INSTALLATION INSTRUCTIONS

EARTH LOOP INSTALLATION GUIDE

IMPORTANT

ATTENTION INSTALLERS:

It is your responsibility to know this product better than your customer. This includes being able to install the product according to strict safety guidelines and instructing the customer on how to operate and maintain the equipment for the life of the product. Safety should always be the deciding factor when installing this product and using common sense plays an important role as well. Pay attention to all safety warnings and any other special notes highlighted in the manual. Improper installation of this system or failure to follow safety warnings could result in serious injury, death, or property damage.

These instructions are primarily intended to assist qualified individuals experienced in the proper installation of this appliance. Some local codes require licensed installation/service personnel for this type of equipment. Please read all instructions carefully before starting the installation. Return these instructions to the customer's package for future reference.

DO NOT DESTROY. PLEASE READ CAREFULLY & KEEP IN A SAFE PLACE FOR FUTURE REFERENCE.

IMPORTANT SAFETY INFORMATION

Please read all instructions before servicing this equipment. Pay attention to all safety warnings and any other special notes highlighted in the manual. Safety markings are used frequently throughout this manual to designate a degree or level of seriousness and should not be ignored.

WARNING indicates a potentially hazardous situation that if not avoided, could result in personal injury or death.

CAUTION indicates a potentially hazardous situation that if not avoided, may result in minor or moderate injury or property damage.

NOTE TO INSTALLER READ THIS BEFORE YOU DIG!

Before you begin digging, you need to have possible underground electric, gas, water, or other utilities located. Many areas have a "One Call" number that may assist in (but should not necessarily be relied upon) locating underground utilities. Some laws require that a locate request be placed at least three (3) working days prior to any digging projects. The utilities should respond to your request by marking the approximate location of their utilities or notifying you that they have no utilities in your dig site area. After confirming utility response, you can then proceed with your excavation avoiding damages. Failure to check for, and to avoid underground utilities may result in physical injury or death.

⚠ WARNING:

The information listed below and on the next page must be followed during the installation, service, and operation of this unit. Unqualified individuals should not attempt to interpret these instructions or install this equipment. Failure to follow safety recommendations could result in possible damage to the equipment, serious personal injury or death.

REQUIREMENTS & CODES

- **The installer must comply with all local codes and regulations which govern the installation of this type of equipment. Local codes and regulations take precedence over any recommendations contained in these instructions. Consult local building codes for special installation requirements.**
- Check for underground utilities. Many areas have a "One Call" number that may assist in (but should not necessarily be relied upon) locating underground utilities. Failure to comply with local laws may subject the homeowner or excavator to expensive fines, legal fees or prosecution. Failure to check for, and to avoid, underground utilities may also result in physical injury or death.
- Obtain all requisite permits (Federal, State, and/or Local) prior to commencing work. This may include mechanical, electrical, drilling/excavation, erosion control, and grouting permits. Additionally, some subdivision developments or some homeowner associations have certain landscaping, etc., requirements where approvals must be obtained prior to excavation or equipment positioning.
- It is the installing/servicing dealer's/authorized contractor's sole responsibility to obtain and possess, or to insure the appropriate possession of, all necessary licenses prior to installing or servicing.
- Check for full and complete compliance with all applicable local mechanical, drilling, excavation, grouting, erosion control, and building codes, and check for full and complete compliance with all applicable national codes/regulations (such as OSHA and the National Electrical Codes, for example).
- **IMPORTANT: DO NOT UNDERSIZE THIS SYSTEM - The heat transfer ability of the ground surrounding the geothermal heat exchange tubing will be overstressed.**

REQUIRED EQUIPMENT & MATERIALS

- **Copper line sets, sub-surface copper liquid and vapor lines -** Sufficient soft refrigerant grade copper to connect all boreholes to the compressor unit and the interior air handler.
- **Refrigerant piping insulation -** All insulation must be non-corrosive to copper and have a minimum 3/4 inch (19 mm) wall thickness. The common practice of using a "one size larger" I.D. insulation tubing can permit unwanted water infiltration during system installation.

  a.) All insulation must meet the temperature requirements as indicated in Table 2 (page 6).
  b.) All sub-surface insulation must be capable of withstanding the compressive forces of any fill material.
  c.) Insulate all refrigerant tubing that will be extending through Grout 111 (or any other rigid material) for a distance of at least 1 foot (300 mm) into and 1 foot (300 mm) out of the rigid material. This allows for the expansion and contraction of the tubing without rubbing directly against the rigid material.
  d.) Use un-split insulation tubing for all but 3 inches (75 mm) to 1 ft (300 mm) on each end of the copper tubing segments (leave adequate room for coupling/brazing when necessary). Slide the new insulation over the un-insulated and newly brazed segments after completion of brazing and adequate cooling, or use pre-split insulation with glue strip insulation segments to cover all coupled segments after brazing and adequate cooling. Spiral tape all glue strip insulation segments as a safety precaution, as glue strips tend to separate over time if not reinforced. Do not place insulation over newly brazed segments or the insulation may melt.

  IMPORTANT NOTE:
  While the insulation material may meet the minimum high temperature requirements, the glue used on split insulation may not. When split insulation is used, high temperature electrical tape must be wrapped around the glued segments to prevent opening under high temperature conditions.

- **Nitrogen tank**- A gentle flow of nitrogen must be used to purge the refrigerant system of oxygen while joints are being brazed.
- **Plastic pipe -** PVC (or similar) of sufficient diameter to fully encase insulated refrigerant lines (both liquid and vapor) extending through building walls or below foundations. Any exterior refrigerant lines installed less than 4 ft (1.2 m). deep should also be encased to help prevent accidental damage from shallow digging, gardening, etc. **Place insulated liquid and vapor lines into separate pipes (liquid lines in one pipe and vapor lines in another pipe)**. Holes through walls should be placed above-ground to prevent water infiltration.
- **Excavation equipment -** A means to excavate a trench, the greater of 2 ft (600 mm) deep or 2 ft (600 mm) below the maximum frost line, for burying the fully insulated refrigerant

tubing extending from the structure to the borehole. While the trench may be dug by hand, the use of a mechanical trencher or backhoe is recommended. The insulated liquid line(s) must always be placed on the opposite side of the trench from the vapor line(s). If future excavation in the area is a concern, the insulated liquid and vapor line(s) must be placed into separate protective pipes (PVC piping for moderate protection, and steel piping for better protection). The excavation must always equal any minimum depth required by applicable codes.

- **Warning tape -** Prior to final trench backfilling, an underground warning tape is recommended to be placed 12" (300 mm) above all trenched line-sets, so as to provide ease in location and future excavation warning.

GENERAL INFORMATION

Geothermal heating/cooling systems operate via sub-surface conductive heat transfer, using the naturally renewable temperature of the earth's crust as a heat source in the winter, and as a heat sink in the summer. However; within any climate zone, the weather and underground conditions vary from place to place. The system must be sized and installed to meet the climate conditions in your area. To determine your climate zone, see Figure 1 (page 10).

Earth Loop Design Length

The sub-surface refrigerant lines used for geothermal heat exchange purposes must be sized to accommodate the maximum of the greater of the heating or cooling capacity design loads. Typically, in mostly non-porous rock or in permanently water saturated soil, an earth loop length between 65 ft and 100 feet per ton (5.6-10.8m/kW) of capacity is required.

Within the United States, see Figure 1 (page 10) to help determine the appropriate earth loop length.

For installations outside of the United States, the following rules will dictate the sizing of the earth loop. These rules assume that the earth loop will be installed within bedrock or permanently water saturated ground.

For the building to be conditioned, calculate the annual heating and the annual cooling loads. Use ACCA Manual J or other locally recognized load calculation program.

Divide the annual cooling load by the annual heating load. If this result is less than or equal to one, then the system will require 65 ft of earth loop per ton of system size (5.6 m/kW). If the result is greater than one but less than 1.75, then the system will require 80 ft of earth loop per ton of system size (8.7 m/kW). If the result is greater than 1.75, then the system will require 100 ft of earth loop per ton of system size (10.8 m/kW).

Vertical Elevation Differential Design

The vertical elevation differential between the bottom of the earth loop and the top of the air handler must be no greater than 125 ft per ton (10.8m/kw), with a maximum borehole depth of 400 ft (122 m). If the required vertical elevation exceeds this design criteria, the maximum depth can be shortened by the addition of a second borehole.

DRILLING, LOOP INSTALLATION, & GROUTING

Drilling Guidelines

Use a fully licensed, qualified, and experienced driller to supply the requisite borehole(s). Most local drillers will have a reasonable estimate of the sub-surface elements/geology that will be encountered in your particular area. This information can be helpful in obtaining drilling cost estimates for a particular job. Request that the drilling company provide cost estimates in advance for potential casing costs if loose soil is encountered. Make sure all necessary permits are obtained prior to commencement of work.

Borehole Diameters - Boreholes are generally 5 inches (125 mm) to 6 inches (150 mm) in diameter. Cased boreholes may be 4 inches (100 mm) in diameter. Maximum depth per borehole is 400 ft (122 m).

Multiple Boreholes / Minimum Spacing - In installations where there are mulitple boreholes, there are minimum distances that must be maintained:

- If there are only two boreholes, they must be spaced at least 15 feet (4.5 m) from each other.
- If there are three or more boreholes arranged in a line, they must be spaced at least 20 ft (6 m) from each other.
- If there are three or more boreholes arranged in a matrix, they must be spaced at least 30 ft (9 m) from each other.

Boreholes of Equal Depths - Multiple boreholes for one compressor unit must always be of equal depths.

Record all borehole(s) and all brazed joint locations - The location of all boreholes, and the location of all sub-surface brazed joints (typically in trenches between the borehole and the structure) should be measured (triangulated) from two separate points of an existing permanent structure, recorded, and maintained in the installing contractor's file. A copy should also be provided to the property owner.

Drilling Log - A drilling log should be maintained by the driller. The log should identify differing sub-surface geologies, water tables, underground streams, and voids. Consult the log before you install earth loops, to determine if any pea gravel is necessary for underground voids/aquifers, or if any weights will be necessary to offset buoyancy in water-filled boreholes. Pea gravel is preferable for filling any void areas or for filling any water zone areas that might wash away Grout 111.

IMPORTANT NOTE

Never permit the driller to use bentonite clay during the drilling process (such as to provide a mud wall to keep the borehole open). Bentonite clay has a poor heat transfer rate and prohibits necessary geothermal heat exchange.

Earth Loop Installation

Check all model numbers and earth loop spool length designations upon receipt. Check the nitrogen charge of each spool. If the designated shipping nitrogen charge is not found, there is likely damage or a leak.

Earth loops are fully assembled and ready to place into the ground. The loop includes the vapor line, an insulated liquid line, and a bottom torpedo unit, shown in Figure 2 (page 11). The loop/spools typically come with an approximate 30 psig (200 kPa) dry nitrogen charge. This charge is applied after a 250 micron vacuum has been pulled at the factory to ensure that there are no leaks.

The best and preferred method of lowering earth loops into boreholes is using the hoist on the drilling rig, immediately after the hole is completed. **NOTE:** This is the preferred method because, if there is a blockage in the borehole, the copper tubing can be manually pulled out of the borehole, and the rig will be in an exact position to re-drill and clear the hole.

1. Place a heavy wall steel pipe through the center of the earth loop spool.
2. Using the drilling rig's hoist, raise the spool 15 ft (4.6 m) or 20 ft (6 m) above the ground.
3. Attach the tremie tube as described in the "Attaching the Tremie Tube to the Earth Loop" section (page 4).
4. Slowly lower the tubing into the borehole.

Other means besides the drilling rig can be used to support the spool during earth loop installation. Regardless of method, the following cautions should be observed:

- The structure should be capable of securely holding the rotating spool during insertion of the earth loop.
- An adequate braking mechanism should also be available. This may be as simple as an appropriate piece of lumber that can be wedged against the perimeter of the spool. **NOTE:** Braking is necessary to slow the descent of the copper tubing into the borehole, particularly when the earth loop is over 50% installed and the weight of the copper becomes a pulling factor within a dry hole. The weight of the copper lines is between 0.5 lbs and 1 lb per ft (0.74-1.49 kg/m). The weight of the torpedo segment is about 8 lbs (3.5 kg). The weight of the tremie tube is extra and will vary depending on type and size.

Attaching the tremie tube to the earth loop

The earth loop systems are shipped from the factory pre-assembled and leak tested. The spool contains 2 large un-insulated vapor lines, one small insulated liquid line and a bottom segment called the torpedo. See Figure 2 (page 11).

- The torpedo is approximately 16" (400 mm) long and is comprised of PVC tubing and a cap. It contains a lower copper line u-bend, two copper vapor lines, and a copper liquid line sealed within a heavy gauge polyethylene tube. The lower end of the torpedo is filled with grout.
- A small hole has been drilled into the side wall of the torpedo (about an inch from the top) at the factory. An 18 gauge copper wire will need to be inserted through the hole, wrapped around the exterior of the tremie tube twice, and secured with 3 twists by the installing contractor. **NOTE:** This will keep the tremie tube lightly attached to the earth loop as they are all lowered into the borehole but also permit the tremie tube to be pulled loose during the actual grouting procedure.
- The unit needs to be carefully lowered into the borehole, together with the tremie tube used for the insertion of the Grout 111. The lower end of the tremie tube should be placed above the existing cured grout within the torpedo.

High water table and off-setting liquid line insulation buoyancy

If a borehole has sufficient water, buoyancy may occur when the loop is lowered into the borehole. When water is encountered, drop the copper tubing into the borehole as far as possible using its own weight.

- If resistance occurs and the loop stops its own downward progression, gently raise and lower the loop again to ensure the torpedo is not snagged on a ledge.

  NOTE: Do not push or force the lines down into the borehole, as this may crimp or damage the line. Also the risk of the loop "floating" out of the borehole during or after the grouting process may occur. Should the loop float out of the borehole (more than 3% of the design depth) after grout has been added, the loop should be immediately pulled out of the borehole, washed off, and re-installed into a newly drilled borehole.

- Supplemental weight may be added to the earth loop to offset the buoyancy. Approximately one-half lb of weight per linear ft (0.74 kg/m) will be required to offset the buoyancy of the earth loop.

  NOTE: 2 inch (50 mm) diameter rebar weighs 10.68 lbs per ft (15.89 kg/m) 1.75 inch (44.4 mm) diameter weighs 8.18 lbs per ft (12.17 kg/m) 1.5 inch (38.1 mm) diameter weighs 6.01 lbs per ft (8.94 kg/m).

- If 3/4 inch (19 mm) diameter or smaller rebar is used, segments should be no more than 10 ft (3 m) in length. If the segments are longer, they are more prone to jamming in a borehole that is not perfectly straight and vertical.
- Prior to attachment, the top and bottom ends of the rebar must be wrapped in tape (duct or electrical) to protect the copper from the top and bottom edges of the steel. Steel is a sacrificial anode to copper, and will not adversely affect any adjacent copper tubing. Securely tape on 5 ft (1.5 m) (or shorter) segments of 2 inch (50 mm) diameter (maximum) rebar to the line set to continue the installation to its full borehole design depth.
- Add as many segments of rebar as necessary, consisting of at least one-half lb per ft (.74 kg/m), in a vertical manner, so that it doesn't restrict the available diameter of the borehole. Multiple segments of rebar may be bundled into one segment so long as the diameter of the borehole will not be restricted.
- If a jam in the insertion results, there may be a bend in the borehole. Bends in the borehole can jam the installation process when using rebar (copper tubing is soft and will bend as necessary, but rebar is more rigid and will not bend). If a bend in the borehole is encountered, the entire assembly must be carefully withdrawn from the borehole, the rebar must be cut into shorter lengths, and then the assembly must be carefully re-inserted.

Insulating the vapor line

Insulate the vapor line in the borehole from the surface to a depth greater of 2 ft (600 mm) deep, or 2 ft (600 mm) below the frost line.

- If the frost line is deeper than 1 foot (300 mm) (so that the total insulated vapor line distance from the surface exceeds 3 ft (900 mm)), the depth of the boreholes must be extended to accommodate any additional depths, to a maximum of an additional 5 ft (1.5 m)
- If any such requisite borehole depth extension exceeds an original borehole design depth of 5 ft (1.5 m), you are in danger of losing the earth loop in the borehole, as there is only an extra approximate 10 ft (3 m) length of copper tubing installed on any individual earth loop (to accommodate slight errors in tubing lengths and drilling depths).

Line set integrity testing

Once installed, a sub-surface earth loop should be free from any leaks or restrictions. A kink may be caused by falling debris within the borehole or improper handling during installation. If a kink has occurred in a line during installation, such a restriction could impair system operation.

- The only solution for a significant kink impairment found after the system has been fully installed would be to re-drill a new borehole and replace the earth loop.
- If there is any doubt about the presence of a kink that occured during the insertion of the earth loop into the borehole, it is best to remove, repair, and reinsert before grouting.

Short Borehole Resolution

Obstructions or other borehole depth problems can create situations where full design depths may not be reached by the earth loop. If the full design earth loop depth is compromised by more than 3%, the borehole must be re-drilled.

What to do if the tremie tube detaches during installation

⚠ CAUTION:

Manually feed the tremie tube into the borehole as the earth loop is lowered into place. The retaining wire will not be sufficient to pull down the entire weight of the tremie tube. Never pull up on the tremie tube until grouting commences. This may pull the tremie tube loose from the torpedo.

If the tremie tube breaks loose during the earth loop installation process and you are unable to manually push the tremie tube into the bottom of the borehole, pull out the earth loop, re-attach the tremie tube to the torpedo, and re-insert the entire assembly.

If the tremie tube pulls loose less than halfway down, roll the earth loop back up onto the spool. If the earth loop is past the halfway point of the borehole and is too heavy to pull out by hand, carefully pull the loop up and out of the hole using mechanical means, such as a mechanical winch or the trailer hitch of a truck. Be careful when pulling the earth loop out of the borehole.

If mechanical means are not used to pull the tubing straight up and out of the hole (and the ends of the copper lines are attached to a truck), be careful and provide a smooth, rounded borehole exit means for the copper lines as they are pulled out across the top edge of the borehole so that the tubing doesn't get distorted or kinked.

What to do if copper tubing is kinked or crimped during installation

When installing the earth loops, or other copper tubing, repair or replace any crimped or kinked segments of the insulated liquid line or vapor line impaired during installation before the line segment continues to be lowered into the borehole. Ream out all rough edges on the interior of any cut line segments and make sure no copper shavings or debris fall into the lines.

Grouting

IMPORTANT NOTES:

Use Grout 111 only. The grout must be installed from the bottom of the borehole up to the top. Grout 111 weighs about 18.2 lbs per gallon (2,181 kg/m^3) and must be thoroughly mixed with a contra-flow ribbon mixer.

Do not use a paddle mixer. Otherwise sand will settle to the bottom and a bad mix will occur.

Precautions

- Keep out of reach of children.
- Grout 111 contains portland cement which can cause irritation or burning of skin.
- Avoid direct contact with skin and take necessary precautions to protect skin.
- Use of a dust respirator, safety goggles, and rubber gloves is required.
- Avoid prolonged contact with clothing.
- In case of contact with eyes, immediately flush with water for at least 15 minutes. Get prompt medical attention.
- DO NOT wear contact lenses when working with this product.
- DO NOT take internally. Read all warnings provided by the product manufacturer.

Product Description

- Grout 111 is a non-shrinking grout designed for use with geothermal heat pump systems.
- It can be obtained pre-blended and packaged, typically requiring only the addition of water.
- Its principal constituents are a finely graded quartz silica sand, Portland cement, and an additive mixture to control pumpability and set time.
- This high thermal conductivity, ultra-low permeability, grout fills the remaining empty annular space in the borehole, coupling the earth loop to the subterranean formation, insuring efficient heat transfer, while protecting the copper line-sets and preventing aquifer mixing ground water contamination from surface spills.
- Grout 111 is non-toxic and is considered safe for contact with potable ground water.

Properties

Typical properties are as follows:

- Grout 111 is mixed with 16 percent water (by weight) to produce a highly plastic and pumpable slurry. The grout is specially designed to sweep residual mud and water out of the borehole, assuring a strong bond between the formation and the earth loop.
- Grout 111 set time can vary from less than 1 hour to more than 4 hours depending on temperature of the grout. It is recommended that equipment clean-up happen as soon as possible.
- Wet density is approximately 18.2 lbs per gallon (2,181 kg/m^3).
- 28-day compressive strength exceeds 4,000 psig, and measured permeability is 4.5 x 10^{11} cm/sec. The thermal conductivity of Grout 111, when cured in wet subterranean conditions is equal to 1.40 BTU/hr-ft.-°F (2.42 Watt / (m-°K)).

Procuring

- Grout 111 can be purchased pre-mixed or mixed on site.
- If blending your own grout on site, proceed to the Mixing Grout 111 section (page 6).

Grout Volume Requirements

NOTE: Each borehole may require more than the calculated volume of grout due to oversized holes, voids, mud seams, and fractured formations. It is recommended to have at least 10% more grout than calculated on hand to ensure that the annular space is completely filled. See Table 1.

To maintain a grout head level above the lower bottom end of the grout line, make sure the grout line is extracted at a slower pace than the grout is supplied. This helps to eliminate air gaps in the fill material. Slowly withdraw the grout line as grout is pumped into the hole through the bottom of the grout line. Make sure the bottom of the grout line always stays below the grout level to prevent air pockets and to ensure a complete grout fill for maximum heat transfer.

Voids and Caverns

When voids or caverns are encountered, an extra amount of material may be required, depending on actual sub-surface conditions encountered. The following procedures should be used to minimize the loss of material into the formation:

1. Carefully review the drill log prior to commencement of the grouting operation. If any excessively large voids are encountered, the borehole operation should be abandoned and a new borehole drilled. **NOTE:** Make note of the footage range of all voids, fractures, and lost circulation zones. If your driller does not typically keep these records, insist that this information be given to you.
2. Calculate the volume of grout needed to fill the annular space from the bottom of the hole to the void space or cavern. Pump the calculated volume of grout while slowly retrieving the tremie

HOLE DIAMETER (INCHES)	GALLONS OF GROUT REQUIRED (PER FT OF DEPTH)
5 1/2 (140 mm)	1.12 (13.9 L/m)
6 (150 mm)	1.35 (16.8 L/m)
6 3/8 (160 mm)	1.54 (19.1 L/m)
7 (175 mm)	1.88 (23.3 L/m)
8 (200 mm)	2.49 (30.9 L/m)

Table 1. Grout Requirements

line to a depth just above the void or cavern. When designated depth is achieved, pump any unused grout left in the hopper into the void.

3. Slowly add pea gravel or #9 stone, or the like, into the borehole until the void space is filled.
   - Add the gravel with a shovel.
   - Add no more than a 5 gallons (19 L) at a time. Adding gravel or stone at a faster rate is more likely to create "bridging" and blockages before reaching the area to be filled. This can result in void areas with poor heat transfer, and can place undue weight/stress on the copper lines within the borehole (potentially resulting in damage to the earth loop lines).
   - Grout should then be pumped above the stone plug until the annular space is completely filled and sealed.

Receiving & Storage of Grout 111

All bagged products should be checked for dryness prior to signing shipping papers. Grout 111 should be stored in a cool and dry interior space, or adequately covered with waterproof tarping and separated from the ground by palleting. Materials should never be exposed to high moisture, rain, or snow.

Standard Packaging of Grout 111

- 50 lb (23 kg) bags
  - Triple-lined
  - 60 bags/pallet, 15 pallets per truckload
  - Approximate yield: 0.60 ft^3 or 4.5 gallons (17 L)
- Super Sack
  - 2,500 lbs (1134 kg).
  - Reusable
  - 18 Super Sacks per truck
  - Approximate yield: 30.0 ft^3 (.84 m^3) or 224.4 gallons (849 L)

Mixing the Pre-mix

1. Mix one gallon of clean (sulfur, chlorine, and other chemical free) cool water (with a pH level between 6 and 10) with every 50 lbs (22.6 kg) of Grout 111. The water should be metered and placed in the mixer with blades rotating before adding the pre-blended dry grout mix.
2. Mix the grout for a minimum of 5 minutes until a smooth, lump free consistency is achieved.

Mixing Grout 111

Grout 111 is a cement-sand grout for use with vertical ground loops for geothermal heat pumps. The grout is designed to have improved thermal conductivity and sealing capability compared with other grouts. Grout 111 consists of cement, water, silica sand (of a particular gradation) and a small amount of superplasticizer. The superplasticizer is an additive that improves the pumpability of the grout while enabling the water/cement ratio to be kept low.

The material proportions and sand gradation are critical to achieving pumpability and critical properties of the final product (thermal conductivity, coefficient of permeability, shrinkage resistance and durability).

Required Materials:

- **Cement** - The cement used shall conform to ASTM C150 - Type I. If the site conditions require that sulfate resistant cement is necessary, then Type II or Type V cement can be used. Cement that already contains a waterproofing additive should not be used as this has been found to cause slight foaming of the grout and reduce the thermal conductivity.
- **Water** - The water shall be potable. Water with excessive impurities may affect the final properties of the grout.
- **Silica Sand** - The silica sand shall conform to ASTM C33 in terms of soundness and absence of deleterious substances only. The sand shall have a silica content of greater than 98%. The particle size gradation shall conform to that in Table 2 below (not that given in ASTM C33).

  The sand has been selected on the basis of grout pumpability, thermal conductivity of hardened grout and other grout properties. Other sands that do not meet the specifications may cause pumpability problems or reduce thermal conductivity.

  The bags of sand should be kept dry at all times. Sand that contains moisture should not be used as this will increase the water/cement ratio of the grout.
- **Superplasticizer** - The superplasticizer shall be ~42% sodium naphthalene sulfonate conforming to ASTM C494 Type F.

Equipment:

The grout should be mixed in a high shear (colloidal) grout mixer. Improved sand carrying capacity, decreased water requirement, reduced bleeding and greater flowability of grout is achieved when mixed this way.

It is preferable to use a grout mixer in conjunction with a larger capacity agitator in which the grout is stored and agitated until use. This is necessary to keep the particles in suspension, and, in the case of thixotropic grouts, keep the grout mobile and fluid. As discussed previously, the grout can be pumped continuously from the agitator tank while the next batch is mixed. Thus, pumping is not interrupted and the risk of plugging the tremie tube is reduced. It is critical that a proper grout mixer suited to cement-sand grouts be used. Mixing of the grout by hand, pumps or concrete ready mix trucks is not acceptable.

Piston pumps are recommended for pumping Grout 111. Excessive wear may be encountered when using a helical rotor (progressing cavity) pump.

Based on the field trials a minimum 1.25-inch (32 mm) diameter tremie tube with an open end and several side discharge outlets is recommended.

SIEVE NO (SIZE, MM)	PERCENTAGE PASSING (%)
8 (2360)	100
16 (1180)	95 - 100
30 (595)	55 - 80
50 (297)	30 - 55
100 (149)	10 - 30
200 (75)	0 - 10

Table 2. Specification for Particle Size Gradation of Silica Sand

Cement	(x1) 94 lb (43 kg) bag
Water	6.19 gallons (23.5 L)
Sand (conforming to gradation spec)	(x2) 100 lb (45 kg) bags
Superplasticizer	21 fl. oz (639 ml) not to exceed 28.7 fl oz (851 ml)

Table 3. Mix Proportions and Yield for Batch of Mix 111 Based on One Bag of Cement

Grout Mix Proportions:
The basic mix is given in Table 3. This mix, with one 94 lb (43 kg) bag of cement, will yield 19.1 gallons (72 L).

The amount of grout that can be mixed at once will depend on the capacity of the grout mixer. It is preferable to mix as much as possible per batch.

Depending on the mixing equipment and actual particle size gradation of sand used, the rheology of the grout may vary. Use of excessive water will be detrimental to the hardened grout properties (e.g., shrinkage, permeability, durability, thermal conductivity) and probably induce segregation of the sand.

Since the properties of Grout 111 are very sensitive to the water/cement ratio and superplasticizer dosage, it is critical that the amounts of water and superplasticizer required for a batch are measured accurately. Superplasticizer should be limited to a maximum of 20 ml/kg cement. This is equivalent to 29 fl oz (851ml) per 94 lb (43 kg) bag of cement.

Quality Control:
Every batch of freshly mixed grout should be measured for specific gravity prior to pumping. The specific gravity is sensitive to water/cement ratio, sand/cement ratio and uniformity of mixing. Grout 111 with the proportions given above has a specific gravity of 2.18 +/- 0.02 (Density: 18.2 +/- 0.2 lb./gal).

Placing Grout 111

Place grout continuously and quickly with appropriate mixing and pumping equipment. DO NOT VIBRATE. DO NOT mix or place grout with water temperatures below 40° F. (4 ° C). **NOTE:** Grout can still be mixed and placed with air temperatures below 32° F (0° C), as long as the mix water is at least 40° F (4° C).

- As the grout is being installed underground, antifreeze within the grout mixture itself is not required. Water that is exposed to excessive sun or temperatures above 80° F (26° C) will decrease working time and accelerate the curing schedule.
- It may be necessary to add ice to your mix water to maintain a temperature below 80° F (26° C) on hot summer days. DO NOT over water the grout mix. This can cause bleeding or separation.
- DO NOT add additional sand, cement, aggregate, or admixtures.
- In between batches of grout, it may be necessary to pump small amounts of water through your pump to keep the tremie line lubricated and prevent packing off or premature curing. Simply place your water hose into your pump hopper and slowly pump a few gallons (liters) of water until you resume pumping grout. The addition of such water into the borehole will not adversely affect Grout 111, as it weighs about 18.2 lbs per gallon (2,181 kg/m^3), while water only weighs about 8.34 lbs per gallon (1,000 kg/m^3). The water used to keep the tremie line clear will simply be displaced by the much heavier Grout 111 as it is pumped into the borehole.

Earth Loop Insulation

⚠ CAUTION:

Before pulling a vacuum on the polyethylene tube, the surrounding grout must be in place and fully cured. Failure have the polyethylene tube fully encased in cured grout may cause the the tube and inner liquid line to collapse.

The liquid line of the earth loop is encased within a polyethylene tube. For optimal insulating properties, a vacuum should be pulled on this tube. There is a schrader valve located on the top end of the polyethylene tube for this purpose.

TRENCHING

NOTE TO INSTALLER
READ THIS BEFORE YOU DIG!

Before you begin digging, clearly mark the location of all trenches to prevent accidents and personal injury. Fully comply with all trench excavation regulations required by the U.S. Department of Labor and the Occupational safety & Health Administration (OSHA).

Trench excavations are subject to rules and regulations of the U.S. Department of Labor and the Occupational Safety & Health Admninistration. Should any NORDYNE trench excavation instructions differ from OSHA or other applicable regulations, follow the rules and regulations enforced by OSHA and the U.S. Department of Labor

⚠ WARNING:

When a trench is being excavated, advise the excavator that full and complete compliance with OSHA and any other applicable state and local regulations are mandatory, without exception. Failure to comply to all applicable safety guidelines and reasonable due care under all circumstances, can result in personal injury or death.

⚠ WARNING:

If a person must go into a trench, the trench must be fully excavated and shored in full compliance with OSHA regulations and all other applicable rules and regulations. Failure to comply to all applicable safety guidelines, and reasonable due care under all circumstances, can result in personal injury or death.

⚠ CAUTION:

Never install inadequately insulated refrigerant tubing in a trench in close proximity to a slab, foundation wall, water line or septic tank. Failure to comply may cause damage from potential ground water freezing around the exposed sub-surface vapor refrigerant line. Consult a professional or licensed Engineer to determine appropriate set back distances.

- **OSHA rules and regulations govern safety precautions which must be fully observed and complied with, in addition to any and all other applicable state and local regulations. Trenching requirements are available, generally free of charge from most OSHA offices.**

Trenching Requirements

Trenching will always be required to connect the refrigerant lines in a borehole to the interior refrigerant lines leading to the compressor unit.

- At minimum, a 4 inch (100 mm) wide trench must be excavated from the borehole to the wall of the structure. The trench must be of adequate depth, typically about 2 ft (600 mm). below the frost line in any particular geographic area.

- As the insulated tubing is typically installed within the borehole prior to trenching, it is usually safer to dig out the final segments of the trench adjacent to the borehole and adjacent to the wall by hand than with a trenching machine, to be sure neither the tubing nor the structural wall is damaged.
- A refrigerant line set, comprised of fully insulated liquid and vapor refrigerant lines, are placed at the bottom of the trench, preferably with the liquid line on one side of the trench and the vapor line on the other side.
- The liquid and vapor refrigerant lines must be the same size as the fittings on the compressor unit.
- The line sets (when more than one) should be tied into an appropriate distributor in an inside accessible location whenever possible. The refrigerant distributor must always be vertically oriented, without exception. Otherwise, there may be unequal refrigerant flow to the boreholes.
- If surface rock is encountered, either fill material can be supplied to build up an area over the fully insulated refrigerant lines, or a more expensive rock trencher can be rented that is designed to trench through rock.

Final Backfilling

- Prior to final backfilling, it is recommended that geothermal marking tape be placed 12" (300 mm) above all trenched line-sets, to provide ease in location and to provide a future excavation warning.
- The trench should be backfilled with a self-compacting fill material, such as sand, pea gravel, or similar, with a final and top several inches of dirt to promote grass or other cover growth. Avoid the use of large rock for backfilling.
- Stone powder resulting from drilling debris may also be used.
- If only dirt is used to backfill the trench, "bridging" and air gaps will result, which will require additional fill material and work after initial settling.

INSULATION REQUIREMENTS & ENCASEMENT PRECAUTIONS FOR UNDERGROUND REFRIGERANT TUBING

IMPORTANT NOTE:

In all applications, in all areas within potential heat transfer distances of, or proximity to, structural walls, water lines, sewer lines, septic systems, and the like:

a. **The liquid line must be fully insulated with either a Tubolit or neoprene insulation, with wall thickness of at least 3/4 inch (19 mm), closed cell, and non-corrosive to copper; and**
b. **The vapor line must be insulated with at least a 3/4 inch (19 mm) Armaflex or neoprene insulation, with at least a 3/4 inch (19 mm) thick wall, must be closed cell, and non-corrosive to copper.**

- Insulate the liquid and vapor line with closed-cell insulation material in all underground areas. See Table 4.
- In all sub-surface locations, and in all areas proximate to water/sewer/septic lines and structural walls, etc., the liquid line must be insulated with either a closed-cell neoprene insulation (typically with an adhesive back that is rolled around the tubing to the requisite minimum wall thickness), or with a closed cell Tubolit (expanded polyethylene foam) insulation.

  NOTE: Neoprene and Tubolit (expanded polyethylene foam) both have relatively rigid walls that resist crushing/thinning (unlike the softer walled Rubatex) when fill material is added. Tubolit has a melting point of 180° F (82° C); however, the liquid line should never exceed this temperature. Both neoprene and Tubolit have enough structural integrity to remain effective within only a few feet of fill by the pressure of the Grout 111 or other common fill materials.

LIQUID LINE		VAPOR LINE	
ABOVE SURFACE	BELOW SURFACE	ABOVE SURFACE	BELOW SURFACE
3/4" (19 mm) Min. Wall Thickness		3/4" (19 mm) Min. Wall Thickness	
Closed Cell Foam		Closed Cell Foam	
Non-Corrosive to Copper		Non-Corrosive to Copper	
Min. Hi-Temp Rating 180° F (82° C)		Min. Hi-Temp Rating 220° F (104° C)	
Min. Lo-Temp Rating -20° F (-28° C)		Min. Lo-Temp Rating -20° F (-28° C)	
Armaflex SS	Armaflex SS	Armaflex SS	Armaflex SS
Expanded Polyethylene	Expanded Polyethylene	Expanded Polyethylene	Expanded Polyethylene
Neoprene	Neoprene	Neoprene	Neoprene
Rubatex	—	Rubatex	—
Tubolit	Tubolit	—	—

Table 4. Insulation Requirements

- Both the liquid and the vapor line must be doubly insulated (insulation providing at least a 1.5 inch (38 mm) thick wall) in all areas proximate to structural walls, water lines, sewer lines, septic systems, and the like, with any such vapor line insulated lengths excluded from any and all sub-surface heat transfer tubing length calculations. Always check with the design engineer to make sure that a 1.5 inch (38 mm) thick insulation wall will be sufficient and to determine the distances where such double thick insulation must be applied in the proximity of all such items.
- Insulate all refrigerant tubing that will be extending through Grout 111 (or any other rigid material) for a distance of at least 1 foot (300 mm) into and 1 foot (300 mm) out of the rigid material. This allows for the expansion and contraction of the tubing without rubbing directly against the rigid material.

Copper tubing protection in corrosive sub-surface environments.

- Avoid any installation in corrosive environments where the copper tubing is to be installed within soils, waters, materials that are corrosive to copper (typically with pH levels below 5.5 or above 11, or in sub-surface sulfur or other chemically concentrated water (chlorine, etc.).
- Stray electrical currents can also be corrosive to copper. Electrical shorts in water-well pumps (particularly DC current pumps), etc., can result in sub-surface stray electrical currents. Checking for any stray electrical currents in the sub-surface area of an installation is necessary prior to any earth loop or sub-surface line set installation. Special precaution should be taken if water-pumps, or other sub-surface pumps, are nearby.
- Equipment operating on nearby direct current (DC) power will present a significant potential stray current hazard, that must be periodically monitored for early stray current detection. All stray currents affecting copper tubing must be eliminated prior to copper tubing installation, and immediately upon subsequent discovery. Any such stray electrical currents can corrode copper tubing.
- Never place, or permit a well driller to place, chlorine tablets into a borehole intended for earth loop use. Chlorine is corrosive to copper.

⚠ CAUTION:

Water well drillers commonly insert chlorination tablets in the bottom of a borehole to purify the water. NEVER DO THIS in a system borehole, as chlorine is highly corrosive to copper.

Potential Freezing Concerns

IMPORTANT NOTE:

DO NOT install any uninsulated refrigerant line (in a trench system, pit system, or in any other geothermal heat transfer application) within close proximity of a slab, bearing wall, water line, sewer line, septice system, etc., This may potentially cause a freezing problem. Consult a qualified or licensed engineer to determine appropriate set-back distances necessary to prevent any potential damage caused by freezing temperatures prior to installation.

All refrigerant lines within close proximity of a slab, bearing wall, water line, sewer line, septic system, etc., must be fully insulated with at least a 1.5 inch (38 mm) wall of closed-cell, water-proof insulation for a safe distance so as not to result in any damage caused by the freezing ground. Refer to the insulation requirements listed above for additional information.

Safe distances are typically 15 ft (4.5 m); however, this distance is a general estimate only and may vary depending on surface conditions, water table elevations, and other factors. Consult a qualified or licensed engineer.

Installing Line Sets between Boreholes & Compressor Unit

- Line sets between the borehole and the structure, and between the structural wall and the compressor unit, must be comprised of refrigerant grade copper tubing. All line sets between the borehole and the structure, and between the structural wall and the compressor unit, must be comprised of the designated line set size as used in each individual borehole.
- With multiple boreholes on a single compressor unit, individual liquid lines and vapor lines from each earth loop must be joined to their distributors, adjacent to the compressor unit, or otherwise located in an accessible location. The distributors must be vertically oriented, without exception. See Table 5 for distributor kit info.
- If an elbow is incorporated within 12 inches (304 mm) of the inlet side of the distributor, it must be oriented perpendicular to the plane of the two outlet lines as shown in Figure 3 (page 11).
- The liquid and vapor line must be fully insulated according to the requirements listed in Table 4 (page 8).
- Make sure to insulate the vapor line extending into the borehole from the ground surface for the greater of a distance equal to at least 2 ft (600 mm). deep below the surface, and 2 ft (600 mm). below the frost line in the particular geographic area of installation.
- Use Grout 111, powdered stone, pea gravel, or sand to totally surround and fully support the bend from the top of the borehole to the refrigerant lines in the trench. The bend must not be greater than 90°. If using a 90° angle, use a store-bought, machined, 90° angle. If the bend is not fully surrounded and supported as required, by loose ground settling, the copper lines could become damaged. Only hard copper store-bought angles of 90° may be used.
- It is recommended that both the liquid line and the vapor line protruding from the borehole be surrounded by a protective 6 inch (150 mm) diameter PVC, or similar pipe segment. At this point it is very susceptible to damage and this will help prevent any accidental bending/crimping of the refrigerant tubing.

P/N	DESCRIPTION
1003462	Distributor, geothermal, 3/4" to 3/4"
1003463	Distributor, geothermal, 7/8" to 3/4"

Table 5. Distributor Kits

IMPORTANT NOTE:

Replace any damaged refrigerant line segment prior to grouting and backfilling by cutting away the damaged segment and coupling the remaining good segments. De-burr all cut lines, with open ends facing down so no debris falls into the lines.

- The insulated line set, extending from the borehole to the structure, must be installed within a trench or within protective piping. When installed within a trench, the separately insulated vapor and liquid lines must be on opposite sides of the trench. When installed within a pipe, other than a short access/entrance pipe through the structural wall (where the wall does not exceed a thickness of 2 ft (600 mm)) each line must be individually insulated and installed in its own pipe.

IMPORTANT NOTE:

Even though the lines are insulated, too much heat transfer loss (short-circuiting) may occur if both the liquid and the vapor lines are installed within a single longer pipe segment. Protective piping is recommended for shallow trenches and for installations that will be located under pavement or traffic. If location is in a high traffic area, use steel pipes. PVC piping only provides light protection from gardening, etc.

- If the trench is backfilled with a flowable fill material (such as Grout 111), the insulated, horizontal lines within the trenches will tend to "float" out of the heavy fill material. If flowable fill material is used to backfill (all or a portion of the trench), the insulated refrigerant lines must be secured to the bottom of the trench with added weight or with 1 ft (300 mm) long crossed nail spikes, typically placed at 4 ft (1.2 m). intervals.
- If more than one set of refrigerant lines share the same trench, the individually insulated liquid lines must be placed on one side of the trench, and the individually insulated vapor lines must be placed on the opposite side of the trench.

IMPORTANT NOTES:

Always keep the liquid lines separated, to the greatest extent possible, from the vapor lines. This also applies to all interior line sets. Do not tape the insulated vapor line and the insulated liquid line tightly together, as is a common trade practice for aesthetics. Leave an air gap in between the liquid lines and the vapor lines to prevent a short-circuiting of heat transfer.

When two or more line sets are placed in the same vicinity, keep all the individually insulated liquid lines together, and all the individually insulated vapor lines together, to the greatest extent possible. Multiple insulated liquid refrigerant lines may be taped together, and multiple insulated vapor refrigerant lines may be taped together, but liquid and vapor lines may not be taped together.

- When running line sets through a wall, a 4 inch (100 mm) PVC pipe is recommended for one insulated line set, and a 6 inch (150 mm) PVC pipe is recommended for two insulated line sets. If more than two insulated line sets are to use a common wall entry point, it is recommended that all insulated vapor lines go through one PVC pipe of sufficient size, and that all insulated liquid lines go through another separate PVC pipe of sufficient size. This assists in avoiding "short-circuiting" heat transfer between the lines.

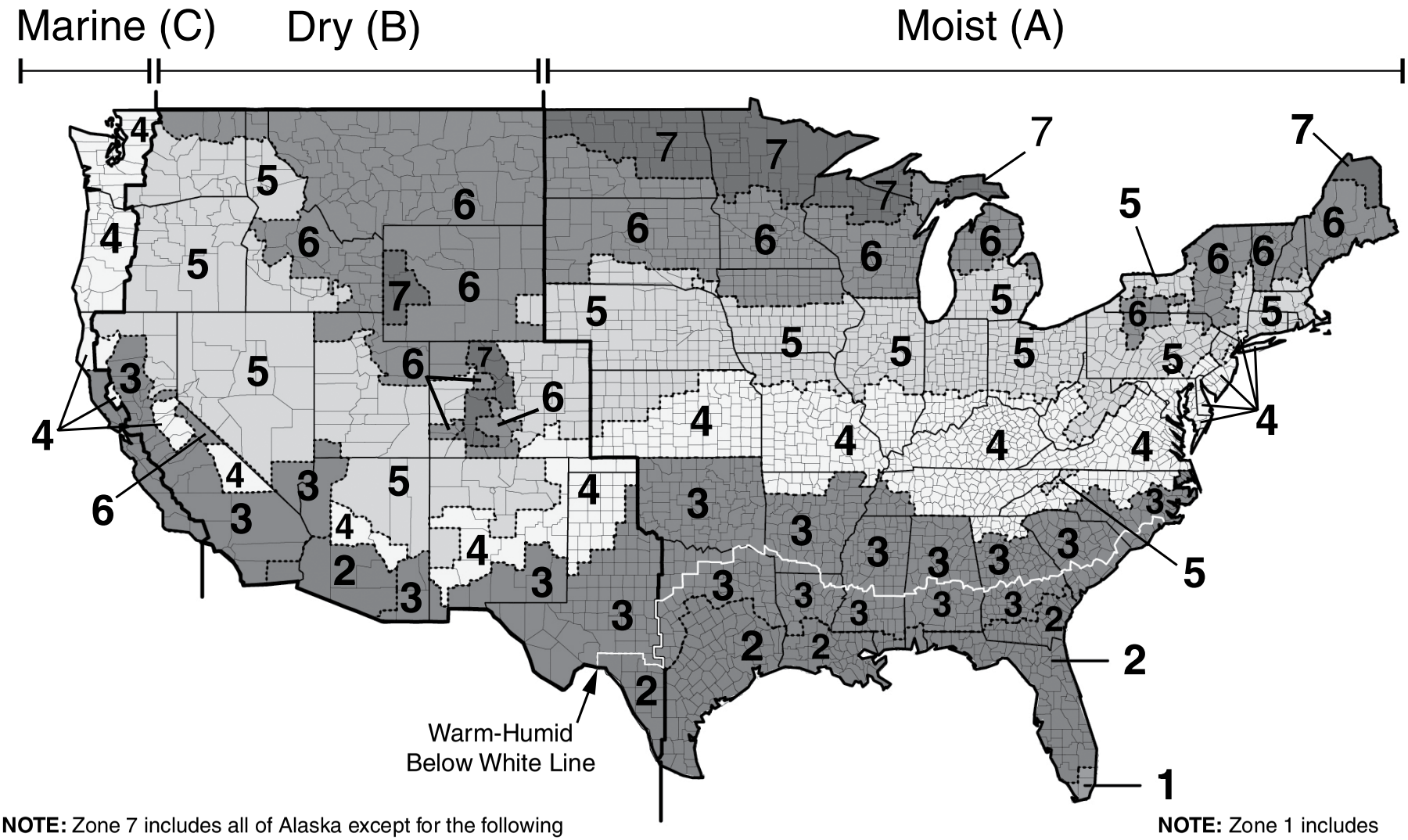

Figure 1. Climate Map

NOTE: Zone 7 includes all of Alaska except for the following burroughs in Zone 8: Bethel, Northwest Arctic, Dellingham, Southeast Fairbanks, N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope.

IECC ZONES	EARTH LOOP SIZE (FT/TON)
1, 2, 3A, 3B	100
3C, 4A, 4B	80
4C, 5, 6, 7, 8	65

There are exceptions to the earth loop sizes shown in this table. Within a climate zone, the weather, and underground conditions vary from place to place. The earth loop length may need to be adjusted accordingly.

Earth loop size indicated in the table assumes installation within bedrock or permanently water saturated ground.

NOTE: Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands

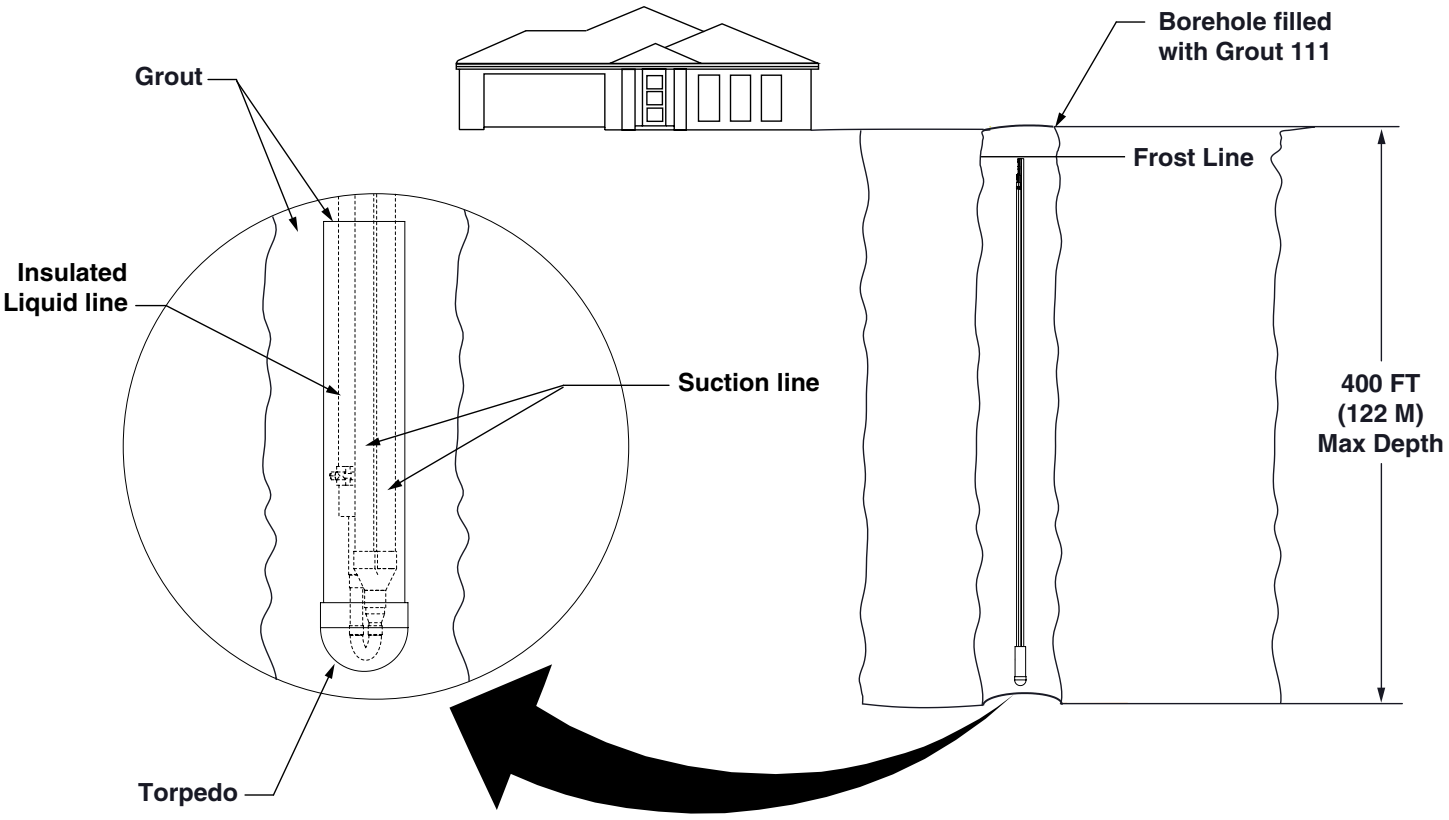

Figure 2. Vertical Borehole with Earth Loop

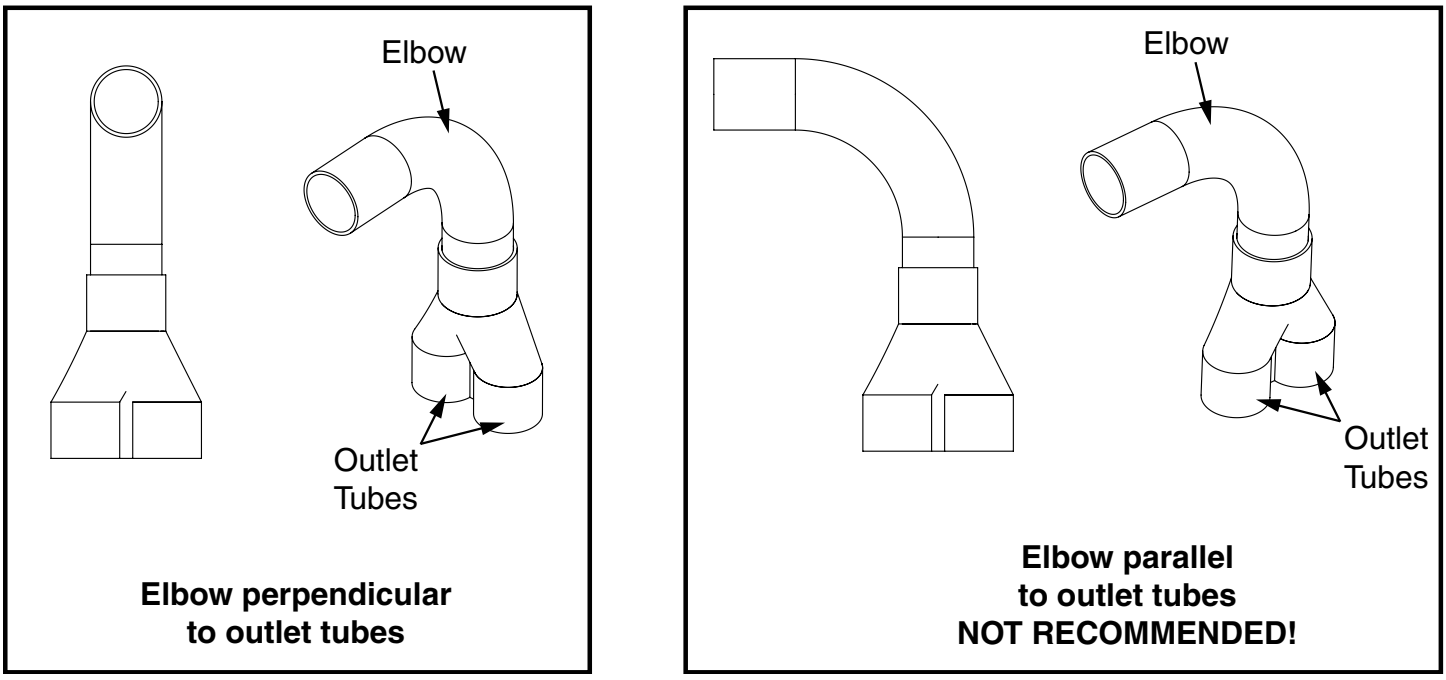

Figure 3. Outlet Tubes

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