
USACE / NAVFAC / AFCEA / NASA UFGS-23 81 47 (April 2006)

Preparing Activity: USACE Replace without changing
UFGS-15741 (November 2003)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMR L dated 9 October 2006

Latest change indicated by CHG tags

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SECTION 23 81 47

VERTICAL GROUND-COUPLED HEAT EXCHANGE SYSTEMS (VGCHES) 04/06

NOTE: This guide specification covers the requirements for vertical ground-coupled heat exchange systems for use with HVAC systems.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

PART 1 GENERAL

NOTE: This section is intended for performance designed systems in which only the information necessary for the Contractor to design the system is indicated on the contract drawings. The Contractor will lay out and size piping to transfer the heat specified, including any boring, trenching, installation of piping, and connection to the piping in applicable HVAC System.

Coordinate this specification with other applicable sections to ensure that all necessary requirements and components are included in the contract specifications for fully operational HVAC systems.

The designer should be familiar with ASHRAE's

"Ground Source Heat Pumps: Design of Geothermal Systems for Commercial and Institutional Buildings" (1997) and the applicable requirements in the most current ASHRAE Handbooks before preparing the design.

The calculations necessary to determine the viability of a VGCHES will be performed using one of the following approved computer aided design programs that include the effects of thermal interaction between adjacent boreholes: GCHP Calc (Energy Information Services Co.) or GLHE Pro (International Ground-Source Heat Pumps Association).

The following parameters will be used in the calculations. The maximum entering water temperature to the heat pumps under the peak air conditioning load design condition should not exceed 32 degrees C (90 degrees F). The minimum entering water temperature to the heat pumps under the peak heating load design condition should be no lower than -1 degrees C (30 degrees F). Adjacent VGCHES will not be spaced closer than 4 meters (15 feet). For projects where the total heating design load for all VGCHES exceeds 7000 kW (2,400,000 btu/hr) or the total cooling design load exceeds 7000 kW (200 tons), insitu thermal properties testing will be conducted to determine soil thermal properties prior to VGCHES design. These tests must be conducted in accordance with the procedures outlined in ASHRAE's "Ground Source Heat Pumps: Design of Geothermal Systems for Commercial and Institutional Buildings" (1997) by a firm regularly engaged in the conduct of such tests.

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the

extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 1693	(2005) Environmental Stress-Cracking of Ethylene Plastics
ASTM D 2447	(2003) Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
ASTM D 2513	(2004a) Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D 3035	(2003a) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D 3261	(2003) Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D 3350	(2002a) Polyethylene Plastics Pipe and Fittings Materials
ASTM F 1055	(1998e1) Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2003; R 2004) Motors and Generators
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1.2 COORDINATION OF TRADES

Pump supports, piping offsets, fittings, and any other accessories required shall be furnished as required to provide a complete installation and to eliminate interference with other construction.

1.3 DELIVERY AND STORAGE

All equipment shall be delivered and placed in storage with protection from the weather, humidity and temperature variations, dirt, dust, and other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

1.4 FIELD MEASUREMENTS

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field and shall advise the Contracting Officer of any discrepancy before performing the work.

1.5 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals

required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings[; G][; G, [_____]]

Drawings consisting of VGCHES layout and system details as specified.

SD-03 Product Data

VGCHES Piping Components[; G][; G, [_____]]
General Equipment Requirements[; G][; G, [_____]]

Manufacturer's catalog data included with the VGCHES Installation Drawings for the following items. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with contract requirements for the following:

- a. VGCHES piping components, including recommendations for preparing joints using an electrofusion process.
- b. VGCHES circulating pump(s)

Propylene glycol to be supplied in the VGCHES. The concentration, the conductivity of the propylene glycol (at all concentration levels ranging from zero to 100 percent in ten percent intervals) and other characteristics of the propylene glycol/water mixture at the concentration proposed. This data shall be supplied for each of the two extreme return temperatures of the water/propylene glycol mixture from the heat pump(s), i.e. the maximum mixture design temperature during the cooling season and the minimum design temperature during the heating season.

VGCHES Calculations[; G][; G, [_____]]

Calculations, submitted concurrently with the VGCHES Installation Drawings, demonstrating that the VGCHES will perform as specified.

VGCHES Tests[; G][; G, [_____]]

Proposed test procedures, at least 2 weeks prior to the start of related testing.

System Diagrams[; G][; G, [_____]]

Proposed diagrams, at least 2 weeks prior to start of related testing.

VGCHES Designer[; G][; G, [_____]]

A letter no later than 14 days [_____] after the Notice to Proceed providing the name and Statement of Qualifications of the individual who will prepare the VGCHES Design and Calculations.

VGCHES Specialist[; G][; G, [_____]]

A letter not later than 14 days [_____] after the Notice to Proceed, providing the name and Statement of Qualifications of the individual who will serve as the VGCHES Specialist.

On-Site Training[; G][; G, [_____]]

Proposed On-site Training schedule, at least 14 days [_____] prior to the start of related training.

Hydrostatic Test[; G][; G, [_____]]

Proposed test schedule, at least 14 days [_____] prior to the start of related testing.

Performance Test[; G][; G, [_____]]

Proposed test schedule, at least 14 days [_____] prior to the start of related testing.

SD-06 Test Reports

VGCHES Tests[; G][; G, [_____]]

Test reports, signed by both the VGCHES Designer and the VGCHES

Specialist, for the hydrostatic and performance tests in booklet form, no later than 14 days [_____] after completion of testing. Reports shall document all phases of tests performed including initial test summary, all corrections and adjustments made, and final test results.

SD-07 Certificates

Detail Drawings[; G][; G, [_____]]
VGCHES Calculations[; G][; G, [_____]]
VGCHES Piping Installation[; G][; G, [_____]]

Concurrent with the submittal of VGCHES Detail Drawings and the VGCHES Calculations, submit certification by both the VGCHES Designer and the VGCHES Specialist that the VGCHES drawings and calculations have been coordinated with related work and will perform as specified.

Concurrent with submittal of the VGCHES Test Reports, submit certification by the VGCHES Specialist that the VGCHES is installed in accordance with the contract requirements, including signed approval of the VGCHES Test Reports.

VGCHES Designer[; G][; G, [_____]]

Concurrent with submittal of the VGCHES Detail Drawings, submit certification by the VGCHES Designer that the VGCHES design and calculations conform to all contract requirements, including signed approval of the VGCHES Test Reports.

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions[; G][; G, [_____]]

[Six] [_____] manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to on-site training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. [Each service organization submitted shall be capable of providing [4] [_____] hour on-site response to a service call on an emergency basis.]

1.6 VGCHES DESIGNER

The VGCHES shall be designed by an individual who is a registered professional engineer and is regularly engaged in the design of the type and capacity of system(s) specified in this project for the immediate three years prior to the submittal of the VGCHES Designer's Statement of Qualifications. The VGCHES Designer's Statement of Qualifications shall include data identifying the location, VGCHES type, and capacity of at least three systems designed by the proposed VGCHES Designer during that period. The Contractor shall furnish documentation from the owner of each of these three VGCHES verifying that each system has performed in the manner intended for the 6 months prior to submission of the Statement of Qualifications.

1.7 VGCHES SPECIALIST

Work specified in this section shall be performed under the supervision of and certified by the VGCHES Specialist. The VGCHES Specialist shall be a Certified as an "Installer" by the International Ground Source Heat Pump Association (IGSHPA) and shall be engaged in the installation of the type and capacity of the system(s) specified in this project for the immediate three years prior to the submittal of the VGCHES Specialist's Statement of Qualifications. The VGCHES Specialist's Statement of Qualifications shall include a copy of IGSHPA Installer Certification and data identifying the location, VGCHES type, and capacity of at least three systems installed under the guidance of the proposed VGCHES Specialist during that period. The Contractor shall furnish documentation from the owner of these three VGCHES verifying that each system has performed in the manner intended for the 6 months prior to submission of the Statement of Qualifications.

1.8 VGCHES CALCULATIONS

**NOTE: To reduce first cost and operating energy
consumption, base the VGCHES design on peak block
loads rather than the total capacity of all
equipment served where applicable.**

Heat transfer calculations shall be prepared by the VGCHES Designer using computer software specifically intended for VGCHES's. The design shall be based on calculations that will provide the most life cycle cost effective VGCHES using an expected life of 25 years and shall be sized based upon [the loads shown on the drawings] [_____]. The diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss, and the maximum expected expansion and contraction of the pipe shall be indicated in the program output. An accompanying schematic drawing showing reference points used in the calculations shall be included with the calculations. The maximum entering water temperature to the heat pumps under the peak air conditioning load design condition should not exceed 32 degrees C 90 degrees F. The minimum entering water temperature to the heat pumps under the peak heating load design condition should be no lower than -1 degrees C 30 degrees F. Adjacent VGCHES will not be spaced closer than 4 m 15 feet.

1.9 DETAIL DRAWINGS

The Contractor shall submit drawings including VGCHES layout, assembly and installation details, and electrical connection diagrams; installation details of circulation pumps, distribution manifolds and all piping, including points of connection to piping specified in other Sections, or heat pumps and other equipment shown on the drawings and to piping specified in related sections. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function within the HVAC system and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance and the test point locations where the VGCHES will be monitored during testing.

1.10 DELIVERY AND STORAGE

Equipment placed in storage shall be protected from the weather, humidity

and temperature variations, dirt and dust or other contaminants.

PART 2 PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

2.1.1 Standard Products

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.1.2 Nameplates

Major components of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate permanently affixed to the item of equipment.

2.2 VGCHES PIPING COMPONENTS

NOTE: Show the location (including surface area and depth) where VGCHES piping will be installed. Provide a detail drawing of the connection between the VGCHES piping and the above ground piping to heat pumps, manifolds, or heat exchangers. This detail should include all fittings, including the threaded transaction fitting, test ports, vents, exterior valve vaults or point of entry into the building, etc. necessary to ensure a fully operable and easily maintainable VGCHE. The detail will identify the transition between the VGCHES piping and above ground piping. The Section in which the above ground piping is specified will be noted below.

VGCHES piping terminates at the point shown on the drawings. The connecting piping shall be as specified in Section [_____].

2.2.1 Pipe

Piping and heat-fused materials shall be manufactured from virgin polyethylene and an extrusion compound material conforming to [ASTM D 2513](#) with PE345434C or PE355434 cell classification with an [ASTM D 3350](#) Class C, D, or E UV stabilizer, with the exception that the material shall exhibit zero failures (FO) when tested for 192 hours or more in accordance with [ASTM D 1693](#), condition C as required in [ASTM D 3350](#). Pipe shall be manufactured as specified in [ASTM D 2447](#) Schedule 40 or [ASTM D 3035](#) with a standard dimension ratio (SDR) of 13.5 for pipe diameters ranging from [32 mm 1.25 inches](#) and less to [75 mm 3 inches](#), and a minimum SDR of 17.0 for pipe diameters [75 mm 3 inches](#) and greater.

2.2.2 Fittings

Butt and sidewall fittings shall be polyethylene and conform to [ASTM D 3261](#) Socket fittings shall conform to [ASTM D 2513](#); electrofusion fittings shall conform to [ASTM F 1055](#). Barbed fittings and hose clamps shall not be used.

2.3 ELECTRICAL WORK

NOTE: Electrical characteristics, motor starter type, enclosure type, and maximum rpm should be shown on the drawings in the equipment schedules.

Electrical motor-driven equipment shall be provided complete with motor, motor starter, and controls. Electrical service shall be provided for all items recommended by the VGCHES manufacturer to meet the requirements specified herein. Unless otherwise specified, electric equipment, including wiring and motor efficiencies, shall conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics and enclosure type shall be as shown. Unless otherwise indicated, motors of 745 W 1 Hp and above shall be high efficiency type. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary. Each motor shall conform to NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Any manual or automatic controls, protective or signal devices, and corresponding wiring required for VGCHES operation shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for 0.745 kW through 7.45 kW fractional hp through 10 hp ratings. Adjustable frequency drives shall be used for larger motors.

2.4 CONTROLS

NOTE: The sequence of control for the VGCHES should be shown on the drawings in text as a performance sequence so that the system manufacturer's standard controls can be used. The designer should investigate the requirement for connection of the VGCHES to the installation's Utility Monitoring Control System (UMCS).

Controls for the VGCHES shall be integrated with the HVAC system controls package specified in Section 23 09 23 DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS. VGCHES controls shall be designed in accordance with the manufacturer's recommendations and to comply with the sequence of controls shown on the drawings.

PART 3 EXECUTION

3.1 VGCHES PIPING INSTALLATION

Piping components shall be joined by a heat fusion method that conforms the piping manufacturer's recommendation for this application.

3.2 EARTHWORK

Earthwork shall be performed in accordance with applicable provisions of Section 31 00 00 EARTHWORK, except that thermally enhanced grouts shall be used where indicated on the approved VGCHES Installation Drawings.

3.3 FIELD PAINTING AND FINISHING

Field painting and finishing are specified in Section 09 90 00 PAINTS AND COATINGS.

3.4 TESTING, ADJUSTING, AND BALANCING

Testing, adjusting, and balancing shall be as specified in Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the entire HVAC system, including controls, has been completed with the exception of performance tests. The VGCHES shall be charged with premixed propylene glycol solution (type and concentration as specified by the VGCHES Designer) prior to testing, adjusting, and balancing.

3.5 VGCHES TESTS

3.5.1 Hydrostatic Test

Prior to any cover or backfill of bore holes or trenches, the VGCHES piping shall be isolated from all connections to piping specified in Section [_____] and shall be flushed of all dirt and debris using potable water flowing at twice the normal operating VGCHES flow rate for a minimum of four hours or until no dirt or debris is visible, whichever is greater. The VGCHES piping shall then be plugged or capped as necessary in preparation for the hydrostatic test(s). The piping shall be pressurized to 1000 kPa 150 psi and monitored for a period of 8 hours. If there is any pressure loss or visible leakage during this period, the leak shall be identified and repaired in accordance with the piping components manufacturer's recommendations. Test shall be repeated until there is no loss in pressure during the test period.

3.5.2 Performance Test

Test(s) shall be repeated in entirety until results are considered satisfactory by the VGCHES Designer. Test shall be conducted by the VGCHES Specialist. All items required to perform the tests, including the [heat] [heating and cooling] source(s) necessary to maintain constant water temperature to the [ground] [ground and interface to the HVAC systems and all instruments required for tests shall be furnished by the Contractor. The accuracy of test instruments shall be as specified in Section 23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Test shall demonstrate that the entire system is functioning according to the Sequence of Operation [specified in Section [_____] [on the drawings]]. The operational test shall cover a period of not less than [72] [_____] continuous hours of operation using only system controls in normal mode. Supply and [return] [discharge] VGCHES flow and temperatures shall be recorded at the locations shown on the VGCHES Installation Drawings for each VGCHES piping system at hourly intervals for the duration of the test period. In addition, weather conditions, including the ambient temperature and humidity in a shaded and weather protected area shall be recorded at hourly intervals along with supply and [return] [discharge] VGCHES temperatures and the VGCHES temperatures at locations shown on the drawings. The report shall include calculations which will provide the capacity when operating during the peak design conditions listed on the drawings.

3.5.3 System Diagrams

The Contractor shall submit System diagrams that show the layout of equipment, piping, and circulation pumps, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

3.6 ON-SITE TRAINING

NOTE: The number of hours of instruction should be
determined based on the number and complexity of the
systems specified.

The VGCHES Designer shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of [16] [_____] hours of normal working time and shall start after the system is functionally complete but prior to the performance tests. The on-site training shall cover all of the items contained in the approved [Operating and Maintenance Instructions](#).

-- End of Section --