

SECTION 48 16 23
GEOTHERMAL ENERGY ELECTRICAL POWER 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.

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, testing and commissioning of electrical geothermal power generation systems.
- B. 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 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirement for seismic restraint for nonstructural components.//
- E. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION: Requirements for steam generation.
- F. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- G. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Requirements for low-voltage conductors.
- H. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and requirements for providing a low impedance path for possible ground fault currents.
- I. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Requirements for medium-voltage conductors, splices, and terminations.
- J. Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS: Requirements for boxes, conduits, and raceways.
- K. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Requirements for forming an underground raceway system.
- L. Section 26 08 00, COMMISSIONING OF ELECTRICAL SYSTEMS: Requirements for commissioning the electrical system, subsystem, and equipment.

- M. Section 26 13 00, MEDIUM-VOLTAGE SWITCHGEAR: Requirements for medium-voltage switchgear.
- N. Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS: Requirements for enclosed disconnect switches.

1.3 DEFINITIONS

- A. Unless otherwise specified or indicated, geothermal energy terminology used in these specifications, and on the drawings, shall be defined in ASTM E957-03.

1.4 QUALITY ASSURANCE

- A. Products and Services pertaining to this specification shall comply with Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. 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.
- C. Adequate information shall be presented to demonstrate the earth's ability to support ground wells. Provide all required soil sampling and consult a professional civil engineer licensed in the state in which the project is located prior to proceeding with design.
- D. If paralleling arrangement is desired, the system shall have anti-islanding capability such that it is incapable of exporting power to the utility distribution system in the absence of utility power. Paralleling must be approved by serving electric utility. Provide written correspondence from the utility confirming its requirements.
- E. For turbine generator module warranty, furnish 10 year manufacturer's warranty against defects in materials and workmanship.
- F. The batteries supplied shall be intended for use in geothermal systems.
- G. 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.
- H. Warranty: The electrical geothermal power generation system shall be subject to the terms of FAR Clause 52.246-21.

1.5 SUBMITTALS

- A. Where proposed system shall be a Net Meter project, prepare appropriate applications and submittals to the //Resident Engineer// //Contracting

Officer's Representative (COR)//. Where proposed system shall be connected in front of the serving electrical utility meter and a paralleling arrangement is required, prepare appropriate applications and submittals to the //Resident Engineer// //COR//. 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. Provide written documentation confirming approval from the utility company with a description of the proposed geothermal system.

B. Submittals shall comply with paragraph, SUBMITTALS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:

- a. Submit sufficient information to demonstrate compliance with drawings and specifications.
- b. Include steam system, 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.
- c. Type of system being designed, inlet water quality requirements, assessment of available water sources, and condenser/cooling tower water quality requirements.

2. Product Data:

- a. Include detailed information for components of the geothermal energy system.
 1. Geothermal Well and Piping Systems
 2. Heat Rejection Equipment
 3. Cooling Tower
 4. Pumps.
 5. Radiators.
 6. Wiring.
 7. Wiring Specialties.
 8. DC-AC Inverter.

9. Geothermal Energy Storage Battery Option.
10. Turbine Generator Modules.
11. Instrumentation and Metering.
12. Switchgear.
13. DC and AC disconnects.
14. Combiner boxes.
15. Monitoring and control systems, including appropriate interfacing with existing facility data collection systems.

SPEC WRITER NOTE: Include the following paragraph for projects in moderate-high, high and very high seismic zones as listed in Table 4 of VA Handbook H-18-8, Seismic Design Requirements.

//b. Certification from the manufacturer that the equipment has been seismically tested to International Building Code requirements. Certification shall be based upon simulated seismic forces on a shake table or by analytical methods, but not by experience data or other methods.//

3. Manuals:

- a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 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.
- b. If changes have been made to the maintenance and operating manuals originally submitted, then submit updated maintenance and operating manuals two weeks prior to the final inspection.
- 3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturers of all major items of the electrical geothermal power generation system conform to the requirements of the drawings and specifications and that they have jointly coordinated and properly integrated their equipment and controls to provide a complete and functional installation.
 - b. Certification by the Contractor that the electrical geothermal power generation system system has been properly installed, adjusted, tested, commissioned, and warrantied. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies meet contract requirements.
 - C. 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 //Resident Engineer// //COR//.
 - D. Submittals and shop drawings for independent items, containing applicable descriptive information, shall be furnished together and complete in a group. Final review and approvals will be made only by groups.
 - E. Closeout Submittals:
 - 1. Complete set of as-built documents, including geothermal heat exchange well system distribution piping in AutoCAD drawing format (latest version).

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):
- 60-16.....Drinking Water Treatment Chemicals - Health Effects
- C. American Petroleum Institute (API):
- 611-14.....General-Purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Service
- 612-14.....Petroleum, Petrochemical and Natural Gas Industries - Steam Turbines - Special-Purpose Applications
- D. American Society of Mechanical Engineers (ASME):
- B31.1-16.....Power Piping
- E. American Society for Testing and Materials (ASTM):
- E1-14.....Standard Specification for ASTM Liquid-in-Glass Thermometers
- E947-15.....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 Methods for Geothermal and Other High-Temperature Liquid Applications
- E1068-09.....Standard Test Method for Testing Nonmetallic Seal Materials by Immersion in a Simulated Geothermal Test Fluid
- E1069-09.....Standard Test Method for Testing Polymeric Seal Materials for Geothermal and/or High Temperature Service Under Sealing Stress
- E1675-12.....Standard Practice for Sampling Two-Phase Geothermal Fluid for Purposes of Chemical Analysis
- A213/A213M-17.....Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes

- A249/A249M-16.....Standard Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes
- A268/A268M-16.....Standard Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service
- A269/A269M-15.....Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
- A789/A789M-17.....Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
- F. Institute of Electrical and Electronics Engineers (IEEE):
- 519-14.....Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
- 1547.2-08.....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-15.....International Building Code
- H. International Organization for Standardization (ISO):
- 9001-15.....Quality Management Systems - Requirements
- 14001-15.....Environmental management systems -- Requirements with guidance for use
- 6759-80.....Seamless steel tubes for heat exchangers
- I. National Electrical Manufacturer's Association (NEMA):
- 250-14.....Enclosures for Electrical Equipment (1,000 Volts Maximum)
- J. National Fire Protection Association (NFPA):
- 70-17.....National Electrical Code (NEC)
- K. Underwriters Laboratories (UL):
- 6-07.....Electrical Rigid Metal Conduit - Steel
- 94-13.....Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
- 797-07.....Electrical Metallic Tubing - Steel
- 969-17.....Standard for Marking and Labeling Systems

1242-14.....Standard for Electrical Intermediate Metal
Conduit - Steel

1741-10.....Standard for Inverters, Converters, Controllers
and Interconnection System Equipment for Use
with Distributed Energy Resources

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide materials to fabricate functional geothermal energy system assemblies in accordance with ANSI, API, ASME, ASTM, IEEE, ICC, ISO, NEMA, NFPA, and UL, as specified in this section, and as shown on the drawings.
- B. Factory-prefabricated geothermal equipment packages which include turbine generators, pressure chambers, support structures, batteries or other energy storage devices, and instrumentation and controls and which meet the requirements of this section are acceptable.
- C. Geothermal energy system shall comply with all applicable federal and local requirements. Contractor shall familiarize himself with the most current environmental requirements. Contractor is responsible for filing all appropriate paperwork with and obtaining all permitting from governing authorities.
- D. Investigate whether the //Resident Engineer// //COR// or local environmental entities require environmental impact studies which may include but not be limited to, for example, effects upon wildlife or emissions. The Contractor shall determine which entity has jurisdiction over environmental matters and shall make appropriate inquiry and comply with all applicable regulations.
- E. Investigate any other local ordinances that may apply to geothermal installations in the proposed location.

2.2 GROUNDING

- A. All applicable components of the geothermal energy electrical power generating system must be grounded per current NEC requirements.

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.

2.4 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. All exposed conductors shall be rated for geothermal applications. Insulation for all exposed conductors shall be black for its ability to withstand ultraviolet light damage. Utilize distinctive markings at termination points.
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. Non-metallic conduit is not permitted.
2. Shall use expansion joints on long conduit runs to account for thermal expansion. Projected thermal expansion shall be evaluated per NEC.

C. Weather proof enclosures: Shall be NEMA 3R or better. Dust-proof enclosures: Shall be NEMA 4X or better.

D. Cable Assemblies and Junction Boxes:

1. Shall be UL-listed.
2. Shall be rated to 5VA flammability per UL 94.

E. Prohibited Wiring Materials: Not UL-listed, or listed materials used in environments outside those covered in their listing.

2.5 GEOTHERMAL BINARY UNIT

A. Turbine Generator Module:

1. Shall comply with API 611 or 612, as applicable.
2. Enclosure shall be rated IP 20 and IP 56.
3. Unit shall be approved to operate in Class I Division 2/Zone 2 environments as defined by CSA International.

B. Condenser Tube

1. Shall conform to the following specifications: ISO 6759, ASTM A213, ASTM A249, ASTM A268, ASTM A269, and ASTM A789.

2.6 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.
- E. Shall include anti-islanding protection if paralleling arrangement is required.
- F. Shall have 95% or greater efficiency (with isolation transformer).

//2.7 BATTERY CHARGE CONTROLLER

- A. Shall be capable of withstanding 25% over-amperage while charging for limited time per the NEC or minimum of five minutes, whichever is greater.
- B. Shall be capable of withstanding 60% over-amperage while discharging for a minimum of five minutes.
- C. 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.
- D. Shall be listed to UL 1741.
- E. Charge controller shall include maximum power point tracking (MPPT) and temperature compensation.
- F. Shall be manufactured in a facility with ISO 9001 certification.//

//2.8 BATTERY

- A. General: Comply with the NEC. Flooded lead-acid, captive electrolyte lead acid and nickel-cadmium are acceptable. Consider climate when selecting battery type. Batteries must be rated for PV application, so primary batteries are not permitted.
- 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. Confirm that all terminal connections are properly tightened.

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. Sensors: Provide sensors and instrumentation as required by the manufacturer.
- B. 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 the NEC, this section, and the manufacturer's requirements.
- //B. In seismic areas, systems shall be adequately anchored and braced per details on structural contract documents to withstand seismic forces at locations where installed.//
- C. 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.
- D. Drilling Contractor shall be a National Ground Water Association (NGWA) Certified Well Driller (CWD).

- //E. Surface Discharge shall comply with Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) regulations.//
- //F. Reinjection Well shall comply with Environmental Protection Agency (EPA) Underground Injection Control (UIC) regulations for Class V (Shallow Non-Hazardous Injection) wells.//
- G. Borehole construction shall be performed per International Ground Source Heat Pump Association (IGSHPAI) Design and Installation Guide, latest edition.
 - 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.
- H. Piping installation shall be compliant with ASME B31.1, and ICC IMC Section 1206.
- I. Install control and instrumentation as required by the manufacturer.
- J. Provide safety signage per NEC.

3.2 FIELD QUALITY CONTROL

- A. Field Inspection: Perform in accordance with manufacturer's requirements. Prior to initial operation, inspect the geothermal energy electrical power generation system for conformance to drawings, specifications, NEC, and the manufacturer's requirements. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify required area clearances.
 - d. Verify the correct operation of all sensing devices, alarms, and indicating devices.
- B. Tests: Provide equipment and apparatus required for performing tests. Correct defects disclosed by the tests and repeat tests. Conduct tests in the presence of the //Resident Engineer// //COR//.
 - 1. Operational Tests: Perform tests 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. Comply with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
- B. If paralleling arrangement is required, connect the geothermal electrical power generation system to the serving electrical utility grid only after receiving prior approval from the serving electric utility company.
- C. If paralleling arrangement is required, only qualified personnel shall connect the system to the serving electric 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 date requested by the //Resident Engineer// //COR//.

---END---