PART 1  GENERAL

1.01  SCOPE
A. The Contractor shall furnish and install the primary and/or secondary substation transformers as specified herein and as shown on the contract drawings.

1.02  RELATED SECTIONS
A. Section 16950B – Transformer Supplemental Acceptance Testing.

1.03  REFERENCES
A. The substation transformers shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and ANSI. NEMA 201, 210; IEEE 100, ANSI C57

1.04  SUBMITTALS – FOR REVIEW/APPROVAL
A. The following information shall be submitted to the Engineer:
   1. Master drawing index
   2. Front view elevation and weight
   3. Plan view
   4. Schematic diagrams
   5. Nameplate diagram
   6. Component list
   7. Conduit entry/exit locations
   8. Ratings including:
      a. kVA
      b. Primary and secondary voltage
      c. Taps
      d. Primary and secondary continuous current
      e. Basic Impulse Level
      f. Impedance
      g. Insulation class and temperature rise
      h. Sound level
   9. Cable terminal sizes
B. Where applicable the following additional information shall be submitted to the Engineer:
   1. Busway connection
   2. Connection details between close-coupled assemblies
   3. Composite floor plan of close-coupled assemblies
4. Key interlock scheme drawing and sequence of operations.

1.05 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:
   1. Final as-built drawings and information for items listed in section 1.04
   2. Wiring diagrams
   3. Certified production test reports
   4. Installation information
   5. Seismic certification.

B. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

1.06 QUALIFICATIONS

A. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for Zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 2.15g’s (3.2 – 11 Hz), and a ZPA of 0.86g’s applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

   -- •OR--

B. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through Zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, CBC: a peak of 2.15g’s, and a ZPA of 0.86g’s applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

   -- •OR--

B. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the BOCA National Building Code, paragraph 1612.6. This shall include both vertical and lateral required response spectra as specified. Alternatively, the manufacturer’s certification may be based on a detailed computer analysis of the entire assembly structure and its components. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The equipment manufacturer shall

* Note to Spec. Writer – Select one
document the requirements necessary for proper seismic mounting of the equipment. The test response spectra shall meet or exceed the required response spectra peak acceleration of 1.6g’s (3.2 – 11 Hz), and a ZPA of 1.0g as specified in the BOCA National Building Code, for all equipment natural frequencies up to at least 35 Hz. 

C. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.07 REGULATORY REQUIREMENTS
A. UL label required (Type VPI and VPE only.)

1.08 DELIVERY, STORAGE AND HANDLING
A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.09 OPERATION AND MAINTENANCE MANUALS
A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

1.10 FIELD MEASUREMENTS
A. Measure primary and secondary voltages and make appropriate Tap adjustments.

**Note to Spec. Writer:**

Select Part 2A for liquid transformers.
Select Part 2B for dry-type transformers.
Select Part 2C for RESIBLOC® cast resin transformer.
Select Part 2D for cast-coil transformers.

PART 2A PRODUCTS – LIQUID TRANSFORMERS

2.01 MANUFACTURERS
A. Cutler-Hammer
SUBSTATION TRANSFORMERS
SECTION 16322

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

2.02 RATINGS

A. The ratings of the transformer shall be as follows or as shown on the drawings:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>[OA] [OA/FFA] [OA/FA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>kVA Rating</td>
<td><em><strong><strong><strong><strong>/</strong></strong></strong></strong></em></td>
<td>[+]/- 7-1/2% [ANSI Standard Tolerance] [Minimum] [Maximum]</td>
</tr>
<tr>
<td>Impedance</td>
<td>_________</td>
<td>%</td>
</tr>
<tr>
<td>HV</td>
<td>_________</td>
<td>kV [Delta] [Wye]</td>
</tr>
<tr>
<td>HV BIL</td>
<td>_________</td>
<td>[delta] [Wye]</td>
</tr>
<tr>
<td>HV De-energized Taps</td>
<td>_________</td>
<td>+/- 2 - 2-1/2% full capacity</td>
</tr>
<tr>
<td>LV</td>
<td>_________</td>
<td>Volts [Wye] [Delta]</td>
</tr>
<tr>
<td>LV BIL</td>
<td>_________</td>
<td>kV</td>
</tr>
</tbody>
</table>

2.03 CONSTRUCTION

A. The unit shall be [mineral oil-] [R-Temp®/high fire point liquid] [silicone/high fire point liquid-] [high-molecular-weight hydrocarbon/high fire point liquid-] filled and shall be in accordance with the latest edition of the NEC. High fire point fluids shall be Factory Mutual and UL listed.

B. The transformer shall carry its continuous rating with average winding temperature rise by resistance that shall not exceed 65 degrees C, based on an average ambient of 30 degrees C over 24 hours with a maximum of 40 degrees C.

    -- 'OR --

B. The transformer shall carry its continuous rating with average winding temperature rise by resistance that shall not exceed 55 degrees C, based on average ambient of 30 degrees C over 24 hours with a maximum of 40 degrees C. The insulation system shall allow an additional 12% kVA output at 65 degrees C average winding temperature rise by resistance, on a continuous basis, without any decrease in normal transformer life.

C. Transformer shall include [provisions for] [all] devices, wiring, fans, and auxiliary equipment necessary for automatic temperature controlled forced air cooling to obtain an additional 15% capacity on units 300 through 2000 kVA and an additional 25% capacity on units 2500 kVA and over. Control power for fans shall be 230 Vac, single phase furnished from [a control transformer in the secondary equipment] [a separate control power source as shown on the drawings.]

D. The transformer shall be designed to carry short time emergency overloads in accordance with ANSI C57.12.92 as applicable. Duration and magnitude of designed withstand capability

• Note to Spec. Writer – Insert data in blanks
• Note to Spec. Writer – Select one
shall be as outlined in ANSI C57.12.90 and the latest draft of the IEEE short-circuit test code.

E. The transformer shall be designed to meet the sound level standards for liquid transformers as defined in NEMA TR1. The measurement procedure shall be as specified in ANSI C.57.12.90.

F. High-voltage and low-voltage windings shall be [aluminum] [copper]. Insulation between layers of the windings shall be by Insuldur paper or equal.

G. The main transformer tank and attached components shall be designed to withstand pressures 25% greater than the required operating design value without permanent deformation. Construction shall consist of carbon steel plate reinforced with external sidewall braces. All seams and joints shall be continuously welded.

H. Each radiator assembly shall be [individually welded] [removable with valves] and receive a quality control pressurized check for leaks. The entire tank assembly shall receive a similar leak test before tanking. A final six-hour leak test shall be performed after the transformer is tanked, welded and completed to ensure that there are no leaks before shipment.

2.04 ACCESSORIES

A. Transformer features and accessories shall include:
   1. De-energized tap changer with cover mounted, externally operated, [padlockable] [Kirk keyed] handle
   2. Combination drain and filter valve and sampling device
   3. Manual gas pressure test connection
   4. Filling plug and filter press connection in cover
   5. Dial-type top liquid thermometer
   6. Magnetic liquid level gauge
   7. Provisions for lifting, provisions for jacking, base designed for skidding or rolling in two directions
   8. Ground pad – stainless steel
   9. Instruction nameplate – stainless steel
   10. Pressure vacuum gauge
   11. Welded-on main tank cover and handhole in cover
   12. [Pressure relief device] [automatic pressure relief device that automatically reseals after operation, with semaphore operation indicator, for silicone filled transformers]

*** [Alarm contacts shall be provided on the following devices: *________, *________, *________].

2.05 FINISH

* Note to Spec. Writer – Select one
* Note to Spec. Writer – Insert data in blanks
A. The paint shall be applied using an air spray with air dry acrylic topcoat system to a minimum of three mils average thickness. Outdoor liquid transformer units shall include suitable outdoor paint finish. Units shall be painted ANSI 61 for indoor service or outdoor service and shall match the primary and secondary equipment.

2.06 TERMINAL COMPARTMENTS/FLANGE CONNECTIONS

A. The transformer unit supplied shall include a *[HV close coupled flange] [HV cable terminal compartment] and a *[LV close coupled flange] [busway flange] [LV cable terminal compartment]. Connections between the primary device and transformer shall be *[cable] [bus], and between the transformer and secondary shall be flexible bus braid.

2.07 BUSHING POWER FACTOR SENSING EQUIPMENT

A. The transformer shall be equipped with a continuous monitoring system to allow for pre-and post-shipment measurement of bushing power factor and internal partial discharges. In addition, vibro-acoustics testing shall be completed both prior to shipment and after final installation. Vibro-acoustics testing will indicate any initial winding looseness prior to shipment, and confirm that no additional internal stress has occurred during shipment and installation. The system shall be as specified in Section 16950B.

PART 2B PRODUCTS – DRY-TYPE TRANSFORMERS

2.01 MANUFACTURERS

A. Cutler-Hammer

B. *

C. *

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

2.02 RATINGS

A. The ratings of the transformer shall be as follows or as shown on the drawings:

<table>
<thead>
<tr>
<th>kVA Rating</th>
<th>*____<strong><strong>/</strong></strong>_____</th>
<th>*[AA] [AA/FFA] [AA/FA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance</td>
<td>*________</td>
<td>%*[+/- 7-1/2%] [ANSI Standard Tolerance] [Minimum] [Maximum]</td>
</tr>
<tr>
<td>HV</td>
<td>*________</td>
<td>kV *[Delta] [Wye]</td>
</tr>
<tr>
<td>HV BIL</td>
<td>*________</td>
<td>kV</td>
</tr>
<tr>
<td>HV De-energized Taps</td>
<td>*________</td>
<td>+/- 2 - 2-1/2% full capacity</td>
</tr>
</tbody>
</table>

* Note to Spec. Writer – Select one
* Note to Spec. Writer – Optional
* Note to Spec. Writer – Insert data in blanks
2.03 CONSTRUCTION

A. Transformer shall be cooled by natural air convection (AA).

-- 'OR --

A. Future forced air (FFA) for units 300 kVA and above shall contain all brackets and provisions required for addition of future fan cooling package. All current carrying bus/parts shall be sized to accommodate the (FFA) rating.

-- 'OR --

A. Future forced air (FFA) units for 300 kVA and above shall include all necessary wiring and the relay required for the automatic control of future fans (not included) to increase the kVA rating by 33%. Include the electronic temperature monitor and fan control unit. The temperature monitor and fan control relay shall include digital readout, GREEN – power on, YELLOW – fan on, RED – high temperature indicating lights; audible high temperature alarm with alarm silence pushbutton; max. temperature memory with read and reset switch; auto/manual fan control switch, system test switch; temperature sensing in all three low-voltage coils. Auxiliary alarm contact and means for remote control and temperature monitoring shall be provided. Control power shall be provided from ['a control power transformer in the secondary equipment'] ['a separate, external control power source'] ['internal control power transformer'].

-- 'OR --

A. Forced air (FA) units for 300 kVA and above shall contain all necessary components and wiring, including fans, for automatically increasing the kVA rating by 33%. The (FA) package shall include an electronic temperature monitor and fan control unit. The temperature monitor and fan control shall include digital readout, GREEN – power on, YELLOW – fan on, RED – high temperature indicating lights; audible high temperature alarm with alarm silence pushbutton; maximum temperature memory with read and reset switch; auto/manual fan control switch, system test switch; temperature sensing in all three low-voltage coils. Auxiliary alarm contact and means for remote control and temperature monitoring shall be provided. Control power shall be provided from ['a control power transformer in the secondary equipment'] ['a separate, external control power source'] ['internal control power transformer'].

B. The electrical insulation system shall utilize class H material in a fully rated 220 degrees C system. Transformer design temperature rise shall be based on a 30 degrees C average ambient over a 24-hour period with a maximum of 40 degrees C. Solid insulation in the transformer shall consist of inorganic materials such as porcelain, glass fiber, electrical grade glass polyester, or Nomex. All insulating materials must be rated for continuous 220 degree C duty. The insulation between the high- and low-voltage coils shall be more than sufficient for the voltage stress without the need of a varnish.

Note to Spec. Writer – Select one
**Note to Spec. Writer:**

Select desired temperature rise; note associated overload capacity. Insert in the following paragraph.

<table>
<thead>
<tr>
<th>Temperature Base Rise</th>
<th>kVA Base</th>
<th>Capability above Continuous (AA) Base kVA Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 degrees C</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>115 degrees C</td>
<td>100%</td>
<td>17%</td>
</tr>
<tr>
<td>80 degrees C</td>
<td>100%</td>
<td>35%</td>
</tr>
</tbody>
</table>

C. The transformer shall be designed for a temperature rise of *________* degrees C and shall be capable of operating at *_______* % above base nameplate kVA capacity continuously without any loss of life.

D. The transformer shall be designed to meet the sound level standards for dry-type transformers as defined in NEMA TR1. The measurement procedure shall be as specified in ANSI C57.12.90.

E. The transformer shall be UL labeled.

F. The transformer shall be of explosion-resistant, fire-resistant, air-insulated, ventilated dry-type construction, and cooled by the natural circulation of air through the windings.

G. High-voltage and low-voltage windings shall be *aluminum* [copper]. Insulation between layers of the windings shall be by Insuldur paper or equal.

H. *The high- and low-voltage coil assembly shall be Vacuum Pressure Impregnated (VPI) polyester*. [For enhanced environmental protection, the entire core and coil assembly shall be Vacuum Pressure Encapsulated (VPE) with a silicone resin per MIL-1-24092. The total VPE process shall apply a four (4) cycle shield of silicone resin to the coils and a two (2) cycle protective shield to the bus, core and support structure. The VPE process shall effectively encapsulate the entire core and coil assembly which results in a transformer which is virtually impermeable to moisture, dust, dirt, salt, air, and other industrial contaminants].

I. The high- and low-voltage coil assembly shall be preheated to evaporate any moisture, then placed into a vacuum pressure tank. The air in the tank shall be evacuated; and at extremely low absolute pressure, all air bubbles are to be drawn out of the insulating materials. The resin shall be introduced to a level that submerges all parts while the vacuum is maintained for approximately one (1) hour. Then the vacuum shall be released and pressure applied for approximately 1/2 hour, after which the coil shall be removed and placed in an oven for several hours in order for the resin to catalyze into a composite mass, completely sealing and binding the winding.

J. The transformer shall be supplied in a knockdown case design, for ease in fitting through limited openings, and shall be of heavy gauge sheet steel construction, equipped with removable panels for access to the core and coils. Front and rear panels shall incorporate lowered ventilating grills.

---

* Note to Spec. Writer – Insert data in blanks
* Note to Spec. Writer – Select one
K. Where outdoor dry-type transformers are shown on the drawings, they shall include thermostatically controlled space heaters fed from [an external source which remains energized when the transformer is de-energized] [a fused control power transformer connected to the primary side of the substation transformer]. Provide NEMA 3R enclosure with special ventilating grills that restrict the passage of rain or spray.

2.04 ACCESSORIES

A. Transformer shall include:
   1. Diagram instruction plate
   2. Provisions for lifting and jacking
   3. Removable center panel for access to high-voltage strap-type connector taps for de-energized tap changing
   4. Two ground pads with continuous ground bus.

2.05 FINISH

A. The paint shall be applied using an electrostatically deposited dry powder system to a minimum of three (3) mils average thickness. Outdoor dry-type transformer units shall include suitable outdoor paint finish. Units shall be painted ANSI 61 for indoor service or outdoor service and shall match the primary and secondary equipment.

2.06 TERMINAL COMPARTMENTS/FLANGE CONNECTIONS

A. The transformer unit supplied shall include a *[HV close coupled flange] [HV cable terminal compartment] and a *[LV close coupled flange] [busway flange] [LV cable terminal compartment]. Connections between the primary device and transformer shall be *[cable] [bus], and between the transformer and secondary shall be flexible bus braid.

2.07 BUSHING POWER FACTOR SENSING EQUIPMENT

A. The transformer shall be equipped with a continuous monitoring system to allow for pre-and post-shipment measurement of bushing power factor and internal partial discharges. In addition, vibro-acoustics testing shall be completed both prior to shipment and after final installation. Vibro-acoustics testing will indicate any initial winding looseness prior to shipment, and confirm that no additional internal stress has occurred during shipment and installation. The system shall be as specified in Section 16950B.

PART 2C PRODUCTS – RESIBLOC CAST RESIN TRANSFORMERS

2.01 MANUFACTURERS

A. Cutler-Hammer
B. *
C. *

* Note to Spec. Writer – Select one
* Note to Spec. Writer – Optional
* Note to Spec. Writer – Insert data in blanks
The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

2.02 RATINGS

A. The ratings of the transformer shall be as follows or as shown on the drawings:

<table>
<thead>
<tr>
<th>Component</th>
<th>Specification Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>kVA Rating</td>
<td><strong><strong><strong><strong><strong>/</strong></strong></strong></strong></strong></td>
</tr>
<tr>
<td>Impedance</td>
<td>__________ %[+/- 7-1/2%]</td>
</tr>
<tr>
<td>HV</td>
<td>__________ kV [Delta]</td>
</tr>
<tr>
<td>HV BIL</td>
<td>__________ kV</td>
</tr>
<tr>
<td>HV De-energized Taps</td>
<td>__________ +/- 2 - 2-1/2% full capacity</td>
</tr>
<tr>
<td>LV</td>
<td>__________ Volts [Wye]</td>
</tr>
<tr>
<td>LV BIL</td>
<td>__________ kV</td>
</tr>
</tbody>
</table>

2.03 CONSTRUCTION

A. Transformer shall be cooled by natural air convection (AA).

-- OR --

A. Future forced air (FFA) for units 300 kVA and above shall contain all components such as temperature sensor and wiring (except fans) for [+33%] [+50%] increased kVA. All current carrying bus shall be sized to accommodate the (FFA) rating.

-- OR --

A. Future forced air (FFA) units for 300 kVA and above shall include all necessary components and wiring, including fans, for automatically increasing the kVA rating by [+33%] [+50%]. The (FFA) package shall include an electronic temperature monitor and fan control unit. The temperature monitor and fan control relay shall include digital readout, GREEN – power on, YELLOW – fan on, RED – high temperature indicating lights; audible high temperature alarm with alarm silence pushbutton; max. temperature memory with read and reset switch; auto/manual fan control switch, system test switch; temperature sensing in all three low-voltage coils. Auxiliary alarm contact and means for remote control and temperature monitoring shall be provided. Control power shall be provided from [a control power transformer in the secondary equipment] [a separate, external control power source] [internal control power transformer].

-- OR --

A. Forced air (FA) units for 300 kVA and above shall contain all necessary components and wiring, including fans, for automatically increasing the kVA rating by [+33%] [+50%]. The (FA) package shall include an electronic temperature monitor and fan control unit. The temperature monitor and fan control shall include digital readout, GREEN – power on, YELLOW – fan on, RED – high temperature indicating lights; audible high temperature alarm with alarm silence pushbutton; maximum temperature memory with read and reset switch;

* Note to Spec. Writer – Insert data in blanks
* Note to Spec. Writer – Select one
auto/manual fan control switch, system test switch; temperature sensing in all three low-voltage coils. Auxiliary alarm contact and means for remote control and temperature monitoring shall be provided. Control power shall be provided from [*a control power transformer in the secondary equipment] [a separate, external control power source] [internal control power transformer].

B. The electrical insulation system shall utilize material with a fully rated 155 degrees C system. Transformer design temperature rise shall be based on a 30 degrees C average ambient over a 24-hour period with a maximum of 40 degrees C. Solid insulation in the transformer shall consist of inorganic materials such as glass fiber, electrical grade epoxy and Nomex. All insulating materials must be rated for continuous 155 degrees C duty.

C. For enhanced environmental protection and improved withstandability to thermal shock and short-circuit stresses, the primary coil assemblies shall be RESIBLOC design. The secondary coil assemblies shall be DyNI RESIBLOC design. Each RESIBLOC coil assembly shall be wet wound and reinforced with glass fiber filament to assure complete, void-free epoxy resin impregnation throughout the entire insulation system.

-- *OR--

C. For enhanced environmental protection and improved withstandability to thermal shock and short-circuit stresses, the primary and secondary coil assemblies shall be of RESIBLOC design. Each RESIBLOC coil assembly shall be wet-wound, and reinforced with glass fiber filament to ensure complete, void-free epoxy resin impregnation throughout the entire insulation system.

D. The average temperature rise of the transformer windings shall not exceed 80 degrees C when the transformer is operated at full nameplate rating. The transformer(s) shall be capable of carrying 100% of nameplate kVA rating in a 40 degrees C max. 30 degrees C average ambient as defined by ANSI C57.12.00.

E. High- and low-voltage windings shall be copper.

F. The transformer shall be supplied in a knockdown case design, for ease in fitting through limited openings, and shall be of heavy gauge sheet steel construction, equipped with removable panels for access to the core and coils. Front and rear panels shall incorporate ventilating grills.

G. The transformer shall be designed to meet the sound level standards for dry transformers as defined in NEMA TR1. The measurement procedure shall be as specified in ANSI C57.12.90.

H. Where outdoor RESIBLOC transformers are shown on the drawings, they shall include thermostatically controlled space heaters fed from [*external source which remains energized when the transformer is de-energized] [a fused control power transformer connected to the primary side of the substation transformer.] Provide NEMA 3R enclosure with special ventilating grills that restrict the passage of rain or spray.

I. The unit shall be partial discharge free with less than 20 pc at 120% of rated voltage.

2.04 ACCESSORIES

A. Transformer shall include:

* Note to Spec. Writer – Select one
1. Diagram instruction plate
2. Provisions for lifting and jacking
3. Removable center panel for access to high-voltage strap-type connector taps for de-energized tap changing
4. Two ground pads with continuous ground bus.

2.05 FINISH
A. The paint shall be applied using an electrostatically deposited powder system to a minimum of three (3) mils average thickness. Outdoor RESIBLOC transformer units shall include suitable outdoor paint finish. Units shall be painted ANSI 61 for indoor service or outdoor service and shall match the primary and secondary equipment.

2.06 TERMINAL COMPARTMENTS/FLANGE CONNECTIONS
A. The transformer unit supplied shall include a ‘[HV close coupled flange] [HV cable terminal compartment] and a ‘[LV close coupled flange] [busway flange] [LV cable terminal compartment]. Connections between the primary device and transformer shall be ‘[cable] [bus], and between the transformer and secondary shall be flexible bus braid.

2.07 BUSHING POWER FACTOR SENSING EQUIPMENT
A. The transformer shall be equipped with a continuous monitoring system to allow for pre-and post-shipment measurement of bushing power factor and internal partial discharges. In addition, vibro-acoustics testing shall be completed both prior to shipment and after final installation. Vibro-acoustics testing will indicate any initial winding looseness prior to shipment, and confirm that no additional internal stress has occurred during shipment and installation. The system shall be as specified in Section 16950B.

PART 2D PRODUCTS – VACUUM CAST-COIL DESIGN TRANSFORMERS

2.01 MANUFACTURERS
A. Cutler-Hammer
B. _________
C. _________

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

2.02 RATINGS

* Note to Spec. Writer – Select one
* Note to Spec. Writer – Optional
* Note to Spec. Writer – Insert data in blanks
A. The ratings of the transformer shall be as follows or as shown on the drawings:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>kVA Rating</strong></td>
<td></td>
<td>*[AA] [AA/FFA] [AA/FA]</td>
</tr>
<tr>
<td><strong>Impedance</strong></td>
<td></td>
<td>% [+/- 7-1/2%] [ANSI Standard Tolerance] [Minimum] [Maximum]</td>
</tr>
<tr>
<td><strong>HV</strong></td>
<td></td>
<td>kV *[Delta] [Wye]</td>
</tr>
<tr>
<td><strong>HV BIL</strong></td>
<td></td>
<td>kV</td>
</tr>
<tr>
<td><strong>HV De-energized Taps</strong></td>
<td></td>
<td>+/- 2 - 2-1/2% full capacity</td>
</tr>
<tr>
<td><strong>LV</strong></td>
<td></td>
<td>Volts *[Wye] [Delta]</td>
</tr>
<tr>
<td><strong>LV BIL</strong></td>
<td></td>
<td>kV</td>
</tr>
</tbody>
</table>

2.03 CONSTRUCTION

A. Transformer shall be cooled by natural air convection (AA).

--- OR ---

A. Future forced air (FFA) for units 300 kVA to 3750 kVA shall contain all components such as temperature sensor and wiring except fans for a *[33%] [50%] increased kVA. All current carrying bus shall be sized to accommodate the (FFA) rating. Units above 3750 kVA shall have an increase of 25%.

--- OR ---

A. Future forced air (FFA) units for 300 kVA to 3750 kVA shall include all necessary wiring and the relay required for the automatic control of future fans (not included) to increase the kVA rating by 33% The (FFA) package shall include an electronic temperature monitor and fan control unit. The temperature monitor and fan control relay shall include digital readout, GREEN – power on, YELLOW – fan on, RED – high temperature indicating lights; audible high temperature alarm with alarm silence pushbutton; max. temperature memory with read and reset switch; auto/manual fan control switch, system test switch; temperature sensing in all three low-voltage coils. Auxiliary alarm contact and means for remote control and temperature monitoring shall be provided. Control power shall be provided from *[a control power transformer in the secondary equipment] [a separate, external control power source] [internal control power transformer]. Units above 3750 kVA shall have an increase of 25%.

--- OR ---

A. Forced air (FA) units for 300 kVA to 3750 kVA shall contain all necessary components and wiring, including fans, for automatically increasing the kVA rating by *[33%] [50%]. The (FA) package shall include an electronic temperature monitor and fan control unit. The temperature monitor and fan control shall include digital readout, GREEN – power on, YELLOW – fan on, RED – high temperature indicating lights; audible high temperature alarm with alarm silence push button; maximum temperature memory with read and reset switch; auto/manual fan control switch, system test switch; temperature sensing in all three (3) low-voltage coils. Auxiliary alarm contact and means for remote control and temperature monitoring shall be provided. Control power shall be provided from *[a control power transformer in the secondary equipment] [a separate, external control power source] [internal control power transformer]. Units above 3750 kVA shall have an increase of 25%.

---

* Note to Spec. Writer – Insert data in blanks
* Note to Spec. Writer – Select one
B. The electrical insulation system shall utilize class F material in a fully rated 185 degree C system. Transformer design temperature rise of [80] [115] degrees C shall be based on a 30 degrees C average ambient over a 24-hour period with a maximum of 40 degrees C. Solid insulation in the transformer shall consist of inorganic materials such as glass fiber, electrical grade epoxy and Nomex. All insulating materials must be rated for continuous 185 degrees C duty.

C. For enhanced environmental protection and improved with standability to thermal shock and short-circuit stresses, the primary coil assemblies shall be cast coil design. The secondary coil assemblies shall be DyNI cast design. Each cast coil shall be cast under vacuum to ensure complete, void-free epoxy resin impregnation throughout the entire insulation system.

-- OR --

C. For enhanced environmental protection and improved withstandability to thermal shock and short-circuit stresses, the primary and secondary coil assemblies shall be of cast coil design. Each cast-coil shall be cast under vacuum to ensure complete, void-free epoxy resin impregnation throughout the entire insulation system.

D. The average temperature rise of the transformer windings shall not exceed [80] [115] degrees C when the transformer is operated at full nameplate rating. The transformer(s) shall be capable of carrying 100% of nameplate kVA rating in a 40 degrees C maximum 30 degrees C average ambient as defined by ANSI C57.12.00.

E. High- and low-voltage windings shall be [copper] [aluminum].

F. The transformer shall be supplied in a knockdown case design, for ease in fitting through limited openings, and shall be of heavy gauge sheet steel construction, equipped with removable panels for access to the core and coils. Front and rear panels shall incorporate ventilating grills.

G. The transformer shall be designed to meet the sound level standards for dry transformers as defined in NEMA TR1. The measurement procedure shall be as specified in ANSI C57.12.90.

H. Where outdoor cast-coil transformers are shown on the drawings, they shall include thermostatically controlled space heaters fed from [external source which remains energized when the transformer is de-energized] [a fused control power transformer connected to the primary side of the substation transformer]. Provide NEMA 3R enclosure with special ventilating grills that restrict the passage of rain or spray.

2.04 ACCESSORIES

A. Transformer shall include:
   1. Diagram instruction plate
   2. Provisions for lifting and jacking
   3. Removable center panel for access to high-voltage strap-type connector taps for de-energized tap changing
   4. Two ground pads with continuous ground bus.

2.05 FINISH

* Note to Spec. Writer – Select one
A. The paint shall be applied using an electrostatically deposited dry powder system to a minimum of three (3) mils average thickness. Outdoor cast-coil transformer units shall include suitable outdoor paint finish. Units shall be painted ANSI 61 for indoor service or outdoor service and shall match the primary and secondary equipment.

2.06 TERMINAL COMPARTMENTS/FLANGE CONNECTIONS

A. The transformer unit supplied shall include a ‘[HV close coupled flange] [HV cable terminal compartment] and a ‘[LV close coupled flange] [busway flange] [LV cable terminal compartment]. Connections between the primary device and transformer shall be ‘[cable] [bus], and between the transformer and secondary shall be flexible bus braid.

2.07 BUSHING POWER FACTOR SENSING EQUIPMENT

A. The transformer shall be equipped with a continuous monitoring system to allow for pre-and post-shipment measurement of bushing power factor and internal partial discharges. In addition, vibro-acoustics testing shall be completed both prior to shipment and after final installation. Vibro-acoustics testing will indicate any initial winding looseness prior to shipment, and confirm that no additional internal stress has occurred during shipment and installation. The system shall be as specified in Section 16950B.

PART 3 EXECUTION

3.01 FACTORY TESTING

A. The following standard factory tests shall be performed on all equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this project
2. Ratio tests on the rated voltage connection and on all tap connections
3. Polarity and phase-relation tests on the rated voltage connections
4. No-load loss at rated voltage on the rated voltage connection
5. Exciting current at rated voltage on the rated voltage connection
6. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating on this project
7. Applied potential test
8. Induced potential tests
9. For dry-type and cast-coil units, the manufacturer shall perform additional 100% quality control impulse test on each unit.

B. The manufacturer shall provide three (3) certified copies of factory test reports.
C. The following special factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest revision of ANSI and NEMA standards.

1. Temperature test(s) shall be made on [all units] [one unit only of a project covering one or more units of a given kVA rating.] Tests shall not be required when there is available a record of a temperature test on an essentially duplicate unit. When a transformer is supplied with auxiliary cooling equipment to provide more than one rating, temperature tests as listed above shall be made on the lowest kVA OA or AA rating and the highest kVA FA rating.

2. ANSI impulse test on all windings

D. Factory tests as outlined above shall be witnessed by the owner's representative.

1. The manufacturer shall notify the owner two (2) weeks prior to the date the tests are to be performed.

2. The manufacturer shall include the cost of transportation and lodging for up to three (3) owner’s representatives. The cost of meals and incidental expenses shall be the owner’s responsibility.

3.02 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer’s representative to assist the contractor in installation and start-up of the equipment specified under this section for a period of ______ working days. The manufacturer’s representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained herein.

B. The Contractor shall provide three (3) copies of the manufacturer’s field start-up report.

3.03 MANUFACTURER’S CERTIFICATION

A. A qualified factory-trained manufacturer’s representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer’s recommendations.

B. The Contractor shall provide three (3) copies of the manufacturer’s representative’s certification.

3.04 TRAINING

A. The contractor shall provide a training session for up to five (5) owner’s representatives for ______ normal workdays at a jobsite location determined by the owner.

B. The training session shall be conducted by a manufacturer’s qualified representative. Training program shall include instructions on the transformer, auxiliary devices and other major components.

3.05 INSTALLATION

* Note to Spec. Writer – Optional
* Note to Spec. Writer – Select one
* Note to Spec. Writer – Insert data in blanks
A. The Contractors shall install all equipment per the manufacturer's recommendations and the contract drawings.
B. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

3.06 FIELD ADJUSTMENTS
A. Adjust taps to deliver appropriate secondary voltage.

3.07 FIELD TESTING
A. Measure primary and secondary voltages for proper tap settings.
B. Megger primary and secondary windings
C. Liquid transformers – Test oil for dielectric strength.