

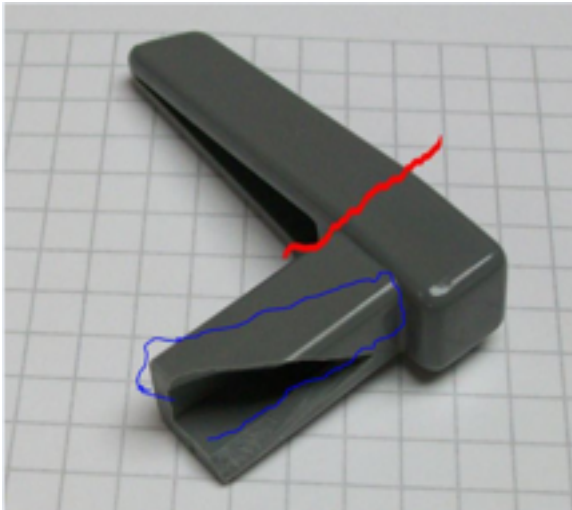
Printing Spare Parts

Joe Yarbrough – Xcel Energy

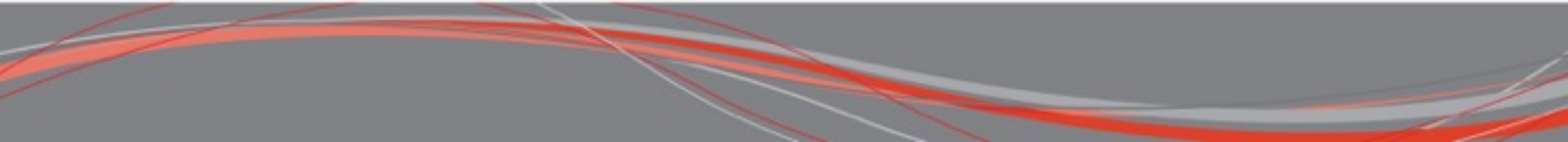
Jeff Gehlhar – Xcel Energy

Problem –EDG Panel Switch Failures

- 28 pistol grip switches
- High susceptibility to failure with two failure mechanisms

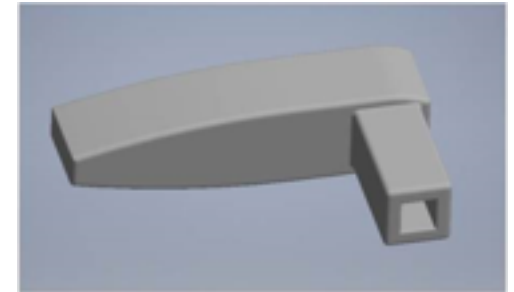
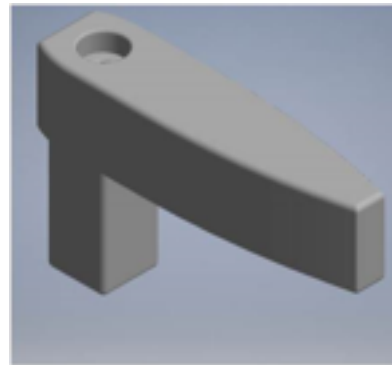
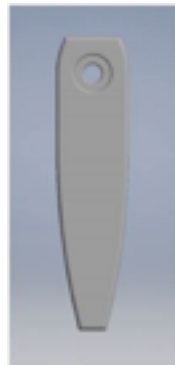


Investigation into Failures

- **Switch material is molded nylon polymer and can be extremely brittle when not reinforced with glass fiber**
 - **Original vendor could not provide material strength properties of switch and not interested in using new materials**
 - **Machining or injection molding new parts expensive**
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Solution – 3D Printing

- **Rapid prototyping via Additive Manufacturing**
- **Identified high strength 50% fiber reinforced nylon materials**
- **Just needed *.STL 3D CAD file of the part**
 - **How long, how wide, how tall, ID, OD, countersunk depth...**



Benefits of 3D printing

- **Low cost - \$90 for first then \$10/ part vs \$35 for ones that fail**
- **Known/improved material properties**
- **Rapid production – manufactured and delivered within a few days**



| POWDER PROPERTIES | | TEST METHOD | ALM PA 615-GS |
|-------------------------------|-------------------|-------------|-------------------|
| Bulk Density | ASTM D1895 | | 0.67 grams/CC |
| Average Particle Size (D50) | Laser Diffraction | | 50 microns |
| Particle Size Range (D10-D90) | Laser Diffraction | | 35 to 100 microns |
| Sintered Part Density | ASTM D792 | | 1.49 grams/CC |

| THERMAL PROPERTIES | | TEST METHOD | ALM PA 615-GS |
|----------------------------------|------------|-------------|----------------|
| Melting Point | ASTM D3418 | | 196 Deg C |
| Melt Flow Rate (3mm, 5.0g, 235C) | ASTM D1238 | | 50 grams/10min |

| MECHANICAL PROPERTIES | | TEST METHOD | ALM PA 615-GS |
|--|-----------|-------------|-----------------------------|
| Heat Deflection Temp @ 0.45 MPa | ASTM D648 | | 179 Deg C |
| Heat Deflection Temp @ 1.82 MPa | ASTM D648 | | 134 Deg C |
| Ultimate Tensile Strength (XY) | ASTM D638 | | 31 MPa / 4,500 psi |
| Tensile Modulus (XY) | ASTM D638 | | 4,100 MPa / 595 kpsi |
| Flexural Modulus (XY) | ASTM D790 | | 3,100 MPa / 450 kpsi |
| Tensile Modulus (Z) | ASTM D638 | | 2,137 MPa / 310 kpsi |
| Elongation at Break (XY) | ASTM D638 | | 1.6% |
| IZOD Impact Strength (Unnotched) | ASTM D256 | | 101 J/m |
| IZOD Impact Strength (Notched) | ASTM D256 | | 96 J/m |
| Volume Resistivity (23C, 50%RH, 500V) | ASTM D257 | | 2.0×10^{14} ohm-cm |
| Surface Resistivity (23C, 50%RH, 500V) | ASTM D257 | | 2.3×10^{14} ohm |
| Dielectric Constant | | | 3.7 |

Actual part properties may vary slightly from those listed above based on processing parameters, operating conditions, and material usage. The above properties were based on virgin ALM PA 615-GS using nominal operating parameters on a 2500+ platform. Advanced Laser Materials, LLC makes no warranties of materials for any particular application, nor does it make a warranty of any type, expressed or implied, including, but not limited to, the warranties of merchantability for a particular purpose.

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Questions

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