LOVAG

GENERAL INSTRUCTION G2

MEASUREMENT UNCERTAINTY

This instruction of a general nature and does not relate to specific standards.

It provides additional information ensuring a suitable degree of repeatability of the tests between the different test stations.

This Instruction covers the requirement for measurements made during the testing of all electrical equipment within the scope of LOVAG.

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Third Edition
August 2008

1. INTRODUCTION

The purpose of this document is to give guidance in the application of the measurement uncertainty in the LOVAG scheme. This instruction amends the more general provisions of IEC Guide 115:2007 ad take into account the requirements of ISO/IEC 17025 and of the GUM (Guide to the Expression of Uncertainty in Measurement, ISBN: 92-67-10188-9)

These Instructions have also been prepared to assist both in the unification of measurement techniques and to ensure that measurement accuracies are within such limits prescribed in IEC Standards/Publications and European Norms.

Different devices and techniques may be employed for the determination of the various quantities. However, it is a requirement of these instructions that the total system uncertainty of measurement does not exceed that specified in section 4 within the frequency range stated in clause 4 for those quantities that determine ratings. Where instrument class accuracy or a value for the measurement uncertainty is specified in a relevant Product Standard then this shall be used. However, the overall uncertainty of measurement stated in the table of section 4 shall still apply.

2. MEASUREMENT SYSTEMS

The measurement of a test quantity is effected through a measuring system. This is made up from a chain of elements which in its simplest form may be represented as shown in Figure 1. The elements may not always be separable or in the same order.

The overall accuracy of the system depends on the response and fidelity of each of the elements. Care should be taken that one element does not affect the response of another to such an extent that the accuracy of the overall system falls outside the prescribed tolerances. Calibration procedures must be adopted to determine the sensitivity and also its uncertainty with reference to standard calibration procedures, either of the overall system or of the elements.

For the policy regarding application of uncertainty see section 6.

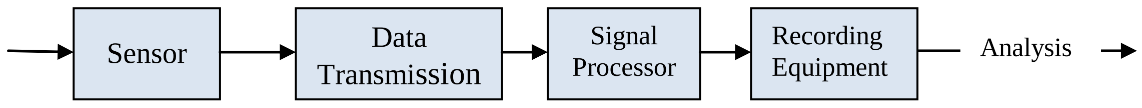


Figure 1: A Simplified Measurement System

3. EVALUATION OF MEASUREMENT UNCERTAINTIES

The evaluation of measurement uncertainty has to be done as required by ISO/IEC 17025:2005, 5.4.6.2 and 5.10.3.1 item c. . For the application with LOVAG only procedure 1 of IEC Guide 1145:2007 has to be used. Therefore the uncertainty of a measurement has to be calculated and the result has to be compared with the uncertainty band to a defined acceptable limit. Unless otherwise specified, evaluation of measurement uncertainties is made for a probability of 95%.

4. TOTAL MEASUREMENT SYSTEM UNCERTAINTY

The maximum values of total measurement system uncertainty for quantities that determine ratings and/or characteristics of the equipment under test are given in the Table below:

Table 1: - Measurement of Quantities .

Quantity	Total System Uncertainty	Notes
Voltage (e.g. applied, recovery, peak, arc, TRV, switching, and auxiliary…)		
	± 2 millivolt up to 150 millivolts	
	± 1.5% above 150 millivolts and up to 100 volts	
	± 3% above 100 volts and up to 10kV	7,8
Current (e.g. making, breaking, short-time, cut-off, …)		
	± 1.5% up to and including 5A	1
	± 2.5% above 5A	
Power	± 20 milliwatts up to 1 watt	2 & 3
	± 3.0% above 1 watt and up to 3kW	
	± 5% above 3kW watts	

Joule Integral	(e.g. pre-arc and total let-through energy…) ± 15%	
Power Factor	± 0.05	
Frequency	± 0.2% up to 10 kHz	
Resistance	± 5% up to 100 mΩ and above 1 MΩ	4
	± 1% for all other cases except where stated in the note.	
Temperature	± 2.0°C up to 100°C	5
	± 2.0% above 100°C to 500°C	
	± 3.0% above 500°C except for measurements related to relative humidity	
Time (e.g. making, opening, arcing, short-circuit duration, time constant, joule integral…)	± 5% from 10ms to 200ms	
	± 10ms above 200ms to 1 second	
	± 1.0% above 1 second	
Linear Dimensions	± 0.05mm up to 25mm	
	± 0.25% above 25mm	
Mass	± 1.0% above 10g and up to 100g	
	± 2.0% above 100g	
Force	± 2% for all values	
Mechanical Energy	± 10% for all values	
Torque	± 10%	
Angles	± 1 degree	
Relative Humidity	± 5% RH (over the range 30% to	

	95% RH) This implies temperature uncertainty measurements within ± 0.1°C	
Barometric Air Pressure	± 0.01 MPa	
Gas & Fluid Pressure	± 5% for static measurement	6

Notes

1) For temperature rise tests using ac, true rms reading instrumentation shall be used unless the ac waveform is free of significant harmonics.

2) Where measurements of the order of 5 milliwatts to 1 watt are required, it is recommended that instruments of accuracy class 0.3 or better, be used. Moving iron instruments are deemed to indicate true RMS value when the waveform contains moderate harmonics (THD < 20%)

3) True rms indicating instruments shall be used for power loss/acceptance measurements made on ac, care being taken to avoid errors due to interaction between measurement leads.

4) The measurement of resistance falls into two categories dependent on the function performed by the instrumentation i.e.

    a) General Resistance Measurements for which no specified stressing voltage is required, but it may be necessary to make them at a specified current.

    b) Insulation Resistance Measurement for which a specified stressing voltage is applied.

    The level of acceptable measurement accuracy is not compatible between these two categories largely due to the availability of suitable instrumentation which has been historically accepted. The levels of accuracy for the two categories of resistance measurement are set out below.

    Note: Where resistance measurements are made using separate instruments (voltmeter and ammeter) the levels of uncertainty are applicable to the computed value of resistance and not to the individual instruments.

<u>General Resistance Measurements</u>

Unless otherwise specified in the relevant Standard, the measurement of cold resistance of fuse-links and MCCB's shall be made at a current not exceeding 10% of the normal current rating of the apparatus unless otherwise stated in the standard.

<u>Insulation Resistance Measurements</u>

As the scaling used on the instruments normally used for the purpose of the measurement of insulation resistance is essentially non-linear and often follows a square law, no generalised measurement accuracy can be applied. However, for the purposes of this instruction it is sufficient that any marked points on the instrument scale are within + 10% of the marked value when checked against a standard resistor of that value.

If the stressing voltage is generated within the instrument, the terminal voltage shall not be less than the specified value under open circuit conditions and no less than 80% of this value when loaded with a 1 MΩ resistor. The effect of the voltage measuring device input impedance should be taken into account in the load.

5) Where the uncertainty applies to the temperature ascertained by thermocouple and associated indicating instrument, care should be exercised as the major inaccuracy occurs in the thermocouple wire (see IEC 60584-1: 1995, IEC 60584-2: 1989 and IEC 60584-3: 2007). For certain temperature measurements it is preferred that laboratories use materials that comply with class 1 of IEC 60584-2: 1989.

   For the temperature rise test the measurement uncertainty of the ambient temperature and of the object under test temperature must be individually within the limits of the Table 1.

6) The overall uncertainty of measurement of pressure by means of gauges shall not exceed + 5% of the instrument full scale. The actual measurement shall be taken between 10% and 90% of the maximum scale value.

7) Application of the test voltage. (Power frequency voltage test). The test apparatus shall produce a practical sinusoidal waveform, (THD < 3 %) and at a frequency between 45 Hz and 62Hz.

   The characteristics of the test voltage shall be such that, when the value of the test voltage is adjusted to the required value and then shortcircuited, the output shall not be less than 0.2A. The overcurrent protection of the test apparatus shall not trip below 0.1A.

8.) For impulse-voltages IEC 61180-1 and IEC 61180-2 apply

5. FREQUENCY RESPONSE REQUIREMENTS

The measurement uncertainty of the overall system should not deviate by more than the values in the table above over the frequency ranges prescribed for the following quantities to be measured. These values are mandatory for parameters that determine ratings in the relevant Standard.

The lower frequency limit for each of the ranges prescribed below is appropriate for tests at rated frequencies of 25Hz and above. For tests at lower rated frequencies and with direct current, the lower frequency limit shall be reduced to zero Hz.

QUANTITIES	FREQUENCY RANGE	NOTES
VOLTAGE		
Applied Voltage	rated frequency + 20%	
Recovery Voltage (allowing for dc neutral shift and rapid recovery)	20 Hz to 200 Hz	
Switchgear Voltage:		
Supply side voltage	20 Hz to 20 kHz	
Prospective Transient Recovery Voltage:		
Tuned load side circuit	fn + 5%	

Note: Reference should be made to the appropriate standard for the definition of fn

Fuse Arc/Switching Voltage	20 Hz to 20 kHz	1

CURRENT & JOULE INTEGRAL

Short-Circuit & Load Breaking Current	20 Hz to 200 Hz	
Injection Current for Prospective TRV	20 Hz to 50 kHz	
Peak, Making & Asymm Breaking Current	5 Hz to 200 Hz	
Out-of-Phase Current	20 Hz to 200 Hz	
Charging Current	20 Hz to 500 Hz	
Small inductive Current	20 Hz to 500 Hz	

CURRENT DURATION OF LESS THAN 1 CYCLE AT RATED FREQUENCY:

Circuit breakers, current limiting	20 Hz to 500 Hz	
Fuses, non current limiting	20 Hz to 500 Hz	
Fuses, cut-off current		
Prospective/fuse rated current ratio $\leq$ 100	20 Hz to 500 Hz	
Prospective/fuse rated ratio > 100	20 Hz to 5 kHz	2 & 3

STEADY STATE CURRENT e.g. temperature rise overload release characteristics, time current characteristics etc. rated frequency + 20%

AUXILIARY QUANTITIES:

Closing, Opening or Release Current	zero to 200 Hz
Travel	zero to 200 Hz

NOTES:

1) This upper limit may be ignored for overload tests on fuse-links. It is recognised for certain dc tests made on fuse links at Test Duty 2 (I_2) conditions, difficulties arise in achieving the upper frequency limit due to the duration of the arcing time. In these cases, the best achievable upper limit of frequency shall be utilised.

2) Where the ratio of prospective current to normal rated current of the fuse exceeds a value of 5000, the uncertainty of measurement given in Table 1 of section 4 for this quantity cannot be guaranteed within the range of frequency stated.

3) The methods for demonstrating compliance with this requirement are under consideration. However, provisions should be made to achieve the best possible performance using the present state of the art until such time as a unified method of demonstrating compliance is available.

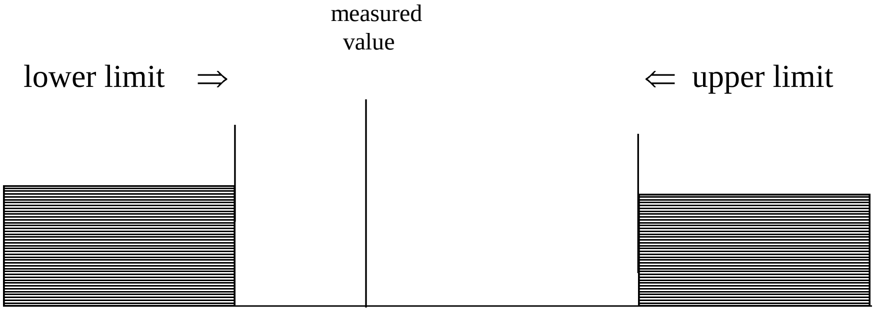
6. COMPLIANCE REQUIREMENTS

The policy of LOVAG is that unless otherwise specified in the relevant Product Standard it will operate on the basis of the measured value being within the test tolerance specified, provided that the uncertainty of measurement that determine ratings is demonstrated to be within the limits identified in section 4 of this LOVAG instruction. The measurement complies with the requirement if the probability is being within the limit is at least 50% (Figure1 of IEC Guide 115:2007)

So as to clarify this position, several conditions are shown below explaining compliance or non-compliance with the requirements of the Standard, the notes giving an explanation of the cases shown.

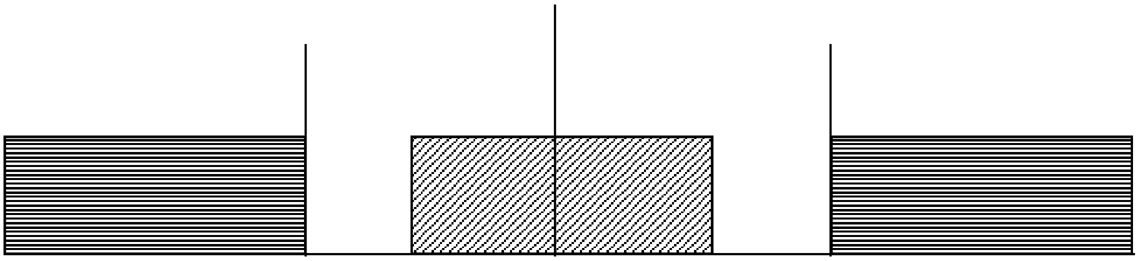
a) Indeterminate

Uncertainty is not expressed. Compliance with limits cannot be determined.



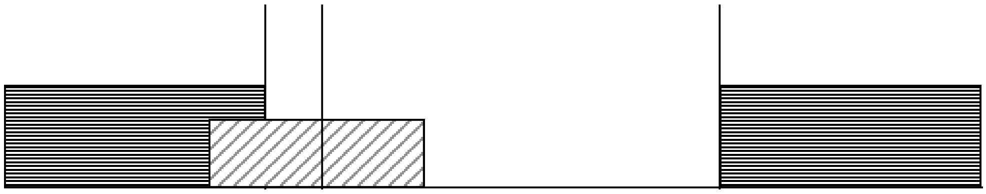
b) <u>Compliance</u>

The measured value together with its uncertainty gives assurance of compliance.



c) <u>Conditioned Compliance</u>

This is accepted in practice provided the measured value does not exceed the tolerance limit.



d) <u>Non-Compliance</u>

Measured value outside the compliance limits of the Standard and uncertainty not expressed.

e) <u>Non-Compliance</u>

Measured value outside the compliance limit of the Standard even though the band of uncertainty indicates that the true value could be within the compliance limits.

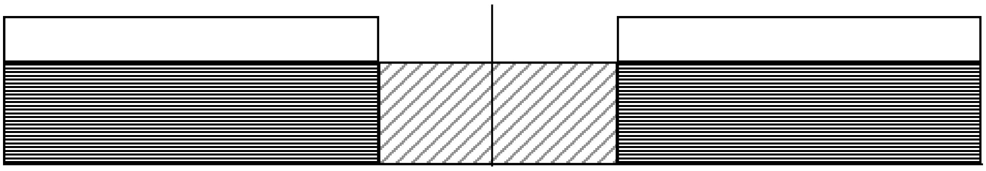
f) Non-Compliance

Measured value together with its uncertainty outside the compliance limit of the Standard.

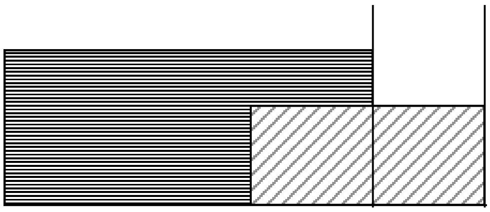
g) Conditional Compliance

This is accepted in practice, provided the measured value does not exceed the tolerance limits and the limit of the measurement uncertainty is not exceeded.

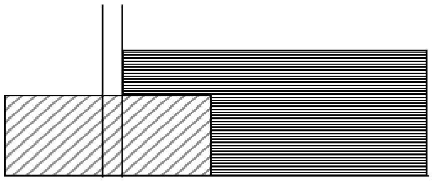
Where no test tolerance is specified in the Standards, the requirement is considered to have been met if the measured value excluding the uncertainty range, as evaluated is not less severe than that specified in the Standards. As an example, figures h and i, demonstrate this principle for current and powerfactor measurements respectively.



h) Compliance-example for current



i) Compliance - example for power factor



7. REPORTING-FORM OF PRESENTATION

A measured value is expressed by the means of a number and a unit prefixed by p-, n-, µ-, m-, k-, M-, G-, T- etc. The value number should be in the range 1.00 to 999.

The measured values are to be presented in the report rounded to three digits.

e.g	Measured		Reported
	1.00 A	=	1.00 A
	50024 V	=	50.0 kV
	0.007115 ohm	=	7.12 mohm

With the above given number of digits, the contribution to the total uncertainty for the reported value due to the form of presentation will be $\leq \pm$ 0.5%. It may be necessary to report to four digits for certain measurements where the uncertainty limits demand a low contribution due to the form of presentation.