Section C
Work Specification

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Furnish, Install, and Deliver Autotransformer

POWER AUTOTRANSFORMER

TECHNICAL SPECIFICATIONS

1 GENERAL

1.1 The autotransformer described in the following technical specifications shall be furnished, delivered, and installed, FOB job site, to Southwestern Power Administration's (SWPA) Springfield Substation, 2858 South Golden, MO 65807. The Contractor shall set, completely assemble, install, fill with oil, connect, test, and place the autotransformer in complete readiness for operation immediately after delivery. All aspects of the local, state, and Federal requirements involving the environment, safety, and health shall be adhered to. The Contractor must furnish certification that all oils are polychlorinated biphenyls (PCB) free.

1.2 The autotransformer shall be of the outdoor, three-phase, 60 Hertz, three-winding, oil-immersed type, self- and forced-cooled, Class OA/FA/FA, Class OA/FA/FOA, Class OA/FOA/FOA, or equivalent, rated at 42000/56000/70000 kVA. Power will normally flow from the high-voltage side to the low-voltage side. **The autotransformer manufacturer shall include with his bid a footprint drawing of the new autotransformer, to ensure that it will fit on the existing transformer foundation at the Springfield substation.**

1.3 The autotransformer shall be designed and built to withstand repeated earthquake accelerations of 0.3g and wind loads of 20 lb/sq ft on projected area (nonsimultaneous) without damage to component parts and without impairment of operation.

1.4 Except as otherwise specified herein, the autotransformer accessories and spare parts shall conform to the requirements of American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE) Standard C57.12.00-2000 or latest revision.

1.5 The following Standards shall apply to the design, manufacture, and testing of the autotransformer. The Standards shall be the editions or revisions in effect on the date proposals are received:

ANSI/IEEE C57.12.00-2000	General Requirements for Liquid-Immersed Distributions, Power, and Regulating Transformers
ANSI C57.12.10	Safety Requirements for Transformers 230000 Volts and Below 833/958 Through 8333/10471 kVA, Single-Phase, and 750/862 Through 60000/80000/100000 kVA, Three Phase without Load Tap Changing and 3750/4687 through 60000/80000/100000 kVA with Load Tap Changing

ANSI/IEEE C57.12.90	Test Code for Liquid-Immersed Distribution Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
ANSI C57.13	Requirements for Instrument Transformers
ANSI C76.2	IEEE Standard Electrical, Dimensional and Related Requirements for Outdoor Apparatus Bushings
NBS T.N. 1204	National Bureau of Standards Technical Note 1204, Calibration of Test Systems for Measuring Power Losses of Transformers
NFPA/NEC	National Fire Protective Association (National Electrical Code) Std 70
ANSI C62.11	Standard for Surge Arresters for AC Power Circuits (IEEE)
NEMA TR1	Transformers, Regulators and Reactors

2 TRANSFORMER LOADING

2.1 The autotransformer shall be capable of delivering its full kVA rating at high-side voltages 5% higher or lower than rated voltage at load power factors of 80% or higher, and shall be capable of operating at 10% higher than rated voltage at no load without exceeding the specified temperature rise. The autotransformer shall be designed for the following simultaneous arithmetic MVA loading conditions at 55°C copper temperature rise by resistance.

H	L	T
In 70	Out 70	Out 0
In 70	Out 45	Out 24

3 RATING

3.1 The autotransformer ratings and the electrical characteristics shall be as follows:

Class OA/FA/FA or OA/FA/FOA or OA/FOA/FOA

Continuous rating, kVA as step-down transformer	42000/56000/70000
Tertiary rating, kVA, minimum	10500/14000/17500
Limit of temperature rise by resistance	55°C

With supplementary ratings at	65°C
Ambient air temperature, average Maximum	30°C 40°C
Frequency, hertz	60
Number of phases	3
High voltage, rated volts (line-to-line)	161000
Low voltage, rated volts (line-to-line)	69000
Tertiary voltage, rated volts (line-to-line)	13800
High- and low-voltage winding connection	Grounded Wye
Tertiary winding connection	Delta
Minimum impedance at OA rating, percent	6.20
Basic impulse level of the line ends of the high-voltage windings, kV	750
Basic impulse level of the neutral ends of the high-voltage windings, kV	150
Basic impulse level of the line ends of the low-voltage windings, kV	350
Basic impulse level of the tertiary winding, kV	150
No-load regulating taps, in windings	+-5%
LTC tap voltage, low-voltage winding	+-10%

3.2 The transformer shall be furnished with all the necessary equipment and accessories for operation in parallel with existing units located in our substations

4 THERMAL DESIGN

4.1 The observable temperature rise above ambient temperature of the transformer or of the parts thereof, when carrying full-rated load, shall not exceed the values shown in Section 5.11 of ANSI Standard C57.12.00-2000 or latest revision. The transformer shall be built with thermally stabilized insulation materials, permitting operation at 65°C average copper rise by resistance, with no increase in loss of life over that which conventional insulation materials would have at 55°C average copper rise.

4.2 Oil ducts and baffles shall be provided to direct the flow of oil from the heat exchangers around each winding and through or around the cores, with quantity and rate of flow in proportion to the thermal requirements of the various parts of the transformer.

5 CORES

5.1 The transformer cores shall be constructed of high-quality, non-aging, cold-rolled, grain-oriented, highly permeable, silicon alloy steel of low hysteresis loss. The cores shall be built up of thin sheets, properly annealed after cutting. Each sheet shall have burrs and sharp points removed, and shall have an insulating surface treatment or coating on each side. The cores shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength to support the windings and to withstand handling, shipping, and operating forces. The core ground shall be attached to the transformer tank at a point within 12 inches of a transformer manhole. The serial number shall be stamped on the core in a conspicuous place.

6 WINDINGS

6.1 Windings shall be designed with attention to the securing of free circulation of the cooling oil as well as to mechanical strength. Coils shall be made up, shaped, and braced to provide for expansion, contraction, and shrinkage due to temperature changes and aging in service in order to avoid abrasion of insulation and to provide rigidity to resist movement and distortion caused by abnormal operating conditions. Suitable insulating barriers shall be provided between the coils, between the windings, and between the windings and the cores. Insulation materials, varnishes, and compounds that will come in contact with the insulating oil shall not affect the oil or be affected by the oil. End coils shall have additional protection against normal line disturbances.

6.2 All windings shall be high tensile strength annealed copper, paper insulated, no smaller in cross sectional area than the existing wire, and shall be continuous for each coil. All windings shall be completely self-protected to withstand fault conditions and voltage surges. Where joints or connections are necessary in the coils or leads, including connections to bushings, they shall be brazed or welded, not soldered.

6.3 Coils and cores shall be dried using a heat or vacuum process prior to impregnation with oil. The insulation power factor shall be monitored during dryout and shall not exceed 0.005.

6.4 The windings shall be designed to withstand impulse, induced, and applied test voltages in accordance with ANSI Standard C57.12.00-2000 or latest revision.

6.5 The transformers shall meet the short-circuit requirements given in Section 7 of ANSI Standard C57.12.00-2000 or latest revision entitled, "Short-Circuit Characteristics". The short-circuit current shall be assumed to be limited by the impedance of the transformer, and 0.4% 161-kV system impedance at 48 MVA. Conformance to this requirement shall be demonstrated by submission of certified test data on a tested transformer with core and coil of identical design and construction, or

by presentation of a history of successful experience with transformers of identical or similar ratings, design, and construction, with data on all such transformers that have been manufactured, including their ratings, installation dates, location, and failures, if any.

7 BUSHINGS

7.1 Sealed, oil-filled, porcelain bushings with high mechanical strength shall be provided for the high, low, and tertiary leads of the transformer and for the neutral lead from the high-voltage winding. The low-voltage bushings shall be 1200A, the high-voltage bushings shall be 1200A minimum, the tertiary bushings shall be 1200A, and the neutral bushings shall be 1200A, in accordance with ANSI C76.2. The bushings shall be well protected against leakage and shall have adequate electrical clearance from all parts of the apparatus. All bushings shall be hermetically sealed and bushings of the same type shall be interchangeable. Oil-filled bushings shall be equipped with sight gauges to indicate oil level.

7.2 Bushings shall be designed to prevent undue stress caused by temperature changes. Ample provision shall be made to accommodate conductor expansion by means, which will keep the bushing oil tight. Bushings shall be so designed to create no radio disturbance at rated voltage.

7.3 Line and neutral bushings shall be arranged to accommodate the bushing-type current transformers specified. The bushings shall be constructed such that they may be removed from the transformer case without disturbing the current transformers or their connections.

7.4 Bushings shall be in accordance with ANSI C76.2, "Standard Electrical, Dimensional, and Related Requirements for Outdoor Apparatus Bushings". Bushings shall be arranged such that "H-2" and "X-2" are on the same centerline. "H-1" and "X-1" shall be located on the left side when viewed from the low-voltage side. The bushing-mounting angle with respect to the vertical shall not exceed 30° for the high-voltage and low-voltage bushings. Tertiary bushings shall be located on the left when viewed from the low-voltage side and 90° to high- and low-voltage bushings.

7.5 Transformer terminal bushings shall be condenser type and shall be rated as follows:

Terminal Voltage	161-kV	69-kV	13.8-kV	Neutral
Insulation Class, kV	161-kV	69-kV	25-kV	25-kV
Dry withstand voltage, 1 minute: kV-rms	365-kV	160-kV	60-kV	69-kV
Wet withstand voltage, 10 seconds: kV-rms	315-kV	140-kV	50-kV	50-kV

Impulse withstand voltage, 1.2 x 50 microsecond, full wave dry kV-crest	750-kV	350-kV	150-kV	150-kV
Minimum creep distance in inches	114	48	17	17

7.6 All porcelain used in the bushings shall be wet-process porcelain; homogeneous; nonporous; free from lamination, cavities, or other flaws affecting its mechanical strength or dielectric quality; and shall be well vitrified, tough, and impervious to moisture. The glazing of the porcelain parts shall be uniform in color and free from imperfections such as blisters or burns. The color of the bushings shall be ANSI No. 70 gray.

7.7 All bushings shall be supplied with a capacitance. The terminal bushings of the tertiary windings shall be brought out at one end of the tank, enclosed in an air-filled junction box with suitable cable or metal-enclosed bus connections to a load break, fused, three-pole, 15-kV disconnect switch mounted in the junction box. The switch shall be gang operated, equipped with current limiting fuses. The transformer manufacturer shall provide three spare fuses. The high- and low-voltage bushing terminals shall be furnished with silver-plated NEMA 4-hole terminal pads of size to accommodate the bushing's stud size (Anderson Type HDSF-TP or equivalent).

8 LOAD/NO-LOAD TAP CHANGING

8.1 Equipment shall be furnished under this item to enable full kVA capacity taps at 169.050, 165.025, 161.000, 156.975, and 152.950 kV with an externally operated no-load tap changer. The operating handle shall be located on the side of the tank at a height convenient to the transformer design. The tap changer handle shall have provisions for padlocking, consisting of a 3/8-inch minimum diameter hole, and shall provide visible indication of the tap position without unlocking. For a given winding, the number "1" or the letter "A" shall be assigned to the tap having the greatest number of effective turns.

8.2 Equipment shall be furnished under this item to enable voltage-regulating taps to be changed while the transformer is under load. The primary purpose of the equipment is to maintain a predetermined low voltage, with power input at varying high-side voltages, and varying power output from the low-voltage winding.

8.3 The autotransformer shall have a Reinhausen Manufacturing Load tap Changer VacuTap. With the load tap changer equipment on a position at or above normal, the transformer shall be capable of supplying its rated kVA. With the load tap changer equipment on a position below normal, the transformer shall be capable of supplying current equal to the current at rated kVA and rated voltage. The load tap changer's range shall be plus or minus 10% of the rated low voltage, with one voltage tap at rated low voltage and eight equally spaced voltage taps above and below rated low voltage.

8.4 The equipment shall include an electrically driven mechanism of proven reliability arranged for local and remote, automatic or manual control, complete with all necessary

devices to make a completely operable installation, including voltage regulating relays, time delay devices, and line drop compensation with a suitable current transformer included in the regulated winding. A remote position indicator, and provision for remote position indicating by supervisory control, shall be included. The equipment shall be designed to operate in parallel with other autotransformers.

8.5 The equipment shall be so arranged that only one tap position can be changed for each actuation of a "raise" or "lower" switch. The mechanism shall operate to complete the tap change once initiated and, if auxiliary power fails during a tap change, the mechanism shall automatically restart on restoration of power and operate until a tap position is reached.

9 TANKS

9.1 Transformer tanks shall be oil-tight and of substantial construction. Tanks shall be made of steel plates electrically welded together and shall be provided with oil-tight covers and gaskets of a material, which will not deteriorate throughout the expected life of the transformer under normal operating conditions. No welding of any type shall be required for field installation. All devices attached to the transformer tanks and all leads brought through the transformer tanks shall be constructed to prevent the leakage of oil. The tanks shall be provided with suitable removable radiators or tubes for cooling. The radiators shall be provided with drain plugs at the bottom, vent plugs at the top, and lifting eyes. Shut-off valves or Ball valves shall be provided to permit the removal of the radiators without draining the transformer tank. A separate oil-tight blank flange shall be provided for each tank connection for use when the radiator is detached.

9.2 All surfaces of the transformers to be painted shall be shot or sandblasted before the paint is applied. Each tank shall be provided with a relief valve with alarm contacts, which will prevent the accumulation of undue pressures and, at the same time, will exclude moisture from the transformer. Each tank shall be provided with inert gas type oil preservation equipment or, if accepted by Southwestern, with the manufacturer's recommended equivalent system. The tank and the cores shall be provided with suitable guides to assure the cores will be correctly placed in assembly and cannot shift or be damaged in transit. All parts of the transformers, including the tanks, shall be equipped with suitable eyebolts or lugs for handling or removing parts. The tanks shall also be provided with jacking pads and pulling eyes. The base of the transformer shall be constructed of structural steel designed to set the transformer on a flat concrete foundation.

9.3 The cooling liquid shall conform to requirements of applicable Sections of ANSI C57.12.00-2000 or latest revision. Cooling or insulating liquids containing polychlorinated biphenyl shall not be acceptable. Cooling or insulating liquids shall meet all Environmental Protection Agency regulations. Cooling or insulating liquids shall have minimum breakdown strength of 30-kV.

9.4 The Tank cover shall be welded on the transformer to prevent leaks. The tank shall be equipped with a sufficient number of gasketed manholes and handholes to provide access for internal inspections and adjustments without removing the tank cover or any other transformer equipment. One handhole shall be located within 12 inches of

the core grounding connection to allow it to be readily disconnected without lowering the oil level in the tank. Oval or rectangular manholes shall be 16" x 18" minimum.

9.5 Each transformer tank shall be designed and constructed for vacuum filling (full vacuum) in the field and shall be capable of withstanding, without leakage or distortion, an internal gas pressure 25% greater than the maximum operating pressures. All valves, fittings, and piping affected by this requirement shall be designed and constructed for such filling.

9.6 Each tank shall be provided with two grounding pads, copper faced with two holes at 1 ¾-inch spacing drilled and tapped for ½-inch, 13 NC (National Coarse) bolts. The pads shall be located on or near the base of opposite ends of the tank. An additional ground pad and grounding strap, 1000 MCM or equivalent, shall be provided adjacent to the neutral bushing.

10 ACCESSORIES

10.1 In addition to those described elsewhere in this specification, the transformer shall be provided with the following accessories as a minimum:

10.1.1 A fault gas monitor shall be installed capable of detecting combustible gases and providing visual indication. Alarm contacts shall be provided for remote annunciation. The monitor shall be Syprotec Inc., Hydran 201R or equivalent.

10.1.2 Cooling fans and pumps and required controls shall be provided to provide double-stage cooling. Control transfer switches shall be provided to allow selection of automatic or manual control of cooling equipment and to permit selection of lead stage if under manual control. Switching equipment shall be enclosed in a control cabinet complete with all conduits and wiring for the cooling equipment. Each stage of cooling shall be and operate fully independent of the other.

10.1.3 The cooling fan motors shall be weatherproof, totally enclosed, induction type rated 208 volts, three-phase, 60 hertz. Each fan motor shall have individual thermal overload devices and disconnecting means. Fans shall be balanced and operate without vibration. Shrouds shall be placed over fan blades for personnel protection. Fans shall be mounted a minimum of 2 feet above base of transformer.

10.1.4 The oil circulating pumps and motors shall be enclosed in an oil-tight container and shall be oil immersed and shall require no lubrication. Each pump motor shall be provided with an individual disconnect and an oil-tight terminal outlet for electrical connection to the motor. The pump motors shall be rated 208 volts, three-phase, 60 hertz.

10.1.5 A combination drain and lower filter valve shall be provided for complete drainage of the oil to within 1 inch of the bottom of the tank and for outlet to oil filtering equipment. The drain valve shall be 2 inches with National Pipe Thread (NPT) threads and a pipe plug in the open end. The valve shall have a ½-inch built-in capped sampling device between the valve seat and the pipe plug.

10.1.6 An upper filter valve located below the 25°C liquid level and in the same segment as the drain valve shall be provided for the return of filtered oil. The valve shall be 1 inch in size with NPT threads and a pipe plug in the open end. Also a Valve for vacuum 2 inches in size on top in addition to upper filter valve located with enough distance it will not pick up oil while vacuum filling.

10.1.7 All oil connections shall be designed for use with hot transformer oil.

10.1.8 A liquid level indicator shall be mounted on the tank, which shows the 25 degrees C level, and maximum and minimum levels. Alarm contacts shall be provided to operate on minimum level.

10.1.9 A dial type oil temperature indicator with maximum temperature indicating device shall be installed with the sensing element located such that it will detect the hottest oil in the transformer.

10.1.10 A dial type winding temperature indicator shall be provided, with contacts for automatic two-stage control of cooling equipment. Excessive winding temperature shall close alarm contacts.

10.1.11 An oil flow indicator with alarm contacts shall be provided for each pump.

10.1.12 A pressure/vacuum gauge with alarm contacts for both pressure and vacuum shall be provided. The gauge shall have a shut-off valve for sealed tanks.

10.1.13 Standard copper resistance temperature detectors (RTD) shall be supplied for remote logging of oil temperature and approximate hot-spot temperature logging of each series and common winding. The detectors shall have a resistance of 10 ohms at 25°C, with a temperature coefficient of resistance of 9.99385 and a calibration accuracy of +-0.2%.

10.1.14 Each transformer tank shall be provided with a sudden pressure relay or Buchholz type system which will operate on abnormal rates of pressure rise in the gas-filled space in the transformer and LTC compartment The relay shall not be affected by mechanical shock, in-rush or exiting currents, short circuits, or impulse voltages. The sudden pressure relay shall have an auxiliary seal-in relay and reset switch and be suitable for 125 VDC supply.

10.1.15 An annunciator shall be mounted within the transformer control cabinet. Alarm lights shall seal in and have provisions for manual reset and testing at the transformer. The annunciator shall be connected to contacts from the following:

- Winding temperature – high oil temperature
- Control voltage
- Cooling system auxiliaries power supply failure
- Loss of either auxiliary power source
- Sudden pressure relay operation

- Low oil flow
- Low oil level

10.1.16 Each annunciator point shall have at least one "dry" auxiliary contact to provide for grouped alarm indicating to the SCADA remote terminal unit located in the control building. A circuit breaker shall be provided for the 125 VDC source. All input and output points to the annunciator shall be wired from the annunciator to the control cabinet terminal blocks for connection by others; splices in the wiring are not acceptable.

10.1.17 A split-type terminal box (control cabinet) shall be provided on the transformer with facilities for termination (terminal blocks) of all control and signal wiring, including bushing current transformer leads. The control cabinet shall include a light and a 120 VAC ground fault interrupting type receptacle. All terminal blocks used for current transformer leads inside the control cabinet shall be provided with shorting devices for shorting current transformers with the transformer in or out of service. The terminal blocks shall be as manufactured by General Electric Company Type EB-25 and EB-27 (shorting type) or equal. All control and signal wiring shall be furnished and installed complete to the terminal blocks; splices in the wiring shall not be acceptable. No more than two wires shall be terminated at any one terminal point. Wiring shall be marked with designation as shown on manufacturer's wiring diagram. Wiring shall be No. 9 AWG, 19-strand, ethylene propylene rubber (EPR) insulation for current transformers; and No. 12 AWG, 7-strand, EPR insulation for potential transformers and power and control circuits. Wiring used for interconnecting transformer equipment enclosures shall be protected with rigid or intermediate conduit, and flexible conduit for motors. The conduit system shall conform to the National Electric Code and shall be water-tight. RTD wiring shall be isolated and shielded from power leads as far as possible to minimize inductive pickup and to allow the detectors to provide accurate inputs to solid-state data loggers.

10.1.18 The transformer shall be furnished with a nameplate conforming to ANSI C57.12.00-2000 or latest revision and C57.12.10.

10.1.19 Indicators and control devices mounted in the transformer control cabinet shall have device nameplates made from engraved laminated plastic, black with white letters.

10.1.20 Dial-type indicators shall be positioned to be easily read by personnel standing at the same level as the transformer base. Each indicator located more than 90 inches above the bottom of the transformer base shall have the indicator face inclined downward at a 30° angle.

10.1.21 A 208-volt, three-phase, 60-hertz feeder with circuit breaker protection will be furnished and installed by others to the transformer control cabinet. Any dry-type transformers required for auxiliary power from this 208-volt feeder or for motor control circuits (maximum of 120 volt) shall be included in the auxiliaries to be furnished under this contract.

10.1.22 The cabinets for the auxiliaries shall be mounted at a height that is accessible from ground level after installation.

11 SURGE ARRESTERS

11.1 The transformer shall be furnished with nine station-type surge arresters, one for each line terminal, suitable for protecting the windings of the transformer. These arresters shall conform to IEEE C62.11 and shall be of the metal-oxide type. The arresters shall be base-mounted adjacent to the bushings on brackets attached to the transformer tank. Surge arresters for the tertiary windings shall be mounted in the terminal enclosure adjacent to the bushings. The bases of each set of surge arresters shall be interconnected and connected to both ground pads with 500 MCM copper cable. The color of the arresters shall be ANSI No. 70 gray.

12 CURRENT TRANSFORMERS

12.1 Current transformers shall be standard bushing-type multi-ratio current transformers, with fully distributed windings suitable for the operation of relays and indicating instruments. Each current transformer shall have ten uniformly distributed windings according to ANSI C57.13. Current transformers shall be installed on the transformer as indicated below.

12.1.1 High-voltage bushings shall have three 1200/5, multi-ratio bushing-type current transformers in each bushing, accuracy Class C800, each with five leads.

12.1.2 Low-voltage bushings shall have three 1200/5 multi-ratio bushing-type current transformers in each bushing, accuracy Class C400, each with five leads. Low-voltage bushings X1 and X3 shall have one 1200/5 multi-ratio bushing-type current transformer in each bushing, accuracy Class C400, each with five leads for use with LTC circulating current control circuit.

12.1.3 Tertiary bushings shall have one 1200/5 multi-ratio bushing-type current transformer in each bushing, accuracy Class C400, with five leads.

12.1.4 The tertiary winding shall have one 1200/5 multi-ratio relaying-type current transformer per each delta connected winding, each with five leads, accuracy Class C400.

12.1.5 The neutral bushing shall have one 1200/5 multi-ratio relaying-type current transformer, accuracy Class C400, with five leads.

12.2 Ratio and correction curves shall be furnished for each current transformer.

13 SPARE PARTS

13.1 The Contractor shall furnish spare parts as listed below. The cost of these parts shall be included in the bid price for this contract. All spare parts shall be of the same material and workmanship and shall be interchangeable with the parts in service on the transformer.

One (1) – bushing with complete sets of gaskets; sealed for long-term storage, of each type and size as furnished with the transformer.

One (1) – Surge Arrester (161/69-kV) with complete sets of gaskets; sealed for long-term storage, of each type and size as furnished with the transformer.

Two (2) – complete sets of gaskets for the transformer; sealed for long-term storage.

One (1) – gallon of touchup paint.

14 SPECIAL TOOLS AND ACCESSORIES

14.1 The Contractor shall furnish a complete set of all special tools (including any metric tools) required or useful in assembling, disassembling, or maintaining the transformer.

14.2 All accessories or appurtenances necessary for satisfactory operation of the transformer, or regularly furnished therewith and not specified herein, shall be furnished with the transformer.

15 INSTRUCTION BOOKS

15.1 At least four (4) copies of a complete, bound, instruction book shall be furnished, complete with index and tabs, operating instructions, and list of parts for renewal or replacement purposes. Instruction books shall include instructions for installation, energization, inspection, and maintenance. Instruction books shall also include data sheets showing model numbers, applicable drawings appropriately reduced in size, warranties and guarantees, and name and address of manufacturer's authorized service facility nearest Springfield, Missouri. An additional copy shall be supplied with the transformer in a suitable holder in the control compartment.

16 FACTORY TESTS AND MEASUREMENTS

16.1 SWPA shall have the right to witness all tests and inspect the core and coil assembly before tanking. The manufacturer shall advise SWPA fifteen (15) working days in advance of test and tanking of core and coils. SWPA reserves the right to waive witnessing tests. The transformer shall be fully assembled at the factory and subjected to the following tests and measurements in accordance with ANSI/IEEE Standards C57.12.00-2000 or latest revision and C57.12.90.

16.2 Dielectric Tests

16.2.1 Impulse Test: The transformer shall receive a complete impulse test to demonstrate its impulse insulation level. The test shall consist of one reduced full wave, two chopped waves, and one full wave applied to each winding terminal, one at a time, without 60-hertz excitation.

16.2.2 Applied Potential Tests: These tests shall be applied to demonstrate the insulation strength from the windings to the core and the tank.

16.2.3 Induced Voltage Tests: These tests shall be made as specified in the above Standards, sufficient voltage being applied to the low-voltage terminals to induce a 1.73 p.u. test voltage for 7200 hertz at the high-voltage terminals, followed by at least a 1.5 p.u. voltage for a period of one (1) hour.

16.2.4 Insulation Resistance: The insulation resistance shall be determined for each winding.

16.3 Loss Tests, Regulation and Efficiency

16.3.1 The Contractor shall provide guaranteed no-load losses, guaranteed load copper losses at 70 MVA, and guaranteed auxiliary equipment losses as listed on the bid schedule. These losses will be used in the bid evaluation for the contract award.

16.3.2 No-Load Excitation Loss and No-Load Excitation Current: These values shall be measured on the rated voltage connection with sine wave voltages at 100% of rated voltage, at rated frequency, and at ambient temperatures between 15° and 25°C.

16.3.3 Impedances: The impedances shall be determined at rated current with the taps set for nominal voltage ratings.

16.3.4 Regulation: The regulation shall be determined in accordance with the ANSI Standards, for unity (1.0) power factor, nine-tenths (0.9) power factor, and eight-tenths (0.8) power factor, lagging.

16.3.5 Efficiency and Losses: The efficiency and losses shall be determined in accordance with the ANSI Standards at 25%, 50%, 75%, and 100% of rated load, OA. (The load losses shall be reported at 85°C.)

16.3.6 The test report shall include the measurement errors of the test system actually used in testing each transformer as traceable to the National Bureau of Standards (NBS) described in Technical Note 1204.

16.4 Resistance

16.4.1 The resistance of all windings shall be measured hot and cold. Data shall be recorded and furnished as specified in Section 16.13.

16.5 Insulation Power Factor

16.5.1 The insulation power factor shall be determined for each winding at room temperature. Data shall be recorded and furnished in accordance with Section 16.13.

16.6 Partial Discharge

16.6.1 The partial discharge test shall be made during the induced voltage test to demonstrate the absence of damaging discharge. The test shall consist of the

measurement of the radio influence voltage (RIV) during the full-induced voltage test in general accordance with ANSI/IEEE Standard C57.12.90 or latest revision.

16.7 Winding Ratios

16.7.1 The winding ratios, polarity, and phase relations shall be determined on the rated voltage connection and on all tap positions.

16.8 Polarity and Phase Relation

16.8.1 Tests shall be made on the rated voltage connection.

16.9 Temperature Tests

16.9.1 The temperature tests shall be made on the transformer in accordance with the ANSI Standards. Records of test, which have been made on thermally duplicate units, will be accepted in lieu of test performed on the transformer furnished under this contract.

16.10 Pressure and Vacuum Tests

16.10.1 Pressure and vacuum tests of the tank shall be made to demonstrate freedom from oil and air leaks.

16.11 Audible Sound Level

16.11.1 The transformer unit shall have a Standard NEMA sound level test performed. The audible sound level shall not exceed the values in accordance with NEMA TR1. The maximum sound level shall not exceed 75 db.

16.12 Surge Arrester Tests

16.12.1 Surge arrester tests shall consist of 60-hertz spark over voltage, RIV at rated voltage, and grading current check.

16.13 Dew Point in accordance with C57.12.12.1980 or latest revision.

16.13.1The dew point of the air (or gas) in the tank shall be determined just prior to shipment and at the final shipping destination to verify that the insulation moisture content is less than 0.7%. The manufacturer shall furnish all equipment necessary to perform the dew point at the final shipping destination.

16.14 The manufacturer shall furnish to SWPA certified copies of the results of all the factory tests performed and shall also furnish copies of curves showing the characteristics of the transformer as determined by these tests.

17 PAINTING

17.1 All surfaces shall be thoroughly cleaned and treated with phosphatizing process or equal, and all necessary filler shall be applied before painting. All unfinished metal surfaces of the equipment shall be given one coat of corrosion-resistant primer and at least two finish coasts of ANSI No. 70 gray transformer paint prior to shipment. The Contractor shall use lead free base paint on all areas to be painted. All finished surfaces shall be coated with a rust-preventive compound. All finished brass work shall be wrapped or otherwise protected from damage during the shipment.

18 SHIPMENT

18.1 The transformer shall be shipped with the cores and coils in the tanks. If oil is shipped separately, oil shall arrive no later than five (5) days after the transformer shipment. Suitable provisions shall be made for preventing atmospheric air, dirt, and moisture from gaining access to the tank during shipment.

18.2 The transformer shall be shipped with the oil removed and dry air under pressure shall be used to fill the tank to facilitate the inspection at the delivery point before unloading.

18.3 The transformer shall be shipped with two 30-day sealed, three-axis impact recorders attached to measure longitudinal, lateral, and vertical impacts received during shipment. The recorders shall be operative for the entire "in-transit" time. Upon arrival of the transformer at the job site, SWPA will remove the recorders, review the recorder charts, and return the recorders to the manufacturer. The charts will be retained by SWPA. An internal inspection of the transformer and additional on-site testing shall be made by the manufacturer as required by SWPA if:

1. The recorders fail to record the entire ride.

2. The transformer is subjected to impacts above the manufacturer's acceptable limits. These limits shall be provided to SWPA prior to shipment for use in interpreting the impact recorder charts.

18.4 The manufacturer shall install a pressure/vacuum gauge on the transformer tank prior to shipment to indicate that adequate pressure has been maintained during shipment.

18.5 Within eight (8) hours of shipment, the manufacturer shall check and record the transformer tank dew point, temperature, and pressure. One copy of the data shall be shipped with the transformer and two copies sent to the Contracting Officer's Representative (COR), One West Third Street, Tulsa, OK 74103.

19 SUBMITTALS

19.1 The Contractor shall furnish four (4) copies in English of the following:

19.1.1 Outline drawings showing exact bushing terminal locations, low-voltage flange details, accessory equipment locations, weights, and dimensions

19.1.2 Ratio correction factors and excitation curves of all bushing current transformers in accordance with paragraph 12.2

19.1.3 Transformer nameplate drawing

19.1.4 Wiring diagrams of transformer accessories and cooling system

19.1.5 Instruction books in accordance with paragraph 15.1

19.1.6 Loss test reports in accordance with paragraph 16.3.5

19.1.7 Certified copies of results of factory tests in accordance with paragraph 16.14

19.1.8 Field engineer's report in accordance with paragraph 25.7

19.1.9 Completed data forms from paragraph 26

19.1.10 Spare parts list in accordance with paragraph 13

20 DRAWINGS AND DATA TO BE FURNISHED BY THE CONTRACTOR

20.1 General

The drawings, correspondence, literature, and technical data required to be furnished by the Contractor shall be in English. Units of measurement shall be in the International System of Units (SI) or SI and United States standard.

The Contractor shall furnish the following drawings, literature and technical data:

Autotransformer Nameplate Drawing
Outline Drawings
Bushing Drawings
Surge Arrester Drawings
Winding Construction Drawings
Core Drawing
Sudden Pressure Relay information
Automatic Pressure Relief Device data
Information on all indicators and gauges
Fan and Motor data
Description of LTC
Description of No Load Tap Changer

These drawings shall be full-size on Mylar, or equal, and in electronic format applicable to SWPA's drawing system from the original tracings by photographic-type reproduction and shall be of such quality and clarity as to permit sharp and thoroughly legible microfilm copying. Reproducibles using the Diazo process or

Sepias are not acceptable. These drawings shall show all changes and revisions made up to the time the equipment is completed and accepted, and the substation name and contract number shall be shown thereon. The number and name shall be located immediately above the title block if possible. The drawings and data shall be complete and accurate in their content. Originals and all copies shall be legible. Drawings shall be drawn to scale, and shall have neat lettering. Freehand sketches will not be accepted. Drawing and data submittal requirements are listed on Table 20-1.

SWPA shall have the right to require the Contractor to make any changes in the drawings and data which may be necessary to show the equipment furnished conforms to the requirements of these specifications. Review by SWPA of the Contractor's drawings shall not relieve the Contractor of meeting all requirements of these specifications or for the correctness of the drawings.

One copy of each transmittal letter shall be sent to:

U. S. Department of Energy
Southwestern Power Administration
One West Third Street
Tulsa, OK 74103-3519
Attn: Unknown
Contracting Officer

Table 20-1 summarizes the drawings and data required for electrical equipment being furnished under these specifications.

TABLE 20-1

DRAWINGS AND DATA SCHEDULE FOR POWER AUTOTRANSFORMER

Type of Drawings and Data	Section	Delivery Time	Type of Material	Quantity to Project Manager	Quantity to Accompany the Equipment
Photographs	21	Two weeks after installation of core and coils		4 sets	1
Drawings and data to be furnished by the Contractor	20.1	When equipment is ready for shipment	Repro-ducibles	4 sets	2
Equipment test reports	20.2	2 weeks after tests are completed	Certified data	4 sets	2
Transformer Data	26.1	100 days after contract award		4 sets	0

20.2 Test Reports

Two weeks after completion of those tests required on the electrical equipment, the Contractor shall furnish certified copies of all test reports, performance curves, and data. Any equipment, which does not successfully pass the testing requirements, will be rejected. The reports shall be sent to the destination listed in Table 20-1.

20.3 Mailing Address

The mailing address for the drawings and technical data to be furnished by the Contractor to the COR is as follows.

U. S. Department of Energy
Southwestern Power Administration
One West Third Street
Tulsa, OK 74103-3519
Attn: Carlos E. Valencia, S3300

21 PHOTOGRAPHS

Three sets of color photographs of the core and coil assembly shall be furnished in accordance with Table 7-1. The photographs shall be taken just prior to

placing the completed core and coil assembly into the tank. All photographs shall be 215 mm x 280 mm (8-1/2" x 11") glossy prints labeled with the transformer manufacturer's name and serial number. Five different views shall be provided as follows: top view, front view, left side view, right side view, and rear view.

22 INSPECTION

SWPA or its representative shall at any time during the Contractor's normal working hours be permitted to visit the factory to review the transformer work progression and/or witness testing.

23 WARRANTY

The Contractor shall for a period of five (5) years from the date of installation, warrant that the autotransformer is free from defects in parts, material and workmanship and that properly used, will perform in full accordance with these specifications. Should the autotransformer fail to meet these standards within the five year warranty period described above, it will be replaced or repaired at the expense of the contractor, such expenses including but not limited to all parts, material, testing, transportation, disassembling and assembling.

24 LOSS EVALUATION

The transformer loss measurements shall be determined in accordance with ANSI C57.12.90 or latest revision and shall be stated at the nominal voltage tap positions.

The Contractor shall submit the guaranteed loss information required under Section B, line item Nos. 0001A and 0001B with their bid for the autotransformer. The guaranteed losses information shall also be furnished on the transformer data form. The transformer data shall be submitted 30 days after contract award.

The guaranteed losses will be taken into consideration for the evaluation of bids using the loss dollar values indicated on Design and Data sheets and in Section B.

If the total losses of the new autotransformer are higher than the proposed guaranteed losses by the Contractor, the Contractor's price will be reduced using the loss dollar values indicated on Design and Data sheets.

25 FIELD TECHNICAL DIRECTION

25.1 The Contractor shall provide a field engineer to give technical direction to SWPA regarding methods and procedures for installation of equipment covered by the specification; to assist the SWPA representatives in making inspections as are specified in the specification; and to instruct SWPA's authorized operating personnel in the recommended methods and procedures for starting, operating, and maintaining the equipment.

25.2 The Contractor shall provide technical direction on an intermittent basis to direct the following activities:

a) The inspection of the autotransformer for shipping damage before unloading.

b) The unloading and transferring of the major equipment from carrier to storage and/or the final installation location.

c) The assembly and installation of the equipment in the final location.

d) The energizing of the equipment and the placing of it in good operating condition.

e) The instruction of SWPA operating and maintenance personnel in proper operation and maintenance procedures.

25.3 The field engineer shall also perform the following services:

a) Consult with SWPA's installation contractor on plans, schedules, equipment, methods, and procedures.

b) Inspect the major parts as to proper assembly, clearances, alignment, and cleanliness.

c) Coordinate shipment of parts from the factory to minimize delays in transit.

d) Observe or monitor the work and practices of SWPA's installation contractor to assure that manufacturer's installation procedures are not violated.

e) Provide estimates on time requirements for accomplishment of the transformer installation.

f) Make available at the site any necessary additional drawings and procedures for installation, maintenance, and operation.

25.4 Technical direction, to be performed by the Contractor, will be required only during SWPA regular working hours. Normal working hours is 7:00 a.m. to 5:30 p.m., Monday through Thursday. The field engineer must be on the job site for his time to be counted as service to SWPA. The actual payment for field engineering services will be calculated on the proposed daily rate of line item no. 0002 in Section B, as explained in the following example: If the daily rate, unit price, for engineering services is $100 and the total engineering services are 8 ½ days, the total amount due will be $850.

25.5 In the event that delays occur during the periods of assembly, erection, or testing, wherein the services of the field engineer are not required, SWPA may direct the field engineer to return to his home station, in which case payment will not be made for the time he is not at the site of the work, or direct the field engineer to remain at the site of the work, in which case he will be paid as provided by the contract.

25.6 The prices paid under this item shall include the cost and expense of Employee's Liability Insurance to be carried by the manufacturer for the field engineer.

25.7 The manufacturer shall supply SWPA with four (4) copies of the field engineer's report on the field erection. The report shall cover all phases of the installation work.

26 DATA TO BE SUBMITTED UPON CONTRACT AWARD

26.1 The following data shall be supplied within ten (10) days after the contractor has received official notice of award:

26.2 Transformer Data

A. Manufacturer _____

B. Type of Construction _____

C. Winding Material:
   1. Low Voltage _____
   2. High Voltage _____

D. Shipment:
   1. Is transformer shipped by rail? _____
   2. Major items shipped unassembled _____
   3. Manhours estimated to field-assemble the above items _____
   4. Are transformer, radiators, and all other items shipped in one carload. If not, state how many carloads. _____
   5. Shipment of transformer will be made from (location) _____
   6. Shipment of transformer will be be made to (location) _____

E. Dimension and Weights:
   1. Width, overall _____
   2. Depth, overall _____
   3. Height of top of tank _____
   4. Height over LV bushings _____
   5. Height over HV bushings _____
   6. Total weight _____
   7. Shipping weight _____
   8. Weight of core and coils _____
   9. Weight of case and fillings _____
   10. Weight of oil _____
   11. Gallons of insulating oil _____
   12. Approximate base dimensions _____
   13. HV bushing stud dimension _____
   14. LV bushing stud dimension _____
   15. Proposal outline drawing _____

F. No-Load Losses:

1. 90% rated voltage _____
2. 100% rated voltage _____
3. 110% rated voltage _____

G. Regulation, Percent:

1. At 1.0 pf; 42000 kVA _____
2. At 0.8 pf; 42000 kVA _____
3. At 1.0 pf; 56000 kVA _____
4. At 0.8 pf; 56000 kVA _____
5. At 1.0 pf; 70000 kVA _____
6. At 0.8 pf; 70000 kVA _____
7. At 1.0 pf; 78400 kVA _____
8. At 0.8 pf; 78400 kVA _____

H. Losses and Efficiency:

	Losses in kV			Efficiency	
	Excitation	Load	Aux.	Total	Percent
1. At 42000 kVA	_____	____	____	____	_____
2. At 56000 kVA	_____	____	____	____	_____
3. Guaranteed at 70000 kVA	_____	____	____	____	_____
4. At 78400 kVA	_____	____	____	____	_____

I. Percent Impedances:

	Positive	Zero
42000 kVA rating	_____	____

	LTC Tap Position		
	Max Raise	Middle	Min Lower
J. Impedance at 42000 kVA:			
1. H-X	_____	_____	_____
2. H-Y	_____	_____	_____
3. X-Y	_____	_____	_____
Impedance at 56000 kVA:			
1. H-X	_____	_____	_____
2. H-Y	_____	_____	_____
3. X-Y	_____	_____	_____
Impedance at 70000 kVA:			
1. H-X	_____	_____	_____
2. H-Y	_____	_____	_____
3. X-Y	_____	_____	_____

K. Cooling Equipment:

1. OA/FA/FA, OA/FA/FOA, or OA/FOA/FOA _____
2. Number of radiators _____
3. Cooling fans:
   a. Number _____

b. HP each _____
c. Total kVA _____

4. Pumps:
   a. Number _____
   b. HP each _____
   c. Total kVA _____

L. Oil
1. Manufacturer _____
2. Type _____
3. Gallons of oil shipped separately from main tank _____
   a. Allowable Impact Meter Readings
      1. Longitudinal _____
      2. Vertical _____
   b. Maximum Auxiliary Equipment Load
      1. Voltage _____
      2. kVA _____
      3. Single phase _____
   c. Equipment Locations
      1. Radiator banks quadrant no. _____
      2. Load tap changer quadrant no. _____
      3. HV bushing quadrant no. _____
      4. LV bushing quadrant no. _____
      5. Neutral Xo bushing quadrant no. _____
      6. Control cabinet quadrant no. _____
      7. Station service enclosure quadrant no. _____
   d. Arresters
      1. 161-kV arrester manufacturer and rating _____
      2. 69-kV arrester manufacturer and rating _____
      3. 13.8-kV arrester manufacturer and rating _____