

New York State Electric Meter Engineers' Committee

Guide for Uniform Practices in Revenue Quality Metering

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1.0 Purpose

- 1.1 The main purpose of this guide is to identify accepted practices for revenue quality metering systems that will result in optimum accuracy and in cases where required, to provide the minimum functional requirements to deliver revenue grade load profile data to end users.
- 1.2 The scope of this guide is limited to the measurement of revenue grade, gross watt-hour values. This guide may also be applicable to measurements intended for local monitoring, power system control and operation. It does not include processes that may be used by Meter Authorities or others beyond the validation of gross watt-hour values and is not applicable to measurements intended for station relaying applications.
- 1.3 Equipment, if any, necessary to telemeter non-billing or instantaneous measurements to remote locations is not covered by this guide. This includes metering data collected by SCADA remote terminal units (RTU's) for control and operational reasons or measurements of instantaneous quantities that are transmitted directly to the end user.
- 1.4 This guide is intended to apply to new or completely revised metering installations. Its application when upgrading the capabilities of existing installations is encouraged.

2.0 General

- 2.1 The revenue metering installation may also be the source for supplying SCADA with real time or instantaneous values (i.e. metering data collected by SCADA RTU's for operational reasons). Metered quantities that are used for the purpose of operating or controlling the "power system" may also be derived from discrete transducers.
- 2.2 Data supplied to an end user for revenue purposes should at minimum be based on measurements made with "instruments" that are in compliance with the requirements detailed in this manual. These instruments shall be traceable to NIST standards, approved for revenue purposes by the NYSPSC and meet or exceed all applicable ANSI C12 Series (Code for Electricity Metering) requirements in effect at the time of their design.
- 2.3 Instrument transformers should meet or exceed ANSI standard C57.13 and all applicable ANSI C12 Series standards that are in effect at the time of design.
- 2.4 The revenue quality installation should conform to Blondel's measurement theorem that states: "In a system of N conductors, N-1 meter elements, properly connected, will measure the power or energy taken. The connection must be such that all voltage coils have a common tie to the conductor in which there is no current coil." A neutral conductor that is grounded through high impedance so that the "system" becomes effectively ungrounded can be excluded from the conductor count. Compliance to Blondel's measurement theorem precludes the use of two and one-half element (i.e. FM 6) meters in applications involving grounded Wye connected sources.
- 2.5 The revenue metering installation should be designed in a manner that minimizes the effects of scaling and resolution errors.

- 2.6 Each revenue meter and instrument transformer should be provided with a nameplate that lists the manufacturer's name, serial number, and type of device as well as class accuracy and pertinent input and output ratings including impulse levels, where applicable, and necessary connection diagram and polarity designations.
- 2.7 Wiring connections between the instrument transformers and the metering devices should conform to standards specified in Sections 3.0 and 4.0 of this guide.

3.0 Current Transformers (CT's)

- 3.1 All CT's should conform to the ANSI standard accuracy class for metering service of 0.3 or better and shall be provided with certificates of test stipulating the ratio and phase angle corrections at 10% and 100% of rating with the standard ANSI burden nearest to the actual "in-service" burden.
- 3.2 Where the secondary circuit will impose different burdens on the individual current transformers, certificates shall be provided showing ratio and phase angle corrections for the ANSI burdens nearest to the highest and the lowest "in-service" burden.
- 3.3 The metering CT burden in the secondary circuit should be kept as small as practicable and should be limited to those measurement devices requiring a highly accurate current source. Relays, meters and other devices intended mainly for local control and operation should not be connected to these transformers.
- 3.4 Other than a test block or switch that is specifically designed for the purpose of testing meters, no other switch(es), test block(s), fuse(s), or other quick disconnecting means should be placed in the secondary circuits of the CT's.
- 3.5 All secondary wiring connected to the CT's should be a minimum of #10AWG copper and should be limited to the minimum length necessary to complete the circuit to the revenue meter. Short lengths of smaller conductors on switchboard panels may be utilized providing the additional burden imposed by these conductors is negligible when compared to the overall circuit burden.
- 3.6 The wiring for the secondary circuits of metering CT's should utilize separate leads from each secondary terminal of the CT to the meter test block. When a common CT secondary return conductor is utilized, the conductor should be separate from the common return of the voltage transformers. Regardless of which method is used (i.e. separate leads or a common return conductor); the CT and voltage transformer commons shall be grounded at only one point, preferably at the test switch near the meter.
- 3.7 Secondary circuits should be routed so as to avoid the possibility of induced voltages and the effects of ground faults. Where this is not practical, the secondary circuit should be designed to minimize these effects. In those circuits involving solid state metering, suitable protection against the effects of fault and switching generated over-voltages should be provided (refer to ANSI C37.90a).
- 3.8 CT secondary windings should not be connected in parallel.
- 3.9 Whenever practical, the CT's should be designed to withstand continuous operation and maintain class 0.3 or better metering accuracy at twice or more of rated current (ex. transformer thermal rating factor greater than or equal to 2). In these cases, the nominal primary rating of

the CT should be one-half, or the nearest standard rating above one-half, of the long-term emergency rating of the tie.

4.0 Voltage Transformers (VT's)

- 4.1 All VT's should conform to the ANSI standard accuracy class for metering service of 0.3 or better and be provided with certificates of test stipulating the ratio and phase angle corrections at 100% rating with zero burden and with the rated maximum standard burden.
- 4.2 The VT burden in the secondary circuit should be limited to those measuring devices that require a highly accurate voltage source. Relays, meters, and other devices intended mainly for local control and operation should not be connected to these transformers.
- 4.3 Where the VT has multiple secondaries, the revenue measuring devices requiring a highly accurate voltage source should be connected to a separate secondary winding from that supplying the remaining burdens. Care should be exercised not to overburden the windings where non revenue grade devices are connected since this can affect the accuracy of the voltage supplied by the windings that are dedicated to revenue measurement devices.
- 4.4 Secondary fuses, if any, should be of a high speed, high-current interrupting construction with current ratings sufficient to assure low electrical impedance and the mechanical ruggedness to resist the effects of corrosion and vibration. In no case should fuses be placed in the common secondary return or the ground circuit of instrument transformers.
- 4.5 All test switches, fuse blocks, and fuses in the secondary voltage circuit should be designed to introduce as small an impedance as practical to the secondary circuit. The overall resistance and reactive impedance of the secondary circuit should be measured. These values should be multiplied phasorially by the burden current to determine the in-phase and quadrature components of the lead voltage drop. These values should be utilized to calculate the overall voltage transformer corrections to be applied to the metering circuit, if instrument transformer correction is used.
- 4.6 All secondary wiring supplying voltage to the revenue meters should be a minimum of #12 AWG copper and should be limited to the minimum length necessary to complete the circuit to the metering device.
- 4.7 Where a common VT secondary return conductor is utilized, the conductor should be separate from the common return of the CT's. The VT and CT common return should be grounded at only one point, preferably at the test switch near the meter.
- 4.8 Secondary circuits should be routed so as to avoid the possibility of induced voltages and the effects of ground faults. Where this is not practical, the secondary circuit should be designed to minimize these effects. Suitable protection against the effects of faults and switching generated overvoltages should be provided.
- 4.9 VT's should be of a wound or cascade type. Coupling capacitor voltage transformers (CCVT's) should not be used for revenue metering purposes.

5.0 Revenue Meters

- 5.1 The revenue meters should be digital, true RMS measuring devices that meet or exceed ANSI C12.20 that is in effect at the time of design and in cases where required, they shall have the ability to record load profile data.

- 5.2 Where applicable, the revenue meter may be used as a source for measurement of instantaneous values. The interface between the revenue meter and SCADA RTU may be through an analog current loop or a digital, real time metering port using DNP 3.0 or other suitable communication protocol and having an RS-232 or RS-485 interface.
- 5.3 To facilitate the transfer of revenue quality, register and load profile data, the revenue meters should be remotely accessible through use of conventional dial up or other communication technology.
- 5.4 Where there is need for a revenue meter to measure, display and/or record time differentiated usage, its primary time base should be synchronized with the line frequency. Its secondary time base should have an accuracy that meets or exceeds +/- 0.02% (ANSI C12.13). In cases where revenue data is retrieved by a translation system through remote dial up or other communication means, the translation system should be synchronized to a national time standard on a daily basis. Meter time should be adjusted if it exceeds the time reference of the translation system by more than an “allowable” tolerance. While this “allowable” tolerance varies between Meter Authorities, it should be kept as small as practicable. As a target, Meter Authorities should try to maintain meter time to within a +/- 15-second window from the translation system reference.
- 5.5 Compensation for line and transformer losses, when utilized should be accomplished in accordance with procedures defined in the latest edition of Edison Electric Institute’s “Handbook for Electricity Metering”. Compensation should be effected by applying a correction for copper losses that are proportional to the square of the current and a correction for transformer core losses or line energization losses that are proportional to the square of the voltage. These corrections should be continuous and should be added to (or subtracted from) the watt-hours and reactive volt-ampere-hours (if metered) passing through the electrical point of measurement.
- 5.6 Compensation for instrument transformer errors, when utilized should be accomplished in accordance with procedures defined in the latest edition of Edison Electric Institute’s “Handbook for Electricity Metering”. The calculation of Final Correction Factor (FCF) should be based on ratio and phase angle error measurements made with instruments that are traceable to NIST standards and at minimum, are more accurate than the equipment under test by a factor of four.
- 5.7 Test blocks or switches should be located at or near the revenue meter. These test blocks should be designed to provide a means to measure the input quantities from the current and/or voltage transformers and to allow the application of test quantities. Where the output quantity is electrical rather than visual, provisions should be made for the convenient and efficient measurement of these quantities.
- 5.8 The revenue meters should be located inside a building or structure that provides adequate protection of the equipment and maintenance personnel from the weather. Adequate lighting should be provided in the area as required for testing, maintenance, and adjustment.

6.0 Validation of Revenue Data

- 6.1 Revenue quality (register and profile) data should be retrieved and validated by an industry-approved translation billing system. On occasion, visual register reads may also be needed to perform validations upon request.

6.2 Where applicable, SCADA data may be checked against revenue data for validation reasons. Revenue information that is collected by the translation system should be compared against SCADA integrated instantaneous and accumulated hourly pulse values. The source for final revenue reconciliation should be from the revenue quality installation and data collection system.

7.0 Backup Revenue Meter

7.1 Where a backup meter is used, it should meet or exceed all of the requirements described in this guide and have all pertinent functional capabilities of the primary meter. To minimize common mode failure, primary and backup meters should be of a different type and manufacturer.

7.2 If a backup meter is used, the revenue meters should be designated and marked as primary and backup. The transfer of revenue quality, register and hourly profile data for billing purposes should be restricted to the primary metering source. The revenue quality data from the backup meter should be used for billing purposes only during periods of time when the primary metering has experienced a failure.

8.0 Testing and Calibration

8.1 Test equipment and test standards intended for testing and calibration of revenue meters should be certified to values of accuracy and precision which are better than the required accuracy of the equipment under test by a factor of at least four.

8.2 Test equipment and test standards intended for the testing of new instrument transformers should be certified to values of accuracy and precision that are better than the required accuracy of the equipment under test by a factor of at least four.

8.3 All test standards used for revenue meter testing should be supplied with certified corrections that have been derived no longer than one year prior to their use.

8.4 All test standards used for instrument transformer testing for revenue quality installations should be supplied with certified corrections that have been derived no longer than four years prior to their use.

8.5 All certified corrections should be obtained by comparison against laboratory standards whose accuracies are traceable to the National Institute of Standards and Technology.

8.6 Standards utilized for the purpose of checking instantaneous voltage and current to the revenue measurement devices should be of the RMS sensing type.

8.7 Except in those cases where the involved parties agree to the contrary, the Meter Authority is responsible for any maintenance and calibration. All stakeholders affected by the measurements may request to be notified of pending calibrations and may be present during maintenance and calibration proceedings. In any case, copies of the maintenance and calibration record should be forwarded to all stakeholders upon request.

8.8 Where a dispute over the accuracy or performance of a revenue meter exists, the stakeholders may request a comparison of standards and/or a separate calibration of the revenue meter.

- 8.9 New revenue meters should be acceptance tested. All tests should be made at nominal nameplate rating. The series test points should be at Full Load (FL), Light Load (LL) and Power Factor (PF). FL is at 5 amperes at unity power factor. LL is at 0.5 amperes (10% of FL) at unity power factor and the PF test point is at 5 amperes at 0.5 power factor.
- 8.10 In-service revenue meters shall be periodically tested at the above test points. The revenue meters should be adjusted to bring the registration at all test points within the accuracy specifications defined in ANSI C12.20.
- 8.11 It is considered good practice to periodically field check the condition of metering instrument transformers. The condition of in-service CT's can be periodically checked by use of one of two methods. The preferred method for the detection of abnormal conditions is to monitor the CT's admittance. An increase of sufficient magnitude would indicate an abnormal condition such as an error or fault that may affect billing accuracy. The other method involves burden testing where external burdens are added in steps to the secondary loop of the CT. The change in secondary current is monitored during each step and compared against the value of secondary loop current without the external burden added. The stepped decreases in secondary current are then compared against those of the other CT's in the same installation. A difference in the magnitude of current decreases within each step and between CT's would indicate an abnormal condition that may affect billing accuracy.
- 8.12 Where possible, a periodic functional inspection of the VT's should be made. This involves making voltage measurements near the VT secondary terminals and at the meter test block. An excessive drop in voltage may indicate the presence of an abnormal condition. During planned outages involving older installations, consideration should be given to high pot testing the secondary wiring of VT's.
- 8.13 Revenue meters should be tested in both directions if used in a bi-directional manner for revenue purposes.
- 8.14 If the revenue meters are compensated for line and/or transformer losses, they should be tested both with and without loss compensation to determine the accuracy of the compensation at each test point (i.e. FL, LL and PF). Since this requires access to an accurate and stable voltage and current source, it should be done prior to installation. The intent of subsequent in-service testing is not to verify accuracy but rather the presence of the compensation.
- 8.15 Revenue meters that have both an analog output and an integrated pulse output should be tested for the accuracy of both outputs.
- 8.16 The integrity of the meter readings should be maintained. A meter test should be made during a period of no load or when the load is constant so that the reading can be adjusted upon completion of the test. The I/O circuits should be made inoperative during the test.

9.0 Test Schedules and Records

- 9.1 Revenue meters should at minimum be tested once every two years.
- 9.2 Test records should be maintained for a period of at least six years. Copies of all tests should be forwarded to all the stakeholders that are interested in receiving such information.

10.0 Exchange of Information

- 10.1 Upon installation, the metering authority should furnish all stakeholders with pertinent metering information that includes the following:
- a. Connection diagram(s).
 - b. Type and rating of revenue meters, current and voltage transformers, and other associated devices.
 - c. Copies of certificates of test for the metering current and voltage transformers. When certificates are not available, a typical curve for the type of transformers should be furnished, and the parties should agree on the transformer correction, if any, to be applied.
 - d. Secondary burdens applied to the voltage and current transformers.
 - e. The resistance and reactive impedance of the voltage transformer secondary leads.
 - f. The derivation of compensated metering correction, if used, and the method of compensation.
- 10.2 The forms upon which the above are reported should include the Company's name, the location of the installation, identification numbers of the meters and instrument transformers, feeder identification, and direction of flow being measured.
- 10.3 All stakeholders shall be advised of proposed changes in the metering equipment or circuits which could affect the accuracy of the measurement(s).

11.0 Definitions

- 11.1 Where there is a question on the meaning of terms used in this guide, the definitions in Section 2 of ANSI Standard C12 should be used. If ANSI Standard C12 does not address the question, the definition, by order of priority, should be obtained from the following:
- a. IEEE Standard Dictionary of Electrical and Electronic Terms.
 - b. McGraw Hill Dictionary of Scientific and Technical terms.
 - c. Webster's Unabridged Dictionary.
- 11.2 The following definitions are terms used throughout this guide. These definition are limited to this document:
- a. Instruments – All devices that make up the revenue metering installation. This includes but is not limited to meters, instrument transformers, demand recorders, totalizers, etc.
 - b. SCADA: System Control And Data Acquisition system.
 - c. RTU: Remote Terminal Unit
 - d. ANSI: American National Standards Institute

- e. NIST: National Institute of Standards and Technology
- f. NYSPSC: New York State Public Service Commission
- g. RMS: Root Mean Square
- h. Stakeholder: Parties or entities that have direct involvement with points of interchange.