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IEC standard voltages

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

HORIZONTAL STANDARD
NORME HORIZONTALE

IEC standard voltages

Tensions normales de la CEI





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International Standard IEC 60038 has been prepared by IEC technical committee 8: System aspects for electrical energy supply.

This seventh edition supersedes the sixth edition (1993), its Amendment 1 (1994) and its Amendment 2 (1997). It constitutes a technical revision. The significant technical changes are:

- a clarification of the scope;
- the addition of the values of 230 V (50 Hz) and 230/400 V (60 Hz) to Table 1;
- the update of Table 1 to take into account the end of the transition period for the values of 230/400 V and 400/690 V;
- the replacement of the utilization voltage range at LV by a reference to the relevant standard and an informative annex;
- the addition of the value of 30 kV to Table 3;
- the replacement of the value of 1 050 kV by 1 100 kV in Table 5.

The text of this standard is based on the following documents:

FDIS	Report on voting
8/1260/FDIS	8/1264/RVD

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

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

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

IEC STANDARD VOLTAGES

1 Scope

This publication applies to

- a.c. transmission, distribution and utilization systems and equipment for use in such systems with standard frequencies 50 Hz and 60 Hz having a nominal voltage above 100 V;
- a.c. and d.c. traction systems;
- a.c. and d.c. equipment having nominal voltages below 120 V a.c. or below 750 V d.c., the a.c. voltages being intended (but not exclusively) for 50 Hz and 60 Hz applications; such equipment covers batteries (from primary or secondary cells), other power supply devices (a.c. or d.c.), electrical equipment (including industrial and communication), and appliances.

This publication does not apply to voltages representing or transmitting signals or measured values.

This publication does not apply to standard voltages of components and parts used within electrical devices or items of equipment.

This publication specifies standard voltage values which are intended to serve

- as preferential values for the nominal voltage of electrical supply systems, and
- as reference values for equipment and system design.

NOTE 1 Two main reasons have led to the values specified in this standard:

The values of nominal voltage (or highest voltage for equipment) specified in this standard are mainly based on the historical development of electrical supply systems throughout the world, since these values turned out to be the most common ones, and have achieved worldwide recognition;

The voltage ranges mentioned in this standard have been recognized to be the most appropriate ones as a basis for design and testing of electrical equipment and systems.

NOTE 2 It is nevertheless the task of system and product standards to define appropriate testing values, testing conditions and acceptance criteria.

2 Normative references

The following referenced documents are indispensable for the application 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 60364-5-52: *Electrical installations of buildings – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

3 Terms and definitions

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

For alternating voltages, the voltages stated below are r.m.s. values.

3.1

nominal system voltage

a suitable approximate value of voltage used to designate or identify a system

[IEV 601-01-21, modified]

3.2

highest voltage of a system (excluding transient or abnormal conditions)

the highest value of operating voltage which occurs under normal operating conditions at any time and at any point on the system

NOTE It excludes transient overvoltages, such as those due to switching operations, and temporary variations of voltage.

[IEV 601-01-23, modified]

3.3

lowest voltage of a system (excluding transient or abnormal conditions)

the lowest value of operating voltage which occurs under normal operating conditions at any time and at any point on the system

NOTE It excludes transient voltages, such as those due to switching operations, and temporary variations of voltage.

[IEV 601-01-24, modified]

3.4

supply terminals

point in a transmission or distribution network designated as such and contractually fixed, at which electrical energy is exchanged between contractual partners

3.5

supply voltage

the phase-to-phase or phase-to-neutral voltage at the supply terminals

NOTE An equivalent definition is: the line-to-line or line-to-neutral voltage at the supply terminals.

3.6

supply voltage range

the voltage range at the supply terminals

3.7

utilization voltage

the phase-to-phase or phase-to-neutral voltage at the outlets or at the points where utilisation equipment is intended to be connected to the fixed installation

NOTE An equivalent definition is: the line-to-line or line-to-neutral voltage at the outlets or at the points where utilisation equipment is intended to be connected to the fixed installation.

3.8

utilization voltage range

the voltage range at the outlets or at the points where utilisation equipment is intended to be connected to the fixed installation

NOTE Attention is drawn to the fact that in some equipment standards (for example, IEC 60335-1 and IEC 60071), the term "voltage range" has a different meaning.

3.9

highest voltage for equipment

highest voltage for which the equipment is specified regarding:

- a) the insulation;
- b) other characteristics which may be linked to this highest voltage in the relevant equipment recommendations.

NOTE Equipment may only be used on systems having a highest system voltage less than or equal to its highest voltage for equipment.

4 Standard voltages

4.1 AC systems having a nominal voltage between 100 V and 1 000 V inclusive and related equipment

The nominal voltage of an a.c. system in the range from 100 V to 1 000 V should be selected from the values given in Table 1.

Table 1 – AC systems having a nominal voltage between 100 V and 1 000 V inclusive and related equipment

Three-phase four-wire or three-wire systems		Single-phase three-wire systems
Nominal voltage V		Nominal voltage V
50 Hz	60 Hz	60 Hz
–	120/208	120/240 ^d
230 ^c	240 ^c	–
230/400 ^a	230/400 ^a	–
–	277/480	–
–	480	–
–	347/600	–
–	600	–
400/690 ^b	–	–
1 000	–	–

^a The value of 230/400 V is the result of the evolution of 220/380 V and 240/415 V systems which has been completed in Europe and many other countries. However, 220/380 V and 240/415 V systems still exist.

^b The value of 400/690 V is the result of the evolution of 380/660 V systems which has been completed in Europe and many other countries. However, 380/660 V systems still exist.

^c The value of 200 V or 220 V is also used in some countries.

^d The values of 100/200 V are also used in some countries on 50 Hz or 60 Hz systems.

In Table 1, the three-phase four-wire systems and single-phase three-wire systems include single-phase circuits (extensions, services, etc.) connected to these systems.

The lower values in the first and second columns are voltages to neutral and the higher values are voltages between phases. When one value only is indicated, it refers to three-wire systems and specifies the voltage between phases. The lower value in the third column is the voltage to neutral and the higher value is the voltage between lines.

Voltages in excess of 230/400 V are intended for heavy industrial applications and large commercial premises.

Concerning supply voltage range, under normal operating conditions, the supply voltage should not differ from the nominal voltage of the system by more than $\pm 10\%$.

For the utilization voltage range, in addition to the voltage variations at the supply terminals, voltage drops may occur within the consumer's installations. For more information, see IEC 60364-5-52. This utilization voltage range should be taken into account by product committees.

NOTE The highest and lowest voltage values at supply terminals and at utilization terminals, as they can be derived from the above and from IEC 60364-5-52:2001, are provided for information in Annex A.

4.2 DC and a.c. traction systems

The voltages of a d.c. or a.c. traction system should be selected from the values given in Table 2.

Table 2 – DC and a.c. traction systems ^a

	Voltage			Nominal frequency of a.c. systems Hz
	Lowest V	Nominal V	Highest V	
DC systems	(400) 500 1 000 2 000	(600) 750 1 500 3 000	(720) 900 1 800 3 600 ^b	
AC single-phase systems	(4 750) 12 000 19 000	(6 250) 15 000 25 000	(6 900) 17 250 27 500	50 or 60 16 2/3 50 or 60
<p>a The values indicated in parentheses should be considered as non-preferred values. It is recommended that these values should not be used for new systems to be constructed in future. In particular for a.c. single-phase systems, the nominal voltage 6 250 V should be used only when local conditions make it impossible to adopt the nominal voltage 25 000 V.</p> <p>The values indicated in the table above are the values agreed by the international mixed committee on electric traction equipment (C.M.T.) and by IEC technical committee 9, Electrical equipment and systems for railways.</p> <p>b In certain European countries, this voltage may reach 4 000 V. The electrical equipment of vehicles operating international services in these countries shall be capable of withstanding this absolute maximal voltage for brief periods of up to 5 min.</p>				

4.3 AC three-phase systems having a nominal voltage above 1 kV and not exceeding 35 kV and related equipment

The voltages for an a.c. three-phase system having a nominal voltage above 1 kV and not exceeding 35 kV should be selected from the values given in Table 3.

Table 3 – AC three-phase systems having a nominal voltage above 1 kV and not exceeding 35 kV and related equipment ^a

Series I			Series II	
Highest voltage for equipment kV	Nominal system voltage kV		Highest voltage for equipment kV	Nominal system voltage kV
3,6 ^b	3,3 ^b	3 ^b	4,40 ^b	4,16 ^b
7,2 ^b	6,6 ^b	6 ^b	–	–
12	11	10	–	–
–	–	–	13,2 ^c	12,47 ^c
–	–	–	13,97 ^c	13,2 ^c
–	–	–	14,52 ^b	13,8 ^b
(17,5)	–	(15)	–	–
24	22	20	–	–
–	–	–	26,4 ^{c,e}	24,94 ^{c,e}
36 ^d	33 ^d	30 ^d	–	–
–	–	–	36,5 ^c	34,5 ^c
40,5 ^d	–	35 ^d	–	–

NOTE 1 It is recommended that in any one country, the ratio between two adjacent nominal voltages should be not less than two.

NOTE 2 In a normal system of series I, the highest voltage and the lowest voltage do not differ by more than approximately $\pm 10\%$ from the nominal voltage of the system. In a normal system of series II, the highest voltage does not differ by more than $+5\%$ and the lowest voltage by more than -10% from the nominal voltage of the system.

^a These systems are generally three-wire systems, unless otherwise indicated. The values indicated are voltages between phases.
The values indicated in parentheses should be considered as non-preferred values. It is recommended that these values should not be used for new systems to be constructed in future.

^b These values should not be used for new public distribution systems.

^c These systems are generally four-wire systems and the values indicated are voltages between phases. The voltage to neutral is equal to the indicated value divided by 1,73.

^d The unification of these values is under consideration.

^e The values of 22,9 kV for nominal voltage and 24,2 kV or 25,8 kV for highest voltage for equipment are also used in some countries.

Two series of highest voltages for equipment are given above, one for 50 Hz and 60 Hz systems (series I), the other for 60 Hz systems (series II – North American practice). It is recommended that only one of the series should be used in any one country.

It is also recommended that only one of the two series of nominal voltages given for series I should be used in any one country.

4.4 AC three-phase systems having a nominal voltage above 35 kV and not exceeding 230 kV and related equipment

The voltages for an a.c. three-phase system having a nominal voltage above 35 kV and not exceeding 230 kV should be selected from the values given in Table 4.

Table 4 – AC three-phase systems having a nominal voltage above 35 kV and not exceeding 230 kV and related equipment ^a

Highest voltage for equipment kV	Nominal system voltage kV	
(52)	(45)	–
72,5	66	69
123	110	115
145	132	138
(170)	(150)	(154)
245	220	230

^a The values indicated in parentheses should be considered as non-preferred values. It is recommended that these values should not be used for new systems to be constructed in future. The values are voltages between phases.

Two series of nominal system voltages are given above. It is recommended that only one of the two series should be used in any one country.

It is recommended that in any one country only one value in the following groups should be used for the highest voltage for equipment:

- 123 kV or 145 kV;
- 245 kV or 300 kV (see Table 5) or 362 kV (see Table 5).

4.5 AC three-phase systems having a highest voltage for equipment exceeding 245 kV

The highest voltage for equipment for an a.c. three-phase system exceeding 245 kV should be selected from the values given in Table 5.

Table 5 – AC three-phase systems having a highest voltage for equipment exceeding 245 kV ^a

Highest voltage for equipment kV
(300)
362
420
550 ^b
800 ^c
1 100
1 200

^a The values indicated in parentheses should be considered as non-preferred values. It is recommended that these values should not be used for new systems to be constructed in future. The values are voltages between phases.

^b The value 525 kV is also used.

^c The value 765 kV is also used; the test values for equipment should be the same as defined by the IEC for 765 kV.

It is recommended that in any one geographical area, only one value in the following groups should be used for the highest voltage for equipment:

- 245 kV (see Table 4) or 300 kV or 362 kV;

- 362 kV or 420 kV;
- 420 kV or 550 kV;
- 1 100 kV or 1 200 kV.

NOTE In the above sentence, the term "geographical area" may indicate a single country, a group of countries which agree to adopt the same voltage level, or a part of a very large country.

4.6 Equipment having a nominal voltage below 120 V a.c. or below 750 V d.c.

The nominal voltage for equipment below 120 V a.c. or below 750 V d.c. should be selected from the values given in Table 6.

Table 6 – Equipment having a nominal voltage below 120 V a.c. or below 750 V d.c.

DC		AC	
Nominal values		Nominal values	
Preferred V	Supplementary V	Preferred V	Supplementary V
	2,4		
	3		
	4		
	4,5		
	5		5
6	7,5	6	
	9		
12	15	12	15
24	30	24	
36	40		36
48		48	
60			60
72	80		
96			100
110	125	110	
220	250		
440	600		

NOTE 1 Because the voltage of the primary and secondary cells is below 2,4 V, and the choice of the type of cell to be used in various applications will be based on properties other than the voltage, these values are not included in the table. The relevant IEC technical committees may specify types of cells and related voltages for specific applications.

NOTE 2 It is recognized that for technical and economic reasons, additional voltages may be required for certain specific fields of application.

Annex A
(informative)

Highest and lowest voltage values at supply and utilization terminals for a.c. systems having a nominal voltage between 100 V and 1 000 V

Table A.1 gives the highest and lowest voltage values at supply terminals and at utilization terminals, as they can be derived from the text related to Table 1 in Clause 4, and from the indications provided by IEC 60364-5-52:2001.

NOTE Values in Table A.1 are based on the note in IEC 60364-5-52:2001, Clause 525, which indicates that "In the absence of other considerations, it is recommended that in practice the voltage drop between the origin of consumer's installation and the equipment should not be greater than 4 % of the nominal voltage of the installation".

Clause 525 of IEC 60364-5 is presently under consideration. Values for lowest utilization voltages should be modified in future in accordance with revisions of IEC 60364-5-52.

Table A.1 – Highest and lowest voltage values at supply and utilization terminals for a.c. systems having a nominal voltage between 100 V and 1 000 V

Systems	Nominal frequency	Voltage			
		Highest supply or utilization voltage	Nominal voltage	Lowest supply voltage	Lowest utilization voltage
	Hz	V	V	V	V
Three-phase four-wire or three-wire systems	50	253	230 ^c	207	198
		253/440	230/400 ^a	207/360	198/344
		440/759	400/690 ^b	360/621	344/593
		1 100	1 000	900	860
	60	132/229	120/208	108/187	103/179
		264	240 ^c	216	206
		253/440	230/400 ^a	207/360	198/344
		305/528	277/480	249/432	238/413
		528	480	432	413
		382/660	347/600	312/540	298/516
	660	600	540	516	
Single-phase three-wire systems	60	132/264	120/240 ^d	108/216	103/206

a) The value of 230/400 V is the result of the evolution of 220/380 V and 240/415 V systems which has been completed in Europe and many other countries. However, 220/380 V and 240/415 V systems still exist.

b) The value of 400/690 V is the result of the evolution of 380/660 V systems which has been completed in Europe and many other countries. However, 380/660 V systems still exist.

c) The value of 200 V or 220 V is also used in some countries.

d) The values of 100/200 V are also used in some countries on 50 Hz or 60 Hz systems.

Bibliography

IEC 60050-601:1985, *International Electrotechnical Vocabulary – Chapter 601: Generation, transmission and distribution of electricity – General*

IEC 60071 (all parts), *Insulation co-ordination*

IEC 60335-1, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60364-5-52:2001, *Electrical installations of buildings – Part 5-52: Selection and erection of electrical equipment – Wiring systems*
