

Construction of Vertical Loop Wells for Geothermal Heat Pump Systems

Subjects

Geothermal heat pumps; ground-coupled heat pumps; groundwater source heat pumps; grouting of loop wells; loop well construction; groundwater protection

Audience

Homeowners, legislators, governmental officials, building contractors, water well contractors, geothermal drilling contractors, building owners/developers

Definitions

Annular space:

Annular space (AS) is the area of the borehole minus the area of the loop tubing times the depth of the borehole.

Area of the borehole (A_b) is the diameter of the borehole times π .

Area of the loop tubing (A_l) is the outside diameter of the loop tubing times π times the number of loops in the borehole times 2.

$$AS = (A_b - A_l)$$

Aquifer:

A geologic formation, group of formations, or part of a formation that contains saturated permeable material that yields water.

Certified Vertical Closed Loop Driller (CVCLD):

An individual who has passed a written examination administered by the National Ground Water Association that evaluates an individual's knowledge of skills and competencies associated with constructing a loop well.

Closed loop system:

In a ground-coupled system, a heat exchanger consisting of the ground heat exchanger, the circulating pump, and the water-source heat pump in which the heat transfer fluid is not exposed to the atmosphere.

Geothermal heat pump (ground-coupled heat pump):

A heat pump that uses the Earth itself as a heat source and heat sink. It is coupled to the ground by means of a closed loop heat exchanger installed horizontally or vertically underground.

Groundwater:

Water in the zone of saturation.

Grout:

Grout is a high solids bentonite or cement mixture that has been developed to be used as a thermal grout. Specific additives can be mixed in a specified amount following a particular procedure with the thermal grout to enhance the performance of the thermal grout.

Grouting (positive emplacement):

A technique of installation of grouting materials whereby emplacement is achieved by positive pressure extended from the bottom of the zone upward via a grout pipe extending from the surface.

Loop field:

A loop field is a subsystem of a geothermal heat pump system designed and built in a vertical configuration of one or more vertical loop wells, interconnected to the horizontal header that allows the heat transfer fluid circulated within the loop tube(s) to exchange heat with the subsurface geologic environment.

Loop tube:

The heat exchanger conduit of a geothermal heat pump system through which the heat exchange fluid is circulated and thermal energy transfer takes place. The loop tube is emplaced to the bottom of the vertical borehole and grouted from the bottom of the vertical borehole to the Earth's surface at the drill site.

Loop well:

The subsystem of a geothermal heat pump system that consists of the drilled vertical borehole into the Earth that is equipped with a heat exchange media conveyance tube (loop tube), and is grouted from the bottom of the vertical borehole to the Earth's surface at the drilling site. Construction of a geothermal heat pump loop well includes, in continuous order, drilling of the vertical borehole, placement of the loop tube to the bottom of the vertical borehole with the grout tremie, and grouting of the vertical borehole from the bottom of the vertical borehole to the Earth's surface at the drill site. When these three steps are completed, the vertical borehole may now be considered a loop well. Loop tube emplacement and grouting should be performed in a timely manner to guarantee successful loop tube placement, grout installation, and environmental protection.

Loop well contractor:

Any person or firm engaged in the business of contracting for constructing, altering, testing, developing, or repairing a loop well.

Loop well driller:

Any person engaged in constructing, altering, testing, developing, or repairing a loop well.

Tremie:

Tremie is a pipe of sufficient diameter to allow for the pumping of thermal grouts to the bottom of the borehole.

Vertical borehole:

Any excavation that is drilled, bored, cored, driven, or otherwise constructed which penetrates an aquifer or which may degrade the quality of an aquifer.

Water-source heat pump, closed loop:

Closed loop systems which circulate a heat transfer fluid (such as water or a mixture of water and food grade/non-toxic anti-freeze) to exchange heat with the subsurface geological environment.

Water well contractor:

Any person or firm engaged in the business of contracting for the constructing, altering, testing, developing, or repairing a water well.

Water well driller:

Any person engaged in constructing, altering, testing, developing, or repairing a water well.

Background

The loop well of a ground source heat pump system (commonly known as a geothermal heat pump) installed into the Earth is designed using a combination of loop well geometry, loop tube configuration and placement, grout thermal properties, and appropriate ground thermal characteristics (conductivity, diffusivity, and mean earth temperature) for the site.

The final step in the geothermal heat pump system design process is to design the loop field. The results of the design process will include total loop well footage requirement, loop tube diameter, loop well diameter, grout materials, loop field layout, circuit arrangement, and individual loop well depth. Some of these design parameters may be selected based on good design practice or the capacity of the available drilling equipment, while others must be computed for the specific design conditions.

Issue

Is the loop tube an integral part of the loop well for a geothermal heat pump system?

Position

The National Ground Water Association believes the grout and the loop tube are integral parts of the loop well and that qualified individuals, such as a Certified Vertical Closed Loop Driller (CVCLD), should be authorized to construct a loop well.

Construction of a geothermal heat pump loop well includes, in continuous order, drilling of the vertical borehole into the Earth, placement of the loop tube to the bottom of the vertical borehole with the grout tremie, and grouting of the vertical borehole from the bottom of the vertical borehole to the Earth's surface. When these three steps are completed, the vertical borehole may now be considered a loop well. Loop emplacement and grouting should be performed in a timely manner to guarantee successful loop tube placement, grout installation, and environmental protection.

The loop tube shall extend to the bottom of the vertical borehole. If an obstruction is encountered in the vertical borehole, preventing the installation of the loop tube to the vertical borehole bottom, the loop tube and the obstruction must be removed or provisions made for the sealing of the vertical borehole below the obstruction and the designer needs to be notified so adjustments can be made to the design of the system.

Completing a vertical borehole for a loop well requires placing grout in the space between the loop tube and the vertical borehole wall and between the loop tube by pressure pumping grout through the tremie.

The reasons for grouting are: (1) protection of the aquifer, or aquifers, including limiting the potential for water movement between aquifers, for purposes of maintaining quality or preserving the hydraulic response of the producing zone(s); (2) provide thermal contact between the loop tube and the formation (interior wall of the loop well); and (3) accomplishing 1 and 2 in an efficient and economical manner.

In determining the specific grouting requirements of a loop well at a designated site, consideration must be given to existing surface conditions, especially the location of sources of pollution, and to subsurface geologic and hydrologic conditions. In all cases, formations which yield water must be adequately sealed off to prevent cross-contamination of the overlying or underlying water-bearing zones. To accomplish this, the annular space shall be grouted to prevent surface water runoff through the annular space, as well as to seal off water-bearing subsurface zones.

The tremie should be temporarily attached to the loop tube to carry it to the bottom of the vertical borehole. After the tremie has been installed, water should be pumped through the tremie to ensure that it is open. Grout shall then be placed by pressure pumping through the tremie and the tremie should be raised slowly as the material is introduced. The tremie should be continuously submerged in the grout. All grout shall be emplaced to the maximum extent possible in a single continuous operation upward from the bottom of the loop well. Due to the specific gravity of the loop tube, it may be necessary to artificially weight the loop tube to allow placement to the bottom of the vertical borehole. External weights shall be attached to the loop tube in a manner that does not damage the loop tube. Only potable water may be placed inside the loop to add weight to the loop. Using a steel tube pipe as the tremie can assist in the placement of the loop tube to the bottom of the vertical borehole.

Qualified individuals, such as a Certified Vertical Closed Loop Driller (CVCLD), have demonstrated their knowledge of the skills and competencies necessary to construct the complete loop well. Some loop well professionals may have skills and competencies to make loop tubing connections.

Contact

National Ground Water Association
Industry Practices Administrator
601 Dempsey Rd.
Westerville, OH 43081-8978
614 898.7791, ext. 560
fax 614 898.7786
info@ngwa.org

References

Guidelines for the Construction of Vertical Wells for Closed Loop Heat Pump Systems, 2nd ed., National Ground Water Association, 2009, Westerville, Ohio.

Ground Water Protection Strategy, p. 11, U.S. Environmental Protection Agency, 1984.

Gateway Area Development District Water Well Study Report, Kentucky Natural Resources and Environmental Protection Cabinet, Division of Water, and Kentucky Geological Survey, 1988.

Manual of Water Well Construction Practices, National Ground Water Association, 1998.

Michigan Water Well Grouting Manual, Michigan Department of Public Health, 1988.

Date

Originally adopted by the NGWA Board of Directors on February 9, 2010. NGWA statements are updated as needed to reflect changes in information.

©2010, National Ground Water Association, Westerville, Ohio

The National Ground Water Association is a not-for-profit professional society and trade association for the groundwater industry. Our more than 13,000 members from all 50 states include some of the country's leading public and private sector groundwater scientists, engineers, water well contractors, manufacturers, and suppliers of groundwater-related products and services. The Association's vision is to be the leading groundwater association that advocates the responsible development, management, and use of water.