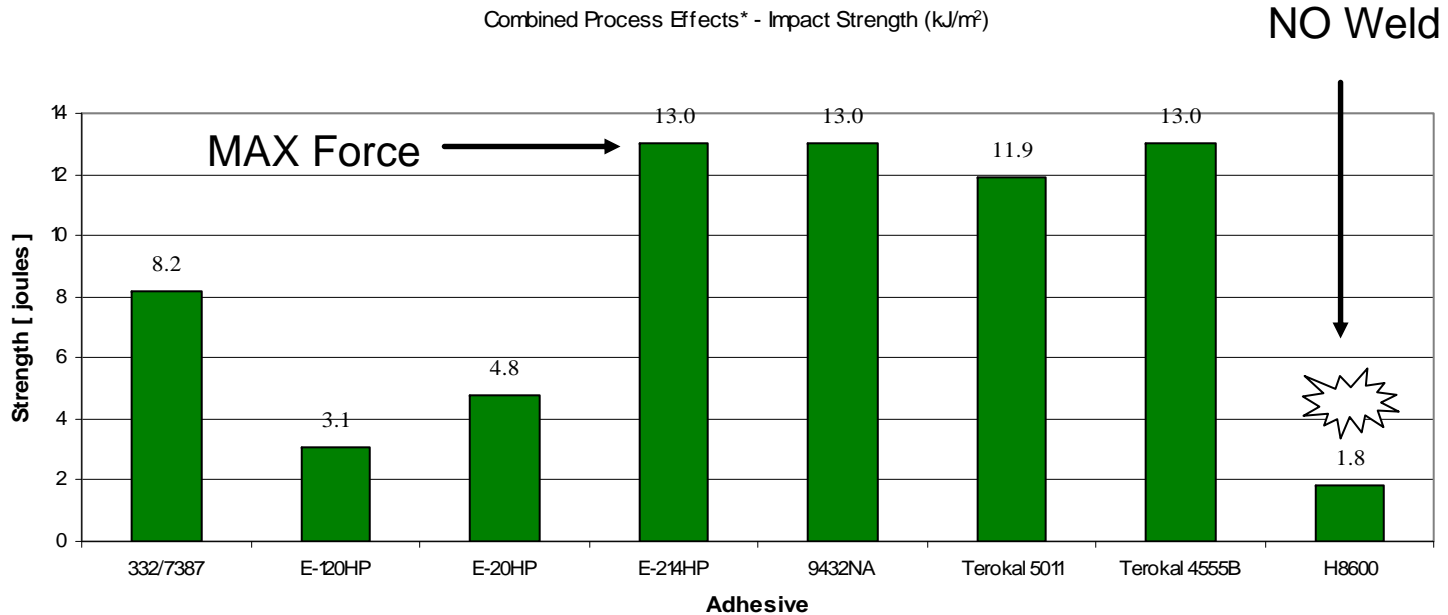
Combined Process Effects* - Shear Strength (psi)
30 kN Load Cell, 0.5"/min. Cross Head Speed



**Shear Strength Testing, 1/2" overlap,
Spot Welded assemblies!**

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Combined Process Effects - Impact Strength, kJ/m²



**Impact Strength Testing, 1/2" overlap,
Spot Welded assemblies!**

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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!



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

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Product Selector Tree Diagram



PRODUCT SELECTOR TREE





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Questions?

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