3M™ ACCR

More Amps

More Confidence

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Senior Applications Engineer
What is 3M™ ACCR?

- A high voltage, overhead transmission conductor…
- …designed as a drop-in replacement for ACSR and other conventional conductors on existing, thermally limited lines …
- …allowing utilities to use existing structures…
- …capable of carrying 2 or more times the current…
- …reliably for decades.
Improving Performance of a Proven Conductor Design

**ACSR**

**Coated Steel Core Wires:**
- Strength: 1275 MPa
- Density: 7.8 g/cm³
- Coefficient of Thermal Expansion: $12.0 \times 10^{-6}/°C$

**Hardened 1350 H19 Aluminum Conductor Wires**
- Rated to 93 °C

**ACC**

**Aluminum Composite Core Wires:**
- Strength: 1380 MPa
- Density: 3.3 g/cm³
- Coefficient of Thermal Expansion: $6.3 \times 10^{-6}/°C$

**Hardened Aluminum Zirconium Conductor Wires**
- Rated to 210 °C continuous, 240 °C for 1,000 hours

- Same reliable design as ACSR
- Reduced sag & higher temperature rating → ~2 times higher ampacity
- All Aluminum core improves corrosion resistance and conductivity

- A Century of Proven Reliability
- Ampacity limited by sag & conductor temperature
ACCR Composite Core Wire

~ 20,000 Continuous Aluminum Oxide Fibers

Infiltrated with pure, ductile aluminum

Aluminum Matrix Composite Wire

Fiber Properties:
Lightweight and Strong
Low thermal expansion
Extremely stable and heat resistant

Composite Wire Properties:
Strength of steel with half the weight
Coefficient of Thermal Expansion half of steel
Superior stability & corrosion resistance
3M ACCR Maximizes Ampacity of Thermally Constrained Lines

Assumes ACSR and 3M ACCR at 396 m ruling span, initial tension 2,948 kg @ 15°C, max. loading @ -1°C, no ice, 0.5 kg/m² wind; ambient conditions: 0.6m/s wind, 35°C, perpendicular wind direction, 0.5 emissivity and solar absorption.
## Property Comparison: 3M ACCR vs. ACSR

<table>
<thead>
<tr>
<th>Metric Units</th>
<th>Diameter</th>
<th>Weight</th>
<th>Strength</th>
<th>Strength / Weight</th>
<th>Resistance</th>
<th>Ampacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>N/m</td>
<td>N</td>
<td>%</td>
<td>DC @ 20°C</td>
<td>AC @ 75°C</td>
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<tr>
<td>Ostrich 300</td>
<td>17.3</td>
<td>6.0</td>
<td>56,500</td>
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<td>0.1859</td>
<td>0.2272</td>
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<tr>
<td>ACSR</td>
<td>17.2</td>
<td>4.9</td>
<td>53,800</td>
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<td>0.1826</td>
<td>0.2240</td>
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<tr>
<td>ACCR</td>
<td>-0.4%</td>
<td>-18.2%</td>
<td>-4.7%</td>
<td>+16 %</td>
<td>-1.8%</td>
<td>-1.4%</td>
</tr>
<tr>
<td>ACCR vs ACSR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+94 %</td>
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<tr>
<td>Hawk 477</td>
<td>21.8</td>
<td>9.6</td>
<td>86,700</td>
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<td>0.1167</td>
<td>0.1430</td>
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<td>ACSR</td>
<td>21.6</td>
<td>7.8</td>
<td>85,400</td>
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<td>0.1153</td>
<td>0.1414</td>
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<tr>
<td>ACCR</td>
<td>-0.7%</td>
<td>-18.8%</td>
<td>-1.5%</td>
<td>+21 %</td>
<td>-1.3%</td>
<td>-1.2%</td>
</tr>
<tr>
<td>ACCR vs ACSR</td>
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<td></td>
<td></td>
<td></td>
<td>+96 %</td>
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<tr>
<td>Drake 795</td>
<td>28.1</td>
<td>15.9</td>
<td>140,100</td>
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<td>0.0702</td>
<td>0.0862</td>
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<td>ACSR</td>
<td>28.6</td>
<td>13.6</td>
<td>143,200</td>
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<td>0.0808</td>
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<tr>
<td>ACCR</td>
<td>+1.9%</td>
<td>-14.9%</td>
<td>2.2%</td>
<td>+20 %</td>
<td>-6.2%</td>
<td>-6.4%</td>
</tr>
<tr>
<td>ACCR vs ACSR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+107 %</td>
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<tr>
<td>Curlew 1033</td>
<td>31.6</td>
<td>19.4</td>
<td>162,800</td>
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<td>0.0541</td>
<td>0.0692</td>
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<td>ACSR</td>
<td>31.7</td>
<td>16.6</td>
<td>158,400</td>
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<td>0.0534</td>
<td>0.0655</td>
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<td>ACCR</td>
<td>+0.1%</td>
<td>-14.7%</td>
<td>-2.7%</td>
<td>+14 %</td>
<td>-1.4%</td>
<td>-5.4%</td>
</tr>
<tr>
<td>ACCR vs ACSR</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>+106 %</td>
</tr>
<tr>
<td>Bittern 1272</td>
<td>34.2</td>
<td>20.9</td>
<td>151,684</td>
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<td>0.0445</td>
<td>0.0563</td>
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<td>19.3</td>
<td>171,256</td>
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<td>0.0450</td>
<td>0.0552</td>
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<tr>
<td>ACCR</td>
<td>+0.3%</td>
<td>-7.5%</td>
<td>12.9%</td>
<td>+122%</td>
<td>+1.7%</td>
<td>-1.6%</td>
</tr>
<tr>
<td>ACCR vs ACSR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+108%</td>
</tr>
</tbody>
</table>

Ampacity at 25°C, 2.0 ft/s (0.6 m/s) wind, 0.5 emissivity and absorptivity at sea level, using IEEE Std. 738-1993.
Extensive Product Testing

**Conductor**
- Mechanical Design
  - Conductor strength
  - Dead-end strength
  - Joint strength
  - Stress-Strain behavior
  - Stiffness
  - Thermal expansion

**Conductor**
- Electrical Design
  - Conductor resistance

**Installation**
- Sheave Testing
- Torsion

**Accessory Design**
- DE Strength
- Joint Strength
- Current Cycle
- Dampers
- Repair Sleeve
- Galloping
- Aeolian Vibration
- Corona RIV
- Spacer
- Repair Splice
- Suspension - turn angle
- Suspension - unbalanced load
- Suspension - ET profile

**Long-term Confidence**
- Creep
- Aeolian Vibration
- Damping
- Galloping
- Impact
- Corrosion Resistance
- Lightning Resistance
- Fault current
- Shotgun
- Suspension slip & strength
- Hardware Temperature
- DE Sustained Load – RT, ET
- Thermal/Current Cycling

**High Temperature Performance**
- Validate sag / tension calculations
- Validate stability of conductor and accessories during thermal cycling
Transmission Upgrade Cost Comparison
100% ampacity upgrade of 17 mile, double circuit 220 kV line

<table>
<thead>
<tr>
<th>Conductor (inc. connectors)</th>
<th>Structures</th>
<th>Stringing</th>
<th>Substation</th>
<th>Land &amp; Permitting</th>
<th>Construction Outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build parallel line with ACSR 1033 kcmil (823mm²) Curlew</td>
<td>$119,000</td>
<td>$1,546,000</td>
<td>$180,000</td>
<td>$180,000</td>
<td>No outage but several years to build</td>
</tr>
<tr>
<td>Rebuild line with twin bundled ACSR 1033 kcmil (823mm²) Curlew</td>
<td>$238,000</td>
<td>$1,332,000</td>
<td>$300,000</td>
<td>---</td>
<td>24 month outage</td>
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<tr>
<td>Reconductor with 3M ACCR 1622 kcmil (823mm²) Pecos</td>
<td>$755,000</td>
<td>$63,000</td>
<td>$150,000</td>
<td>---</td>
<td>Two 2-month outages</td>
</tr>
</tbody>
</table>

Notes: 1) Total costs reported by utility, some component costs estimated

Million US Dollars per Mile

```
$0.0  $0.2  $0.4  $0.6  $0.8  $1.0  $1.2  $1.4  $1.6  $1.8  $2.0  $2.2  $2.4  $2.6
Parallel Line  ACSR Rebuild  3M ACCR
$2.2M/mi  $1.9M/mi  $1.0M/mi
```
ACCR Advantage

ACCR Maximizes Ampacity
- Typically doubles ampacity of ACSR lines
- Provides significantly more ampacity than other high capacity conductors for most lines

ACCR Avoids Tower Rebuilds
- Lower weight and thermal expansion of ACCR reduces sag without increasing loads on towers

ACCR is Extremely Robust
- Resistant to heat, cold, corrosion, NO$_2$, UV
- Resistant to fatigue and creep
- Modulus matches ACSR (low strain under load)

ACCR is Reliable
- >100 installations around the world
- > 15 years of very reliable field history

Value to Utility

Maximizes Value of Existing Lines
- More Revenue from more power
  (200 amp upgrade on 220 kV line can deliver energy worth $3M/year)
- Flexibility to accommodate changing power flows
- Quick access to renewables
- Increased grid robustness and reliability

Saves Time and Money --- Easier
- Significantly reduced construction costs
- Much shorter outages
- Less impact on communities & environment
- Reduced or no permitting

ACCR Works Everywhere
- Deserts, wetlands, coasts, & mountains
- Congested cities & long water crossings
- Heavy ice and wind loads

Confidence
- 100% successful installations