

SETTLEMENT METERING – OVERALL ACCURACY AND UNCERTAINTY

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PURPOSE AND SCOPE

This Technical Guidance Note provides an assessment of the overall accuracy and associated uncertainty achieved by National Grid Settlement Metering installations.

Since the metering systems utilize a range of different metering equipment and include site specific features this is a generic assessment and includes worst case elements.

The assessment can be used as supporting evidence for the requirements of Metering Code of Practice One (COP 1) with respect to Overall Accuracy.

The assessment applies to the standard NG three phase four wire metering installations which comprise the great majority of applications.

Informative: Site specific calculated values of metering system error (which only excludes the actual energy meter error) are included in a spreadsheet / database which is used for meter compensation purposes to reduce the total overall operating error of a given metering system.

Informative: Metering Codes of practice are industry documents available on the Elexon website.

PART 1 – GUIDANCE

1 CODE OF PRACTICE REQUIREMENTS

1.1 Accuracy

The overall accuracy requirements are covered in Metering COP 1 clause 4.2.1 and for convenience are included in Appendix A of this document.

COP 1 further defines the conditions under which the overall accuracy is achieved as being the reference conditions under which the energy meters are required to meet their specifications.

The main reference conditions relevant are taken to be:

Temperature	23 +/- 2 deg C
Voltage	Reference 63.5 Vac +/- 1%
Frequency	Reference (taken as 50 HZ) +/- 0.5%
Waveform	Sinusoidal voltages, distortion less than 1%
External induction	Magnetic induction at zero

In terms of metering system errors (other than actual meter errors), these reference conditions are also considered to apply and therefore reduce the magnitude of variations or additional errors. (For example temperature influences or magnetic induction effects on measurement transformer cabling to the meters.)

1.2 Measurement Uncertainty

COP 4 covers Measurement Uncertainty requirements specifically for Measurement Transformers and Energy Meters. The uncertainty figures being calculated to a confidence level of 95% in accordance with UKAS Directive M3003.

2 METERING SYSTEM ERRORS

There are three main sources of measurement errors in the Metering System (MS):

- (i) Measurement Transformer errors
- (ii) Interconnecting cabling errors
- (iii) Energy Meter errors

The errors for (i) and (ii) are both expressed in the form of, Ratio Error (RE) and a Phase Angle Error (PAE) and the combined errors resulting cause an 'incorrect energy' to be fed to and measured by the energy meter.

It is generally accepted that in normal circumstances (exceptions could be excessive electrical faults and bad / high resistance connections) the errors of measurement transformers and cabling do not change or age.

The three errors 'add' to produce the total MS registration error which should be within the error limits set down in the COP where the MS is situated at or referred to the Defined Metering Point (DMP). The accuracy requirements apply to both the Main and Check metering systems.

For most practical cases this means that the measurement transformers should be located at the Defined Metering point. eg For a GSP at the LV side of SGTs feeding to the Disco.

2.1 Measurement Transformer Errors

The measurement transformers presently used for Settlement Metering are wound electromagnetic voltage transformers (VTs) and current transformers (CTs). Many of the measurement transformers at 132 kV and lower system voltage units are combined voltage and current units where both units are in one physical assembly.

There are about six manufacturers of the installed VTs and CTs, three of which constitute the great majority.

All the VTs and CTs employed are provided with separate windings for the Main and Check metering.

The test certificates for the measurement transformers provide errors that apply at the output terminals of the devices under specified burden conditions.

2.1.1 Voltage Transformers

The voltage transformers used are IEC 60044-2 accuracy class 0.2 units.

The error limits for these units are: (when used within defined specification parameters)

Ratio Error +/- 0.2%

Phase Angle Error +/- 10 mins

Informative: These error limits translate to energy measurement errors of, +/- 0.2% at unity pf and +/- 0.7% at 0.5 pf

Working burden (WB) errors for the voltage transformers are calculated based on nominal (confirmed by site measurement) burden values and test certificates errors for the voltage transformers. The standard nominal burden value for new installations is 3.75 VA upf (equates to 25% of the standard VT rated burden value of 15VA) achieved by tight tolerance (+/-5%) resistors mounted in the meter cubicle. Because the WB is very close to the VT certificate lower burden test values the WB errors will be very close to the certificate values. (Apart from a minority of cases where the VT errors provided by the manufacture is measured at 0.8 pf burden)

2.1.2 Current Transformers

The current transformers used are IEC 60044-1 accuracy class 0.2S units. The burden rating for the units being either 5 VA or 7.5 VA

The error limits for these units are: (when used within defined specification parameters)

Secondary Current (%)	1	5	20	100	120
Ratio Error (%)	0.75	0.35	0.2	0.2	0.2
Phase Error (mins)	30	15	10	10	10

Informative: These limit errors translate to energy errors of, +/- 0.2% at unity pf and +/- 0.7% at 0.5 pf for currents in the range 20% to 120%.

Working burden errors for the current transformers are calculated based on site measurement of the CT loop resistances and test certificate errors for the current transformers.

2.1.3 Combined Voltage & Current Measurement Transformers

For this type of measurement transformer there can be additional errors due to mutual influence effects between the two separate measuring parts of the combined device.

The test certificate errors do not include for the mutual influence effects (errors) because the standard tests to provide the certificate errors only include the measurands involved.

The errors resulting from this influence condition are small and are not included in this assessment but for information are available as part of the standard Type Test data provided by the manufacturer at the time of Type Registration.

2.2 Interconnecting Cabling Errors

2.2.1 Voltage Transformer lead errors.

The VT cabling between the VT terminals and the energy meter VT measurement input represent series impedance with consequent voltage drop. Both the magnitude and phase of the voltage drop need to be assessed and expressed in RE and PAE terms and added to the VT terminal errors to arrive at the total magnitude and phase errors presented to the meter.

In the standard NG MS arrangement the VT cabling is described in two sections, section 1 covering the connections between the VT marshalling box and the meter cubicle and section 2 covering the connections between the VT terminals to the marshalling box. Typically the section 2 cabled distance is short with loop resistance values ranging from about 0.2 to 0.4 ohms, section 1 cabled distance is significantly longer but uses two cores per phase leg which reduces resistance values to below 2 ohms for distances up to 500 m. Though the lead impedances will include an inductive reactance component the resistive component will dominate in the resulting errors.

The section 1 loop impedance will be high because the meter VT input impedance is high and no other burdens are connected at the meter panel. A typical meter VT measurement input burden being 0.1 VA or less (equating to about 40 kohm impedance).

The section 2 loop impedance is significantly smaller (nominal 1100 ohms) because the VT burden resistors equating to a nominal 3.75 VA are connected to section 2 via separate cores from the marshalling box to the meter cubicle.

The section 1 errors are at maximum (longest cable run of 700m) -0.007% and phase error of -0.15min.

The section 2 ratio error is the dominant lead error with a maximum value associated with a section resistance of 0.5 ohm and a nominal VT burden of 1100 ohm giving a ratio error of -0.045%. (i.e. negligible phase error).

Figure 1 below shows one phase of the overall connection arrangement.

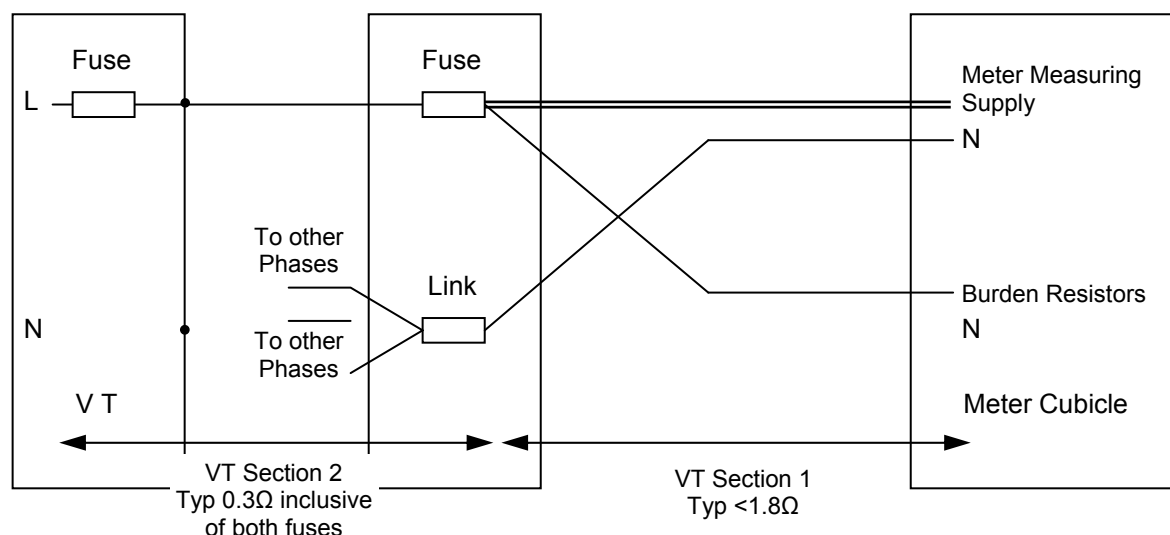


Figure 1 - One phase of VT Secondary wiring

2.3 Current Transformer lead errors.

The CT lead errors do not exist in a separate form since the lead (and meter) voltage drop causes magnitude and phase errors at the CT output. In practical terms the great majority of the burden presented to the CT results from the voltage drop on the interconnecting cabling from the CT to the meter cubicle, The typical meter CT input burden being less than 0.1 VA at 1 A.

CT loop resistances range from 1.0 to 7.5 ohms.

2.4 Energy Meter Errors

The energy meters used for COP 1 applications are required to meet BS EN 62053-22 class 0.2S for active energy and BS EN 62053-23 class 2.0 for reactive energy.

The errors limits for these specifications are also detailed in metering COP 4.

For balanced load conditions at the meter reference test conditions the limits are:

Active Energy

Current (I_n)	From 1% to <5% ,at upf	From 5% to I_{max} , at upf	From 2% to <10% , at 0.5 lag & 0.8 lead	From 10% to I_{max} , at 0.5 lag & 0.8 lead
Error	+/- 0.4%	+/- 0.2%	+/- 0.5%	+/- 0.3%

Reactive Energy

Current (I_n)	From 5% to I_{max} at zero pf	From 20% to I_{max} , at pf 0.866
Error	+/- 2%	+/- 2%