SECTION 23 2113.33 - GROUND-LOOP HEAT-PUMP PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:
1. Heat Exchanger
2. Materials
3. Thermally Enhanced Bentonite Grout
4. Horizontal Backfill Material
5. Polyethylene Valve Vault

1.2 RELATED SECTIONS

A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

B. In addition, reference the following:
1. Division 31, Earthwork
2. Section 23 21 13 - HVAC Piping
3. Section 23 23 00 - Refrigerant Piping
4. Section 22 30 00 - Plumbing Equipment

1.3 REFERENCES AND STANDARDS

A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the current edition of the following:
1. 49 CFR 192.285 - Plastic Pipe: Qualifying Persons to Make Joints; current edition.
2. APHA (EWWW) - Standard Methods for the Examination of Water and Wastewater; American Public Health Association.
3. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications, Chapter 32, Geothermal Energy; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
4. ASTM B 88 - Standard Specification for Seamless Copper Water Tube.
5. ASTM B 88M - Standard Specification for Seamless Copper Water Tube (Metric).
6. ASTM B 280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
7. ASTM D 92 - Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester.
8. ASTM D 1177 - Standard Test Method for Freezing Point of Aqueous Engine Coolants.
9. ASTM D 2447 - Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.
10. ASTM D 2683 - Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
11. ASTM D 2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.

12. ASTM D 3035 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
13. ASTM D 3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
14. ASTM D 3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Material.
15. ASTM F 714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
16. ASTM F 1055 - Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
17. ASTM F 1105 - Standard Test Method for Preparing Aircraft Cleaning Compounds, Liquid-Type, Temperature-Sensitive, or Solvent-Based, for Storage Stability Testing.
18. EPA 712-C-02-190 - Health Effects Test Guidelines OPPTS 870.1100 Acute Oral Toxicity; United States Environmental Protection Agency.
19. IGSHPA (GROUT) - Grouting Procedures for GHP Systems; International Ground Source Heat Pump Association.
20. IGSHPA (GVERT) - Grouting for Vertical GHP Systems; International Ground Source Heat Pump Association.
21. IGSHPA (INSTALL) - Closed-Loop/Ground-Source Heat Pump Systems: Installation Guide; International Ground Source Heat Pump Association.
22. IGSHPA (SLINKY) - Closed-Loop Geothermal Systems Slinky Installation Guide; International Ground Source Heat Pump Association.
23. NFPA 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response; National Fire Protection Association.
24. PPI TR4 - PPI Listing of Hydrostatic Design Basis (HDB), Strength Design Basis, Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe; Plastics Pipe Institute.
25. USGS (FMWQ) - National Field Manual for the Collection of Water-Quality Data; United States Geological Survey; current edition.

1.4 SUBMITTALS

A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, provide:
1. Product Data, Polyethylene Piping: Provide manufacturer's data for piping and pipe fittings, showing compliance with specified requirements.
    a. Provide manufacturer's recommendations for fusion jointing.
    b. Include certification of long term hydrostatic basis, or test reports.
2. Product Data, Heat Exchange Fluid: Provide data showing compliance with specified requirements.
    a. Provide manufacturer's Material Data Safety Sheets.
    b. Provide results of biodegradability studies conducted in accordance with APHA (EWWW):
        1) Statement of ecological behavior.
        2) Total oxygen demand, in pounds of oxygen per pound of fluid.
        3) Percent of fluid degraded in five days.
3. Product Data, Grout and Slurry: Provide information on thermal conductivity of proposed materials.

4. Shop Drawings: Show complete piping layout, water table, water level, depths of excavation, final depths of piping, backfill placement, point of entrance to building, point of connection to equipment, test point locations, and fittings used for joints and connections.
5. Design Calculations: Submit design calculations along with drawings.
6. Pipe Samples: Provide one 2-inch length of pipe in selected size.
7. Soil and Rock Samples: Provide one sample from the area of proposed installation.
8. Geoexchange Sample Test Bore Reports:
    a. Thermal Response Testing: Not less than 80 hours; indicate dates and times on Test Report.
    b. Test Results:
        1) Tested formation thermal conductivity: BTU/(hr. x ft. x degrees F).
        2) Tested undisturbed ground temperature at 100 feet: Degrees F.
        3) Tested borehole thermal resistance: hr. x ft. x degrees F/BTU.
        4) Calculated formation thermal diffusivity: sq.ft./day.
    c. Drilling Results:
        1) Contractor Name:
        2) License Number:
        3) Bore Diameter:
        4) Drilling Technique Used:
        5) Static Water Level:
        6) Productivity Time:
        7) Adverse Drilling Conditions:
        8) Sample Log of Drilling:

Formation Log	**Color**	**Hardness of Formation**	**Depth from (ft.)**	**Depth to (ft.)**
			0	20
			21	40
			41	100
			101	200
			201	400

    d. Vertical Heat Exchanger Installation:
        1) Active depth of installation: ft.
        2) Pipe Type: (See specifications).
        3) Field pressure testing: Pass/Fail.
        4) Pipe diameter and SDR: inches/SDR.
        5) Grout Type: (See specifications.)
        6) Grout volume required to fill grade:
        7) Installation record filed with:
        8) Record identification number:
    e. Testing and Data Collection Procedures: Follow International Ground Source Heat Pump Association (IGSHPA) Standards (latest edition). Identify complete testing procedures in report.
    f. Soil Temperature Measurement: IGSHPA Standards (latest edition).
    g. Provide graphs indicating:
        1) Control quality of testing: Time (hours) versus Temperature (degrees F).

2) Temperature vs. Linear Time: Logarithmic Time (LN(hr)) vs. Temperature (degrees F).
3) Borehole Saturation Time: Time (hrs) vs. Borehole Thermal Resistance.
4) Temperature vs. Time: Test Duration vs. Fluid Temperature (degrees F) over 80 hours.
5) Fluid Delta T vs. Time: Test Duration vs. Delta T (degrees F) over 80 hours.

h. Provide graph depicting heat rate and consistency of power applied to each test. Provide heat development to comply with ASHRAE/IGSHPA recommendations.
i. Thermal Conductivity Calculation: Heat transfer model such as a line source method analysis. IGSHPA/ASHRAE calculation methods to be used.
j. Thermal Diffusivity Calculations: Provide results that relate to each formation.
k. Borehole Thermal Resistance: Use formula provided by Gehlin (2002).
l. For horizontal directional drilling samples, provide data for soil formations at: 15 feet, 30 feet, and 45 feet below grade.

9. Record Documents: Record actual locations of underground piping installed relative to Owner's permanent structure on same property.
10. Grout Sampling: Loop Field Contractor to take at least three separate grout samples from the grout mixing/holding tank and provide results as submittals. Samples to be taken from the actual grouting process. Samples to be taken after ten percent of bores, 50 percent of the bores and 80 percent of the bores are completed. Loop Field Contractor to submit the samples to an independent testing agency to determine permeability and thermal conductivity. Loop Field Contractor to indicate to the Engineer what laboratory will be used to perform the tests. Grout composition to be changed as needed to bring non-compliant grout into specification compliance. The Owner reserves the right to take independent grout samples and have them tested during the process to confirm what the contractor testing finds.
11. Geothermal Bore Log Submittal: Loop Field Contractor to keep daily bore logs that document the history of each bore as it is installed and provide as a submittal. The log to include but is not limited to the following information.
    a. Number bore, and depth of installation.
    b. Date and time bore was finished.
    c. Grouting information for each bore.
    d. Sign off on bore log each day by the installing contractor’s representative and the Owner’s Authorized Representative and the Mechanical Contractor site representative.
    e. Loop Field Contractor to provide a copy of the log to the Engineer, Owner, and the Mechanical Contractor.
12. Operation and Maintenance Data: Provide procedures for pressurizing, charging, and isolation for equipment replacement.

1.5 QUALITY ASSURANCE

A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirement.

B. In addition, meet the following:
1. Designer Qualifications: Licensed Professional Engineer, regularly engaged in the design of systems of the type and capacity specified in this Section, with not less than five years of documented experience, and accredited by IGSHPA.

2. Installer Qualifications: Company specializing in performing the work of this Section with minimum five years of documented experience and accredited by IGSHPA. Supply with the bid information on past jobs of similar scope. The following information must be supplied:
   a. Name of Project/Customer
   b. Location of Project
   c. Customer Contact Name (Reference) with Phone Numbers
   d. Project Designer/Engineer
   e. Date of Installation
   f. Number of Wells
   g. Depth of Wells
   h. Grout Used
3. The Engineer will be the sole judge whether a specific contractor is qualified based on the qualifications submitted.
4. Heat Fusion Technician Certification: IGSHPA training and certification, certified within three years from the date of project commencement.

1.6 WARRANTY

A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, provide:
   1. The pipe manufacturer to provide a minimum warranty of twenty-five years. The warranty to be transferable.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver piping and fittings to project site in shipping containers with labeling in place.
   1. Comply with local and state regulations.
   2. Verify that labels on piping indicate manufacturer's name, pipe or tube size, and PE cell classification.
   3. Verify that piping complies with specifications and is undamaged.

B. Deliver chemicals for heat exchange fluid to project site in unopened shipping containers with labeling in place; comply with local and state regulations.

C. Protect from weather, humidity and temperature variations, dirt and dust, and other environmental contaminants.

D. Store piping capped or plugged until time of installation.

1.8 PRICE AND PAYMENT PROCEDURES

A. See Division 01, General Requirements.

B. Piping:
   1. Basis of Measurement: By the linear foot (meter).
   2. Basis of Payment: Includes excavating.

1.9 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Convene one week before starting work of this Section. Require attendance by installers involved with site work and HVAC work.

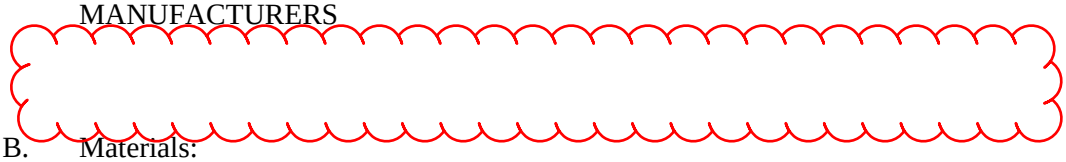
1.10 SITE RESTORATION AND CLEANUP

A. Keep the premises clean and orderly at all times during the Work. Upon completion of the Work, repair damage caused by equipment, remove equipment, tools, materials, containers and debris and leave the project and staging area free of rubbish, protective materials or excess materials of any kind.

B. Wastes generated to be properly contained and disposed of in accordance with local State and Federal regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS



B. Materials:
1. GEM Products, Ground Energy Manufacturing Products, Phone: 515-758-3920
2. HDPE Fabricator
3. Performance Pipe
4. Centennial Plastics
5. Or approved equivalent.

C. Thermally Enhanced Bentonite Grout:
1. GedPro Inc.
2. Or approved equivalent.

D. Horizontal Backfill Material:
1. Reference "Horizontal Backfill Material" article below.

E. Polyethylene Valve Vault:
1. Geothermal Sales Company Inc., Horse Cave, Kentucky, Phone: 270-786-3010
2. Or approved equivalent.

2.2 HEAT EXCHANGER

B. Contractor is responsible for design and execution of the closed-system ground-coupled heat exchanger, to the requirements of and within the limitations of the Contract Documents.
1. Design in accordance with methodology in IGSHPA Closed-Loop/Ground-Source Heat Pump Systems: Installation Guide.
2. Design heat exchanger to comply with heat pump manufacturer's specifications and operating requirements.
3. Circulator pumps, utilization equipment, gauges, and sensors are specified elsewhere and are the responsibility of this designer.

4. If the Drawings do not indicate the interface between the heat exchanger and the equipment, provide three valves and a by-pass to isolate the heat exchanger from the equipment plus at least one charging valve.
5. Provide an IGSHPA registered system, with certificate and label.

F. Heat Exchanger Performance:
1. Heat Transfer Capacity for Heating: 53,200 Btuh.
2. Heat Transfer Capacity for Cooling: 77,7000 Btuh.

4. Maximum Working Pressure: 100 PSIG.
5. Design Operating Pressure: 45 PSIG.
6. Minimum Winter Temperature of Fluid (Winter Inlet Temperature): 32 degrees F.
7. Maximum Summer Temperature of Fluid (Summer Inlet Temperature): 77 degrees F.

2.3 MATERIALS

A. Pipe: High density polyethylene pipe, Type PE3408, PE3608, or PE4710, with minimum ASTM D 3350 cell classification of PE345364C.
1. Markings: Sufficient information, including numerical markings every two (2)-feet, to be permanently marked on the length of the pipe. This information is defined by the

appropriate ASTM pipe standard. Fittings to be similarly marked. Marked information to include:

a. Manufacturer's name
b. Nominal size
c. Pressure rating
d. Relevant ASTM standards
e. Cell classification number
f. Date of manufacture

2. Pipe Used in Vertical Bore Applications: Comply with ASTM D 3035 with minimum working pressure rating of 160 PSI (DR-11).
3. Piping used for the u-bend heat exchanger (pipe located in the borehole) will have factory hot-stamped lengths impressed on the side of the piping indicating the length of the heat exchanger to that point. The length to read "0" (zero) on one end and the actual heat exchanger total length on the other end.
4. The u-bend assembly for the vertical bore hole to be factory- manufactured or shop-fabricated in a controlled environment and randomly tested at 100 PSI under quality control conditions and be constructed of the same material designation prior to delivery to the Site. The vertical heat exchanger to have a factory-fused u-bend with pipe lengths long enough to reach grade from the bottom of the bore so no field fusion welds are required below the header pit.
5. Other Pipe of 3-inches Diameter and Larger: Comply with ASTM D 3035 or ASTM F 714, with minimum working pressure rating of 100 PSI, or ASTM D 2447 Schedule 40.
6. Other Pipe 1-1/4-inches But Less Than 3-inches In Diameter (Nominal): Comply with ASTM D 3035 with minimum working pressure rating of 110 PSI, or ASTM D 2447 Schedule 40.
7. Other Pipe Less Than 1-1/4-inches in Diameter (Nominal): Comply with ASTM D 3035 with minimum working pressure rating of 160 PSI.
8. Infield Extended Header: Infield extended headers to be manufactured by a geothermal HDPE fabrication company. Approved geothermal HDPE fabricator for headers is Ground Energy Manufacturing Products (GEM Products) or Engineer approved equivalent. The Loop Field Contractor may field fabricate the extended headers from HDPE piping as long as actual fabrication personnel are certified in HDPE fusion welding as indicated by certifications included in submittal. Ground Energy Manufacturing Products; phone 515-758-3920.
9. Long Term Hydrostatic Design Basis: 1600 PSI at 73 degrees F, when tested in accordance with ASTM D 2837; appropriate listing in current edition of PPI TR-4 will constitute evidence of compliance with this requirement; otherwise, submit independent test results.
10. Joints and Fittings: Polyethylene of same type as pipe, of sizes and types suitable for the pipe being used; use only heat fusion or stab-type mechanical fittings that are quality controlled to provide a leak-free union between piping ends that is stronger than the piping itself. Do not use other barbed fittings or hose clamps.
    a. Electrofusion Type Fittings: Comply with ASTM F 1055.
    b. Butt Fusion Fittings: Comply with ASTM D 3261.
    c. Socket Type Fittings: Comply with ASTM D 2683.
    d. Where threaded fittings must be used for connection to equipment or dissimilar piping, use fittings and thread sealant compatible and effective with antifreeze used.

B. Pipe, Fittings, and Jointing: Copper, as specified in Section 23 23 00, coated with polyethylene for corrosion protection.
   1. Pipe Over 7/8-inches Outside Diameter: Copper tubing, refrigeration grade, ASTM B 280, H58 hard drawn.
   2. Pipe of 7/8-inches Outside Diameter or Less: Copper tubing, refrigeration grade, ASTM B 88 (ASTM B 88M) Type K annealed.

E. Heat Exchange Fluid: Water and antifreeze solution, 20 percent propylene glycol by weight.

I. Antifreeze:
   1. Antifreeze solutions to meet local and state requirements and be USDA approved food grade and be acceptable by component manufacturers.
   2. Geothermal heat pump systems to be labeled and identified at the loop charging valves:
      a. Antifreeze type and concentration
      b. Service date
      c. Company name
      d. Company phone number and responsible party or person
   3. Form: These standards are intended to cover corrosion-inhibited, biodegradable, food grade, propylene glycol liquid antifreeze materials as received at the job site.
   4. Application: For used in closed-loop geothermal heat pump systems for the transfer of energy to provide heating and cooling in residential and commercial applications.
   5. Safety: While these standards attempt to define antifreeze materials characteristics that are safe to environment and personnel, it is the sole responsibility of the user to become familiar with the safe and proper used of materials provided under these standards and to take necessary precautionary measures to ensure the health and safety of personnel involved.
   6. Technical requirements:
      a. Material: The composition of the fluid to be at the option of the manufacturer. The fluid may contain corrosion inhibitors, etc., as required to produce a product meeting the specified requirements.
         1) Biodegradability: Provide fluid not be less than 90 percent biodegradable. Results of the biodegradable studies conducted in accordance with “Standard Methods of the Examination of Water and Waste Water: for

biodegradability and bioassay to, when requested by the Owner, be provided by the fluid manufacturer to the Owner and contain not less than the following information:
(a) A statement of ecological behavior of the fluid.
(b) The total oxygen demand (TOD) of the fluid, expressed in pounds of oxygen per pound of fluid.
(c) The percent of the fluid demonstrate low corrosion to internal surface of materials found in geothermal heat pump systems.

2) Corrosion: Fluid to demonstrate low corrosion to internal surface of materials found in geothermal heat pump systems.
3) The propylene glycol water mixture to be 25 percent glycol/75 percent water nominally. The heat pump system has been designed on this ratio. The glycol water mixture to be premixed and contain de-mineralized or de-ionized water.

b. Properties: Fluid to conform to the following requirements, and tests performed in accordance with specified test methods on the fluid:
1) Flash point: Not lower than 194 degrees F. determined in accordance with ASTM D92.
2) Biological oxygen demand; Five days BOD at 50 degrees F. not-to-exceed 0.2 gram oxygen per gram nor be less than 0.1 gram oxygen per gram.
3) Freezing point: Not-to-exceed +18 degrees F. determined in accordance with ASTM D1177.
4) Toxicity: Not less than LD 50 (oral-rats) of 5 grams per kilogram. The NFPA hazardous material rating for health not more than 1 (slight).
5) Storage stability: The fluid, tested in accordance with ASTM F1105, to show neither separation from exposure to heat or cold, nor show increase in turbidity.

c. Quality: The fluid, as received by the Owner, to be homogenous, uniform in color and free from skins, lumps, and foreign materials detrimental to usage of the fluid.

7. Packaging and identification:
a. Fluid delivered in bulk. Make up fluid packaged in container and size agreed upon by the Owner.
b. Containers of fluid prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging and transportation of the fluid to ensure carrier acceptance and safe delivery.
c. An up-to-date Material Safety Data Sheet to be supplied to the Owner upon request and concurrent with each delivery.

8. The propylene water mixture to be provided by Interstate Chemical, Barsol, Houghton, Dow, or Engineer approved equal.

J. Good quality threaded fittings and a thread sealant specified for use with the antifreeze selected to be used. Some antifreeze solutions require more fittings torque than others to prevent leaks and corrosion of external surfaces when the antifreeze is exposed to oxygen.

K. Pipe Insulation: Closed cell, water resistant plastic foam with thermal resistance of at least R2.

L. Detectable Underground Tape: Warning tape to be foil backed, 2” wide or greater with a continuous message printed every 36” or less reading: “CAUTION GEOTHERMAL PIPELINE BURIED BELOW”. Tape to be highly resistant to alkalis, acids and other destructive agents

found in the ground. Provide warning tape to indicate the location of the horizontal and vertical portions of the entire geothermal loop field. Provide heat exchanger loop piping location using GPS technology.

M. Backfill for Vertical Boreholes: Thermally enhanced Bentonite grout.

2.4 THERMALLY ENHANCED BENTONITE GROUT

A. General:
1. Summary: Thermally-enhanced bentonite grout to be used to seal and backfill each vertical u-bend well bore of the closed-loop ground heat exchanger to ensure proper thermal contact with the earth and to ensure the environmental integrity of each vertical bore column. Grouting material to remain in a plastic state (moldable) throughout the life of the system and not generate heat during the hydration process. No other backfill material accepted.
2. Submittals: Manufacturer's published data sheets including thermal conductivity, permeability, percent solids, grout weight, linear shrinkage potential, maximum particle size and unit yield along with verification of the required listing(s).
3. Quality Assurance: Grouting compound (bentonite-based and silica sand additive) to be certified and listed by NSF (National Sanitation Foundation International) to ANSI/NSF Standard 60, "Drinking Water Treatment Chemicals - Health Effects".

B. Product:
1. Manufacturer/Product: Grouting material to be one of Black Hills Bentonite's Thermal Grout products as supplied by GeoPro, Inc. or pre-approved equivalent. The thermal enhancement compound (high-grade silica sand) to be specified and supplied by the developer and supplier of the bentonite base material. Approved supplier is GeoPro, Inc. or pre-approved equivalent.
2. Thermal Conductivity: The thermal conductivity of the grouting compound must be 1.00 Btu/hr-ft-°F or greater as determined when tested in accordance to ASTM D-5334, “Standard Test Method for Determination of Thermal Conductivity of Soils and Soft Rock by Thermal Needle Probe Procedure”. The reported thermal conductivity value to be verified by an independent company which has a minimum of 5 years experience in measuring thermal conductivity using this method. A copy of the verification report to be supplied upon request from the engineer.
3. Permeability: The grout mixture to have a maximum permeability rate of less than 8.0 x 10-8 cm/s as determined by using ASTM D-5084, "Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter, Method C - test with increasing tailwater level". The reported permeability to be verified by an independent lab with a copy of the report being supplied upon request from the engineer. Credentials of the independent laboratory to also be supplied upon request from the design engineer.
4. Total Solids and Enhancement Compound Percentage: The thermally enhanced bentonite grout used to have a minimum manufacturer’s recommended mixture of 65.1 percent solids. The thermal enhancement compound (high-grade silica compound) to constitute a minimum of 54.2 percent by weight of the aqueous slurry.

5. Installed Material Set: The installed grouting material to be fully set into a putty consistency within a minimum of 4 hours after being pressure pumped in the vertical bore annulus.

C. Packaging: Provide Bentonite and thermal enhancement compound pre-manufactured and pre-packaged prior to delivery to the job site.

2.5 HORIZONTAL BACKFILL MATERIAL

B. Earth Fill: Approved type of soil classified, in accordance with ASTM D-2487, as GW, GP, GM, SW, SP, SM, SC, ML or CL and free of foreign substances, obtained from excavation on this project, or other approved source, and having a plasticity index between 7.5 and 17.

2.6 POLYETHYLENE VALVE VAULT

A. Polyethylene valve vault constructed from 1" high-density polyethylene sheet stock material and manufactured from the same material as the ground heat exchanger pipe and fittings. Pipe penetrations through the vault wall to be heat welded both on the inside and outside of the vault. Vault constructed as shown on the Drawings.

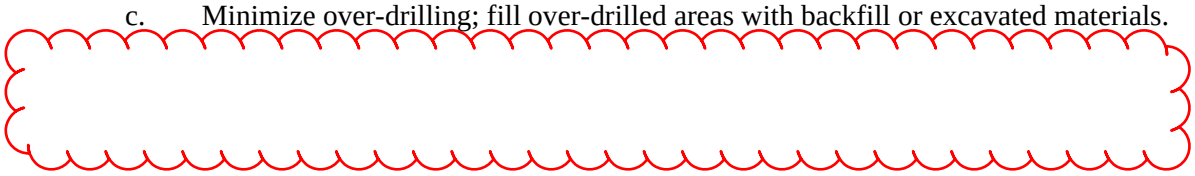
PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Examination and Preparation:
1. Verify location of existing structures and utilities prior to excavation.
2. Verify soil composition and rock depth, if any, before beginning excavation.
3. Protect adjacent structures from the effects of excavation.
4. Verify that layout dimensions are correct and that available land is sufficient for design.
5. Notify Architect of unsatisfactory conditions.
6. Do not proceed with installation until unsatisfactory conditions have been corrected.
7. Coordinate work with site grading, site backfilling, and foundation construction.
8. Loop Field Contractor to obtain permission from adjacent property owners if needed, to setup boring and grouting equipment. Loop Field Contractor responsible for any repairs and cleanup of these adjacent properties required as a consequence of installing the loop field.

B. Excavation:
1. Excavate in accordance with requirements of authorities having jurisdiction.

2. Remove rock as specified in Division 31.
3. Vertical Boreholes: Drill to depths required:
    a. Drill bore hole in accordance with local, State or Federal requirements.
    b. Follow requirements for bore hole drilling as prescribed by the AHJ. Receive permission in writing from the AHJ prior to proceeding and be responsible for maintaining any drilling logs that may be required. Bore hole installation cannot proceed until written proof of permission given by the AHJ has been provided.
    c. Minimize over-drilling; fill over-drilled areas with backfill or excavated materials.



5. Trenches: Excavate trenches for piping to lines and grades shown on drawings.
    a. Minimize over-excavation; fill over-excavated areas with backfill or excavated materials.
    b. Excavate to accommodate grade changes.
    c. Excavate using the procedures specified in Division 31, Trenching for Site Utilities.
    d. Maintain trenches free of debris, material, and obstructions that may damage pipe.
    e. General: The horizontal ditches for the closed-loop ground heat exchanger header may be dug with a chain type trenching machine or a backhoe. Perform excavation of every description and of whatever substance encountered to the depths indicated on drawings. During excavation, deposit material suitable for backfill in an orderly manner, a sufficient distance from the excavation banks to avoid overloading and to prevent slides or cave-ins. Grade as necessary to prevent surface water from flowing into trenches or other excavations, and remove water accumulating therein by pumping or other acceptable method. Unless otherwise indicated, excavation to be by open cut. Keep banks of trenches and excavation for structures as nearly vertical as practicable and where required, properly sheet and brace. Fill unauthorized excavation below levels indicated for pipe with sand.
    f. Trench Excavation: Excavate true to line to a depth to provide at least 5-feet above top of pipe and to provide clear space of not less that two (2)-inches on either side of pipe. Grade bottom of trenches accurately to provide uniform bearing and support for each Section of pipe on six (6)-inches of sand along it’s entire length.
    g. Shoring Requirements: Perform shoring and sheeting that is required to protect the excavation and to safeguard employees in accordance with OSHA. Widen excavation to provide for space occupied by shoring and sheeting. Shoring to meet the requirements of applicable codes and regulations.
    h. De-watering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project Site and surrounding area. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings and soil changes detrimental to stability of sub-grades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines and other de-watering system components necessary to convey water away from excavations. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed form excavations to collecting or runoff areas. Do not use trench excavations as temporary ditches.
6. Install in compliance with local authorities having jurisdiction.

7. Vertical Boreholes: Backfill after pipe installation in accordance with IGSHPA Grouting Procedures for GHP Systems.

9. Trenches:
   a. Provide minimum 60-inch cover over piping.
   b. Backfill trenches after pipe has been installed and tested, using fill free of rocks and other debris.
   c. Backfill: Prepare dimensioned drawings of the complete ground heat ex-changer piping system before backfilling. Trench backfilled by hand with a minimum of six (6)-inches of sand or fine soil material on each side and on top of the pipes. A horizontal underground-type metallic tracer warning tape placed twelve (12)-inches to eighteen (18)-inched below grade for the entire length of each header pipe. After piping is installed, tested, purged, inspected and approved, the remaining trench fill may be excavated material, free of boulders, large rocks, general debris or foreign matter. Care taken to avoid driving construction equipment over newly filled trenches unless bridging is provided to support load over trenches. Reference ASTM D-2321 for backfill procedures. Compact trenches to 90 percent dry density.
   d. Backfill spiral pipe installation ("Slinky") in accordance with ISGHPA Slinky Installation Guide.
8. Protect piping from displacement.

C. Cleaning:
1. Leave adjacent paved areas broom clean.
2. Clear debris, including excess backfill and excavated dirt and rock, from heat exchanger area.

D. Protection:
1. Protect area during excavation from excess runoff and erosion.
2. Protect pipe protrusions from damage until connections to building systems are installed.

E. Flushing and Purging:
1. Before backfilling the trenches, systems flushed and purged of air and flow tested to ensure portions of the closed-loop ground heat exchanger are properly flowing. A portable temporary purging unit to be utilized and consist of the following:
   a. Purge pump - high volume and high head
   b. Open reservoir
   c. Filter assembly with by-pass
   d. Flow meter
   e. Pressure gauge
   f. Connecting piping
   g. Connecting hoses
2. Using the purging unit described above, flush and purge each Section free of air, dirt and debris. A minimum velocity of 2-feet/second in each piping Section must be maintained for a minimum of fifteen (15) minutes to remove air. A change of more than one (1)-inch in the level of fluid in the purge pump tank during pressurization indicates air still trapped in the system. The flushing and purging operation conducted with the supply and return lines to the building capped and sealed at the flange termination connection within

the building. Supply and return lines to the building filled as full as possible with water. Building mechanical contractor will be responsible for flushing and purging the interior portion of the system and a final purging of the entire system. Refill 100 percent of the piping installed with a mixture of water and food grade (USP grade) propylene glycol (20 percent by volume, polypropylene glycol or water.

3.2 HEAT EXCHANGER

A. Solder/sweat connections utilize 45 percent silver solder AWS grade BAg-24 or equivalent bronzing flux to be AWS specification FB3C AMS No. 3411 or equivalent.

B. Use a wetted rag (soaked with water around base of connector. Do not overheat purge unit with nitrogen.

C. Do not braze unit in horizontal, sitting flat position.

D. Install per manufacturers written instructions and guidelines.

3.3 MATERIALS

A. Polyethylene Piping Installation:
   1. Join piping and fittings using heat fusion or electrofusion; do not use solvents, adhesives, or mechanical fittings.
   2. Provide flanges or unions to connect heat exchanger piping to equipment or piping of different type; locate transitions between piping of different types inside the building or otherwise accessible (i.e. above grade).
   3. Keep dirt, water, and debris out of pipe assemblies; cap or plug open ends until connected to adjacent piping.
   4. Do not bend piping to shorter radius than recommended by pipe manufacturer; do not kink piping; use elbow or other fittings for sharp bends.
   5. Partially backfill radius bends in narrow trenches by hand to ensure that piping is properly supported and to prevent kinking.
   6. Installation (Header System):
      a. Connections: Header pipes to be installed and fusion connected to the vertical u-bend assembly. The pipe and fittings must be joined using the socket, butt fusion or electrofusion process. No other method is acceptable. The quantity of fusion joints in the system to be kept to an absolute minimum. Reduction fittings to be used at pipe reductions to eliminate trapped air. Use reducing tees and pre-fabricated reducing type close headers. Consult pipe and/or fitting manufacturer for available fittings and headers.
      b. Avoid sharp bends in piping runs. Minimum bend radius determined by the following:
         1) Minimum Radius = Pipe O.D. (actual) x 25
            (a) Use only continuous lengths of pipe in bends. Install elbows fittings for required bends which are tighter radii than calculated above.
            (b) Lateral piping supply and return lines or bundles separated to minimize thermal interference between the two. The number of points where the supply and return lines cross one another to be minimized.
      c. Testing: After headers have been laid in the trenches and prior to backfill, the system to be pressurized with water and “back-up” air to a minimum of 100 PSI

with no loss of pressure for a minimum of thirty (30) minutes. Each joint to be visually and physically inspected, using industry standards, for cold joints. Any joints failing the test to be completely removed from the system and a new joint or fitting installed with the test being repeated.

7. Installation (U-Bend)
   a. Immediately after completion of the borehole and full removal of drilling equipment, the pre-tested, water filled u-bend assembly inserted into the borehole, u-bend first. A stiffener which does not present potential damage to the assembly may be use to straighten the leading Section of the assembly and to add counter weight for easier insertion.
   b. Care to be taken so that the sealed pipe ends do not “drop” into the open borehole below graded surface.
   c. When bore holes are drilled with a mud-rotary system, the u-bend to be staked and tied to prevent the assembly from “floating” out of the bore prior to the “setting” of the bentonite grout.
8. Test piping to be installed in boreholes after assembly but before installation in boreholes; re-cap tested assemblies before installation.
9. Testing (U-Bend): Perform hydrostatic test on piping; portions of assembled piping may be tested separately.
   a. Prior to testing, isolate piping from connections to building systems.
   b. Flush dirt and debris using potable water flowing at twice the normal operating flow rate for a minimum of four hours or until no dirt or debris is visible, whichever is longer.
   c. Plug or cap piping.
   d. Just prior to the u-bend assembly being placed in the borehole, it is ti be flow tested to ensure that there are no kinks, bends of pinches. The test to consist of forcing clean water into one end of the assembly, and visually inspecting the discharge. If it is visible that an obstruction exists, the obstructed Section of pipe to be removed and replaced with an equal length Section which is free of obstructions and re-attached by heat fusion.
   e. Assembly to be pressurized with water and “back-up” with air as needed to a achieve a minimum of 100 PSI. Assembly to have no significant loss in pressure for a minimum of 30 minutes. Allowances in pressure loss to be made for expansion per pipe manufacturer’s recommendations. At the conclusion of the test, the pipe ends to be sealed with a cap, plug or tape.
   f. Circuits of closed-loop ground heat exchanger system to be water filled and pressure tested to 100 PSI for a minimum of one (1) hour prior to backfill of the trenched. Every weld to be visually and physically examined. If any leaks are detected at a fusion joint, they are to be cut out and replaced at which time that Section will be re-tested according to this Section.
   g. Repeat test until there is no loss of pressure for the duration of the test.
10. Insulation: Insulate the following heat exchanger piping:
    a. Above ground piping: Insulate similar to chilled water.
    b. Belowground but within 36-inches of ground surface. Insulate with a 1-inch closed-cell adhesive backed insulation.
    d. Belowground running parallel with and within 5-feet of walls, structures, or water pipes.

e. Indoor piping that will be colder than ambient air temperature. Insulate similar to chilled water.

B. Copper Piping:
1. Install and test piping as specified in Section 23 23 00.
2. Join pipe and fittings by brazing. Do not bend pipe, use fittings. Provide flanges or unions to connect to equipment and building piping system.
3. Keep dirt, water, and debris out of assembled piping; plug or cap open ends immediately.
4. Provide for thermal movement of components in system.
5. Insulation: Insulate the following heat exchanger piping:
a. Immediately after completion of the borehole and full removal of drilling equipment, the pre-tested, water filled u-bend assembly to be inserted into the borehole, u-bend first. A stiffener which does not present potential damage to the assembly may be use to straighten the leading Section of the assembly and to add counter weight for easier insertion.
b. Care taken so that the sealed pipe ends do not “drop” into the open borehole below graded surface.
c. When bore holes are drilled with a mud-rotary system, the u-bend to be staked and tied to prevent the assembly from “floating” out of the bore prior to the “setting” of the bentonite grout.
6. Where piping passes through foundation walls, provide sleeves sealed with non-hardening, waterproof material.
7. Coordinate charging of piping with refrigerant with Section 23 23 00.

3.4 THERMALLY ENHANCED BENTONITE GROUT

A. Mixing: Thermally enhanced bentonite grouting material mixed according to manufacturer's written instructions.

B. Installation: Grout material pressure pumped through a one (1)-inch, one and one-quarter (1-1/4)-inch or a one and one-half (1-1/2)-inch inside diameter tremie pipe and placed in the bore column from the bottom to the top. Grouting process to conform to the manufacturer's instructions and "Grouting for Vertical Geothermal Heat Pump Systems -- Engineering Design and Field Procedures Manual", as published by the International Ground Source Heat Pump Association (IGSHPA), Oklahoma State University (OSU), latest edition. Completed grouted surface placed at ground level to ensure complete fill of the bore column.

C. Inspection: Since some settling may occur after initial placement of the grout material, the installer to monitor each borehole and continue adding grout as required for a period of no less than thirty (30) minutes and no longer than two (2) hours.
1. Grouting manufacturer to provide testing of site mixed grouting material in accordance to ASTM D-5334 to verify thermal conductivity. Manufacturer to provide a minimum of three, sample analysis for this project.
2. At a minimum, sampling to be taken once at the beginning of the project, once at approximately one-third of completion, and finally at approximately two-thirds of completion. In the event that the analysis indicates a thermal conductivity value below the minimum specified value, corrective action to be taken to increase thermal conductivity value back to minimum specified requirement. A written report will be submitted defining corrective action taken.

3.5 HORIZONTAL BACKFILL MATERIAL

A. For Horizontal Piping Systems:
   1. Sharp bending of pipe around trench corners must be prevented by using a shovel to round corners, or by installing an appropriate elbow fitting. Manufacturer's procedures must be followed.
   2. Backfilling procedures will include prevention of any sharp-edged rocks from coming into contact with the pipe by removal of the rocks before backfilling. Use the IGSHPA Slinky backfilling procedures found in IGSHPAs Slinky Installation Guide to assure elimination of air pocket around the pipes.
   3. Return bends in narrow trenches must be partially backfilled by hand to properly support the pipes and prevent kinking.
   4. All buried GHP pipes in systems containing an antifreeze and passing parallel within 5-feet of any wall, structure, or water pipe shall be insulated with R2 minimum closed cell insulation.

3.6 POLYETHYLENE VALVE VAULT

A. Polyethylene valve vault to be installed according to the diagram found on the Ground-Loop Heat Exchanger Site Plan drawings. Manufacturer’s written installation procedures and instructions to be followed. A copy of these procedures to be supplied with other submittal data.

END OF SECTION