PART 1 GENERAL

1.01 SCOPE

A. All transformers rated 34.5 kV and higher that have bushings with capacitance/voltage taps must be provided the equipment described in this section.

1.02 Note to Spec. Writer: This system must be only installed on bushings that have capacitance/voltage taps that are normally grounded

RELATED SECTIONS

1.03 REFERENCES

1.04 SUBMITTALS – FOR REVIEW/APPROVAL

A. This equipment is an integral part of the large power transformer and is subject to the submittals specified with the related product.

1.05 SUBMITTALS – FOR CONSTRUCTION

A. This equipment is an integral part of the large power transformer and is subject to the submittals specified with the related product.

1.06 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. 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.

C. The manufacturer and service organization of the equipment shall have been regularly engaged in the manufacture & service of medium voltage equipment this is to be installed in for a period of at least thirty (30) years and demonstrate that these products have been utilized in satisfactory use in functioning systems for similar applications. The service organization shall be familiar with interpreting, servicing, and maintaining this increased sophistication level of switchgear for at least five (5) years.

D. The manufacturer shall have a minimum net worth of $500 million to ensure financial stability during and after the completion of the retrofit process.

1.07 REGULATORY REQUIREMENTS
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, MAINTENANCE MANUALS AND SOFTWARE
   A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.
   B. All end user software shall be provided on a compact Disk and shipped with the equipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. Eaton / Cutler-Hammer products
   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 BUSHING SENSORS
   A. All transformer primary and secondary windings rated 34 kV (in some cases 20 – 24 kV bushings on large transformers may have capacitive taps) and above (maximum 800 kV) shall have dual sensors that can be used for periodic partial discharge measurements and provide signals to monitor the primary bushing capacitance and bushing dielectric losses (power factor) while the equipment is energized. These sensors are to be installed on all bushings that have a capacitance tap.
   B. Overvoltage and open circuit protection must be integrated into the sensor to provide proper protection of the bushing tap and sensor circuitry from operating voltage, switching and lightning over-voltages on the high-voltage side of the bushing.
      1. Particularly, power frequency voltage must be kept below 10 V rms with the monitor connected and below 200 V rms if the measuring circuit is accidentally open circuited. This protection must be built into the sensor. Refer to the following parameter table.

   * Note to Spec. Writer – Insert data in blanks
### Bushing Rating Table

<table>
<thead>
<tr>
<th>Bushing Rating</th>
<th>69 kV and Below</th>
<th>69 - 500 kV</th>
<th>500 - 800 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Power Frequency Voltage at tap if open circuited</td>
<td>75</td>
<td>135</td>
<td>140</td>
</tr>
<tr>
<td>Max. impulse voltage at Tap during Transients (peak)</td>
<td>325</td>
<td>550</td>
<td>735</td>
</tr>
<tr>
<td>Expected number of impulse shots equal to bushing BIL: (typically transformer is rated to take 20 - 40)</td>
<td>1000</td>
<td>800</td>
<td>500</td>
</tr>
</tbody>
</table>

C. Sensors must be Cutler-Hammer, or approved equal.

#### 2.03 TRANSFORMER BUSHING MONITORING SYSTEM.

A. The system shall continuously monitor the changes in the bushing insulation, for a set of three bushings in a group, based on changes in bushing capacitance and bushing power factor. The "sum of current" methods is the recommended method. The resultant quantity is known as "Gamma." The system shall detect changes in the power frequency current through the bushing insulation. The system shall also provide provisions for the connection of instrumentation for periodical electrical partial discharge measurements, on-line, using portable equipment without requiring a transformer outage, or any modifications to the sensing circuit.

**Note to Spec. Writer:** This system must be only installed on bushings that have capacitance taps that are normally grounded.

B. Monitoring system should be suitable for outdoor installation within industrial temperature range.

C. A separate NEMA 4 enclosure, suitable for outdoor use shall contain the transformer bushing monitor circuitry, relay, alarm indications and access ports for the periodic detection of partial discharges.

D. Must be a stand-alone microprocessor-controlled monitoring device specially designed to monitor the Gamma value in 60/50 Hz sets of bushings, to store the information in its internal memory and to provide an alarm signal based on Gamma-parameter characteristics at an early stage of insulation degradation.

E. The monitor must be able to display the following at a minimum:

1. Gamma parameter
2. Phase Angle
3. Alarm condition (Alarm and alarming parameter)
4. Trend
5. Temperature dependencies
6. Input signal magnitude from each sensor
7. Tan delta and capacitance for each bushing

F. The monitor also must determine the phase angle between the Gamma vector and current in phase A that can be used for estimating what bushing(s) has (have) the developing defect(s).

G. The monitor should allow for measurement schedule based on time or time interval.

H. The monitor should continuously watch for appearance of an alarm signal and trigger a measurement in the case of such an event regardless to schedule.

I. The monitor must have Temperature Input from a100 ohm RTD. This temperature should approximate the top oil temperature of the transformer. It is permissible to install the RTD on a radiator or cooler header for estimating purposes.

J. The monitor must calculate Gamma vs. Temperature dependencies. These dependencies provide advanced diagnostic capabilities in determining the type of defect in the bushing.

K. Before each measurement, the monitor shall perform a self-calibration and self-test and also test for a presence of a normal signal from each sensor. If any problem is detected, the Alarm relay dry contacts will be opened and an appropriate message will appear on the display. Loss of power will be indicated in the same way by opening Alarm relay contacts.

L. The monitor shall have the following outputs
   1. One alarm Relay - Form C contacts
   2. 4 – 20 ma dc isolated output proportional to the Gamma value
   3. The monitor shall also have either an RS-232 or RS-485 port for unit configuration and up loading of stored data. RS-485 models must be able to be networked with each monitor addressable to up to 255 addresses

M. The monitor shall have accessible ports in order that a suitable Partial Discharge (PD) analyzer can be easily connected in order to make PD measurements.

N. The bushing monitoring system must have sensitivity of at least 0.1% of power factor or capacitance change.

O. The monitor shall alarm on the following conditions:
   1. Gamma-parameter magnitude
   2. Gamma-versus-temperature variations (temperature coefficient of Gamma)
   3. Gamma Trend
   4. Also a log of alarms and monitor malfunctions must be created and stored within the device

P. Instrumentation must be completely isolated from high voltages and feature immunity to high voltage transients.

Q. Manufacturers authorized field engineers must complete full field calibration, after installation and the procedures shall be supplied with the instrument's operation manual.

R. The monitor must have enough memory to store all data for at least a five-year period.
S. Monitor to be Cutler-Hammer type, or approved equal.

2.04 SOFTWARE

A. The provided software must be able to be used to configure the monitor as well as upload all data and store it in a database.

B. Software must be provided with the unit and have the following features:
   1. Ability to communicate with the monitor by:
      a. Direct connection to the monitor via the RS-232 or RS-485 port
      b. RS-485 network
      c. Remotely via a landline or cellular modem utilizing either one of communication interfaces.

C. Software shall provide the ability to graphically display the following:
   1. Gamma in %
   2. Gamma Phase Angle in degrees divided by 100
   3. Temperature coefficient of the Gamma parameter in % per °C
   4. Absolute values of the input signal for the phases A, B and C in mV.
   5. Temperature in °C.
   6. Gamma trend calculated by the device in % of Gamma per year.
   7. Polar Graph that represents the Gamma parameter in polar coordinates (Gamma, Phase Angle)
   8. Tan Delta trend for each bushing
   9. Capacitance trend for each bushing

D. The software must provide the user unlimited licenses.

PART 3 EXECUTION

3.01 FACTORY TESTING

A. The factory must verify and record continuity of all connections between sensors and monitor.

B. The factory must verify proper operation of the monitor prior to shipment.

3.02 FIELD TESTING

A. The field engineering service testing group shall provide all material, equipment, labor and technical supervision to perform such tests and inspections.

B. Calibration of the system must take place in the field after all cables are installed and prior to energizing equipment.

C. After energizing the main equipment, baseline measurements and final startup procedures should be performed.
D. Upon completion of the tests and inspections noted in these specifications, a label shall be attached to all serviced devices. These labels will indicate date serviced and the engineering service testing group responsible.

E. The tests and inspections shall determine suitability for initial continued reliable operation.

3.03 REMOTE MONITORING DIAGNOSTICS SERVICE

A. Vendor must supply services to remotely monitor each PD relay on an annual contract basis.
   1. Each PD relay must be accessed remotely on a minimum of a weekly basis and data uploaded
      a. Vendor must review data and inform owner of any significant changes or new developments in PD activity.
   2. Vendor must submit a formal biannual report for each piece of equipment monitored by each PD Relay. This report must detail the following:
      a. Trends of PD activity for each channel
      b. Dependencies of PD activity with Temperature, Humidity and Load for each channel
      c. Review of phase resolved data and analysis of the fingerprints
      d. Assessment as to the overall condition of the equipment and any recommendations.

* Note to Spec. Writer – Optional