LANDIS & GYR

AZ 61 / E 135 a

Instructions on the Use of L & G Rotating Sub-Standard Meters
(Reference Standard)

By opening the lid of our rotating sub-standard meters, access is gained to all the controls and terminals. The clamping device, for protecting the rotor against shocks during transport, is also released at the same time.

If the sub-standard meter is constructed for more than one rated voltage or possesses several current ranges, the selector switches marked **Volt** and **Amp** * should first be set to correspond to the particulars given on the nameplate of the meter to be tested. The latter (and the phantom load) may then be connected up to the sub-standard in accordance with the diagram of connections fixed on the inside of the lid. A box spanner for the terminals is also provided in the lid.

The check on the meter under test and a determination of its errors of calibration may be carried out in one of the following ways:

a) a short-duration test by comparison between the revolutions of the sub-standard and the test meter and calculation of the error as given below;

b) a long-duration test by direct comparison of the readings of the counters of the sub-standard and the test meter.

a) **Determination of Errors** (short-duration test)

To determine the error of the test meter by the short-duration test, use is made of the special revolution counter situated at the top of the sub-standard.

The revolution counter and the rotor of the sub-standard can be engaged and disengaged by means of a friction coupling, which also prevents any jumping of the pointers at the moment of engagement and any resulting errors. The coupling may be operated either mechanically, by means of the two buttons **I** and **O** (see fig. 2), or electrically by two relays controlled from a hand switch on a remote control cable which can be plugged into a socket

* Single-element sub-standard meters have only a current range selector switch. If they are supplied for several rated voltages, additional terminals are provided for the additional voltages.

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on the sub-standard. With the plug of the electric-release cable inserted, the mechanical coupling mechanism is rendered ineffective; the buttons **O** and **I** should not be operated as this may lead to damage of the windings of the relays for electrical control.

If the revolution counter 8 is not at zero, it should first be restored to this position by turning the reset knob 2 clockwise. If necessary, the revolution counter should previously be stopped by operating the stop button **O** or the button on the side of the remote control hand switch.

The error of the meter under test can now be determined by counting a number of revolutions (the number depending on the load) and comparing them with the number of revolutions of the sub-standard. Fractions of a revolution can be read off scale 8 marked in 1/100 divisions, while scale 9 gives the units and scale 10 the tens.

If

n_1 = revolutions shown on the sub-standard

n_2 = revolutions counted on the test meter

K_1 = constant of the sub-standard } in revs. per kWh

K_2 = constant of the test meter }

the error at any load can be calculated from any one of the following equivalent formulae:

$$F = \frac{n_2 \cdot K_1 - n_1 \cdot K_2}{n_1 \cdot K_2} \cdot 100 \quad \% \qquad (1)$$

$$F = \frac{n_2 \cdot \frac{K_1}{K_2} - n_1}{n_1} \cdot 100 \quad \% \qquad (2)$$

$$F = \left(\frac{n_2 \cdot K_1}{n_1 \cdot K_2} - 1\right) \cdot 100 \quad \% \qquad (3)$$

The above calculations can be greatly simplified if the ratio of the constant of the meter under test to the observed number of revolutions is a round number k. The number of revolutions of the sub-standard during the same time should then be

$$n'_1 = \frac{K_1}{k} \qquad (4)$$

if the sub-standard and test meter are measuring the same amount of energy with the same accuracy of measurement.

If the actual number of revolutions n_1 is not equal to this value, i.e. if

$$n'_1 \lessgtr n_1 \qquad (5)$$

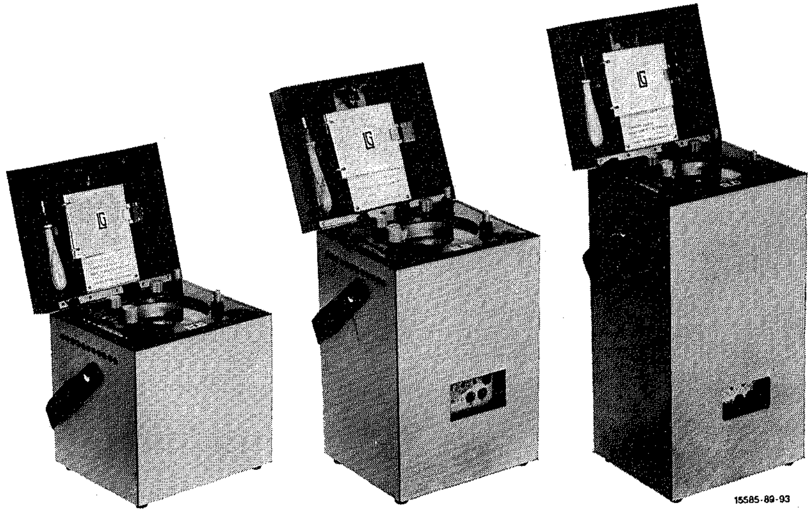

Fig. 1
Sub-Standard Meters with one, two and three driving elements

then the error of the meter under test is given by

$$F = \frac{n'_1 - n_1}{n_1} \cdot 100 \quad \% \qquad (6)$$

Correction for the Errors of the Sub-Standard

As the errors of the sub-standard are very small, especially if it is of our high-precision type, the errors as calculated above can be regarded as the errors of the meter under test. If measurements of the highest order of accuracy are required, then the errors of the sub-standard itself must be taken into consideration. The number of revolutions n_1 read off the revolution counter of the sub-standard must be corrected for its own error.

For this purpose, the error at the given load can be taken from the test certificate supplied with each sub-standard; intermediate values can be determined with sufficient accuracy by interpolation.

The corrected number of revolutions is given by the equation

$$n_c = \frac{100}{100 \pm F_1} \cdot n_1 \qquad (7)$$

where

n_c = the revolutions of the sub-standard after allowing for its own error;

F_1 = error of the sub-standard as obtained from the test certificate.
(For positive errors the sign is + and vice versa.)

In the formulae (1) to (3) this corrected value n_c is to be used in place of n_1. We then have the following:

Formulae including Errors of the Sub-Standard

$$F = \frac{n_2 \cdot K_1 - n_c \cdot K_2}{n_c \cdot K_2} \cdot 100 \quad \% \qquad (8)$$

$$F = \frac{n_2 \cdot \frac{K_1}{K_2} - n_c}{n_c} \cdot 100 \quad \% \qquad (9)$$

$$F = \left(\frac{n_2 \cdot K_1}{n_c \cdot K_2} - 1\right) \cdot 100 \quad \% \qquad (10)$$

Note

Equation (7) gives a mathematically accurate correction. It has the advantage of being exact but the disadvantage that the evaluation of many measurements as required to determine an error curve, involves appreciably more calculation.

In the majority of cases, it is usually sufficient to add algebraically the separate errors of the sub-standard (taken from its test certificate) and the meter under test.

Example 1

Assume it is required to check the accuracy of a 3-phase 3-wire meter with the following characteristics:

Rated voltage	3 × 380 V
Frequency	50 cycles
Rated current	5 A
Meter constant	540 revs./kWh

The 380 V range on the sub-standard meter is first selected and one of the current ranges, 1, 5 or 10 A, according to the load current. The corresponding constants of the sub-standard are thus 2500, 500 and 250 respectively.

The various quantities to be observed and measured are given in the following table, where the figures for the errors given in the last column have been obtained using one of the formulae already given.

Table of Errors

Current in % of rated value	cos φ	No. of revs. on test meter	Current range of sub-standard A	No. of revs. of sub-standard	Error of test meter in % (equ. 1, 2 or 3)
200	1	80	10	37.75	− 1.89
200	0.5	40	10	18.80	− 1.52
100	1	40	5	36.74	+ 0.84
100	0.5	20	5	18.35	+ 0.93
50	1	20	5	18.52	0.0
50	0.5	10	5	9.11	+ 1.64
20	1	8	1	37.04	0.0
20	0.5	4	1	18.33	+ 1.04
10	1	4	1	18.33	+ 1.0
10	0.5	2	1	9.08	+ 2.08
5	1	2	1	9.08	+ 2.08

Example 2

A 3-phase 4-wire meter is to be tested for accuracy, for which the ratings are as follows:

Rated voltage	3 × 380/220 V
Rated current	5 A
Frequency	50 cycles
Meter constant K_2	600 revs./kWh

On the sub-standard meter the voltage range 3 × 220 is selected and one of the current ranges, 10, 5 or 1 A according to the load. The corresponding constants of the sub-standard are assumed to be 120, 240 and 1200. At twice the rated current and cos φ = 1, and on the assumption that k = 10, we have

$$n'_1 = \frac{K_1}{k} = \frac{120}{10} = 12$$

The number of revolutions to be observed on the test meter is 60, as given by $\frac{K_2}{k}$. If the sub-standard makes 12.16 revolutions in this time instead of 12, the error is

$$F = \frac{12 - 12.16}{12.16} \cdot 100 = -1.32\,\% \qquad \text{(a)}$$

For the smallest load range we select k = 200; as K_1 is now 1200, we obtain

$$n'_1 = \frac{K_1}{k} = \frac{1200}{200} = 6$$

while $\frac{600}{200} = 3$ revolutions are to be observed on the test meter.

If the sub-standard now makes only 5.92 revolutions, the error here amounts to

$$F = \frac{6 - 5.92}{5.92} \cdot 100 = +1.35\,\% \qquad \text{(b)}$$

All the results obtained in this way may either be given in tabular form (as in example 1) or the error curve may be plotted.

The intrinsic error of the sub-standard itself may also be taken into consideration if the highest accuracy is desired. If this error amounts to +0.2 % for (a), then for the correct number of revolutions we have

$$n_c = \frac{100}{100 + 0.2} \cdot 12.16 = 12.135$$

Substituting this value in (a), we obtain for the true error

$$F = \frac{12 - 12.135}{12.135} \cdot 100 = +1.11\,\%$$

Assuming the error of the sub-standard to be −0.3 % in (b), then

$$n_c = \frac{100}{100 - 0.3} \cdot 5.92 = 5.938$$

and

$$F = \frac{6 - 5.938}{5.938} \cdot 100 = +1.044\,\%$$

b) Long-duration Test

For determining the errors of the meter during long-duration tests, two and three-element* rotating sub-standard meters are provided with an ordinary kWh register, which permits a direct comparison of the readings of the two meters. The rotating sub-standard meter is also provided with a knob 1 for preventing the rotor from being blocked when the lid is closed. This is necessary as the latter has to be closed and locked during long-duration tests to prevent unauthorised persons from having access to the controls and thus interfering with the measurement.

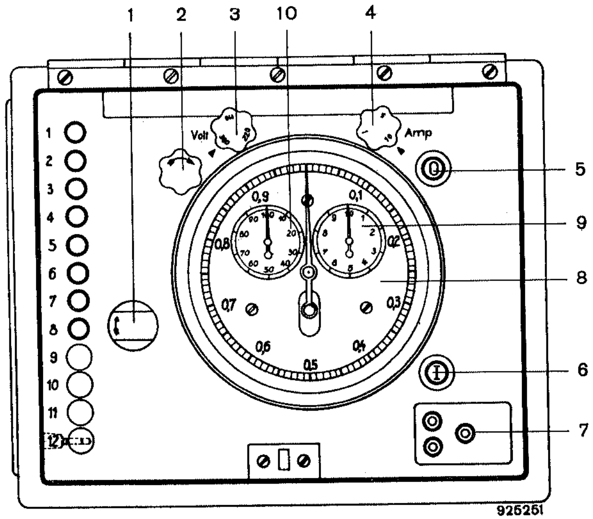

Fig. 2
Controls and Terminals of LG Rotating Sub-Standard Meters with Electrical Release of Test Dial

1 Knob for releasing the clamp on the rotor during long-duration tests
2 Knob for resetting the test dial
3 Rated voltage selector switch
4 Current range selector switch
5 Push button for mechanical release of test dial
6 Push button for mechanical coupling of test dial
7 Socket for control cable
8 Dial reading to 1/100 revolution
9 Dial for units
10 Dial for tens of revolutions

* Single-element sub-standard meters are provided with a kWh register on special request only. This should be specified when ordering.

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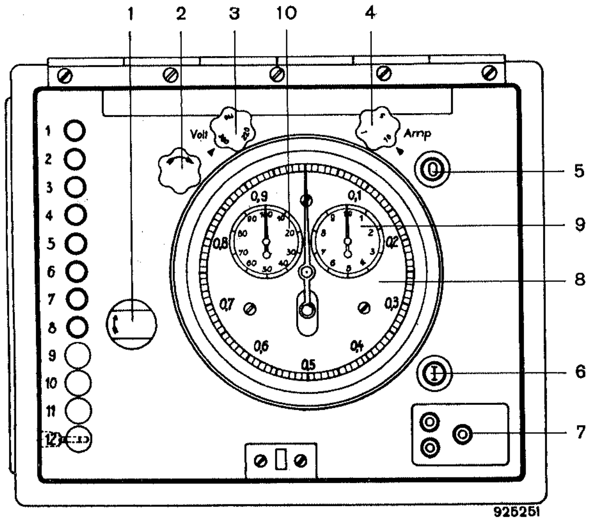

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The method of procedure for long-duration tests is as follows:

First the meter under test is connected up in accordance with the diagram of connections on the inside of the lid of the sub-standard meter; then the correct current range of the latter is selected. Knob 1, which primarily ensures that the rotor is blocked when the lid is closed, is rotated clockwise a quarter of a turn. As soon as the stop is felt, the knob can be released in this position, where it then remains. The lid can be closed but the rotor of the sub-standard still remains free, thus permitting measurements of the energy consumed in the network. The readings of the sub-standard and the test meter are then noted carefully and the test is allowed to proceed without further attention. At the end of the period of test – several days in certain cases – the readings of both meters are again taken and the two differences in their readings determined. The true energy consumption is obtained by multiplying the difference on the sub-standard by the constant for the particular range in use. If the meter under test is free from all defects, it shoud indicate the same energy consumption as that obtained from readings of the sub-standard. The average error of the meter under test can be calculated; while this gives no indication as to the shape of the error curve, it does indicate if the test meter may be left on site or if it has to be removed for overhaul and recalibration.

If

A_1 = energy measured by the sub-standard and
A_2 = energy measured by the meter under test the average error in per cent is given by

$$F' = \frac{A_2 - A_1}{A_1} \cdot 100 \qquad \%$$

If the average error determined in this way exceeds ± 2 %, the meter under test usually needs overhauling.

Measurement of Power using Sub-Standard Meters

Rotating sub-standard meters, with their inherent high accuracy, are also well suited for use in acceptance tests on electrical apparatus, for determining load, efficiency, etc. The sub-standard meter is connected up as an ordinary meter, for example, on the input side of a motor or on the output side of an alternator. If the mechanical input or output is measured separately, the efficiency can be obtained directly.

A stop watch is used to determine accurately the time t in seconds in which the sub-standard makes n_1 revolutions. The average power during the time t is then given by

$$P_{el} = \frac{n_1 \cdot 3600 \cdot 1000}{t \cdot K} \quad \text{watts}$$

$$P_{el} = \frac{n_1 \cdot 3600}{t \cdot K} \quad \text{kW}$$

If the mechanical power is also expressed in watts or kW, the efficiency is

a) **Motor**

$$\eta = \frac{P_{mech}}{P_{el}} \cdot 100 \quad \%$$

b) **Generator**

$$\eta = \frac{P_{el}}{P_{mech}} \cdot 100 \quad \%$$

If P_{mech} is measured in H.P. and P_{el} in kW, the following relationships hold:

a) **Motor**

$$\eta = \frac{0.736 \cdot P_{mech}}{P_{el}} \cdot 100 \quad \%$$

b) **Generator**

$$\eta = \frac{P_{el}}{0.736 \cdot P_{mech}} \cdot 100 \quad \%$$

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