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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

E-waste and circular economy

## Method for evaluation of the environmental, health and safety performance of true wireless stereo headphones

Recommendation ITU-T L.1016

ITU-T L-SERIES RECOMMENDATIONS

**ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT**

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# Recommendation ITU-T L.1016

## Method for evaluation of the environmental, health and safety performance of true wireless stereo headphones


### Summary

In recent years, more and more headphones belonging to the group of true wireless stereo (TWS) products have become commercially available. In 2019, sales of TWS earbuds surpassed the sales of (non-TWS) wireless earphones.

The advent of true wireless stereo headphones raises the question on their performance in terms of health and safety of the user. There is a close link between the health/safety of the user and substances used in true wireless stereo headphones.

The concept of products with minimal substances of concern and the phasing out of harmful substances for non-essential uses is one of the key aspects in the *European Sustainable Chemicals Strategy*, which is an important building block towards the goal of zero-pollution, essential for a circular economy. While the idea of non-essential uses is somewhat new in EU legislative initiatives, it originates from the 1978 *US Toxic Substances Control Act* and was taken up by other countries such as Canada. The concept was finally enshrined in the *Montreal Protocol*, designed to protect the ozone layer. As more and more countries recognize the importance of a circular economy to combat climate change, the notion of products with minimal substances of concern is gaining relevance.

With increasing relevance, the need for a method to compare the environmental, health and safety performance of TWS products is rising. Recommendation ITU-T L.1016 aims to establish a standardized methodology to evaluate a score of the aforementioned aspects.



### History

| Edition | Recommendation | Approval | Study Group | Unique ID* |
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| 1.0 | ITU-T L.1016 | 2022-02-13 | 5 | 11.1002/1000/14847 |

### Keywords

Environment, health, safety, true wireless stereo.


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# Recommendation ITU-T L.1016

## Method for evaluation of the environmental, health and safety performance of true wireless stereo headphones

### 1 Scope

The objective of this Recommendation is to provide a standardized method to evaluate the performance of true wireless stereo headphones with regards to compliance with existing environment, health and safety regulations and standards.

Furthermore, this Recommendation suggests a method to evaluate an aggregate score, reflecting the overall performance and compliance.

This Recommendation evaluates the following attributes:

– Substance health risk

– Hearing health risk

– Ergonomics

– Radio frequency (RF) radiation safety

– Battery safety

This Recommendation is applicable to true wireless stereo (TWS) headphones such as smart earphones, including headphones and necklace headphones.

### 2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T H.870] Recommendation ITU-T H.870 (2018), *Guidelines for safe listening devices/systems*.

[ITU-T K.91] Recommendation ITU-T K.91 (2022), *Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields*.

[IEC 61249-2-21] IEC 61249-2-21:2003, *Materials for printed boards and other interconnecting structures – Part 2-21: Reinforced base materials, clad and unclad – Non-halogenated epoxide woven E-glass reinforced laminated sheets of defined flammability (vertical burning test), copper-clad*.

[IEC 62479] IEC 62479:2010, *Assessment of the compliance of low-power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz)*.

| | |
|---|---|
| [IEC 62133] | IEC/EN 62133:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes –Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications*. |
| [IEC 62209-3] | IEC/EN 62209-3:2019, *Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Part 3: Vector measurement-based systems (Frequency range of 600 MHz to 6 GHz).* |
| [IEC 62368-1] | IEC 62368-1:2018, *Audio/video, information, and communication technology equipment – Part 1: Safety requirements*. |
| [IEC/IEEE 62209-1528] | IEC/IEEE/EN 62209-1528:2020, *Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Part 1528: Human models, instrumentation, and procedures (Frequency range of 4 MHz to 10 GHz).* |
| [ISO 21067-1] | ISO 21067-1:2016, *Packaging – Vocabulary – Part 1: General terms.* |

## 3 Definitions

### 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

**3.1.1 product** [b-ETSI TR 103 679]: Good or service.

**3.1.2 packaging** [ISO 21067-1]: To be used for the containment, protection, handling, delivery, storage, transport and presentation of goods, from raw materials to processed goods, from the producer to the user or consumer, including processor, assembler or other intermediary.

**3.1.3 substance** [b-GHS]: Chemical element and its compounds in the natural state or obtained by any manufacturing process, including any additive necessary to preserve its stability and any impurity deriving from the process used, but excluding any solvent which may be separated without affecting the stability of the declarable substance or changing its composition.

### 3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

**3.2.1 true wireless stereo (TWS) headphones**: True wireless stereo headphones are traditional headphones with a built-in intelligent wireless transmission mode, for example Bluetooth, and connected to mobile terminals, such as smartphones. Smart headphones can implement various external application functions.

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BaA Benz(a)Anthracene

BaP Benzo(a)Pyrene

BbFA Benzo(b)Fluoranthene

BeP Benzo(e)Pyrene

BjFA Benzo(j)Fluoranthene

BkFA Benzo(k)Fluoranthene

CHR Chrysene

DBAhA Dibenz(a,h)Anthracene

ECF Elemental Chlorine-Free

EPS Expanded Polystyrene

FSC Forest Stewardship Council

HBCD Hexabromocyclododecane

PAHs Polycyclic-Aromatic Hydrocarbons

PCS Process Chlorine free

PEFC Programme for the Endorsement of Forest Certification

PFOA Perfluorooctanoic Acid

PFOS Perfluorooctanesulfonic Acid

PPB Parts Per Billion

PPM Parts Per Million

PVC Polyvinyl Chloride

REACH Registration, Evaluation, Authorisation and Restriction of Chemicals

RF Radio Frequency

RoHS Restriction of the use of certain Hazardous Substances in electrical and electronic equipment

SAR Specific Absorption Rate

SCCP Short-Chain Chlorinated Paraffins

SVHCs Substances of Very High Concern

TCF Total Chlorine Free

TWS True Wireless Stereo

## 5 Conventions

None.

## 6 Methodology

The performance of true wireless stereo (TWS) headphones in terms of health and safety can be comprehensively evaluated by five aspects: substance health risk, hearing health risk, ergonomics, radio frequency (RF) radiation exposure and battery safety. Each aspect is classified into mandatory criteria and voluntary criteria.

The overall performance is evaluated by determining the score based on the voluntary criteria listed in clause 7. In any case, the requirements of the mandatory criteria have to be fulfilled. A voluntary requirement not met results in 0 points in the respective criterion.

The overall performance can be distinguished in three levels, level 1, level 2, and level 3 (Table 1), with level 1 being the highest performance level. The rules for evaluating the levels are as follows:

Level 1: All mandatory criteria are met. The total score of voluntary criteria is 80 points or higher.

Level 2: All mandatory criteria are met. The total score of voluntary criteria is equal to or above 50 points and below 80 points.

Level 3: All mandatory requirements are met. The total score of voluntary criteria is below 50 points.

If a product does not achieve 100% of the mandatory criteria, it cannot be rated any level.

**Table 1 – Evaluation requirements for TWS headphones**

| Evaluation level | Evaluation level requirements | |
|---|---|---|
| | Compliance rate to mandatory criteria | Total score of voluntary criteria |
| Level 1 | 100% | > 80 |
| Level 2 | 100% | 80 > X ≥ 50 |
| Level 3 | 100% | 50 > X |

# 7 Criteria

## 7.1 Mandatory criteria

### 7.1.1 Substance health risk

Table 2 lists the requirements for the evaluation of the mandatory criteria of TWS headphones in terms of substance health risks.

**Table 2 – Substance health risk evaluation indicators for TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 1 | RoHS compliance | The TWS headphones shall meet the EU RoHS and China RoHS limit requirements. | [b-EU2011/65] [b-EU2015/863] [b-GB/T26572] | Mandatory | N/A | Check test report |
| 2 | SCCP limitation | SCCP content shall be < 0.15% | [b-EU2019/1021] | Mandatory | N/A | Check test report or product material composition data |
| 3 | HBCD limitation | HBCD content shall be < 0.01% | [b-EU2019/1021] | Mandatory | N/A | Check test report or product material composition data |
| 4 | Hexavalent chromium limitation | Hexavalent chromium content in leather materials in direct contact with skin shall be < 0.0003% | [b-EU2006/1907] | Mandatory | N/A | Check test report |

**Table 2 – Substance health risk evaluation indicators for TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 5 | Nickel release limitation | Nickel release from metal parts in direct contact with skin for long periods shall be < 0.5 μg/cm²/week | [b-EU2006/1907] | Mandatory | N/A | Check test report |
| 6 | Azo dyes limitation | Leather/textile material azo dye content shall be < 30 ppm | [b-EU2006/1907] | Mandatory | N/A | Check test report |
| 7 | Formaldehyde limitation | Formaldehyde content in leather/textile materials shall be < 75 ppm | [b-EU2006/1907] | Mandatory | N/A | Check test report |
| 8 | Dimethyl fumarate limitation | Dimethyl fumarate in leather/textile materials shall be < 0.1 ppm | [b-EU2006/1907] | Mandatory | N/A | Check test report |
| 9 | PFOS/PFOA limitation | PFOS content in leather/textile materials shall be < 1 μg/m$^2$;<br>PFOA content shall be < 25 PPB | [b-EU2006/1907] | Mandatory | N/A | Check test report |
| 10 | Battery directive compliance | In batteries,<br>Hg content shall be ≤ 0.0005%;<br>Cd content shall be ≤ 0.002%;<br>Pb content shall be ≤ 0.004%. | [b-EU2006/66] and [b-EU2013/56] | Mandatory | N/A | Check test report or product material composition data |
| 11 | Packaging directive compliance | The sum of lead, cadmium, mercury, and hexavalent chromium in the packaging material shall not exceed 100 ppm. | [b-EU1994/62] | Mandatory | N/A | Check test report or packaging material composition data |

### 7.1.2 Hearing health risk

Table 3 lists the requirements for the evaluation of the mandatory criteria of TWS headphones in terms of hearing health risk.

**Table 3 – Hearing health risk evaluation indicators of TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 1 | Maximum weekly sound exposure | Maximum weekly sound exposure ≤ 1.6 Pa²h | [IEC 62368-1]<br>[ITU-T H.870] | Mandatory | N/A | Check test report |

### 7.1.3 Ergonomics

There are no mandatory requirements in terms of ergonomics for TWS headphones.

### 7.1.4 RF radiation exposure

Table 4 lists the requirements for the evaluation of the mandatory criteria of TWS headphones in terms of RF radiation exposure.

**Table 4 – RF radiation exposure evaluation indexes of TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 1 | Specific Absorption Rate (SAR) | Head SAR shall be < SAR limit (2.0 W/kg)<br>NOTE – limit may vary in different countries. | [IEC/IEEE 62209-1528]<br>[IEC 62209-3]<br>[ITU-T K.91] | Mandatory | N/A | Check test report |

### 7.1.5 Battery safety

Table 5 lists the requirements for the evaluation of the mandatory criteria of TWS headphones in terms of battery safety.

NOTE – Battery test can be conducted on the battery itself before the product is assembled.

**Table 5 – Battery safety evaluation indexes of TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 1 | Plane extrusion requirements | After the electrochemical cell test, no explosion or fire shall occur. | [IEC 62133] | Mandatory | N/A | Check test report |
| 2 | Safety protection requirements | 1. During the battery safety protection verification test, the charging voltage and current of the battery shall not exceed the maximum voltage and current specified in the specifications.<br>2. Charging test under abnormal temperature:<br>(1) Charging of the battery shall be stopped when the electrochemical cell temperature exceeds the maximum charging temperature.<br>(2) When the electrochemical cell temperature is lower than the minimum charging temperature, the battery charging circuit shall limit the current to the value specified in the battery specifications. | [IEC 62368-1] | Mandatory | N/A | Check test report |

**Table 5 – Battery safety evaluation indexes of TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 3 | Overcharge and overdischarge requirements | During the electrochemical cell test, no explosion, fire, or electrolyte leakage shall occur. | [IEC 62368-1] | Mandatory | N/A | Check test report |
| 4 | Drop requirements | During the battery drop test:<br>(1) The battery shall not explode, leak, or catch fire.<br>(2) Disconnect the battery and test the open-circuit voltage 24 hours later. The voltage difference between the open-circuit voltage and the open-circuit voltage of the battery that has not been dropped shall not exceed 5%.<br>NOTE – The charging and discharging functions can be disabled after the product is dropped, but the battery is not allowed to explode, fire, or leak. | [IEC 62368-1] | Mandatory | N/A | Check test report |
| 5 | 130-degree thermal shock | During the battery test, no fire or explosion shall occur. | [IEC 62133] | Mandatory | N/A | Check test report |

## 7.2 Voluntary criteria

### 7.2.1 Substance health risk

Table 6 lists the requirements for the evaluation of the voluntary criteria of TWS headphones in terms of substance health risks.

**Table 6 – Substance health risks evaluation indicators for TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 1 | Low halogen limitation | The halogen content of the entire product shall meet the following requirements: Br < 900 ppm, Cl < 900 ppm, and Cl + Br < 1500 ppm. | [IEC 61249-2-21] | Voluntary | 4 | Check test report or product material composition data |

## Table 6 – Substance health risks evaluation indicators for TWS headphones

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 2 | Polycyclic aromatic hydrocarbons limitation | The PAH content in contactable plastics, coatings or rubber components shall meets the following requirement: a total of (BaP; BeP; BaA; BbFA; BjFA; BkFA; CHR; DBAhA; Benzo [g, h, i] perylene; Indeno [1, 2, 3-cd] pyrene) < 0.5 ppm; Naphthalene < 2 ppm; 15 PAHs < 10 ppm. | [b-AfPS] | Voluntary | 4 | Check test report |
| 3 | Antimony and its compounds limitation | Antimony and its compounds shall constitute less than 0.1% of the mass of the entire product.<br>Exemptions from this requirement: glass and ceramic materials. | This Recommendation | Voluntary | 3 | Check test report or product material composition data |
| 4 | Beryllium and its compounds limitation | The content of beryllium and its compounds in the entire product shall be less than 0.1%. | This Recommendation | Voluntary | 3 | Check test report or product material composition data |
| 5 | Phthalate limitation | The content of each phthalate in the entire product shall be less than 1000 ppm. | This Recommendation | Voluntary | 4 | Check test report or product material composition data |
| 6 | PVC restrictions | PVC plastics shall not be used in the entire products. | This Recommendation | Voluntary | 4 | Check the material composition data of the product. |
| 7 | REACH Substances of Very High Concern (SVHC) restriction | Any SVHC, according to EU REACH, shall be less than 0.1% in an article.<br>Applicable exemptions from the requirement: RoHS exemptions<br>$B_2O_3$ exemptions in glass/ceramics | [b-EU2006/66], This Recommendation | Voluntary | 5 | Check the material composition data of the product. |
| 8 | Collecting information about product material components | A dedicated database shall be available for information on the product material composition based on substance and material information obtained in the supply chain<br>NOTE – The tracked material composition of the entire product, by mass, needs to reach at least 90%. | This Recommendation | Voluntary | 5 | Screenshots of product data collection from the database and the material composition data |

**Table 6 – Substance health risks evaluation indicators for TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 9 | Packing requirements | The use of EPS materials shall be prohibited in sales packaging. | This Recommendation | Voluntary | 2 | Check the packing list of all materials or check the product packaging on site. |
| 10 | | The paper used in packaging shall be made of either:<br>100% FSC, FSC Mix, or PEFC certified paper or recycled paper or a combination thereof | This Recommendation | Voluntary | 2 | Check the Forest Stewardship Council (FSC) certificate or manufacturer's statement of recycled paper. |
| 11 | | Elemental chlorine shall not have been applied to the gift box, or manual packaging paper for bleaching.<br>This can be achieved by the absence of bleaching, or by ensuring bleaching is elemental chlorine-free (ECF), total chlorine free (TCF), or process chlorine free (PCF). | This Recommendation | Voluntary | 2 | Check the manufacturer's statement. |
| 12 | | All plastic packaging components with a $\geq 50$ $cm^2$ surface area, or equal to 25g or higher shall be labelled, excluding tape, plastic wraps, labels, inks, coatings, and adhesives. | [b-GB/T18455] or [b-ASTM/D7611] | Voluntary | 1 | Check the labels of the packaging plastic materials on site. |
| 13 | | The weight of the plastic packaging, including plastic roll film, plastic bag, and plastic tray; and excluding inks, coatings, and adhesives; shall be less than 4%. | This Recommendation | Voluntary | 4 | Check the product package on site, check the weight statement of the plastic film on the gift box surface, or check the packaging material composition data. |
| 14 | Antibacterial material requirements | Antibacterial rate of glucose bacterium aureus shall be $\geq 90\%$ – applicable to refurbished products only | This Recommendation | Voluntary | 5 | Check test report |
| 15 | | Material of the component in contact with the human ear shall meet the following requirement:<br>E. coli antibacterial rate $\geq 90\%$ – applicable to refurbished products only | This Recommendation | Voluntary | 5 | Check test report |

### 7.2.2 Hearing health risk

Table 7 lists the requirements for the evaluation of the voluntary criteria of TWS headphones in terms of hearing health risks.

## Table 7 – Health evaluation indicators of TWS headphones

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 1 | Sound safety sign requirements | The product appearance, package, or user manual shall have sound safety labels.<br>The labels shall include the following elements:<br>– Icon  <br>– "Excessive sound pressure" or equivalent description.<br>– "Risk of hearing impairment" or equivalent description<br>– "Do not use under excessive sound pressure for extended periods of time" or equivalent description | [IEC 62368-1] | Voluntary | 1 | Check the product packaging and instructions. |
| 2 | Security warning requirements for ambient sound shielding | The product appearance, package, or user manual shall have the following safety warning:<br>"Do not use this machine when walking, driving, cycling, or doing work that requires attention to external sounds, otherwise accidents may occur" or equivalent description | This Recommendation | Voluntary | 1 | Check the product packaging and instructions. |
| 3 | Auditory dose statistics and prompts | 1. The headphones shall have a system to track the audio dose during the use and display the status of the audio exposure of the headphones (displayed on the mobile phone)<br>2. When the user exceeds 100% of the weekly allowable amount of audio exposure, the headphones shall provide warnings and action prompts related to hearing risks.<br>3. When the exposure exceeds maximum weekly sound exposure ≤ 1.6 $Pa^2h$, the headphones shall provide a warning and action reminder of the risk of hearing.<br>NOTE – Requirements 1-3 shall be fulfilled to achieve the score of 10. | This Recommendation | Voluntary | 10 | Check the headphones or provide screenshots. |

### 7.2.3 Ergonomics

Table 8 lists the requirements for the evaluation of the voluntary criteria of TWS headphones in terms of ergonomics.

**Table 8 – Ergonomics evaluation indicators for TWS headphones**

| No. | Evaluation indicator | Evaluation indicator Requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 1 | Short-term wearing comfort rate | Comfort rate of short-term wear according to Annex A:<br>≥ 9: 5 points<br>≥ 7; 4 points<br>≥ 6; 3 points<br>≥ 5; 2 points<br>< 5; 1 point | This Recommendation | Voluntary | 1-5 | Organize panel tests to check or check test reports. (see Annex A) |
| 2 | Long-term wearing comfort rate | Comfort rate of long-term wear according to Annex A:<br>≥ 9: 5 points<br>≥ 7; 4 points<br>≥ 6; 3 points<br>≥ 5; 2 points<br>< 5; 1 point | This Recommendation | Voluntary | 1-5 | Organize panel tests to check or check test reports (see Annex A) |

### 7.2.4 RF radiation exposure

Table 9 lists the requirements for the evaluation of the voluntary criteria of TWS headphones in terms of RF radiation exposure.

**Table 9 – RF radiation exposure evaluation indexes of TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 1 | SAR | TWS headphones shall comply with low power exclusion standard (20 mW) | [IEC 62479] | Voluntary | 10 | Check test report |

### 7.2.5 Battery safety

Table 10 lists the requirements for the evaluation of the voluntary criteria of TWS headphones in terms of battery safety.

**Table 10 – Battery safety evaluation indicators for TWS headphones**

| No. | Evaluation indicator | Evaluation indicator requirements | | Requirement type | Score | Evaluation method |
|---|---|---|---|---|---|---|
| | | Reference value | Reference | | | |
| 1 | Needle puncture requirements | During test, no hazardous situation shall occur.<br>NOTE – Hazardous situation means fire or explosion. | [b-GB/T31485] | Voluntary | 10 | Check test report |
| 2 | 140-degree thermal shock | During test, no hazardous situation shall occur.<br>NOTE – Hazardous situation means fire or explosion. | [b-GB/T18287] | Voluntary | 5 | Check test report |

# Annex A

## Wearing comfort test

(This annex forms an integral part of this Recommendation.)

The wearing comfort test (clause 7.2.3) shall be conducted as a panel test.

The panel shall consist of 30 individuals, 15 men and 15 women.

**Test procedure**

The test is divided into a test for short-term wearing comfort and a test for long-term wearing comfort. The short-term wearing comfort test shall last for 10 minutes, the test for long-term wearing comfort shall last for 60 minutes.

The test shall be conducted in a laboratory with 25 ± 5°C. The best fitting ear-plug or ear-pad size is individually chosen for each panellist.

The panellists wear the TWS headphones for 10 or 60 minutes respectively and shall rate the comfort level on a scale of 0-10, where:

0 = very uncomfortable

1-2 = uncomfortable

3-4 = rather uncomfortable

5 = neutral

6-7 = rather comfortable

8-9 = comfortable

10 = very comfortable

For the evaluation in clause 7.2.3, the score is averaged.

# Bibliography


[b-ETSI TR 103 679] ETSI TR 103 679 V1.1.1 (2019), *Environmental Engineering (EE); Explore the challenges of developing product group-specific Product Environmental Footprint Category Rules (PEFCRs) for smartphones*.

[b-AfPS] AfPS GS 2019:01, *PAK Testing and assessment of Polycyclic Aromatic Hydrocarbons (PAHs) in the awarding of GS Marks*.

[b-ASTM/D7611] ASTM D7611, *Standard Practice for Coding Plastic Manufactured Articles for Resin Identification*.

[b-EU1994/62] European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste.

[b-EU2006/66] Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC.

[b-EU2006/1907] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH).

[b-EU2011/65] Directive 2011/65/EU OF the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

[b-EU2013/56] Directive 2013/56/EU of the European Parliament and of the Council of 20 November 2013 amending Directive 2006/66/EC of the European Parliament and of the Council on batteries and accumulators and waste batteries and accumulators as regards the placing on the market of portable batteries and accumulators containing cadmium intended for use in cordless power tools, and of button cells with low mercury content, and repealing Commission Decision 2009/603/EC.

[b-EU2015/863] Commission Delegated Directive (EU) 2015/863 of 31 March 2015 amending Annex II to Directive 2011/65/EU of the European Parliament and of the Council as regards the list of restricted substances.

[b-EU2019/1021] Regulation (EU) 2019/1021 of the European Parliament and of the Council of 20 June 2019 on persistent organic pollutants.

[b-GB/T18287] GB/T 18287-2013 General specification of lithium-ion cells and batteries for mobile phone.

[b-GB/T18455] GB/T 18455-2010, *Package recycling marking*.

[b-GB/T26572] GB/T 26572, *Limitation requirements for restricted substances in electronic and electrical products*.

[b-GB/T31485] GB/T 31485-2015, *Safety requirements and test methods for traction battery of electric vehicle*.

[b-GHS] *Globally Harmonized System of Classification and Labelling* (2017).

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