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SERIES X: DATA NETWORKS, OPEN SYSTEM COMMUNICATIONS AND SECURITY

Information and network security – Telebiometrics

Telebiometrics related to human physiology

Recommendation ITU-T X.1082

ITU-T X-SERIES RECOMMENDATIONS

DATA NETWORKS, OPEN SYSTEM COMMUNICATIONS AND SECURITY

PUBLIC DATA NETWORKS	X.1–X.199
OPEN SYSTEMS INTERCONNECTION	X.200–X.299
INTERWORKING BETWEEN NETWORKS	X.300–X.399
MESSAGE HANDLING SYSTEMS	X.400–X.499
DIRECTORY	X.500–X.599
OSI NETWORKING AND SYSTEM ASPECTS	X.600–X.699
OSI MANAGEMENT	X.700–X.799
SECURITY	X.800–X.849
OSI APPLICATIONS	X.850–X.899
OPEN DISTRIBUTED PROCESSING	X.900–X.999
INFORMATION AND NETWORK SECURITY	
General security aspects	X.1000–X.1029
Network security	X.1030–X.1049
Security management	X.1050–X.1069
Telebiometrics	**X.1080–X.1099**
SECURE APPLICATIONS AND SERVICES	
Multicast security	X.1100–X.1109
Home network security	X.1110–X.1119
Mobile security	X.1120–X.1139
Web security	X.1140–X.1149
Security protocols	X.1150–X.1159
Peer-to-peer security	X.1160–X.1169
Networked ID security	X.1170–X.1179
IPTV security	X.1180–X.1199
CYBERSPACE SECURITY	
Cybersecurity	X.1200–X.1229
Countering spam	X.1230–X.1249
Identity management	X.1250–X.1279
SECURE APPLICATIONS AND SERVICES	
Emergency communications	X.1300–X.1309
Ubiquitous sensor network security	X.1310–X.1339
CYBERSECURITY INFORMATION EXCHANGE	
Vulnerability/state exchange	X.1520–X.1539
Event/incident/heuristics exchange	X.1540–X.1549
Exchange of policies	X.1550–X.1559
Heuristics and information request	X.1560–X.1569
Identification and discovery	X.1570–X.1579
Assured exchange	X.1580–X.1589

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T X.1082

Telebiometrics related to human physiology

Summary

Recommendation ITU-T X.1082 uses the framework defined in Recommendation ITU-T X.1081 for optimal safety and security in telebiometrics. It gives names and symbols for quantities and units concerned with emissions from the human body that can be detected by a sensor, and with effects on the human body produced by the telebiometric devices in its environment. It is applicable to both physiology and biometrics (the measurement of physiological, biological and behavioural characteristics). A taxonomy of wetware and hardware/software interactions is defined. Thresholds specified using the set of international system of quantities (ISQ) and the related international system of units (SI) are specified.

Source

Recommendation ITU-T X.1082 was approved on 13 November 2007 by ITU-T Study Group 17 (2005-2008) under Recommendation ITU-T A.8 procedure.

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Human physiology, IN and OUT modalities, personal identification, personal privacy sphere, sensory-motor modalities, symbols for telebiometric devices, telebiometrics, verification and authentication, wetware.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

CONTENTS

Introduction

This Recommendation is an adaptation of IEC 80000-14. The ISO/IEC 80000-series of standards consists of many parts with the common title: *Quantities and units*. The current and proposed parts of that International Standard are:

ISO 80000-1 – Part 1: General

ISO 80000-2 – Part 2: Mathematical signs and symbols to be used in the natural sciences and technology

ISO 80000-3 – Part 3: Space and time

ISO 80000-4 – Part 4: Mechanics

ISO 80000-5 – Part 5: Thermodynamics

IEC 80000-6 – Part 6: Electromagnetism

ISO 80000-7 – Part 7: Light

ISO 80000-8 – Part 8: Acoustics

ISO 80000-9 – Part 9: Physical chemistry and molecular physics

ISO 80000-10 – Part 10: Atomic and nuclear physics

ISO 80000-11 – Part 11: Characteristic numbers

ISO 80000-12 – Part 12: Solid state physics

IEC 80000-13 – Part 13: Information science and technology

IEC 80000-14 – Part 14: Telebiometrics related to human physiology

Names and symbols for physiological units and quantities that are in widespread use are specified in this Recommendation.

The basis for the determination of the quantities and units to be addressed is the taxonomy specified in the telebiometric multimodal model (TMM, see Recommendation ITU-T X.1081). In the TMM, ten aspects of the interaction between the human body and its environment are recognized (base modalities). These interactions are assumed to occur at various scales of propinquity and at various intensities across the "personal privacy sphere" (see Figure 1 of Recommendation ITU-T X.1081).

Using the terminology of the TMM, these interactions (base modalities) are classified as follows (see the definition of terms in clause 3):

- TANGO-IN
- TANGO-OUT
- VIDEO-IN
- VIDEO-OUT
- AUDIO-IN
- AUDIO-OUT
- CHEMO-IN
- CHEMO-OUT
- RADIO-IN
- RADIO-OUT

It is also recognized that the temperature of (parts of) the human body are important both for safe operation of a telebiometric device and for its use in providing telebiometric security. This aspect of the interaction of a human body with its environment uses the base modalities TANGO-IN, TANGO-OUT, VIDEO-IN and VIDEO-OUT, but is sufficiently important that it is defined in this part of this Recommendation as an additional derived modality:

- CALOR-IN describes the absorption of heat by the whole human body mediated by electromagnetic radiation (including infra-red or microwave radiation), heat conduction (by direct contact) or heat convection (by a heat-transporting liquid or gas).
- CALOR-OUT describes the loss of heat by the whole human body mediated by electromagnetic radiation, heat conduction, heat convection or evaporation.

Each of the main clauses of this Recommendation defines quantities and units for the in and out aspects of one of the interactions of the human body with a telebiometric device.

The terminology used in this classification is derived as follows:

TANGO:	from Latin: tangō, -ēre, tetigī, tāctum (from tago)	Latin, meaning "I touch"

NOTE 1 – TANGO-IN has been listed first because in terms of the development of life, skin sensitivity came first, and other input organs were specializations of that.

NOTE 2 – There are two forms of skin, glabrous and hairy (see Figures 1 and 2). These have different properties for sensitivity, giving rise to different TANGO-IN units.

VIDEO:	from Latin: videō, -ēre, vīdī, vīsum	Latin, meaning "I see"
AUDIO:	from Latin: audiō, -īre, -īvī (iī), -ītum	Latin, meaning "I hear"
CHEMO:	from medieval Latin: chemia, from Arabic: al-kimia	Medieval Latin meaning "chemistry"
RADIO:	from Latin: radiō, -āre, -āvi, ātum and from Latin: radius, radiī (m)	Latin, meaning "I radiate" Latin, meaning "ray, beam"
CALOR:	from Latin: calor, calōris (m)	Latin, meaning "warmth, heat"

In Annex C a code is specified that can be applied to classify a telebiometric device, and a compact graphical symbol that can be used to represent that code. This is based essentially on whether the device is an actuator or a sensor and on which modalities it uses.

Recommendation ITU-T X.1081 provides a framework for establishing thresholds related to safety and security in the telebiometric multimodal model, but does not contain any such thresholds. The thresholds to be used in telebiometrics are based on units standardized in the International Standards of the ISO/IEC 80000-series, and in particular on the quantities and units of IEC 80000-14.

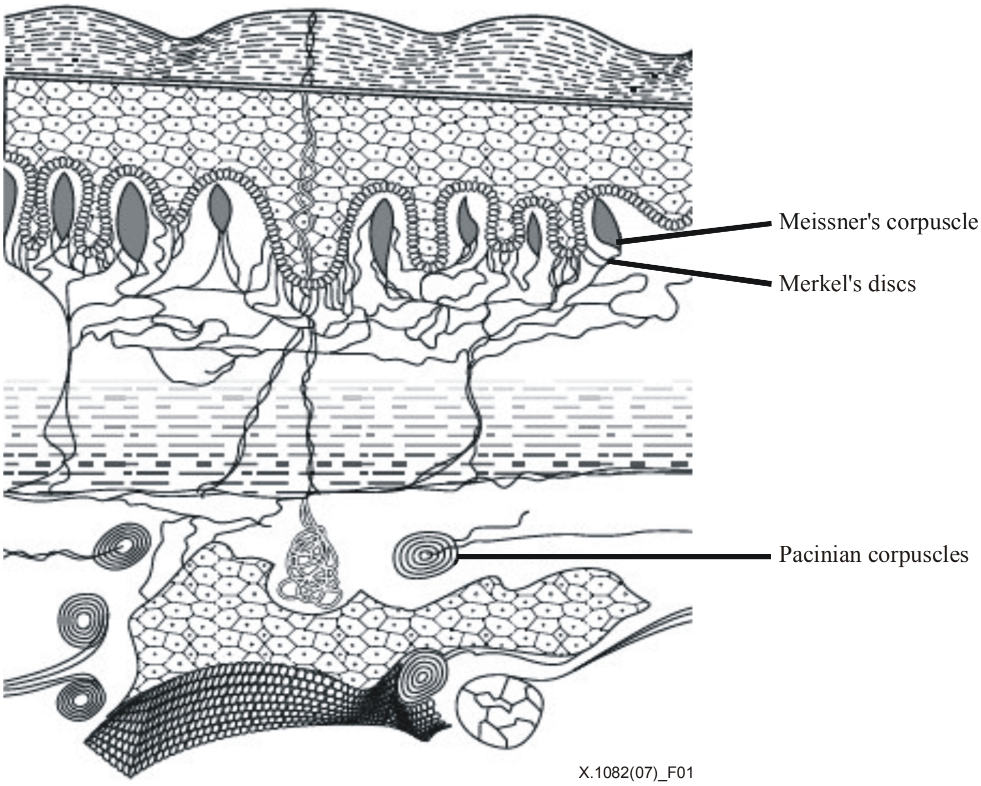

Figure 1 – Schematic drawing of a cross-section of glabrous skin

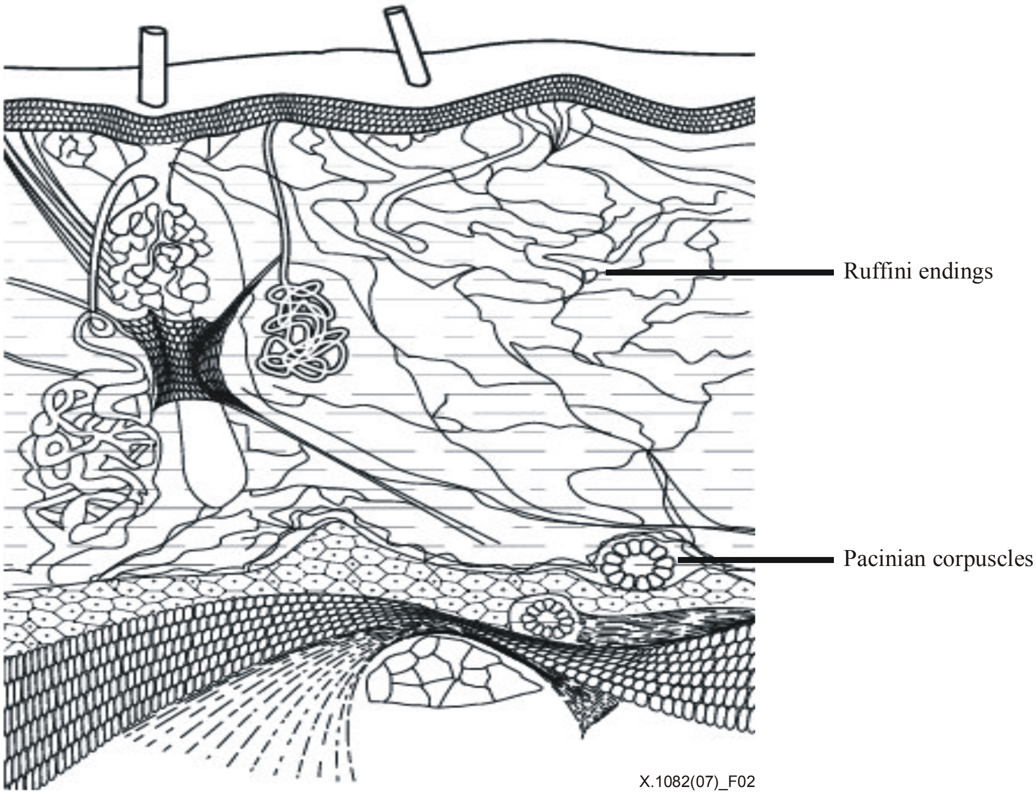

Figure 2 – Schematic drawing of a cross-section of hairy skin

Recommendation ITU-T X.1082

Telebiometrics related to human physiology

1 Scope

This Recommendation specifies names and definitions for quantities and units (and associated symbols) for telebiometrics related to human physiology.

This Recommendation defines quantities and units for physiological, biological or behavioural characteristics that might provide input or output to telebiometric identification or verification systems (recognition systems), including any known detection or safety thresholds.

It also includes quantities and units concerned with effects on a human being caused by the use of a telebiometric device.

NOTE – The quantities and units, their names and letter symbols specified here are those widely used in the disciplines and specialities related to telebiometrics: the telebiometric industry and telebiometry. Telebiometric units are SI units (see [b-ISO/DIS 80000-1]).

A code and an associated graphical symbol for the identification of the type of a telebiometric device are also specified in this Recommendation.

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 X.1081] Recommendation ITU-T X.1081 (2004), *The telebiometric multimodal model – A framework for the specification of security and safety aspects of telebiometrics*.

[ISO 80000-3] ISO 80000-3:2006, *Quantities and units – Part 3: Space and time*.
<http://www.iso.org/iso/catalogue_detail?csnumber=31888>

[ISO 80000-4] ISO 80000-4:2006, *Quantities and units – Part 4: Mechanics*.
<http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31889>

[ISO 80000-5] ISO 80000-5:2007, *Quantities and units – Part 5: Thermodynamics*.
<http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31890>

[IEC 80000-6] IEC 80000-6:2008, *Quantities and units – Part 6: Electromagnetism*[1].
<http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31891>

[ISO 80000-8] ISO 80000-8:2007, *Quantities and units – Part 8: Acoustics*.
<http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=40669>

[ISO/FDIS 80000-9] ISO/FDIS 80000-9:draft, *Quantities and units – Part 9: Physical chemistry and molecular physics*[1].
<http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31894>

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[1] In preparation.

3 Definitions

For the purpose of this Recommendation, the following definitions apply.

3.1 Definitions in [ITU-T X.1081]

The following definitions in [ITU-T X.1081] are used in this Recommendation:

a) TMM metric layer;

b) TMM scientific layer;

c) TMM sensory layer;

d) telebiometrics;

e) telebiometrology;

f) telebiometronomy.

3.2 General concepts

3.2.1 base modality: One of the classifications of the interaction of a human body with its environment based on the physical nature of the interaction or on the human sensory system that it affects (see clauses 3.5.1 to 3.5.10).

NOTE – If the interaction is from the environment to the human body, it is described as an in-modality. If it is from the human body to the environment, it is described as an out-modality

3.2.2 derived modality: One of the classifications of the interaction of a human body with its environment based on a property of the human body that is determined or changed using one or more of the base modalities (see clauses 3.5.11 and 3.5.12).

NOTE – The temperature of the human body or parts of the human body can be detected (CALOR-OUT) by an infrared radiation detector or by conduction to a thermometer and can be changed by convection, conduction or various forms of radiation (CALOR-IN).

3.2.3 in-modality: Modality of interactions from the environment to the human body.

3.2.4 out-modality: Modality of interactions from the human body to the environment.

3.2.5 wetware: That physical aspect of a human being that is affected by or affects telebiometric devices.

NOTE – This term is not used in the normative text, but it is extensively used in Appendix I and the definition is provided here for completeness.

3.2.6 biometric: Of or having to do with biometrics.

NOTE – The use of "biometric as a noun to mean, for example, biometric characteristic, is deprecated.

EXAMPLE Incorrect usage #1: ICAO resolved that face is the biometric most suited to the practicalities of travel documents.

EXAMPLE Correct usage #1: ICAO resolved that face recognition is the biometric modality most suited to the practicalities of travel documents.

EXAMPLE Incorrect usage #2: The biometric recorded in my passport is a facial image.

EXAMPLE Correct usage #2: The biometric characteristic recorded in my passport is a facial image.

3.2.7 biometrics: Automated recognition of individuals based on their behavioural and biological characteristics.

NOTE 1 – "Individual" is restricted in scope by SC37 to humans.

NOTE 2 – The general meaning of biometrics encompasses counting measuring and statistical analysis of any kind of data in the biological sciences including the relevant medical sciences.

3.2.8 telebiometrics: Application of biometrics to telecommunications and of telecommunications to remote biometric sensing.

3.2.9 telebiometric device: Sensor or actuator interacting remotely with a human being, using telecommunication means.

3.2.10 telebiometric multimodal model (TMM): Model of the interactions of a human being with its environment using modalities based on the human senses.

3.2.11 TMM metric layer: Layer in the TMM taxonomy that identifies the SI units used to describe an IN or OUT interaction.

3.2.12 TMM scientific layer: Layer in the TMM taxonomy that identifies the scientific discipline that investigates the properties and thresholds of an IN or OUT interaction.

3.2.13 TMM sensory layer: Layer in the TMM taxonomy that identifies the human senses involved in producing or detecting an IN or OUT interaction.

3.3 Thresholds

3.3.1 threshold: Boundary between two identifiable regions of the stimulus to response curve for human sensors.

3.3.2 detection threshold: Level at which a stimulus applied to a conscious human subject just produces a response.

3.3.3 suprathreshold stimulus: Stimulus greater than the detection threshold.

3.3.4 comfort threshold: Levels (above or below) which a stimulus is known to cause discomfort for most human beings.

3.3.5 safety threshold: Level at which a stimulus changes from being safe to not being safe.

NOTE – In many cases a stimulus is safe below a safety threshold (a maximum safe level) and unsafe above (for example a hot object), but there are cases where the stimulus is safe above a safety threshold (a minimum safe level) and unsafe below (for example a cold object).

3.3.6 pain threshold: Level above which a stimulus is known to cause the sensation of pain.

3.3.7 damage threshold: Level above which a stimulus may cause temporary or permanent damage.

NOTE – Damage thresholds often depend on the duration of the exposure to a stimulus as well as the level of that stimulus.

3.4 Safety and security

3.4.1 safety: Property of a physical device or procedure that determines (and limits through mechanisms, procedures, regulations and permitted operating thresholds) the extent of the damage that the device can cause to one or more human beings.

NOTE – Examples of mechanisms, procedures, regulations and permitted operating thresholds are permitted electronic emissions from devices, the temperature of surfaces on operating devices, the volume of sounds in public entertainment, and mechanisms to ensure the shut-down of nuclear power plants in the event of some failure. In many cases, the operation of a device within these limits can be both sensed and controlled by telecommunications.

3.4.2 security: Protection of a human being's activities (particularly those involving privileges and financial activities) from attack by other human or computer activities, usually achieved by the use of mechanical or electronic devices or mechanisms associated with the protected human being.

NOTE – Examples of security devices and mechanisms are physical door-locks, the use of PINs or biometrics to protect credit cards or passports, and the use of biometrics for access control. In many cases, these devices and mechanisms use telecommunications as an essential part of their operation.

3.4.3 safe telebiometric device: Telebiometric device that is harmless to human physiology, culture, psychology and meets public information rights requirements and privacy requirements.

NOTE 1 – The telebiometric multimodal model (see [ITU-T X.1081]) provides a framework for the identification of safety aspects of biometric devices and for the specification of limits (safety thresholds) by analysing and categorizing the interactions between a human body and its environment.

NOTE 2 – Safe telebiometric devices meet a specified set of conditions derived from identified safety thresholds.

3.4.4 telebiometric security: Security obtained through the use of telebiometric devices for authentication of a human being, using one or more of the modalities of interaction between a human body and its environment, meeting public information rights requirements and privacy requirements.

NOTE – The "out" modalities specified in the telebiometric multimodal model (see [ITU-T X.1081]) provide a framework for the identification of devices that can provide telebiometric acquisition and processing.

3.4.5 telebiometric identification: Telebiometric system function that performs a one-to-many comparison to obtain a candidate list using telecommunications to access one or more biometric systems.

3.4.6 telebiometric verification: Telebiometric system function that performs a one-to-one comparison to show true or false, using telecommunications to access one or more biometric systems.

3.4.7 identify (biometrics): Biometric search against an enrolment database to find and return the biometric reference identifier(s) attributable to a single individual.

3.4.8 biometric identification: Process of identifying.

NOTE – The term identifying, in the above definition, refers to **identify (biometrics)**.

3.4.9 verify (biometrics): Confirm a biometric claim through biometric comparisons.

NOTE 1 – Criteria for confirmation will be determined by policy.

NOTE 2 – It is understood that Popperian's argue claims can never be verified, only falsified.

3.4.10 biometric verification: Process of verifying.

NOTE – The term verifying, in the above definition, refers to **verify (biometrics)**.

3.5 Modalities

3.5.1 TANGO-IN: Characterization of any stimulus that can be detected by nerve endings in the human body, other than by the specialized nerves active in seeing, hearing, tasting and smelling, or that affects or damages human cells.

NOTE 1 – The term TANGO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a TANGO-IN stimulus.

NOTE 2 – The human body is sensitive to the impact of objects or to irritation by (for example) nano-particles or abrasion or chemical substances related to the use of telebiometric devices, and this forms part of the safety levels associated with TANGO-IN.

NOTE 3 – Safety levels for TANGO-IN also include the pain caused by pressure to activate a telebiometric device (or other mechanical effects of a device on the body) or by chemical substances.

3.5.2 TANGO-OUT: Characterization of any force or other non-sound effect produced by a part of the human body, including but not limited to blows with or without an associated instrument or tool, that can be detected by a sensor or another human being.

NOTE 1 – The term TANGO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a TANGO-OUT specific output.

NOTE 2 – TANGO-OUT includes quantities and units related to the ability of the human body to produce a force or physical effect, including measurements of both muscular and lung capability. This also includes quantities and units used in measurements of obesity and of general fitness.

3.5.3 VIDEO-IN: Characterization of any stimulus that can be detected by, affects or is likely to affect or damage, the human eye.

NOTE 1 – The term VIDEO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a VIDEO-IN stimulus.

NOTE 2 – VIDEO-IN includes quantities and units related to the sensing by the eye of (non-ionizing) electromagnetic radiation at various wavelengths and at various intensities.

3.5.4 VIDEO-OUT: Characterization of any output from a human being that can be detected by the human eye or an image sensor, including but not limited to behaviour or signs produced by a human being that can be observed by another human being or a sensor.

NOTE – The term VIDEO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a VIDEO-OUT specific output.

3.5.5 AUDIO-IN: Characterization of any sound stimulus that can be detected by, affects or is likely to affect or damage, the human ear or otherwise impair hearing.

NOTE 1 – The term AUDIO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to an AUDIO-IN stimulus.

NOTE 2 – AUDIO-IN includes quantities and units related to both the effect of loud sounds on the ear, and the frequency range and possible impairment of human hearing.

3.5.6 AUDIO-OUT: Characterization of any sound produced by the vocal chords of a human being, or through activators for disabled speech, or by mechanical, possibly amplified, production of sound that can be detected by the human ear or a sensor.

NOTE 1 – The term AUDIO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to an AUDIO-OUT specific output.

NOTE 2 – AUDIO-OUT includes quantities and units related to the production of sound by the vocal chords, including musical ranges (alto, tenor, etc.) or production of sound with amplification and the quantification of the loudness of such output, where it affects the human physiology or may be used in telebiometrics.

3.5.7 CHEMO-IN: Characterization of any stimulus that can be detected by, affects, or is likely to affect, the human sense of taste or smell or to damage these chemo senses.

NOTE 1 – The term CHEMO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a CHEMO-IN stimulus.

NOTE 2 – CHEMO-IN includes quantities and units related to the ability of the human body to smell or taste chemical substances, including both descriptions of tastes and smells (for example of food and wine) and the lethality of specific chemicals.

3.5.8 CHEMO-OUT: Characterization of any chemical emission from the human body that can be detected by the chemical sensing organs of a human being or by a sensor (including but not limited to the use of sniffer dogs, sniffer wasps and olfactory chips as sensors).

NOTE – The term CHEMO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a CHEMO-OUT specific output.

3.5.9 RADIO-IN: Characterization of any stimulus from external sources of radiation (except those covered by VIDEO-IN and AUDIO-IN) that can affect or damage the human body or implanted devices.

NOTE 1 – The term RADIO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a RADIO-IN stimulus.

NOTE 2 – An implanted device may be any of (not exclusive):

– a cochlear-implant that activates ear nerves directly by signals from a signal processor;
– a pacemaker to control the heart beat;
– an implanted cardioverter-defibrillator to provide immediate defibrillation of the heart;
– a transcutaneous electrical nerve stimulator (an electronic pain reducer);

– a muscle activator;

– an implanted radio frequency identification tag (RFid tag).

3.5.10 RADIO-OUT: Characterization of any output from the human body (or from implanted devices) that is a source of radiation (except those covered by VIDEO-OUT and AUDIO-OUT).

NOTE 1 – The term RADIO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a RADIO-OUT specific output.

NOTE 2 – RADIO-OUT is concerned with the measurement of all sources of radiation from the human body, for example after exposure to or ingestion of radio-active material, except those radiations covered by VIDEO-OUT and AUDIO-OUT.

NOTE 3 – The base modalities do not encompass non-ionizing electromagnetic radiation from and to the human body that is outside the visible spectrum.

3.5.11 CALOR-IN: Characterization of any stimulus that can be detected by thermo sensors (cold receptors and warm receptors) in the human skin and mucous surfaces and any kind of heat transfer into the human body.

NOTE 1 – The term CALOR-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a CALOR-IN stimulus.

NOTE 2 – CALOR-IN is a derived modality.

NOTE 3 – Heat transfer into the human body can occur by conduction of hot surfaces, by convection of air above skin temperature, by radiation from the sun, heat bulbs, thermo cameras, etc., and by microwave radiation.

3.5.12 CALOR-OUT: Characterization of any kind of heat transfer from the human body.

NOTE 1 – The term CALOR-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a CALOR-OUT specific output.

NOTE 2 – CALOR-OUT is a derived modality.

NOTE 3 – Heat transfer from the human body can occur by conduction to cold surfaces, by convection of air below skin temperature, by infra-red radiation to a cold environment and by evaporation.

4 Abbreviations, symbols and conventions

4.1 Abbreviations

This Recommendation uses the following abbreviations:

CGPM General Conference on Weights and Measures (Conférence Générale des Poids et Mesures)

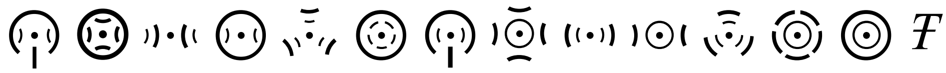
CIPM International Committee for Weights and Measures (Comité International des Poids et Mesures)

ICRU International Commission on Radiation Units and Measurement

TMM Telebiometric Multimodal Model

4.2 Symbols used in telebiometrics

The following symbols are used to denote telebiometric devices (see Annex C and threshold tables):



The symbol ⊚ represents conformance to safety and security limits for a given modality or set of modalities; where possible, this symbol should be displayed in green.

The symbol T is used to denote a threshold, with subscripts that denote, or are related to, the modality that the threshold references.

4.3 Conventions

4.3.1 Where a quantity relates to a safety threshold which if exceeded might cause discomfort, pain or damage to the human body, it is, where possible, characterized in the remarks column of the tables by a safety threshold value.

4.3.2 Quantities and units that are applicable to several modalities are given in clause 5. Quantities and units that are specific to a single modality are given in clauses 6 to 11.

5 Quantities and units used for more than one telebiometric modality

Table 1 contains the base quantities of the international system of quantities (ISQ) and its units which are the seven base units of the international system of units (SI) and additionally those derived quantities and units which are relevant for more than one telebiometric modality.

Table 1 − Quantities, units and definitions for multiple modalities

Multiple modalities									
Quantities						Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Modality**	**Name**	**Symbol**	**Definition**	**Remarks**
14-5.1.1	length *fr longueur* (f)	*l, L*	one of the base quantities in the International System of Quantities (ISQ), on which the International System of Units (SI) is based	Length is that quantity that can often be measured with a measuring rod.	TANGO VIDEO AUDIO CHEMO RADIO CALOR	metre	m	Length of the path travelled by light in a vacuum during a time interval of 1/299 792 458 of a second.	This definition implies that the speed of light in a vacuum is exactly 299 792 458 m/s. [17th CGPM (1978)]. See [ISO 80000-3].
14-5.1.2	breadth *fr largeur* (f)	*b, B*		14-5.1.1 to 14-5.1.13 are various quantities that are used to specify a length.	TANGO VIDEO				
14-5.1.3	height *fr hauteur* (f)	*h, H*			TANGO VIDEO AUDIO				
14-5.1.4	thickness *fr épaisseur* (f)	*d*, δ			TANGO AUDIO				
14-5.1.5	radius *fr rayon* (m)	*r, R*			TANGO AUDIO				
14-5.1.6	radial distance *fr distance* (f) *radiale*	r_Q, ρ			TANGO VIDEO AUDIO				
14-5.1.7	diameter *fr diamètre* (m)	*d, D*			TANGO VIDEO				
14-5.1.8	length of path *fr longueur* (f) *curviligne*	*s*			TANGO VIDEO AUDIO				
14-5.1.9	distance *fr distance* (f)	*d, r*			TANGO VIDEO				

Table 1 − Quantities, units and definitions for multiple modalities

Multiple modalities									
Quantities						Units			
Item No.	Name	Symbol	Definition	Remarks	Modality	Name	Symbol	Definition	Remarks
14-5.1.10	cartesian coordinates *fr coordonnées cartésiennes* (f)	*x, y, z*			TANGO VIDEO AUDIO RADIO				
14-5.1.11	position vector *fr rayon* (m) *vecteur*	*r*			TANGO VIDEO AUDIO				
14-5.1.12	displacement *fr déplacement* (m)	Δr			TANGO AUDIO				
14-5.1.13	radius of curvature *fr rayon* (m) *de courbure*	ρ			TANGO VIDEO AUDIO				
14-5.2	curvature *fr courbure* (f)	κ	κ = 1/ρ where ρ is the radius of the curvature		TANGO VIDEO	metre to the power minus one	m^{-1}		
14-5.3	area *fr aire* (f)	*A*, (*S*)	$A = \iint \mathrm{d}x\,\mathrm{d}y$ where x and y are cartesian coordinates	For an element of area d*A*, d*σ* is sometimes used.	TANGO CALOR	square metre	m^2		
14-5.4	volume *fr volume* (m)	*V*	$V = \iiint \mathrm{d}x\,\mathrm{d}y\,\mathrm{d}z$ where *x*, *y* and *z* are cartesian coordinates	$V = \int \mathrm{d}V$ For an element of volume d*V*, d*τ* is sometimes used.	TANGO CHEMO	cubic metre	m^3		
						litre	l, L	$1\ \mathrm{l} := 10^{-3}\ \mathrm{m}^3 = 1\ \mathrm{dm}^3$	In international standards only the lower case l is used

Table 1 − Quantities, units and definitions for multiple modalities

Multiple modalities									
Quantities						Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Modality**	**Name**	**Symbol**	**Definition**	**Remarks**
14-5.5	angle, plane angle *fr angle* (m), *angle plan*	α, β, γ, ϑ, φ	for the angle between two half-lines terminating at the same point, $\alpha = s/r$ where s is the length of the included arc of the circle, with its centre at that point, and r is the radius of that circle	Other symbols are also used. See [ISO 80000-3].	TANGO VIDEO AUDIO CHEMO	radian	rad	1 rad := 1m/m = 1	The radian is the angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius.
14-5.6	solid angle *fr angle* (m) *solide*	Ω	$\Omega = A/r^2$ where A is the area of the included surface of a sphere in a cone with its apex at the centre of the sphere, and r is the radius of the sphere		TANGO VIDEO AUDIO CHEMO RADIO CALOR	steradia n	sr	1 sr := 1 m^2/m^2 = 1	The steradian is the solid angle of a cone that, having its apex in the centre of a sphere, cuts off on the sphere a surface equal in area to a square with sides of length equal to the radius of the sphere.
14-5.7	mass *fr masse* (f)	m	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [ISO 80000-4], item 4-1.	TANGO CHEMO	kilogra m	kg	unit of mass equal to the mass of the international prototype of the kilogram	See [ISO 80000-4]. [3rd CGPM (1901)]

Table 1 − Quantities, units and definitions for multiple modalities

Multiple modalities									
Quantities						Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Modality**	**Name**	**Symbol**	**Definition**	**Remarks**
14-5.8	time, duration *fr temps* (m), *durée* (f)	*t*	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [ISO 80000-3], item 3-7.	TANGO VIDEO AUDIO CHEMO RADIO CALOR	second	s	duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom	See [ISO 80000-3]. [13th CGPM (1966-67)]
14-5.9	electric current *fr courant* (m) *électrique*	*I*	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [ISO 80000-6], item 6-1.	TANGO VIDEO AUDIO CHEMO RADIO CALOR	ampere	A	that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed one metre apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre ([9th CGPM (1948)]	This definition implies that the magnetic constant μ_0 (see item 6-25.2 of [IEC 80000-6]) is exactly 4π x 10^{-7} H/m. [9th CGPM (1948)] See [IEC 80000-6].
14-5.10	thermodynamic temperature *fr température* (f) *thermo-dynamique*	*T*	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [IEC 80000-5]. item 5-1.	TANGO CHEMO CALOR	kelvin	K	fraction 1/273.16 of the thermodynamic temperature of the triple point of water	The units of thermodynamic and Celsius temperature intervals are identical. [9th CGPM (1971)] See [ISO 80000-5], item 5-1.a.

Table 1 − Quantities, units and definitions for multiple modalities

Multiple modalities									
Quantities						Units			
Item No.	Name	Symbol	Definition	Remarks	Modality	Name	Symbol	Definition	Remarks
14-5.11	Celsius temperature *fr température* (f) *Celsius*	t, ϑ	$t = T - T_0$ where T is thermodynamic temperature and $T_0 := 273.15$ K	The thermodynamic temperature T_0 is exactly 0.01 K below the thermodynamic temperature of the triple point of water.	TANGO CHEMO CALOR	degree Celsius	°C	special name for the kelvin for use in stating values of Celsius temperature 1°C := 1 K	
14-5.12	amount of substance *fr quantité* (f) *de matière*	n, (ν)	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [ISO 80000-9], item 9-1.	TANGO CHEMO	mole	mol	the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilograms of carbon 12. [14th CGPM (1971)]	When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles or specified groups of such particles. The definition applies to unbound atoms of carbon 12, at rest and in their ground state. [14th CGPM (1971)] See [ISO 80000-9], item 9-1.a.

Table 1 − Quantities, units and definitions for multiple modalities

Multiple modalities									
Quantities						Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Modality**	**Name**	**Symbol**	**Definition**	**Remarks**
14-5.13	luminous intensity *fr intensité* (f) *lumineuse*	I, (I_v)	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [b-ISO/FDIS 80000-7], item 7-33.	VIDEO TANGO CHEMO	candela	cd	luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} Hz and that has a radiant intensity in that direction of 1/683 W/sr	See [b-ISO/FDIS 80000-7], item 7-33.a. [14th CGPM (1971)]
14-5.14	frequency *fr fréquence* (f)	f, (v)	$f = 1/T$ where T is the period	See [ISO 80000-3], item 3-15.1.	TANGO VIDEO AUDIO CHEMO RADIO CALOR	hertz	Hz	1 Hz := 1 s^{-1}	See [ISO 80000-3].
14-5.15	pressure, stress *fr pression* (f)	p	$p = dF/dA$ where dF is the force component perpendicular to the surface element of area dA	The symbol p_e is recommended for gauge pressure, defined $p - p_{amb}$, where p_{amb} is the ambient pressure. See [ISO 80000-4], item 4-15.1.	TANGO CHEMO CALOR	pascal	Pa	1 Pa = 1 N/m^2	bar (bar), 1 bar = 100 kPa The use of the bar should be restricted to the existing uses in the field of fluid pressure.

Table 1 − Quantities, units and definitions for multiple modalities

Multiple modalities									
Quantities						Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Modality**	**Name**	**Symbol**	**Definition**	**Remarks**
14-5.16	sound intensity *fr intensité* (f) *acoustique*	i	$i = p \cdot v$ where p is sound pressure (see also item 14-8.1) and v is sound particle velocity	See [ISO 80000-8], item 8-17.1.	TANGO AUDIO	watt per square metre	W/m^2		See [ISO 80000-8].
14-5.17	absorbed dose *fr dose* (f) *absorbée*	D	for any ionizing radiation, mean energy $\mathrm{d}\bar{\varepsilon}$ imparted to an element of irradiated matter divided by the mass $\mathrm{d}m$ of this element	$D = \frac{\mathrm{d}\bar{\varepsilon}}{\mathrm{d}m}$	CHEMO RADIO	gray	Gy	1 Gy = 1 J/kg	The gray is a special name for joule per kilogram, to be used as the SI unit for these quantities. rad (rad), 1 rad = 10^{-2} Gy
14-5.18	dose equivalent *fr équivalent* (m) *de dose*	H	at the point of interest in tissue, $H = D \cdot Q \cdot N$ where D is the absorbed dose, Q is the quality factor and N is the product of any other modifying factors	For Q and N, see [b-CIPM Rec. 1] and [b-ICRU] Report 33	CHEMO RADIO	sievert	Sv	1 Sv = 1 J/kg	The sievert is a special name for joule per kilogram, to be used as the SI unit for dose equivalent. rem (rem), 1 rem = 10^{-2} Sv
14-5.19	sound pressure level *fr niveau* (m) *de pression acoustique*	L_p	$L_P = 10 \lg \frac{p^2}{p_0^2}$ dB where p is sound pressure and the reference value in airborne acoustics is $p_0 = 20\ \mu\mathrm{Pa}$	See [ISO 80000-8], item 8-22.	TANGO VIDEO AUDIO CHEMO	bel	B	1 B is the sound pressure level when $\rho/\rho_0 = \sqrt{10}$	See [ISO 80000-8], item 8-22.a. Decibel (dB) is normally used for speech sounds: 1 B = 10 dB

6 Quantities and units for TANGO-IN and TANGO-OUT

Table 2 − Quantities, units and definitions for the TANGO modality

TANGO-IN and TANGO-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-6.1	conduction speed *fr vitesse* (f) *de conduction*	c		Conduction speed in nerve fibres.	metre per second	m/s	see [IEC 80000-6]	Afferent nerve fibre conduction speed varies between 0.60 m/s and 80 m/s
14-6.2	angular frequency, pulsatance *fr pulsation* (f)	ω	$\omega = 2\pi f$ where f is frequency	See [ISO 80000-3], item 3-16.	(a) radian per second (b) second to the power minus one	rad/s s^{-1}		
14-6.3	phase difference *fr déphasage (m), différence* (f) *de phase*	φ	difference between the phase of the voltage $u = \hat{u} \cos \omega t$ and the electric current $i = \hat{\imath} \cos (\omega t - \varphi)$ where u is the instantaneous value of the voltage, i is the instantaneous value of the electric current, $\hat{\imath}$ is its peak value, ω is the angular frequency, and t is time		radian	rad		

Table 2 − Quantities, units and definitions for the TANGO modality

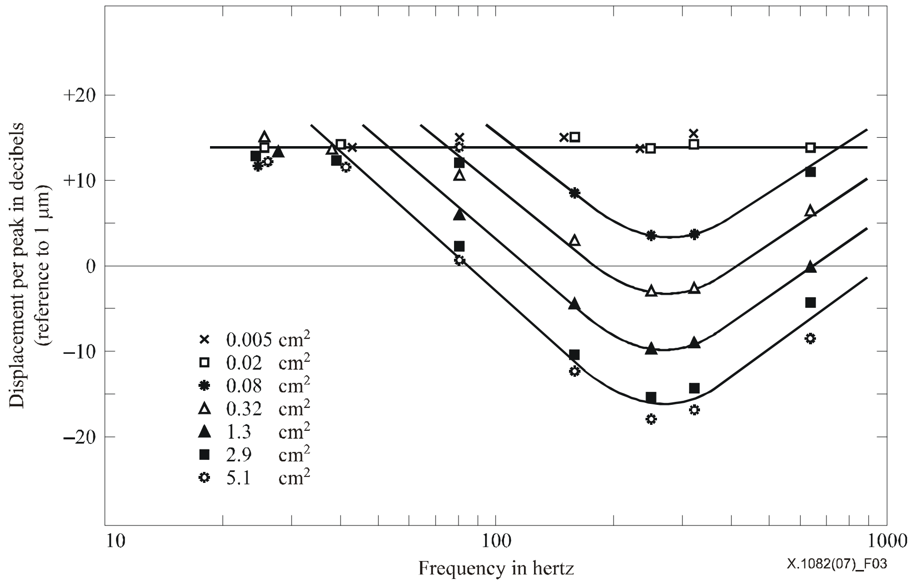
TANGO-IN and TANGO-OUT								
Quantities					Units			
Item No.	Name	Symbol	Definition	Remarks	Name	Symbol	Definition	Remarks
14-6.4	impedance *fr impédance* (f)	z	Z = U/I where *U* is the complex representation of voltage, and *I* is the complex representation of electric current, item 14-5.9	See [IEC 80000-6], item 6-51.1. $Z = \|Z\| e^{j\varphi}$	ohm	Ω		
14-6.5	active energy *fr énergie* (f) *active*	*W*	$W = \int_0^T ui\ dt$ where *u* and *i* are the instantaneous values of voltage and current, respectively, and *T* is the duration of observation	See [IEC 80000-6], item 6-52.	(a) joule (b) watt hour	J W · h		1 kW · h = 3.6 MJ
14-6.6	electric potential *fr potentiel* (m) *électrique*	*V*, φ	for electrostatic fields, a scalar quantity, the gradient of which, with reverse sign, is equal to the electric field strength *E*= – grad *V*	[IEC 80000-6], item 6-11.1 gives φ as a reserve symbol.	volt	V	1 V = 1 kg · $m^2/(s^3 \cdot A)$	millivolt – mV, microvolt – μV are normally used in human physiology.
14-6.7	capacitance *fr capacité* (f)	*C*	charge divided by potential difference	See [IEC 80000-6], item 6-13.	farad	F	1 F = 1 C/V	picoFarad – pF, nanoFarad – nF are normally used in human physiology.

Table 2 − Quantities, units and definitions for the TANGO modality

TANGO-IN and TANGO-OUT								
Quantities					Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-6.8	force *fr force* (f)	F	$F = \mathrm{d}p/\mathrm{d}t$, where F is the resultant force acting on a body, p is momentum of a body, and t is time	If the mass of a particle is constant then $F = ma$, where m is mass and a is acceleration. See [ISO 80000-4], item 4-9.1.	newton	N	$1\ \mathrm{N} = 1\ \mathrm{kg \cdot m/s^2}$	See [ISO 80000-4].
14-6.9	touch thresholds *fr seuils* (m) *du toucher*	$\mathcal{T}_t$	thresholds for touch, vibration and other stimuli to the skin	See Figures 1, 2, 3 and 4. See also [b-Verrillo 1], [b-Verrillo 2], [b-Verrillo 3], [b-Verrillo 4], [b-Bolanowski] and [b-Kapit]. NOTE – All the thresholds defined in clause 3.3 are applicable to the TANGO-IN modality, but the threshold values are outside the scope of this Recommendation, and are in some cases not yet determined. For TANGO-IN thresholds, safety thresholds are always above the detection thresholds. The comfort threshold depends on the type of receptor that is being stimulated. For the TANGO-IN				Units used in the specification of touch thresholds can involve any of the units listed in clause 5 and any of the units listed in 14-6.1.a to 14-6.8.a. It is out of the scope of this Recommendation to specify the units for each touch threshold, as these are dependent on the nature of the TANGO-IN stimulus, and on whether it is sensed by free-nerve endings, Merckel disks, Meissner, Ruffini or Pacinian corpuscles. Detection thresholds for vibration contactors are shown in Figure 3. Figure 4 shows suprathreshold curves for all receptor channels. **Pacinian corpuscles**: Maximum sensitivity is between 250 and 500 Hz; –20 dB (0.1 µm). These corpuscles integrate energy over space (area) and time (frequency,

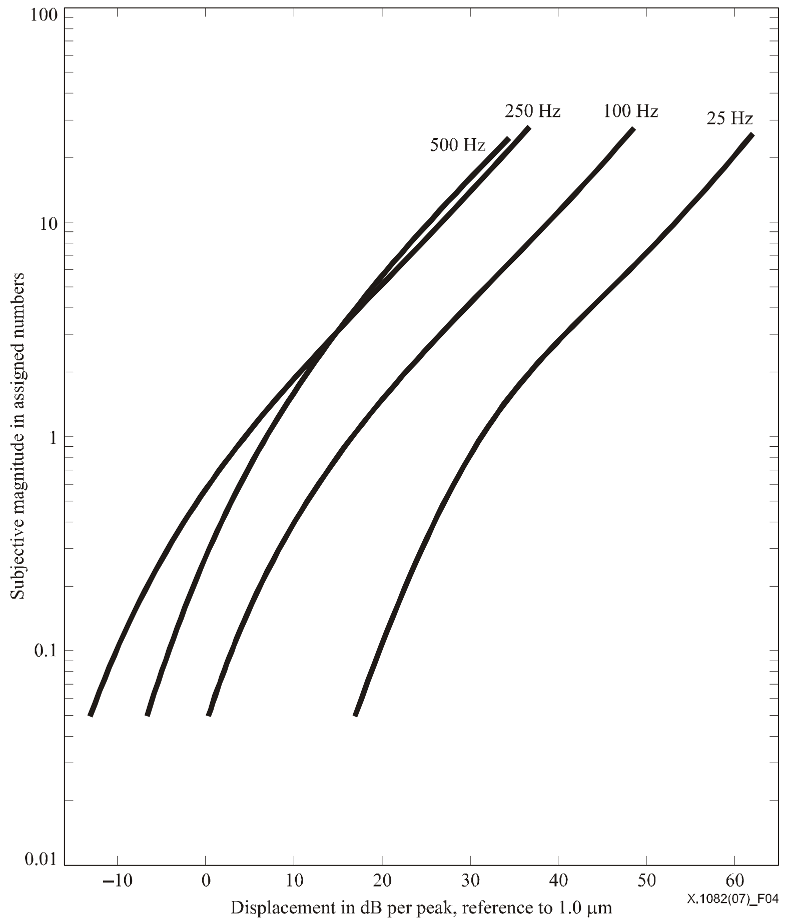
Table 2 − Quantities, units and definitions for the TANGO modality

TANGO-IN and TANGO-OUT								
Quantities					Units			
Item No.	Name	Symbol	Definition	Remarks	Name	Symbol	Definition	Remarks
				thresholds, the maximum stimulation possible without pain is normally used as the safety threshold and is approximately 50 dB above the detection threshold for all forms of taction stimulation.				duration). The response curve is a U-shaped curve as a function of frequency. **Meissner corpuscles**: Maximum sensitivity is at approximately 30 Hz; +15 dB (15 µm). The response curve is independent of the area of stimulation (no spatial integration) and is a shallow U-shaped curve. **Merkel disks (neurite complex)**: Flat curves at low frequencies (0.4 to 100 Hz), +25 dB (25 µm). The response curve is independent of the area of stimulation and of time. **Ruffini-Paciniform**: The response curve is a U-shaped curve at high frequencies (100 to 500 Hz); approximately 20 dB above Pacinian thresholds. Maximal sensitivity at 250 to 300 Hz; +10 dB (10 µm).
NOTE – Supplementary quantities and units and their letter symbols in [ISO 80000-3] (skin contact manifests itself in 4D coordinates), [ISO 80000-4], [ISO 80000-5], [IEC 80000-6], [ISO 80000-9], [b-ISO/FDIS 80000-10] (the skin is sensing this physical energy and reflecting it too) may be relevant to TANGO-IN and/or TANGO-OUT.								



NOTE – The effects of contactor size (spatial summation) are shown as a progressive increase of sensitivity as the contactor area increases from 0.005 to 5.1 cm^2.

Figure 3 – Detection thresholds for vibration contactors, measured at the thenar eminence in dB per peak with reference to 1.0 µm



NOTE – All of the curves describe power functions with exponents of 1.0 in the mid to upper range of intensities. The curves, in order from left to right, are the suprathresholds for the Pacini, Ruffini-Paciniform, Meissner and Merkel receptor channels.

Figure 4 – Subjective magnitude of vibration in assigned numbers as a function of vibration amplitude in dB per peak with reference to 1.0 µm

7 Quantities and units for VIDEO-IN and VIDEO-OUT

7.1 Introductory text on dark adaptation

The visual detection threshold depends on the preceding history of stimulation of the eye. In other words, the detectable amount of light is dependent upon the level of light (or lack thereof) that the subject has recently been exposed to, and the duration of that exposure.

Exposure to light levels that are clearly visible is called light adaptation or phototopic vision and exposure to very low levels is called dark adaptation or scotopic vision. A common experience of light adaptation is the inability to discriminate objects in a darkened environment after moving from a light environment (for example, entering a darkened movie theatre). Dark adaptation produces the reverse effect: the near-painful experience of moving from a darkened movie theatre into sunlight.

These relationships are complex, involving many parameters of light measurements. One important factor is the very different neural enervation of the fovea and periphery of the retina itself. Figure 7 shows the detection thresholds for a flash of light. The threshold luminance is plotted as a function of minutes in the dark. Figure 7 shows that the curves at the fovea and the periphery of the eye are extremely different: the fovea curve is flat and the peripheral curve decreases exponentially. (Figure 7 is derived from [b-Hecht]).

7.2 Quantities and units

Table 3 − Quantities, units and definitions for the VIDEO modality

VIDEO-IN and VIDEO-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-7.1	luminous flux *fr flux* (m) *lumineux*	Φ, (Φ_e)	See [ISO 80000-7], item 7-30		lumen	lm	1 lm := 1 cd · sr	
14-7.2	radiant flux, radiant power *fr flux* (m) *énergétique*	P	See [ISO 80000-7], item 7-11		watt	W	1 W :=1 J/s	
14-7.3	irradiance *fr éclairement* (m) *énergétique*	E,(E_e)	See [ISO 80000-7], item 7-17		watt per square metre	W/m^2		
14-7.4	radiant intensity *fr intensité* (f) *énergétique*	I,(I_e)	See [ISO 80000-7], item 7-12		watt per steradian	W/sr		
14-7.5	radiant exitance *fr exitance* (f) *énergétique*	M, (M_e)	See [ISO 80000-7], item 7-16	Formerly called radiant emittance.	watt per square metre	W/m^2		
14-7.6	luminous exitance *fr exitance* (f) *lumineuse*	M,(M_v)	See [ISO 80000-7], item 7-38	Formerly called luminous emittance.	lumen per square metre	lm/m^2		

Table 3 − Quantities, units and definitions for the VIDEO modality

VIDEO-IN and VIDEO-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-7.7	radiance *fr radiance* (f)	$L,(L_e)$	See [ISO 80000-7], item 7-13		watt per steradian and square metre	$W/(sr \cdot m^2)$		
14-7.8	spectral emissivity *fr émissivité* (f) *spectrale*	$\epsilon(\lambda)$	See [ISO 80000-7], item 7-19.1 and its remark		watt per hertz	W/Hz		
14-7.9	spectral transmittance *fr facteur (m) de transmission, transmittance* (f)	$\tau(\lambda)$	See [ISO 80000-7], item 7-20.3 and its remark		one	1		
14-7.10	spectral reflectance *fr réflectance* (f) *spectrale*	$\rho(\lambda)$	See [ISO 80000-7], item 7-20.2 and its remark		one	1		
14-7.11	illuminance *fr éclairement* (m)	$E,(E_v)$	See [ISO 80000-7], item 7-34		lux	lx	$1\ lx := 1\ lm/m^{-2}$	
14-7.12	luminance *fr luminance* (f)	$L,(L_v)$	See [ISO 80000-7], item 7-35		candela per square metre	$cd \cdot m^{-2}$		

Table 3 − Quantities, units and definitions for the VIDEO modality

VIDEO-IN and VIDEO-OUT								
Quantities					Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-7.13	luminous efficiency *fr efficacité* (f) *lumineuse relative*	*V*	See [ISO 80000-7], item 7-28		one	1		
14-7.14	photo threshold of awareness function *fr seuil (m) de la fonction d'attention à la lumière*		the ability of the human eye to detect a light that results in a 1° radial angle at the eye with a given duration (temporal summation)	Scotopic and photopic modes of vision are shown in Figure 5.	lux	lx		
14-7.15	temporal summation function *fr fonction* (f) *de sommation temporelle*		the ability of the human eye to produce a composite signal from the signals coming into the eye during a short time interval	Detectability is directly proportional to duration (temporal summation) of the number of light units (photons) received, up to duration of 60 to 70 ms (Bloch law). Beyond 70 ms, the time of exposure is irrelevant. See Figures 6 and 7.	one per second and steradian		1/(s · sr)	

Table 3 − Quantities, units and definitions for the VIDEO modality

VIDEO-IN and VIDEO-OUT								
Quantities					Units			
Item No.	Name	Symbol	Definition	Remarks	Name	Symbol	Definition	Remarks
14-7.16	spatial summation function *fr fonction* (f) *de sommation spatiale*		the ability to produce a composite signal from the signals coming into eyes from different directions	The rate of photon emission per unit area (spatial summation) at a given stimulus duration is dependent upon the size of the stimulated area (Ricco law). See Figure 8. Up to 100 sr, there is a direct proportionality between photon emission and spatial integration. Beyond this area the ratio obeys Piper law, which states that the luminance is inversely proportional to the square root of the stimulus area.	metre	m		
14-7.17	adaptation *fr adaptation* (f)		recovery of visual ability following exposure to light (dark adaptation)	This follows a lawful progression up to about 35 min in the dark. The change in the ability of the eye to adapt to darkness following exposure to light covers an intensity range of 10^{10}:1.	second	s		

Table 3 − Quantities, units and definitions for the VIDEO modality

VIDEO-IN and VIDEO-OUT								
Quantities					Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-7.18	vision thresholds *fr seuils* (m) *de la vision*	$Ŧ_{\mathrm{v}}$	thresholds of sensitivity of the eye	See Figures 5, 6 and 7.				Units used in the specification of vision thresholds can involve any of the units listed in clause 5 and any of the units listed in 14-7.1.a to 14-7.17.a. It is out of the scope of this Recommendation to specify the units for each vision threshold, as these are dependent on the nature of the VIDEO-IN stimulus, and on whether it stimulates rods or cones within the retina.
NOTE – Supplementary quantities and units and their letter symbols in [ISO 80000-3] (the eye manifests itself in coordinate systems for space and time, and iris scans use either Cartesian or spherical space coordinates – see [b-ISO/IEC 19794-6]) and [b-ISO/FDIS 80000-7] (the eye is sensing the energy of light and human body surfaces are also reflecting it) may be relevant to VIDEO-IN and/or VIDEO-OUT.								

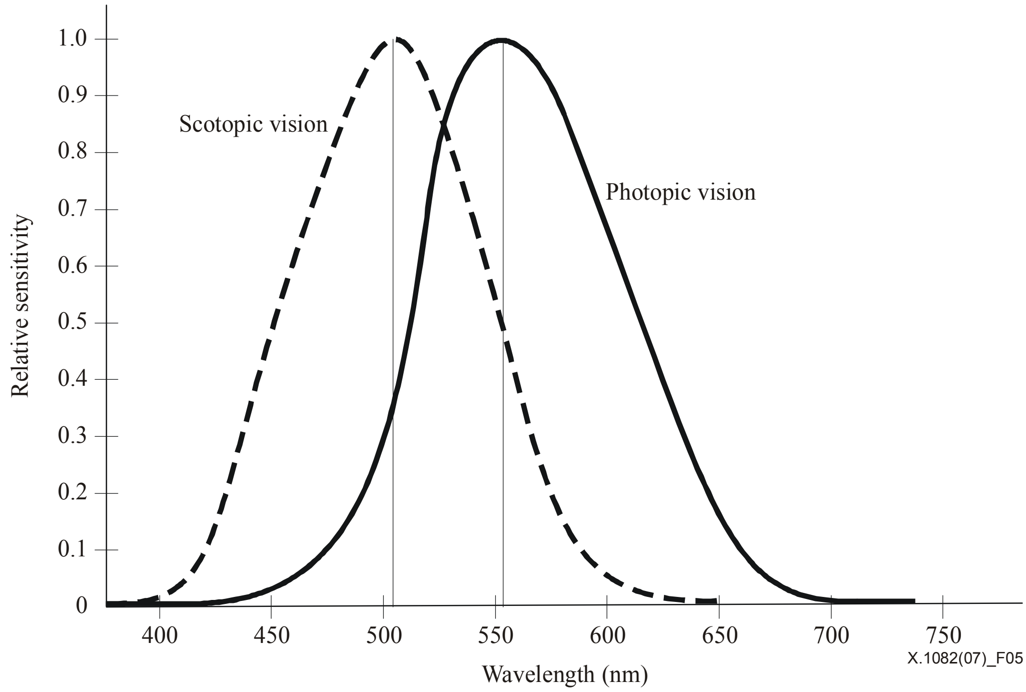
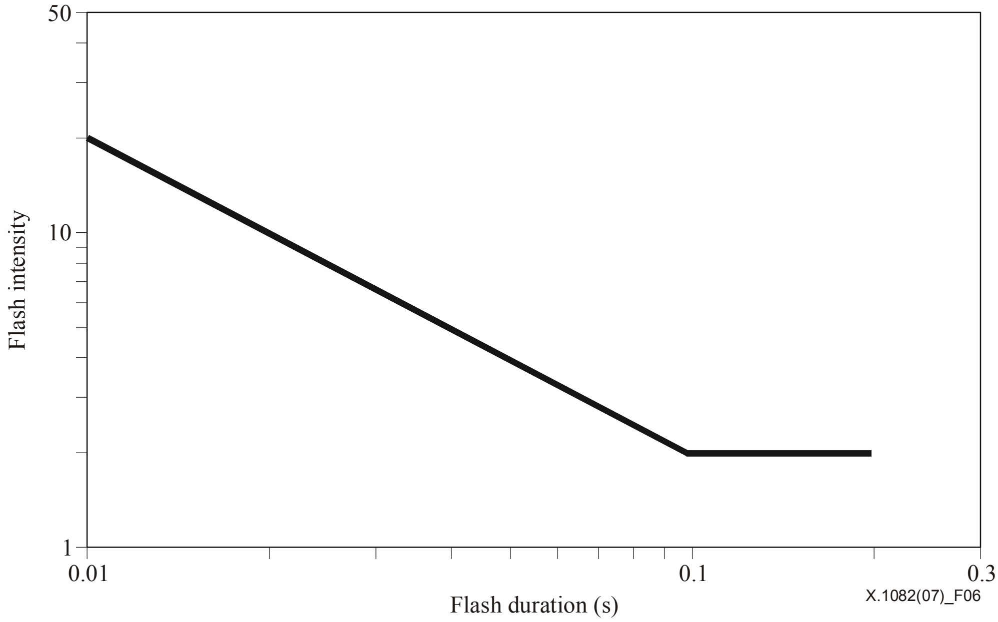


Figure 5 – Spectral sensitivity of the eye



NOTE – Above this line the flash is considered detectable. Below the line it is not.

Figure 6 – Temporal summation – Bloch law

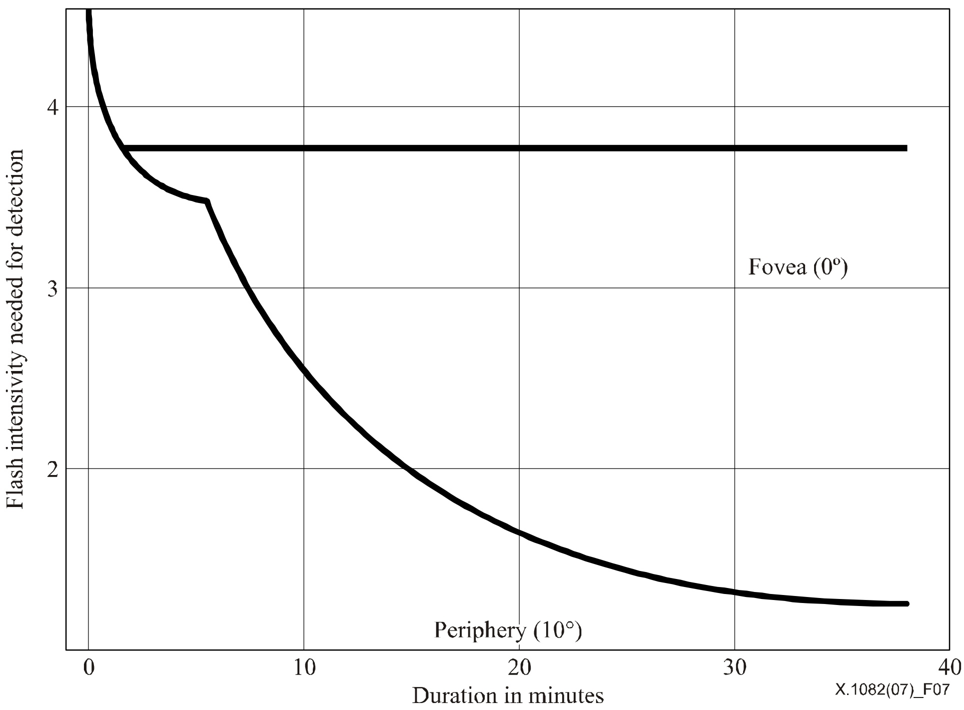
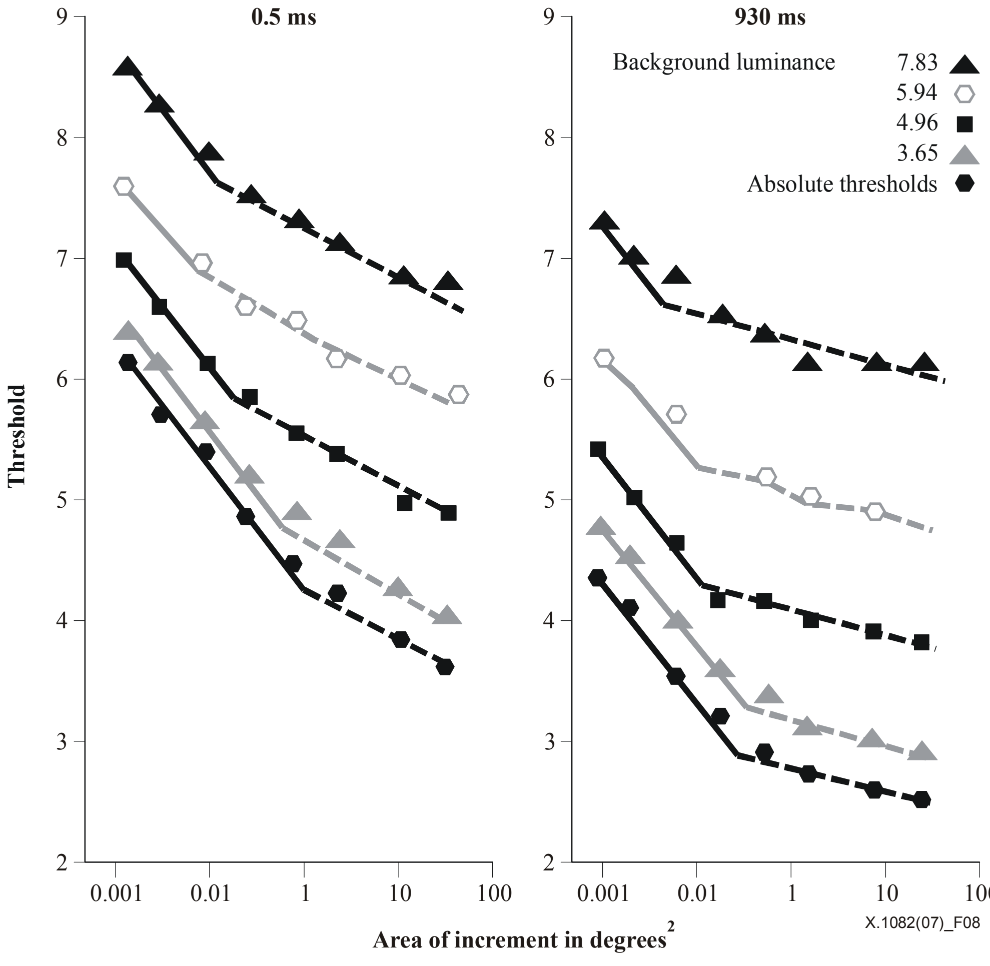


Figure 7 – Threshold of the fovea and periphery of the eye for detection of a test flash using a white disc after dark adaptation (see [b-Hecht])



NOTE – The solid line represents the area where Ricco law holds. Beyond is dictated by Piper law.

Figure 8 – Spatial summation

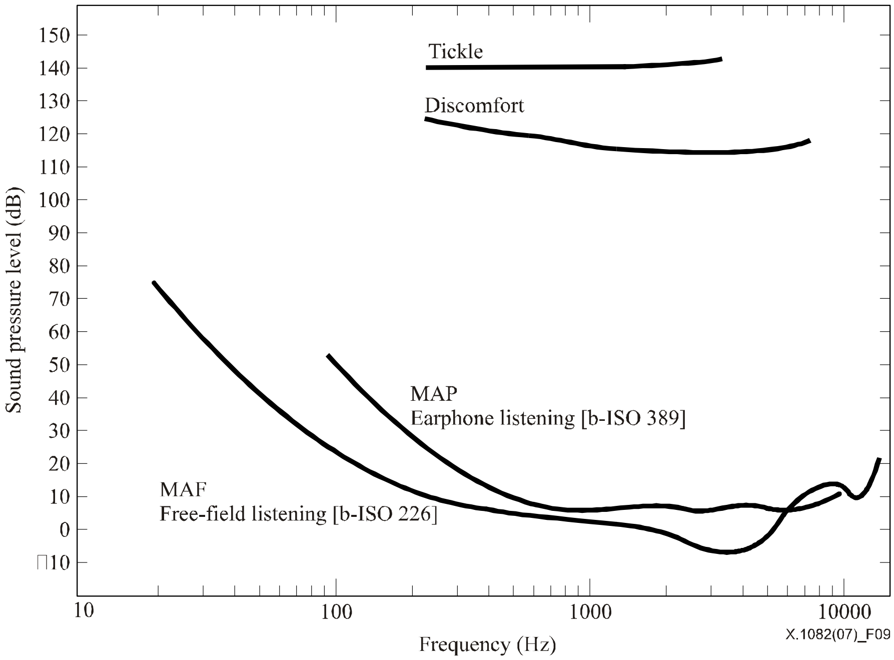
8 Quantities and units for AUDIO-IN and AUDIO-OUT

Table 4 − Quantities, units and definitions for the AUDIO modality

AUDIO-IN and AUDIO-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-8.1	sound pressure, stress *fr pression* (f) *acoustique*	p_i, (P_a)	difference of the instantaneous pressure and the static pressure	The symbol for sound pressure is often used without modification for the root-mean-square (rms) value. For sound pressure level, see item 14-5.19. See [ISO 80000-8], item 8-9.2. See Figures 9 and 10.	pascal	Pa	1 Pa =1 N/m^2	The threshold for sensitivity to acoustic pressure for the human ear is 20 µPa
14-8.2	acoustic impedance *fr impédance* (f) *acoustique*	Z_a	at a surface, the complex quotient of the average sound pressure over that surface and the sound volume flow rate through that surface	See [ISO 80000-8], item 8-20.	pascal second per cubic metre	Pa · s/m^3		
14-8.3	sound power *fr puissance* (f) *acoustique*	P, (P_a)	power emitted, transferred or received as sound waves	See [ISO 80000-8], item 8-16.	watt	W	1 W := 1 J/s	
14-8.4	potential difference *fr différence* (f) *de potentiel*	U, (V)		See [IEC 80000-6], item 6-11.2.	volt	V	1 V := 1 W/A	

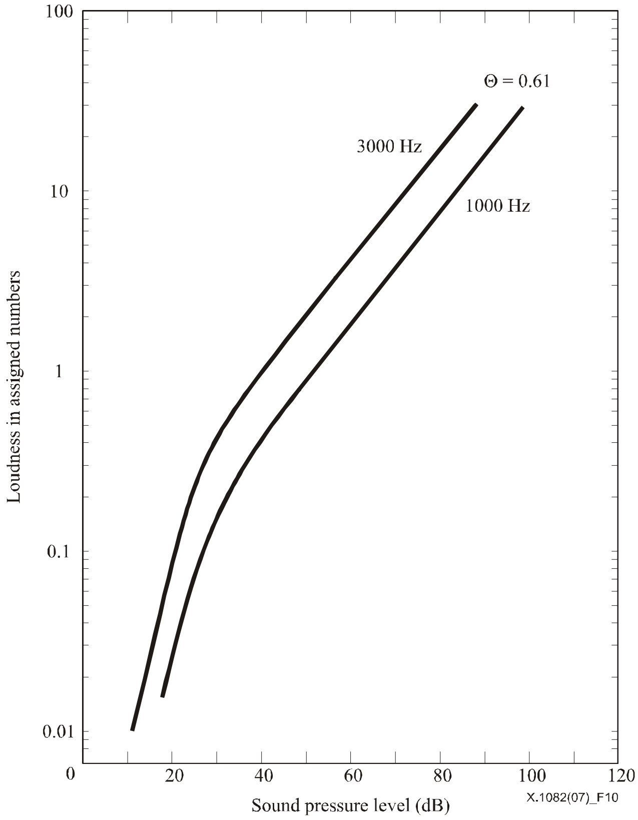
Table 4 − Quantities, units and definitions for the AUDIO modality

AUDIO-IN and AUDIO-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-8.5	auditory thresholds *fr seuils* (m) *de l'audition*	$Ŧ_{\mathrm{a}}$	thresholds of sensitivity to auditory signals and other input to the ear or the sense of hearing					Units used in the specification of auditory thresholds can involve any of the units listed in clause 5 and any of the units listed in 14-8.1.a to 14-8.4.a. It is out of the scope of this Recommendation to specify the units for each auditory threshold, as these are dependent on the nature of the AUDIO-IN stimulus, and on whether it uses cilia, cochlea or tympanum.
NOTE – Supplementary quantities and units and their letter symbols in [ISO 80000-3] (the ear manifests itself in coordinate systems for space and time) and [ISO 80000-8] (the ear senses the physical energy of sound and phonation) may be relevant to AUDIO-IN and/or AUDIO-OUT.								



NOTE – The bottom curves represent the minimum audible pressure (MAP) that young adults with normal hearing can hear in an earphone and the minimum audible field pressure (MAF) that can be heard binaurally in a free field. Thresholds for discomfort and tickle are also shown.

Figure 9 – Thresholds as a function of frequency



NOTE – The curves describe power functions with an exponent of 0.61 over the middle to high range of intensities.

Figure 10 – Subjective magnitude in assigned numbers as a function of sound pressure level in decibels

9 Quantities and units for CHEMO-IN and CHEMO-OUT

Table 5 − Quantities, units and definitions for the CHEMO modality

CHEMO-IN and CHEMO-OUT								
Quantities					Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-9.1	mass density, density *fr masse* (f) *volumique*	ρ	mass divided by volume	See [ISO 80000-4], item 4-2.	kilogram per cubic metre	kg/m^3		
14-9.2	mass concentration of B *fr concentration* (f) *en masse de B*	ρ_B	mass of B divided by the volume of the mixture, also indicated as [B]		kilogram per cubic metre	kg/m^3		Other units like kg/l or mg/l are often used. Also 10^{-3} mg/l is a useful unit of concentration for human sensors.
14-9.3	energy *fr énergie* (f)	E	all kinds of energy		joule	J		
14-9.4	Avogadro constant *fr constante* (f) *d'Avogadro*	L, N_A	number of elementary entities divided by amount of substance $N_A = N/n$ See 14-5.12.a	N_A = 6.022 141 79 (30) · 10^{23} mol^{-1} (CODATA 2006) See [ISO 80000-9], item 9-4.	mole to the power minus one	mol^{-1}		
14-9.5	osmotic pressure *fr pression* (f) *osmotique*	Π	excess pressure required to maintain osmotic equilibrium between a solution and a pure solvent separated by a membrane permeable only to the solvent	See [ISO 80000-9], item 9-26.	pascal	Pa		

Table 5 − Quantities, units and definitions for the CHEMO modality

CHEMO-IN and CHEMO-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-9.6	ionic strength *fr force* (f) *ionique*	I	the ionic strength of a solution is defined as: $I = (1/2)\ \Sigma z_i^2 m_i$ where the summation is carried out over all ions with molalities m_i		siemens per metre	S/m		1 S = Ω^{-1}
14-9.7	electrolytic conductivity *fr conductivité* (f)	κ, σ	electrolytic current density divided by the electric field strength	See [IEC 80000-6], item 6-42.	mole per kilogram	mol/kg		
14-9.8	olfactory threshold *fr seuils* (m) *de l'olfaction*	$Ƒ_\mathrm{o}$	thresholds for the concentrations of various classes of smell that can be detected	This includes detection by the human nose and other sensors. Thresholds depend on the nature of the odour. Tables exist giving the values of thresholds, but are outside the scope of this Recommendation.				Units used in the specification of olfaction thresholds can involve any of the units listed in clause 5 as well as 14-9.1.a to 14-9.7.a.

Table 5 − Quantities, units and definitions for the CHEMO modality

<table>
<tr><th colspan="9">CHEMO-IN and CHEMO-OUT</th></tr>
<tr><th colspan="5">Quantities</th><th colspan="4">Units</th></tr>
<tr><th>Item No.</th><th>Name</th><th>Symbol</th><th>Definition</th><th>Remarks</th><th>Name</th><th>Symbol</th><th>Definition</th><th>Remarks</th></tr>
<tr><td>14-9.9</td><td>gustatory thresholds
fr seuils (m) de la gustation</td><td>$Ƭ_g$</td><td>thresholds for classes of taste that can be detected by the human mouth and thresholds of sensitivity to foods, drinks and other substances</td><td>The subjective intensity of taste for a number of solutions (sweet, salt, bitter, sour) increases as a power function of the strength of the concentration (slopes range between 1.0 and 1.3).
Over wide ranges of molar concentration, the taste sensations may change.
Thresholds depend on the nature of the substance being tasted.
Classifications of types of taste exist in other publications, but are outside the scope of this Recommendation.</td><td></td><td></td><td></td><td>Units used in the specification of gustation thresholds can involve any of the units listed in clause 5 as well 14-9.1.a to 14-9.7.a.</td></tr>
<tr><td colspan="9">NOTE – Supplementary quantities and units and their letter symbols in [ISO 80000-3] (chemo-senses manifest themselves in 4D coordinates), and [ISO 80000-9] (chemo-senses are sensing this physical energy and reflecting it too) may be relevant to CHEMO-IN and/or CHEMO-OUT.</td></tr>
</table>

10 Quantities and units for RADIO-IN and RADIO-OUT

Table 6 − Quantities, units and definitions for the RADIO modality

RADIO-IN and RADIO-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-10.1	activity *fr activité* (f)	*A*	amount of spontaneous nuclear transitions per unit of time	For exponential decay, $A = \lambda N$, where λ is the decay constant. *N* is the number of nuclei in the particular energy state considered. A half-life period is also commonly used, defined as the time it takes for the activity to reduce to half its original value (for exponential decay, twice this time is needed for the activity to reduce to one quarter of its original value, and so on).	becquerel	Bq	$1\ \text{Bq} = 1\ \text{s}^{-1}$	The becquerel is a special name for second to the power minus one, to be used as the SI unit of activity. Conversion factor: curie (Ci). $1\ \text{Ci} = 3.7 \cdot 10^{10}\ \text{Bq}$
14-10.2	massic activity, specific activity *fr activité* (f) *massique*	*a*	activity divided by the total mass of the sample		becquerel per kilogram	Bq/kg		
14-10.3	exposure rate *fr débit* (m) *d'exposition*	*X′*	$X' = \mathrm{d}X/\mathrm{d}t$		coulomb per kilogram second	C/(kg · s)		$1\ \text{C/(kg} \cdot \text{s)} = \text{A/kg}$

Table 6 − Quantities, units and definitions for the RADIO modality

RADIO-IN and RADIO-OUT								
Quantities					Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-10.4	activity thresholds *fr* *seuils* (m) *d'activité*	$Ŧ_{\mathrm{r}}$	thresholds of sensitivity to activity	Thresholds depend on the nature of the radioactivity.				Units used in the specification of radioactivity thresholds can involve any of the units listed in clause 5 and any of the units listed in 14-10.1.a to 14-10.3.a. It is out of the scope of this Recommendation to specify the units for each radioactivity threshold, as these are dependent on the nature of the RADIO-IN stimulus, and on the part of the human body which is affected.
NOTE – Supplementary quantities and units and their letter symbols in [ISO 80000-3] (the human body manifests itself in 4D coordinates), [b-ISO/FDIS 80000-7] (the human body reacts to electromagnetic radiation and can emit it) and [b-ISO/DIS 80000-10] (the human body reacts to radiation and can also emit it due to ingestion of radioactive material or from embedded devices) may be relevant to RADIO-IN and/or RADIO-OUT.								

11 Quantities and units for CALOR-IN and CALOR-OUT

11.1 Introductory text on body temperature

The derived modalities of CALOR-IN and CALOR-OUT (see [b-IUPS] and [b-Klinke]) are important because the survival of a human being depends on the capacity of the body to maintain its core temperature within a narrow range centred around 37°C. Any large deviation from this will usually prove to be fatal.

A part of the mechanism to maintain core body temperature is located in the skin or controlled by neural units within the skin. These include sweating, shivering and the modulation of blood supply to the vascular system located in the skin.

The stimulus for thermal sensations is the presence of heat (or its lack thereof) at or near the skin's surface. The neural elements receptive to temperature changes are located approximately 150 µm to 200 µm below the surface. The sensation of hot, cold, warm, cool, etc., are dependent on a number of factors in complicated relationship to each other, central to which are physiological zero and neutral zone.

Physiological zero is the temperature sensation, which varies at various body sites (low: 32°C at the earlobe; high: 37°C on the forearm). A thermal sensation occurs when the temperature of the skin changes above or below physiological zero beyond a narrow range called the neutral zone. Change of temperature within the neutral zone is within the detection thresholds and will not elicit a thermal sensation.

The size of the neutral zone is dependent on the value of physiological zero at that part of the body site stimulated and the rate of temperature change. All these factors are controlled largely by the temperature of the skin just prior to stimulation which is a critical factor in thermal sensation.

There are many methods used to produce temperature changes on the skin and the means to measure them. The earliest method was the transfer of heat by conduction, that is, by placing objects in contact with the skin. The resultant sensation is complex, because it involves both mechanical and thermal sensations. The mechanical element is eliminated by using infrared lamps to provide radiation. A more modern device is the Peltier refrigerator, which utilizes the Peltier principle in a solid-state device consisting of two dissimilar electrical conductors whose temperature is a function of the amount, rate and direction of the current passed through it. The device can provide a temperature range from 0.05°C to 20°C with a rate of change between 0°C/s to 2°C/s.

Critical experiments have been performed that map the calor detection thresholds as a function of:

a) the change from the adapting temperature as a function of the adapting temperature;

b) the change from skin temperature as a function of the time of exposure; and

c) the change from skin temperature as a function of the rate of temperature change.

A matter of great concern is the temperature that produces pain. At the upper end, a temperature of about 45°C will invariably elicit a sensation of pain in normal subjects. At low temperatures, the situation is more complicated because, as the skin surface-temperature is lowered, the vascular system is activated in order to provide heat to the skin to counteract the drop in temperature. Thus the temperature at which pain is reported continues to drop to lower levels with time. However, a reasonable judgment of the temperature range at which cold-pain occurs is between 14°C and 18°C.

A critical factor for the comfort and health of humans is the ambient temperature. Again, there are many studies, in large part by industries that manufacture equipment designed to control the temperature of internal spaces where people work and live. One such study determined the growth of discomfort as a function of the departure from the comfort threshold for warm and cold stimulation. It was shown that discomfort due to falling temperatures develops more rapidly than discomfort due to rising temperatures. Also, temperatures at 14°C above or below the comfort threshold produced the same amount of discomfort.

11.2 Quantities and units

Table 7 − Quantities, units and definitions for the CALOR modality

CALOR-IN and CALOR-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-11.1	heat, amount of heat *fr quantité* (f) *de chaleur*, *chaleur*	Q	difference between the increase of the total energy of a physical system and the work done on the system, provided that the amounts of substances within the system are not changed	See [ISO 80000-5], item 5-18. The heat transferred in an isothermal phase transformation should be expressed as the change in the appropriate thermodynamic functions, e.g., $T \cdot \Delta S$, where T is thermodynamic temperature (item 14-5.10), and S is entropy (see [ISO 80000-5]). NOTE − A supply of heat may correspond to an increase of thermodynamic temperature or to other effects such as phase change or chemical processes.	joule	J		
14-11.2	heat flow rate *fr flux* (m) *thermique*	Φ	rate at which heat (item 14-11.1) crosses a given surface	See [ISO 80000-5], item 5-7. For physiological kinds of heat transfers see items 14-11.7 to 14-11.11, which do not apply to hypothermia and hyperthermia.	watt	W		

Table 7 − Quantities, units and definitions for the CALOR modality

CALOR-IN and CALOR-OUT								
Quantities					Units			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-11.3	areic heat flow rate, density of heat flow rate *fr densité* (f) *de flux thermique, flux thermique surfacique*	q, φ	$q = \Phi/A$ where Φ is heat flow rate (item 14-11.2) and A is area (item 14-5.3)	See [ISO 80000-5], item 5-8.	watt per square metre	W/m^2		
14-11.4	thermal conductivity *fr conductivité* (f) *thermique*	λ, (κ)	areic heat flow rate (item 14-11.3) divided by thermodynamic temperature (item 14-5.10) gradient	See [ISO 80000-5], item 5-9.	watt per metre kelvin	$W/(m \cdot K)$		
14-11.5	coefficient of heat transfer *fr coefficient* (m) *de transmission thermique*	K, (k)	areic heat flow rate (item 14-11.3) divided by thermodynamic temperature (item 14-5.10) gradient	See [ISO 80000-5], item 5-10.1.	watt per square metre kelvin	$W/(m^2 \cdot K)$		
14-11.6	surface coefficient of heat transfer *fr coefficient* (m) *de transmission thermique de surface*	h, (α)	$q = h(T_s - T_r)$ where q is areic heat flow rate (item 14-11.3), T_s is the thermodynamic temperature (item 14-5.10) of the surface and T_r is a reference thermodynamic temperature (item 14-5.10) characteristic of adjacent surroundings	See [ISO 80000-5], item 5-10.2.	watt per square metre kelvin	$W/(m^2 \cdot K)$		

Table 7 − Quantities, units and definitions for the CALOR modality

CALOR-IN and CALOR-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-11.7	combined non-evaporative heat transfer coefficient *fr coefficient (m) combiné de transmission thermique sans évaporation*	h	$h = h_r + h_c + h_k$ where h_r is the linear radiative heat transfer coefficient, h_c is the convective heat transfer coefficient, and h_k is the conductive heat transfer coefficient	The linear radiative heat transfer coefficient h_r (see remark to item 14-11.10) can only be used for small temperature differences.	watt per square metre kelvin	$W/(m^2 \cdot K)$		$kJ/(m^2 \cdot h \cdot K)$ is normally used in human physiology
14-11.8	conductive heat transfer *fr transmission* (f) *thermique par conduction*	Φ_k	proportional to temperature gradient and area of contact	The determining factor depends on the thermal conductivity of the conduction medium.	watt	W		kJ/h is normally used in human physiology.
14-11.9	convective heat transfer *fr transmission* (f) *thermique par convection*	Φ_c	Convective heat transfer coefficient times temperature difference times exchange area		watt	W		kJ/h is normally used in human physiology.

Table 7 − Quantities, units and definitions for the CALOR modality

CALOR-IN and CALOR-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-11.10	radiative heat transfer *fr transmission* (f) *thermique par rayonnement*	Φ_r	radiation proportional to $(T_1^4 - T_2^4)$ and area of the surface, where T_1 and T_2 are thermodynamic temperatures (see [ISO 80000-5], item 5-1) of two black surfaces, for non totally black surfaces, an additional factor less than 1 is needed)	If $(T_1 - T_2)/T$ is small, where $T = (T_1 + T_2)/2$, then approximately $(T_1^4 - T_2^4) = 4T^3(T_1 - T_2)$. Hence $4\sigma T^3$ with σ the Stephan-Boltzmann radiation constant can be treated as a linear radiative heat transfer coefficient.	watt	W		kJ/h is normally used in human physiology.
14-11.11	evaporative heat transfer *fr transmission* (f) *thermique par evaporation*	Φ_e	evaporative heat transfer coefficient times water vapour pressure difference between skin and environment times exchange area	The water vapour pressure difference is measured in Pa, in physiology in kPa.	watt	W		kJ/h is normally used in human physiology.
14-11.12	evaporative heat transfer coefficient *fr coefficient* (m) *de transmission thermique par évaporation*	h_e	areic heat flow rate divided by water vapour pressure difference between the surface and the ambient gas	h_e is measured in W/(m² · Pa), while the three other heat transfer coefficients h_r, h_c, h_k, are measured in W/(m² · K).	watt per square metre pascal	W/(m² · Pa)		

Table 7 − Quantities, units and definitions for the CALOR modality

CALOR-IN and CALOR-OUT								
Quantities					**Units**			
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**	**Name**	**Symbol**	**Definition**	**Remarks**
14-11.13	cold receptor threshold *fr seuil* (m) *de récepteur au froid*	$Ŧ_{c}$	threshold of cold-sensitive free nerve-ending	Cold and warm receptors are specialized neurons, which transfer signals to the temperature-regulation centres. These receptor detection thresholds are the smallest difference in temperature that is "felt", but these are not fixed values, as they depend on the extent of adaptation to an ambient temperature.				Units used in the specification of calor thresholds can involve any of the units listed in clause 5 as well as 14-11.1.a to 14-11.12.a. It is out of the scope of this Recommendation to specify the units for each temperature threshold.
14-11.14	warm receptor threshold *fr seuil (m) de récepteur au chaud*	$Ŧ_{w}$	threshold of warm-sensitive free nerve-ending	See the remark in 14-11.13.				

Annex A

Codes and templates for specifying thresholds

(This annex forms an integral part of this Recommendation)

A.1 Telebiometric coding scheme for identifying thresholds

Figure A.1 shows the structure of a coding scheme to be used to identify safety thresholds based on the field of study, the modality of interaction with the human or the environment, and the SI units involved. The code would normally be used in association with minimum and maximum threshold values for safe operation. The example used in Figure A.1 is for *molar heat capacity* (see Table A.4), in the field of physical chemistry, applicable to modalities TANGO-IN, TANGO-OUT, CALOR-IN and CALOR-OUT with SI units $m^2kg^1s^{-2}K^{-1}mol^{-1}$. The methodology underlying the construction of these codes is given in Annex B.

$$\underbrace{11000}_{\substack{\textbf{Scientific layer}\\ \text{(field of study)}}}\ \underbrace{\overbrace{100001}^{\textbf{input}}\ \overbrace{100001}^{\textbf{output}}}_{\substack{\textbf{Sensory layer}\\ \text{(human/environment}\\ \text{interaction)}}}\ \ \underbrace{2\ 1\ \text{-}2\ 0\ \text{-}1\ \text{-}1\ 0}_{\substack{\textbf{Metric layer}\\ \text{(SI unit code)}}}\ \ \underbrace{\text{(min) (max)}}_{\substack{\textbf{Permissible values}\\ \text{(human safety range)}}}$$

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Figure A.1 – Telebiometric code

Codes for the scientific, sensory and metric layers are provided in clause A.2.

A.2 Table of codes for the scientific, sensory and metric layers

Tables A.1, A.2 and A.3 provide the codes for the first three layers depicted in Figure A.1. For more detail, see [ITU-T X.1081]. The primary entities for the metric layer (see Table A.3) are the SI base units.

Table A.1 – Primary entities and their codes for the scientific layer

Code	Field of study
10000	Physics
01000	Chemistry
00100	Biology
00010	Culturology
00001	Psychology

Table A.2 – Primary entities and their codes for the sensory layer

Code	Sense
100000 000000	TANGO-IN
010000 000000	VIDEO-IN
001000 000000	AUDIO-IN
000100 000000	CHEMO-IN
000010 000000	RADIO-IN
000001 000000	CALOR-IN
000000 100000	TANGO-OUT
000000 010000	VIDEO-OUT
000000 001000	AUDIO-OUT
000000 000100	CHEMO-OUT
000000 000010	RADIO-OUT
000000 000001	CALOR-OUT

Table A.3 – Examples of primary entities and their codes for the metric layer

Code	Name of quantity	Symbol of quantity	Name of unit	symbol of unit
1 0 0 0 0 0 0	length	l, L, b, B, h, H, d, δ, r, R, r_Q, ρ, d, D, s, Δr, x, y, z	metre	m
0 1 0 0 0 0 0	mass	M	kilogram	kg
0 0 1 0 0 0 0	time	T	second	s
0 0 0 1 0 0 0	electric current	I, i	ampere	A
0 0 0 0 1 0 0	thermodynamic temperature	T, (Θ)	kelvin	K
0 0 0 0 0 1 0	amount of substance	n, (v)	mole	mol
0 0 0 0 0 0 1	luminous intensity	I, (I_V)	candela	cd
–1 0 0 0 0 0 0	reciprocal length	$\{l, L, b, B, h, H, d, \delta, r, R, rQ, \rho, d, D, s, \Delta r, x, y, z\}^{-1}$	metre to the power minus one	m^{-1}
0 –1 0 0 0 0 0	reciprocal mass	M^{-1}	kilogram to the power minus one	kg^{-1}
0 0 –1 0 0 0 0	reciprocal time	t^{-1}	second to the power minus one	s^{-1}
0 0 0 –1 0 0 0	reciprocal electric current	I^{-1}, i^{-1}	ampere to the power minus one	A^{-1}
0 0 0 0 –1 0 0	reciprocal thermodynamic temperature	T^{-1}, (Θ^{-1})	kelvin to the power minus one	K^{-1}
0 0 0 0 0 –1 0	reciprocal amount of substance	N^{-1}, (v^{-1})	mole to the power minus one	mol^{-1}
0 0 0 0 0 0 –1	reciprocal luminous intensity	I^{-1}, (I_V^{-1})	candela to the power minus one	cd^{-1}

A.3 An example of the use of the codes in a table of threshold values

Table A.4 is an illustration of a template containing details of the phenomenon, quantity (see the other tables of this annex), the telebiometric codes, and the three layers and SI units identified by the code. The last two columns are for the insertion of appropriate threshold values to record either safety or sensitivity levels.

Table A.4 – Telebiometrics code of sample phenomena

Phenomenon	Quantity	Telebiometrics code	Scientific Layer (field of study)	Sensory layer (human/ environment interaction)	Metric Layer (unit) (coordinate symbol)		Permissible range	
							(min)	(max)
LIGHT	light exposure	10000 010000 000000 -2 0 1 0 0 0 1	Physics	VIDEO-IN	lux second	$m^{-2}s^{1}cd^{1}$		
HEAT	thermal resistance	10000 100001 100001 -2 -1 3 0 1 0 0	Physics	TANGO-IN TANGO-OUT CALOR-IN CALOR-OUT	kelvin per watt	$m^{-2}kg^{-1}s^{3}K^{1}$		
MECHANICS	density	10000 100000 000000 -3 1 0 0 0 0 0	Physics	TANGO-IN	kilogram per cubic metre	$m^{-3}kg^{1}$		
ACOUSTICS	sound intensity	10000 001000 001000 0 1 -3 0 0 0 0	Physics	AUDIO-IN AUDIO-OUT	watt per square metre	$kg^{1}s^{-3}$		
ELECTRICITY	electric charge	10000 100000 100000 0 0 1 1 0 0 0	Physics	TANGO-IN TANGO-OUT	coulomb	$s^{1}A^{1}$		
MAGNETISM	magnetic flux density	10000 100000 000000 0 1 -2 -1 0 0 0	Physics	TANGO-IN	tesla	$kg^{1}s^{-2}A^{-1}$		
ELECTRO-MAGNETIC RADIATION	radiant energy fluence	10000 000010 000000 0 1 -2 0 0 0 0	Physics	RADIO-IN	joule per square metre	$kg^{1}s^{-2}$		
CHEMICAL REACTION	ionic strength	01000 000100 000100 0 -1 0 0 0 1 0	Chemistry	CHEMO-IN CHEMO-OUT	mole per kilogram	$kg^{-1}mol^{1}$		
THERMO-CHEMICAL REACTION	molar heat capacity	11000 100001 100001 2 1 -2 0 -1 -1 0	Physical-chemistry	TANGO-IN TANGO-OUT CALOR-IN CALOR-OUT	joule per mole kelvin	$m^{2}kg^{1}s^{-2}K^{-1}mol^{-1}$		
NUCLEAR REACTION	absorbed dose rate	11000 000110 000110 2 0 -3 0 0 0 0	Chemo-physics (molecular physics)	CHEMO-IN CHEMO-OUT RADIO-IN RADIO-OUT	gray per second	$m^{2}s^{-3}$		

Annex B

Construction of the telebiometric code

(This annex forms an integral part of this Recommendation)

B.1 Structure of the model

This model is an extension of Lalvani's 22-dimensional morphological model for telebiometrics [b-Lalvani] (adding two primary entities – and two extra dimensions – for CALOR).

The model comprises three distinct layers that specify telebiometrics, namely the scientific discipline involved (scientific layer – layer 1), the interaction between a human being and the environment (sensory layer – layer 2), and the metric quantifying the measurable quantities involved in associated physical phenomena of this interaction (metric layer – layer 3).

The layers are independent and are each represented in higher-dimensional space where each vertex in these spaces is indexed by its coordinates. These higher-dimensional coordinates provide a code for each entity that is mapped. This coordinate is the telebiometric code for that entity. The composite model requires the superimposition of the three layers in one space. The model is representative of a general approach and can be modified by adding or taking away primary entities within any layer as new knowledge transforms what is currently known.

The scientific layer is 5-dimensional and specifies 5 primary entities: these are the 5 basic fields of study (physics, chemistry, biology, culturology and psychology) and 32 combinations of these fields. The combinations are mapped onto the vertices of a 5-dimensional cube, with each vertex specifying a distinct combination. The basic fields are represented by vertices of this cube, which are unit vectors identified by the codes in Table A.1.

The sensory layer is 12-dimensional and specifies 12 primary entities that represent all human sensory interactions with technology and the environment and their 4095 combinations. These 12 interactions include TANGO, VIDEO, AUDIO, CHEMO, RADIO and CALOR, each in their IN and OUT states. The combinations are mapped onto the vertices of a 12-dimensional cube. The senses are represented by vertices of this cube, which are unit vectors, identified by the codes in Table A.2.

The metric layer has 7 independent dimensions based on the 7 ISQ base quantities of measurement, namely, LENGTH (metre, m), MASS (kilogram, kg), TIME (second, s), ELECTRIC CURRENT (ampere, A), THERMODYNAMIC TEMPERATURE (kelvin, K), AMOUNT OF SUBSTANCE (mole, mol), and LUMINOUS INTENSITY (candela, cd). This layer is mapped onto the vertices of an asymmetric portion of a 7-cubic lattice.

The composite model is mapped into a 24-dimensional space.

B.2 The metric layer

The metric layer is more complex than the other two layers as each of the 7 entities has a varying power (i.e., when the entity is raised to a power, for example, "metre squared" or m^2, or when the entity is used in its reciprocal state, e.g., "metre to the power minus one" or m^{-1}). The ranges of powers in use for each basic SI unit were summarized in Table A of [b-Lalvani], and the 128 combinations of primary quantities (where each quantity is raised to the power 0 or 1) are listed in Table 4 of [b-Lalvani]. Assuming all combinations of these powers are permissible measurable quantities, the number of possible quantities equals 26'730 (a number obtained by multiplying all available powers including 0). This is admittedly a large number, but most of these quantities are not in use at the moment. What is currently in use, a much smaller number, is most likely going to change in the future. The proposed model allows for these changes to be accommodated and for new measurable quantities to be added. The Lalvani model thus offers a general framework for all possible multimodal interactions.

B.3 The primary entities and their use in the telebiometric code

The primary entities comprising the 3 layers are listed in Annex A with their corresponding codes. These are the generators of the hybrids and composite entities.

Figure A.1 illustrates a representative telebiometric code, a composite code of all the three layers. Appended to the 24 single code numbers are two additional numbers specifying the permissible range of values given by a minimum and a maximum for a specific measurable quantity. These permissible ranges for different quantities are mapped independently within a logarithmic "powers of ten" scale as suggested, for example, by Bielawski (see [ITU-T X.1081]).

Table A.2 illustrates sample phenomena and their telebiometric code. The permissible values are expected to be filled in by experts within their respective fields and published in subsequent standardization. This table can be extended to include all quantities included in Tables 6-15 in [b-Lalvani] to provide a code for all measurable quantities in use in science and technology today.

B.4 Closing remarks

This subclause is informative.

Several closing remarks on the telebiometric code follow. These issues point to possible future refinements of the code.

First, the proposed code is a discrete code, with each entity existing as a discrete unit. This means that digits in the code are integers. It is possible to use the same code to represent continuously morphing entities, or some intermediate gradation between the entities by introducing real numbers in the code. For example, for layer 1, if two stages were introduced "between" two primary fields, say chemistry as (0,1,0,0,0) and biology (0,0,1,0,0), we would then have the possibility of introducing bio-chemistry as (0,.66,.33,0,0) or chemo-biology as (0,.33,.66,0,0) as suggested in [b-Lalvani]. In this system, all knowledge of both chemistry and biology will have a code (0, 1, 1, 0, 0). Although finer gradations than this may not be of practical value, in principle, it is possible to think of all knowledge as a continuum and all fields of knowledge as a continuum from one field to another. On a philosophical level, this makes sense as nature has no separate departments of physics or chemistry or biology. It is all acting as one inter-connected organic whole. Similarly, a continuum model for the sensory and metric layers are possibilities as pointed out in [b-Lalvani]. For the sensory layer, this deals with the issue of emergence of distinct senses from a generalized or universal sensor, and for the metric layer, this deals with the emergence of primary entities like space, time, mass, temperature, etc., also possibly from a universal origin. Continuously morphing primary entities will require the proposed code to use real numbers instead of the integers.

Second, the telebiometric code can be extended further by refining each layer. For example, the sensory layer can be further divided by introducing additional dimensions emanating from some of the sensory actions. The CHEMO state can be broken down to SMELL and TASTE, each of which can be mapped into a smell space and a taste space. Similarly, TANGO can be broken down into different types and intensities of the touch sense, VIDEO and AUDIO can be decomposed into all aspects that respectively impact the visual and the audio senses. This would involve adding additional digits to the code.

Third, the incorporation of the scalar metric for each of the quantities in the metric layer requires the integration of the "powers of ten" scale or introduction of a universal metric for all phenomena at all scales, for example, the Planck units as universal measuring units of all nature ranging from the elementary particles to the cosmos. This issue remains to be resolved and will require re-addressing the two numbers added for the permissible values at the end of the telebiometric code.

Annex C

Specification of the telebiometric code and its graphical symbols

(This annex forms an integral part of this Recommendation)

C.1 The telebiometric codes

A detailed code can be constructed based on the model presented in Annexes A and B. Part of this is presented in Table C.1 for the classification of telebiometric devices based on the TMM. Clause C.2 specifies associated graphics symbols. Table C.1 contains only the entries 1 to 29 and 4067 to 4095. The full table can be deduced from these entries.

Table C.1 – Part of the table of all combinations of human-machine IN and OUT interaction states and all types of possible telebiometric unimodal and multimodal devices

1	000000-000001	CO
2	000000-000010	RO
3	000000-000011	RO CO
4	000000-000100	XO
5	000000-000101	XO CO
6	000000-000110	XO RO
7	000000-000111	XO RO CO
8	000000-001000	AO
9	000000-001001	AO CO
10	000000-001010	AO RO
11	000000-001011	AO ROCO
12	000000-001100	AO XO
13	000000-001101	AO XO CO
14	000000-001110	AO XO RO
15	000000-001111	AO XO RO CO
16	000000-010000	VO
17	000000-010001	VO CO
18	000000-010010	VO RO
19	000000-010011	VO RO CO
20	000000-010100	VO XO
21	000000-010101	VO XO CO
22	000000-010110	VO XO RO
23	000000-010111	VO XO RO CO
24	000000-011000	VO AO
25	000000-011001	VO AO CO
26	000000-011010	VO AO RO
27	000000-011011	VO AO RO CO
28	000000-011100	VO AO XO
29	000000-011101	VO AO XO CO

4067	111111-100011	TI VI AI XI RI CI TO RO CO
4068	111111-100100	TI VI AI XI RI CI TO XO
4069	111111-100101	TI VI AI XI RI CI TO XO CO
4070	111111-100110	TI VI AI XI RI CI TO XO RO
4071	111111-100111	TI VI AI XI RI CI TO XO RO CO
4072	111111-101000	TI VI AI XI RI CI TO AO
4073	111111-101001	TI VI AI XI RI CI TO AO CO
4074	111111-101010	TI VI AI XI RI CI TO AO RO
4075	111111-101011	TI VI AI XI RI CI TO AO RO CO
4076	111111-101100	TI VI AI XI RI CI TO AO XO
4077	111111-101101	TI VI AI XI RI CI TO AO XO CO
4078	111111-101110	TI VI AI XI RI CI TO AO XO RO
4079	111111-101111	TI VI AI XI RI CI TO AO XO RO CO
4080	111111-110000	TI VI AI XI RI CI TO VO
4081	111111-110001	TI VI AI XI RI CI TO VO CO
4082	111111-110010	TI VI AI XI RI CI TO VO RO
4083	111111-110011	TI VI AI XI RI CI TO VO RO CO
4084	111111-110100	TI VI AI XI RI CI TO VO XO
4085	111111-110101	TI VI AI XI RI CI TO VO XO CO
4086	111111-110110	TI VI AI XI RI CI TO VO XO RO
4087	111111-110111	TI VI AI XI RI CI TO VO XO RO CO
4088	111111-111000	TI VI AI XI RI CI TO VO AO
4089	111111-111001	TI VI AI XI RI CI TO VO AO CO
4090	111111-111010	TI VI AI XI RI CI TO VO AO RO
4091	111111-111011	TI VI AI XI RI CI TO VO AO RO CO
4092	111111-111100	TI VI AI XI RI CI TO VO AO XO
4093	111111-111101	TI VI AI XI RI CI TO VO AO XO CO
4094	111111-111110	TI VI AI XI RI CI TO VO AO XO RO
4095	111111-111111	TI VI AI XI RI CI TO VO AO XO RO CO

C.2 The graphic symbols for codes of telebiometric devices

Figure C.1, Telebiometric logotype chart, depicts the symbols for the codes listed in Table C.1. The symbols are intended for easy human recognition on products and shipments to supplement the use of the full codes. The chart containing the full codes is shown in Table C.2, parts 1, 2 and 3, respectively as the first, middle and last parts of the chart. The full chart can be deduced from these entries.

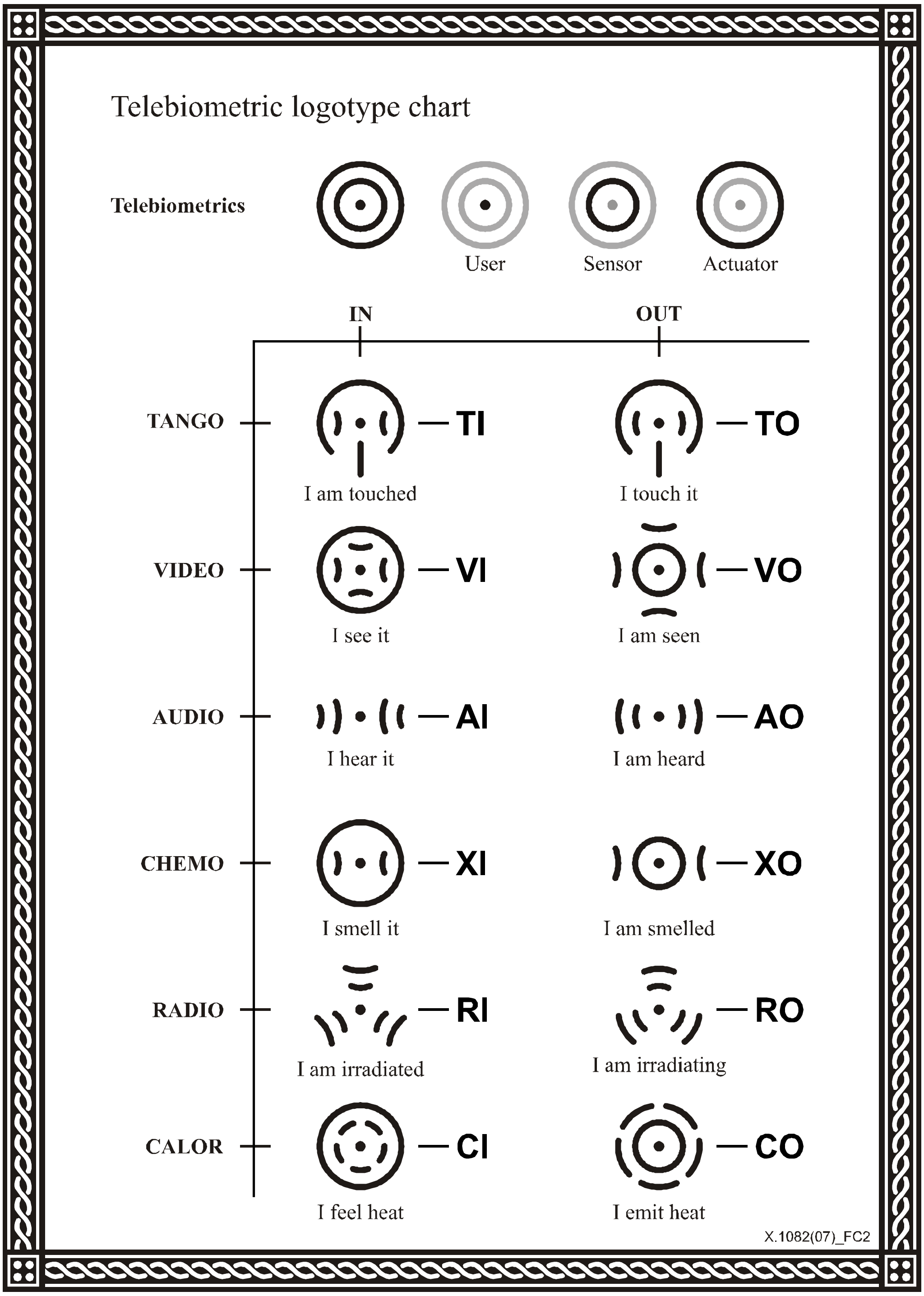

Figure C.1 – Telebiometric logotype chart

Table C.2 part 1 – Full codes of the telebiometric chart: First part

Code	TO	VO	AO	XO	RO	CO
0001						CO
0002					RO	
0003					RO	CO
0004				XO		
0005				XO		CO
0006				XO	RO	
0007				XO	RO	CO
0008			AO			
009			AO			CO
0010			AO		RO	
0011			AO		RO	CO
0012			AO	XO		
0013			AO	XO		CO
0014			AO	XO	RO	
0015			AO	XO	RO	CO
0016		VO				
0017		VO				CO
0018		VO			RO	
0019		VO			RO	CO
0020		VO		XO		
0021		VO		XO		CO
0022		VO		XO	RO	
0023		VO		XO	RO	CO
0024		VO	AO			
0025		VO	AO			CO
0026		VO	AO		RO	
0027		VO	AO		RO	CO
0028		VO	AO	XO		
0029		VO	AO	XO		CO
0030		VO	AO	XO	RO	
0031		VO	AO	XO	RO	CO
0032	TO					
0033	TO					CO
0034	TO				RO	
0035	TO				RO	CO
0036	TO			XO		

Table C.2 part 2 – Full codes of the telebiometric chart: Middle part

2017	VI AI XI RI CI TO CO
2018	VI AI XI RI CI TO RO
2019	VI AI XI RI CI TO RO CO
2020	VI AI XI RI CI TO XO
2021	VI AI XI RI CI TO XO CO
2022	VI AI XI RI CI TO XO RO
2023	VI AI XI RI CI TO XO RO CO
2024	VI AI XI RI CI TO AO
2025	VI AI XI RI CI TO AO CO
2026	VI AI XI RI CI TO AO RO
2027	VI AI XI RI CI TO AO RO CO
2028	VI AI XI RI CI TO AO XO
2029	VI AI XI RI CI TO AO XO CO
2030	VI AI XI RI CI TO AO XO RO
2031	VI AI XI RI CI TO AO XO RO CO
2032	VI AI XI RI CI TO VO
2033	VI AI XI RI CI TO VO CO
2034	VI AI XI RI CI TO VO RO
2035	VI AI XI RI CI TO VO RO CO
2036	VI AI XI RI CI TO VO XO
2037	VI AI XI RI CI TO VO XO CO
2038	VI AI XI RI CI TO VO XO RO
2039	VI AI XI RI CI TO VO XO RO CO
2040	VI AI XI RI CI TO VO AO
2041	VI AI XI RI CI TO VO AO CO
2042	VI AI XI RI CI TO VO AO RO
2043	VI AI XI RI CI TO VO AO RO CO
2044	VI AI XI RI CI TO VO AO XO
2045	VI AI XI RI CI TO VO AO XO CO
2046	VI AI XI RI CI TO VO AO XO RO
2047	VI AI XI RI CI TO VO AO XO RO CO
2048	TI
2049	TI CO
2050	TI RO
2051	TI RO CO
2052	TI XO

Table C.2 part 3 – Full codes of the telebiometric chart: Last part

4069	TI	VI	AI	XI	RI	CI	TO			XO		CO
4070	TI	VI	AI	XI	RI	CI	TO			XO	RO	
4071	TI	VI	AI	XI	RI	CI	TO			XO	RO	CO
4072	TI	VI	AI	XI	RI	CI	TO		AO			
4073	TI	VI	AI	XI	RI	CI	TO		AO			CO
4074	TI	VI	AI	XI	RI	CI	TO		AO		RO	
4075	TI	VI	AI	XI	RI	CI	TO		AO		RO	CO
4076	TI	VI	AI	XI	RI	CI	TO		AO	XO		
4077	TI	VI	AI	XI	RI	CI	TO		AO	XO		CO
4078	TI	VI	AI	XI	RI	CI	TO		AO	XO	RO	
4079	TI	VI	AI	XI	RI	CI	TO		AO	XO	RO	CO
4080	TI	VI	AI	XI	RI	CI	TO	VO				
4081	TI	VI	AI	XI	RI	CI	TO	VO				CO
4082	TI	VI	AI	XI	RI	CI	TO	VO			RO	
4083	TI	VI	AI	XI	RI	CI	TO	VO			RO	CO
4084	TI	VI	AI	XI	RI	CI	TO	VO		XO		
4085	TI	VI	AI	XI	RI	CI	TO	VO		XO		CO
4086	TI	VI	AI	XI	RI	CI	TO	VO		XO	RO	
4087	TI	VI	AI	XI	RI	CI	TO	VO		XO	RO	CO
4088	TI	VI	AI	XI	RI	CI	TO	VO	AO			
4089	TI	VI	AI	XI	RI	CI	TO	VO	AO			CO
4090	TI	VI	AI	XI	RI	CI	TO	VO	AO		RO	
4091	TI	VI	AI	XI	RI	CI	TO	VO	AO		RO	CO
4092	TI	VI	AI	XI	RI	CI	TO	VO	AO	XO		
4093	TI	VI	AI	XI	RI	CI	TO	VO	AO	XO		CO
4094	TI	VI	AI	XI	RI	CI	TO	VO	AO	XO	RO	
4095	TI	VI	AI	XI	RI	CI	TO	VO	AO	XO	RO	CO

Appendix I

Explanatory notes

(This appendix does not form an integral part of this Recommendation)

I.1 Unimodal and multimodal wetware interaction

Any human input-output organ (e.g., skin, eye, ear, nose, tongue), or the whole of the human body – a wetware component, can interact with sensors and actuators within any enclosing ecosystem (and in particular with a telebiometric device) in a unimodal mode.

Unimodal wetware interaction is defined as any interaction between wetware and a telebiometric device where the measurements are taken using only one of the output modalities of the wetware. This relates to vibratory display, visual, aural, gas display, injurious and/or painful display means and any associated output.

Wetware can also interact multimodally with one or more telebiometric devices if several modes are in use and the measurements are taken using at least two of the modalities or two distinct uses of a single modality of the wetware.

The contours of the volume of the wetware and its many outputs are queried by sensors of the appropriate modality (e.g., the luminance of the skin can be registered by video capture).

By interacting with actuators, unimodal wetware components can show divergences from the cognitive modalities of the wetware being browsed, transmitting information devoid of intent but available for measurement, e.g., the speed and cadence of typing on a keyboard transmits information about the user that is not captured by the semiotic content of the typed letters.

The conditions of connectivity to telebiometric displays, sensors and actuators are characterized by unimodal wetware component specifications: only then do the unimodal wetware protocols (see clause I.2) apply.

I.2 Wetware protocols

Wetware protocols (c.f. diplomatic protocols) – see [b-Doyle] and [b-Raymond], specified by international standards, define the conditions under which human bodies may be safely treated as information systems as defined by the life sciences. It is intended that robust and redundant quantitative and qualitative data for each modality supporting wetware protocols be collected in an open database hosted on the world wide web for recording thresholds and ranges to ensure safe interactions between wetware and telebiometric devices. Capturing information from a wide variety of experts, the database will help integrate the human side of the man/machine interface into the information technology design requirements for the safe development and use of telebiometric devices. These conditions in these protocols will establish a "bill of rights" for end users while providing a robust set of design heuristics for the engineer.

I.3 Semi-open telebiometric systems

A semi-open telebiometric system is a system which allows multiple exchanges between the wetware component and the remote system, perhaps without knowledge by the wetware component, but which has a boundary that restricts the class of exchanges to ensure acceptable safe and secure operation, both at the physical and at the sociological/political level. Semi-openness involves selective interaction with telebiometric devices. Wetware protocols (see clause I.2) provide the conditions of operation for such semi-open systems.

I.4 Technophobia

Technophobia can be described as the widespread fear of a general or specific technological adjunct, actual or in development. The collective fear response emerges from real effects (e.g., electrocution, cancer, the unintended proliferation of transgenic alleles) or imagined effects of the widespread or individual use of a technology. Such technophobia can become the occasion for the production of an international standard when fear responses impact the adoption and ease of use of a technology (e.g., electrification).

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