Lord Corporation

• 20+ years

• Automotive Market

• Chemically weld, instead of welding
LORD structural adhesives chemically weld:

- Heavy Duty Class 6-8 Truck/Trailer Assembly
- Commercial & Military Aircraft Assembly
- Armored Personnel Carriers & Weapon Systems Armor Assembly
- >50-million OEM Vehicles

- LORD Structural Adhesives **Chemically Weld** High-Value Assets
- Vehicles: on and off road
- Require **Maximum Strength and Long-Term Durability**

Oil & Gas Pipeline Repair
1. Current State
Frequent Questions:

1. Is it a **Type A** (reinforcement), or **Type B** (pressure retaining) repair?

2. Will line need to be **shutdown, or, line pressure reduced**?

3. Will residual stress from welding **have a negative impact on aging pipeline**?
Traditional Welded Repair

• Welding:
  – Is only applied to perimeter of the sleeve
  – Creates a hot spot for rust and corrosion
  – Molecularly changes the integrity of the steel
  – Requires certified welders
  – Can be hazardous
Welding Incidents

Industry best practices do not guarantee a safe repair.

<table>
<thead>
<tr>
<th>Consequence</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalities</td>
<td>19</td>
</tr>
<tr>
<td>Injuries</td>
<td>96</td>
</tr>
<tr>
<td>Property Damage</td>
<td>$292.6 Million</td>
</tr>
</tbody>
</table>

Reference: Pipeline and Hazardous Materials Safety Administration
2 Chemical Welding
What is Chemical Welding?

The adhesion and chemical cross-linking of two substrates using structural adhesives that meet or exceed the strength requirements of welding alone.

Actual Example:

‘Tug-of-war’ between traditionally welded plates and LORD-Chemically Welded plates: Traditionally welded plates failed at 1056 lbs of force

‘Tug-of-war’ between Chemically Welded plates using LORD structural adhesives: Substrate failure before Chemically Welded Joint even deforms
Chemically Welded Repair

Procedure
- Once the half-sleeves have been fixtured in place, the repair is put into compression
- After 2 hours a composite wrap (fiberglass cloth and resin) is installed (belt and suspenders)

Benefits of Chemical Weld
- Complete mating surface is chemically welded
- No heat affect zone
- No possibility of burn through
- No possibility of causing hydrogen cracks
- No worries about inside pipe temperature
- No worries about carbon fiber interfering with cathodic protection
- High degree of safety for workers
- No reduction in product flow
- Environmentally friendly

Once pressurized, the pipe yielded outside the repair at approximately 2,100 psi, and completely failed (burst) at 27,788 psi.
Chemical Welding vs. Traditional Welding

1. Greater throughput → adhesive is applied faster than a continuously welded seam.

2. Greater strength → load is evenly distributed across continuously cross-linked substrates. No residual stresses, like with welding.

3. Greater durability → welds are prone to moisture ingress (corrosion), and fracture with vibration. LORD Structural adhesives are engineered to prevent moisture and vibration induced cracking; ensuring long-term durability.

4. Greater labor flexibility → welding is an expensive alternative, with fewer qualified welders. Structural adhesives can be dispensed with relatively little training; allowing bottle-neck resolution in labor-intensive processes.

5. Increased safety → no flame source to ignite source materials (contaminants or product).
ComposiSleeve

• Reduces the cost of a repair by ~50%

<table>
<thead>
<tr>
<th>Repair Type</th>
<th>Labor</th>
<th>Equipment</th>
<th>Material</th>
<th>Non-Destructive Test</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>ComposiSleeve</td>
<td>$1,082</td>
<td>$129</td>
<td>$1,289</td>
<td>$0</td>
<td>$2,500</td>
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<td>Type B Welded</td>
<td>$3,100</td>
<td>$200</td>
<td>$1,125</td>
<td>$1,200</td>
<td>$5,625</td>
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<td></td>
<td>Sleeve</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

“Last year [one] company paid 60 welders more than $150,000 and two of them over $200,000.”

• Pipelines — and welders — are getting older
• Pipeline infrastructure continues to grow (more to maintain with fewer qualified welders)
Chemical Welding in Pipeline Repair
Tension Test Results

Load (Kips) vs. Displacement (mils) graph showing different types of tests and their results. The graph includes labels for various tests such as Air Logistics with tape, Air Logistics, no tape, Pipe Wrap with tape, Pipe Wrap, no tape, Western Specialties with tape, Western Specialties, no tape, Citadel with tape, Citadel, no tape, Armor Plate with tape, and Armor Plate, no tape.

- AYS = 51.5 ksi
- SMYS = 42 ksi