Appendix B:
Excerpts From Draft IEC Standard 62040-3 Ed. 2.0

The following excerpts from the draft International Electrotechnical Commission (IEC) standard 62040-3 Ed. 2.0 CDV are referenced by the draft ENERGY STAR test procedure for uninterruptible power supplies (UPS). They are provided here for reference purposes only, to assist stakeholders involved in the development of the ENERGY STAR test procedure, as a courtesy of the IEC technical committee 22 U.S. Technical Advisory Group.

As IEC standard 62040-3 Ed. 2.0 has not yet been finalized, all content contained in this appendix is subject to change. EPA is closely monitoring the IEC process, and will amend its draft test procedure, if necessary, to account for any changes.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

UNINTERRUPTIBLE POWER SYSTEMS (UPS) –

Part 3: Method of specifying the performance and test requirements

FOREWORD

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International Standard IEC 62040-3 has been prepared by subcommittee 22H: Uninterruptible power systems (UPS), of IEC technical committee 22: Power electronic systems and equipment.

This standard cancels and replaces the first edition of IEC 62040-3, published in 1999 and constitutes a technical revision. This standard, in harmonization and alignment with current world best practices, updates some of the requirements of the first edition and adds the following:

– reference test load - review of definition (sub-clause 3.3) and use of (sub-clause 6.1.1.3)
– test schedule - streamlined (sub-clause 6.1.6, Table 3) replacing 1st Ed dispersed schedules
– dynamic output voltage performance characteristics - guidance to measure (annex H)
– energy efficiency - requirements and methods of measure for UPS (annexes I, J, K)
– functional safety – guidance for UPS safety integrity level classification (annex L)
– environmental information – disclosure requirements (annex M)
– output short-circuit withstand current: guidance to measurement (annex N)

Annexes E, G, J form an integral part of this standard.
Annexes A, B, C, D, H, I, K, L, M, N, O are for information only
Annex F (backfeed protection) now refers to IEC 62040-1 that covers the same subject

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

FDIS	Report on voting
22H/XXX/FDIS	22H/XXX/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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.
.
In this standard, the following print types are used:
– requirements proper and normative annexes: in roman type;
– compliance statements and test specifications: *in italic type*;
– notes and other informative matter: in smaller roman type;
– normative conditions within tables: in smaller roman type;
– terms that are defined in Clause 3: **bold**.

A list of all parts of the IEC 62040 series, under the general title: *Uninterruptible power systems (UPS)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date1) 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.

1) The National Committees are requested to note that for this publication the maintenance result date is 20xx.

limitations under prescribed conditions of operation. The duration of overload capability is valid after steady-state operation when rated load has resulted in thermal equilibrium. The overload power factor shall be specified.

NOTE The figures given are valid under floating voltage of the energy storage system, if not otherwise agreed to.

m) Current limit identification given by the ratio of current limitation to rated output current which can be supplied by the UPS for a specified time while the UPS output voltage collapses accordingly.

n) Fault clearing capability: the rated fault clearing capability shall be given as the maximum load protective device rating with which the UPS can co-ordinate under fault conditions. [a)]

o) Rated **load power factor** [a)]

p) Permissible **displacement power factor** range of the load (cos Φ) [a)]

q) Voltage unbalance and phase angle displacement between line-to-line or line-to-neutral voltages resulting from 100% load unbalance (multi-phase only)

r) **UPS efficiency** at 25%, 50%, 75% and at 100% **reference test load** (refer to annex J for guidance)

[a)] Characteristic to be declared also for the bypass transfer switch when included with a single or parallel UPS.

NOTE 1 The declaration may be in the form of a technical data sheet and may be included in the user manual.. Annex D presents a technical data sheet for guidance.

NOTE 2 Particular performance characteristics under abnormal conditions, e.g. transfer time from UPS to bypass under non-synchronised conditions, may be declared

5.3.3 Characteristics and conditions to be identified by the purchaser

The purchaser shall identify any condition and characteristic that are more severe than those declared by the manufacturer

Further, the purchaser shall identify any particular condition that may be required by national wiring regulation and any adverse or special load condition including.

a) Loads generating harmonic currents, in particular even harmonic currents, except for loads complying with the maximum levels permitted in IEC 61000-3-2 (load ≤ 16A), IEC 61000-3-12 (16A < load ≤ 75A), or IEC 61000-3-4 (load > 75A)

b) Asymmetric loads requiring circulation of a d.c. current, for example half-wave;

c) Independent Earth of the output neutral required

d) Load distribution facilities

e) Requirements for all-pole isolation of the UPS from the load

f) Requirements for coordination with characteristics of protective devices of the UPS load;

g) Future extension / expansion requirements

h) Standby generator characteristics, if any.

i) Functional safety (see annex L) and degree of redundancy (see annex A)

j) Output overvoltage protection

5.3.4 Performance classification

The manufacturer shall classify UPS complying with this standard in accordance with the coding.

AAA BB CCC

where

AAA = Input dependency characteristic
describing to which extent, for operation in normal mode, the load power depends on the quality of the a.c. input supply

Note: This classification is performance based and does not exclude any specific technology or topology as the means for achieving compliance with such classification.

"VFD":
UPS classified VFD shall protect the load from power outage.
The output of the VFD UPS is dependent on changes in a,c, input voltage and frequency and is not intended to provide additional corrective functions, such as those arising from the use of tapped transformers.

Compliance with VFD classification is verified when performing test 6.2.2.7 and by observing that as a minimum the UPS switches from normal mode of operation to battery mode while input voltage is interrupted

"VI ":

UPS classified VI shall protect the load as requested for VFD and in addition from:
under-voltage applied continuously to the input

over-voltage applied continuously to the input

An output voltage tolerance band narrower than input voltage window shall be defined by the manufacturer. The output of the VI UPS is dependent on a,c, input frequency and the output voltage shall remain within prescribed voltage limits (provided by additional corrective voltage functions, such as those arising from the use of active and / or passive circuits).

Compliance with VI classification is verified when performing tests 6.4.1.1 and by observing that as a minimum the UPS output voltage remains within the prescribed limits and that the UPS remains in normal mode of operation while the input voltage is kept continuously (at least 1 minute) at the maximum and the minimum value of the input voltage limits.
"VFI":

UPS classified VFI is independent of supply (mains) voltage and frequency variations as specified in 5.2 and shall protect the load against adverse effects from such variations without depleting the stored energy source.

Compliance with VI classification is verified when performing tests 6.4.1.1 and 6.4.1.2 and by observing that as a minimum the output voltage and frequency remain within a specified output tolerance band while input voltage and frequency are moved in a wider input voltage and frequency tolerance band.

BB = Voltage waveform characteristic
describing the steady-state waveform of the voltage when operating in:

- normal or bypass mode (1st character)
- stored energy mode (2nd character)

"S": voltage waveform is sinusoidal

- presenting total harmonic distortion ≤ 8% and individual harmonic distortion within limits of "Table 2 – Compatibility levels for individual harmonic voltages in low voltage networks" under all linear and reference non-linear load conditions.

"X": voltage waveform is sinusoidal / non-sinusoidal
- meeting "S" specification under all linear load condition
- not meeting "S" specification under rated non-linear load condition

"Y": voltage waveform is non-sinusoidal
- not meeting "S" specification under reference linear load condition

Non-sinusoidal voltage waveforms shall present:

- peak voltage $U_P \leq$ rated voltage x $\sqrt{2}$
- rise/fall rates dU/dt ≤ 10V/ µs

Refer to the typical non-sinusoidal voltage waveform shown in figure 5.3.4

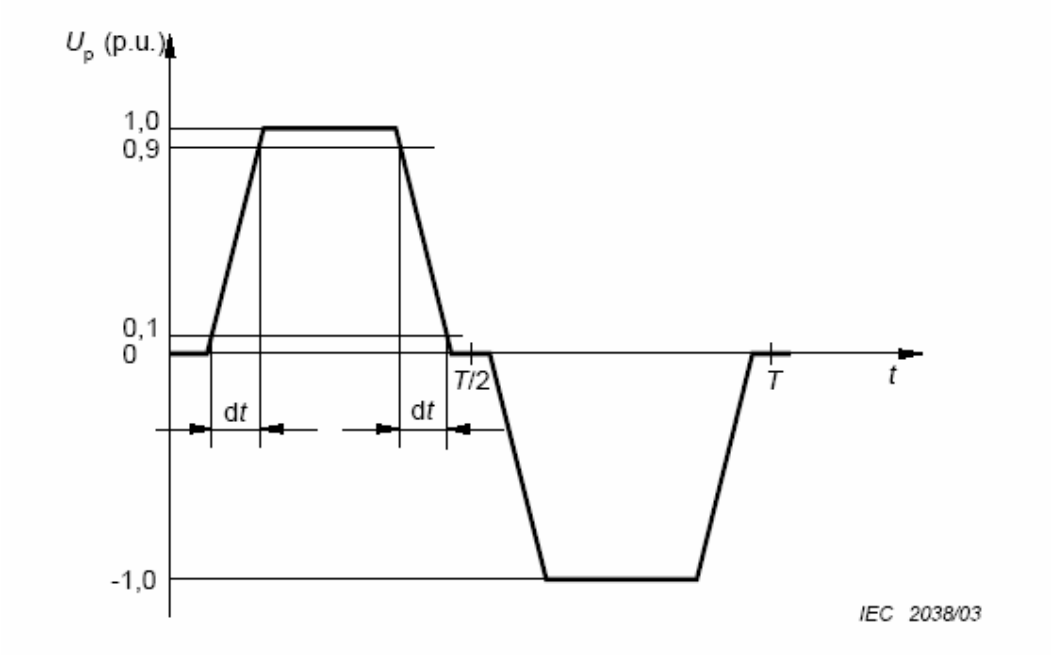


Figure 5.3.4 – Typical "non-sinusoidal" output voltage waveform

Compliance with the voltage waveform classification declared is verified by performing the applicable steady-state electrical type tests described in 6.4.2.1 to 6.4.2.4 and 6.4.3.1, 6.4.3.2 and by observation that test results obtained are within the limits of applicable s, x, or y characteristics

CCC = Dynamic output performance
describes the voltage variation caused by:

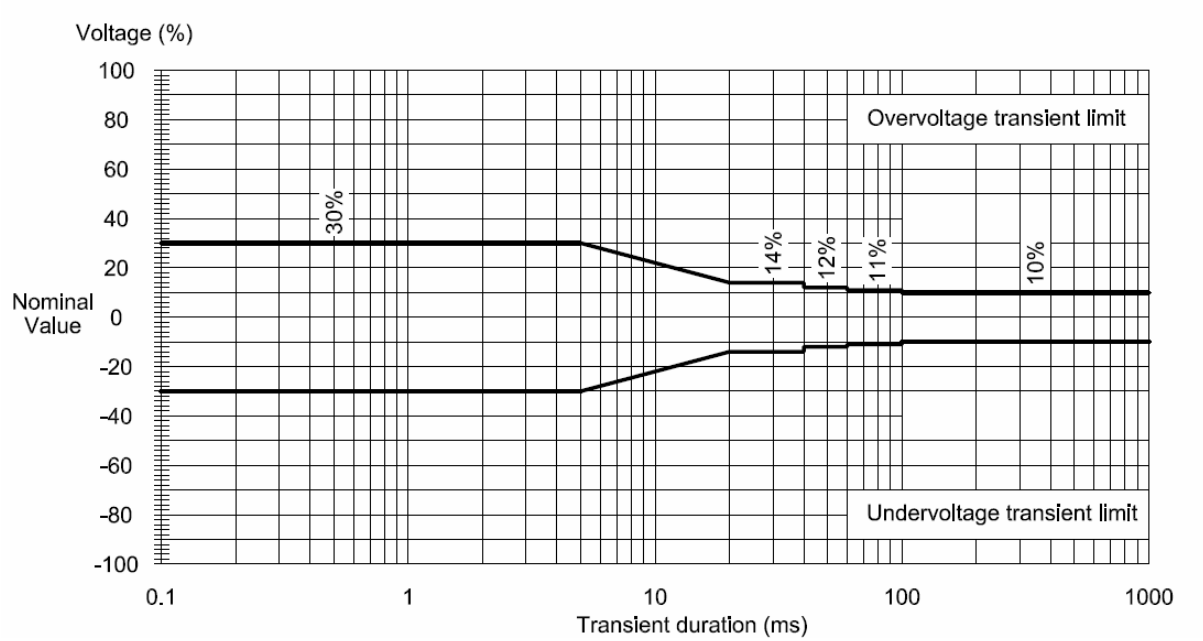
- change of mode of operation (1st character)
- linear load step application (2nd character)
- non-linear load step application (3rd character)

where each character takes form of either 1, 2 or 3 with the following meaning

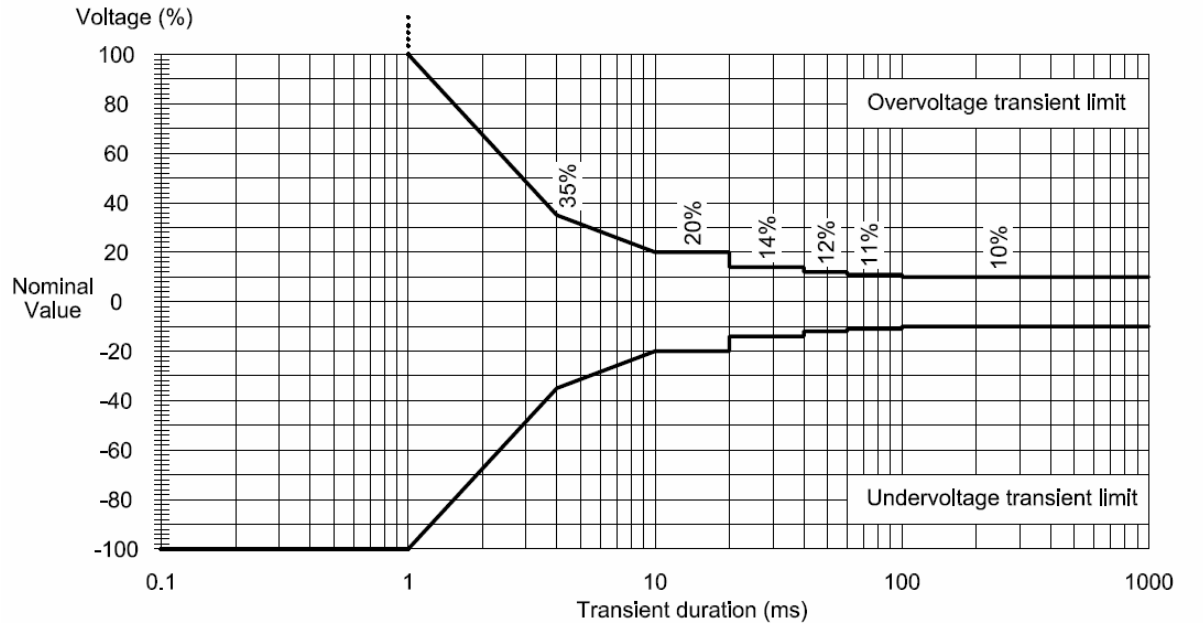
"1": performance is required for sensitive critical loads
The UPS output voltage remains within the limits of curve 1 of this sub-clause

"2": performance is accepted by most types of critical load
The UPS output voltage remains within the limits of curve 2 of this sub-clause

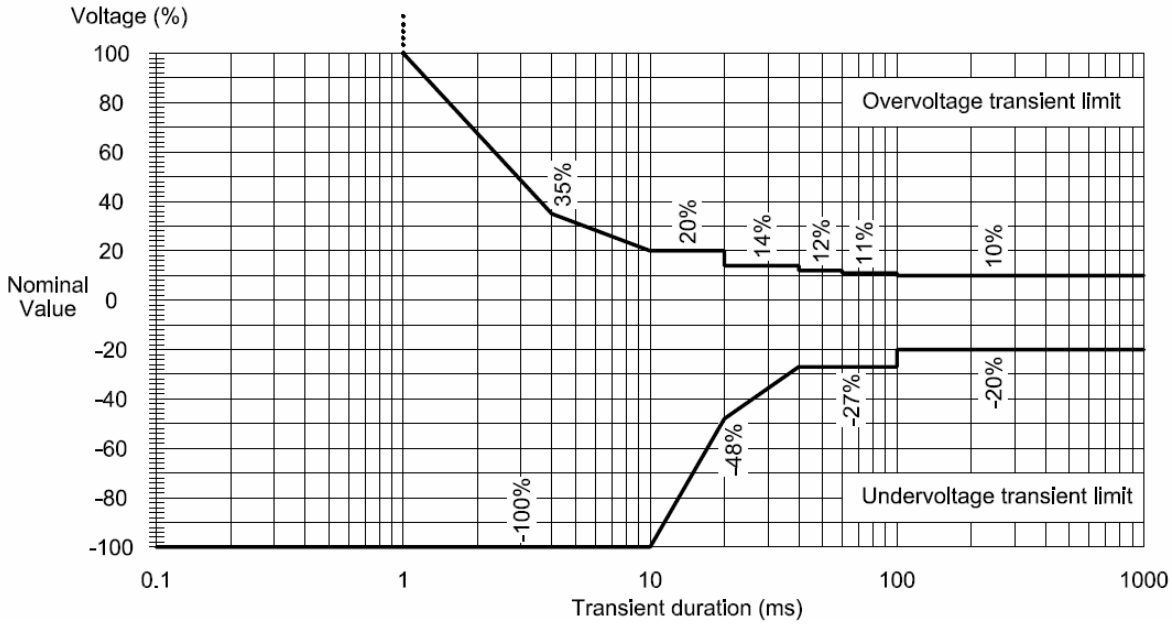
"3": performance is accepted by general purpose IT loads e.g. switched-mode power supplies
The UPS output voltage remains within the limits of curve 3 of this sub-clause



Curve 1 – Dynamic output performance classification 1



Curve 2 - Dynamic output performance classification 2



Curve 3 - Dynamic output performance classification 3

Compliance with the dynamic output performance declared is verified by performing the electrical type tests described in 6.4.2.11 and 6.4.3.3 and by observation that test results obtained are within the limits of the applicable curve 1, 2 or 3

NOTE 1 The objective of classifying UPS by performance is to provide a common base on which all UPS manufacturer's/supplier's data are evaluated. This enables purchasers, for similar UPS power ratings, to compare different manufacturer's products under the same measurement conditions.

NOTE 2 Purchasers are reminded that due to the diversity of load types, UPS manufacturers' data are based on industry standard test loads that simulate typical load applications expected.

NOTE 3 The actual performance in a given application may be subject to variation under transient conditions since actual load ratings, individual sequencing, and start currents may differ from standardized test situations.

NOTE 4 Single-cord connected UPS designed to be installed by the operator for use in an office environment, either desk or floor-mounted, and / or intended to be marketed by a third party without reference to the manufacturer, should, within the UPS rating, be capable of accepting any load suitable for connection to the public low voltage a.c. supply, unless any limitations are stated by the manufacturer within the user instructions.

NOTE 5 Non-linear step loading is performed as described in annex E.

NOTE 6 Refer to annex H for guidance on measurement techniques

NOTE 7 Refer to annex B for examples of applicable UPS topologies

5.4 Stored energy specification

5.4.1 General

This sub-clause specifies details that apply to secondary batteries, presently the most common technology selected to provide energy storage for use when the a.c. input supply is unavailable.

It is recognised that other technologies, e.g. flywheel systems, may replace the need for a battery system. Such technologies may be fully compatible with UPS characteristics primarily intended for batteries. With this in mind, subject to an agreement between the

6.4.1.2 Input frequency tolerance

The steady-state input voltage tolerance test (6.4.1.1) shall be repeated with the input frequency adjusted to the limits specified by the manufacturer in conjunction with the input voltage variations (see note).

Where the UPS output frequency is synchronized with the input frequency, the range of synchronization shall be checked.

Where the total input frequency range exceeds the stated range of synchronization, the UPS output normally reverts to free running operation. The free running frequency shall be recorded for non-synchronous conditions.

NOTE A decrease in frequency is assumed not to coincide with an increase in line voltage, and vice versa.

6.4.1.3 Inrush current

The inrush current test shall be performed after an absence of input voltage for more than 5 min and after an absence of 1 s. The measured values shall not exceed the manufacturer's declared value.

For the purpose of this test, initial current surges attributable to energization of RFI capacitors in input filters with a time duration of less than 1 ms shall be disregarded.

The a.c. input power supply shall be capable a prospective short-circuit current so that the **short-circuit ratio Rsce** is at least 33.

The mains input supply shall be switched on to the UPS input coincident with various angular points on the input voltage waveform in order to determine the worst-case inrush current condition.

NOTE 1 Test and evaluation by calculation is permitted for testing of large UPS if the test site Rsce is less than 33

NOTE 2 The test should be repeated sufficiently to obtain worst-case peak current which will normally be found for transformer coupled units, when switched at the zero voltage point and for direct rectifier/capacitor loads at or near the peak of the input supply voltage waveform.

6.4.1.4 Harmonic distortion of input current

The harmonic distortion of the input current is tested at reference linear load.

Compliance is verified when the total harmonic distortion figures of the UPS input current are within the limits declared by the manufacturer.

NOTE 1 The limits declared by the manufacturer should at least comply with those prescribed by IEC 61000-3-2 (UPS ≤ 16A), IEC 61000-3-12 (16A < UPS ≤ 75A), or IEC 61000-3-4 (UPS > 75A) taking into consideration the minimum **short-circuit power** capacity of the a.c. input supply as declared by the manufacturer.

NOTE 2: Where the reference test load is implemented by means of returning the output power to the UPS input, the harmonic distortion of the input current of concern is that actually drawn by the UPS input (as opposed to that drawn from the a.c. input source).

6.4.1.5 Power factor

The input power factor is tested at **reference linear load** in normal mode of operation and at rated a.c. input supply conditions.

Compliance is verified when the input power factor of the UPS input current is equal or greater that that declared by the manufacturer

NOTE 1: Where the reference test load is implemented by means of returning the output power to the UPS input, the input power factor of concern is that referred to the current actually drawn by the UPS input (as opposed to that drawn from the a.c. input source).

6.4.1.6 Efficiency

The **UPS efficiency** shall be measured at 25%, 50%, 75% and 100% reference test load as prescribed in annex J.

Compliance is verified when the computed efficiency values are within the manufacturer's declared characteristics.

NOTE Refer to annexes I and K for applicable minimum efficiency values to be considered.

6.4.1.7 Backfeed protection

Automatic backfeed protection is a safety requirement not within the scope of this standard.

NOTE: Backfeed protection compliance is verified during the applicable UPS safety certification. See Annex I of IEC 62040-1.

6.4.1.8 Residual earth current

Residual earth current („earth leakage“) is a safety requirement not within the scope of this standard.

NOTE Earth leakage compliance is verified during the applicable UPS safety certification. See clause 8.1 General provisions for earth leakage of IEC 62040-1.

6.4.1.9 Standby generator compatibility test

The applicable routine tests listed in Table 3 shall be repeated using the output of a standby generator as the source of input supply. The characteristics of the standby generator shall be specified by the manufacturer.

NOTE 1 This test may be performed in conjunction with the input voltage and frequency tolerance tests (6.4.1.1 and 6.4.1.2)

NOTE 2 Subject to an agreement between the manufacturer/supplier and the purchaser, this test may be performed on site.

NOTE 3 IEC 60034-22 may be consulted regarding characteristics for internal combustion engine driven generating sets.

6.4.1.10 Electromagnetic compatibility

Electromagnetic compatibility is an emission and susceptibility requirement not within the scope of this standard

NOTE Electromagnetic compatibility compliance is verified during the applicable UPS EMC certification. See IEC 62040-2

6.4.2 Output – Linear load

Where the manufacturer/supplier specifies the power factor range of the load that can be connected to the UPS output, the following tests shall include measurement of parameters at each end of the power factor range in addition to any nominal power factor measurement taken.

6.4.2.9 Periodic output voltage variation test (modulation)

Only when, subject to a specific agreement between the purchaser and the manufacturer, this test is specified, it shall be checked by voltage recording at different loads and operating conditions.

Compliance is verified when, during the test, the UPS output voltage remains within the limits of curve 1, 2 or 3 of 5.3.4, as applicable

6.4.2.10 Overload and short-circuit

6.4.2.10.1 Overload - Normal mode

With the UPS operating under at light load in normal mode apply a resistive load which shall load result in the UPS output in excess of the manufacturer's full load rating. Check that the UPS continues to operate within the manufacturer's stated conditions for the time duration specified.

NOTE In some cases, the UPS will change mode of operation to bypass mode where so declared by the manufacturer.

The UPS shall not be damaged, or show signs of over-heating.

6.4.2.10.2 Overload - Stored energy mode

The test of 6.4.2.10.1 shall be repeated in stored energy mode, with the storage energy device fully charged. The UPS shall not be damaged and shall function correctly when restarted.

6.4.2.10.3 Short-circuit - Normal and bypass mode

With the UPS a.c. input connected to a supply designed to deliver the applicable short time withstand current as declared by the UPS manufacturer and with the UPS otherwise operating under normal mode test conditions of 6.4.2.1, a light load may be applied if desired. A short-circuit shall then be applied across the UPS output phase terminals (or across the phase-to-neutral terminals if a neutral is provided).

The test shall be repeated, where applicable, with the UPS operating in static and manual bypass modes.

If the UPS is rated for operation at multiple input and output voltages, the short circuit test shall be performed at the highest nominal rated input and output voltages. Additional rated voltages and short-circuit currents may be tested at the manufacturer's option.

Compliance is verified

- when the UPS withstands the applicable short time withstand current until the over-current protective devices open or for the time declared by the manufacturer

Note: refer to Annex N for typical short time withstand currents and times

and

Annex J
(normative)

UPS efficiency - methods ofmeasurement

J.1 Introduction

This annex prescribes conditions and methods to be followed when determining **UPS efficiency** during type tests specified in 6.4.1.6.

J.2 Measurement conditions

J.2.1 Environmental conditions

The ambient temperature shall be between 20°C to 30°C and remaining environmental conditions shall be within the limits specified in 4.2.

1) A.

J.2.2 Operational and electrical conditions

The efficiency measurements shall be performed with a **reference test load** capable of being adjusted so that the UPS delivers 25%, 50%, 75% and 100% of the active power (W) for which it is rated. The following conditions apply during the measurement:

1) The UPS shall operate in **Normal Mode**
2) There shall be no significant transfer to and from the **energy storage system.** Alternatively, the energy storage system may be disconnected during the test.
3) The UPS and the load shall have reached steady-state conditions

NOTE Trend variation of less than 2% in the measured values and less than 2 deg C temperature variation over not less than three consecutive readings with no less than 10 minutes interval may be considered steady-state for the purpose of this annex. Instrument power readings may be used in this case.

4) All UPS sub-systems intended to be operational in Normal Mode shall be activated.
5) The a.c. input to the UPS shall be at rated voltage and frequency and otherwisewithin the tolerances specified in IEC 61000-2-2.
6) Instruments used for the measurement of electrical parameters shall

- provide true r.m.s. values of the active input and output power notwithstanding that voltage and current waveforms may include harmonic components.
- measure input and output values simultaneously- provide accuracy of the active power measurement equal or better than 0,5%

NOTE 1 The test with resistive load is considered to be the most reliable in terms of repeatability and constitutes a solid base for the evaluation of efficiency improvements at all load levels
NOTE2 : Instruments providing fast serial sampling (“multiplexed sampling”) are deemed to provide simultaneous measurements

NOTE 3 For tolerances, refer to IEC 60146-1-1

J.3 Measurement method

Under the conditions specified in J.2.1 and J.2.2, the measurement of the UPS efficiency shall be carried out as follows:

1) 100% **reference test load** shall be applied to the output of the UPS and a suitable stabilization time be allowed to reach the steady-state conditions as specified above

2) The active input and output power (W) shall be measured simultaneously in three successive readings. The **UPS efficiency** shall be calculated for each reading, and the arithmetic mean of the measures shall then be obtained. The result is considered to be the value of the efficiency measure.

   NOTE: Where the reference test load is implemented by means of returning the output power to the UPS input, the total input power equals the UPS output power plus that supplied by the a.c. input source.

3) Steps 1 and 2 shall be repeated for 75%, 50%, and 25% load conditions.

Alternative method: separate instruments with an accuracy less then 0,5% may be used provided that the following procedure is followed

1) 100% **reference test load** shall be applied to the output of the UPS and a suitable stabilization time be allowed to reach the steady-state conditions as specified above

2) The active input and output power (W) shall be measured simultaneously in three successive readings. The **UPS efficiency** shall be calculated for each reading, and the arithmetic mean of the measures shall then be obtained. The result is considered to be the value of the efficiency measure.

   NOTE: Where the reference test load is implemented by means of returning the output power to the UPS input, the total input power equals the UPS output power plus that supplied by the a.c. input source.

3) The input and output measuring instruments shall be swapped and step 2 shall be repeated

4) The arithmetic mean of the values calculated in step 2) and step 3) is considered to be the value of the efficiency measure.

5) Steps 1 to 4 shall be repeated for 75%, 50%, and 25% load conditions.

J.4 Test report

The following information shall be recorded in the test report:

J.4.1 Equipment details

– Brand, model, type, and serial number

– Product description, as appropriate

– Rated voltage and frequency

– Rated output active and apparent power

– Details of manufacturer marked on the product (if any)

– In the case of products with multiple functions or with options to include additional modules or attachments, the configuration of the appliance as tested shall be noted in the report

NOTE The details above can be found and should be consistent with those of D.6 Technical data sheet - Manufacturer's declaration

J.4.2 Test parameters

– Ambient temperature (°C)

– Input and output test voltage (V) and frequency (Hz)

– Total harmonic input voltage distortion

– Information and documentation on the instrumentation, set-up and circuits used for electrical testing

J.4.3 Measured data

– Efficiency in % rounded to the first decimal place at the given **rated** load fraction

– Measurement method used e.g. J.3 of IEC 62040-3

– Any notes regarding the operation of the equipment

J.4.4 Test and laboratory details

– Test report number/reference

– Date of test

– Name and signature of authorized test person(s)