

***GeoPro, Inc.***

**THERMAL GROUT COMMISSIONING &  
QUALITY ASSURANCE**

[www.geoproinc.com](http://www.geoproinc.com)

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# THERMAL GROUT COMMISSIONING & QUALITY ASSURANCE

There is always some uncertainty involved in the final installation of a loopfield. Was the pipe properly fused? Was the right thermal grout used? Were the bores grouted properly? There is a never-ending list of potential problems that, by design, are buried when a geothermal system is installed.

The selection, mixing and placement of thermal grout is too often a secondary consideration, despite the fact that thermal grout is one of the most critical components to geothermal loopfield installations. It is the bridge between the pipe and the Earth and facilitates heat transfer between the two. The grout thermal conductivity value chosen by the designer directly affects the performance of the system and has a huge impact on first cost. So, it is worth your time as the design engineer to consider ways of improving the likelihood that the loopfield will perform as intended.

This document is intended to serve as a road map for ensuring the success of your system through the design and installation process from a grouting perspective. We will take you through an overview of the documentation that you should provide during the planning stages of the project and the sampling/testing requirements for the installing contractor to follow during installation.

These recommendations are based on our own experience as design engineers and as grout suppliers that work directly with the boots on the ground. Following these recommendations will decrease the need to interpret the 'intent of a design' in the field and will save you time, money and a lot of worry... it might even get a contractor to smile.



## PLANNING AND DOCUMENTATION

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Arguably, the most important part of the design phase is final documentation. Learn what to include in detail drawings, specifications and product submittals to ensure that everyone is on the same page prior to beginning work.

## INSTALLATION AND TESTING

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Once installation begins, the contractor needs to take samples and submit the proper documentation so you can monitor progress and verify that project specifications are met. Understanding the advantages and disadvantages of the various sampling methods at your disposal can save everyone on the project time, money and frustration.

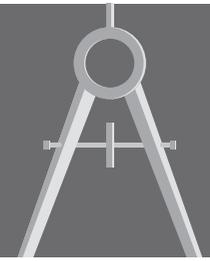


## INFORMATION AND RESOURCES

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Take advantage of the tools we have created to simplify your work. GeoPro has an extensive library of calculators, forms, reference documents and other resources to increase your understanding of all things thermal grout.

# PLANNING AND DOCUMENTATION



## PRE-CONSTRUCTION: DOCUMENTATION

The first step toward a successful installation occurs before work begins. As a system designer, you must provide clear documentation – specifications and detail drawings. There should be no question in the installing contractor's mind as to what you are asking for, both in terms of finished product and quality control during installation in the field.

### PROVIDE CLEAR DETAIL DRAWINGS

Your set of mechanical drawings should always include a bore detail drawing for the loopfield, among other things. At minimum, the bore detail drawing should clearly show:

1 IN IPS-OD HDPE PER SPECIFICATION

MINIMUM BORE DEPTH

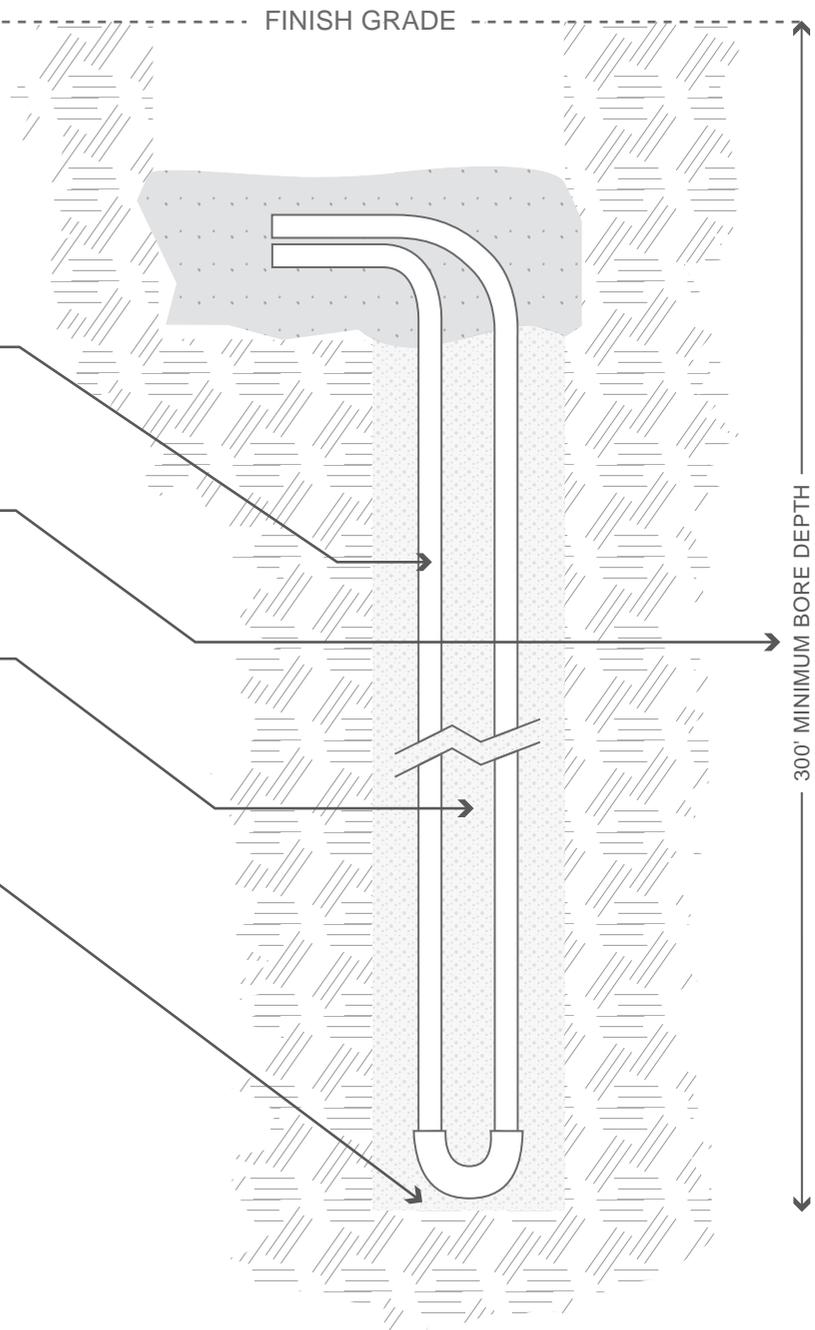
THERMALLY ENHANCED GROUT ( $k=0.88$  Btu/hr-ft-F) FROM 0' - 300' PER SPECIFICATIONS

5-6 INCH BORE DIAMETER

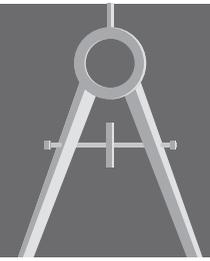
UNDISTURBED FORMATION

SAND BACKFILL

GROUT



# PLANNING AND DOCUMENTATION



## PROVIDE CLEAR PROJECT SPECIFICATIONS

In addition to providing detail drawings that are effective and understandable, your specifications need to be clear. Regarding grouting products and the installation process, your specifications should at least require:

- Certification and listing by the National Sanitation Foundation to ANSI/NSF Standard 60 to ensure that the grouting materials themselves don't pose a risk to human health.
- Determination of published TC values according to the industry-accepted testing methods.

## IGSHPA RECOMMENDS

IGSHPA formally recognizes ASTM D-5334, "Standard Test Method for Determination of Thermal Conductivity of Soils and Soft Rock by Thermal Needle Probe Procedure" as the only acceptable testing method for determining the TC of bentonite-based grouting products.

- Permeability less than  $1 \times 10^{-7}$  cm/sec, again as determined by industry-accepted testing methods.

## IGSHPA RECOMMENDS

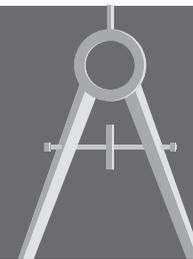
IGSHPA formally recognizes ASTM D-5084, "Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter, Method C - test with increasing tailwater level" as the only acceptable method for determining the permeability of bentonite-based grouting products.

- Product submittal information for the grouting product being used, which is a manufacturer's statement that guarantees a certain level of performance from the selected product.
- Field inspection of delivered product via random sampling and testing, which verifies that the contractor is installing the product per your specifications.

As part of your specifications, it is best to require full-length grouting in the bore to ensure thermal contact between the pipe and the Earth, which will maximize heat transfer and provide proper groundwater protection. Grout should be placed via pressure-tremie placement methods, filling the bore from bottom to top. However, before you write your specifications, make sure that they adhere to state and local code requirements. Grouting regulations can vary significantly, depending on where the project is located.



# PLANNING AND DOCUMENTATION



## REQUIRE PRODUCT SUBMITTALS

As the designer, it is your responsibility to make sure that the design meets the needs of the structure. As such, all aspects of installation need to be reviewed. Verify that the appropriate materials and installation methods are used according to industry-accepted standards and practices.

To confirm that a given product will meet the design requirements, you should ask for submittal sheets for each product/material that is to be used. Most submittal sheets include:

- Manufacturer, product and/or trade name.
- Engineering properties such as thermal conductivity, permeability, %-solids and mud weight (density, lb/gal).
- Instructions for use, including the exact recipe, along with mixing & pumping instructions.
- Sample submission information for field quality control.

Requesting product submittals will do two things. First, because a submittal is a manufacturer's statement that guarantees a certain level of performance from a given product, you will have something to fall back on in the event that it does not perform as advertised. Second, asking the installing contractor for submittals will ensure that they choose a product that will meet or exceed your specifications.

If you don't want to leave product selection up to the contractor, you can directly provide a list of acceptable products in your specifications. Doing so will eliminate any confusion as to which product is appropriate for your project.

### Thermal Grout Select (1.20 Btu/hr ft °F) PRODUCT SUBMITTAL INFORMATION



Materials are supplied by GeoPro, Inc. and are mixed according to the following specifications, Thermal Grout Select bentonite-based grouting material with a minimum thermal conductivity of 1.20 Btu/hr ft °F.

Conformance to ASTM D-5334, "Standard Test Method for Determination of Thermal Conductivity of Soils and Soft Rock by Thermal Needle Probe Procedure."

| Thermal Conductivity (Btu/hr ft °F) | Silica Compound (lb) | Fresh Water (gal) | Yield (gal) | Density (lb/gal) | % Solids (by weight) | % Silica (by weight) |
|-------------------------------------|----------------------|-------------------|-------------|------------------|----------------------|----------------------|
| 1.20                                | 400                  | 21.6              | 42.2        | 14.93            | 71.4                 | 63.5                 |

Thermal Conductivity values are based on using a silica compound supplied by GeoPro, Inc.

GeoPro grouts are shipped on heat shrunk 54 bag pallets.

#### INSTRUCTIONS

Mix in a conventional paddle mixer with required volume of fresh water (according to mix table).

Run mixer and add a bag of TG Select (part I). Mix for 1 minute.

Then add required weight of Silica Compound (part II). This should take 1-2 minutes.

When all Silica Compound is added, continue to mix for an additional 1-2 minutes.

#### PUMPING

Pump with a positive displacement pump (piston pump recommended) through a 1-1/4" inside diameter tremie pipe at a rate of 5 to 15 gallons per minute.

#### WARNING:

Adding more than the specified amount of water may make this product more difficult to pump.

Mix water should be between 50°F and 80°F.

Permeability of this mixture will be equal to or less than  $1.0 \times 10^{-7}$  cm/sec, which has been verified by an independent testing laboratory using Method C-4, "Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter, Method C - test with water level". This permeability is below most state's regulations and the U.S. Environmental Protection Agency's maximum permitted permeability of  $1.0 \times 10^{-7}$  cm/sec. Copies of the independent lab reports are available upon request.

#### QUALITY CONTROL

GeoPro strongly recommends that a field quality control process be employed when using any thermally-enhanced grouting material. Therefore, GeoPro will supply, at no charge, three sample containers with return cartons per commercial quantity of Thermal Grout Select. Through the course of the project, it is recommended that at least three sample containers be taken of the mixed grouting material.

The recommended frequency would be as follows: once at the beginning of the installation; once approximately one-third through the installation; and once approximately two-thirds through the installation. Each time GeoPro receives the sample, a laboratory analysis will be performed in accordance to ASTM D-5334 to verify the specified thermal performance of the material. A written report being sent immediately to the entity requesting the analysis.

For larger projects, additional sample containers can be supplied and analyses performed for a modest fee.

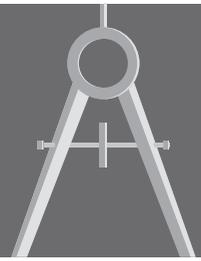
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# PLANNING AND DOCUMENTATION



## REQUIRE INDEPENDENT VERIFICATION OF ENGINEERING PROPERTIES

It is critical that each product does in fact perform as advertised. That's why we believe in unbiased, independent verification of the engineering properties that we publish for our products. We won't publish anything unless it has been corroborated by an outside firm.

Third party verification is so important that it's formally called out by the IGSHPA Standards committee in section 2B.1.2 of their Design & Installation Standards manual.

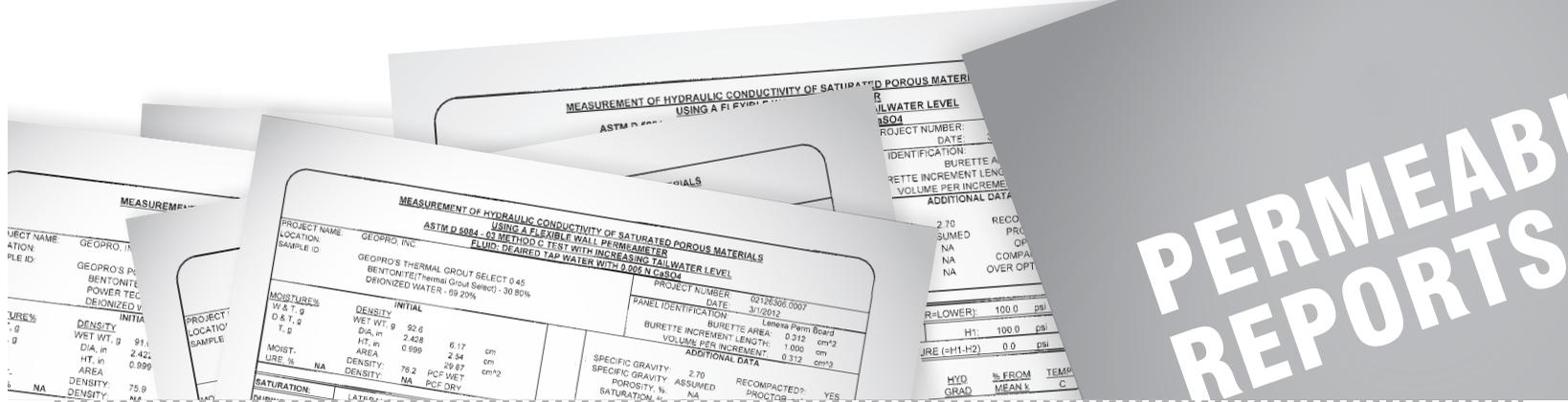
## IGSHPA RECOMMENDS

In Standard 2B.1.2.3, IGSHPA requires that all reported thermal conductivity values are verified by an independent company which has a minimum of 5 years' experience in testing according to ASTM D-5334.

Additionally, IGSHPA requires that all reported permeability values be verified by an independent lab which has been certified by AMRL (American Association of State Highway & Transportation Officials, Materials Reference Laboratory) and validated by the US Army Corps of Engineers by using ASTM D-5084.

To date, we are the only grout supplier that uses a third party lab to verify our published values. By subjecting our products to the scrutiny of independent testing, our products are guaranteed to perform as advertised. We are happy to provide copies of the independent lab reports upon request.

As a system designer, you should make sure that the engineering properties of any material being used have been verified by a qualified, independent testing facility.



# INSTALLATION AND TESTING



## GROUT COMMISSIONING AND QUALITY CONTROL

Commissioning and Quality Control (QC) should be an integral part of the system installation process. Simply put, these methods allow you to make sure that the installation matches up with what you put down on paper during the design phase.



### AVOID THE OBVIOUS HAZARDS

There are three common hazards on the road to meeting design specifications for thermal grout performance. Understanding each will enable you to avoid delays and decide on corrective action in the event that testing exposes a problem.

#### CHOOSE THE RIGHT PRODUCT

This goes without saying, but the right product needs to be selected for the application. A contractor will be in trouble from the start if they try to mix BH20 with 400 lb. of silica sand in an attempt to reach a 1.20 Btu/hr-ft-°F grout thermal conductivity (TC) value. By requesting product submittals before beginning work, you will have already made sure that the contractor selected the right product.

#### USE AN APPROVED THERMAL ENHANCEMENT COMPOUND

For thermal grout applications, thermal enhancement compounds (TECs) are necessary components. TECs typically come in two forms - silica sand or graphite (PowerTEC<sub>x</sub>) and are used to raise the thermal conductivity of the grout slurry to the desired value.

Even when our mix recipes are followed exactly, the contractor will only reach a specific grout TC value if they use an approved TEC. PowerTEC<sub>x</sub> are packaged under GeoPro's quality control standards and are approved for use with GeoPro's thermal grouts.

For silica sand to be approved for use with GeoPro thermal grouts, its silica dioxide content must be greater than 99.0%. The grade of sand used must have an appropriate particle size distribution and should be washed, dried and prepackaged. GeoPro will test silica sand samples at no cost to ensure minimum specifications are met.

#### CHECK THE MIXING PROCESS

To reach a given grout TC value, the individual components (thermal grout, TEC and mix water) need to be mixed in the correct ratio. Assuming that the right grouting product and TEC are being used, delivering a specific TC value is a matter of counting bags and accurately measuring mix water volume according to our recipes. There are several ways to determine if the contractor is mixing thermal grout in the right ratio to meet project requirements.

During the commissioning process, when verifying that loop depths, bore spacing, trench compaction, pipe fusion procedures, etc. all meet your specifications, there are a few steps to take in order to make sure that the grouting products and installation processes are acceptable. These include: material usage reports, mud balance testing and sample TC testing.

# INSTALLATION AND TESTING



## GROUT INSTALLATION AND MATERIAL USAGE REPORT

It is good practice to ask the contractor to submit a report that provides grout type, installation procedure and the material usage for the project. The report should include:

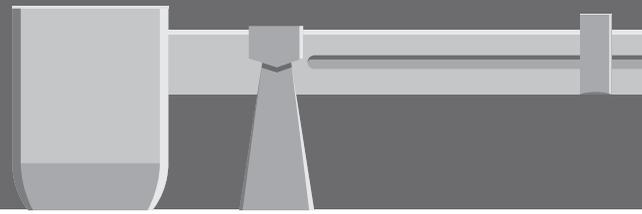
- Project name and location
- Contractor name and contact information
- Grout placement method / equipment used
- Estimated project material requirements, based on volume calculations
- Actual project material usage, based on simple bag count

As previously explained, delivering a specific grout TC value is a matter of counting bags and accurately measuring mix water volume. This report would provide a quick look at the project to determine if the contractor used the right recipe to reach the desired TC value. From a material usage report, look for a few things:

1. The ratio of bags of thermal enhancement compound to bags of thermal grout - this should be in correct proportion according to the recipe that was used.
  - For example, if TG Lite 88 with silica sand (Target TC = 0.88 Btu/hr-ft-°F) was used for your project and the contractor used 200 bags of TG Lite, they also should have used 800 bags of sand as our recipe calls for a 4:1 sand to TG Lite ratio.
2. The total amount of material used during installation should be close to the estimated requirements based on volume calculations. Don't expect an exact match, but be aware of what major variations might indicate.
  - If the amount of material used was considerably less than the estimated volume requirements, the contractor may have overwatered the grouting mixture, had issues with bore collapse or failed to insert the tremie line all the way to the bottom of the bores. You will want to determine the cause for the discrepancy and from that point, decide if corrective action is necessary.
  - If the amount of material is considerably more than the estimated volume requirements, the contractor may have underwatered the mixture (which would boost grout performance) or may have had issues with formation losses. In either event, you will want to determine the cause as a change order may be coming your way. If the overage was due to formation losses and out of the installer's control, the change order will be necessary to compensate them for the additional material that was required.

For smaller projects, a single report that provides this information for the entire loopfield installation will probably be sufficient. For large projects, it is best to ask the installer to submit a report periodically (i.e. – on a daily, weekly or monthly basis). Just keep in mind that the longer you allow them to wait to submit a report, the more likely they are to forget what they actually did during that time period. Periodic reporting will allow you to narrow down the potential causes if/when an error actually occurs.

# INSTALLATION AND TESTING



As part of the grout installation process, you should also require that the contractor occasionally collect grout samples to be tested. There are two different ways to test grout samples that are collected in the field. The first is to measure mud weight, or density with a mud balance and the second is to send the samples to our lab where we directly measure TC value.

## FIELD TESTING WITH A MUD BALANCE

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Delivering a specific grout TC value is matter of mixing the correct components according to our recipe. Measuring the density of a grout sample is a quick and easy way to determine if the mix ratios are where they need to be.

A mud balance, also known as a mud scale, is used to measure the density of any type of liquid or slurry. It is a scale that consists of a graduated beam with a bubble level and a weighted slider along its length. To take a measurement, you fill a cup on the end of the scale (which has a known volume), and measure its weight. Because you know the weight and volume of the material in the cup, you can quickly determine its density.

Our product submittal sheets and our mix tables provide the mud weight or density (lb/gal) for each recipe. Here are a few things to remember with mud balance testing:

- ⊕ **Proper sampling is critical.**
- ⊕ To get accurate readings, the cup on the mud balance itself needs to be completely full. When taking readings, the contractor must also remember to clean off the outside of the cup to reduce measurement error.
- ⊕ Mud balance testing is a great way to monitor the grout mixing process and get immediate feedback from the field.
- ⊕ With mud balance testing, you are only verifying that the components are being mixed in the correct ratio.
- ⊕ Mud balance testing does not provide a direct measurement of grout TC, so you still need to ensure that the right product and additive have been selected for the project.

If the density readings with a mud balance match up with our published values, all is well in the world. If the density readings are significantly lower than published values, it could mean one of three things:

1. The ratio of thermal enhancement compound (TEC) to bentonite is incorrect. If this is the case, the contractor will need to adjust the amount of TEC being added to the mixture to match our recipe.
2. The grout is being overwatered. If this is the case, the contractor needs to adjust mix water volume to match our recipe.
3. The contractor is not taking a good sample. For example, if they skim off the top of the mixing tank to collect the sample, the density reading will be lower than it should be. Make sure that the contractor follows our guidelines to collect a representative sample.

Mud balance testing will help the contractor fine-tune the mixing process and verify that their water volume measurements are accurate. Once the mixing process is refined and well understood, repeatable results are relatively easy to get (measure the water and count the bags). Because of this, it's not usually necessary to ask the contractor to take a measurement on every batch or every bore.

# INSTALLATION AND TESTING



## LAB TESTING TO MEASURE SAMPLE TC

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To confirm that everything is coming together as it should (the contractor is using approved products and additives as well as properly mixing them together in the field), sample TC testing is a must. Sample TC testing will provide a direct measurement of the conductivity of the grout as mixed in the field.

However, to perform sample TC testing is a bit more involved:

- Contact GeoPro to request grout sample containers. Note that you must use our containers as they have been properly sized for our testing equipment.
- Take a sample using the process described on our website and in our Product Handling Guide, filling the provided sample container completely to the top.
- Send the sample to our lab using the provided box along with the completed Thermal Conductivity Analysis Sample Submission Sheet. Make sure that the Sample Submission Sheet is completely filled out, including project name and location, contact information for the recipient of the test results and preferred delivery method for the report.
- Once the test results are available, we will send them using the preferred delivery method.

## THINGS TO REMEMBER ABOUT GROUT SAMPLE TC TESTING

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- Proper sampling is critical. If test results do not meet specifications, it doesn't necessarily mean that there was a problem. The contractor could have submitted a poor sample.
- Sample TC testing is the only way to directly measure the thermal properties of the grout being placed in the field.
- Since sample TC testing must be performed in a lab, you will not receive immediate feedback as to whether the product is meeting specifications. For immediate feedback, mud balance testing can be used.
- Because of the delay, sample timing is critical. The first sample must be taken early in the installation process to give adequate time for corrective action when necessary.

If the TC test results match up with our published values, all is well. If test results are significantly lower than published values, it could mean one of four things:

1. If silica sand is being used, the contractor is not using sand from an approved source. GeoPro will test the sand from any source to determine its suitability as a free service to our customers.
2. The ratio of thermal enhancement compound (TEC) to bentonite is incorrect. If this is the case, the contractor will need to adjust the amount of TEC being added to the mixture to match our recipe.
3. The grout is being overwatered. If this is the case, the contractor needs to adjust mix water volume to match our recipe.
4. The contractor is not taking a good sample. For example, if they skim off the top of the mixing tank to collect the sample, TC measurements will be lower than they should be. Make sure that the contractor follows the guidelines given in our Product Handling Guide to collect a representative sample.

# INSTALLATION AND TESTING

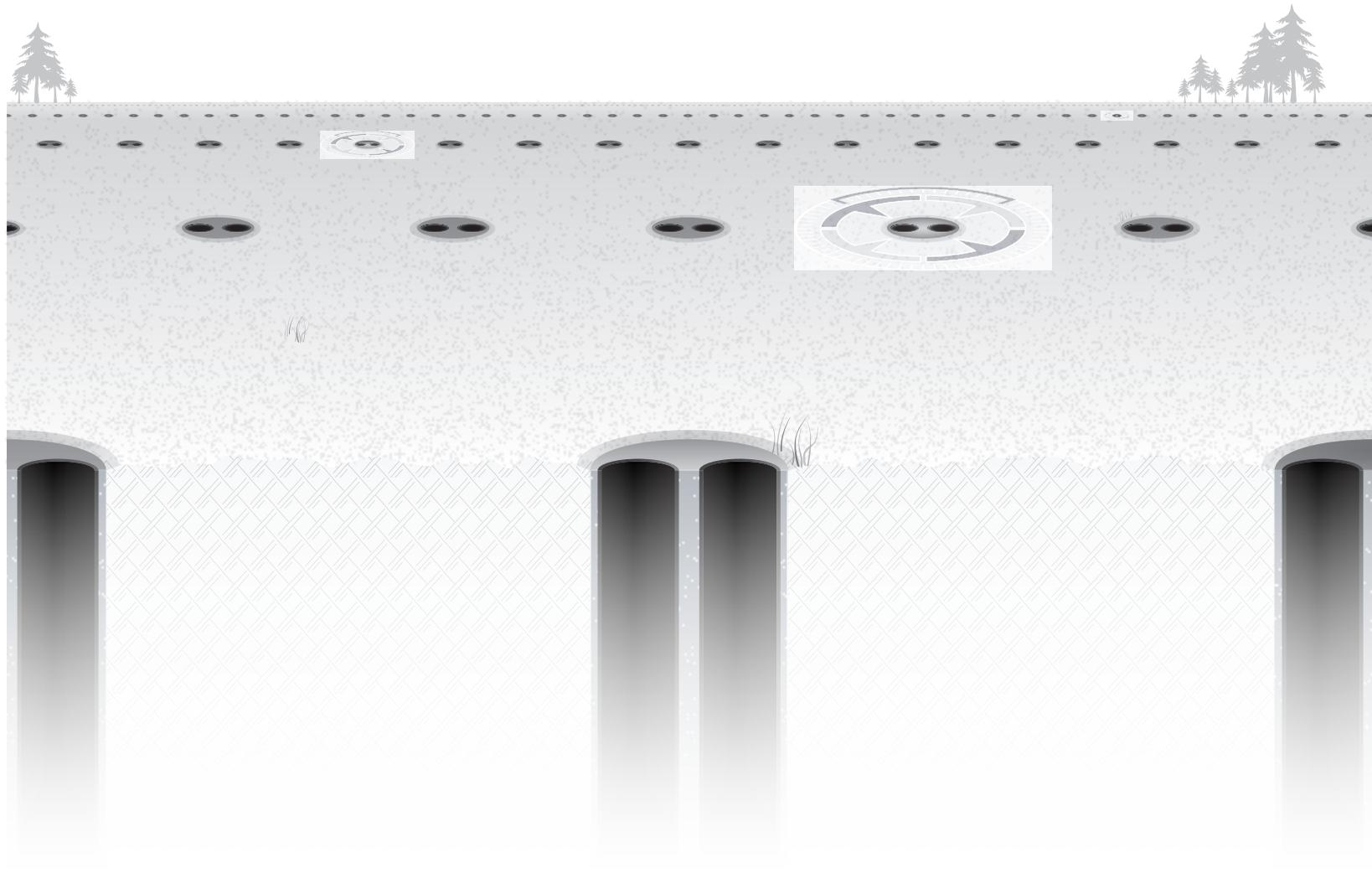


## HOW OFTEN SHOULD I CHECK MY GROUT TC?

A big question is how often to require the contractor to submit samples for testing. GeoPro recommends taking a minimum of three samples for an average commercial project (~50 bores). We recommend once at the beginning of the project, once at approximately one-third of completion, and finally at approximately two-thirds of completion. However for larger projects, three samples may not be sufficient. In those situations, we recommend three samples per 50 bores to make sure that the grouting process stays on track through the project's entirety.

It is important to note that sample TC testing is not intended to be a way of policing each and every batch that is pumped for a given project. It is meant to serve as a spot check to ensure that the product is performing according to manufacturer's specifications and that the contractor is properly mixing the product in the field. We've already mentioned this, but it is worth repeating. Once the mixing process is refined and well-understood, repeatable results are easy to get (measure water and count bags).

A better and much simpler method to monitor the entire grouting process is to use the Material Usage Report. By simply filling out this form, the contractor will be able to track their progress and confirm that the right amount of material is being used.



# INFORMATION AND RESOURCES



GeoPro has collected a lot of useful information throughout our years in the geothermal industry. Our resources are here to shed some light on topics like grout selection, ground heat exchanger design and just generally useful bits of information for geothermal system installers and designers. All of this information can be found in the resources section on our website at: [www.geoproinc.com](http://www.geoproinc.com).

## PRODUCT HANDLING GUIDE



Learn how to select and handle the correct GeoPro grout. This document is a great resource for designers and contractors.

[geoproinc.com/resources/product\\_handling\\_guide.html](http://geoproinc.com/resources/product_handling_guide.html)

## THE IMPORTANCE OF GROUT TC



This informative guide explains how choosing the correct grout thermal conductivity value can save a lot of money on your next geothermal system design.

[geoproinc.com/resources/importance\\_of\\_grout\\_tc.html](http://geoproinc.com/resources/importance_of_grout_tc.html)

## PRODUCT SUBMITTAL SHEETS



Submittals provide proper mixing and pumping instructions for every thermal grout product we sell with all the specifications for accurate loopfield grouting.

[geoproinc.com/resources/documents.html#submittals](http://geoproinc.com/resources/documents.html#submittals)

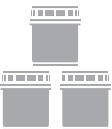
## RECOMMENDED GROUTING SPECS



Suggested specifications for the correct materials, target thermal conductivity, proper installation and inspection of each borehole.

[geoproinc.com/resources/documents.html#specs](http://geoproinc.com/resources/documents.html#specs)

## SAMPLING GUIDELINES



Accurate grout thermal conductivity testing results for geothermal applications start in the field with proper sampling.

[geoproinc.com/services/grout\\_sample\\_collection\\_101.html](http://geoproinc.com/services/grout_sample_collection_101.html)

## GROUT VOLUME & COST CALCULATOR



This calculator will allow you to estimate the installed volume of grout required for your project, help to estimate total project costs including: material, freight and labor.

[geoproinc.com/calculators/grout\\_calculator.htm](http://geoproinc.com/calculators/grout_calculator.htm)

# CONTACT

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