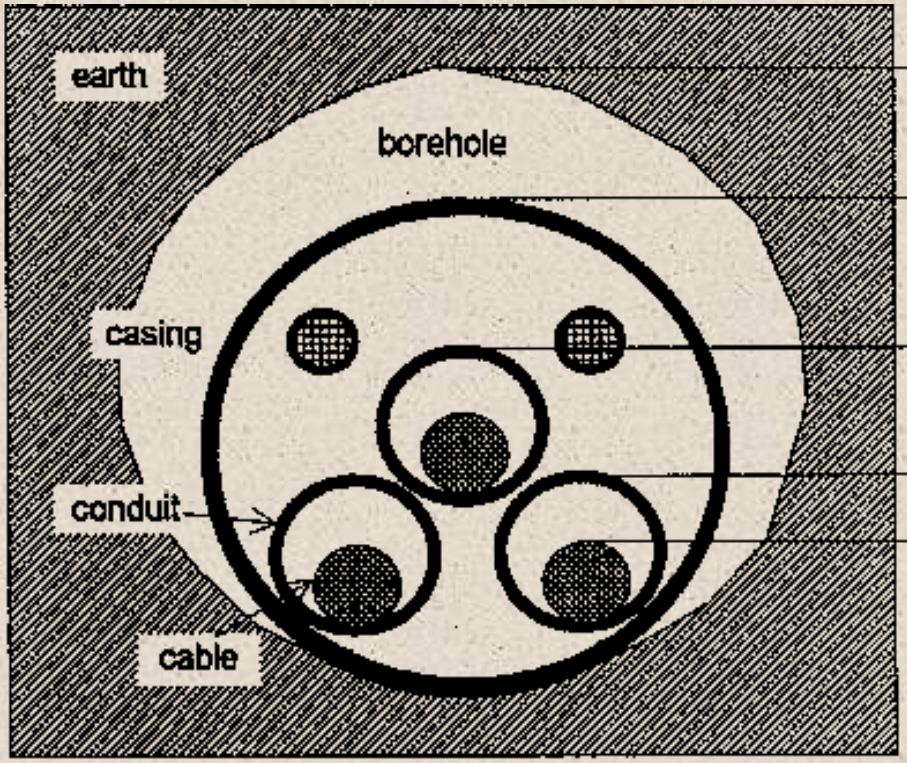
THERMAL GROUTS FOR POWER CABLES IN HDD INSTALLATIONS

Power cables installed in casing in HDD bores are de-rated because of :

1. **the large volume of air surrounding the conduits and cables in the casing – this is the largest contributing factor because of its proximity to cables and very high thermal resistivity (don't count on convection)**
2. **the air gap between the casing and the native soil**
3. **deeper burial depth**
4. **thermal resistance of various components – conduits casing, spacers, etc. (HDPE or PVC)**

(that's what you cable engineers tell us !!!)



Clearance for drilling (20-50%) Can be filled with thermally improved drilling mud

Clearance for installing conduits in casing - Can be filled with modified FTB or cement based thermal grout

Clearance for installing cable in conduit – Can be filled with non-hardening type grout or slurry

Air spaces add to the total thermal resistance of the circuit. If these are filled with a low thermal resistivity material, the thermal resistance will be lowered and the cable Ampacity will increase

A wide range of grouts are used in the construction (civil) industry for specific purpose; employing various installation techniques:

1. **Injection or Pressure Grouting: chemical or cement based grout to fill-in fine cracks and voids to solidify the material – fissures in rock, crack and voids in concrete and soil, it seals and reduces permeability**
2. **Consolidation Grouting: cement , bentonite, flyash and sand based grouts to fill-in large voids and to consolidate the material, it can also lift foundations of structures**
3. **Pumpable Grout (hardening and non-hardening type): cement, bentonite, flyash, sand or silica-flour based grouts of low thermal resistivity, engineered strength and good flow characteristic**

For power cable applications: thermal, strength, flow (viscosity), density, segregation/settlement, rate of hardening and heat of hydration are some of the parameters that must be considered

What are the prime requirements ?

1. low thermal resistivity
2. compressive strength
3. high fluidity (low time of efflux)
4. low heat of hydration
5. slow rate of hardening
6. no segregation or settlement

DO NOT USE ANY AIR-ENTRAINING AGENT OR LIGHT-WEIGHT MATERIALS

HEAT OF HYDRATION CAN CAUSE DEFORMATION, COLLAPSE AND EVEN MELTING OF CONDUITS AND COMPONENTS

EXCESSIVE PUMPING PRESSURE CAN BURST/BREAK GROUT PIPE AND CONDUITS AND CAN ALSO RESLT IN GROUT SEGREGATION AND PLUGGING GROUT PIPE

END RESULT - ENTIRE INSTALLATION MAY BE LOST

SOME IMPORTANT FACTORS

1. Length of the HDD installation
2. Total surface area of all components; including casing
3. Number of spacers and net opening
4. Change in elevation
5. Diameter of grout pipe
6. Limiting pumping pressure for conduits and joints
7. Limiting hydrostatic pressure
8. Total volume to be filled-in
9. Type of pumps (rate of pumping and maximum surge pressure)
10. Method of pumping (one end, both ends, multiple grout pipes, tremie, etc.)
11. Quality control and assurance during the construction phase

VOLUME – PRESSURE – RATE OF PUMPING

These 3 parameters are related

Example:

For a given volume to be pumped, the rate of pumping will develop a certain pressure. If this is higher than the 'safe' pressure for any of the components, there will be problems (collapse, burst or joint failure)

To keep within the pressure limits, the rate of pumping must be reduced. This will result in longer time to pump the same volume.

This extended time may not be acceptable for a grout mix that may start to hydrate (gel or set) and result in plugging the grout pipe

Every installation is different and therefore the grout must be designed taking into consideration all limiting factors. This is critical for cement-based grout that will set hard and also generate high heat of hydration.

Non-hardening, Bentonite based grout will also gel if allowed to sit for any length of time

GROUT INSTALLATION MUST BE A CONTINUOUS PROCESS FROM START TO FINISH stoppage; even for short time will require higher pumping pressure on re-start (inertia, change in viscosity, settlement, increase in back-pressure, etc.)

THERMAL GROUT DESIGN

1. **Low thermal resistivity can be achieved only by having high % of solids – water has resistivity of ~1.65 K-m/W and that of sand is ~0.4 K-m/W. The difference in the specific gravity (1 vs. 2.65) results in segregation; thus a water thickening agent (Bentonite or similar) may be required and this may adversely affect the strength. If the annular space is restrictive, sand can be replaced with a finer material such as silica flour. The thermal resistivity will increase somewhat but this may be the only option. Addition of metallic powder and graphite have been investigated but considered 'not practical' for general use because of the high cost**
2. **Strength is a function of the quantity of cement and the water:cement ratio. High quantity of cement helps to lower thermal resistivity and minimize segregation (finer particles). Major concern: HEAT OF HYDRATION and rate of hardening. Ad-mixtures and special type of cement can be used to mitigate.**
3. **Fluidity (time of efflux – ASTM flow-cone test) is the most important parameter for the grouter. Flow is the function of the quantity of water. Time of efflux of water is 8.3 seconds and grouts with a time of efflux of 20-40 seconds are considered 'easy to pump'. However; time and maximum pumping pressure are the governing factors**
4. **Slurry density is a function of the total weight/unit volume. Higher density will give lower thermal resistivity but will require higher pumping pressure and therefore, rate of pumping and rate of hardening of the grout are crucial**

Thermal and mechanical parameters of the conduit and casing must also be taken into considered

Designing a thermal grout is a relatively a simple task if only 1 or 2 parameters are to be satisfied. In most cases there are numerous parameters and the most important factor/player is the 'GROUTER'

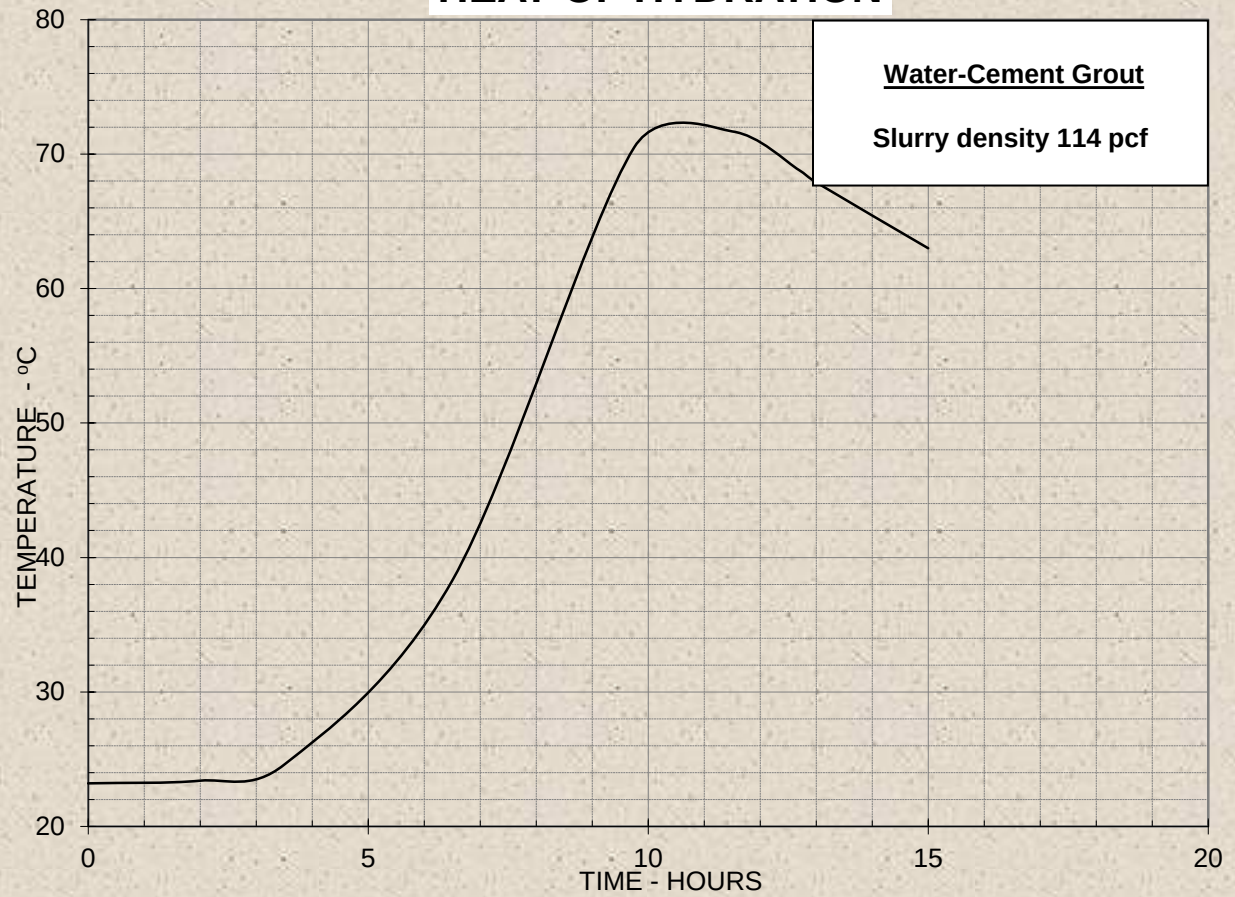
Similar to designing and manufacturing a cable in a sophisticated, high-tech, quality controlled facility, a thermal grout can also be designed to satisfy all the thermal and mechanical requirements. However, if for any reason it is not installed properly, the desired performance will not be achieved and in the worst case the entire installation will be lost. With a cement based grout, you get only ONE chance to do it RIGHT.

THERE ARE OPTIONS AND MEANS FOR MITIGATION OF HEAT OF HYDRATION, PUMPING PRESSURE AND OTHER ISSUES

KNOWLEDGE, EXPERIENCE & EQUIPMENT ARE THE KEY WORDS

A TRIAL RUN AND A SCALED DEMONSTRATION IS A MUST

HEAT OF HYDRATION



HEAT OF HYDRATION

Cement based Thermal Grout

February 2010 **River Crossing**

Figure 1


FORNEY


1/2"


1/2"


1/2"


ADVA
FLOW

Time	S #1	S #2	S #3	S #4	S #5
200	28.21	28.21			
TR	64	63			
TC	1.552	1.577			
CD	0.999	0.998			
220	28.34	28.34			
TR	65	64			
TC	1.547	1.572			
CD	0.998	0.998			
241	28.46	28.46			
TR	65	64			
TC	1.542	1.567			
CD	0.998	0.998			


USA


Putzm


PIONEER


Putzmeister
TK 40


160LC


ATLANTA SAND
AND SUPPLY
COMPANY


DEERE
Tucco
TEREX


DEERE
TUCCO
160LC
ATLANTA SAND AND SUPPLY COMPANY
SHORING


SUNBELT
RENTALS
PUMP, POWER &
TRENCH SHORING

THERE IS A DETAILED SECTION ON 'GROUTING' IN

THE GUIDE FOR TRENCHLESS TECHNOLOGY APPLICATIONS FOR UNDERGROUND CABLES

PS: Don't forget to give a BIG HUG to your grouter if he has done a good job !!!

Any Questions ?