HDD Training

Construction Observation

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Effective HDD construction observation requires an competent understanding of the following key items:

- A competent understanding of the HDD process, inclusive of risk versus reward of potential shortcuts and/or for proceeding forward under problematic conditions.
- A competent understanding of the Contractor’s downhole survey system and the ability to interpret its readings.
- A competent understanding of the contract documents.

The primary objectives of HDD construction observation consist of the following key items:

- Assist with the interpretation of the contract documents.
- Monitor daily progress so that problems can be addressed and remedial action taken ASAP.
- Document conformance, or non-conformance, by the HDD Contractor relative to successfully completing the HDD within compliance of project specifications and federal regulations.
- Minimize financial impact to the Owner during construction and/or post-construction for dispute resolutions, if necessary, in the event operations are not conducted as anticipated by the HDD Contractor.
Key Items to Verify / Document:

- The coordinates and elevations of the staked HDD entry and exit point locations relative to those depicted on the latest HDD IFC drawing.

- Visually check the workspaces and HDD alignment near the staked HDD entry and exit points for any construction issues which may have been missed on the latest HDD IFC drawing, or may be misrepresented on the referenced drawing which may cause constructability issues (i.e. – existing pipelines, overhead lines, elevation of existing grade, roads, railroads, etc.)

- HDD equipment, drill pipe, drilling fluid products and downhole tools mobilized on-site.

- That the secondary survey surface coil is not being placed within unauthorized locations.

- That the drill rig is erected to or within the specified tolerances depicted on the latest HDD IFC drawing or within the contract documents.

- That the Contractor’s Superintendent and pilot hole surveyor are cognizant of the specified pilot hole tolerances.

- Visually check the HDD drill rig alignment relative to the staked HDD alignment.
Mobilization / Rig Up

Potential Problems:

- The HDD entry and exit points were incorrectly staked per the superseded alignment sheets as opposed to the latest HDD IFC drawing.
- The HDD equipment, drill pipe, drilling fluid products and downhole tools are not within conformance with the Contractor’s Drill Plan, the contract requirements, and/or existing permit conditions.
- Encroachment on, undermining of, or damage to existing utilities, roadways, or structures because existing site conditions were not verified, the drill rig was not erected at the correct angle and/or the drill rig was rigged up at the incorrect location.
- The pilot hole exceeding the specified alignment, elevation, and/or radius tolerance because the drill rig was not correctly aligned with the HDD alignment and/or was erected at the wrong angle.
- Permit violations from the secondary surface survey coil being placed within unauthorized areas.
Pilot Hole Operations

Key Items to Verify / Document:

- BHA composition inclusive of drill bit diameter, bit to probe, total BHA length, vise to entry.
- Photographs documenting the pre-use and post-use condition of all BHA's.
- The actual entry and exit point locations relative to their staked locations.
- Pilot hole downhole survey data and position calculations.
- Conformance/non-conformance with pilot hole tolerances.
- That pilot hole surveys are being obtained at vise break-out and at the correct tool face orientation.
- Logged hours of cutting time on drill bits and positive displacement mud motors relative to manufacture’s recommendations, and relative observed wear on tools previously used downhole (rock crossings).
- The rotary torque required to “break out” the BHA at the beginning of each shift.
- The length of the fabricated pull section relative to the actual pilot hole length upon completion.

<table>
<thead>
<tr>
<th>Rock Creek HDD</th>
</tr>
</thead>
</table>

Pilot Hole 3-JOINT AVERAGE RADIUS ANALYSIS (EASTWARD)

<table>
<thead>
<tr>
<th>DATE/Time</th>
<th>JOINT #</th>
<th>M</th>
<th>INC</th>
<th>AZ</th>
<th>VERTICAL CURVE (J-OUT)</th>
<th>HORIZONTAL CURVE (J-OUT)</th>
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<tbody>
<tr>
<td>12-Aug-11</td>
<td>1</td>
<td>41.40 ft</td>
<td>78.00°</td>
<td>42.69°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16-23</td>
<td>2</td>
<td>72.96 ft</td>
<td>77.94°</td>
<td>41.09°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16-35</td>
<td>3</td>
<td>104.10 ft</td>
<td>77.60°</td>
<td>36.69°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16-44</td>
<td>4</td>
<td>135.50 ft</td>
<td>78.14°</td>
<td>35.62°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16-51</td>
<td>5</td>
<td>167.20 ft</td>
<td>77.97°</td>
<td>38.48°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>13-Aug-11</td>
<td>6</td>
<td>185.90 ft</td>
<td>78.70°</td>
<td>40.07°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7-26</td>
<td>7</td>
<td>232.50 ft</td>
<td>78.00°</td>
<td>36.39°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7-35</td>
<td>8</td>
<td>285.60 ft</td>
<td>78.29°</td>
<td>38.64°</td>
<td>-</td>
<td>-</td>
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<tr>
<td>7-46</td>
<td>9</td>
<td>297.40 ft</td>
<td>78.29°</td>
<td>38.64°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8-12</td>
<td>10</td>
<td>330.50 ft</td>
<td>80.69°</td>
<td>38.70°</td>
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<td>-</td>
</tr>
<tr>
<td>8-32</td>
<td>11</td>
<td>364.30 ft</td>
<td>81.24°</td>
<td>36.70°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8-42</td>
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<td>397.90 ft</td>
<td>81.24°</td>
<td>36.70°</td>
<td>-</td>
<td>-</td>
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<tr>
<td>8-55</td>
<td>13</td>
<td>430.40 ft</td>
<td>82.08°</td>
<td>36.82°</td>
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<td>-</td>
</tr>
<tr>
<td>9-13</td>
<td>14</td>
<td>463.00 ft</td>
<td>84.05°</td>
<td>38.90°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9-23</td>
<td>15</td>
<td>494.80 ft</td>
<td>84.59°</td>
<td>37.87°</td>
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<td>-</td>
</tr>
<tr>
<td>10-16</td>
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<td>526.80 ft</td>
<td>88.48°</td>
<td>34.24°</td>
<td>-</td>
<td>-</td>
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<tr>
<td>10-27</td>
<td>17</td>
<td>556.30 ft</td>
<td>86.62°</td>
<td>34.77°</td>
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<td>-</td>
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<tr>
<td>10-47</td>
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<td>590.10 ft</td>
<td>87.57°</td>
<td>34.77°</td>
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<table>
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<tr>
<th>Rock Creek HDD</th>
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Pilot Hole TOLERANCE ANALYSIS (EASTWARD)

<table>
<thead>
<tr>
<th>Joint #</th>
<th>Station</th>
<th>Profile Elevation</th>
<th>Survey Elevation</th>
<th>Above (+) / Below (-)</th>
<th>Right (+) / Left (-)</th>
<th>Calculated Survey</th>
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<tbody>
<tr>
<td>1</td>
<td>4+68.71</td>
<td>173.21 ft</td>
<td>177.96 ft</td>
<td>-0.31 ft / -0.06 ft</td>
<td>175.58 ft / 175.61 ft</td>
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</tr>
<tr>
<td>2</td>
<td>4+39.52</td>
<td>171.66 ft</td>
<td>171.94 ft</td>
<td>-0.32 ft / -0.08 ft</td>
<td>171.89 ft / 171.94 ft</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4+10.02</td>
<td>155.14 ft</td>
<td>164.65 ft</td>
<td>-0.35 ft / -0.09 ft</td>
<td>165.05 ft / 165.12 ft</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4+00.80</td>
<td>150.76 ft</td>
<td>146.80 ft</td>
<td>-0.37 ft / 1.60 ft</td>
<td>152.37 ft / 150.92 ft</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5+31.75</td>
<td>152.06 ft</td>
<td>151.72 ft</td>
<td>-0.34 ft / 0.01 ft</td>
<td>152.02 ft / 152.05 ft</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>5+62.76</td>
<td>145.74 ft</td>
<td>145.74 ft</td>
<td>-0.33 ft / 1.15 ft</td>
<td>145.83 ft / 145.92 ft</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>5+93.62</td>
<td>139.15 ft</td>
<td>139.15 ft</td>
<td>-0.26 ft / 1.29 ft</td>
<td>139.31 ft / 139.18 ft</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>6+37.24</td>
<td>131.68 ft</td>
<td>131.48 ft</td>
<td>-0.20 ft / 1.22 ft</td>
<td>131.48 ft / 131.66 ft</td>
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<tr>
<td>9</td>
<td>6+59.09</td>
<td>125.46 ft</td>
<td>125.27 ft</td>
<td>-0.21 ft / 1.18 ft</td>
<td>125.40 ft / 125.32 ft</td>
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<tr>
<td>10</td>
<td>6+91.19</td>
<td>119.05 ft</td>
<td>119.05 ft</td>
<td>-0.22 ft / 2.41 ft</td>
<td>119.03 ft / 119.06 ft</td>
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<tr>
<td>11</td>
<td>7+24.70</td>
<td>114.03 ft</td>
<td>119.81 ft</td>
<td>-0.22 ft / 2.70 ft</td>
<td>117.81 ft / 115.10 ft</td>
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<tr>
<td>12</td>
<td>7+58.02</td>
<td>103.12 ft</td>
<td>106.94 ft</td>
<td>-0.18 ft / 2.99 ft</td>
<td>106.35 ft / 103.15 ft</td>
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<tr>
<td>13</td>
<td>7+90.39</td>
<td>104.03 ft</td>
<td>104.74 ft</td>
<td>-0.15 ft / 3.02 ft</td>
<td>102.74 ft / 104.62 ft</td>
<td></td>
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<tr>
<td>14</td>
<td>8+22.06</td>
<td>101.19 ft</td>
<td>101.08 ft</td>
<td>-0.11 ft / 3.18 ft</td>
<td>99.97 ft / 101.21 ft</td>
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</tr>
<tr>
<td>15</td>
<td>8+54.26</td>
<td>96.38 ft</td>
<td>97.93 ft</td>
<td>-0.15 ft / 3.02 ft</td>
<td>95.80 ft / 96.25 ft</td>
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<tr>
<td>16</td>
<td>8+86.00</td>
<td>95.48 ft</td>
<td>95.63 ft</td>
<td>-0.15 ft / 3.07 ft</td>
<td>93.80 ft / 95.43 ft</td>
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<tr>
<td>17</td>
<td>9+17.02</td>
<td>93.38 ft</td>
<td>92.99 ft</td>
<td>-0.39 ft / 2.70 ft</td>
<td>90.99 ft / 93.72 ft</td>
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<tr>
<td>18</td>
<td>9+49.50</td>
<td>91.79 ft</td>
<td>91.50 ft</td>
<td>-0.45 ft / 1.00 ft</td>
<td>89.35 ft / 91.90 ft</td>
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</table>
Potential Problems:

- As-built drawings that can’t be tied back to the actual HDD entry and exit point locations.
- The pilot hole exceeding specified tolerances and resulting in minimum design constraint separations not being maintained.
- Pilot hole surveys obtained “to make it look like” the pilot hole minimum radius tolerance is within compliance “on paper.”
- Finding out that the pull section is too short upon “almost completing” pullback operations.
- Lost steel/drill pipe failure downhole.
- Insufficient removal of cuttings from downhole.
- Abandoning a portion of the pilot hole because of pilot hole tolerance violations or lost steel downhole.
- Unsuccessful installation of the product pipe pull section as a result of pilot hole geometry.
Reaming Operations

Key Items to Verify / Document:

- Photographs documenting the pre-use and post-use condition of all reaming assemblies.
- Logged hours of cutting time on hole openers and cutter revolutions on hole openers relative to the manufacture’s recommendations, and relative to observed wear on tools previously used downhole (rock crossings).
- The drill rig’s rotary and push/pull pressure gauge readings.
- The rotary torque required to “break out” the reaming assembly at the beginning of each shift.
Reaming Operations

Potential Problems:

- The drill pipe string downhole “key seating” into sand formations with a side bend incorporated into the HDD alignment.
- Exceeding the manufacturer’s recommended life of the hole opener and loosing a cutter or a portion of the hole opener’s centralizer ring downhole
- Experiencing a drill pipe failure downhole.
- Insufficient removal of cuttings from downhole.
- Lodging the reaming assembly downhole.
- Abandoning a portion of/or the entire reamed hole and re-drilling the pilot hole.
Key Items to Verify / Document:

- Photographs documenting the pre-use and post-use condition of all swab pass assemblies.
- The drill rig’s rotary and pull pressure gauge readings.
- How the swab assembly passes “mechanically” through the hole, noting areas downhole that raise concerns for the condition of the hole being acceptable for receiving the product pipe pull section.
Swab Pass Operations

Potential Problems:
- Cuttings remaining downhole which could obstruct the installation of the product pipe pull section.
- Experiencing a drill pipe failure downhole.
- Lodging the swab assembly downhole.
- Abandoning a portion of/or the entire reamed hole and re-drilling the pilot hole.
Pullback Operations

Key Items to Verify / Document:

- The pipe stencil on the product pipe pull section relative to the pipe specifications depicted on the HDD IFC drawing.
- Photographs documenting the pre-use and post-use condition of the pullback assembly.
- If buoyancy control measures are implemented inclusive of details.
- The break over angle of the product pipe pull section as it enters the hole relative to the actual pilot hole exit angle.
- The drill rig’s rotary and pull pressure gauge readings (comparison of actual pull force verses allowable pull force via the drill rig’s conversion charts from psi to pounds of pull force).
- If there is enough planned storage capacity to contain and/or transport the drilling fluid displaced by the product pipe pull section.
- The maximum pull force applied to the product pipe pull section.
- The post-installation condition of the leading end of the product pipe pull section.
Pullback Operations

Potential Problems:

- Not enough capacity on-site store and/or tanker trucks available to transport drilling fluid displaced by the product pipe pull section.
- The swivel within the pullback assembly “locking up” downhole during pullback operations.
- Insufficient pullback capacity of the drill rig to successfully install the product pipe pull section.
- Extracting the product pipe pull section because of a higher than anticipated pull forces.
- Exceeding the maximum specified pull force of the product pipe pull section.
- Damage to the FBE/ARO coating and/or product pipe pull section.
- The pull section becoming lodged downhole.
Key Items to Verify / Document:

- Casing installation and extraction.
- Penetration rates.
- Drilling fluid pump rates and pressures.
- The downhole annular pressure tool calibration offset and downhole annular pressures, if applicable.
- Annular solids within the drilling fluid returns.
- Monitor drilling fluid returns and check for inadvertent drilling fluid returns along the HDD alignment if drilling fluid returns begins to diminish or cease.
- Equipment failures.
- Downtime.
- Daily progress relative to the project schedule.
Potential Problems:

- Not having appropriate documentation to defend a Contractor claiming “changed conditions.”
- The casing or a weld between joints of the casing fails downhole.
- The installed casing cannot be extracted from downhole.
- Inadvertent drilling fluid returns within environmental/publicly sensitive areas, and potentially undermining roadways, railroads, and existing utilities.
- Project delays due to equipment maintenance/failures.
- Exceeding the project schedule and not meeting the specified project completion date.

Additional Observations Relative to All Phases