SECTION C - DESCRIPTION/SPECIFICATIONS

SUBSECTION C.1 - GENERAL REQUIREMENTS

C.1.1. THE REQUIREMENT

It is required that there be furnished and delivered complete in accordance with these specifications, including the drawings listed in Section J hereof, the three excitation systems described in the schedule for Headgate Rock Powerplant, Headgate Rock Hydroelectric Project, Arizona.

The equipment being furnished under these specifications is required for the production of power at the above-named installation which is located on the Colorado River about 14.4 miles below Parker Dam and 1 mile north of the town of Parker, Arizona, within the Colorado River Indian Reservation, as shown on the location map, Drawing No. 1 (1117-D-2).

The Government will remove the old exciters and ship them to the offeror's plant so the offeror can disassemble and test the following items:

1. Copper buswork
2. Heatsink assemblies and thyristors
3. Field flashing and discharge resistors
4. Unit circuit breaker(s)
5. Power potential transformer (PPT)
6. PPT fused disconnects

In the event that any of the items are salvageable, the contractor shall reuse them on the new exciters. However, should an item not be salvageable, the contractor shall furnish and install a new item. For example, if one of the power potential transformers is not salvageable then new power potential transformers for all three excitation systems shall be furnished and installed. This shall apply to all six of the above items. Upon completion of the work, the contractor shall ship the salvageable or new excitation systems to Headgate Rock Powerplant. Whether the items are reused or new the contractor shall supply a minimum 1 year warranty for each of the above items.

The contractor shall furnish the excitation systems and all other required equipment, devices and controls to complete a coordinated design and installation. The contractor will deliver the exciters to Headgate Rock Dam for installation by Government forces. The contractor shall provide an erecting engineer to supervise during Government-installation work and commissioning/testing. Also, the erecting engineer shall complete all preliminary excitation tests required after installation and prior to commissioning/testing.

The offeror shall warrant that the characteristics of each refurbished and/or new excitation system will be comparable to the original excitation systems.

The contractor shall utilize all existing cables/conduits and buswork as specified in these specifications, for interface to external equipment. It shall be the contractor's responsibility to verify cable/conduit and buswork lengths, locations and alignments. Any cable/conduit or buswork which does not connect properly shall be corrected and/or replaced and installed by the contractor at his expense.

C.1.2. GENERAL DESCRIPTION OF POWERPLANT

Headgate Rock Dam was completed in 1941. It was constructed to raise the water level of the Colorado River to provide permanent gravity-flow diversion facilities for irrigation of land on the Arizona side of the reservation.

Headgate Rock Powerplant is located immediately downstream from the existing radial spillway gates 8, 9 and 10.

The powerplant is of the outdoor-surface type located at an elevation of approximately 330 feet.

The reservoir, Lake Moovalya, formed by Headgate Rock Dam contains essentially no active storage capacity. The river flow past Headgate Rock Dam consists of the entire regulated Parker Dam flow minus the diversions to the reservation main canal.

C.1.3. SUBMITTAL REQUIREMENTS

a. General. - The Contractor shall furnish submittals to the Government in accordance with this paragraph, the requirements in the provisions of FAR (Federal Acquisitions Regulations) clauses, Table C.1, and paragraphs C.1.4 and C.4.1 of these specifications.

The word "submittals" shall be interpreted to include drawings, data, manuals, certifications, test reports, curves, samples, brochures, and other items furnished by the Contractor for approval, information, or other purposes.

In Table C.1, the Contractor shall send the number of submittal copies designated in the column headed "No. of sets to be sent to:" to the applicable office at the addresses listed below:

1. CO: Contracting Officer, Attention: LC-3112, Bureau of Reclamation, P.O. Box 61470, Boulder City, NV 89006-0400.

2. CE: Construction Engineer, Bureau of Reclamation, Lower Colorado Dams Facilities Office, Attention: LCD-2000, P.O. Box 60400, Boulder City, NV 89006-0400.

Each submittal shall be sent with a cover letter. A copy of the cover letter shall be sent to the office that is not sent the submittal. The cover letter shall include the following information:

1. Reference to the Government contract/specifications number.
2. Description of materials being submitted.

b. When a catalog sheet is submitted, the particular item to be furnished shall be underlined or marked. The data shall be comprehensive and shall fully demonstrate that the material or equipment meets the requirements of the specifications.

c. The time required for review of submittals furnished for approval as specified herein will not begin until the Government receives complete sets of all the submittal materials required for that Required Submittal Number (RSN).

The Government will require 20 calendar days for review of submittals furnished by the contractor for approval, and this review time will apply to each separate submittal or resubmittal whether the submittals are approved, not approved, or returned for revision.

Table C.1 - List of submittals

RSN	Item	Reference provision, clause, or paragraph	Responsible code	Submittal items	No. of sets to be sent to:*		Due date or delivery time
					CO	CE	
E1	Excitation system	C.1.4.	CE	Approval data/drawings (Manufacturer's format)	0	5	Within 30 calendar days after receipt of notice of contract award
E2	Excitation system	C.4	CE	Test reports: 1. Factory tests	0	5	Within 30 days after tests are performed
E3	New power potential transformer (PPT) and refurbished or new PPT fused disconnect	C.1.4.d.	CE	Approval data/drawings (Manufacturer's format)	0	5	Within 30 calendar days after receipt of notice of contract award
E4	Refurbished or new power potential transformer (PPT) and refurbished or new PPT fused disconnect	C.1.4.h. C.3.5.b.	CE	Test reports: 1. Factory tests	0	5	Within 30 days after tests are performed
E5	New AC field breaker	C.1.4.d.	CE	Approval data/drawings (Manufacturer's format)	0	5	Within 30 calendar days after receipt of notice of contract award
E6	Refurbished or new AC field breaker	C.1.4.h. C.3.5.c.	CE	Test reports: 1. Factory tests	0	5	Within 30 days after tests are performed

RSN	Item	Reference provision, clause, or paragraph	Responsible code	Submittal items	No. of sets to be sent to:*		Due date or delivery time
					CO	CE	
E7	New alternating and direct-current copper buswork	C.1.4.d	CE	Approval data/drawings (Manufacturer's format)	0	5	Within 30 calendar days after receipt of notice of contract award
E8	Refurbished or new alternating and direct-current copper buswork	C.3.5.d	CE	Test reports: 1. Factory tests	0	5	Within 30 days after tests are performed
E9	New heatsink assemblies and thyristors	C.1.4.d	CE	Approval data/drawings (Manufacturer's format)	0	5	Within 30 calendar days after receipt of notice of contract award
E10	Refurbished or new heatsink assemblies and thyristors	C.3.6.b(12)	CE	Test reports: 1. Factory tests	0	5	Within 30 days after tests are performed
E11	New field flash and discharge resistors	C.1.4.d	CE	Approval data/drawings (Manufacturer's format)	0	5	Within 30 calendar days after receipt of notice of contract award
E12	Refurbished or new field flash and discharge resistors	C.3.6.b(8)	CE	Test reports: 1. Factory tests	0	5	Within 30 days after tests are performed
E13	Current Transformer (CT) (if applicable)	C.3.6.b(4) C.3.8.	CE	Approval data/drawings (Manufacturer's format)	0	5	Within 30 calendar days after receipt of notice of contract award
E14	Current Transformer (CT) (if applicable)	C.3.6.b(4) C.3.8.	CE	Test reports: 1. Factory tests	0	5	Within 30 days after tests are performed
E15	Schematic diagrams and key drawings	C.1.4.	CE	Drawings and descriptions	0	5	Within 45 calendar days after receipt of notice of contract award
E16	Manufacturer's as-builts	C.1.4.g.	CE	Marked drawings	0	2	Before equipment is ready for shipment
E17	Manufacturer's installation and operating instructions	C.1.4.	CE	Books, manuals, cut sheets	0	5	Before equipment is ready for shipment
C1	Paint and coating materials	C.5.1.	CE	Approval and certification	0	1	Not less than 30 days prior to use of associated paint and coating materials.
C2	Warranty	1452.246-901	CO	Standard commercial warranty or equivalent to standard commercial warranty on refurbished equipment	2	0	Prior to final payment
C3	Liability insurance	DOI 1452-228-70	CO	Acceptable evidence showing that insurance has been obtained	1	0	Prior to commencement of work under this contract
C4	Mandatory information for electronic funds transfer	52.232-33	CO	Payment information	1	0	After award, but no later than 14 days prior to submission of first invoice or first financing request
C5	Release of claims	DOI 1452-204-70	CO	Release of claims	1	0	After completion of the work and prior to final payment

*CO indicates Contracting Officer and CE indicates Construction Engineer. For mailing addresses, see paragraph C.1.3, entitled "Submittal Requirements."

C.1.4. ELECTRICAL DRAWINGS AND DATA TO BE FURNISHED BY THE CONTRACTOR

a. General. - All drawings and data shall be in accordance with this paragraph; paragraph C.1.3; and the applicable equipment and/or materials paragraph. All drawings and data shall be written in English, shall be made expressly for this contract (typical drawings will not be acceptable), shall be complete and accurate in their content, and shall be legible. Freehand sketches will not be accepted. The units of measurements shall be given in the United States Customary System.

(1) The Construction Engineer will require 20 calendar days to answer correspondence and to return each submittal of data or drawings (see paragraph C.1.3.).

(2) When revised drawings are submitted for approval, the changes from the previous submittals shall be clearly identified on the drawings with every revision made during the life of the contract shown by number, date and subject in a revision block and a notation shall be in the drawing margin to permit rapid location of the revision. The drawings shall be clear and legible in all respects.

b. Key drawings and data. -

(1) Drawings and information provided by the contractor shall show the major dimensions and the proposed design of all important components of the exciter, excitation power equipment, supporting structures, and foundations. The drawings shall include an axial cross-sectional drawings showing the general construction and overall dimensions of the exciter cabinet height and weights of principal parts. The drawings shall also show the clearances required for assembly and dismantling.

(2) Electrical schematic diagrams of the excitation system as well as complete and detailed descriptions of their operation. The descriptions shall be specific as to the operation of the equipment and the actual control and regulator circuits furnished shall include a typical oscillogram to demonstrate that the excitation system voltage response time will be in compliance with these specifications. The function and protective features of each device shall be fully described.

All schematic circuitry shall be shown in “vertical ladder” form and each schematic drawing shall include a list giving an explanation and function of each device number shown thereon.

Switch developments for all control switches to be furnished by the contractor shall be included with the above diagrams. Schematic or elementary diagrams shall be drawn similar to the typical schematic and single-line diagrams as shown on Drawings Nos. 55 (104-D-876) and 56 (104-D-889). The schematic drawings shall include a block diagram showing the complete excitation and voltage-regulating equipment. Each block shall identify the

device and show the reference drawing number on which the device is shown. All relay contacts shall be shown in the nonoperated or coil-deenergized position. The block diagram shall show the origin and termination of the various signals at each module or unit of the exciter and regulator.

An index drawing shall be furnished showing a tabulation of all the excitation drawings. Each drawing on the tabulation shall have an abbreviated number or reference number for easy identification. The purpose of this requirement is to facilitate identification and location of the drawings for review and maintenance purposes.

The description shall be written in a coherent narrative form, shall be indexed, and shall provide a complete step-by-step explanation of the operation of the regulator circuits through the following sequences:

(aa) Normal startup.

(bb) Normal shutdown.

(cc) Abnormal shutdown (load rejection).

(dd) Operation and recommended settings of auxiliary circuits such as limiters, overexcitation protection, etc.

The explanation must be explicitly written and arranged so that Government field and operating personnel can easily follow it through step by step.

(3) The following data on equipment shall be provided by the contractor. This data may be ommitted if it is found on the drawings required at C.1.4.b(4) below.

(aa) Ratings in horsepower of 460-volt, 3-phase, 60-hertz motors for the following:

1. Cooling equipment for static exciter (see paragraph C.3.4.).

(bb) Continuous and short-time, direct-current requirements from 125-volt station battery for excitation control and voltage-regulating equipment (see paragraph C.3.5. for limitation).

Amperes, continuous _____

Amperes, short time _____ for _____ seconds

(cc) Dimensions, weights, and arrangement of the static exciter, excitation power equipment, and voltage-regulator cubicle.

(dd) Power transformer rating for excitation system:

kilovolt ampere _____ ;

and volts _____

(ee) Direct-current requirements from 125-volt station battery for flashing generator field and period of time required. See paragraph C.3.5. for limitation.

Amperes _____ for _____ seconds

(ff) Rating in volts, kilowatts and amperes of the exciter.

(gg) Volt ampere capacity and accuracy classification for potential transformers to be used with voltage regulator:

1. Volt ampere capacity _____

2. Accuracy classification _____

(hh) Power required at 460 volts, 3 phase, 60 hertz for the voltage regulator.

(4) A drawing showing connections proposed for terminations at the generator and excitation system power supply including both alternating-current bus and direct-current bus.

c. Design data. -

(1) Generator. -

(a) Field current and collector-ring voltage required for rated kilovolt-ampere output at rated voltage and rated power factor.

Table C-1B - Generator at rated power factor, rated voltage and rated kilovolt-ampere

Losses	Percent of full-load rating			
	25%	50%	75%	100%
Excitation system				
TOTAL LOSSES				

Table C-1C - Generator at unity power factor, rated voltage and rated kilovolt-ampere

Losses	Percent of full-load rating			
	25%	50%	75%	100%
Excitation system				
TOTAL LOSSES				

(aa) Ceiling voltage of exciter.

(bb) Rating in volts, kilowatts and amperes of the exciter.

(cc) Direct-current requirements of excitation control system.

(dd) Direct-current requirements for flashing generator field in amperes and length of time in seconds required.

(ee) Excitation-system voltage response time.

(ff) K_A regulator gain.

(gg) T_A regulator time constant in seconds.

(hh) K_F feedback gain.

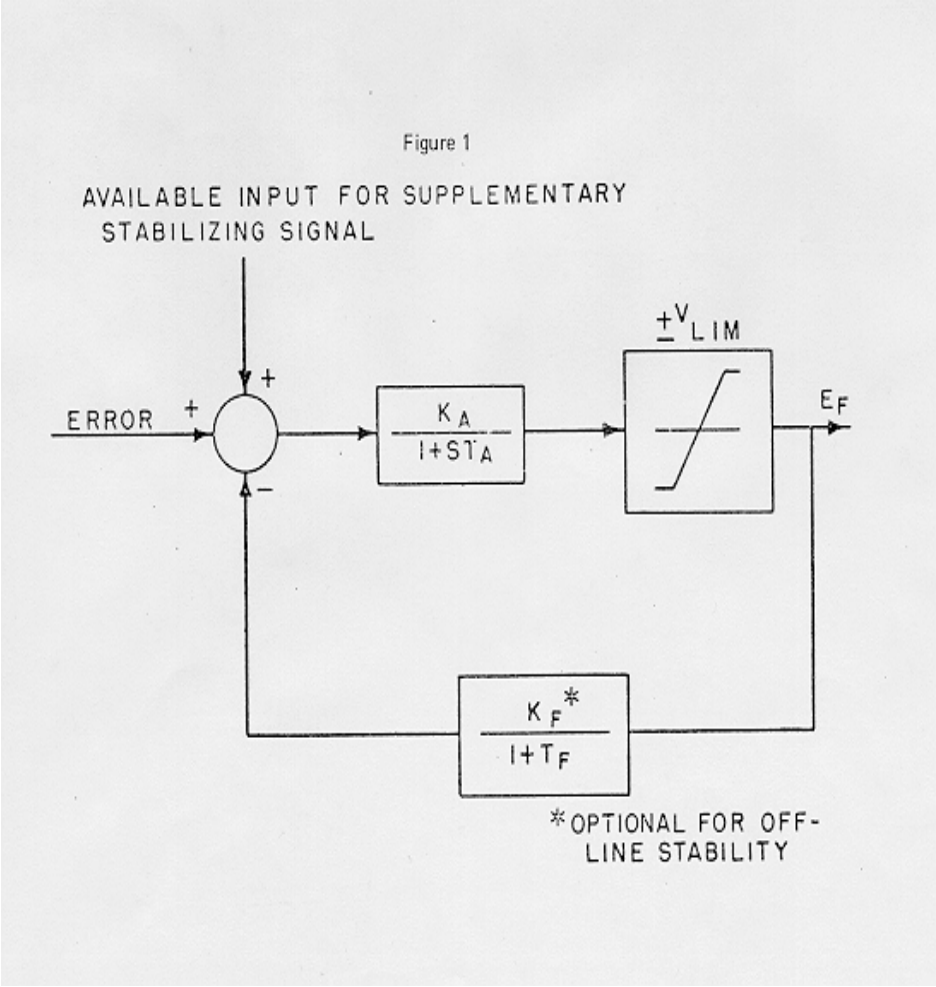
(ii) T_F feedback time constant in seconds.

(jj) V_{LIM} maximum exciter voltage in per unit.

(kk) The functional diagram shown in figure 1 below represents a typical static exciter system. An appropriate function diagram prepared in a similar manner and which represents the equipment to be supplied shall be furnished. The parameters listed in subparagraphs (ff) through (jj) above apply to the typical diagram shown in figure 1 below. If these parameters are not used in representing the equipment

to be furnished, then the values of similar parameters which do apply should be furnished.

FIGURE 1



(aaa) Data on the alternating- and direct-current circuit breaker in the excitation circuit:

		A-C circuit breaker	D-C circuit breaker
1	Closing current at 125 volts direct current, amperes	_____	_____
2	Tripping current at 125 volts direct current, amperes	_____	_____
3	Closing time from the time the control circuit is energized until the main contacts close, cycles	_____	_____
4	Opening time from the time the control circuit is energized until the main contacts open, cycles	_____	_____

d. Approval drawings. - Within 30 calender days after receipt of notice of contract award, the contractor shall furnish the following drawings and data for the excitation systems.

(1) Excitation equipment drawings and data. -

(a) Schematic diagrams. - The contractor shall submit to the Construction Engineer for approval five sets of the complete electrical schematic diagrams of the excitation control system and five sets of a complete and detailed description of the operation of all control and regulator circuits.

(b) Other approval drawings. - The contractor shall submit to the Construction Engineer for approval not less than five sets of such drawings and wiring diagrams as may be required in addition to the key drawings to demonstrate fully that the equipment to be furnished will conform to the requirements and intent of these specifications. The following shall be included, where applicable:

(aa) Equipment layouts showing physical front and rear views of panels and sections. The drawings shall show location of all equipment including nameplates, auxiliary devices, cable supports, terminal blocks and wiring ducts. The rear views shall show all devices in their relative physical locations and whether they are located on the panels, side sheets or brackets. The drawings shall show the floor plans and show the location of anchor boltholes. Layout drawings shall show all nameplates sequentially numbered (N1, N2, N3, etc.).

Outline drawings and drawings showing punching and drilling dimensions for the devices required in paragraph C.3.5. shall be included.

Also, detailed drawings of the excitation power transformer and cubicle shall be furnished.

(bb) Bills of material giving information on each piece of equipment including type, style, manufacturer, and other pertinent information such as scales, trip ratings, escutcheon engraving, etc., as applicable. The bills of material shall be as complete as the information to the contractor will permit.

Nameplate lists showing the engraved lettering on the nameplates will be furnished to the contractor by the Government.

(cc) The wiring diagrams shall:

1. Be based on approved schematic drawings.

2. Identify the panel, side sheet or door.

3. Locate the equipment on the panels and the studs on the equipment in their relative physical locations. Equipment on swinging panels shall be shown in their relative location as viewed from the rear of the panel in the full-open position.

4. Show stud or terminal numbering, if any.

5. Identify each piece of equipment.

6. Show wire designation taken from elementaries.

7. Be similar to Drawing No. 54 (104-D-873) which is included in these specifications to show the desired manner in which wiring diagrams are to be prepared.

8. Show internal wiring of equipment. Complex circuits may be on a separate drawings or drawings.

9. Show and identify each individual wire and show exactly to which device each wire goes. Wiring diagrams must identify each conductor as it leaves a termination and shall include the identifying number of its identification.

Wiring diagrams which do not meet the above requirements will not be acceptable.

It shall be the responsibility of the contractor to insure that the wiring diagrams agree with the schematics as the terminal block layout only for outgoing connections will be approved by the Government.

(c) The manufacturer's data for each device or item of equipment, such as catalog cut sheets, shall include the manufacturer's name and address and comprehensive product information including catalog number, type, style, or model number, electrical ratings, and dimensions. Where several items are listed on the same data sheet, the data being submitted for approval shall be clearly marked. The data shall fully demonstrate that the device and/or item of equipment proposed meets the requirements of these specifications. The manufacturer's data shall include a reference to the RSN number(s) that it is being submitted for.

e. Final drawings and data. - The contractor shall furnish the Construction Engineer with an AutoCAD Version 12, 13 or 14, five complete sets of final correct assembly drawings, electrical schematic and wiring diagrams, and such construction drawings as in the opinion of the Construction Engineer may be required for dismantling and reassembly, maintenance and repair of all components of the equipment furnished by the contractor.

The contractor shall furnish as part of the data and recommended settings required for subparagraphs (1) and (2) below actual calculations and formulae used in determining the resulting data and settings.

(1) Recommended settings for the overexcitation limiter device, exciter protective relays and loss-of-field relay.

(2) Recommended settings for the underexcitation limiter device.

The Government will furnish data on the characteristics of the external system for the contractor’s use under subparagraphs (1) and (2) above.

f. Drawings shall be provided with manufacturer’s title blocks located in accordance with Drawing No. 53 (104-D-809) and of a size to permit the Government to trim off manufacturer’s title and revision blocks so as to leave record drawings that are sized and have margins in accordance with standard drawing sizes shown on Drawing No. 49 (40-D-5056) and have the Government title block within the margin sized in accordance with Drawing No. 50 (104-D-786).

g. Manufacturer's "as-built" prints. - The contractor shall furnish revised prints showing all changes and revisions with revision dates made on the drawings up to the time the equipment is completed and accepted.

h. Test reports. - After completion of those tests required at the factory and those tests required after installation but before commissioning/tests, the contractor shall furnish five certified copies of all test reports, data, curves showing the characteristics of the machines as determined by the tests, etc.

i. Payment. - Payment for furnishing electrical drawings and data will be made at the lump-sum price bid therefor in the schedule, which price shall include the cost of providing approval manufacturer's data, bill of materials and test reports for the equipment.

C.1.5. OPERATING CONDITIONS

Each generator is designed to operate at 4,160 volts, 60 hertz, either singly or in parallel with another generator at transmission voltage, and at an elevation of approximately 333 feet. Each generator is connected by non-segregated-phase bus through a generator voltage circuit breaker to a 3-phase, 7,250-kilovolt ampere power transformer. Each generator is loaded from no load to rated load at a rate which is limited only the maximum operating speed on the gates. Additionally, the generators are cycled from rest to full load twice daily with more starts per day during system emergency conditions or they are operated continuously at any load up to rated load for extended periods of time (continuous duty). Station-service power is taken from the generator voltage bus between the unit breaker and main power transformer.

The powerplant is designed for unattended operation and is controlled by means of supervisory control equipment.

The turbine and generator are exposed to outdoor conditions and directly exposed to the sun with ambient air temperatures ranging from 0 to 45°C. Maximum dust content is 420 micrograms per cubic meter. Maximum temperature of the cooling water is 30°C.

SUBSECTION C.2 - MATERIALS AND WORKMANSHIP

C.2.1. MATERIALS AND WORKMANSHIP - RECLAMATION

a. Materials. - In accordance with the FAR clause entitled "Material and Workmanship," all materials furnished by the Contractor shall be refurbished like new or new and of the most suitable grade for the purpose intended considering strength, ductility, durability, and best engineering practice.

Except as specified, materials shall conform to Federal specifications or standards, or, if there are no applicable Federal specifications or standards, materials shall conform to the specifications or standards of the most current versions of the ANSI (American National Standards Institute), ASTM (American Society for Testing and Materials), ASME (American Society of Mechanical Engineers), IEEE (Institute of Electrical and Electronic Engineers), NFPA (National Fire Protection Association), or other nationally recognized standards organization. If the Contractor proposes to deviate from, or to use materials not covered by, the aforementioned specifications and standards, the Contractor shall submit, for approval, the justification for and exact nature of the deviation, and complete specifications for the materials proposed for use.

Parts shall be made accurately to standard gauge where possible. Threads, including but not limited to those of bolts, nuts, screws, taps, pipes, and pipefittings shall be unified screw threads conforming to ANSI B1.1 (1989) or B1.20.1 (1983, revised 1992). For internal connections only, the Contractor will be permitted to deviate from the ANSI standards, provided the Contractor furnishes a complete set of taps and dies as might be required to facilitate repair or replacement.

All fasteners shall be permanently marked with a symbol identifying the manufacturer and with symbol(s) indicating grade, class, type, and other identifying marks in accordance with reference or applicable standards.

b. Workmanship. - The Contractor shall be responsible for the accurate manufacture and fabrication of materials in accordance with best modern practice and the requirements of these specifications, notwithstanding minor errors or omissions therein.

Safety and adequate shock-absorbing features shall be used throughout designs, especially for parts subjected to variable stress or shock, including alternating or vibrating stress or shock. Shock-absorbing features and parts subject to vibration shall include provisions which prevent components from loosening.

C.2.2. WORKMANSHIP

All work shall be performed and completed in a thorough, workmanlike manner and shall follow the best modern practice in the manufacture of high-grade machinery, notwithstanding any omissions from these specifications. All work shall be performed by mechanics skilled in their various trades. All parts shall be made accurately to standard gage so as to facilitate replacement and repairs.

C.2.3. WORK AND MATERIALS TO BE FURNISHED BY THE CONTRACTOR

The contractor shall furnish all labor and materials, including all foundation metalwork, equipment, instruments and tools required in connection with the manufacture and testing (preliminary onsite testing) of the excitation system.

The contractor shall bear all cost of transporting all materials from the contractor's shipping point or points to the jobsite.

The contractor shall be responsible for all materials during periods of transportation and for any necessary storage and protection of materials prior to their installation.

C.2.4. REFERENCE SPECIFICATIONS AND STANDARDS

Materials, contractor design, and other requirements which are specified by reference to Federal Specifications, Federal Standards, or other standard specifications or codes shall be in compliance with the latest editions or revisions thereof in effect on the date bids are received, including any amendments or supplements. In the event of conflicting requirements between a referenced specification, standard, or code and these specifications, these specifications shall govern.

Unless otherwise specified, all materials that will become a part of the completed work shall be refurbished like new or new, and shall conform to the Federal or other specifications and standards referred to herein. Where reference specifications numbers are designated throughout these specifications, they refer to Federal Specifications unless otherwise noted. In the event that the materials are not covered by Federal or other specifications, the materials furnished shall be of standard commercial quality. Where types, grades, or other options offered in the reference specifications are not specified in these specifications, the material furnished will be acceptable if it is in accordance with any one of the types, grades, or options offered.

SUBSECTION C.3 - EXCITATION SYSTEM REPLACEMENT

C.3.1. TYPE, RATING AND CAPABILITY

a. The generator is of the horizontal-shaft, hydraulic-turbine-driven, alternating-current, synchronous type, external to the water passage and conforms to the applicable standards of ANSI in regard to rating, characteristics, test, etc., unless otherwise specified herein. The generator and all associated equipment is suitable for satisfactory operation at an elevation of 333 feet above mean sea level.

b. The rating of the generator is as follows:

Kilovolt ampere	7,222
Power factor	.90 percent at full load
Frequency	60 hertz
Number of phases	3
Voltage between phases	4,160 volts
Speed	75 RPM
Poles	96
Excitation rating	250 KW, 250 VDC

C.3.2. ELECTRICAL CHARACTERISTICS

The electrical characteristics of the excitation system shall be as follows:

a. The excitation system voltage response time shall be not more than 1/20 second.

b. The maximum voltage (ceiling voltage) of the excitation system when delivering its rated current shall be at least 2.5 times the per unit excitation system voltage unless the generator direct-axis transient open circuit (field open circuit) time constant is greater than 6 seconds. In the latter case, the exciter ceiling voltage shall be increased in proportion to the generator field time constant.

c. Existing Exciter Nameplate Data:

Maximum AC Input: 320 VAC	455 Amps	3 Phase	60 Hz	
DC Output Volts: 231 Nominal	360 Ceiling			
DC Output Amps: 479 Nom	550 Max	Cont 825	30 SEC	
AMB AIR: 40 Degrees Celsius Max	5 Degrees Celsius Min			

C.3.3. TERMINAL BOXES, CONDUIT AND WIRING

a. General. - The contractor shall furnish and install all terminal boxes, internal wiring and internal conduits for auxiliary circuits for the static excitation equipment cubicle including wiring and conduits between the terminal blocks in the speed-signal-device housing and the main terminal box.

The contractor shall reuse all external conduits and wiring.

Installation of terminal boxes, conduits, conduit accessories and wiring shall be performed in accordance with the applicable provisions of NEC ANSI C1 (1997) of the National Fire Protection Association.

b. Terminal blocks. - Terminal blocks for terminating leads with circuit voltages of 60 volts or less shall be of the 600-volt, 25-ampere, molded-block type. Terminal blocks shall accommodate ring lugs one-half inch wide (diameter) at the terminal screws.

Terminal blocks shall be furnished with binder-head or washer-head screws having serrated or grooved contact surfaces or having lockwashers. Terminal blocks shall be furnished with molded insulating barriers between terminals, brass terminal strips and a removable marking strip with the wire designations marked thereon. Terminal blocks for control wiring shall be suitable for use with No. 10 AWG wire and shall be provided with approximately 25 percent spare terminals for terminating spare conductors in each control cable and for possible future use. Each terminal block shall be provided with a removable cover to prevent accidental contact with any terminal point. Examples of terminal blocks meeting the above requirements are:

Buchanan catalog Nos. B104T through B112T
Marathon catalog Nos. 1604116 through 1612116
General Electric Company type EB-25

Terminal blocks for terminating leads having circuit voltages of over 600 volts shall have an adequate current rating, be capable of withstanding the “hi-potential” voltage level of the equipment located at the circuit source and be of the molded-block type with post-type terminals with barriers between terminals suitable for connection of terminal lugs with insulated cover and a removal marking strip with the wire designations marked thereon.

The terminal blocks for the current transformer circuits (if applicable) shall be of the short-circuiting type.

Adjacent rows of terminal blocks shall be separated at least 6 inches edge to edge and shall be at least 6 inches from any barrier or edge of the terminal box.

Designations shall be machine lettered, stamped, engraved, or neatly marked with permanent ink and shall be in accordance with wire designations marked on schematic and detail wiring diagrams approved by the Government.

Individual screws or studs and nuts with retainer-type washers or wire terminals shall be furnished for each incoming and outgoing conductor. The terminal blocks for the Government's connections for circuits less than 600 volts shall accommodate No. 10 AWG control cable without crowding.

The type and composition of the terminal blocks and the terminal arrangement shall be subject to the approval of the Construction Engineer.

c. Wire. - All insulated control and other auxiliary wiring for circuits of not more than 480 volts alternating current or 250 volts direct current shall be not smaller than No. 12 AWG and the alarm circuits shall be No. 16 AWG or larger. The conductors shall be stranded tinned copper with type AVA or SIS insulation in accordance with NEC, ANSI C1 (1997).

Insulated wiring in the static exciter and excitation cubicles shall conform to the latest standards of NEMA publication No. SG5, Power Switchgear Assemblies (1995), and conductors shall have type AVA, AVB, TA, SIS or TBS insulation.

All output leads from transducers (if applicable) shall be shielded.

C.3.4. EXCITATION SYSTEM

a. Requirements. - The continuous capacity of the excitation system shall be at least 10 percent in excess of the actual capacity (in amperes) required to supply the field excitation current of the generator when the latter is operating at 100 percent rated kilovolt ampere output, rated power factor, and rated voltage. The excitation system shall be capable of supplying full-load collector-ring voltage and corresponding field current down to 70 percent rated generator terminal voltage.

The excitation system shall perform within the specified time when the voltage-regulator error signal is greater than 10 percent or when a supplementary signal is applied.

Excitation-system, voltage-response time tests shall be made by a combined test on the voltage regulator and on the exciter after the synchronous machine regulating system has been adjusted for normal operation.

The tests shall be performed as outlined in paragraphs C.4.1. and C.4.2., respectively.

b. Definitions. - The excitation system shall include all of the components required to meet the specified performance and shall be based upon the following definitions.

(1) A synchronous machine excitation system is the source of field current for the excitation of a synchronous machine and included the exciter regulator and manual control.

(2) Rated excitation-system voltage is the exciter rated voltage.

(3) The synchronous machine excitation-system voltage time response is the output voltage of the excitation system expressed as a function of time under specified conditions.

(4) The excitation-system voltage response time is the time required in seconds for the excitation voltage to attain 95 percent of the difference between ceiling voltage and rated-load field voltage under specified conditions.

(5) Exciter ceiling voltage is the maximum voltage that may be attained by an exciter under specified conditions.

(6) Excitation-system ceiling voltage is the maximum direct-current component of system output voltage that may be attained by an excitation system under specified conditions.

(7) A synchronous machine voltage regulator is a regulator which functions to maintain the voltage of a synchronous machine at a predetermined value or vary it according to a predetermined plan.

(8) One per unit excitation-system voltage is the synchronous machine field voltage required to provide rated voltage on the airgap line of the synchronous machine at a field winding temperature of 75°C.

C.3.5. STATIC EXCITATION SYSTEM

a. General. - The generator shall be equipped with exciter and excitation control equipment consisting of static components. The equipment shall conform to the applicable standards of ANSI and where no conflict occurs, with the standards of NEMA. The static excitation system shall permit continuous stable operation of the generator under manual excitation control, voltage-regulator control, or automatic limiter control for all loading conditions including when carrying warranted synchronous condenser capacity, underexcited. The excitation system shall be capable of fully reversing its output voltage in response to a control signal. Intentional negative field current will not be required; however, to minimize generator iron burning in the event of a generator or excitation power transformer fault, the contractor shall furnish all equipment to rapidly reduce the generator field flux until the generator alternating-current terminal voltage is too low to produce excitation output voltage. Sensing equipment shall be furnished to trip the excitation supply breaker at an adjustable time before or upon completion of the demagnetizing action. The contractor shall also furnish a switch to cut the demagnetizing feature in or out of service.

The static excitation system shall meet all performance requirements and receive the tests described in paragraphs C.3.4. and C.3.6. and shall be furnished with electrical, mechanical and physical features required by these referenced paragraphs.

The output shall be connected to the generator field through either a conductor and resistor or a free-wheeling diode to allow field discharge on loss of field excitation. An alternating-current breaker is required at the excitation system input to allow field circuit tripping for either external system conditions or a failure of the excitation components. The alternating-current circuit breaker shall be in accordance with ANSI C37.16 (1997) and NEMA publication No. SG3 (1995).

Direct-current measuring equipment consisting of shunts and leads, transducers and all other equipment required to provide indication of generator field amperes shall be furnished, leads to be wired to terminal blocks for extension to external circuits. The above equipment shall maintain isolation from the generator field circuit.

The continuous capacity of the exciter shall be sufficient for the excitation system capacity requirements of paragraph C.3.4. The exciter shall be suitable for operation with the excitation control and voltage-regulating equipment specified in paragraph C.3.6.

The excitation system shall be complete with its fused switch connected to the generator terminals; power supply transformer; electrically operated, alternating-current air circuit breaker; bus exciter cubicle; electrically operated, direct-current air circuit breaker with nonlinear resistor; power bus connections between exciter cubicle and collector rings; electrically operated, direct-current contactor in the field-flashing circuit; and all necessary devices for indication, protection, alarm and control of the equipment. A molded-case circuit breaker will not be acceptable as the field-flashing circuit breaker. The excitation system must not rely on any other source of power except for the direct-current power source for flashing the generator field. The use of oil as an insulating medium in any of the components is excluded.

Rectifiers of the exciter shall be of the silicon type. The initial capacity of the rectifiers shall have an allowance to cover any loss in capacity which may be caused by aging. A sufficient number of rectifiers (with a minimum of two) shall be used in parallel in any one leg so that failure of any one rectifier in a leg by short circuit will not cause failure of the excitation system. For an entire leg, the rectifiers shall have a Peak Inverse Voltage (PIV) rating of not less than four times the maximum root-mean-square voltage of the input. Voltage spike protection shall be provided.

The static exciter shall be of modular design such that the modules can be readily removed for inspection or replacement. Indicating lights shall be provided on each module to indicate and located individual rectifier failure. The use of electron tubes (see ANSI C42.70-1957, group 70) in any part of the excitation system is excluded.

At least one module (consisting of a 3-phase bridge) of rectifiers shall be removable while the generator is in operation with no resulting reduction in generator capacity or of full-field forcing capability. As an option to the requirement that the module be removable while the generator is in operation, the contractor may furnish two extra modules built into the exciter. The loss of two modules shall not result in a reduction of generator capacity or of full-field forcing capability.

The exciter shall have a self-cooled (self-contained) rating capable of building up generator rated voltage, to speed-no-load. Fans may be used for cooling the rectifiers in the exciter when the exciter is supplying any current greater than that required to produce generator rated voltage at speed-no-load. Two sets of fans shall be furnished, each capable of supplying the above cooling requirement. One set of fans shall be supplied from the static excitation transformer. The other set of fans will be supplied from the powerplant station-service system at 480 volts, 3 phase, 60 hertz. The contractor shall provide contactors for the fans and an automatic throwover system in the event of loss of power supply to either set of fans. Provision shall be made for manual selection of the bank of fans to be used for cooling. Normal supply for the fans will be from the static excitation transformer.

The contractor shall provide two electrically separate auxiliary contacts on each fan contactor that close in the contactor-deenergized position. One contact of each fan contactor will be used for alarm on the Government annunciator. The other contact of each contactor may be used in the automatic transfer scheme. These circuits shall be interlocked so as to be inoperative under starting and stopping of the generator or shutdown under relay operation.

To insure adequate airflow, a suitable temperature detecting device shall be located in the exciter cubicle to indicate complete or partial loss of airflow. The temperature-detecting device shall have three electrically separate contacts that close when temperature rises to a predetermined level. One contact shall be used for annunciation, one contact for shutdown, and one contact for supervisory control.

All contacts shall be suitable for operation on 125 volts, direct current, and shall be rated for at least 5 amperes.

A barrier shall be provided between 480-volt circuits and circuits of lower voltage. All 480-volt control transformers shall have primary fuses in both leads or shall be mounted in a totally enclosed metal enclosure.

The static excitation system shall be provided with devices which will polarize the main generator field from the station battery if necessary to insure generator voltage buildup. Means shall be provided to prevent inadvertent backflow of current from the generator field and exciter output circuit through the contactor to the station battery. The scheme proposed by the contractor shall be subject to approval of the Construction Engineer.

The contractor shall furnish all static excitation equipment including alternating- and direct-current circuit breakers, etc., in a suitable enclosed-cubicle-type switchgear enclosure or enclosures. The exciter and excitation equipment shall be located on the 327.5-foot elevation floor and within the designated area shown on Drawing No. 5 (1117-D-9). The arrangement shall provide suitable access to all components. Maximum height of the cubicles shall be 90.7 inches (includes skid) and all cubicles shall be of the same height. Maximum depth shall be 48 inches and maximum length shall be 262.1 inches including fused disconnect switch and power potential transformer. Refer to Drawing No. 27 (4559-RP-5).

All low-voltage and control wiring between the excitation power transformer cubicle, the static exciter cubicle, and the excitation control cubicle shall be carried in wireways internally between the cubicles.

Low-voltage power supply circuits entering cubicles for fans and heaters shall be provided with disconnecting means and overload protection.

All cubicle-type enclosures shall be supported from structural-steel supports mounted above the floor as shown on Drawing No. 48 (549-D-711). The contractor shall furnish all structural-steel supports and expansion anchors required for the installation.

The excitation power transformer cubicle shall be designed to accommodate a non-segregated-phase bus entrance from above, manufactured by Unibus Inc.. The buswork is currently installed as shown on Drawings Nos. 23 (D-1769-002, sheet 1 of 2), 24 (D-1769-002, sheet 2 of 2) and 25 (D-1769-019).

The following existing cables/conduit and buswork are the contractor's responsibility to connect to and reuse. If the contractor utilizes a different cable/conduit or buswork, he shall submit this change for approval by the Contracting Officer's Representative at no additional cost to the Government. Refer to Drawings Nos. 26 (4559-OV-5 Rev 04 - [A1-400-601-454, sheet 1 of 3]) and 10 (1117-D-1926).

(1) The existing power connection on the line side of the fused disconnect switch is cable.

(2) The existing power connection between the fused disconnect switch and the high side of the potential power transformer is cable.

(3) The existing power connection between the low side of the potential power transformer and field breaker (41E) is cable.

(4) The existing power connection between the excitation system and the generator field is buswork. This buswork travels overhead into the exciter cubicles. Refer to Drawings Nos. 23 (D-1769-002, sheet 1 of 2), 24 (D-1769-002, sheet 2 of 2), and 25 (D-1769-019).

The external existing cable/conduit to be reused, entered the existing excitation cubicles through an open bottom: specifically the DC field circuit cubicle. Refer to Drawing No. 28 (4559-OW-5) for general location. For design purposes, the existing cable lengths are approximately 2 feet of field/cable and approximately 8 feet for all other cables starting at floor level within the DC field circuit cubicle for each excitation system.

If the power connections between the secondary of the transformer, the air circuit breaker, and the exciter cubicles are exposed, then busway or bus structure shall be furnished in accordance with subparagraph C.3.5.d below. If the above power connections are furnished internally as part of the cubicle structures, then the bus shall be insulated.

b. Refurbish existing or furnish new power potential transformer. -

(1) The power transformer shall be designed and manufactured in accordance with ANSI C57 (1995) and where no conflict occurs with NEMA publication No. ST20 (1992), unless otherwise specified herein. The transformer shall be dry type, 3-phase, Δ-Δ connected, 60-hertz, self-cooled, indoor-type. Full-rated-capacity taps on the high-voltage winding shall be provided to accommodate the complete range of regulator operation. The basic insulation level for the primary transformer windings shall be 60 kilovolts at an altitude of 3,300 feet and the temperature rise shall be in accordance with NEMA publication No. ST20 (1992) for dry type. Barriers shall be provided between primary connections to maintain phase isolation within the cubicle. All transformer conductors shall be copper.

The transformer shall be equipped with three current-limiting power fuses rated not less than 39,000 amperes root-mean-square asymmetrical at 4.16 kilovolts. The fuses shall be mounted as part of a gang-operated switch.

In addition to the standard accessories, the power transformer shall be equipped with the following additional accessories:

(a) Ground pad with bolted-type connector for No. 4/0-AWG stranded copper cable.

(b) A bulb-type temperature detector shall be furnished to indicate excessive winding temperature. The temperature-detecting bulb shall be placed in contact with a low-voltage power lead of the transformer. The temperature detector shall be provided with two electrically independent contacts suitable for interrupting:

(aa) 0.02-ampere, direct-current, inductive load;

(bb) 0.20-ampere, direct-current, noninductive load;

(cc) 2.5-ampere, alternating-current, noninductive or inductive load; and

(dd) 250 volts maximum in all cases.

The detector leads shall be extended to the generator terminal box.

(c) For protection against sustained arcing faults in the transformer zone of protection, an induction disk, single-phase, overcurrent relay with an instantaneous attachment shall be furnished in each phase of the excitation power transformer high-voltage side. The relays shall be installed on the front panel of the excitation equipment and connected in the current transformer secondaries.

(d) Two multi-ratio bushing- or wound-type current transformers in each high-voltage phase of the power transformer. At the option of the contractor, these may be located in the gang-operated switch described above. The two bushing-or wound-type current transformers in each phase on the low side of the transformer may be located between the transformer secondary winding and the air circuit breaker. The contractor will be permitted to furnish bushing- or wound-type current transformers in the main generator lead tap to the high-voltage side of the transformer rather than in the bushings of the transformer.

The ratio and accuracy classification of these transformers shall be subject to the approval of the Construction Engineer. Refer to paragraph C.3.6. for additional requirements.

(2) The contacts of all gages, relays and thermometers shall be insulated from ground and suitable for use at 125 volts direct current. All contacts shall be wired to terminal blocks for extension of external circuits. The contacts shall be normally open and shall close in event of abnormal conditions.

(3) Factory tests. - The power transformer shall be completely assembled at the factory and shall be subjected to the following routine and dielectric tests by and at the expense of the contractor and in accordance with NEMA publication No. ST20 (1992):

(a) No-load loss
(b) Exciting current at rated voltage
(c) Polarity check
(d) Ratio check
(e) Applied potential
(f) Induced potential

In addition, for transformers larger than 500 kilovolt amperes, the contractor shall conduct a temperature test as specified under NEMA publication No. ST20 (1992).

The contractor shall furnish five certified copies of reports of the results of the above tests.

c. Refurbish existing or furnish new unit circuit breakers. -

(1) The alternating-current unit (air) circuit breaker shall be in accordance with NEMA publications Nos. SG3 (1995), SG4 (1990) and SG5 (1995). The circuit breaker shall be drawout type, individually enclosed, electrically closed and tripped, and shall be furnished with six auxiliary switches wired to terminal blocks. The closing and tripping circuits shall operate on 125 volts direct current. The interrupting rating of the breaker shall be adequate to insure clearing of maximum short-circuit current possible assuming unlimited fault current supply on high side of transformer.

(2) Main field discharge circuit breaker. - A double-pole air circuit breaker of the (individually) fully enclosed, dead-front type, designed for the inductive circuit of the main field and a discharge resistor shall be furnished. The circuit breaker and discharge resistor shall conform to ANSI C37.18 (1979, revised 1996). Where the equipment is not covered by the above standards, it shall conform to NEMA publication No. SG3 (1995), Low Voltage Power Circuit Breakers. Molded-case circuit breakers will not be acceptable.

The breaker shall be tripped on each unit shutdown. The discharge contacts shall be arranged to short circuit the field through the discharge resistor at the instant preceding the opening of the circuit breaker main contacts. An auxiliary switch shall be provided that has not less than eight circuits which can be changed readily to circuit opening or circuit closing, as required. In addition to meeting the interrupting requirements of ANSI C37.18 (1979, revised 1996), the circuit breaker and discharge resistor shall be capable of interrupting the main field current and limiting the voltage to safe value when the generator is operating at the maximum runaway speed and with the voltage regulator out of service. The rated closing current of the discharge contacts shall be at least equal to the rated short-time current at the main contacts.

The circuit breaker shall be suitable for both local and remote electrical closing and tripping by 125 volts direct current. The circuit breaker shall be operated by means of a stored energy or a solenoid mechanism.

(3) Factory tests. - The air circuit breakers shall be given production tests in accordance with the above standards and the contractor shall furnish five certified copies of reports of the results of tests.

d. Refurbish existing or furnish new alternating- and direct-current bus. - The new excitation system shall be designed to utilize the external existing buswork, buswork alignment and bus design. The internal excitation system buswork shall comply with the following requirements.

(1) If the power connections between the transformer, the air circuit breaker, and the exciter cubicles are exposed and the power transformer secondary voltage is 600 volts or less, the bus shall be furnished as non-segregated-feeder busways in accordance with NEMA publication No. BU1 (1994). If the power transformer secondary voltage is more than 600 volts and the bus is exposed, the bus shall be furnished as non-segregated-phase bus structure in accordance with ANSI C37.2 (1996) and where no conflict occurs NEMA publication No. SG5 (1995). The use of insulated cable will not be permitted.

The maximum temperature rise of the bus conductor when carrying rated current continuously, shall not exceed 50°C when operating in an ambient temperature of 50°C. The maximum temperature rise of the enclosure shall not exceed 30°C at 50°C ambient.

The busway or bus structure shall be designed to withstand factors of safety and the stresses resulting from any short-circuit currents. The contribution of fault current from the system with a short circuit on the primary side of the excitation power transformer will result in approximately 150 megavolt amperes symmetrical (does not include contribution from generator).

(2) Factory tests. -

(a) 600-volt busway. - The tests to be conducted by the contractor shall be those listed in part 3 of the standards. In lieu of actual tests on the busways, the contractor may furnish certified test data on identical busways for temperature and mechanical tests and tests 1 and 2 of paragraph NEMA BU1.1 (1996). The dielectric test UL No. 857 shall be performed on the actual busway furnished under this contract.

(b) Bus structures. - The tests to be conducted by the contractor shall be dielectric, temperature rise limitation, and momentary current capacity tests as required by NEMA publication No. SG5 (1995). Previous test data on identical buses will be acceptable, provided the Construction Engineer agrees that the previous tests are representative of the bus structure being furnished. The dielectric test shall be performed on the actual bus structure furnished under this contract.

The busways and bus structure shall be tested by and at the expense of the contractor. The contractor shall furnish five copies of reports of the test results.

e. Field shunt and transducer. - A shunt and isolation transducer with connections, mounting and housing shall be furnished by the contractor for metering the generator field current and for

field temperature determination. The shunt shall have a 100-millivolt drop at the maximum output of the field circuit. The transducer shall have a 0- to 1-milliampere, direct-current output over a load impedance range of 0 to 10,000 ohms without an adjustment of the output and shall have a ripple of less than 1 percent. Also, it shall provide total isolation of its output from the field shunt. The transducer shall be equal to Scientific Columbus Company model 6271 shunt isolation amplifier. All the equipment shall maintain the isolation from ground of the generator field.

All auxiliary power for the transducers shall be furnished by the contractor although he may use the Government-furnished 125 volts direct current or 120 volts alternating current.

C.3.6. EXCITATION-CONTROL AND VOLTAGE-REGULATING EQUIPMENT

The contractor shall furnish and install for the generator the excitation-control and voltage-regulating equipment described below. The contractor shall furnish the regulator "balance" indicator and the regulator control switch unmounted for mounting and installation by the Government in the field and shall furnish drilling, punching and outline dimensional data as part of the drawings required under subparagraph C.1.4.d.(1). The potential transformers will be connected in open delta and the burden imposed by the regulator shall not exceed the capacity of the potential transformers, each of which will have a thermal burden rating of 400 volt amperes. All other components of the equipment for the generator shall be completely wired and mounted in the metal-enclosed cubicles to be furnished by the contractor as provided in subparagraph C.3.6.c. below.

The Government has provided controls on the main control board for starting and stopping of all unit auxiliaries. The voltage-regulating and excitation-control equipment shall be suitable for control from these master relays. Suitable circuits containing position switches, relays, indicating lights, control switches, and internal wiring within the equipment required to give correct operation and indication and all accessory equipment necessary for this operation shall be provided by the contractor.

a. Voltage regulator. - The voltage regulator shall be of the continuously acting type consisting of static components except where otherwise permitted, responsive to the voltages of all three phases, and shall be of a type which does not require the mechanical acceleration of parts to perform the regulating functions. A continuously acting-type voltage regulator is defined as one which initiates a corrective action for a sustained infinitesimal change in the controlled variable. The use of electron tubes in any element of the voltage-regulating equipment will not be acceptable. The solid-state circuitry shall be conservatively designed so as to be as reliable as practicable and shall incorporate sufficient redundancy (or equivalent measures to insure reliability) that failure of any control element will not cause dangerous or uncontrollable misoperation of the excitation system. The voltage-regulating system shall be of a type that under steady-state operation furnishes all of the control power to the controlled rectifiers exclusive of the potential and current intelligence sources and 125-volt, direct-current power for

motor-operated devices. The voltage-regulating equipment shall also supply control to meet the conditions outlined below:

(1) The voltage regulator shall automatically actuate the controlled rectifiers and shall be capable of performing the following functions:

(a) Maintain the average 3-phase generator voltage within plus or minus 0.5 percent without hunting when operating under steady-load conditions for any load or excitation within operating range of the generator.

(b) After initial generator voltage maximum (neglecting the instantaneous rise) following any load rejection up to 100 percent of rated, shall restore the generator terminal voltage to a value not more than 2 percent above or below the voltage being held before load rejection and shall maintain the voltage within these limits throughout the period of generator overspeed. During the overspeed period, the unit will be under control of the governor with a full-gate closure time of 8 seconds from full gate down to beginning of the cushion (speed-no-load).

(c) Under steady-speed conditions for any overspeed up to 150 percent of normal, maintain generator voltage within plus or minus 5 percent of the value the voltage regulator was holding before overspeed. Also, under steady-speed condition for an overspeed between 150 percent and maximum possible overspeed, maintain generator voltage within plus or minus 5 percent of the value the voltage regulator was holding before overspeed.

(d) Permit continuous stable operation of the generator under control of the voltage regulator or limiters when operating at zero power factor underexcited or when carrying warranted synchronous condenser capacity.

(e) After temperatures of the elements of the voltage regulator have stabilized, slow changes from 15 to 40°C shall not cause changes in voltage of more than 0.5 percent.

(f) Under steady-state conditions with the generator open circuited, the regulator shall not permit the terminal voltage of the generator to vary more than 2.5 percent for variations of 95 to 150 percent in generator frequency. Below 95 percent rated frequency, the terminal voltage may respond to the volts-per-hertz limiter as specified in subparagraph b.(7) below.

(g) The circuitry shall trip the excitation power transformer secondary breaker upon detection of a fault in the generator, main power transformer, bus or high-voltage cables.

Upon detection of line-to-ground faults, the circuit breaker shall be tripped after completion of the demagnetizing action as required in paragraph C.3.5.

(2) The voltage regulator shall be provided with the following features:

(a) Reactive-current compensating devices to provide stable parallel operation of the generators. Paralleling of the generators will be on the 69-kilovolt bus.

(b) Adjustable MNEL (minimum excitation limit) device. - This device shall be excited from potential and current transformers and shall automatically limit the decrease of generator excitation below that may result in pullout of the generator when operating under all specified operating conditions. The characteristics of the MNEL shall closely match the manufacturer's capability curves and shall be such as to permit generator operation from rated kilovolt ampere, rated voltage and unity power factor to the kilovolt ampere rating at rated voltage and zero power factor underexcited. This device shall assume control smoothly and maintain excitation in a stable manner.

(c) An adjustable MXEL (maximum excitation limit) device. - This device shall automatically limit the excitation of the generator to a safe value with the excitation under control of the regulator. The device shall have an adjustable time delay feature to permit short-time operation subject to thermal limitations with ceiling excitation. Times shall be of the synchronous motor-driven type. The use of a solid-state timer will be permitted, provided it is protected from injurious transient overvoltages and shall have an adjustable inverse timing range based on the magnitude of the overexcitation. This device shall limit excitation smoothly while maintaining stability.

b. Auxiliary equipment for excitation control. - The following devices shall be furnished with the excitation-control equipment:

(1) Exciter voltage adjuster. - The exciter voltage-adjusting potentiometer shall be motor operated and shall have a suitable resistance range and current capacity to control the exciter voltage from 120 percent of rated down to 25 percent of rated. The potentiometer shall provide control of the exciter voltage within steps of 0.75 percent. Provision shall be made for adjusting the resistance to permit shifting the operating range after the rheostat is installed. The motor shall be suitable for 125-volt, direct-current operation and shall be arranged for remote control. The motor-operating speed shall be adjustable with provisions to prevent hunting.

Limit switches (Device (*) 70LS1 through 8, with (*) denoting unit number) shall be provided to operate switchboard indicating lamps to show the normal speed-no-load voltage position and the upper and lower limit positions. A limit switch shall also be provided at the

normal speed-no-load voltage position for an interlock in the generator starting control circuit. The limit switches shall be electrically independent. The normal speed-no-load limit switches shall close in this position. The two limit switches shall be closed in intermediate positions and shall open in the limit positions. The potentiometer shall be designed for 50°C ambient temperature.

The potentiometer assembly shall be provided with limit switches to permit automatic repositioning of the exciter-voltage potentiometer to the speed-no-load voltage position following load rejections or shutdown on the generating unit. One limit switch shall be closed from the all-resistance-out position to the preset speed-no-load voltage position. The other limit switch shall be closed from the all-resistance-in position to the preset speed-no-load voltage position.

Means shall be provided to automatically position the exciter voltage-adjusting potentiometer to a predetermined setting or to varying settings as recommended by the manufacturer after the regulator is placed in service and the generating unit is connected to the system. If the manufacturer recommends varying the voltage potentiometer setting as loading is changed on the generating unit, automatic control provided shall incorporate a differential feature that will prevent frequent repositioning of the potentiometer and will not interfere with the regulator's ability to satisfy the requirements of subparagraph C.3.6.a. above.

Regardless of the method used to position the voltage potentiometer, control shall be furnished to insure that there will be sufficient machine excitation under all normal alternating-current loads to give stable operation and avoid objectionable operating disturbances if the excitation system should be suddenly returned to manual control through an emergency resulting in loss of control by the regulator.

(2) Voltage-level adjuster. - The voltage-level-adjusting potentiometer shall be designed for motor operation for local-manual operation and by remote control. The motor shall be suitable for 125-volt, direct-current operation. The potentiometer shall give a voltage control from 25 percent below to 10 percent above normal.

Limit switches ((*) 90LS1 through 8) shall be provided for the voltage-level adjusting potentiometer to permit automatic repositioning of the rheostat to the speed-no-load voltage position following load rejection or shutdown of the generating unit. One limit switch shall be closed from the all-resistance-in-position to the preset speed-no-load voltage position. Another limit switch shall be closed from the all-resistance-out position to the preset speed-no-load voltage position. In addition, limit switches shall be furnished to operate switchboard indicating lamps to show upper and lower limits. The two limit switches shall be closed in the intermediate positions and shall open in the limit positions.

(3) EOV (excitation overvoltage protection). - Suitable equipment shall be furnished to provide exciter overvoltage protection under all conditions of regulator operation or misoperation that will not be detected by protective relays to be furnished on the unit control board. The protective circuitry ((*) 59E1) shall be responsive only to the exciter terminal voltage and its operation shall be separate from and in addition to the operation of the MXEL and its associated controls. The equipment shall have an adjustable time delay feature and a means of adjusting the operating voltage level so as to permit operation that does not interfere with the normal regulator functions. The protection circuitry shall operate at a voltage level slightly higher than that reached when the MXEL functions normally and with sufficient time delay to avoid interference with all normal voltage regulator surges. If this exciter output overvoltage condition persists for a sufficient time, such condition shall initiate the following actions:

(a) The generator lockout relay ((*)86G) shall be tripped to shut down and lock out the generator.

(b) The voltage regulator shall be disconnected from the exciter circuit.

(c) The voltage-adjusting rheostat shall be automatically adjusted to the speed-no-load position.

(d) Provide annunciation.

In addition, if the exciter voltage reaches an extremely high voltage, the above actions shall be initiated immediately ((*) 59E2).

Also, the following additional features shall be furnished: If the regulator control switch is in “MANUAL” or “INDICATE” position and the machine overspeeds to 115 percent overspeed or if the regulator transfer switch is in “REGULATE” position and the regulator drops out of service resulting in exciter overvoltage, then the exciter overvoltage protection circuitry shall operate as described above except that the generator lockout relay shall not be tripped; however, the generator breaker shall be opened and the exciter voltage shall be immediately reduced to the value necessary to return generator voltage to normal.

(4) Current transformers. - In addition to the current transformers required in paragraph C.3.8., the contractor shall furnish all current transformers required for operation of the voltage regulators and their auxiliary components.

(5) Loss-of-field relay ((*)40). - A loss-of-field relay shall be provided to operate a shutdown relay and to annunciate via the annunciator system. The loss-of-field relay shall be of the directional distance, single-phase type operated from armature voltage and current and shall protect the generator from thermal damage and the power system from instability

on low values of generator field current. Any auxiliary relays required to provide annunciation shall be furnished.

(6) A volts-per-hertz limiter ((*) 59F) and all associated equipment shall be furnished to protect the generator armature and main power transformer windings from overheating due to low-frequency operations by tripping the rectifier transformer secondary breaker and shall also provide annunciation by means of the annunciator system. The limiter shall be responsive to both varying voltage and varying frequency.

(7) Regulator "balance" indication. - The contractor shall furnish a "balance" indication signal which will operate a Government-furnished and -installed analog panel meter. The signal shall have a range of 0 milliampere to plus or minus 1 milliampere direct current which shall be equal to full-buck-balanced-full-boost for the regulator. The signal shall be a constant-current output capable of operating into a load impedance of 0 to 10,000 ohms without an adjustment of the output and shall have a ripple of less than 1 percent. The Government meter will have a ground on one lead and it shall be the responsibility of the contractor to produce the isolation necessary to prevent this ground from interfering with the operation of the circuits.

The leads from the isolation transducer shall be terminated at a terminal block to which Government-installed shielded cables can be attached.

All auxiliary power, except for the Government furnished 125 volts direct current or 120 volts alternating current, shall be furnished by the contractor.

(8) Refurbish existing or furnish new field-flashing equipment and discharge resistors . - All equipment necessary to automatically flash the field if required shall be provided to insure proper buildup of voltage on the exciter on each manual or automatic startup. Power for field flashing will be provided by the 125-volt station batteries.

(a) The contractor shall furnish five certified copies of test reports which shall include but not be limited to the following:

(aa) Complete function test to verify that this equipment will automatically flash the field.

(bb) Provide test data which verifies proper buildup of voltage on the exciter on each manual or automatic startup.

(9) Field undervoltage relay. - An alternating-current field undervoltage relay shall be furnished and connected to contractor-furnished potential transformers located on the low side of the power potential transformer.

(10) Field ground detection relay ((*) 64F). - A field ground detection relay shall be provided to operate a Government-furnished shutdown relay and to annunciate via a Government annunciator system. This relay is to operate at the excitation system voltage as determined by the contractor. The field ground detection relay shall be able to detect grounds at all points of the winding and under all operating conditions. The relay shall be equal to Westinghouse type DGF, ASEA type RXNB-4 or General Electric type PJG. The relay shall have a time delay feature. Any auxiliary relays ((*) 64FX) required to provide annunciation shall be furnished.

(11) Accessories. - The Government will furnish potential transformers required for the voltage regulator systems generator bus voltage indication. Data on burdens which will be imposed on the potential transformers shall be furnished by the contractor. The control circuits shall be arranged to operate from a unit control board. All wiring is to be brought to terminal blocks for external connections by the Government.

(12) Refurbish existing or furnish new heatsink assemblies and thyristors - Each double-way power bridge circuit is made up of two sets of three thyristor/heat sink assemblies. There are three double-way power bridge circuits.

c. Excitation control and voltage-regulating equipment cubicles. - The contractor shall furnish for the generator an excitation cubicle or cubicles in which there shall be mounted and wired all excitation control and voltage-regulating equipment.

The equipment to be furnished and installed in the cubicles shall include exciter voltage-adjusting rheostat, voltage-level-adjusting rheostat, magnetic amplifiers, exciter overvoltage protective device, and the loss-of-field relay. The equipment shall be suitable for operation without the use of fans or blowers. The excitation control cubicles shall be located on the elevation 327.5 floor. Exact location will be determined after the contractor has furnished necessary dimensions of the cubicles.

The new excitation control cubicles shall consist of rigid, self-supporting, enclosed units for indoor installation having panels with doors for access to all equipment and a tubular mounting base framework. The tubular bases shall be mounted on the concrete surface. See Drawing No. 48 (549-D-711) for typical base details and Drawings Nos. 27 (4559-RP-5) and 28 (4559-OW-5) for existing excitation cubicle dimensions.

At all shipping splits, the contractor shall furnish terminal blocks in accordance with paragraph C.3.3.b.

A single-phase, 120-volt, alternating-current receptacle, and if the cubicle is a walk-in type, at least one lighting fixture controlled by a switch mounted on the inside of the cabinet in a convenient location near the door shall be provided in the cabinet.

All controls shall be either mounted on the front of the cubicles or be readily accessible from the front. A barrier shall be provided between 240- or 480-volt circuits and circuits of lower voltage. Sufficient louvering shall be provided for ventilation of the equipment. All control transformers shall be mounted separately in totally enclosed metal enclosures. All equipment on the panels shall be back connected to the greatest extent possible with necessary controls on the front of the panels.

d. Auxiliary power. - Auxiliary voltages available for operation of the control devices are 125 volts direct current and 120 volts, single phase, 60 hertz, alternating current. Auxiliary voltages for operation of fans, lights and receptacles and field-flashing requirements are 120 volts, single phase and 480 volts, 3 phase, 60 hertz, alternating current. A separate 125-volt, direct-current circuit will be provided for generator field-flashing requirements. The maximum direct-current power to be furnished by the Government from station battery for one generator unit will be 2 amperes continuous and 150 amperes for 10 seconds.

C.3.7. INDICATING AND PROTECTIVE DEVICES

The contractor shall furnish devices with each exciter system for producing a signal for remote indication of auxiliaries as specified herein. All devices furnished shall be suitable for outdoor, watertight service.

a. Devices for remote indication. - Each device for producing a signal for remote indication of temperature, oil level or pressure shall be a constant-current-type transducer plus transmitting device with an output range of 4 to 20 milliampere direct current. A 4-milliampere output shall correspond to 0°C or 0-pound-per-square inch and 920-milliampere output shall correspond to the higher temperature or pressure that may be encountered.

Signals from the transducers will be used to operate boards at elevation 360.75 floor. Each transducer shall be able to operate into a load impedance of between 0 to 600 ohms without adjustment of the output. The signal shall have a ripple of less than 1 percent from 4 to 20 milliampere. The magnitude of the output signal corresponding to the actual temperature, pressure, or oil level shall be subject to approval by the Construction Engineer.

The output leads from the transducers shall be shielded.

Transducers shall be mounted and output leads terminated in the main terminal board for convenient cabling to Government-furnished monitoring equipment. Each transducer shall be constant-current type with an integral built-in filtered and regulated power supply that will operate directly from the Government-furnished, 120-volt, single-phase, alternating-current power source. Transducers requiring an external power supply to be connected between the transducer and the Government-furnished 120-volt power source will not be permitted.

The contractor shall furnish and install all transducers, flexible tubing, piping, valves, fittings and conduit that are required for connecting the apparatus to the exciter main terminal board.

C.3.8. CURRENT TRANSFORMERS

a. Type. -

TABLE C-6A

Ratio	Metering accuracy classification at following burdens					Relaying accuracy classification
	B-0.1	B-0.2	B-0.5	B-1.0	B-2.0	
All ratios (static excitation system power transformer)	.3	.3	.3	.3	.3	C or T200

(1) The existing current transformers are in accordance with the latest ANSI C57.13 (1978, revised 1987) for Instrument Transformers. The continuous current-carrying capacity is rated for application in an ambient temperature of 50°C. The current transformers have a continuous thermal rating factor of 1.5 or higher. The current transformers have metering and relaying accuracies in accordance with Table C-6A.

The contractor shall furnish and install in the neutral or main leads at his option any current transformers required for the operation of the excitation control and voltage-regulating equipment.

b. Tests. - Any new current transformers required for the excitation control and voltage regulating equipment shall be tested by and at the expense of the contractor in accordance with the requirements of ANSI C57.13 (1978, revised 1987). The contractor shall furnish five certified copies of the results of the tests and standard application data.

C.3.9. ERECTION FACILITIES, ACCESSORIES, TOOLS AND APPLIANCES

The contractor shall furnish all lifting attachments and devices including lifting beam or beams required to attach the excitation systems to the crane hooks and any special wrenches, tools or appliances that may be necessary for assembling and dismantling any part of the equipment furnished under these specifications. All necessary slings and attachments for handling exciter parts during assembling or dismantling shall be furnished by the contractor.

All rails, slings, tackle, eyebolts, etc., required to disassemble, assemble or remove any portion of the exciter assembly with the Government’s crane shall be furnished by the contractor.

C.3.10. SPARE PARTS

All spare parts shall be interchangeable with and shall be the same material and workmanship as the identical parts of the excitation system and auxiliary equipment to be furnished and shall meet the same requirements. The spare parts shall be separately packaged and identified.

C.3.11. NAMEPLATES

Suitable engraved nameplates similar to the nameplates on Drawing No. 52 (40-D-6234) or other nameplates approved by the Construction Engineer shall be furnished and mounted by the contractor. Equipment nameplates shall be size 4, board nameplates shall be size 5 with 1/4-inch lettering, and panel nameplates shall be size 7 with 1/2-inch lettering. All nameplates shall be of the materials specified in Drawing No. 52 (40-D-6234) for type “A” nameplates. Nameplate designations shall be subject to the approval of the Construction Engineer.

SUBSECTION C.4 - EXCITATION SYSTEM TESTING

C.4.1. FACTORY ASSEMBLY AND PRELIMINARY TESTS

The excitation systems furnished shall be subjected at the factory (except at the contractor's option, any or all of the tests required by subparagraphs a. and b. below may be performed as field tests) to the following tests conducted in accordance with ANSI where applicable.

a. One exciter. - One exciter (less excitation power transformer, switchgear assembly, and alternating- and direct-current busway) shall be completely assembled and the following tests on individual components or on the completely assembled system shall be performed to assure that the equipment will operate as designed when it is installed and put into service with the generator at the erection site.

(1) A test voltage of at least three times the maximum RMS input to the rectifier shall be applied in order to check the PIV rating of each rectifier.

(2) Phase- or firing-angle control range.

(3) Measurement of the output ripple voltage.

(4) Logic circuits shall be tested individually and also while operating as a system using voltage and current sources to simulate the current and potential transformers and shunt signal inputs to the regulator to verify connections and polarities.

(5) The 3-phase groups of rectifier units shall be tested separately at rated voltage and then at rated current.

(6) The 3-phase groups of rectifier units shall be tested together at reduced load to verify normal and transient operation of the assembled system using simulated inputs and loads.

(7) Thyristor bridges, the cubicle assemblies of rectifier units, shall be given dielectric tests in accordance with the standards referred to under subparagraph C.4.1.b. below.

(8) Wiring and control circuits shall be given dielectric tests in accordance with ANSI C37.2 (1996).

b. The excitation control cubicles shall be completely assembled at the factory and subjected to routine tests including but not restricted to the following:

(1) Dielectric tests.

(2) Rated voltage test.

(3) Functional check of circuit components for proper operation.

The tests on the static excitation system shall be conducted in accordance with ANSI C34.2, Standard Practices and Requirements for Semiconductor Power Rectifiers. Other tests on excitation system components are listed in paragraph C.3.5.

c. Buses and busways. - The contractor shall fabricate the new exciter system cabinets to match up to all existing buswork, cable and conduit routes.

All of the above tests shall be made in the presence of a Government inspector. The contractor shall furnish five certified copies of reports of the results of the tests and shall also furnish five copies of curves showing the characteristics of exciters as determined by the tests. The contractor shall furnish as part of the reports of factory tests sample calculations and the formulas used in determining the results of the tests.

C.4.2. TESTING

a. During the preliminary onsite tests (after installation and prior to commissioning/testing), the excitation system and auxiliary apparatus shall be tested by and at the expense of the contractor to determine whether the contractor's warranties and the requirements of these specifications have been fulfilled and to provide a complete record of exciter characteristics. The tests shall be made in accordance with the standards and test codes of IEEE and ANSI.

The contractor shall perform without extra charge any minor tests required to establish conformance of the equipment with the warranties and this solicitation. The time of testing will be determined by the Contracting Officer to meet field conditions and the tests shall be performed in accordance with Government coordination and approval.

b. During the commissioning/testing, the Government shall perform the following tests with assistance from the erection engineer:

(a) Determination of efficiency. - The exciter and excitation system losses shall be measured in accordance with the applicable portions of ANSI C34.2, Standard Practices and Requirements for Semiconductor Power Rectifiers. At the option of the contractor, the losses of the exciter and excitation system may be measured as a factory test.

(b) Heat runs. - Must be performed in the field for each unit.

(1) On exciter. - Heat run to determine maximum temperature rise of exciter. These tests shall consist of a heat run at exciter rated output or at the maximum exciter output.

(c) Measurement of excitation system voltage response time and maximum exciter voltage in per unit. These measurements must be performed in the field.

(d) Tests as follows (with oscillograph records where required) on the voltage regulators and excitation systems (these tests must be performed in the field). -

(1) Load rejection at turbine full-gate opening or 100 percent load at rated-voltage and rated-power factor whichever is smaller.

(2) Excitation system frequency response (phase and gain) determination.

(3) Overall response of machine and excitation system to power system voltage changes.

(4) Maximum excitation limiter.

(5) Volts-per-hertz limiter.

(6) Minimum excitation limiter.

(7) Demonstration test to determine that each excitation system is able to protect itself against excessive current.

(e) Operational tests (shall be made on each generator). - The Government will demonstrate with the use of station instruments and with test instruments that the maximum excitation limiter, minimum excitation limiter, loss-of-field relay, volts-per-hertz limiter, and other protective relays will operate satisfactorily to provide protection for the generator. In conjunction with this test, the limiters and relays shall be set at the settings recommended by the contractor and approved by the Government.

The Government will also perform tests (with oscillogram records) to establish proper adjustment and capability of the excitation systems during load rejection. Oscillogram records shall be obtained on all load rejections made as part of the operational tests in addition to tests at 100 percent of rated load to illustrate voltage performance.

SUBSECTION C.5 - PAINTING

C.5.1. SHOP CLEANING AND PROTECTIVE COATING

a. General. - After the equipment has been fabricated, the contractor shall prepare and clean surfaces and apply protective coatings as hereinafter specified. Coated surfaces shall be protected from abrasion or other damage at all times. Surfaces not to be painted shall be protected by appropriate masking during the cleaning and painting of adjacent metalwork.

b. Surfaces of cabinet excitation cubicles shall be furnished with the manufacturer's standard permanent paint system.

c. The contractor shall submit the manufacturer's standard permanent paint system in accordance with Table C.1, List of Submittals.

SUBSECTION C.6 - DRAWINGS

C.6.1. DRAWINGS, GENERAL

a. General. - If there are minor differences as determined by the Contracting Officer between details and dimensions shown on the drawings and those of existing features at the site, the details and dimensions of existing features at the site shall govern.

The contractor shall advise the Contracting Officer of any discrepancies including errors or omissions discovered on any of the drawings.

b. Additional or revised drawings. - Except as otherwise provided in these specifications for drawings to be furnished by the contractor, these specifications drawings will be supplemented by the Government by such additional or revised general and detail drawings as may be necessary or desirable as the work progresses; and the contractor shall do no work without the latest revised drawings and instructions. The additional or revised general and detail drawings furnished by the Government will show dimensions and details necessary for construction purposes more completely than are shown on these specifications drawings for all features of the work. The contractor will be required to perform the work in accordance with the additional general and detail drawings or revisions furnished by the Government at the applicable prices bid in the schedule for such work.

c. Additional copies of drawings. - The contractor will be furnished such additional copies of these specifications and drawings as may be required for carrying out the work. Full-size copies of the original drawings from which the attached reproductions were made will be furnished to the contractor for construction purposes upon request.

d. Informational drawings. - Some of the drawings are marked "for information only" and are intended to show some feature about which additional knowledge is required for bidding or for modification work. If there are differences as determined by the Construction Engineer between details and dimensions shown on these drawings and those of existing features at the site, the details and dimensions of existing features at the site shall govern.

C.6.2. LIST OF DRAWINGS

The following drawings, included as Attachment No. 3 to the solicitation, are made a part of these specifications:

Headgate Rock Powerplant		
1.	1117-D-2	General Map

Headgate Rock Powerplant		
2.	1117-D-3	Location Plan
3.	1117-D-4	General Plan
4.	1117-D-7	General Arrangement - Deck - El. 373.00
5.	1117-D-9	General Arrangement - Floors - El. 327.50 and El. 343.25
6.	1117-D-11	General Arrangement - Transverse Section - Centerline Unit 2
7.	1117-D-13	General Arrangement - Longitudinal Sections
8.	1117-D-522	Electrical Installation - Switchyard - Three Line Diagram
9.	1117-D-495	Electrical Installation - Generating Unit #1 - Three Line Diagram
10.	1117-D-1926	Static Excitation Equipment - System Three Line Block Diagram
11.	1117-D-1927	Static Excitation Equipment - System Three Line Block Diagram
12.	1117-D-824	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Sequencing Section
13.	1117-D-823	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Sequencing Section
14.	1117-D-826	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Sequencing Section
15.	1117-D-827	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Sequencing Section
16.	1117-D-829	Electrical Installation - Unit No. 2 Static Excitation Equipment - Schematic Diagram - Sequencing Section
17.	1117-D-830	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Sequencing Section
18.	1117-D-831	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Sequencing Section
19.	1117-D-832	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Sequencing Section
20.	1117-D-835	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Power Section

Headgate Rock Powerplant		
21.	1117-D-838	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Sequencing Section
22.	1117-D-846	Electrical Installation - Unit No. 1 Static Excitation Equipment - Schematic Diagram - Sequencing Section - Terminal Block Wiring Diagram
Unibus, Inc.		
23.	D-1769-002	Sheet 1 of 2 - Electrical Installation - 600V, 1200A, 2P, 2W, Bus Duct Layout
24.	D-1769-002	Sheet 2 of 2 - Electrical Installation - 600V, 1200A, 2P, 2W, Bus Duct Layout
25.	D-1769-019	Electrical Installation - 600V, 1200A, 2P, 2W, Exciter Termination
Voith		
26.	4559-OV-5	Static Excitation Equipment - System Three Line Block Diagram
27.	4559-RP-5	Static Excitation Equipment - Exciter Cubicle Outline
28.	4559-OW-5	Static Excitation Equipment - Exciter Cubicle Outline
29.	4559-OT-5	Outline - Transformer/Switch Cubicle - Dry Type - Class AA - 15kV
30.	S2-20090-M-411-01	Static Excitation Equipment - Power Input/Output Assembly PIX
31.	4559-2X-5	Static Excitation Equipment - Converter No. 1, Thyristor Assy.
32.	4559-2Y-5	Static Excitation Equipment - Converter No. 2, Thyristor Assy.
33.	S2-20090-M-411-04	Static Excitation Equipment - Converter No. 3, Thyristor Assy.
34.	4559-AAA-5	Static Excitation Equipment - Control/Regulator Cubicle
35.	4559-AAB-5	Static Excitation Equipment - Sequencing Panel Assembly PIX
36.	4559-2I-5	Static Excitation Equipment - Power Input/Output Cubicle Door

Headgate Rock Powerplant		
37.	4559-2J-5	Static Excitation Equipment - Power Input/Output Cubicle Door
38.	S2-20090-M-422-01	Static Excitation Equipment - Regulator Cubicle Door
39.	S2-20090-M-422-02	Static Excitation Equipment - Regulator Cubicle Door
40.	S2-20090-M-423-01	Static Excitation Equipment - Sequencing Cubicle Door
41.	S2-20090-M-423-02	Static Excitation Equipment - Sequencing Cubicle Door
42.	S2-20090-M-424-01	Static Excitation Equipment - Converter #1 Cubicle Door
43.	S2-20090-M-424-02	Static Excitation Equipment - Converter #2 Cubicle Door
44.	S2-20090-M-424-03	Static Excitation Equipment - Converter #3 Cubicle Door
45.	S2-20090-M-424-04	Static Excitation Equipment - Converter Cubicle Door
46.	4559-TU-5	Sheet 3 of 3 - Static Excitation Equipment - Schematic Diagram - Power Section
47.	4559-TU-5	Sheet 1 of 3 - Static Excitation Equipment - Schematic Diagram - Power Section
Standard Drawings		
48.	549-D-711	Electrical Installation - Switchgear Base Details
49.	40-D-5056	Standard Sizes of Drawings
50.	104-D-786	Sample Title Blocks
51.	104-D-1032	Switchboard Wiring and Cabling Methods
52.	40-D-6234	Standard Nameplates

Headgate Rock Powerplant		
53.	104-D-809	Format for Manufacturer's Drawings
54.	104-D-873	Main Control Board CCA - Panel 3R Wiring Diagram
55.	104-D-876	Unit Protection for Centralized Operation - Schematic Diagram
56.	104-D-889	Unit Auxiliaries - Schematic Diagrams