INSTRUMENT TRANSFORMERS

THE FORGOTTEN LINK IN THE ACCURACY CHAIN

By Detlef Ebel and Peter Kurth

For years, energy supply companies have aspired to precisely and fairly account for the power and energy consumed or supplied, and tried to decrease transmission and distribution losses. The proportion of meters of accuracy class 0.5S and 0.2S is growing world-wide. More and more combined meters, capable of measuring active and reactive power at an accuracy of 1%, 0.5%, or even 0.2 % are being used. Voltage (PT) and current transformers (CT) with an accuracy of 0.5S or 0.2S are also installed more frequently, while the use of a higher accuracy class meter as part of the accuracy chain has improved the overall accuracy.

During on-site error examinations, the instrument transformer – though an important factor – is regularly recorded as a constant. However the accuracy of an instrument transformer depends on several influencing factors: the burden, the respective measurement value, the condition of the coils, and environmental conditions such as climate and external magnetic fields. In error examinations the value defined as the accuracy class of the transformer, be it a voltage or current transformer, is in practice only valid in a narrow range.

PERFORMANCE OF INSTRUMENT TRANSFORMERS IN PRACTICAL APPLICATIONS

The intrinsic errors of the PTs and CTs are determined in the laboratory through tests on individual transformers. The tests are carried out in accordance with international regulations – IEC 60044-1 for current transformers and IEC 60044-2 for voltage transformers.

Using transformers that have passed the individual tests in meter installations allows one to conclude that the transformers conform to their accuracy requirements. However, it is important to ensure that the operating burden lies between 25% and 100% of the rated burden specified on the nameplate for both types of transformer. Falling below this operating burden range can lead to additional errors of approximately + 0.3% for voltage and current transformers of class 0.2 and +0.7% for transformers of class 0.5.

Modification of the installation or replacement of components, for example separate Ferraris meters for active and reactive consumption exchanged for an electronic combined meter, also influences the operating burden. Nowadays it is assumed that existing older installations are under-burdened after modification.

Over-burdening is most dangerous for CTs because they can reach saturation, and can thus be destroyed by over-heating. Another factor that influences the measurement accuracy of the transformers is damage caused by surges or faulty layout of the CTs, leading to an over-load of more than the maximum current of, say, 120%.

Figures 1 and 2 show an example where the CTs and PTs were under-burdened after modification of a measurement installation. After integrating additional burdens, the error curve shown in figure 2 was determined. The measurements were carried out at a site where the energy supplier authorised a maximum overall error of ± 0.5% with a meter of class 0.2S connected to PT and CT of class 0.2S. This figure shows that under-burdening causes considerable additional error.

VALUES INFLUENCING THE OPERATING BURDEN

The operating burden connected to the CT or PT in a measurement installation is comprised of:

- Total conductor length
- Conductor cross section
- Conductor material (copper, aluminium, rarely iron)
- Number and state of clamp points (especially problematic for aluminium)
- Type and number of measurement devices (their power consumption in the measuring circuit, condition of the connection clamps)
- Other connected devices, e.g. ammeters, measurement transducers, etc., occasionally even protection relays (which are not allowed but are still sometimes encountered).

These factors cannot be defined or calculated unambiguously. Therefore, in the following cases, an on-site verification which measures the actual operating burden must be considered:

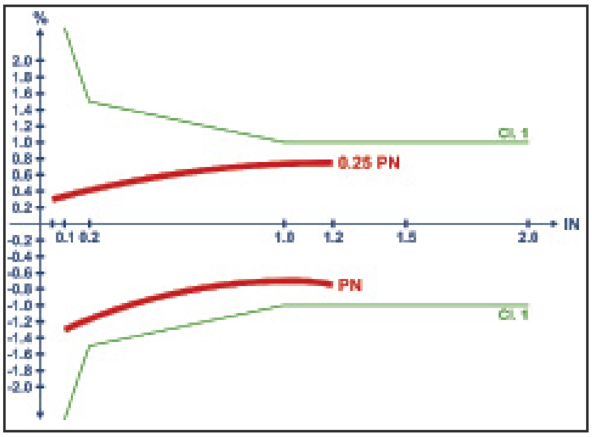


Figure 1 – Errors of under-burdened transformers

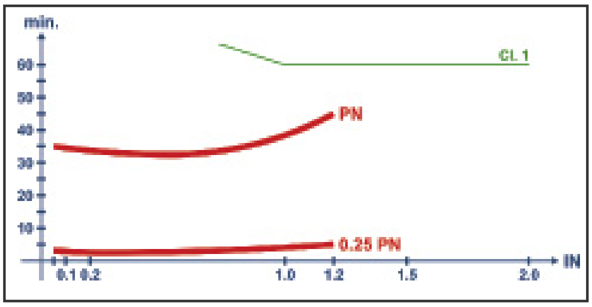


Figure 2 – Errors after increasing the burden

Test point [% of nominal voltage]	80	100	120
Burden [% of rated burden]	25 to 100	25 to 100	25 to 100
Absolute error [% of rated voltage]	± 0.2	± 0.2	± 0.2
Phase displacement [minutes]	± 10	± 10	± 10

Table 1 – Calibration points and error limits for PT Cl. 0.2

Test point [% of rated current]	5	20	100	120
Burden [% of rated burden]	25 to 100	25 to 100	25 to 100	25 to 100
Absolute error [% of rated current]	± 0.2	± 0.2	± 0.2	± 0.35
Phase displacement [minutes]	± 10	± 10	± 10	± 15

Table 2 – Calibration points and error limits for CT Cl. 0.2S

- After reinstalling the measurement installation.
- After modification of the measurement installation, because:
  - Consumer loads with different burdens were integrated
  - Consumer loads were removed
  - Wiring was changed.

Recurring tests can be carried out to detect creeping burden changes if it is suspected that the impedance of the consumer load has changed, or a clamping point has changed.

Incorrect on-site burdening influences the overall measurement accuracy of the installation. If a CT is over-burdened, the transformer reaches saturation and heats up. Measurement errors thereby become negative, and heating can damage the transformer.

If a CT is under-burdened, it can cause an increase in the positive error limit of +0.25% for a transformer of class 0.2. If a PT is over-burdened, the negative measurement error increases. If the burden is too low for a PT, it can cause an increase in the positive error limit. This produces an actual error of about +0.3% for a transformer of class 0.2; the error is thus 1½ times higher than intended.

If over- or under-burdening is detected after measurement of the operating burden, the following actions can be taken to adjust the burden:

- If the CT is over-burdened, the load impedance must be lowered. This can be achieved by:
  - verifying all clamping points
  - verifying the consumer loads
  - verifying the wiring
  - increasing the conductor cross section
  - removing possible redundant loads.
- If the CT is under-burdened, installing an additional burden will increase the load impedance.
- If a PT is over-burdened, the load impedance must be increased. To do this the consumer loads must be verified, and possibly redundant loads must be removed.
- If a PT is under-burdened, installing an additional burden will decrease the loadimpedance.

ANALYSIS OF THE TRANSFORMER TESTS AT THE INSTALLATION SITE

In theory laboratory testing and calibration should be able to establish that the measurement installation, consisting of CTs, PTs and meter, does not exceed an upper limit of a specific overall accuracy. This is, however, not always the case in practice. An example is the under-burdening of transformers. A precise determination of the overall error of a measurement installation can be carried out using a procedure whereby the test values are supplied to the CTs and PTs on the primary winding. A reference standard is connected via additional standard transformers for voltage and current, and the reference standard receives measurement pulses from the installed electronic meter via a scanning head. This allows the overall accuracy of the measurement installation, from the primary winding of the transformers to the output of the meter, to be determined.

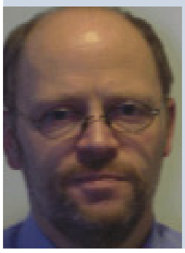
Although the procedure is elaborate, it offers virtual certainty in determining the overall accuracy of the installation. A measurement of the operating burden and the overall error of the measurement installation should be performed from the first measuring point accessible on the secondary winding of the transformers.

As a supplement for measurement devices without an integrated 'burden measurement' feature, the portable transformer tester PTT 2.1 was developed as a separate measurement device. In addition to the burden measurement for PTs and CTs, the transformer ratio and the phase displacement of the CTs can be measured. Appropriate clamp-on CTs are supplied. The PTT 2.1 even allows for measuring at medium voltage transformers, if a 'Hot Stick' is connected to the primary winding. This way, CT ratios and phase displacements can be measured at medium voltage installations of up to 40 kV.

CONCLUSION

The overall accuracy of a measurement installation consists of the errors of the current transformers, voltage transformers and the meter. To improve the accuracy, it is not sufficient to install more accurate meters. The accuracy of the transformers and the additional errors of the installation – especially the transformer burdens – must also be considered and adjusted if need be.

An additional option for increasing the overall accuracy during energy determination is to preset the ratio and phase displacement errors of the transformers in the meter (i.e. save error compensation values in the meter) and to include them using the appropriate calculation formulas in the energy measurement. Even here, it is important that the operating burden of the transformers lies within the permissible range. **MI**



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ABOUT THE COMPANIES: MTE Meter Test Equipment AG, established in 1995, is located in Zug, Switzerland. The company is active worldwide in marketing and sales for stationary and portable measuring technology for electricity meters.

www.mte.ch

EMH Energie-Messtechnik GmbH was established in 1984 and is located in Brackel, Germany. The main field of activities are R&D and manufacturing of stationary and portable measuring technology for electricity meters, CT, PT, power quality analysing systems, and monitoring systems for power transformers.

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