Closed Loop Ground Heat Exchanger (GHX) Contract Administration

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Closed Loop Ground Heat Exchanger (GHX) Contract Administration

Learning Objectives

- Designer awareness of site limitations and advantages, contractor assets and capabilities, and how these considerations will factor into quality assurance through design and execution
- Importance of accurate specifications and drawings that can be followed easily by contractor teams with sufficient detail for submission of correct material submittals, installation standards are clear and key testing requirements are understood
- Significance of direct communications between the GHX designer and the loop installation contractor
- Designer involvement including pre-construction meetings, routine installation site visits and final testing of key GHX installation parameters
Contract administration, or field quality control, is just as important if not greater for the ground heat exchanger installation than for the above ground portion of a GSHP mechanical system:

• Once the field is installed and buried, accessibility is limited or impractical
• Issues or problems with the GHX installation must be resolved quickly to minimize other construction conflicts
• The designer or engineer must be involved with CA, and understand loop construction procedures, to make certain the GHX is compatible with the above ground mechanical portion of the system
Three general types of closed loop ground heat exchangers

Surface Water
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Three general types of closed loop ground heat exchangers

Horizontal Pit
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Three general types of closed loop ground heat exchangers

Vertical
Due to time constraints this presentation will focus on contract administration for vertical closed loop ground heat exchangers. Many of the items covered are applicable to both horizontal and surface water closed loop heat exchanger installation.
Contract Administration (CA) objectives:

- Confirm contractor awareness and comprehension of design details
- Confirm contractor awareness and comprehension of performance objectives
- Field verification of design parameters during installation
- Integrity testing of individual circuits and completed header pairs
- Post installation testing – header pair flow balance, tie-in, other
CA starts with the design of the ground loop

- Awareness of available contractor assets and their capabilities; due diligence for conditions; i.e., some areas might have difficult drilling conditions at a certain depth, etc.
- Generation of drawings and specifications that are sufficiently detailed for ease of contractor interpretation and execution, and as a benchmark for quality assurance during installation
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CA starts with design considerations – an interactive process

- IAQ, Energy Reclamation
- Peak & Energy Loads
- GSHP Schedule, Efficiency Ratings & Flow Rates
- Scheduling or Timing of Job Timeline
- Consideration of Ease of Installation
- Site Conditions, Geology, Access & Area
- Determination of Horizontal, Vertical, Surface Water and/or Hybrid
- Capability of Installation Assets
- Pipe Size, Schedule
- Regulatory Considerations
Specifications - considerations:

• Usually follow a recognized, standard AIA format such as Division 23 for closed loop installations
• Should be tailored and personalized to specific requirements of individual projects
• Grout thermal enhancement value, if necessary, should be clearly stated with reasonable testing schedule during installation
• Submittal requirements from contractors clearly listed and itemized
• Include specific procedures for air purging of ground loop, including minimum calculated flow rate and pressure drop to meet/exceed 2’/second flow velocity – *this should not be left to the installation contractor to determine as most do not understand this critical calculation!*
Drawings:

- Drawn to scale with clearly identified bore locations for surveying
- Proper loop spacing as per calculations clearly noted and scaled on site plan
- Each circuit should have a discreet number for ease of communication and coordination between the contractor and design team
- Detailed reducing manifold schedule (detail sheet)
- Summary details of typical loop installation cross section, etc. (detail sheet)
- Internal building manifolding configuration, including circuit setters if necessary (detail sheet)
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Numbered boreholes for progress tracking: ease of identification and communication of issues during installation, etc.
Example – GHX installation details
### GROUND HEAT EXCHANGER DETAILS

<table>
<thead>
<tr>
<th>Field Configuration</th>
<th>Vertical, U-Bend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Circuits</td>
<td>80</td>
</tr>
<tr>
<td>U-Bend Depth, Fr. Bottom of Header Trench</td>
<td>400’</td>
</tr>
<tr>
<td>U-Bend Depth From Grade, Min.</td>
<td>405’</td>
</tr>
<tr>
<td>U-Bend Pipe Size, Length</td>
<td>810’ x 1.25” DR11 HDPE</td>
</tr>
<tr>
<td>Borehole Spacing</td>
<td>30.0’</td>
</tr>
<tr>
<td>Circuits per Header Pair</td>
<td>10</td>
</tr>
<tr>
<td>Header Pairs</td>
<td>8</td>
</tr>
<tr>
<td>Header Pipe Size</td>
<td>3.00” DR13.5 or 15.5 HDPE</td>
</tr>
<tr>
<td>Header Trench Depth Min. From F.G.</td>
<td>5.0’</td>
</tr>
<tr>
<td>Fine Bedding Fill Over Header, Min.</td>
<td>2.0’</td>
</tr>
<tr>
<td>Antifreeze *</td>
<td>Propylene Glycol</td>
</tr>
<tr>
<td>Antifreeze %, By Volume, Max.</td>
<td>25%</td>
</tr>
<tr>
<td>Grout Thermal Enhancement</td>
<td>0.90 BTUH/FT°F</td>
</tr>
<tr>
<td>Grout Installation</td>
<td>By Tremie, Bottom to Top</td>
</tr>
<tr>
<td>Header Reducing Manifold Schedule</td>
<td>See Sheet GX-2, Detail 3</td>
</tr>
</tbody>
</table>

* Installed after complete air purging of system

Summary details, typically embedded on GHX site plan and detail sheet for convenience
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Drawings - Details

Reducing manifold schedule (least purging effort)
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Drawings - Details

**Header Manifold Detail**

Header pair envelope penetrations
Considerations for contractor submittal review, specification/design compliance:

• HDPE pipe and fittings, warranty
• Grout, silica component (if TE grout is required), manufacturer’s recommendations
• Contractor licensing, IGSHPA or equivalent certifications, fusion endorsements
• Other, as specific to design and permitting authority considerations
Pre-construction meeting with construction team:

- Confirm contractor awareness and comprehension of design details, system performance objectives
- Confirmation of contractor responsibilities
- Expectations: record keeping; testing – grout thermal enhancement, pressure integrity; communication; as-built documentation
- Respond to questions from construction team
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Example Progress Tracking Sheet

<table>
<thead>
<tr>
<th>Header Set A</th>
<th>Each Leg</th>
<th>Time - Drill &amp; Grout Hours</th>
<th>Date Drilled / Complete</th>
<th>Flow test, 9.0 gpm</th>
<th>Date flow tested</th>
<th>Press. Test - PSI</th>
<th>Time on Press. Test - Hours</th>
<th># of 50 lb. bags grout</th>
<th># of 50 lb. bags silica</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borehole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td></td>
<td>4.00</td>
<td>4/8/2014</td>
<td>Yes</td>
<td>4/8/2014</td>
<td>120.0</td>
<td>2.00</td>
<td>21</td>
<td>84</td>
</tr>
<tr>
<td>A2</td>
<td></td>
<td>4.00</td>
<td>4/8/2014</td>
<td>Yes</td>
<td>4/8/2014</td>
<td>120.0</td>
<td>2.00</td>
<td>21</td>
<td>84</td>
</tr>
<tr>
<td>A3</td>
<td></td>
<td>5.00</td>
<td>4/7/2014</td>
<td>Yes</td>
<td>4/7/2014</td>
<td>120.0</td>
<td>2.00</td>
<td>21</td>
<td>84</td>
</tr>
<tr>
<td>A4</td>
<td></td>
<td>5.00</td>
<td>4/4/2014</td>
<td>Yes</td>
<td>4/4/2014</td>
<td>120.0</td>
<td>2.00</td>
<td>21</td>
<td>84</td>
</tr>
<tr>
<td>A5</td>
<td></td>
<td>4.00</td>
<td>4/2/2014</td>
<td>Yes</td>
<td>4/2/2014</td>
<td>120.0</td>
<td>2.00</td>
<td>21</td>
<td>84</td>
</tr>
<tr>
<td>A6</td>
<td></td>
<td>4.00</td>
<td>4/2/2014</td>
<td>Yes</td>
<td>4/2/2014</td>
<td>120.0</td>
<td>2.00</td>
<td>21</td>
<td>84</td>
</tr>
<tr>
<td>A7</td>
<td></td>
<td>5.00</td>
<td>4/1/2014</td>
<td>Yes</td>
<td>4/1/2014</td>
<td>120.0</td>
<td>2.00</td>
<td>21</td>
<td>84</td>
</tr>
<tr>
<td>A8</td>
<td></td>
<td>5.00</td>
<td>3/31/2014</td>
<td>Yes</td>
<td>3/31/2014</td>
<td>120.0</td>
<td>2.00</td>
<td>21</td>
<td>84</td>
</tr>
<tr>
<td>Total:</td>
<td></td>
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<td></td>
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<td>36.00</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Total holes completed this page: 8

Progress log gives perspective for:

- Depth of u-bend installation vs design objectives
- Pressure testing, flow test for loop integrity
- Grout composition, thermal enhancement
- Compliance with specifications
Field CA, verification of installation compliance with design parameters:

- Materials are properly staged and protected
- Boreholes are surveyed to correct spacing, geometry
- HDPE piping is handled to minimize potential for contamination
- Grouting procedures compliant with industry standards and specifications
- Fusion procedures compliant with industry standards and specifications
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Field CA – Site Visits

Appropriate staging and care of components
Avoid potential for GHX contamination
(Fusion crimping of pipe ends - urban location)
GHX contamination
Other trades running over loop ends, headering crew mishandling fittings prior to installation
Excessive tail lengths spoils pile
Potential indication of short-looping, check footage markings on exposed loops
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Importance of site visits

Short tremie - ~175’ tremie line on reel for 600’ bore depth (tipoff - bottom of reel was visible with tremie completely coiled!)
Contaminated header lines – Imagine what else might be in the rest of the ground loop!

Pin flags for borehole locations “relocated” by driller’s pet lab – unauthorized redesign!
Field CA, integrity verification of GHX installation:

• Flow and pressure testing, individual circuits

• Completed header pairs
Pressure testing, prior to and after loop loading
Flow testing installed loop circuit to confirm loop is free of obstructions or crimping
(Recommend min. rate for air purging)
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Grout Testing

<table>
<thead>
<tr>
<th>Average W/m°K</th>
<th>1.659</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Btu/hr/ft./°F</td>
<td>0.962</td>
</tr>
</tbody>
</table>

Testing of grout thermal conductivity:

- Verification of minimum conductance, compatibility with basis of design
- Frequency of testing may be a few times during the installation to every batch of grout as required
- Test samples must be processed quickly to allow for adjustments or changes if necessary
- Excessively high TC value may reduce aquifer protection and increase hydrostatic pressure against HDPE pipe for deeper boreholes
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Field CA – Site Visits

Final header pair pressure testing and purging
Contract Administration (CA) following GHX installation:

- Correct tie-in to mechanical piping
- Final purging, making certain mechanical does not re-introduce or debris from interior mechanical back to GHX
- Antifreeze (if necessary) and/or inhibitors of correct capacity are induced into system
- Post installation testing – header pair flow balance
Documentation:

- As-builts, installed ground heat exchanger adjustments or changes from original design
- All testing results – pressure testing, flow testing and purging
- Manufacturer’s submittals
- All permits, including inspection and other as required by jurisdiction
- Other, as specified by design team
• Designer awareness of site limitations, contractor capabilities, and other factors, should be considered during design for installation integrity and quality assurance

• Accurate specifications and drawings reduce conflicts during installation and make quality assurance (CA) easier

• Designer involvement during installation, from initial preconstruction review through field site visits, establishes and encourages communication between team members

• CA provides value by reducing the potential for installation conflicts or other issues, can potentially reduce change orders and unforeseen costs, and increases confidence in the integrity of the completed closed loop ground heat exchanger
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