Tracer Wire for HDD Applications

Recently the Gas Technology Institute (GTI) conducted laboratory research and field tests to investigate the properties and performance of a number of tracer wires currently used for Horizontal Directional Drilling (HDD) Applications. The research and testing were sponsored by Operations Technology Development (OTD). The summary of laboratory test results and field evaluations are published in this “Tracer Wire for HDD Applications” document.

Products tested in this program are manufactured by: Agave Wire, Ltd.; Copperhead Industries, LLC; Kris-Tech Wire; NEPTCO/Trace-Safe; Paige Electric Company, LLP; and Pro-Line Safety Products Company.

NEPTCO’s Trace-Safe Tracer wire is referred to as “Polymer Fiber Reinforced Solid Copper” throughout the document and is listed as Wire #18 and Company “F” in the overall performance ratings chart on page 3.

If you have any questions, or would like to discuss your particular project or application, please contact: Steve Dumas, National Sales Manager, Utilities sdumas@neptco.com
OPERATIONS INFRASTRUCTURE SUPPORT

Project Description

For more than 20 years, the installation of solid copper tracer wire – buried alongside polyethylene (PE) pipes – has been the standard practice used to help utilities locate underground plastic piping. Copper wire is readily available, highly conductive, and relatively easy to handle. However, the increased use of more demanding operations – such as horizontal directional drilling (HDD) operations – creates challenges and can cause breaks in tracer wire during installation.

Utility practices vary during HDD pipe installations. Some utilities pull multiple wires, while others may rely on a single large-gauge wire. The desire for a stronger tracer wire has led some utilities to turn to copper-clad steel (CCS) wire.

Other options for tracing plastic pipe have been brought to market with mixed levels of satisfaction. These systems primarily lack the needed tensile strength necessary for HDD operations.

To address these challenging installation issues (rocky soils, long pulls, etc.), researchers under the sponsorship of Operations Technology Development (OTD) investigated the properties and performance of currently used tracer wire products as well as new, potentially stronger, tougher-to-cut, and more “HDD friendly” products.

There are many tracer wire variables for operators to consider with different properties, such as: conductor type, gauge size, hardness, insulation thickness, and material type. New tracer wire options for locating plastic pipe primarily attempt to address a lack of tensile strength of traditional tracer wire. One such product, Polymer Fiber Reinforced Solid Copper, differs from traditional tracer wire products in that it employs a layer of insulation placed over the conductive metallic core. Such woven-strip configurations have a very high strength-to-weight ratio and are commonly used in industrial lifting and towing applications at very high levels of loading. In theory, the woven fabric in this wire would contribute to the bulk of the product’s tensile strength and provide additional abrasion resistance, both protecting the wire from damage and reducing the chance of breakage.

In field tests, multiple tracer wires were pulled through a single borehole along with the pipe.
Given the number of tracer wire configurations available, along with new products such as Polymer Fiber Reinforced Solid Copper, the industry supported a comparative evaluation to allow operators to select a cost-effective tracer wire that can withstand the stresses of installation techniques in various environmental and soil conditions.

Test data is presented in a new technical report, *Tracer Wire for HDD Applications*, which is available through the OTD website: [otd-co.org](http://otd-co.org).

**Benefits**

Data developed through this project can be used by the gas industry and its contractors to enhance the efficiency and success of installing and locating plastic piping systems used to transport natural gas.

A more effective tracer wire that is readily locatable, strong, and easy to handle would improve the gas operations by:

- Preventing wire breaks which result in unlocatable plastic pipes (therefore, reducing the risk of third-party damage and potential incidents)
- Reducing cost by allowing for the use of a single wire for a directional-bore pullback instead of using multiple tracer wires
- Providing faster installations by reducing the time required to address breakage of the tracer wire during challenging HDD pipe installations.

**Technical Concept & Approach**

This project included the following tasks:

- Product Review and Test Protocol Development
- Laboratory Testing
- Field Testing
- Development of Recommendations.

Products tested in this program are manufactured by: Agave Wire, Ltd.; Copperhead Industries, LLC; Kris-Tech Wire; NEPTCO, Inc.; Paige Electric Company, LLP; and Pro-Line Safety Products Company.

*Note: In the chart on page 3, companies are coded. More details are provided in the full 81-page report.*

**Results**

**Laboratory Test Results**

- **Tensile Test Results**

  The traditional, soft-drawn solid copper tracer wires have relatively low tensile break load; however, they exhibit greater elongation in the plastic deformation range before the ultimate tensile loads (tensile break load) were reached.

  The extra-high-strength copper-clad steel wires are made with a high-carbon steel core, which significantly improves the wire tensile strength (>1,000 lb for 12 AWG wires). However, this type of wire is more brittle and breaks without significant plastic deformation in the tensile test. Therefore, the tensile break load is significantly reduced when the wire is kinked.
The high-flex copper-clad steel wires are made of low-carbon steel by a special annealing process to make these CCS wires more flexible. They have a slightly higher ultimate tensile load than the traditional soft-drawn copper wire and also exhibit similar elongation properties as traditional, soft-drawn copper wire.

One company’s product exhibited a significantly high tensile load (~1,800 lb), attributed to the polymer fibers which provide the strength. This wire was also exhibited the similar high tensile load when it was tested with a kink. Drawn copper wire and also exhibit similar high tensile load (~1,800 lb), attributed to the polyethylene (LDPE) insulation jackets.

- **Abrasion and Scrape Resistance Test Results**

The abrasion and scrape resistance of the tracer wire jackets varied based on the type of PE material and also the manufacturer of the wire. In general, high-density polyethylene (HDPE) insulation jackets have a higher scrape resistance than low-density polyethylene (LDPE) insulation jackets with the same coating thickness. The increased thickness of the insulation jacket from 30 mils to 45 mils significantly increases the scrape resistance of the wires.

The abrasion resistance of the HDPE jackets from two companies outperformed the other tested PE jackets (LDPE and HDPE).

The scrape resistance of one company’s insulation (containing polymer fiber and HDPE coating) was significantly higher than the traditional HDPE and LDPE coating.

<table>
<thead>
<tr>
<th>Wire #</th>
<th>Co.</th>
<th>Tracer Wires</th>
<th>Overall Performance Rating*</th>
<th>Wire Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tensile Break Load</td>
<td>Insulation Jacket</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No Kink Kinked</td>
<td>Abrasion Scrape</td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>Solid Copper (12 AWG)</td>
<td>NT NT NT NT</td>
<td>YES NT NT</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>Solid Copper (12 AWG)</td>
<td>12 12 51 34</td>
<td>YES NT 73</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>Solid Copper (10 AWG)</td>
<td>18 NT 51 44</td>
<td>YES NT NT</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>Hard Drawn Solid Copper (10 AWG)</td>
<td>26 25 51 34</td>
<td>YES NT 29</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>Solid Copper (14 AWG)</td>
<td>8 8 65 18</td>
<td>YES NT 100</td>
</tr>
<tr>
<td>6</td>
<td>C</td>
<td>Solid Copper (12 AWG)</td>
<td>12 12 65 18</td>
<td>YES NT 100</td>
</tr>
<tr>
<td>7</td>
<td>A</td>
<td>Fully Annealed CCS (12 AWG)</td>
<td>16 16 76 9</td>
<td>YES NT 57</td>
</tr>
<tr>
<td>8</td>
<td>A</td>
<td>Stress Relieved CCS (12 AWG)</td>
<td>32 24 76 45</td>
<td>NT NT 28</td>
</tr>
<tr>
<td>9</td>
<td>A</td>
<td>HDD CCS (12 AWG)</td>
<td>61 28 76 45</td>
<td>YES NT 21</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>Super Flex CCS (14 AWG)</td>
<td>11 11 53 10</td>
<td>YES NT 100</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
<td>Super Flex CCS (12 AWG)</td>
<td>17 17 53 10</td>
<td>NT 88 50</td>
</tr>
<tr>
<td>12</td>
<td>D</td>
<td>High Strength CSS (12 AWG)</td>
<td>23 23 53 10</td>
<td>NT NT 50</td>
</tr>
<tr>
<td>13</td>
<td>D</td>
<td>Extra High Strength CSS (12 AWG)</td>
<td>63 25 53 44</td>
<td>YES NT 23</td>
</tr>
<tr>
<td>14</td>
<td>B</td>
<td>Dead Soft Annealed CCS (12 AWG)</td>
<td>16 16 51 34</td>
<td>NT NT 57</td>
</tr>
<tr>
<td>15</td>
<td>B</td>
<td>Stress Relieved CCS (12 AWG)</td>
<td>30 29 51 NT</td>
<td>NT NT NT</td>
</tr>
<tr>
<td>16</td>
<td>E</td>
<td>High Flex CCS (12 AWG)</td>
<td>19 19 100 56</td>
<td>YES NT 57</td>
</tr>
<tr>
<td>17</td>
<td>E</td>
<td>HDD CCS (12 AWG)</td>
<td>61 45 100 56</td>
<td>NO 63 16</td>
</tr>
<tr>
<td>18</td>
<td>F</td>
<td>Fiber and Copper (19 AWG)</td>
<td>100 100 62 100</td>
<td>YES NT 100</td>
</tr>
</tbody>
</table>

*The overall performance rating NT = Not Tested
- The rating of tensile break load (with and without a kink) was calculated using the laboratory tensile test results by the ratio of the break load of the evaluated wire to that of the best performed wire (118 having the highest tensile break load with and without kink).
- The rating of abrasion resistance was calculated using the laboratory abrasion resistance test results by the ratio of the insulation thickness loss of the best-performed wire (117 having the lowest number of thickness loss) to the evaluated wires.
- The rating of scrape resistance was calculated using the laboratory scrape resistance test results by the ratio of the scrape-through cycles of the evaluated wire to that of the best performed wire (118 having the highest cycles that the insulation was scrape through).
- The rating of the wire tensile performance at exposure to corrosion environment was calculated by the ratio of the break load measured after corrosion test to the break load measured on the as received specimens made from the same wire product.

a: This wire was not tested in this project. The rating is referred to the other product having the same insulation material from the same manufacturer.
• **Corrosion Evaluation**

One company’s CCS wires for HDD application were severely corroded at the locations where the insulation jacket was damaged during the laboratory scrape test or through field installations. The wire completely lost continuity or resulted in a reduced tensile break load at the damaged insulation due to corrosion.

**Field Test Results**

Several tracer wire products were selected for field evaluations based on laboratory test results. The two test sites selected were contained in rocky soils and represented a difficult scenario for HDD pipe installation. Although none of the wires broke during pull in, many of the wires that experienced flaws on their insulation jackets and kinks after they were pulled through the bore hole.

The field test results suggested that the users and wire manufacturers should take into account the selection of high-performance insulation materials that have higher abrasion and scrape resistance in order to prevent wire insulation damage during HDD installations. In one case, corrosion of a CCS wire at the damaged insulation jacket reduced the wire tensile break load and may result in a complete loss of wire continuity during the service life of the wire.

The overall performance of the tracer wire products investigated in this project were rated using the laboratory test results on tensile break loads (with and without kink), flexibility and springback of the wires, abrasion resistance, and scrape resistance together with the corrosion performance post-field installation.

In all, one company’s wire outperformed the other wires based on its rating for the various performance properties evaluated. This wire was also tested in the two field test trials by HDD installation and did not show significant damage on the wire insulation. Furthermore, the continuity of this wire conductor was not affected after a 2,000-hour corrosion test.

The high-strength CCS wires designed for HDD installation had improved tensile break load compared to the traditional solid copper wire; however, some of the CCS wires’ tensile break loads were significantly reduced when the wires were kinked and then tensile tested. These wires with the reduced tensile properties when the wire was kinked are the CCS wires with less flexibility and a higher springback. In addition, the abrasion and scrape resistance of the wires needs to be improved in order to prevent insulation damage during HDD installation (to prevent corrosion of the exposed wire).

**For more information:**

**Maureen Droessler**  
Program Administrator  
Operations Technology Development, NFP  
Phone: 847/768-0608  
maureen.droessler@otd-co.org