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INTERNATIONAL ELECTROTECHNICAL COMMISSION

TECHNICAL COMMITTEE NO. 61: SAFETY OF HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES

Guidance document concerning the battery-operated appliances, separable batteries and detachable batteries for battery-operated appliances

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This guidance document concerning the safety of battery-operated appliances, separable batteries and detachable batteries for battery-operated appliances was developed by TC 61/MT 31 [1] [2]. It is intended to provide supporting information for the users of IEC 60335-1 Edition 6, to understand the requirements concerning battery-operated appliances, separable batteries and detachable batteries for battery-operated appliances.

Battery requirements are detailed in the (sub)clauses 3.1.9, 3.5.9, 3.6.4, 3.6.8 – 3.6.12, 3.10, 5.10, 5.17, 5.18, 5.19, 7.12, 8.3, 11.7, 12, 19.1, 19.11.2, 19.16, 19.17, 22.54, 30.2.3.2, Figure 14 and the new Annex B.

Introduction

Lithium cells and batteries are increasingly being used in household appliances. The safety of lithium cells and lithium batteries and appliances incorporating them, depend on the battery management systems, leading to the new requirements that needed to be developed by IEC TC61/MT31.

This document provides guidance on the application of the IEC 60335-1 (*Household and similar electrical appliances – Safety – Part 1: General requirements*) requirements which supports battery-operated appliances as well as separable batteries and detachable batteries for battery-operated appliances incorporating Lithium cells.

Battery safety aspects in IEC 60335-1 Ed.6.0 are incorporated in the main body of the standard and in Annex B. Details of the clauses in the main body of the standard can be found in Annex A.

IEC 60335-1 and in particular Annex B apply to battery-operated appliances, detachable batteries, separable batteries and integrated batteries. Annex B does not apply to non-rechargeable (primary) batteries by themselves. It does also not apply to general batteries (e.g. automotive cranking battery) that are not incorporated in the appliance or part of the appliance. Appliances where that is the case are considered DC supplied appliances.

[1] IEC 62841-1 Annex K was used as a basis.

[2] IEC TC61/MT31 started its work as IEC TC61/WG31

Explanation of safety aspects related to batteries in general and to Lithium battery technologies.

Lithium batteries have become the preferred energy source to power a wide variety of consumer goods ranging from mobile phones, children's toys, cars, e-bikes and household appliances. Its main reason being its huge energy storage capacity.

Though widely used, most people are not aware that lithium batteries are potentially dangerous goods that can pose a safety risk if they are not correctly used.

Batteries, especially lithium-ion batteries, might seem fully discharged but may still have lots of energy stored in them and pose a safety risk.

Damaged or defective lithium batteries and battery-powered devices containing them are likely to create sparks or produce excessive heat. For this reason, they should be transported, used, and stored in a safe way.

Lithium-ion batteries (in IEC 60335-1 referred to as "Metal-ion") have no inherent overcharge protection and could lead to an exothermic event (potentially resulting in thermal runaway).

An exothermic event of a lithium-ion battery occurs when a cell, or area within the cell, reaches an elevated temperature as a result of a mechanical failure, thermal failure, internal/external short-circuiting, and/or electrochemical abuse. At this elevated temperature, an exothermic decomposition of the cell materials starts. This eventually results in the self-heating rate of the cell being greater than the rate at which heat can be dissipated to the surroundings. The cell temperature rises exponentially, such that the stability is ultimately lost. This loss in stability is unstoppable and happens in milliseconds, where all the remaining energy (both thermal and electrochemical) is released suddenly. The risk of exothermic events occurring increases with the duration of elevated temperature and state of charge.

Battery circuits are generally floating circuits meaning that an electrical shock hazard only occurs upon touching two parts of the circuit with a hazardous potential difference. However, if somehow a connection is made to an accessible reference such as earth, only touching a single point of the circuit with hazardous potential could cause an electrical shock hazard.

Examples of such reference connections are:
- actual protective or functional earth connection
- wired communication connection,
- wired supply connection.

Explanation of battery terms

Primary (non-rechargeable) battery vs. Secondary (rechargeable) battery

- Cell vs. battery (subclauses 3.6.8 and 3.6.9)
- Detachable battery (subclause 3.6.10)
- Separable battery (subclause 3.6.11)
- Integral battery (subclause 3.6.12)
- General-purpose battery (not a defined term)

Cell versus battery

Battery-operated appliances derive their energy from batteries which enables the appliance to perform its intended function without any additional supply connection. Cells come in a variety of shapes and sizes and have various chemistries such as Lithium-ion (Li-ion), Nickel-Metal Hydride (Ni-MH) and lead-acid. The standard uses the term Metal-ion to describe cells / batteries which include Lithium-ion cells / batteries, not to be confused with Lithium-metal cells.

Cells are defined as a basic functional unit, consisting of an assembly of electrodes, electrolyte, container, terminals, and usually separators providing a source of electric energy obtained by direct conversion of chemical energy.

These cells are assembled into a "battery" which is defined as an assembly of one or more cells ready for use as a source of electrical energy, characterized by its voltage, size, terminal arrangement, and capacity.

A battery can be classified into two different categories, either non-rechargeable (primary batteries) or rechargeable (secondary batteries).

A non-rechargeable battery is supplied in a fully charged state and cannot be recharged once depleted. They are made of cells whose electrochemical reaction cannot be reversed. A non-rechargeable battery is not intended to be recharged.

A rechargeable battery has electrochemical cells whose chemical reactions can be reversed by applying a specified voltage, in accordance with the manufacturer's recommendations, to the battery. A rechargeable battery, unlike a non-rechargeable battery, is intended to be discharged and recharged many times.

There are three different "rechargeable battery" designs that are employed in battery-operated appliances. They are either detachable, separable, or integral batteries.

Detachable battery

A detachable battery is a rechargeable battery in an enclosure separate from the battery-operated appliance, intended for use with specific appliances and intended to be removed from the appliance for charging purposes. Figure 1 shows examples of a detachable battery pack.

Figure 1a – Examples of detachable battery pack

Figure 1b – Examples of detachable battery pack

Separable battery

A separable battery is a battery contained in an enclosure separate from the battery-operated appliance, intended for use with specific appliances and connected to the appliance by a cord external to the enclosure of the appliance. Figure 2 is an example of a separable battery pack.

Figure 2 – Example of Separable battery pack

Note that a detachable battery and separable battery have an enclosure that is separate from the appliance but equivalent in properties to that of the appliance itself.

Integral battery

An integral battery is contained within the battery-operated appliance and is not removed from the appliance for charging purposes. An integral battery may have no enclosure or an enclosure less substantial than that of the appliance, as they are protected by the enclosure of the appliance.

Battery-operated appliances typically have a separate charger that plugs into the product or a separate base. Figure 3a is an example of a battery-operated appliance with an integral battery that is non-replaceable and rechargeable. Note that a battery that is only to be removed from the battery-operated appliance for disposal or recycling is still considered to be an integral battery. Some appliances have integral batteries that are either replaceable and rechargeable (See Figure 3b) or non-replaceable and non-rechargeable (See Figure 3c).

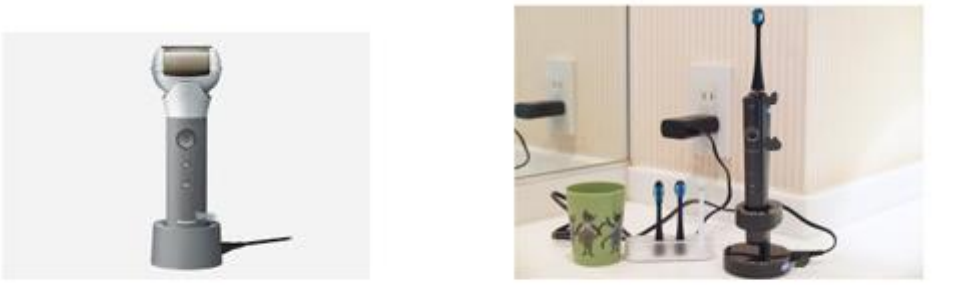


Figure 3a – Example of appliance with an integral battery that is non-replaceable and rechargeable.

An appliance with an “integral battery” that is replaceable and rechargeable is shown in Figure 3b.

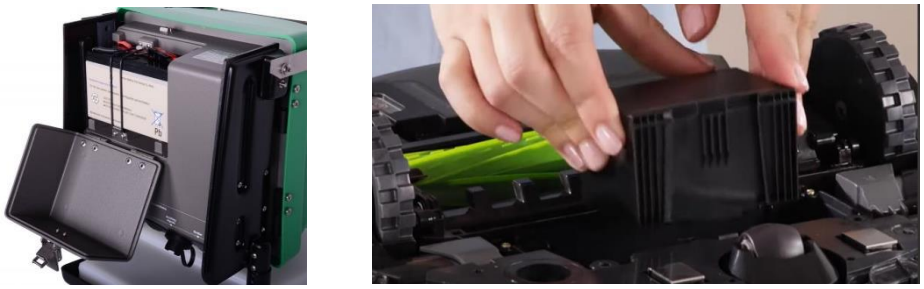


Figure 3b – Example of appliance with integral battery that is replaceable and rechargeable battery.

An appliance with an integral battery that is non-replaceable and non-rechargeable is shown in Figure 3c.

Figure 3c – Example of appliance with integral battery that is non-replaceable and non-rechargeable

General purpose battery

Battery operated appliances may also be powered by general purpose batteries that are replaceable.

IEC 60335-1 includes the requirements for evaluating these types of products where the battery, provided with or intended for the appliance, is replaced with an artificial source. That source consists of a DC power supply or a specially constructed battery, the output of each having the characteristics described in Table B.1 Artificial source characteristics for the relevant battery type. Figure 4a is an example of an appliance with a general-purpose battery that is replaceable and non-rechargeable. Figure 4b is an example of an appliance with a general-purpose rechargeable battery that is replaceable and rechargeable.

Figure 4a – Example of appliances with non-rechargeable general-purpose battery that is replaceable.

Figure 4b - Example of appliances with a rechargeable general-purpose battery that is replaceable.

Explanation of electrical safety principle

For installations within buildings generally, the supply circuit is connected to earth, meaning that touching a single live part could result in an electric shock.

To protect against electric shock there are several different methods. According to the basic safety standard IEC 61140, two independent safety means are required to guard against single fault failures. Usually, protection against electric shock is realized by:

- Basic Insulation (BI) + Insulated Environment = class 0
- Basic Insulation (BI) + Protective Earth (earthed metal enclosure/parts) = class I
- Basic Insulation (BI) + Supplementary Insulation (SI) = class II

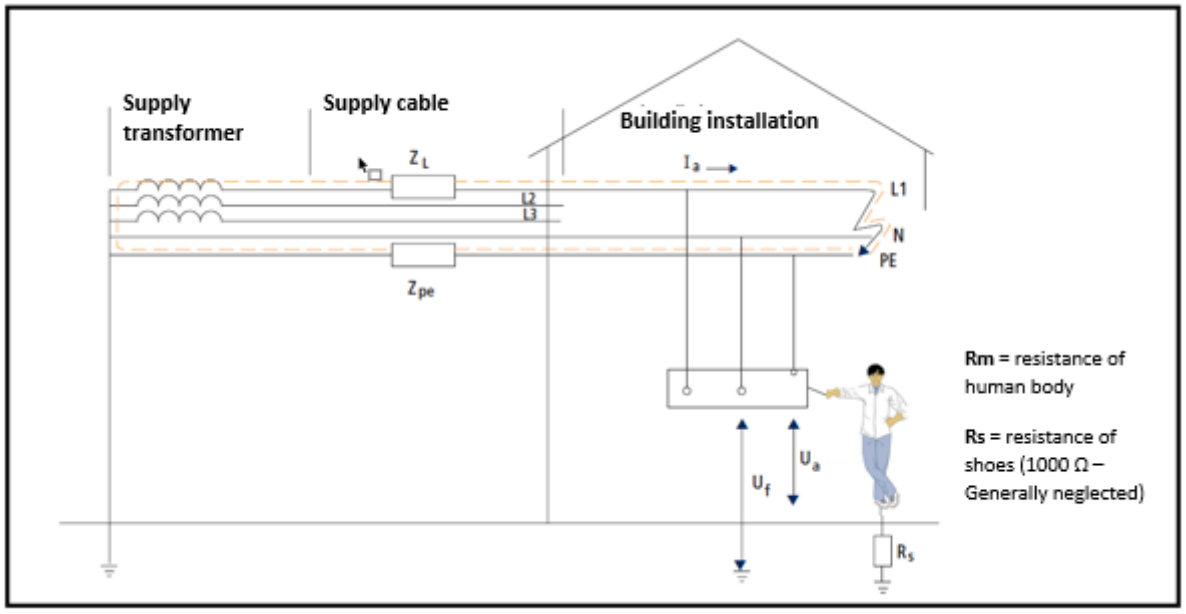


Figure 5a – Explanation protection against electric shock in class I and class II on mains supplied appliances

An alternative to this is creating a circuit that is electrically isolated from the mains supply, and no direct connection to mains reference exists e.g. earth. When this circuit is electrically isolated from mains supply by Double Insulation (meaning Basic Insulation plus Supplementary Insulation) or galvanic isolation from the mains supply and has a voltage that is extra low (< 42,4 V), so-called safety extra low voltage, this is called class III construction, which is not generally considered a shock hazard for contact with dry skin.

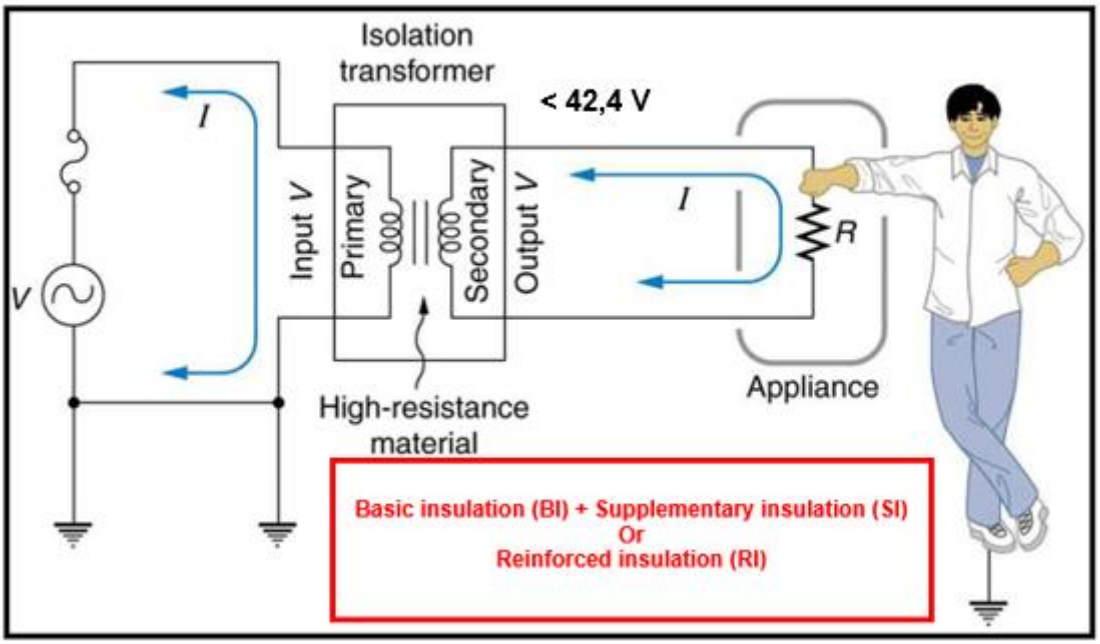


Figure 5b – Protection against electric shock via safety isolating transformer (class III construction)

In battery-operated appliances supplied by the battery, there is generally no voltage reference such as a connection to earth or connection to mains. The voltage of the circuit powered by the battery however is not necessarily low and could be higher than 42,4 V.

This means that without a mains reference (e.g. Protective Earth, Functional Earth, LAN-connection, etc.) there is still a possibility of getting an electric shock but only when at least two parts having a potential difference in excess of 42,4V are touched at the same time (simultaneous contact).

For this reason, it was chosen in the standard to address this topic not in clause 8 but in separate subclauses B.22.3 and B.22.4.

As another consequence, batteries and battery-operated appliances are not classified with protection classes against electric shock, hence any insulation is not classed as Basic, Supplementary or Reinforced.

A further notable difference between mains-operated appliances and battery-operated appliances is that for the purpose of limiting touch currents in battery-operated appliances between two parts having a peak voltage difference above 42,4 V, the requirements of subclauses B.22.3, B22.4, and B22.5 apply. In contrast for mains-operated appliances, impedances used for this purpose are regarded as protective impedance and subject to requirements as such e.g.: subclause 22.42.

When assessing battery-operated appliances according to B.22.3 or B.22.4, impedances limiting touch currents or voltage are not regarded as protective impedance and as such not subject to the requirement of subclause 22.42 etc.

It is important to note that for the situation of subclauses B.22.3, B22.4 and B22.5, there is absolutely no connection to Earth and no connection to any supply reference. As soon as there is any reference connection to mains or earth (for example by having communication via a hard-wired connection), the circuitry has to be evaluated considering that touching a single live part will result in an electric shock.

Relationship between main body and Annex B

The annex is written in such a way that it modifies the requirements as written in the main body of the standard.

Battery-operated appliances, appliance parts and accessories such as remote controls containing batteries are tested using the main part of the standard and Annex B depending on the mode of operation. Some guidance is already given in subclause 5.17 in the main part of the standard.

In short Annex B applies to batteries, battery-operated appliances, appliance parts and accessories such as remote controls containing batteries when working in battery mode.

However, on the moment a battery-operated appliance is connected to the supply mains, the main part of the standard applies. This happens if an appliance has dual supply or when it is connected for charging purposes.

In the 1st paragraph of Annex B is written: “The following modifications to this standard are …”

In the 2nd paragraph of Annex B is stated:” The clause numbers in this annex refer to the clause numbers in the main part of this standard. Clauses that are additional to the clauses in the main part of this standard are identified by the adding the Annex letter with the numbering starting at 1.”

The meaning of the 1st paragraph together with the 2nd paragraph is that when:

- a subclause number mentioned in Annex B is identical to that of the main part of the standard (e.g. subclauses 5.2, 7.1, etc. it is modifying the text of the main part of the standard (in most cases this means a replacement of a specific text, similar structure we use in parts 2).
- a subclause number starting with a “B” (e.g. subclauses B.3.1.1, B.5.1, etc.) is a new subclause and has no relation to the main part of the standard.

How does this work?

The requirement in subclause B.3.6.1 of Annex B for example:

” **non-rechargeable battery**
battery that is supplied in a **fully charged** state and cannot be recharged thereafter”

is a modification to the main part of the standard without a relation to the main part of the standard. In other words, it is a new subclause.

The requirement in subclause 5.2 of Annex B for example “*The tests of subclauses B.19.1 to B.19.6 may be carried out on separate samples.”* is a modification by adding a new 3rd sentence to the 1st paragraph of subclause 5.2 of the main part of the standard.

> **5.2** *The tests are carried out on a single appliance that shall withstand all the relevant tests.*
> *However, the tests of Clauses 12, 20, 22 (except 22.10, 22.11 and 22.18) to 26, 28, 30 and 31 may be carried out on separate appliances. The tests of subclauses B.19.1 to B.19.6 may be carried out on separate samples. The test of 22.3 is carried out on a new appliance.*

The requirement in subclause 6.1 of Annex B for example “*Battery-operated appliances without a supply connection or a functional earth connection are not classified with respect to protection against electric shock.”* is a modification of the complete subclause 6.1 of the main part of the standard. A battery-operated appliance with a supply connection or a functional earth connection, according to subclause 5.17, are tested in accordance with the main part of the standards or Annex B as appropriate.

> **6.1** Appliances shall be of one of the following classes with respect to protection against electric shock:
>
> **class 0**, **class 0I**, **class I**, **class II**, **class III**.
>
> If an appliance consists of a part of **class III construction** and a **detachable power supply part**, the complete appliance is classified as a **class I appliance** or **class II appliance** in accordance with the classification applicable to its **detachable power supply part**.
>
> **Battery-operated appliances** without a supply connection or a functional earth connection are not classified with respect to protection against electric shock.
>
> NOTE Potential for electric shock hazard is considered to exist only between parts of opposite polarity with no reference to earth.
>
> *Compliance is checked by inspection and by the relevant tests.*

The requirement in subclause 19.2 for example “Appliances with heating elements are tested under the conditions specified in Clause 11 but with restricted heat dissipation.” is a modification of the complete subclause 19.2 of the main part of the standard.

> **19.2** Appliances with heating elements are tested under the conditions specified in Clause 11 but with restricted heat dissipation. The supply voltage, determined prior to the test, is that required to provide a power input of 0,85 times rated power input under normal operation when the power input has stabilized. This voltage is

~~maintained throughout the test~~.
~~NOTE Controls that operate during the test of Clause 11 are allowed to operate.~~

Appliances with heating elements are tested under the conditions specified in Clause 11 but with restricted heat dissipation.

NOTE Controls that operate during the test of Clause 11 are allowed to operate

The requirement in subclause 19.11.2 for example "*When any of the fault conditions are simulated, the duration of the test is until steady conditions are established*" is a modification of the penultimate (7th) paragraph of 19.11.2 of the main part of the standard.

19.11.2 *The following fault conditions are considered and, if necessary, applied one at a time, consequential faults being taken into consideration:*
a) short circuit of ***functional insulation*** *if* ***clearances*** *or* ***creepage distances*** *are less than the values specified in Clause 29;*
b) open circuit at the terminals of any component;
….
….
For simulation of the fault conditions, the appliance is operated under the conditions specified in Clause 11 but supplied at ***rated voltage****.*

~~*When any of the fault conditions are simulated, the duration of the test is:*~~
~~- *as specified in 11.7 but only for one operating cycle and only if the fault cannot be recognized by the user, for example, a change in temperature;*~~
~~- *as specified in 19.7, if the fault can be recognized by the user, for example, when the motor of a kitchen machine stops;*~~
~~- *until steady conditions are established, for circuits continuously connected to the supply mains, for example, stand-by circuits.*~~
When any of the fault conditions are simulated, the duration of the test is until steady conditions are established.

In each case, the test is ended if a non-self-resetting interruption of the supply occurs within the appliance.

This concept of modification as done in Annex B is similar to what is done in IEC 60335-2-95:2011 + AMD1:2015 + AMD2:2017.

Take subclause 6.1 for example where the 2nd paragraph of part 1 subclause 6.1 is modified:

6.1 Modification:

Drives shall be class I, class II or class III.

Take subclause 7.1 where in the 1st sentence of the 4th dashed item in the 1st paragraph of part 1 is modified:

7.1 Modification:

Drives shall be marked with the rated power input.

Take subclauses 10.1 and 10.2 where the 2nd paragraph of the test specification of part 1 subclauses 10.1 and 10.2 are modified:

10.1 Modification:

Instead of determining the mean value, the maximum value of power input is determined, the effect of inrush currents being ignored.

10.2 Modification:
Instead of determining the mean value, the maximum value of the current is determined, inrush currents being ignored

With respect to Annex B the wording "Modification" is not repeated each time in each (sub)clause as it is already mentioned at the beginning of Annex B "The following modifications to this standard are applicable …"

More details on what is modified is given in **Appendix B** of this document.

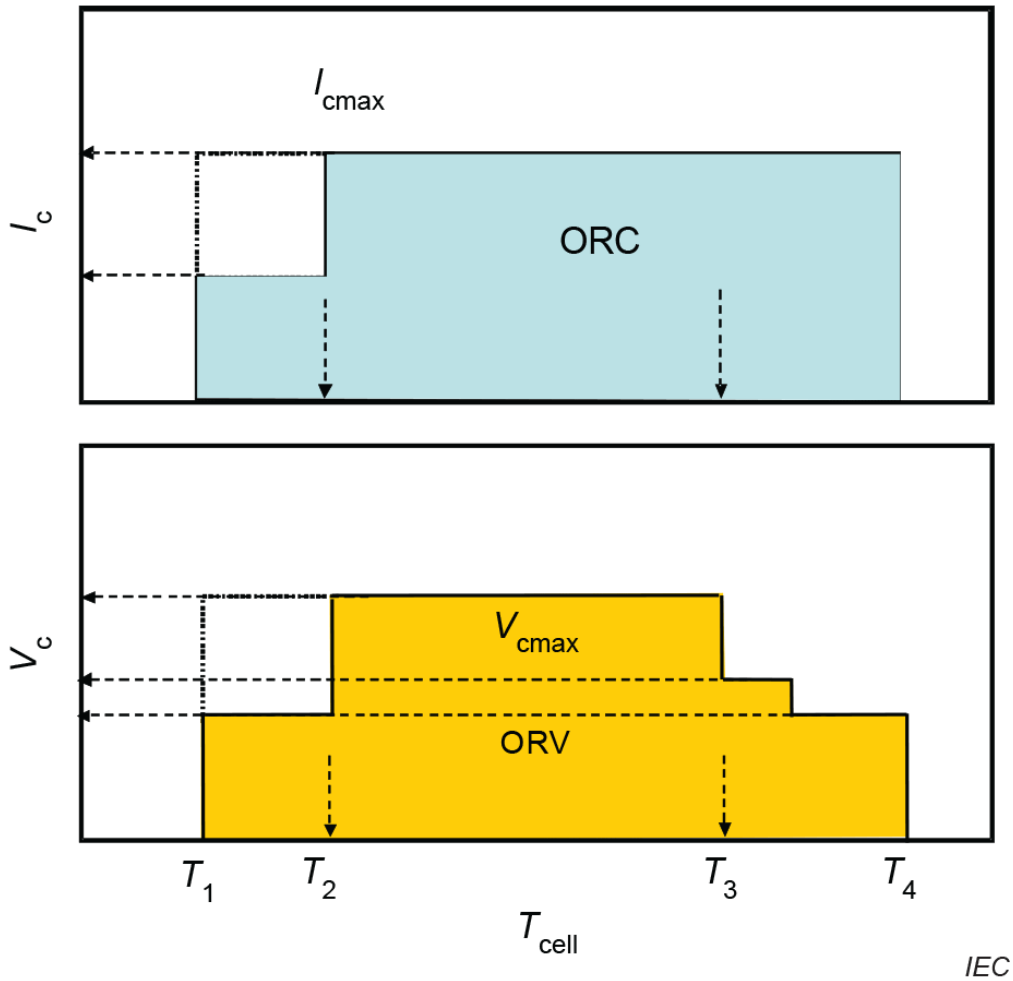
Charging

Reference: clause 12 and subclause 19.17 (Charging of metal-ion batteries)

Although this section is entitled charging of metal-ion batteries, the requirements have been written around lithium-ion batteries as these are well understood and broadly used. Other chemistries of metal-ion are not well documented and therefore these requirements will require adjustment to make them applicable to any future metal-ion chemistry.

The principal concern addressed by clause 12 is overcharging, particularly the repetitive overcharging of a lithium-ion cell. Overcharging of a lithium-ion cell can lead to the progressive degradation of the electrolyte coupled with a higher-than-normal cell energy which can eventually lead to an exothermic event. These exothermic events are associated with extreme temperature, rapid evolution of internal gasses leading to an explosion and a resulting fire that may be projected forcibly out of the cell, sometimes by de-crimping the metal case in the example of rigid cell enclosures. This exothermic event cannot be stopped once initiated and so the only remedy is to avoid those conditions that can cause it. The condition over which the charging system has the most control is to avoid overcharging, both under normal conditions and under fault conditions (see subclause 19.17).

For each specific lithium-ion cell, there is an upper limit charging voltage and a maximum charging current that should not be exceeded for safe operation. These voltage and current limits are generally a function of cell temperature, with the limits being usually constant in the range of 10 °C – 40 °C but may be disallowed entirely outside of that range or have a lower limit. It's important to understand that, unlike a heating test, there is no limit of the cell temperature, it is just that the charging limitations are a function of that cell temperature. There is always a temperature below which the cell is not to be charged and a temperature above which it should not be charged. At other extreme temperatures, the allowable voltage and current may be less than that allowed from 10 °C - 40 °C. This is expressed graphically in Figure 14, reproduced here for convenience. This graphic and the corresponding limit values are from IEC 62133-2, the standard for the safety of lithium-ion cells and batteries. Lithium-ion cells used in products covered by IEC 60335-1 are required to comply with IEC 62133-2 (as per B.24.1) and any assessment under that standard will provide the limit values for voltage and current during charging as a function of the cell temperature. This information is utilized in determining compliance with clause 12 and subclause19.17.



Key
T_1 to T_2 low temperature range
T_2 to T_3 standard temperature range
T_3 to T_4 high temperature range
ORC operating region (current)
I_{cmax} maximum charging current
I_c charging current
ORV operating region (voltage)
V_{cmax} **upper limit charging voltage**
V_c charging voltage
T_{cell} cell surface temperature

Figure 6 - IEC 60335-1 ed.6 Fig.14 – Example of a specified operating region of a lithium-ion cell during charging.

It should be noted that clause 12 and subclause 19.17 refer to the charging system, comprised of all of the elements from the power source (usually, but not always, the mains) to the actual cells being charged. Many products may distribute the functionality of the charging system between various parts of the product. For example, a wall-mounted adaptor may provide a low voltage supply to a charging base that is used to charge a detachable battery pack. In this case all three components would need to be a part of the investigation. In addition, for this example IEC 60335-2-29 may also be applicable to the battery charger consisting of the adaptor and charging base.

During the test, the entire charging system is held at an ambient temperature that is based on the appliance manufacturer's instructions regarding charging. In the case where the charging instructions limit charging to 10 °C - 40 °C, then the test can be run at 20 °C. If the instructions specify an ambient temperature range that is wider than 10 °C - 40 °C, then the test is repeated at those extremes.

During the test, each cell voltage in a series string has to be monitored differentially to check that no cell's voltage exceeds the limit value. Likewise, the charging current into each cell is to be monitored to make sure that the maximum charging current for that cell is not exceeded. When cells are configured in parallel, this can pose a practical problem of determining what current each cell is receiving. Rather than needing to install a current loop into a battery configuration, the standard offers some shortcuts that are considered acceptable.

To determine if the system complies, the cell temperature needs to be determined as this is the independent variable in determining the voltage and current limits. Each cell temperature needs to be monitored and recorded. The cell temperature in the case of when the measurements are made at a 20 °C ambient are adjusted to reflect what these temperatures would be at the ambient temperature limits specified by the appliance manufacturer. In the case where charging is repeated at an extreme ambient outside of the 10 °C - 40 °C range, these temperatures may be determined directly. Note that cell temperatures may change during the charging cycle and therefore the corresponding limit values may also change.

In series configured batteries of lithium-ion cells, the state of charge of the cells with respect to each other will vary over time due to the ageing processes, slight inconsistencies of capacity from cell to cell and temperature differences between cells over the life of the battery. This means, generally, that whatever system is used by the appliance to ensure that cells do not exceed the upper limit charging voltage, it is able to function correctly under this fully anticipated condition. For this reason, the charging test is repeated, but this time with a deliberately induced imbalance in the series battery by having one cell at 50% charge while the remainder are fully discharged. As the battery is charged, this cell will be at a higher voltage than the rest and would be expected to be the cause of charge termination.

This test may be modified if it can be shown by design or testing that this level of imbalance would not occur. An example of each approach is provided in Clause 12, but this is not intended to be an exhaustive list. In any case, if there is a lower level of imbalance, then this imbalance can be used rather than the 50%. This is not as rare a case as might be expected with more battery management system (BMS) integrated circuit controllers being capable of performing cell balancing.

This test utilizing an imbalanced series battery is effectively repeated in subclause 19.17 a) with the exception that, as a test in clause 19, any circuitry responsible for successfully passing the test would be treated as a protective electronic circuit (PEC) and would be subjected to the faults of 19.11.2 being introduced as required by subclause 19.11.3. Additionally, the circuit would need to comply with other sub-clauses related to PEC's, specifically 22.46 and the EMC immunity requirements of subclauses 19.11.4.1 to 19.11.4.8.

When programmable Protective Electronic Circuits are used to ensure compliance, the PEC software is required to contain measures to control the fault/error conditions specified in Table R.1.

In a similar manner in subclause 19.17 b), any electronic circuit that is used to fulfil the lower imbalance testing of clause 12, would itself be treated as a PEC. Note that parts a) and b) of subclause 19.17 are tested separately from each other.

The last of the charging abnormal tests is in subclause 19.17 c) and requires one cell of a series string to be shorted and the remaining cells initially charged to 50%. The shorted cell should be discharged slowly and then shorted across the cell terminals. Charging is conducted without any additional abnormal condition as the cell being shorted is considered the introduction of the fault and any additional fault (such as would be introduced by subclause 19.11.2) would be considered two simultaneous faults.

The purpose of treating these circuits as PEC's underscores the importance of ensuring that cells do not overcharge as this fault alone could result in fire and explosion.

It should be noted that the acceptance criteria for these tests where faults are inserted as in subclause 19.11.2 is that the cell voltages may not be greater than the upper limit charging voltage plus 150 mV unless the charging system permanently disables recharging. The standard describes how to determine this permanent disabling through a discharge followed by an attempted recharge cycle. The 150 mV margin over the upper limit charging voltage is considered to be safe for cells that are not also subjected to subsequent extreme environmental abuse.

It should also be noted that subclause 19.17 does not monitor the battery charging current, just the cell voltages, which are different from the test of clause 12.

In all the tests of subclause 19.17, fire and explosion are, not surprisingly, not permitted outcomes, but venting is allowed. Vents that are a feature of most rigid walled cells, are designed to release internal pressure of the cell before a more violent uncontrolled release occurs, such as the de-crimping of the top cap of a cylindrical cell.

The increased use of pouch type cells, where there is typically no defined vent, challenges the standard as when there is a release of internal pressure it is usually through a seam of the pouch in an unpredictable location. There is a remaining question of how to interpret this situation. Although not directly addressed by the standard, one may judge if this pressure release is equivalent to a vent if its action occurs in the same seam location through multiple trials.

The last test d) of subclause 19.17 differs significantly from the other tests of this subclause as it doesn't concern itself with charging per se, but rather the effect of back feed from the battery back into the rest of the charging system when all the charging system components are connected normally. In this part, short circuits are introduced in locations upstream from the normal path of current to assess if current that is back fed from the battery could cause a fire or any of the other outcomes as listed in subclause 19.13.

Moisture Resistance

Clause 15 of IEC 60335-1 is applicable, and Annex B does not have any specific modifications.

With reference to subclause 5.5, battery compartments covers / doors are kept closed according to the manufacturers' instructions while performing all the moisture resistance testing unless the manufacturers' instructions indicate that the battery compartment can be open in wet conditions.

Subclause 15.1 (protection against harmful ingress of water)

Battery-operated appliances are subject to subclause 6.2 and may have their own IP rating. Minimum IP ratings are specified in the relevant part 2. Such ratings may apply to battery-operated appliances, remote controls, detachable batteries and separable batteries as indicated in Annex B, subclause 7.1. Unless otherwise specified in the standard, different parts of an appliance may have different IP ratings.

The IP rating for liquid ingress is tested as per the requirements of subclause 15.1.

The IP test is to be conducted with detachable / separable batteries in place. Testing of the appliance without the detachable / separable batteries in place should only be considered if the instructions specifically suggest the removal or replacement of batteries while exposed to moisture.

Additionally, as remote controls, detachable batteries and separable batteries may have individual IP ratings, a separate IP test may be applicable to a detachable or separable battery or remote control alone. This moisture resistance test may be different from the moisture resistance test applicable to the appliance.

The provision "the appliance not being connected to the supply mains" contains two pieces of information: The plug system, if any, which varies from country to country, is not required to be evaluated during this test. This has no implication for battery-operated appliances without mains connection. Secondly, the appliance is not in operation, this is also the case for battery-operated appliances.

Therefore, for an IPX4 rated appliance, provided with a detachable battery rated IPX1, the tests must be performed as follows, where the appliance is not in operation during the test:

- IPX4 test for the battery-operated appliance with the detachable / separable battery attached.
- Battery-operated appliances are only tested without the detachable/separable battery attached if such moisture resistance is indicated in the instructions provided with the appliance. Otherwise, it is not necessary to remove detachable/separable batteries for the purposes of 15.1 and 15.3 since this would unnecessarily expose the battery connectors which is only expected during user maintenance either indoors or after such exposure to moisture has ceased.
- IPX1 test for detachable / separable battery individually, if required by subclause 6.2 or by Annex B subclause 7.1.

The electric strength test of subclause 16.3 is part of the test criteria of subclause 15.1. However, the equipment under test is not considered to have Basic, Supplementary or Reinforced Insulation. Therefore, the test of subclause 16.3 does not apply. The equipment is reviewed with respect to the other criteria, such as the inspection of traces of water which could result in a reduction of clearances or creepage distances below the values specified in clause 29. This evaluation has also to take into consideration all applicable modifications to clause 29 in Annex B, such as protection against simultaneous contact.

Subclause 15.2 (Spillage)

The spillage test is performed as per the requirements of subclause 15.2. For the purpose of conducting the tests of subclause 15.2, remote controls, detachable batteries and separable batteries are removed.

Example: For an appliance subject to spillage provided with a detachable battery, the tests have to be performed as follows:

- Spillage test with the detachable / separable battery attached.
- Spillage test with the detachable / separable battery removed.

Consideration of subclause 16.3 is the same as that stated above for subclause 15.1.

Subclause 15.3 (Humidity)

The humidity conditioning will normally apply to all equipment. The electric strength test of subclause 16.3 is the test criterion of subclause 15.3. However, if the equipment under test is not considered to have Basic, Supplementary or Reinforced Insulation, the test of subclause 16.3 and therefore subclause 15.3 does not apply.

Battery abnormal testing

There are some specific abnormal tests in Annex B that are different from other abnormal tests encountered within the remainder of IEC 60335-1.

The acceptance criteria for these tests are in subclause 19.13 of Annex B which overwrites subclause 19.13 of the main part of the standard. In addition to the appliance not emitting flame, there are also some other specific criteria that mirror those in the main part of the standard:

- Subclause B.22.3 – this is essentially the Annex B equivalent of clause 8 in the main standard where protection from an electric shock hazard is prevented by the inaccessibility of the energized parts. Parts at hazardous voltage should not become accessible as a result of the testing.

- Subclause B22.5 – This is basically an electric strength test of insulating barriers in appliances with hazardous voltage. These barriers cannot be degraded by the abnormal test.

- Clause 29 – Creepage distances and clearances cannot be reduced below the minimum values as a result of the test.

Subclause B.19.1

For appliances where the battery terminals have any indication of correct polarity and it is expected that the battery will ~~to~~ be reconnected by the user ~~either~~ such as during replacement of the battery ~~at the battery's end-of-life~~, ~~the~~ reconnection of a detachable battery after recharging, or the connection of the cable of a separable battery, a reversing of the polarity of the battery connector may lead to an unacceptable outcome. Where the physical design of the interface or the battery compartment makes this reversal not possible (as determined by attempting to insert the battery backwards), there should be no attempt to subvert this design to conduct the test. ~~If such a connection is allowed by design, the test should be conducted.~~ In some of these cases, blocking diodes or other electronics may be present to block the flow of current. If this is the case, the device should be treated as a PEC or bypassed, and the test repeated to confirm that the test is reliant on the device or circuit. Although not stated, it is understood that the appliance should be operated during the test otherwise current may not be drawn.

Subclause B.19.2

This requirement is similar in some respects to the requirement of subclause B.19.1 except that it considers the effect of current being supplied to the reversed battery, in addition to the appliance. In this situation, both the appliance and the batteries may experience some effect. Again, if the interface is designed so that reversal is prevented, there should not be any attempt to subvert the design. It should be pointed out that this test is for batteries intended to be removed and replaced, not requiring opening enclosures that are screwed together, removing soldered connections, etc. to replace batteries.

Subclause B.19.3

This requirement checks to see if the internal wiring can withstand the highest expected fault current without

causing a fire. Usually, some components open circuit during the test, interrupting current and ending the test. At the instant where the component opens, there can be a flash which should not be confused with the "emitting flame" of subclause 19.13 of Annex B which establishes the acceptance criteria for the test.

Subclause B.19.4

The purpose of this test is to force a cell into "reverse charging" which is a real-life situation when one cell is at a lower state of charge compared to the other cells in a series string. During discharge, the low charge completely discharges first and then goes negative as the remaining capacity of the other series cells drives current through the cell, reversing its potential. When a cell goes negative, its impedance rises sharply, and it will get very hot due to high $\mathbf{I^2R}$ heating. This test represents the worst-case scenario with a completely discharged cell driven negative by the remaining cells which are all fully charged. The cell is usually destroyed and reaches very high temperatures, sometimes resulting in fire due to forceful venting and the ignition of the (flammable) electrolyte.

This test only needs to be completed if the appliance contains more than one cell.

Subclause B.19.5

This subclause contains three short circuit tests that all have different objectives.

- The test of the first dash is effectively shorting the output terminals of a battery, but because it is a test of a separable battery pack, the interest is on what would happen if a short were to develop in the cord of the separable battery that connects from the battery to the appliance. Generally, the most adverse effects occur when the short is placed furthest away from the battery as this allows for the most dissipation of heat. Test failures occur when the internal conductors get hot enough to ignite the wire insulation. Short circuits are introduced by cutting away insulation at the point to be tested and a jumper of the required resistance inserted. Care should be taken that the jumper is not near enough to the insulation that it causes ignition.

- The second dash is referring to replaceable cells and batteries which could be rechargeable batteries that are integral in appliances that may be changed when the end of life is reached or even primary (non-rechargeable) cells and batteries that are to be changed when they are exhausted. In these cases, the exposure to the battery terminals is infrequent. It does not cover detachable batteries, which are removed frequently for recharging and are not considered to be replaceable. This test involves shorting out the terminals with a straight metal bar such that the portion that makes contact with the terminals (assuming that it actually can) sees no more than 10 mΩ resistance. Compare this to the more intrusive requirement of B.19.6 for detachable and separable batteries.

- The third dash deals with the possibility of back feed from an appliance with integral batteries through charging terminals. Sometimes these products have contact pads that make contact with corresponding locations on a charging base. The test ensures that if in turn these contacts both are readily accessible to a single test probe 13 of IEC 61032, such as without moving any sprung covers to gain access to a terminal, that shorting them through some external path does not create a problem. A similar test exists for the battery charger cable of an integral appliance in 19.17 d) in the main part of the standard.

Subclause B.19.6

This test is checking for the effects of a short-circuit across readily accessible ~~the~~ terminals of a detachable or separable battery, but determines accessibility with ~~the~~ a single ~~IEC~~ test ~~pin~~ probe 13 of IEC 61032 in the same way as the third dashed item of B.19.5, which reflects the likely intrusion of small objects causing a short in real-life. This is much more intrusive than the test of subclause B.19.5, second dash.

Venting

References:

Of cells: Subclauses 3.10.5, 19.13, 19.17, B.22.1, B.22.6

Of Batteries: Subclauses B.20.1, B.20.2

All rigid enclosure cells are provided with a vent that is designed to relieve excessive pressure that may build up in the cell. This excessive pressure is not normal, it is due to some internal failure of the cell or some

external abnormal condition that the cell has been exposed to. The pressure may be a result of overheating causing the expansion of gasses in the cell enclosure, or through chemical activity, brought on through overcharging where the normal gases associated with overcharging are generated. The worst condition is as a result of an exothermic event in lithium-ion cells, where vast quantities of gas can be generated in a very short time. In all but the last case, the cell vent is designed to adequately permit the gases to be released quickly enough to avoid a total rupturing of the cell enclosure. During an exothermic event, this may not be the case and the cell may rupture, typically by blowing off the cap of the enclosure by de-crimping. Rupture can also occur if the vent is damaged or blocked or otherwise prevented from operating. Generally, the standard permits the operation of the vent under abnormal conditions, but not during normal conditions. The cases where it is permitted to operate are given in 19.13, 19.17 and B.22.1. If venting is relied upon for compliance with the standard, cell vents may not be obstructed (see B.22.6), either as received or as a consequence of some test, such as drop or impact. It has been found that open-cell foam, often used to protect the cells from damage within the battery enclosure, does not normally adversely affect the vent's ability to function properly. Correctly designed vents on rigid enclosure cells are designed to release gasses, but not electrolytes when they operate.

Pouch cells do not usually have a explicit vent but tend to release gasses under abnormal conditions by splitting open the pouch, which releases gasses, but which may also release electrolyte. The standard does not specifically address the difference between pouch cells and cells with rigid enclosures (such as cylindrical and prismatic cells) and therefore it takes some interpretation to apply the safety requirements of the standard to these cells.

Batteries that contain lithium-ion cells are also evaluated for the condition that might occur when a cell within the battery may undergo an exothermic event. In this case, vast quantities of gasses may be released either through the vent or through a rupture. The concern is that these gasses may pressurize the battery enclosure to the point where it may rupture itself, sending fragments of the enclosure into the environment, possibly striking the user or a bystander. To evaluate this risk, the battery enclosure must either meet a requirement for a suitably large opening to allow the gasses to escape or to undergo a test where a volume of air at a high pressure is released into the enclosure to simulate the cell-level event. The enclosure must not explosively rupture. Moreover, since it is possible that multiple cells may sequentially fail, the gas must dissipate quickly enough so that there is no stepped build-up of pressure from a multi-cell event. Since the amount of gas generated is expected to be a function of cell capacity, the test parameters are adjusted accordingly. There are two tests for this anticipated condition, B.20.1 for integral batteries where the battery enclosure is considered to be the appliance enclosure and B.20.2 where the battery has a separate enclosure. Otherwise, the tests are equivalent. It should be noted that the tests must be run with the cells (or an equivalent displaced volume) occupying the battery enclosure. Often, to run the test, a special 'sealed fitting' needs to be made to allow the introduction of gas into the enclosure.

Connectors

Subclause B.22.1

This subclause requires that user accessible connectors in the charging system are not able to directly connect to existing mains type plugs or common connector types for existing power adapters that both may inadvertently cause safety concerns from a catastrophic overload of the battery system if the user were to already have access to such unknown or incompatible supplies. The requirement is to ensure that either any user interfaces are proprietary or are alternatively adequately tested against such a foreseeable misuse.

The use of an incorrect supply must include consideration of not just incorrect voltage but also incorrect polarity being connected to the appliance. This is because an incorrect supply may have an unknown polarity but also because the power switching and any associated protection within any appliance may be on either supply line. Compliance must therefore be determined with the most unfavourable polarity of the input supply as the result may differ depending on the input polarity assessed.

Construction

Subclause B.22.5

The new additional subclause B.22.5 has no relation to the requirements of subclause 22.5 of the main body of the standard. The subclause specifies requirements for insulation material in the case that the appliance is just operated by batteries without any supply mains connection. In this case, the voltage inside the appliance has no relation to earth (floating voltage). Touching just one pole of the battery will not cause any hazardous

situation in terms of electrical shock even if the voltage exceeds 42,4V. There can only be a risk if the user touches the two poles of the battery simultaneously and the voltage exceeds the limit for SELV.

For the insulating material itself, there are no requirements for the thickness of the material. The properties are just approved by the electric strength test of the material itself.

Clearances, creepage distances and solid insulation

Clause 29

Clause 29 in Annex B consists of three subclauses. Subclause 29.1 refers to the main body of the standard. The subclauses B.29.1.1 and B.29.2.1 are additional and therefore independent from the main body and provide new requirements. Therefore, all other subclauses of clause 29 of the main body are still applicable without any change of the content.

Subclause 29.1

The requirements of subclause 29.1 of Annex B are to be considered as a modification of the first 5 paragraphs of subclause 29.1 of the main body except for table 16, so the requirement section only.

For mains-operated appliances, the rated impulse voltage is based on supply mains disturbances. For battery-operated appliances, this does not apply, and therefore the clearances for battery-operated appliance are not determined using the values of table 15. However, to stay in line with the general structure and approach of the standard two values are given for rated impulse voltage to be used, 500 V for working voltages less than 50 V and 1 500 V for all other working voltages.

Subclause 29.1.1, 29.1.2, 29.1.3 and 29.1.4 remain unmodified. As well as the complete subclauses 29.2 and 29.3.

Regardless of voltage, this means that battery-operated appliances without supply connection are not specifically required to have Basic Insulation, Supplementary Insulation or Reinforced Insulation and therefore the subclauses:

- 29.1 .1 ~ 29.1.3 and 29.1.5 are not applied,
- 29.2.1 ~ 29.2.3 are not applied,
- 29.3, 29.3.1 ~ 29.3.3 are not applied, and
- Sub-clauses 29.1.4 and 29.2.4 are applied to evaluate Functional Insulation.

For conductive parts where there is a hazardous voltage of > 42.4 V between them, the clearances and creepage distances between these parts to protection against simultaneous contact according subclause B.22.3 and B.22.4 are evaluated using subclause B.29.1.1 and B.29.2.1.

For conductive parts where there is no hazardous voltage between them, there are no requirements with respect to clearances and creepage distances.

Subclause B.29.1.1

This subclause defines clearance distances for battery-operated voltages exceeding 42.4 V without additional supply connection. For the determination of the rated impulse voltage clause 29.1 of Annex B applies. The values are doubled, to guarantee the necessary level of protection against electrical shock in a similar way as required for Double Insulation of mains supplied circuits in the main body of the standard. In addition, one of the two clearance distances needs to comply with minimum distance requirements of 1.0 mm.

It covers the fact that battery-operated circuits without mains connection have no relation to earth. Therefore, single pole contact does not cause any risk of electrical shock. The risk of electrical shock is only possible if the user can get access to two parts simultaneously, where there is a hazardous voltage between those parts.

Subclause B.29.2.1

The determination of creepage distances is based on the actual working voltages generated within the appliance independently from the source. Consequently, the subclause refers to table 17 of the main body. In

table 17 minimum creepage distances are defined in relation to material properties and the pollution degree.

The values are doubled, to guarantee the necessary level of protection against electrical shock in a similar way as required for double insulation of main supplied circuits in the main body of the standard. In addition, one of the two creepage distances needs to comply with minimum distance requirements of 1.0 mm. It covers the fact that battery-operated circuits without additional supply connection have no reference to earth. Therefore, single pole contact does not cause any risk of electrical shock. The risk of electrical shock is only given if the user can get access to two parts simultaneously, where there is a hazardous voltage between those parts.

Resistance to heat and fire

Subclause 30.1

In the way subclause 30.1 of Annex B is written, the ball pressure test (BPT) is carried out only on external parts of non-metallic material of battery-operated appliances, batteries, as covered by Annex B, provided the appliance is not connected to an external power supply.

If the appliance is connected to the (detachable) external power supply, e.g. for charging purposes, subclause 30.1 as in the main body of the standard applies.

Subclause 30.2

For subclause 30.2 nothing is changed by Annex B. This means that the glow wire test (GWT) is carried out on parts of a non-metallic material and parts of non-metallic material supporting current-carrying connections regardless of when the appliance is working in battery-powered mode or if it is connected to an external power supply.

APPENDIX A
Overview of clauses in the main body dealing with batteries, cells or battery-operated appliances

Reference	Brief content
1	Scope
2	Normative reference to standards such as: IEC 62133-2
3.1.9	Addition of normal operation conditions for charging of **battery-operated appliances** within the appliance
3.2.2	Notes 1 and 2 in the definition of **interconnection cord**
3.5.9	Definition of **battery-operated appliance**
3.6.2	Note to entry 3 in the definition of **detachable part** explaining that an integral battery solely removed before scrapping is not considered a detachable part
3.6.4	Note to entry 3 in definition of **live part** explaining the relation between parts not exceeding the limits of B.22.3 and B.22.4 and live parts
3.6.8	Definition of **cell**
3.6.9	Definition of **battery**
3.6.10	Definition of **detachable battery**
3.6.11	Definition of **separable battery**
3.6.12	Definition of **integral battery**
3.10	Definitions related to battery charging and discharging (several sub-clauses)
5.10	Information to be provided by the manufacturer for testing purposes
5.17	Explanation of what is tested according to Annex B or the main part of the standard (battery-operated appliances and remote control)
5.18	Conditioning of rechargeable batteries
5.19	Measurement of cell or battery voltages
7.1	Markings
7.12	Instructions
8.3	Insulation requirements for battery-operated appliances with functional earth or supply connection
11.7	Test duration and condition for battery-operated appliance
12	Charging of metal-ion batteries
19.1	Reference to 19.16 and 19.17
19.11	Explanation of test conditions for electronic circuits having batteries
19.11.2	Introduction of fault condition for cords (15 W) between battery-operated appliance and detachable power supply.
19.16	Abnormal condition to verify safe operation not depending upon the presence of a replaceable battery
19.17	Abnormal conditions for **battery systems** using metal-ion chemistry
22.54	Requirements for button and coin cell batteries accessibility
30.2.3.2	Additional requirements on consequential needle flame test - no battery in the area of the vertical cylinder unless shielded by a barrier.
Figure 14	Example of a specified operating region of a lithium-ion cell during charging

Note: This overview is given to provide clarity where in the main body of the standard requirements can be found specific for battery-operated appliances or batteries. It is not intended to be a substitute of the actual requirements in the published standard nor is it to be considered a complete and full list.

APPENDIX B
Overview of clauses in IEC 60335-1 Annex B dealing with batteries, cells or battery-operated appliances

This appendix provides more detailed information on how Annex B modifies clauses of the main body of the standard.

What does "Modification" mean in the "old-style" terminology "Replacement", Addition"...

The modifications in the Annex B can be:

- an addition to the requirements of the main part.
- a partial replacement – Only one paragraph can be replaced by another one.
- a complete replacement of the text of the main part.
- non-application of the requirements.
- a new (sub)clause

Most of this information is taken from IEC 61/5735/CDV, former Fragment 3 of IEC 60335-1 Ed 6.0 dealing with the content of Annex B before it was rewritten in a more concise manner.

Reference	Instruction	Brief content
(Introduction)	New text explaining what is covered and how to apply annex B	
B.3.1.1	New subclause. B.3.1.1 having additional requirements on normal operation for battery-operated appliances.	Definitions relating to physical characteristics
B.3.6.1	New subclause.	Definitions relating to parts of an appliance
5.2	Modification by adding a new 3rd sentence.	Testing of B.19.1 – B.19.6 on separate samples allowed
5.8.1 5.8.2 5.8.3 5.8.4	Modification of clauses by making them not applicable for battery-operated appliances	N/A
B.5.1	New subclause (addition)	Battery fully charged
B.5.2	New subclause (addition)	Rated voltage = fully charged battery
B.5.3	New subclause (addition) Including Table B.1	DC power supply alternative
6.1	Modifies the complete subclause in the main part by replacing it. (under certain conditions)	No classification for battery-operated appliances w/o supply/earth connection
7.1	Modifies the 1st paragraph in the main parts by replacing it. Additional explanation: The requirements in Annex B subclause 7.12 applies to the battery-operated appliance, detachable battery, etc. The requirements in Main body subclause 7.12 applies to the appliance when connected to the mains, such as to the detachable power supply unit. See also subclause 5.17 (main body)	Markings
7.6	Modification by adding new symbols for battery-operated appliances	Symbols
7.12	Modifies the complete subclause 7.12 of the main part by replacing it. Additional explanation:	Instructions

APPENDIX B

Overview of clauses in IEC 60335-1 Annex B dealing with batteries, cells or battery-operated appliances

Reference	Instruction	Brief content
	The requirements in Annex B subclause 7.12 applies to the battery-operated appliance, detachable battery, etc. The requirements in Main body subclause 7.12 applies to the appliance when connected to the mains, such as the detachable power supply unit. See also subclause 5.17 (main body)	
7.15	Modification by adding requirements for battery operated appliances	Location of markings
8	Modification of the complete clause 8 including all its subclauses (under certain conditions).	Protection against access to live parts
10.1	Modification by making them not applicable to battery-operated appliances	N/A
10.2	Modification by making them not applicable to battery-operated appliances	N/A
11.1	Modifies the complete subclause 11.1 of the main part by replacing it	Heating
11.4 11.5 11.6	Modification of clauses by making them not applicable for battery-operated appliances	N/A
B.11.1	New subclause (addition)	Heating test conditions for battery-operated appliances
19.1	Modification by adding requirements for battery-operated appliances and batteries. The other paragraphs remain applicable for battery-operated appliances. Additional information: The requirements of the main body 19.1 are identical. The modification in Annex B 19.1 is describing the tests applicable (italic text). The tests of 19.3, 19.5, 19.6, 19.8, 19.10, 19.16 and 19.17 in the main body of the standard are not applicable in Annex B. The tests of 19.11.4.3 through 19.11.4.7 in the main body of the standard are not applicable in Annex B (since these test can only be conducted while connected to the mains).	Abnormal operations of battery-operated appliances
19.2	Modifies the complete subclause 19.2 of the main part by replacing it	Test conditions on battery-operated heating appliances
19.7	Modifies the complete subclause 19.7 of the main part by replacing it.	Locking rotor/moving parts for battery-operated appliances
19.11	Modifies the complete subclause 19.11 of the main part by replacing everything except the second paragraph.	Electronic circuits of battery-operated appliances
19.11.2	Modification (Replacement) of the penultimate paragraph incl. the three dashed items of the test	Electronic circuits of battery-operated appliances
19.11.4	Modifies the complete subclause 19.11.4 of the main part by replacing it.	Electronic circuits of battery-operated appliances

APPENDIX B

Overview of clauses in IEC 60335-1 Annex B dealing with batteries, cells or battery-operated appliances

Reference	Instruction	Brief content
19.11.4.8	Modifies the complete subclause 19.11.4.8 of the main part by replacing it.	Electronic circuits of battery-operated appliances
19.13	Modifies the complete subclause 19.13 of the main part by replacing it.	Acceptance criteria for battery-operated appliances
19.15	Modification (Replacement) of the complete sub-clause.	Manual voltage selector switch
B.19.1	New clause (addition).	Abnormal test of battery-operated appliances - Opposite polarity - Reversal of batteries - Short circuiting of terminals
B.19.2	New subclause (addition).	
B.19.3	New subclause (addition).	
B.19.4	New subclause (addition).	
B.19.5	New subclause (addition).	
B.19.6	New subclause (addition).	
B.20.1	New subclause (addition).	Possibility of venting
B.20.2	New subclause (addition).	Possibility of venting
21.1	Modifies the complete subclause 21.1 of the main part by replacing it.	Impact and free fall test on battery-operated appliances
B.21.1	New subclause (addition) specifically explaining mechanical test requirements for separable batteries and detachable batteries.	Impact and free fall test on separable and detachable batteries
22.11	Modification (Replacement) of the first paragraph	Non-detachable parts
22.20	Modification (Replacement) of the 1st and 2nd paragraph	Thermal insulation
22.24	Modification by adding deviations for specific battery-operated appliances.	N/A for battery-operated appliances not containing parts according subclause B.22.3
22.25	Modification by adding deviations for specific battery-operated appliances.	N/A for battery-operated appliances not containing parts according subclause B.22.3
22.26 22.27 22.28 22.29 22.30 22.31 22.32	Modification of clauses by making them not applicable for battery-operated appliances.	N/A
22.33	Modifies the 1st – 5th paragraph of subclause 22.33 of the main part by replacing it.	Conductive liquids
22.34 22.35 22.36 22.37	Modification of clauses by making them not applicable for battery-operated appliances.	N/A
B.22.1	New subclause (addition).	Connectors (other than mains)
B.22.2	New subclause (addition).	Protection of batteries from excessive heat
B.22.3	New subclause (addition).	(Simultaneous contact of) hazardous voltage on battery-operated appliances
B.22.4	New subclause (addition).	(Simultaneous contact of) hazardous voltage on separable and detachable batteries

APPENDIX B
Overview of clauses in IEC 60335-1 Annex B dealing with batteries, cells or battery-operated appliances

Reference	Instruction	Brief content
B.22.5	New subclause (addition).	Electric strength of insulation to protect against (simultaneous contact of) hazardous voltage
B.22.6	New subclause (addition).	Vents of cells
23.3	Modification by adding deviations for battery-operated appliances.	Referring to electric strength test of subclause B.22.3 for battery-operated appliances
23.5	Modification by adding deviations for battery-operated appliances.	Referring to subclause B.22.5 for battery-operated appliances
24.1	Modification by adding deviations for battery-operated appliances.	Batteries need not comply with IEC 62133-1 or -2
24.1.1	Modification of subclause by making it not applicable for battery-operated appliances.	N/A
24.1.3	Modification (Replacement) of the complete sub-clause.	Switches
B.24.1	New subclause (addition).	Cells need to comply with IEC 62133-1 or -2
25.9	Modification by adding requirements for battery-operated appliances.	Applies also to interconnection cords of battery-operated appliances
25.14	Modification by adding requirements for battery-operated appliances.	Applies also to interconnection cords of battery-operated appliances
25.15	Modification by adding requirements for battery-operated appliances.	Applies also to interconnection cords of battery-operated appliances
B.25.1	New subclause (addition).	Requirements for interconnection cords of battery-operated appliances
B.26.1	New subclause (addition).	Terminal devices used in battery-operated appliance for connection separable battery
27.1	Modification by adding requirements for battery-operated appliances.	Battery-operated appliances no provisions for protective earth.
29.1	Modifies subclause 29.1 of the main part and its subclauses by replacing it. Although not written specifically subclauses 29.2 and 29.3 including their sub-clauses do not apply.	Clearances for battery-operated appliances and batteries
B.29.1.1	New subclause (addition)	Clearances for battery-operated appliances and batteries
B.29.2.1	New subclause (addition)	Creepage distances for battery-operated appliances and batteries
30.1	Modification by adding requirements for battery-operated appliances.	External parts of non-metallic materials for battery-operated appliances and batteries
Figures	New Figure B.1 (addition). New Figure B.2 (addition).	Examples of constructions Example of marking polarity of replaceable batteries

Note: This overview is given to provide clarity which clauses of the main body of the standard are modified by Annex B. It is not intended to be a substitute of the actual requirements in the published standard nor is it to be considered a complete and full list.

APPENDIX C
Overview of clauses in IEC 60335-1 Annex B applicable to remote controls

Remote control with non-rechargeable batteries	Remote control with rechargeable (lithium) batteries
B.3.1.1 (3rd dash)	B.3.1.1 (2nd dash)
7.1	B.5.1
7.11	7.1
7.15	7.12
11	11
19.1	19.1
19.13	19.11
B.19.1	19.13
B.19.2	B.19.4
B.19.5	B.19.5
21.1	B.20.1
B.22.1	21.1
B.24.1	B.22.1
29.1	B.22.6
30.1	B.24.1
	29.1
	30.1
Note: for this overview it is considered that the remote control has only voltages < 42,4, V	

Note: This overview is given to provide some clarity which clause would be applicable to remote controls or accessories as these are not battery-operated appliances. It is not intended to be a substitute of the actual requirements in the published standard nor is it to be considered a complete and full list.

APPENDIX D
Determination of applicable requirements for appliances connected to the supply mains and battery-operated appliances covered by Annex B

As the relevant parts of IEC 60335-2-x can modify corresponding requirements in part 1 (IEC 60335-1:202x), it is necessary to consolidate the modifications to determine the applicable requirements of the end-product standard (IEC 60335-2-x).

Appliances connected to the supply mains

For appliances connected to the supply mains, the additions, modifications or replacements of the relevant parts of IEC 60335-2-x add to, modify or replace the relevant text in the main body of this document. See Figure A and Figure C3.

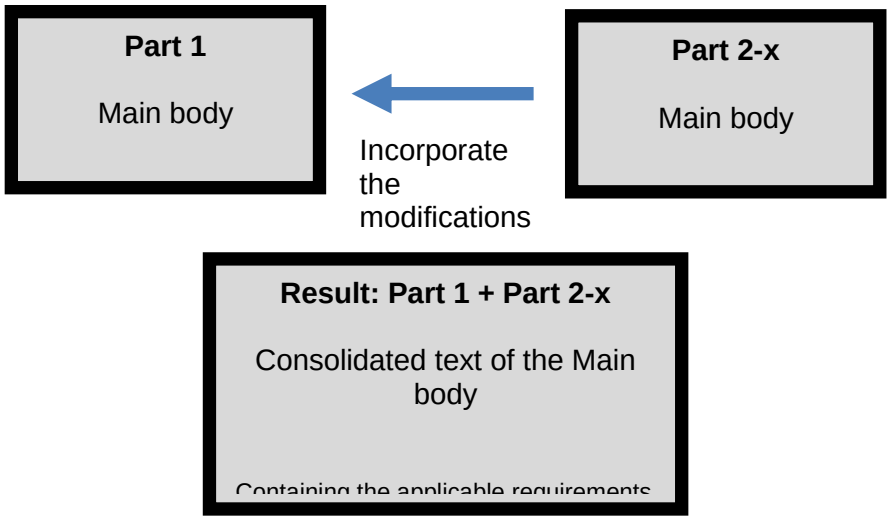


Figure A – The process of creating the consolidated requirements for an appliance connected to the supply mains.

Battery-operated appliances covered by Annex B

For appliances covered by Annex B, two steps are needed to determine the applicable requirements:

1. The respective text from the main body of part 1 and from the main body of the relevant part 2 of IEC 60335 are modified by Annex B.

2. Then, the consolidated text of part 1 and of the relevant part 2-x of IEC 60335 resulting from step 1 are combined by modifying the consolidated text of part 1 with the modifications of the consolidated specific part 2-x of IEC 60335.

See figure B and figure C.

APPENDIX D

Determination of applicable requirements for appliances connected to the supply mains and battery-operated appliances covered by Annex B

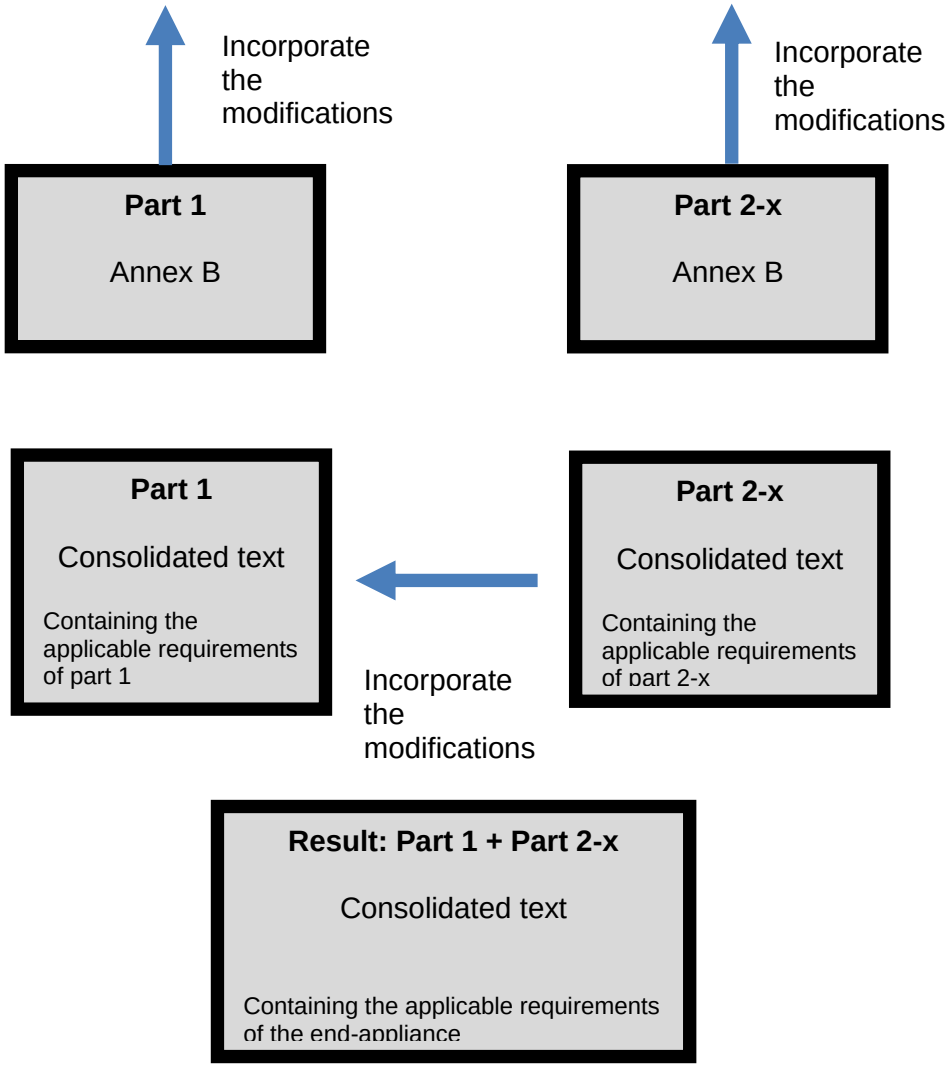


Figure B – The process of creating the consolidated requirements for a battery-operated appliance (covered by Annex B).

APPENDIX D
Determination of applicable requirements for appliances connected to the supply mains and battery-operated appliances covered by Annex B

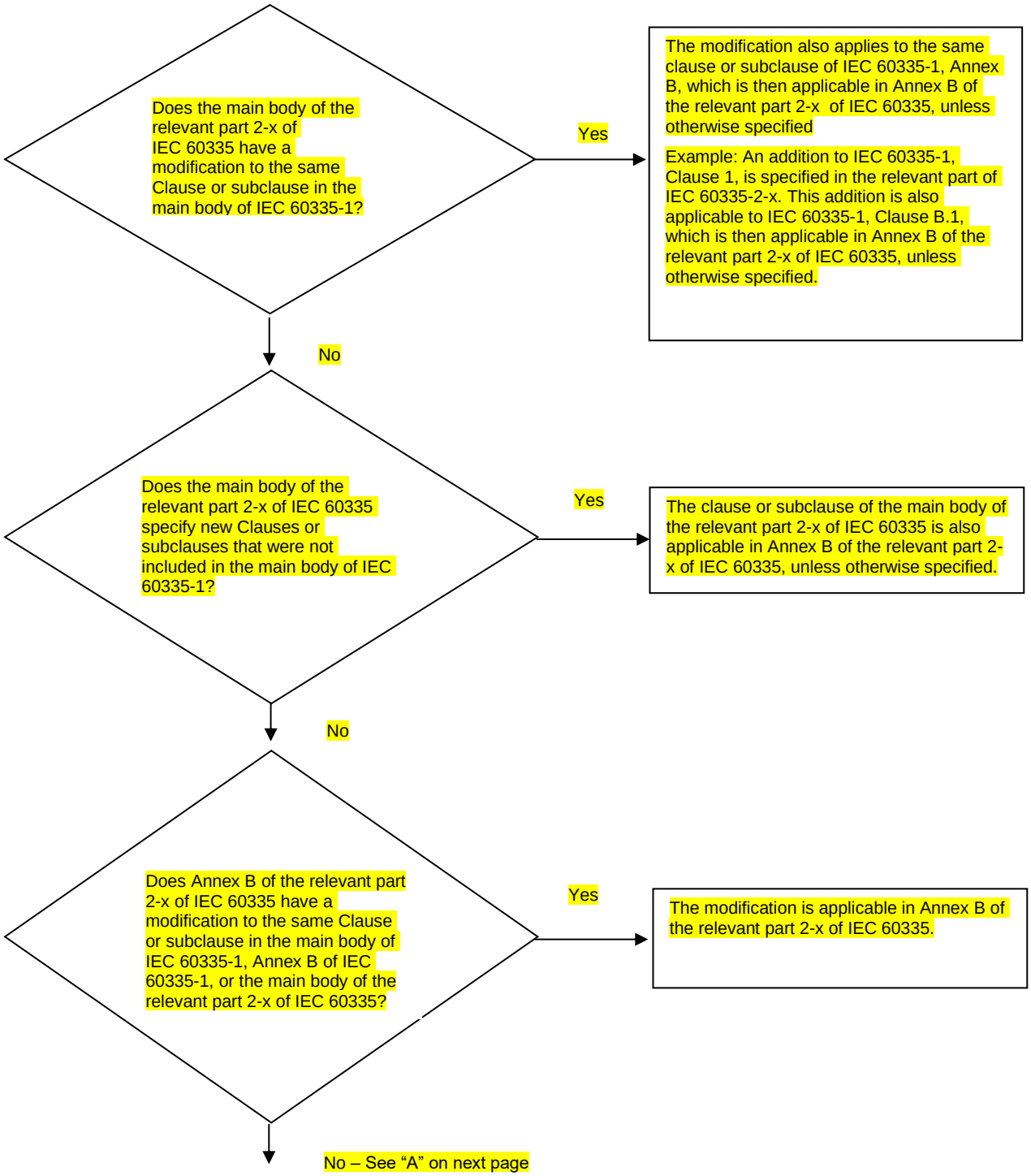


Figure C – Flowchart for determining applicable requirements for mains-operated appliances and battery-operated appliances covered by Annex B

APPENDIX D

Determination of applicable requirements for appliances connected to the supply mains and battery-operated appliances covered by Annex B

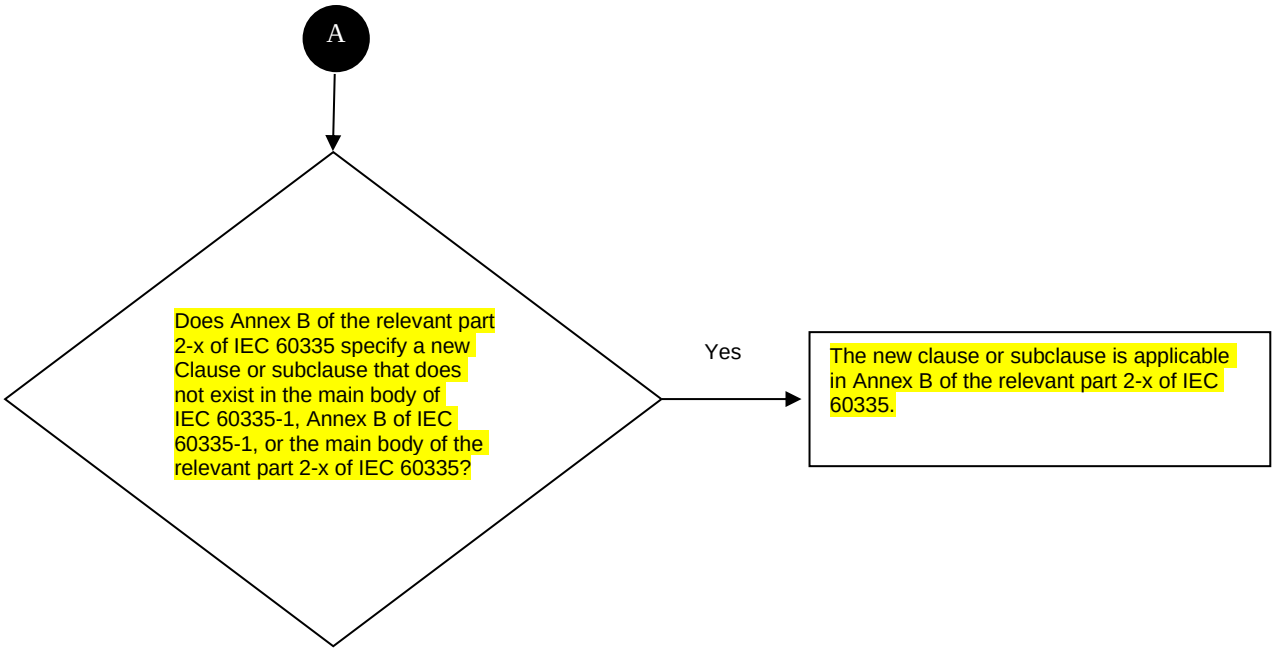


Figure C – Flowchart for determining applicable requirements for mains-operated appliances and battery-operated appliances covered by Annex B (continued)