Association of Designated Laboratories and Notified Bodies

Guidance Notes on: **Measurement Uncertainty**

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1. Introduction

This document specifies the method for dealing with measurement uncertainty in relation to Common Technical Regulations (CTRs). The method applies to all CTRs. Exceptionally, where the method is not suitable for a particular CTR or a requirement in a CTR then, subject to agreement by ACTE, a justified alternative shall be defined and used in that CTR alone.

The method is based on the ISO/TAG 4 : January 1993 *"Guide to the Expression of Uncertainty in Measurement"* and ETSI Technical Report ETR028, March 1992, "*Uncertainties in the measurement of mobile radio equipment characteristics.*" The guide and report may be consulted for detailed background to and explanation of the method.

Where measurement parameters applicable to CTRs are identified which are not included in this document, they should be offered for specification of uncertainty in this document rather than in an individual CTR, unless it is clear that the parameter in question has no applicability outside the context of that particular CTR. This will preserve the value of this document as a common reference for all involved in the production of CTRs.

2. Definitions

The following definitions apply in addition to those of the ISO Guide.

2.1 The measured value is the indicated reading of the measurement system without adjustment for uncertainty of measurement.

2.2 The limit is the value or values in a CTR which define the range of acceptable measured values for a measurement.

2.3 A control quantity is an influence quantity whose magnitude is specified as a reference condition for the test. (**Note:** control quantities include, for example, ambient conditions and input conditions to the EUT specified in the relevant CTR.)

3. The Basic Principles

3.1 Except as provided for below, the expanded uncertainty shall not exceed the values specified in Tables A.1-A.4. The expanded uncertainty figures are based on a k factor of 2 and aim to achieve a confidence level of 95%. The Tables apply to the combined effects of all sources of uncertainty, typically those identified in ETR028. It is for individual laboratories to determine how individual uncertainties are apportioned and combined in their own measurement systems.

Measurement systems having known expanded uncertainties greater than those specified in Table A.1-A.4 are permitted provided adjustment is made to the measured value as follows. The adjustment is made by subtracting the modulus of the relevant expanded uncertainty in Tables A.1-A.4 from the known expanded uncertainty of the measurement. The measured value is then increased or decreased by the result of the subtraction, whichever is the most unfavourable in relation to the limit.

See Figure 2.

3.2 The measured value or adjusted measured value compared to the limit shall be used to determine whether terminal equipment meets the requirements of the relevant CTR.

See Figures 1 and 3.

3.3 Unless otherwise specified in the relevant CTR, the limit shall be inclusive of the value or values which mark the extremes of the limit.

3.4 Control quantities are to be set and maintained such that their contributions to the expanded uncertainty of the measured value do not cause that expanded uncertainty to exceed the relevant value specified in Tables A.1-A.4. Where a control quantity is defined in terms of a range rather than a nominal value then the range shall itself be taken into account in the estimate of the standard uncertainty of the control quantity in question.

3.5 Test reports must contain a statement that expanded measurement uncertainty values are in accordance with this document. The expanded measurement uncertainty value for the measurement of each parameter may also be included in the test report at the discretion of the laboratory provided the expanded uncertainty of measurement does not exceed the values specified in Tables A.1-A.4.

The expanded measurement uncertainty value for the measurement of a parameter must be included in the test report if the expanded uncertainty of measurement exceeds that shown in Tables A.1-A.4 and the limit lies within the expanded uncertainty of measurement.

4. General Conditions for Tests

The following general conditions apply to all tests unless the operating limits for the terminal equipment under test or the test equipment are more restrictive.

4.1 All tests shall be performed at
- an ambient temperature in the range 15°C to 35°C;
- a relative humidity in the range 25% to 75%;
- an air pressure in range 86 kPa to 106 kPa.

4.2 For terminal equipment that is directly powered from the mains supply all tests shall be carried out within ± 5% of the normal operating voltage.

If terminal equipment is powered by other means and those means are not supplied as part of the terminal equipment, eg batteries, stabilized a.c. supplies, d.c., etc all tests shall be carried out within the power supply limit declared by the supplier.

If the power supply is a.c. the tests shall be conducted within ± 4% of the stated frequency as declared by the supplier.

Table A.1 Electrical Quantities

Measurand	Expanded Uncertainty
dc	
Voltage below 0.01 V	± 0.1 mV
Voltage 0.01 - 1000 V	± 1.0%
Voltage above 1000 V	± 2.5%
Current below 1mA	± 1.0% ± 10 μA
Current 1 mA - 2 A	± 1.0%
Current 2 - 20 A	± 1.5%
ac RMS and ac + dc RMS 40 Hz - 1000 Hz*	
Voltage below 0.01V	± 1 mV
Voltage 0.01 - 1000 V	± 1.5%
Voltage above 1000 V	± 5%
Current below 2A	± 1.5%
Current 2 - 20 A	± 2.5%
Power up to 1 W 40 Hz - 60 Hz	± 5 mW
Power above 1 W and up to 3 kW 40 - 60 Hz	± 2.5%
Resistance	
General Circuit - 100 mΩ - 10 MΩ	± 1%**
- Below 100 mΩ and above 10 MΩ	± 5%
Earth Continuity (at a test current stated in the standard)	± 10%
Insulation (up to 10 MΩ at a nominal 500V dc)	± 10%
Capacitance determined from rise time	± 15%
Capacitance 100 pF - 10 μF at 1kHz	± 1.5% ± 10 pF
Inductance 100 μH - 10 H at 1 kHz	± 1.5% ± 10 μH

* *Where it is necessary to make an (RMS) measurement on waveforms that are substantially non-sinusoidal, the meter shall be Root Mean Square (RMS) sensing with a minimum full scale crest factor capability of 3 for voltage and 2 for current, unless otherwise stated in the type-test standard. If the crest factor of the waveform exceeds the meter's capabilities, then either an oscilloscope shall be used, in which case the permissible limit is ± 5% or a thermal sensing instrument may be used.*

Waveforms which visually appear non-sinusoidal on an oscilloscope trace should be measured using a true RMS meter.

** *Where an ohmmeter is used to determine temperature rise by change of resistance method, then the permissible value of* U_t *= ± 0.5%; it is recommended that 4-wire measurement be used below 500Ω.*

Table A.2 Radio Frequency Measurements

Measurand	Expanded Uncertainty
RF Frequency above 1MHz	± 1 part in 10^{-7}
RF Power (valid to 100 W)	± 0.75 dB
Maximum Frequency Deviation	
- within 300 Hz and 6 kHz of audio frequency	± 5%
- within 6 kHz and 25 kHz of audio frequency	± 3 dB
Deviation Limitation	± 5%
Audio Frequency Response of Transmitters	± 0.5 dB
Adjacent Channel Power	± 3 dB
Conducted Emissions of Transmitters	± 4 dB
Transmitter Distortion	± 2%
Transmitter Residual Modulation	± 2 dB
Audio Output Power (electrically measured)	± 0.5 dB
Audio Frequency Response of Receivers	± 1 dB
Amplitude Characteristics of Receiver Limiter	± 1.5 dB
Hum and Noise	± 2 dB
Receiver Distortion	± 2%
Sensitivity for 20 dB SINAD	± 3 dB
Conducted Emissions of Receivers	± 4 dB
Two-Signal Measurements (stop band)	± 4 dB
Three-Signal Measurements	± 3 dB
Radiated Emissions of Transmitters	± 6 dB
Radiated Emissions of Receivers	± 6 dB
Transmitter Attack and Release Time	± 4 ms
Transmitter Transient Frequency	± 250 Hz
Transmitter Intermodulation	± 5 dB
Receiver Desensitization (Duplex op.)	± 0.5 dB

Table A.3 Audio Frequency Measurements

The Table below is provided for guidance only. The values it contains have been extracted from ETS 300 085 : 1990. Further study is required in the context of the uncertainty principles developed in the ISO Guide, ETR028 and this document.

Measurand	Expanded Uncertainty
AF Frequency 100 Hz to 8000 Hz	± 2% *
Sound pressure	± 0.7 dB
Audio signal power levels ≥ -50dBm	± 0.2 dB
Audio signal power levels ≤ -50 dBm	± 0.4 dB
Signal Delay (ms)	± 5%

* The specification of compliance tests requiring measurement at sub-multiples of the sampling frequency should be avoided.

Table A.4 Non-Electrical Quantities

Measurand	Expanded Uncertainty
Mass	± 2%
Air Pressure	± 0.5kPa
Relative Humidity, 30 - 95%	± 5%
Force	± 2%
Torque	± 10%
Angle, functional dimension of a gauge, up to 16° Angle, functional dimension of a gauge, above 16° Angle, metered, 0-45°	± 1.5% ± 15'* ± 1°
Linear Dimensions up to 25 mm Linear Dimensions above 25 mm	± 0.1 mm ± 0.4%
Temperature below 50°C Temperature 50°C to 200°C Temperature above 200°C	± 2°C ± 5°C ± 2½%
Rise Time of Waveform Time and Time interval up to 5 secs. Time and Time interval above 5 secs.	± 15% ± 0.2% ** ± 1% **

* *This figure aligns with a current proposal within IEC TC74 to modify tolerances on the test finger.*

** *These limits do not apply to timing elements implemented in protocol layers. This is a topic for further study.*

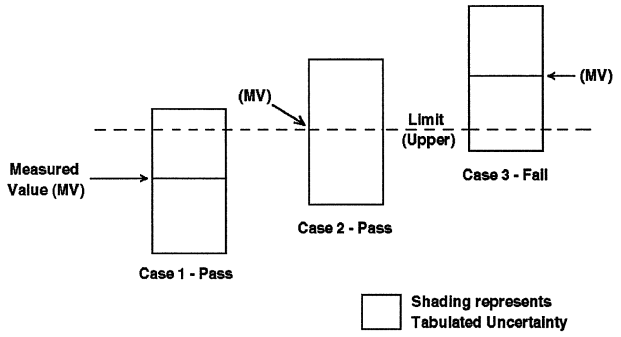

Figure 1: Uncertainty of measurement better than or equal to Table A.1-A.4

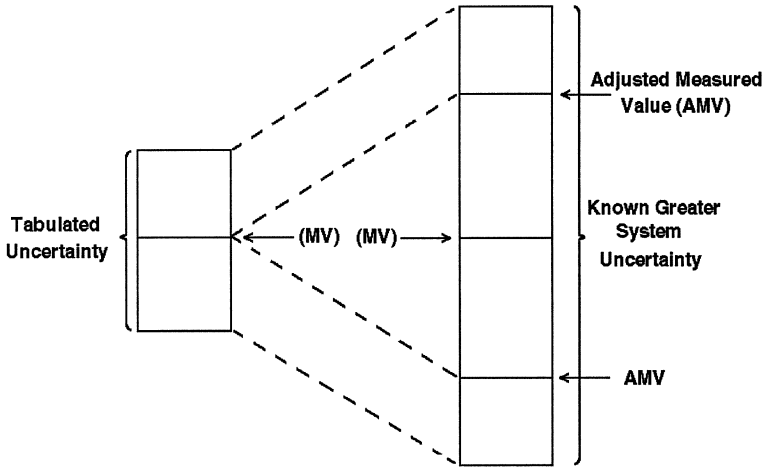

Figure 2: Determination of Adjusted Measured Value

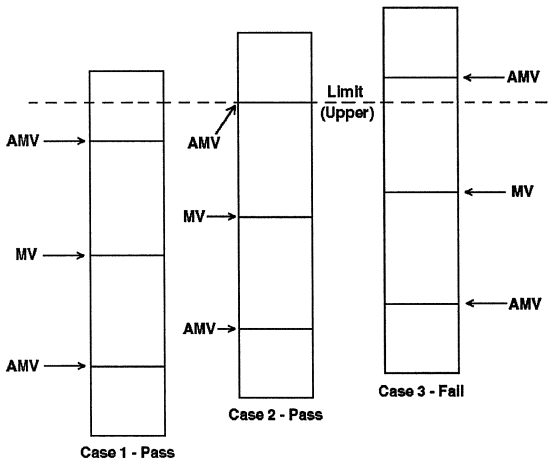

Figure 3: Known uncertainty of measurement greater than Table A.1-A.4

References

1. ISO/TAG 4/WG 3 : January 1993; Guide to the Expression of Uncertainty in Measurement .

2. ETSI Technical Report, ETR028, March 1992, Radio Equipment and Systems (RES); Uncertainties in the measurement of mobile radio equipment characteristics.

3. NAMAS Executive, NIS20, February 1989, Uncertainties of Measurement for NAMAS electrical testing laboratories.