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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Instruments and software used for measurements in high-voltage and high-current tests –
Part 1: Requirements for instruments for impulse tests

Appareils et logiciels utilisés pour les mesurages pendant les essais à tension et courant élevés –
Partie 1: Exigences pour les appareils utilisés pour les essais de choc

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INSTRUMENTS AND SOFTWARE USED FOR MEASUREMENTS IN HIGH-VOLTAGE AND HIGH-CURRENT TESTS –

Part 1: Requirements for instruments for impulse tests

FOREWORD

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International Standard IEC 61083-1 has been prepared by IEC technical committee 42: High-voltage and high-current test techniques.

This third edition cancels and replaces the second edition published in 2001. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Requirements for static integral non-linearity and static differential non-linearity have been removed.
b) Requirement for impulse scale factor non-linearity has been added.
c) Uncertainty requirements for impulse calibrators have been revised.
d) Requirements for peak voltmeter have been revised.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
42/386/FDIS	42/388/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 61083, under the general title *Instruments and software used for measurements in high-voltage and high-current tests*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The electric power industry requires standardized tools to provide confidence in high-voltage and high-current testing results, and to prove equivalence between tests performed in different test facilities.

Analogue capture of test data has today been largely replaced by digital capture with recording instruments based on sampling technology. This part of IEC 61083 specifies requirements for the performance of digital recorders used for high-voltage and high-current impulse tests.

Since the last revision of this standard, significant improvements have been made in many aspects of digitising instruments used for high-voltage and high-current tests. In particular, digitising resolutions have improved several folds since the last revision, with 12-bit to 14-bit being typical resolutions for impulse measurement digitisers. Furthermore, the improvement of A/D converters has led to a situation where other aspects of the instruments, such as linearity of front-end amplifiers and performance of immunity to interference, have replaced performance of A/D converters as the main concern of measurement accuracy and instrument reliability.

The requirements in this edition of the standard have been revised to reflect these technological changes. For example, the number of type tests aimed for evaluating the performance of A/D converters has been reduced, and new requirements for the linearity of complete system (A/D converter and analogue components) have been added.

During preparation of the second edition of this standard in 2001, the need to keep analogue oscilloscopes and peak voltmeters was thoroughly discussed. Requirements for analogue oscilloscopes have now been removed, and only essential requirements for peak voltmeters have been kept.

INSTRUMENTS AND SOFTWARE USED FOR MEASUREMENTS IN HIGH-VOLTAGE AND HIGH-CURRENT TESTS –

Part 1: Requirements for instruments for impulse tests

1 Scope

This part of IEC 61083 is applicable to digital recorders, including digital oscilloscopes, used for measurements during tests with high impulse voltages and high impulse currents. It specifies the measuring characteristics and calibrations required to meet the measuring uncertainties and procedures specified in IEC 60060-2 and IEC 62475.

This document

- defines the terms specifically related to digital recorders;
- specifies the necessary requirements for such instruments to ensure their compliance with the requirements for high-voltage and high-current impulse tests;
- establishes the tests and procedures necessary to demonstrate their compliance;
- covers digital recorders that permit access to raw data from permanent or temporary storage;
- covers peak meters used for measuring the extreme value of lightning impulses, the peak value of switching or current impulses.

It has the status of a horizontal standard in accordance with IEC Guide 108.

This horizontal standard is primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 108. One of the responsibilities of a technical committee is, wherever applicable, to make use of horizontal standards in the preparation of its publications. The contents of this horizontal standard will not apply unless specifically referred to or included in the relevant publications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IE 60060-2:2010, *High-voltage test techniques – Part 2: Measuring systems*

IEC 62475, *High-current test techniques – Definitions and requirements for test currents and measuring systems*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurements (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 General definitions related to digital recorders

3.1.1
digital recorder
digitiser
recording instrument in which the recording is made in digital form on a magnetic or optical medium, or on a solid-state memory medium

Note 1 to entry: The waveform of the digital record is usually displayed on a screen, plotted or printed. This process may change the appearance of the waveform due to the processing involved.

[SOURCE: IEC 60050-313:2001, 313-02-16, modified – "digitiser" and a note to entry have been added]

3.1.2
approved digital recorder
digital recorder that is shown to comply with the requirements set out in this document

3.1.3
assigned measurement range
range of input voltage for which the instrument can be used within the uncertainty limits given in this document

3.1.4
output of a digital recorder
numerical value recorded by a digital recorder at a specific instant

3.1.5
full-scale deflection
minimum input voltage, which produces the nominal maximum output of the instrument in the specified range

3.1.6
offset
output of an instrument for zero input

3.1.7
raw data
original record of sampled and quantized information obtained when a digital recorder converts an analogue signal into a digital form, with the correction of the output for offset and multiplying the record by a constant factor being permitted

3.1.8
processed data
data obtained by any processing (other than correction for offset and/or multiplying by a constant scale factor) of the raw data

Note 1 to entry: Digital recorders which do not allow access to the raw data are not covered by this document.

3.2 Definitions related to rated values

3.2.1
rated resolution
r
reciprocal of two to the power of the rated number of bits N of the A/D converter, namely $r = 2^{-N}$

3.2.2
sampling rate
number of samples taken per unit of time

Note 1 to entry: The sampling time interval is the reciprocal of the sampling rate.

3.2.3
record length
duration of the record expressed either in a time unit or as the total number of samples

3.2.4
warm-up time
time interval from when the instrument is first switched on to when the instrument meets operational requirements

3.3 Definitions related to scale factor

3.3.1
scale factor
factor by which the output corrected for offset is multiplied in order to determine the measured value of the input quantity

Note 1 to entry: The scale factor includes the ratio of any built-in or external attenuator and is determined by calibration.

3.3.2
static scale factor
scale factor for a direct voltage or a direct current input

3.3.3
impulse scale factor
scale factor for an input representing the shape of the relevant impulse

3.3.4
assigned impulse scale factor
impulse scale factor of a digitiser determined at the most recent calibration

3.3.5
base line
value of the output of the recorder during the initial flat part of the record of the impulse, with the value determined from the mean of at least 20 samples in the initial flat part

3.4 Definitions related to dynamic performance

3.4.1
nominal epoch
τ_N
range of values between the minimum (t_{min}) and the maximum (t_{max}) of the relevant time parameter of impulse voltage or impulse current for which the digitiser is to be approved, with the relevant time parameter being:

– the front time T_1 for full and tail-chopped lightning voltage impulse and exponential current impulse

– the time to chopping T_c for front-chopped lightning voltage impulse

– the time to-peak T_p for switching voltage impulses

– pulse rise time $0,5 \cdot (T_t - T_d)$ for rectangular current impulse

Note 1 to entry: Nominal epoch is applicable to the front part of an impulse only.

Note 2 to entry: A digitiser usually has one, two or more nominal epochs for different waveforms. For example, a particular digitiser is approved for:

- full and tail-chopped lightning impulses with an assigned impulse scale factor F_1 over a nominal epoch τ_{N1} from T_1 = 0,84 µs (t_{min}) to T_1 = 1,56 µs (t_{max}),
- full lightning impulses with an assigned impulse scale factor F_1 over a nominal epoch τ_{N1} from T_1 = 2,0 µs (t_{min}) to T_1 = 5,0 µs (t_{max}),
- front-chopped lightning impulses with an assigned impulse scale factor F_2 over a nominal epoch τ_{N2} from T_c = 0,5 µs (t_{min}) to T_c = 0,9 µs (t_{max}),
- and/or standard switching impulses with an assigned impulse scale factor F_3 over a nominal epoch τ_{N3} from T_p = 150 µs (t_{min}) to T_p = 500 µs (t_{max}).

3.4.2
step calibration epoch
time interval in which the impulse scale factor is determined with the step calibration method, with its lower limit being 0,5 times of the lower limit of the nominal epoch ($0,5t_{min}$) and its upper limit being 2 times the upper limit of the nominal epoch ($2t_{max}$), both of which are evaluated from the start of the recorded voltage step

3.4.3
rise time
time interval within which the response to an applied step passes from 10 % to 90 % of its steady-state amplitude

3.4.4
time base
unit of the digitiser horizontal scale against which a time interval is measured

3.5 Definitions related to uncertainties

3.5.1
error
measured quantity value minus a reference quantity value (VIM 2.16)

3.5.2
uncertainty (of measurement)
parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand

Note 1 to entry: Uncertainty is positive and given without sign.

Note 2 to entry: Uncertainty of measurement should not be confused with the tolerance of the test value.

[SOURCE: IEC 60050-311:2001, 311-01-02, modified – notes 1 and 2 to entry have been changed and note 3 to entry deleted]

3.5.3
standard uncertainty
uncertainty of the result of a measurement expressed as a standard deviation

[SOURCE: ISO/IEC Guide 98-3:2008, 2.3.1]

3.5.4
type A evaluation
method of evaluation of uncertainty by statistical analysis of a series of observations

3.5.5
type B evaluation
method of evaluation of uncertainty by means other than statistical analysis of a series of observations

3.6 Definitions related to tests

3.6.1
calibration
set of operations that establishes, by reference to standards, the relationship which exists, under specified conditions, between an indication and a result of a measurement

[SOURCE: IEC 60050-311:2001, 311-01-09, modified – the notes to entry have been deleted]

3.6.2
type test
conformity test made on one or more items representative of the production

Note 1 to entry: For a measuring system, this is understood as a test performed on a component or on a complete measuring system of the same design to characterize it under operating conditions.

[SOURCE: IEC 60050-151:2001, 151-16-16, modified – the note 1 to entry has been added]

3.6.3
routine test
conformity test made on each individual item during or after manufacture

Note 1 to entry: This is understood as a test performed on each component or on each complete measuring system to characterize it under operating conditions

[SOURCE: IEC 60050-151:2001, 151-16-17, modified – the note 1 to entry has been added]

3.6.4
performance test
test performed on a complete measuring system to characterize it under operating conditions

3.6.5
performance check
a simple procedure to ensure that the most recent performance test is still valid

3.6.6
record of performance
detailed record, established and maintained by the user, describing the measuring system and containing evidence that the requirements given in this document have been met, which includes the results of the initial performance test and the schedule and results of each subsequent performance test and performance check

4 Operating conditions

The limits of operating conditions given in Table 1 are those under which the digitiser shall operate and meet the uncertainty requirements specified for this instrument.

Table 1 – Operating conditions

Condition	Range
Environment	
Ambient temperature	5 °C to 40 °C
Ambient relative humidity (non-condensing)	10 % to 90 %
Mains power supply	
Supply voltage	Rated voltage ±10 % (RMS) Rated voltage ±12 % (AC peak)
Supply frequency	Rated frequency ±5 %

Any exceptions to the values given in Table 1 shall be explicitly and clearly stated in the record of performance with an indication that they are exceptions.

NOTE The general requirements for testing electromagnetic compatibility of electrical equipment for measurement, control and laboratory use are described in IEC 61326-1.

5 Calibration and test methods

5.1 Calibration of scale factor and time base

The scale factor and time base shall be determined by either

– impulse calibration (5.2) with two waveforms covering the nominal epoch, or
– step calibration (5.3) with test of scale factor constancy (5.4) and calibration of time base (5.5), or
– an impulse calibration (5.2) with one impulse waveform within the nominal epoch with the constancy of scale factor test (5.4).

5.2 Impulse calibration

Impulse calibration is the reference method to establish the impulse scale factor of approved digital recorders. It is also the reference method to determine the errors of the impulse time parameters caused by the digital recorders. Requirements on reference calibration impulses for calibrating approved digital recorders are given in Table 2. The wave shapes shall be chosen from Table 2 according to the type and polarity of the high-voltage or high-current impulses that the digitiser is approved to measure. The uncertainties of the peak value and time parameters of the applied calibration impulses shall be within the limits given in Table 2, and the actual values shall be entered in the record of performance.

The number of calibration impulses to be applied shall be sufficient for obtaining sufficiently low type A uncertainties for all relevant parameters.

The impulse scale factor is the ratio of the peak value of the input calibration impulse and the peak value of its corresponding impulse recorded by the digitiser. The assigned impulse scale factor is the mean of impulse scale factors determined from a set of individual calibration impulses.

The error of a time parameter is the mean of the time parameter errors determined from individual calibration impulses.

This impulse calibration shall be made in each range of each channel that the digitiser is approved for use in impulse tests.

A digital recorder can be calibrated for exponential current impulses (IEC 62475) and the standard chopped (tail chopped) impulses using the full lightning impulse of a reference impulse generator.

Table 2 – Requirements for reference impulse generators

Impulse type	Parameter being measured	Value	Expanded uncertainty %	Short-term stability %
Full and standard chopped (tail chopped) lightning voltage impulse	Time-to-half value	55 µs to 65 µs	≤ 2	≤ 0,2
	Front time	0,8 µs to 1,0 µs	≤ 2	≤ 0,5
		or		
		0,8 µs to 1,0 µs and 1,5 µs to 1,7 µs	≤ 2	≤ 0,5
	Peak voltage	Within assigned measurement range	≤ 0,7	≤ 0,2
Front chopped lightning voltage impulse	Time-to-chopping	0,45 µs to 0,55 µs	≤ 2	≤ 1
	Peak voltage	Within assigned measurement range	≤ 2	≤ 0,2
Standard switching impulse	Time-to-peak	200 µs to 300 µs	≤ 2	≤ 0,2
	Time-to-half value	1 000 µs to 4 000 µs	≤ 2	≤ 0,2
	Peak voltage	Within assigned measurement range	≤ 0,7	≤ 0,2
Rectangular impulse current	Duration	0,5 ms to 3,5 ms	≤ 2	≤ 0,5
	Peak value	Within assigned measurement range	≤ 2	≤ 1
The short-term stability is the standard deviation of a sequence of at least 10 output impulses.				

NOTE A digital recorder can be calibrated for exponential current impulses (IEC 62475) using either a lightning impulse generator or a switching impulse generator that best matches the waveform of the current impulse.

5.3 Step calibration

The step calibration is the alternative method for establishing the impulse scale factor of an approved digital recorder. To qualify an approved digitiser for measuring impulse time parameters, the scale factor constancy test specified in 5.4 and the calibration of time base as specified in 5.5 shall also be performed if the impulse calibration as specified in 5.2 is not performed.

A direct voltage V_{CAL}, with an uncertainty less than 0,1 % and within the assigned measurement range of the instrument, is applied to the input and then short-circuited to ground by an appropriate switching device, preferably based on a mercury-wetted relay. The resultant transition to zero level is recorded as the output $O(t)$ (an example is shown in Figure 1) and evaluated within the time interval of the step calibration epoch. A number of records (e.g. 10) of the response shall be averaged to reduce the random noise. The deviation of the sample values $O(t)$ in the time interval of the step calibration epoch from their mean O_{sm} shall be within the uncertainty limits specified for the assigned impulse scale factor. The value of O_{sm} shall be evaluated as the mean of all $O(t)$ values within the step calibration epoch (IEC 60060-2:2010). The impulse scale factor is the quotient of the input voltage V_{CAL} and O_{sm}. The rise time of the step shall be less than 10 % of the lower limit of the step calibration epoch.