SECTION 48 16 23
GEOTHERMAL ENERGY - ELECTRICITY GENERATION SYSTEM

SPEC WRITER NOTES:
Delete between // --- // if not applicable to project. Also delete any other item or paragraph not applicable in the section and renumber the paragraphs. The spec writer shall review the Physical Security Design Manual for VA Facilities to determine and include in this section any Mission Critical or Life Safety requirements called out.

PART 1 - GENERAL

1.1 DESCRIPTION
A. The requirements of this Section apply to all sections of Division 48 related to Geothermal Energy Electrical Power Generation Systems.

1.2 RELATED WORK
A. Section 01 00 00, GENERAL REQUIREMENTS: General construction practices.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES: Submittals.
C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS: General requirements for commissioning.
D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical installation requirements.
E. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Requirements for current conductors.
F. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for grounding.
G. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Requirements for medium-voltage cables, splices, and terminations.
H. Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS: Requirements for boxes, conduits, and raceways.
I. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Requirements for forming a complete underground raceway system.
J. Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS: Requirements for commissioning the electrical system, subsystem, and equipment.
K. Section 26 13 00, MEDIUM-VOLTAGE SWITCHGEAR: Requirements for medium-voltage switchgear.
L. Section 26 29 21, DISCONNECT SWITCHES: Requirements for disconnects.
M. ASME Boiler and Pressure Vessel Code, SECTION I: Rules for construction of power boilers.
1.3 DEFINITIONS
A. Unless otherwise specified or indicated, geothermal energy terms used in these specifications, and on the drawings, shall be defined in ASTM E957-03.

1.4 QUALITY ASSURANCE
A. Geothermal Energy Electrical Power Generation System installer(s) shall demonstrate that they have successfully installed at least four projects that, in aggregate, equal or exceed the size of the proposed project. References shall be provided for each of these installed projects.
B. Adequate information shall be presented to demonstrate the earth’s ability to support ground wells.
C. If paralleling arrangement is required, the system shall have anti-islanding capability thereby incapable of exporting power to the utility distribution system in the absence of utility power.
D. Submit Geothermal Energy Electrical Power Generation System data package for the following items:
   1. Troubleshooting guide for geothermal power generation systems
   2. Turbine generator module warranty
   3. Operation instructions
   4. Preventive maintenance and inspection data, including a schedule for system operators
   5. Inlet water quality requirements
   6. Condenser/Cooling tower water quality requirements
E. For piping materials warranty, furnish fifty year manufacturer’s warranty against defects in materials and workmanship.
F. For turbine generator module warranty, furnish five year manufacturer’s warranty against defects in materials and workmanship.
G. Where applicable, the batteries supplied shall be intended for use in geothermal systems.
H. Geothermal Energy Electrical Power Generation System shall include supply of site-appropriate heat rejection equipment, including dry coolers or wet coolers, and any associated support equipment and controls for heat rejection.

1.5 SUBMITTALS
A. Where proposed system shall be a Net Meter project, prepare appropriate applications and submittals to the /Resident Engineer (RE)/ /Contracting Officer’s Technical Representative (COTR)/. Where
proposed system shall be connected in front of the meter and a paralleling arrangement is required, prepare appropriate applications and submittals to the //RE// //COTR//. In all cases, the local utility may have a requirement for further electrical studies, which may include power factor analysis, short circuit protection studies, grid wiring adequacy or capacities of upstream switches or transformers. If such requirements exist and are required by said utility, these requirements shall be fulfilled by the Contractor.

B. Submit six copies in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and with requirements in the individual specification sections, to the //RE// //COTR//.

C. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.

D. If equipment submitted differs in arrangement from that shown on the submittals, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract and acceptable to the //RE// //COTR//.

E. Prior to submitting shop drawings for approval, Contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications from the applicable other manufacturers, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

F. Submittals and shop drawings for independent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.

G. Shop Drawings: Include turbine generator module, //turbine generator module control sequences,// monitoring instruments and controls, battery back-up systems, interconnections and all other components, parts and pieces required to complete the functioning assembly. Where applicable, include shop drawings for foundations or other support structures and, where applicable, pre-fabricated assemblies.
H. Product Data: Include detailed information for components of the geothermal energy system.
   1. Geothermal Well and Piping Systems
   2. Heat Rejection Equipment
      a. Cooling Tower
      b. Pumps
      c. Radiators
   3. Wiring
   4. Wiring Specialties
   5. DC-AC Inverter
   6. Geothermal Energy Storage Battery Option
   7. Turbine Generator Modules
   8. Instrumentation and Metering
   9. Switch gear
   10. DC and AC disconnects, where applicable
   11. Combiner boxes, where applicable
   12. Monitoring and control systems, including appropriate interfacing with existing facility data collection systems.

I. Certificates: submit technical representative’s certification that the geothermal system installation has been implemented as intended by the system designer and where applicable, recommended by the manufacturer.

J. Manufacturer’s Operating Instructions

K. Operation and Maintenance Geothermal Energy Systems Data Package:
   1. Safety precautions
   2. Operator restart
   3. Startup, shutdown, and post-shutdown procedures
   4. Normal operations
   5. Emergency operations
   6. Environmental conditions
   7. Preventive maintenance plan and schedule
   8. Troubleshooting guides and diagnostic techniques
   9. Wiring and control diagrams
   10. Maintenance and repair procedures
   11. Removal and replacement instructions
   12. Spare parts and supply list
   13. Product submittal data
   14. Manufacturer’s instructions
   15. O&M submittal data
16. Parts identification
17. Testing equipment and special tool information
18. Warranty information
19. Testing and performance data
20. Contractor information

L. Closeout Submittals:
   1. Posted operating instructions for geothermal energy system: provide for wiring identification codes and diagrams of geothermal systems, operating instructions, control matrix, and troubleshooting instructions.
   2. Complete set of certified as-built components, including geo-heat exchange well system distribution piping in AutoCAD drawing format.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. American National Standards Institute (ANSI):
   60-11................... Drinking Water Treatment Chemicals – Health Effects

C. American Petroleum Institute (API):
   611-08 .................. General-Purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Service; Ed. 5.0
   612-05 .................. Petroleum, Petrochemical and Natural Gas Industries – Steam Turbines – Special-Purpose Applications; Ed. 6.0

D. American Society of Mechanical Engineers (ASME):
   B31.1-12 ............... Power Piping

E. American Society for Testing and Materials (ASTM):
   E947-07 ............... Standard Specification for Sampling Single-Phase Geothermal Liquid or Steam for Purposes of Chemical Analysis
   E957-11 ............... Standard Terminology Relating to Geothermal Energy
   E1008-09 ............. Standard Practice for Installation, Inspection, and Maintenance of Valve-body Pressure-relief

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Methods for Geothermal and Other High-Temperature Liquid Applications


E1069-09 ............... Standard Test Method for Testing Polymeric Seal Materials for Geothermal and/or High Temperature Service Under Sealing Stress

E1675-04 ............... Standard Practice for Sampling Two-Phase Geothermal Fluid for Purposes of Chemical Analysis


A249/A249M-10a ............ Standard Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes

A268/A268M-10 ............. Standard Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service

A269-10 .................. Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

A789/A789M-10a ............ Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service

F. Institute of Electrical and Electronics Engineers (IEEE):

519-92 .................. Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

1547-03 .................. Standard for Interconnecting Distributed Resources with Electric Power Systems

1561-07 .................. Guide for Optimizing the Performance and Life of Lead-Acid Batteries in Remote Hybrid Systems

G. International Code Council (ICC):

IBC-12 .................. International Building Code

H. International Electrotechnical Commission (IEC):

60529-09 ............... Degrees of Protection Provided by Enclosures (IP Code); Ed. 2.1

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PART 2 - PRODUCTS

2.1 GENERAL

A. Provide materials to fabricate functional geothermal energy system assemblies in accordance with this section. At the Contractor's option, provide factory-prefabricated geothermal equipment packages which include turbine generators, pressure chambers, support structures, batteries or other energy storage devices, and controls which meet the requirements of this section.

2.2 GROUNDING

A. Shall ground according to manufacturer instructions and the NEC.

2.3 SWITCH/DISCONNECTING MEANS

SPEC WRITER NOTE: Certain inverter manufacturers include a DC fused disconnect as part of their inverters. In those cases, a separate disconnect will not be required.
A. Shall be in accordance with the NEC, as shown on the drawings, and as specified.
B. Means of disconnect shall be UL-listed and shall have suitable enclosures (i.e. NEMA 3R for outdoor installation).
C. Refer to //RE// //COTR// for location requirements.
D. Utility External Disconnect Switch (UEDS): Refer to //RE// //COTR//.

2.4 BATTERY CHARGE CONTROLLER
A. Shall be capable of withstanding 25% over-amperage for limited time per the NEC.
B. Charge controller or self-regulating system shall be required for a stand-alone system with battery storage. Charge controller’s adjusting mechanism shall be accessible only to qualified persons.
C. Shall be listed to UL 1741.
D. Charge controller shall include maximum power point tracking (MPPT) and temperature compensation.
E. Shall be manufactured in a facility with ISO 9001 certification.

2.5 WIRING SPECIALTIES
A. Direct Current Conductor:
   1. If Exposed: Shall use USE-2, UF (inadequate at 60°C [140°F]), or SE, 90°C [194°F] wet-rated and sunlight-resistant.
   2. If in Conduit: Shall use RHW-2, THWN-2, or XHHW-2 90°C [194°F], wet-rated conductors required.
B. Conduits and Raceways:
   1. Shall use solid steel conduit listed per UL 6, UL 1242, UL 797 (as appropriate). Weather tight EMT installations shall be allowed for DC wiring in weather protected areas.
   2. Shall use expansion joints on long conduit runs.
C. Weather impacted enclosures: Shall be rated to NEMA 3R or better per NEMA 250.
D. Cable Assemblies and Junction Boxes:
   1. Shall be UL-listed.
   2. Shall be rated IP65 or IP67 per IEC 60529.
   3. Shall be rated to 5VA flammability per UL 94.
E. Prohibited Wiring Materials: Not UL-listed, or listed materials used in unapproved environments.

2.6 GEOTHERMAL BINARY UNIT
A. Adhere to manufacturer’s instructions.
B. Turbine Generator Module
1. Shall adhere to API 611 or 612, as applicable.
2. Shall be certified for communication networks and systems in substations per IEC 61850, as applicable.
4. Enclosure shall be rated IP 20 and IP 56.
5. Unit shall be approved to operate in Class I Division 2/Zone 2 environments as defined by CSA International.

C. Condenser Tube

2.7 DC-AC INVERTER

A. Shall have stand-alone, utility-interactive, or combined capabilities.
B. Shall be listed to UL 1741, per IRC M2302.4.
C. Shall comply with IEEE 519 and IEEE 1547.
D. Shall be listed per FCC Part 15 Class A (commercial) or Class B (residential): Unintended radiators.
E. Shall include maximum power point tracking (MPPT) features.
F. Shall include anti-islanding protection if paralleling arrangement is required.
G. Shall have 95% or greater efficiency (with isolation transformer).
H. Shall be provided in floor-mount, NEMA 3R steel enclosure.
I. Shall be of same manufacturer and model number as all other inverters supplied under contract.

2.8 BATTERY OPTION

A. General: Adhere to NFPA 70 NEC 480, NEC 694 VIII.
B. Off-Grid: Always use high-quality, industrial-grade, deep-cycle batteries.
C. Grid-Interactive with Battery Backup: Best to use sealed-absorbed glass mat (AGM) batteries specifically designed for emergency standby or float service.
D. Optimize Performance and Life: Follow practices per IEEE 1561.
E. Safety and Ventilation:
   1. Use protective enclosure and proper ventilation per NEC.
   2. Exposed battery terminals and cable connections shall be protected, and live parts of batteries shall be guarded—the batteries shall be accessible only to a qualified person via locked room, battery box, or other container.
3. Spacing around battery enclosures and boxes and other equipment shall be at least 915 mm [36 inches]; batteries shall not be installed in living areas, or below enclosures, panelboards, or load centers.

4. Prohibited are conductive cases for flooded, lead-acid batteries operating above 48-volt nominal. Battery racks shall have no conductive parts within 155 mm [6 inches] of the tops of cases.

5. To prevent electric shock, storage batteries in dwellings shall operate at less than 50 volts (48-volt nominal battery bank). Live parts of any battery bank shall be guarded.

F. Interconnection:

1. Battery cables shall be a standard building wire type conductor. Welding and automobile “battery” cables (listed and non-listed) are forbidden.

2. Flexible cables, listed for hard service use and moisture resistance, are permitted (not required) from battery terminals to nearby junction box and between battery cells. Flexible, highly-stranded building-wire type cables (USE/RHW and THW) are available. Consult with manufacturer data if battery terminals are compatible with flexible cables.

2.9 INSTRUMENTATION

A. Charge Controller: See 2.4.

B. Sensors: Temperature sensor shall be a component in the maximum power point tracking control system. Any additional data acquisition sensors shall require a conduit separate from the current conductor conduit.

C. Data logger/Monitoring System: Shall be a packaged system capable of monitoring and logging information of an individual well.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install the geothermal system in accordance with this section and the printed instructions of the manufacturer. Prior to system start-up, ensure no copper wire remains exposed with the exception of grounding wire in certain circumstances per manufacturer instructions.

B. Prior to any excavation, trenching, or drilling, all buried utilities, drainage, and irrigation systems shall be located and flagged by the appropriate utility and contractor representative.

C. Drilling Contractor shall be a National Ground Water Association (NGWA) Certified Well Driller (CWD).
D. Surface Discharge shall be compliant per the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) regulations.

E. Reinjection Well shall be compliant per the Environmental Protection Agency (EPA) Underground Injection Control (UIC) regulations for Class V (Shallow Non-Hazardous Injection) wells.

F. Borehole Construction shall be performed per IGSHPA 2011, Section 2B.
   1. Surface water shall not be used as a source of water during the drilling of a borehole unless it is obtained from a municipal water supply system. Water used for drilling purposes shall be potable water that contains a free chlorine residual of no less than 10 milligrams per liter. Chlorine residual level shall be checked with chlorine test strips.

G. Piping installation shall be compliant with ASME B31.1 and ICC IMC Section 1206.

H. Wiring Installation: Utilize on site measurements in conjunction with engineering designs to accurately cut wires and layout before making permanent connections. Locate wires out of the way of windows, doors, openings, and other hazards. Ensure wires are free of snags and sharp edges that have the potential to compromise the wire insulation.

I. Instrumentation: Install instruments as recommended by the control manufacturers. Locate control panels inside mechanical room.

3.2 FIELD QUALITY CONTROL

A. Field Inspection: Prior to initial operation, inspect the geothermal system for conformance to drawings, specifications and NFPA 70. Inspect the following information on each turbine generator module:
   1. Manufacturer's name or trademark
   2. Model name or number
   3. Certifying agency label and rating.

B. Tests: Provide equipment and apparatus required for performing tests. Correct defects disclosed by the tests and repeat tests. Conduct testing in the presence of the Contracting Officer//QC Representative//COTR.  
   1. Operation Tests: Perform tests on electrical systems, in accordance with the manufacturer’s written recommendations.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the geothermal
electrical power generation system is in good operating condition and properly performing the intended function.

3.4 COMMISSIONING

A. If paralleling arrangement is required, connect the geothermal electrical power generation system to the electrical utility grid only after receiving prior approval from the utility company.

B. If paralleling arrangement is required, only qualified personnel shall connect the system to the utility grid.

3.5 INSTRUCTION

A. A complete set of operating instructions for the geothermal electrical power generation system shall be laminated or mounted under acrylic glass and installed in a frame near the equipment.

B. Furnish the services of a factory-trained technician for one, 4-hour training period for instructing personnel in the maintenance and operation of the geothermal electrical power generation system, on the dates requested by the //RE// //COTR//.

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