Wednesday, February 26, 2020 OFFICIAL DIARY

AGREEMENT by which the Plenary of the Federal Institute of Telecommunications issues the Technical Provision IFT-012-2019: Technical specifications for compliance with the maximum limits of radioelectric emissions non-ionizing products, equipment, devices or appliances intended for telecommunications that can be connected to a telecommunications network and / or make use of the radio spectrum. Absorption Rate Specific (SAR).

In the margin a logo that says: Federal Telecommunications Institute.

AGREEMENT THROUGH WHICH THE PLENARY OF THE FEDERAL INSTITUTE OF TELECOMMUNICATIONS ISSUING THE TECHNICAL PROVISION IFT-012-2019: TECHNICAL SPECIFICATIONS FOR COMPLIANCE WITH THE LIMITS MAXIMUM NON-IONIZING RADIOELECTRIC EMISSIONS FROM PRODUCTS, EQUIPMENT, DEVICES OR DEVICES INTENDED FOR TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A NETWORK OF TELECOMMUNICATIONS AND / OR MAKING USE OF THE RADIOELECTRIC SPECTRUM. ABSORPTION RATE SPECIFIC (SAR).

BACKGROUND

I. On June 11, 2013, the Official Gazette of the Federation (hereinafter, the "DOF") published the "Decree by which various provisions of articles 6, 7, 27, 28, are amended and added 73, 78, 94 and 105 of the Political Constitution of the United Mexican States, regarding telecommunications "(hereinafter, the" Constitutional Decree "), through which the Institute was created Federal Telecommunications (hereinafter, the "Institute"), as an autonomous body with legal personality and own assets.

II. On July 14, 2014, the "Decree issuing the Federal Law on Telecommunications and Broadcasting, and the Law of the State Public Broadcasting System Mexican; and various provisions on the subject of telecommunications and broadcasting "(hereinafter, the" Law Decree "), which, in terms of provided by its first transitory article, entered into force 30 (thirty) calendar days following upon publication, that is, on August 13, 2014.

III. On September 4, 2014, the Organic Statute of the Federal Institute of Telecommunications (hereinafter, the "Organic Statute"), which entered into force on the 26th of same month and year, the last modification of which was published in the DOF on December 7, 2018.

IV. On July 8, 2015, the Plenary of the Institute approved unanimously, in its XIV Session Ordinary the "AGREEMENT THROUGH WHICH THE PLENARY OF THE FEDERAL INSTITUTE OF TELECOMMUNICATIONS DETERMINES TO SUBMIT THE DRAFT FOR PUBLIC CONSULTATION ACCORDING TO WHICH TECHNICAL PROVISION IFT-007-2015 IS ISSUED: OPERATING MEASURES TO COMPLY WITH THE EXPOSURE LIMITS MAXIMUM FOR HUMANS AT ELECTROMAGNETIC RADIATION OF NON-IONIZING RADIO FREQUENCY IN THE RANGE FROM 100 kHz TO 300 GHz IN THE ENVIRONMENT OF RADIOCOMMUNICATIONS TRANSMITTERS ".

V. In accordance with the provisions of article 51 of the Federal Telecommunications Law and Broadcasting, which indicates that for the issuance and modification of rules, guidelines or provisions administrative matters of a general nature, as well as in any case determined by the Plenary, the Institute must carry out public consultations under the principles of transparency and citizen participation, July 10 to 17 and from August 3 to 20, 2015 (20 business days) the public consultation was held of the "DRAFT AGREEMENT THROUGH WHICH THE PROVISION IS ISSUED

TECHNIQUE IFT-007-2015: OPERATING MEASURES TO COMPLY WITH THE LIMITS MAXIMUM EXPOSURE FOR HUMANS TO ELECTROMAGNETIC RADIATION NON-IONIZING RADIO FREQUENCY IN THE RANGE FROM 100 kHz TO 300 GHz IN THE ENVIRONMENT OF RADIOCOMMUNICATIONS TRANSMITTERS ".

SAW. Derived from the public consultation process mentioned in the previous point, it was determined convenient divide the "DRAFT AGREEMENT THROUGH WHICH THE PROVISION IS ISSUED TECHNIQUE IFT-007-2015: OPERATING MEASURES TO COMPLY WITH THE LIMITS MAXIMUM EXPOSURE FOR HUMANS TO ELECTROMAGNETIC RADIATION NON-IONIZING RADIO FREQUENCY IN THE RANGE FROM 100 kHz TO 300 GHz IN THE ENVIRONMENT OF RADIOCOMMUNICATIONS EMITTERS "in two, which are the "PROPOSED DRAFT TECHNICAL PROVISION IFT-007-2016: MAXIMUM EXPOSURE LIMITS FOR HUMANS AT RADIO FREQUENCY ELECTROMAGNETIC RADIATION NO

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VII. On December 8, 2016, the Plenary of the Institute approved by unanimous votes, in its XLIV Session Ordinary the "AGREEMENT THROUGH WHICH THE PLENARY OF THE FEDERAL INSTITUTE OF TELECOMMUNICATIONS DETERMINES TO SUBMIT THE DRAFT FOR PUBLIC CONSULTATION TECHNICAL DISPOSITION IFT-012-2016: TECHNICAL SPECIFICATIONS FOR THE COMPLIANCE WITH THE MAXIMUM LIMITS OF RADIOELECTRIC EMISSIONS NO IONIZERS OF PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A NETWORK OF TELECOMMUNICATIONS AND / OR MAKING USE OF THE RADIOELECTRIC SPECTRUM. INDEX OF SPECIFIC ABSORPTION (SAR) ", for a period of 40 (forty) business days.

VIII. Obeying what is indicated in article 51 of the Federal Telecommunications Law and Broadcasting, which indicates that for the emission and modification of rules, guidelines or administrative provisions of a general nature, as well as in any case that determines the Plenary session, the Institute must carry out public consultations under the principles of transparency and citizen participation, therefore, from December 13 to 21, 2016 and from January 5 to December 21, February 2017 (40 business days) the public consultation of the "PRELIMINARY PROJECT OF TECHNICAL PROVISION IFT-012-2016: TECHNICAL SPECIFICATIONS FOR THE COMPLIANCE WITH THE MAXIMUM NON-IONIZING RADIATION LIMITS OF THE PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS DESTINED TO TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A NETWORK OF TELECOMMUNICATIONS AND / OR MAKING USE OF THE RADIOELECTRIC SPECTRUM. INDEX OF SPECIFIC ABSORPTION (SAR) ".

IX. On February 14, 2017, the National Telecommunications Association (ANATEL) through its Director General, asked the Plenary of the Institute to extend the public consultation period for at least 30 (thirty) calendar days.

X. On February 15, 2017, the Plenary of the Institute approved by unanimity of votes, in its VI Session Ordinary the "AGREEMENT THROUGH WHICH THE PLENARY OF THE FEDERAL INSTITUTE OF TELECOMMUNICATIONS EXTENDS THE PERIOD OF PUBLIC CONSULTATION ESTABLISHED IN THE AGREEMENT THROUGH WHICH THE PLENARY OF THE FEDERAL INSTITUTE OF

TELECOMMUNICATIONS DETERMINES TO SUBMIT THE DRAFT FOR PUBLIC CONSULTATION TECHNICAL DISPOSITION IFT-012-2016: TECHNICAL SPECIFICATIONS FOR THE COMPLIANCE WITH THE MAXIMUM LIMITS OF RADIOELECTRIC EMISSIONS NO IONIZERS OF PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A NETWORK OF TELECOMMUNICATIONS AND / OR MAKING USE OF THE RADIOELECTRIC SPECTRUM. INDEX OF SPECIFIC ABSORPTION (SAR) ".

XI. In accordance with the agreement in Agreement P / IFT / 150217/87 of the VI Ordinary Session of the Plenary of the Federal Telecommunications Institute, carried out on February 15, 2017, expands 30 (thirty) calendar days the public consultation period originally established in the "AGREEMENT THROUGH WHICH THE PLENARY OF THE FEDERAL INSTITUTE OF TELECOMMUNICATIONS DETERMINES TO SUBMIT FOR PUBLIC CONSULTATION THE DRAFT DISPOSAL TECHNICAL IFT-012-2016: TECHNICAL SPECIFICATIONS FOR COMPLIANCE WITH THE MAXIMUM LIMITS OF NON-IONIZING RADIOELECTRIC EMISSIONS OF PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS THAT THEY CAN BE CONNECTED TO A TELECOMMUNICATIONS NETWORK AND / OR MAKE USE OF RADIOELECTRIC SPECTRUM. SPECIFIC ABSORPTION RATE (SAR) ", consequently, the total period of public consultation was 61 (sixty-one) business days, from December 13, 2016 as of March 23, 2017.

XII. The General Coordination of Regulatory Improvement through official letter IFT / 211 / CGMR / 050/2018 issued the Non-binding opinion regarding the draft "AGREEMENT THROUGH WHICH THE PLENARY OF THE FEDERAL INSTITUTE OF TELECOMMUNICATIONS ISSUING THE TECHNICAL PROVISION IFT-012-2018: TECHNICAL SPECIFICATIONS FOR COMPLIANCE WITH THE LIMITS MAXIMUM NON-IONIZING RADIOELECTRIC EMISSIONS OF THE PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS THAT THEY CAN BE CONNECTED TO A TELECOMMUNICATIONS NETWORK AND / OR MAKE USE OF RADIOELECTRIC SPECTRUM. SPECIFIC ABSORPTION INDEX (SAR). ", In said opinion, expressed various recommendations in order to strengthen and improve both the Impact Analysis Regulatory as some provisions of the project, which were analyzed and, where appropriate, attended.

Derived from the above and

CONSIDERING

FIRST.- Competence of the Institute. In accordance with article 28, fifteenth paragraph of the Political Constitution of the United Mexican States (hereinafter, the "Constitution"), the Institute has as object of the efficient development of broadcasting and telecommunications, in accordance with the provisions of the Constitution and in the terms established by law.

For this purpose, in terms of the invoked constitutional precept, as well as articles 1 and 7 of the Law Federal Telecommunications and Radio Broadcasting (hereinafter, "LFTR"), the Institute is in charge of regulation, promotion and supervision of the use, exploitation and exploitation of the radioelectric spectrum, orbital resources, satellite services, public telecommunications networks and the provision of broadcasting and telecommunications services, as well as access to active and passive infrastructure and other essential supplies, guaranteeing the provisions of articles 6. and 7th. of the Constitution.

On the other hand, article 6. Constitutional, in its section B, section II, indicates that the

Telecommunications are public services of general interest, so the State will guarantee that they are provided under conditions of competition, quality, plurality, universal coverage, interconnection, convergence, continuity, free access and without arbitrary interference.

Likewise, the Institute is the authority on economic competition matters for the sectors of broadcasting and telecommunications, so that in these it will exercise exclusively the powers of article 28 of the Constitution, the LFTR and the Federal Law on Economic Competition.

The twentieth paragraph, section IV of article 28 of the Constitution states that the Institute may issue administrative provisions of a general nature exclusively for the fulfillment of its function regulatory in the sector of its competition. In that order of ideas, the second paragraph of article 7 of the LFTR foresees that the Institute is in charge of the regulation, promotion and supervision of the use, exploitation and exploitation of the radioelectric spectrum, and the fourth paragraph of the same article provides that the Institute is authority on technical guidelines related to infrastructure and equipment connecting to the telecommunications networks, as well as in the field of approval and conformity assessment of said infrastructure and equipment.

Article 15, sections I and LVI, of the LFTR indicates that the Institute has the power to issue administrative provisions of a general nature, fundamental technical plans, guidelines, costs, conformity assessment procedures, approval and certification procedures and technical regulations on telecommunications and broadcasting; as well as other provisions for compliance with the provisions of the LFTR.

That is, the Institute is the authority on technical guidelines related to infrastructure and products, equipment, devices or apparatus intended for telecommunications that can be connected to a telecommunications network or make use of the radioelectric spectrum, as well as the test methods to check compliance with these specifications.

In accordance with the foregoing, the Institute has the powers to issue this Agreement and issue the "TECHNICAL PROVISION IFT-012-2019: TECHNICAL SPECIFICATIONS FOR COMPLIANCE WITH THE MAXIMUM LIMITS OF NON-IONIZING RADIOELECTRIC EMISSIONS OF THE PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS WHICH MAY BE CONNECTED TO A TELECOMMUNICATIONS NETWORK AND / OR MAKE USE OF SPECTRUM RADIOELECTRIC. SPECIFIC ABSORPTION RATE (SAR). "(Hereinafter referred to as indistinctly by the full name or "Technical Provision IFT-012-2019"), in accordance with those conferred in Articles 15 section I, LVI, 289, and 290 of the LFTR and 6 section I of the Organic Statute of the Federal Institute of Telecommunications

SECOND.- Telecommunications and radio broadcasting as public services of general interest. Article 28 of the Constitution establishes the obligation of the Institute to guarantee what is established in the 6th articles. and 7th. of the same legal system, which provide, among other things, the human right of access to broadcasting and telecommunications services and grant said services the nature of public services of general interest, in respect of which the State will indicate the conditions of effective competition to provide them.

In that order of ideas, in terms of section II of section B of article 6 of the Constitution and Article 2 of the LFTR, telecommunications are a public service of general interest, so the State will guarantee that they are provided under conditions of competition, quality, plurality, universal coverage, interconnection, convergence, continuity, free access and without arbitrary interference.

In the same sense, in accordance with section III of section B of article 6. of the Constitution and Article 2 of the LFTR, broadcasting is a public service of general interest, so the State will guarantee that it is provided under conditions of competition and quality and provides the benefits of culture to the entire population, preserving the plurality and veracity of the information, as well as the promotion of values of national identity, contributing to the purposes established in article 3. of the Constitution.

THIRD.- The supervision of radioelectric emissions. In order to have a administrative provision of a general nature that contributes to the supervision of radioelectric emissions, In accordance with the provisions of article 54 of the LFTR, which literally says:

> *"... The radioelectric spectrum and orbital resources are assets of the public domain of the Nation, whose ownership and administration corresponds to the State.*
>
> *Said administration will be exercised by the Institute in the exercise of its functions as provided by the Constitution, in this Law, in the international treaties and agreements signed by Mexico, and in as applicable, following the recommendations of the International Telecommunications Union and other International organizations.*
>
> *The administration includes the preparation and approval of plans and programs of use, the establishment of the conditions for the allocation of a frequency band, the granting of concessions,* ***the supervision of radioelectric emissions*** *and the application of the sanctions, without prejudice to the powers that correspond to the Federal Executive.*
>
> *In managing the spectrum, the Institute will pursue the following general objectives for the benefit of the users:*
>
> ***I. The safety of life;***
>
> *II. The promotion of social, regional or territorial cohesion;*
>
> *III. Effective competition in the converging markets of the telecommunications and broadcasting;*
>
> ***IV. The efficient use of the spectrum and its protection;***
>
> *.... ".*

(Emphasis added)

FOURTH.- Technical regulatory framework. The Technical Provisions are instruments of enforcement issued by the Institute in accordance with the provisions of article 15, section I of the LFTR, through of which the characteristics and operation of products, devices and services of telecommunications and broadcasting and, where appropriate, installation of equipment, systems and infrastructure in general associated with these; as well as the specifications that refer to its compliance or application.

In this sense, and based on the maximum limits for non-ionizing radioelectric emissions established by the International Commission on Protection against Non-Ionizing Radiations (hereinafter, "ICNIRP") independent non-governmental scientific organization, this Technical Provision IFT-012-2019, aims to establish that:

a) Products, equipment, devices or apparatus intended for telecommunications that may be connected to a telecommunications network and / or make use of the radioelectric spectrum, which is used close to the head, particularly close to the ear, comply with the basic limits of exposure to non-ionizing radio emissions in the frequency range 300 to 6 MHz GHz;

b) Products, equipment, devices or apparatus intended for telecommunications that may be connected to a telecommunications network and / or make use of the radioelectric spectrum, which is used at a distance less than or equal to 200 mm from the human body, comply with the basic limits of exposure of non-ionizing radioelectric emissions in the frequency range 30 to 6 MHz GHz.

The Institute, under the framework of the powers conferred by the laws on the matter, establishes as a best regulatory practice review the Technical Provision of merit, at least five years after its entry into force, in order to identify if it is still required or if changes should be made based on the conditions that prevail in the Telecommunications and Broadcasting sector and in the market in general. The foregoing in no way limits the powers of the Institute to carry out said review in any time, within the established period.

In this vein of ideas, and due to the specific nature of this Technical Provision, the Institute will review the same when the references and international standards considered in its preparation are updated. It is It is important to mention that various organizations such as the International Telecommunications Union (ITU), the Federal Communications Commission (FCC) in the United States of America, The Swiss Tropical and Public Health Institute (Swiss TPH) and the Federal Office for the Environment (OFMA) both in Switzerland, or the Institute Radioprotection and Nuclear Safety (IRSN, according to its French acronym) in France, have investigated and / or revised the issue relating to non-ionizing radio frequency radiation; However, for the purposes of this Technical Provision, the results of the actions that the company is taking will be taken into account mainly International Commission on Non-Ionizing Radiation Protection and WHO, as well as the best international regulatory practices on the matter.

FIFTH.- Need to issue TECHNICAL PROVISION IFT-012-2019: SPECIFICATIONS TECHNIQUES FOR COMPLIANCE WITH THE MAXIMUM LIMITS OF RADIOELECTRIC EMISSIONS NON-IONIZING PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A TELECOMMUNICATION NETWORK AND / OR MAKE USE OF THE RADIOELECTRIC SPECTRUM. SPECIFIC ABSORPTION RATE (SAR). With basis in the fifteenth and twentieth paragraphs, section IV, of article 28 of the Constitution and the Articles 1, 2, 7, second and fourth paragraphs, and 15, section I, of the LFTR, correspond exclusively to the Institute, as an autonomous constitutional body, issue a provision of general observance that establishes The maximum exposure limits for human beings to Radio Frequency electromagnetic radiation are not ionizers for telecommunications products, equipment, devices or appliances that can be connected to a telecommunications network and / or make use of the radioelectric spectrum, in addition to its

test methods to verify compliance with them, and in this way contribute to the supervision with respect to radio emissions through the certification procedure of the products, equipment, devices or apparatus intended for telecommunications that make use of the spectrum radioelectric, in adherence to the faculties of the Institute regarding the administration of the radioelectric spectrum, for the benefit of the safety of the life of the users and the promotion of effective competition in the converging markets in the telecommunications and broadcasting sectors.

The benefits that are sought when issuing the Technical Provision of merit are primarily to guarantee that the products, equipment, devices or apparatus intended for telecommunications that may be connected to a telecommunications network and / or make use of the radio spectrum, which:

a) are used close to the head, particularly close to the ear, and

b) are used at a distance less than or equal to 200 mm from the human body,

Comply with basic non-ionizing radioelectric emission exposure limits in the range frequencies from 300 MHz to 6 GHz and 30 MHz to 6 GHz, respectively.

SIX.- Public consultation. Based on the provisions of article 51 of the LFTR, the Institute submitted to public consultation under the principles of transparency and citizen participation, the "PROPOSED DRAFT TECHNICAL PROVISION IFT-012-2016: TECHNICAL SPECIFICATIONS FOR THE COMPLIANCE WITH THE MAXIMUM LIMITS OF NON-IONIZING RADIOELECTRIC EMISSIONS OF THE PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A TELECOMMUNICATIONS NETWORK AND / OR MAKE USE OF RADIOELECTRIC SPECTRUM. SPECIFIC ABSORPTION RATE (SAR). "During a period of sixty-one business days, from December 13, 2016 to March 23, 2017

During the public merit consultation, 11 entries were received from legal entities; said Participations were mainly focused on making details of the technical specifications and test methods, which were analyzed, assessed and, where appropriate, strengthened the Technical Provision in I comment.

SEVENTH.- Regulatory Impact Analysis. In accordance with the second paragraph of article 51 of the LFTR, it is established that prior to the issuance of rules, guidelines or administrative provisions of general nature in question, the Institute must carry out and make public a regulatory impact analysis. In this regard, in accordance with the provisions of articles 51 of the LFTR; 4 section VIII, item IV) and 75 Section II of the Statute, the General Coordination of Regulatory Improvement through official IFT / 211 / CGMR / 050/2018 issued the non-binding opinion regarding the draft "AGREEMENT THROUGH THE WHICH THE PLENARY OF THE FEDERAL INSTITUTE OF TELECOMMUNICATIONS ISSUING THE "DISPOSITION TECHNICAL IFT-012-2018: TECHNICAL SPECIFICATIONS FOR COMPLIANCE WITH THE LIMITS MAXIMUM NON-IONIZING RADIOELECTRIC EMISSIONS FROM PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS WHICH MAY BE CONNECTED TO A TELECOMMUNICATIONS NETWORK AND / OR MAKE USE OF SPECTRUM RADIOELECTRIC. SPECIFIC ABSORPTION INDEX (SAR). "", In said opinion, stated various recommendations in order to strengthen and improve both the Regulatory Impact Analysis and some provisions of the project, which were analyzed and, where appropriate, addressed.

For the foregoing and based on articles 6, section B, sections II and III, and 28, tenth paragraphs fifth and twentieth, section IV, of the Political Constitution of the United Mexican States; 1, 2, 7, 15, Sections I, and LVI, 51, and 289 of the Federal Law on Telecommunications and Broadcasting; 4, fraction I, and 6, fraction I, of the Organic Statute of the Federal Institute of Telecommunications, the Plenary of the Federal Institute of Telecommunications issues the following:

AGREEMENT

FIRST.- The "TECHNICAL DISPOSITION IFT-012-2019: SPECIFICATIONS is approved and issued TECHNIQUES FOR COMPLIANCE WITH THE MAXIMUM LIMITS OF RADIOELECTRIC EMISSIONS NON-IONIZING PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A TELECOMMUNICATION NETWORK AND / OR MAKE USE OF THE RADIOELECTRIC SPECTRUM. SPECIFIC ABSORPTION RATE (SAR). ", same that is attached to this Agreement and that forms an integral part of it.

TECHNICAL PROVISION IFT-012-2019: TECHNICAL SPECIFICATIONS FOR COMPLIANCE WITH THE MAXIMUM LIMITS OF NON-IONIZING RADIO FREQUENCY ELECTROMAGNETIC RADIATION OF THE PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS INTENDED FOR TELECOMMUNICATIONS THAT MAY BE CONNECTED TO A TELECOMMUNICATIONS NETWORK AND / OR MAKE USE OF THE RADIOELECTRIC SPECTRUM. SPECIFIC ABSORPTION RATE (SAR).

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1. OBJECTIVE.

This Technical Provision establishes the technical specifications for compliance with the Maximum limits for radio frequency electromagnetic radiation from products, equipment, devices or telecommunications devices that can be connected to a telecommunications network and / or make use of the radio spectrum in the 30 MHz to 6 GHz range, using the absorption rate specific (SAR) measured in proximity to the human body.

The objective of this Technical Provision is to guarantee that:

to) Products, equipment, devices or apparatus intended for telecommunications that may be connected to a telecommunications network and / or make use of the radioelectric spectrum in the interval frequency ranges from 300 MHz to 6 GHz, which are used near the head, particularly near the ear, comply with the basic limits of exposure of electromagnetic radiation of the non-ionizing radio frequency;

b) Products, equipment, devices or apparatus intended for telecommunications that may be connected to a telecommunications network and / or make use of the radioelectric spectrum in the interval frequency ranges 30 MHz to 6 GHz, used at a distance less than or equal to 200 mm from the body comply with the basic limits of exposure of electromagnetic radiation of non-ionizing radio frequency.

2. FIELD OF APPLICATION.

This Technical Provision is applicable to:

Products, equipment, devices, or appliances that have a radio transmitter or transceiver radio frequency, make use of the radioelectric spectrum or connect to a telecommunications network in the frequency range from 30 MHz to 6 GHz and that the following are used:

to) Near the head, particularly close to the ear, in the frequency range 300 to 6 MHz GHz, and / or

b) At a distance less than or equal to 200 mm from the human body, in the frequency range of 30 MHz to 6 GHz.

3. DEFINITIONS, SYMBOLS AND ABBREVIATIONS.

3.1. DEFINITIONS.

For the purposes of this Technical Provision, in addition to the definitions provided in the Law Federal Telecommunications and Broadcasting and other legal, regulatory and administrative regulations, it will be understood by:

II. **Accessory:** Optional component that can be used in conjunction with a fixed or mobile wireless communication and that is included in its packaging;

III. **Certificate of Conformity:** Written statement, issued by a Certification Body third party accredited, and authorized by the Federal Institute of Telecommunications, based on a decision made after review of the fitness, adequacy and effectiveness of the selection and determination activities, and the results of said activities, with regarding the fulfillment of the requirements specified for an object of Evaluation of the Accordance;

IV. **Drift:** Slow variation of a metrological characteristic of a measuring instrument;

V. **Technical Provision:** Instrument of general and mandatory observance issued by the Institute, through which the characteristics and operation of products and services of telecommunications and broadcasting, including infrastructure, where appropriate, the installation of equipment, systems and the infrastructure in general associated with them, as well as the specifications that refer to its compliance or application, among others;

SAW. **Wireless Communication Device (DCI)** : Transmitting equipment, device or apparatus or fixed or mobile radio frequency transceiver, which makes use of the radioelectric spectrum or is connects to a telecommunications network and is used:

a) Particularly close to the ear, and / or

b) At a distance less than or equal to 200 mm from the human body;

VII. **Desktop Wireless Communication Device (DCE):** Device commonly located or mounted on a desk, table or similar support structure; and whose antenna is intended to be used at a distance less than or equal to 200 mm from the human body;

VIII. **Wireless Body-worn Communication Device (DUC): A** portable device that contains a wireless transmitter or transceiver positioned in close proximity to the torso or limbs of a person (except head and / or ear), using a Restraint Accessory during the intended use or operation of its radio communication functions;

IX. **Wireless communication device with articulated or rotating antennas (DAG):** Portable device containing an articulated or rotating antenna (s) that are found in close proximity to the torso or extremities (except head) of a person during the intended use or operation of your radio functions;

X. **Wireless Face-to-Face Communication Device (DFR):** Device commonly held by hand and operated in close proximity to the face, may include *Push to Talk* (*PTT*) devices , two-way radios and the like .;

XI. **Generic Wireless Communication Device (DG):** Device that cannot be included in the device classifications provided for in this Technical Provision;

XII. **Body Supported Wireless Communication Device (DSC): A** device whose Intended use is to transmit, and that is directly touching some part of the body of the user with any portion of the device, and does not require a Holding Fixture, for example, a laptop;

XIII. **Wireless communication device used in the extremities of the body (DEX):** Device whose Intended Use is to be attached to the user's arm or leg while transmitting;

XIV. **Separation** Distance **:** Distance between the equipment under test and the outer surface of the human silhouette model (MSH) or anthropomorphic model of the head (MAC), representing the distance established in the intended Use;

XV. **Equipment Under Test (EBP):** Representative unit of a DCI on which they are carried out tests to verify compliance with the specifications and requirements of this Technical Provision;

XVI. **Conformity Assessment:** Procedure used, directly or indirectly, to determine the degree of compliance of a product, equipment, device or apparatus intended to telecommunications or broadcasting, or telecommunications or broadcasting infrastructure, with the applicable Technical Provisions; the procedures for the Evaluation of the Compliance includes, among others, those of sampling, testing and inspection, certification, verification, and monitoring of compliance with the certification and / or the ruling, registration, separately or in different combinations;

XVII. **Work** factor **:** Average operational time factor; that is, the proportion of time in that which a transmitter transmits during a specific period of time;

XVIII. **Handset:** Hand-held device whose intended use is to be operated in close proximity of the ear. It consists of an acoustic input and output, a radio transmitter and receiver;

XIX. **Uncertainty:** Estimate associated with the result of a test or measurement that characterizes the range of values within which the value is conventionally stated to lie true;

XXIX. **Radio Frequency (RF):** Frequency of electromagnetic waves, greater than 9 kHz and less than 3 000 GHz that propagate in space without artificial guidance and is useful for establishing telecommunications;

XXX. **Test Report (RP):** Document issued by the Third Party Test Laboratory national or recognized foreign Testing Laboratory, with the results of the tests and, in where appropriate, other information relevant to these, made to a Product, in accordance with the mutual recognition agreement signed between governments, the Federal Law of Telecommunications and Broadcasting, standards, Technical Provisions and / or technical regulations foreign;

XXXI. **Transceiver:** Wireless communication device that combines in a single unit a transmitter and receiver, using common components and circuitry, and usually uses the same antenna to transmit and receive;

XXXII. **Multiband transmission:** Mode of operation in which it is transmitted in several bands of frequency simultaneously;

XXXIII. Intended Use: Use for which a Wireless Communication Device is intended, in accordance with the specifications, instructions and information provided by the manufacturer in the user manual and / or travel sheet accompanying the EBP;

XXXIV. Primary Peak SAR Value **:** Maximum SAR value obtained from scan measurements area, and

XXXV. **Secondary peak SAR** value **:** Local maximum **SAR** value determined in measurements scan area whose magnitude is less than the Primary Peak SAR value.

3.2. ABBREVIATIONS AND SYMBOLS.

In this Technical Provision the following abbreviations, symbols, quantities and constants are used physical.

Symbol	Quantity	Units
	Attenuation Coefficient	1 / m
ch	Specific heat capacity	J / (kg K)
AND	Electric field strength	V / m

F	Frequency	Hz
J	Current density	A / m²
P	Average (temporary) power absorbed	W
HE	Specific absorption index	W / kg
T	Temperature	° C

Abbreviations

ANS	Normalized site attenuation
CDMA	Multiple Access by Code Division (*Code Division Multiple Access*).
DCI	Wireless communication device
DT	Technical Provision
EBP	Equipment under test
FDMA	Frequency Division Multiple Access (English) *Frequency Division Multiple Access*).
GPRS	General Packet Radio Service (from English, *General Packet Radio Service*).
GSM	Global System for Mobile Communications *Global System for Mobile communications*)
ICNIRP	International Commission on Radiation Protection no Ionizers (*International Commission on Non-Ionizing Radiation Protection*).
LET	Liquid equivalent to human tissue
MAC	Anthropomorphic Model of the Head
MIMO	Multiple Inputs, Multiple Outputs (*Multiple Input Multiple Output*).
MSH	Human Silhouette Model
OC	Continuous wave

OP	Carrier Wave
PDA	Personal Digital Assistant
PTT	Push-to-talk
RF	Radio frequency
HE	Specific absorption index
STBC	Space-Time Block Coding (*Space Time Block Coding*)
VSWR	Electric voltage standing wave ratio (from English, *Voltage Standing Wave Ratio*)
Wifi	*Wireless Fidelity*
Wlan	*Wireless Local Area Network*

4. TECHNICAL SPECIFICATIONS.

4.1. Fixed and mobile wireless communication devices that make use of the spectrum radioelectric or connected to a telecommunications network in the frequency range 30 to 6 MHz GHz and that are used:

to) Particularly close to the ear, and / or

b) At a distance less than or equal to 200 mm from the human body

They must comply with the basic limits of maximum exposure to electromagnetic radiation of Non-ionizing radiofrequency established in **Table 1** of this Technical Provision.

Table 1. Basic maximum exposure limits.

Kind of exposition	Interval of frequencies	Current density in the head and the trunk [mA / m2] (value effective)	Average SAR in all the body [W / kg]	Localized SAR in the head and the trunk [W / kg]	Localized SAR in the extremities [W / kg]	Density of wave power equivalent flat [W / m2]
Public in general	30 MHz-6 GHz	-	0.08	2	4	-

Notes:

one. Because the human body is not electrically homogeneous, current densities must be averaged over a 1 cm2 cross section, perpendicular to the direction of the current.

2. All SAR values must be averaged over any 6 minute period.

3. The localized SAR is averaged over a volume of continuous tissue containing 10 grams of mass. The maximum SAR value obtained in this way in any area of the head, particularly close to the ear, is the one used to determine if the limits in this table are exceeded. In the interval of frequencies from 0.3 to 6 GHz, for exposure localized to the head, a further limit is added where the Specific energy absorption (SA) averaged over 10 grams of tissue should not exceed 2 mJ / kg for exposure of the general public. This is in order to avoid an auditory effect caused by the expansion of certain brain tissue due to small and rapid changes in temperature, which produce a wave that is transmitted to the inner ear.

The foregoing will be verified with the test methods contained in paragraphs **5.1** and **5.2** hereof. disposition, as appropriate.

4.2. The INNs that, derived from common use or the intended Use, are used by the end user close to the head (particularly close to the ear) **and** at a distance less than or equal to 200 mm from the body human, will be evaluated only with the test methods established in paragraph **5.1** of this Technical provision.

4.3. If the DCI transmits with a maximum power level of 20 mW in all frequency bands of the operation in Mexico and is commonly used near the head (particularly near the ear) or at a distance less than 200 mm from the human body, the DCI can be considered as inherently compliant. In this case, the referred DCIs are not obliged to demonstrate compliance with this Provision Technique; however, the foregoing does not exclude the inherently compliant DCI from compliance with other Applicable Technical Provisions and with their registration in accordance with numeral 8 of this Provision Technique.

The foregoing is verified with paragraph 5.3.

The DCI is not inherently considered compliant if its power level is adjustable to a power in whose range is 20 mW and / or is not commonly used within a distance of less than 200 mm from the body.

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5. TEST METHODS.

Test methods allow evaluation and verification that INNs meet basic limits established in **Table 1** of this Technical Provision.

5.1. TEST METHOD FOR COMPLIANCE WITH THE MAXIMUM LIMITS OF NON-IONIZING RADIO FREQUENCY ELECTROMAGNETIC RADIATION. INDEX OF SPECIFIC ABSORPTION (SAR) IN DCI WEARING PARTICULARLY ON THE HEAD NEAR THE EAR.

5.1.1. GENERAL SPECIFICATIONS OF THE MEASURING SYSTEM.

I. The SAR measurement system for ICDs worn on the head, particularly near the ear, it must consist of at least one Anthropomorphic Model of the Head (MAC) filled with Liquid Human Tissue Equivalent (LET), instrumentation, measurement electronics, a scan and a bra from the EBP.

II. For SAR measurement, a miniature probe must be used, which must be positioned automatically to measure the internal distribution of the electric field in the MAC exposed to electromagnetic fields produced by EBP.

III. The MAC must be filled with LET, to represent the electrical properties of the tissues in the human head.

IV. The LET must be of low viscosity to allow free movement of the probe.

V. The above in order to calculate the SAR distribution and the spatial average peak value of the SAR, from the values of the measured electric field.

The tests must be performed in accordance with the following environmental conditions:

to) The ambient temperature and the LET temperature must be in the range of 18 ° C to 25 ° C, observe numeral **P.2.6.6** of **Annex P** of this Technical Provision, to determine the Uncertainty of the temperature of the referred LET.

b) Before carrying out the measurements of the dielectric properties of the LET and the measurements of the SAR, EBP, measurement system, LET and MAC must remain in the Laboratory of Test long enough for their temperatures to stabilize.

c) During SAR measurements, the temperature of the LET must remain within a tolerance ± 2 ° C of that temperature at which the dielectric properties were measured (or a corresponding to a 5% change in either if the latter is smaller). If the change in temperature exceeds this value, the dielectric properties must be measured again. Observe numeral **P.2.6.6** of **Annex P** of this Technical Provision, to determine the Uncertainty of the temperature sensitivity of the LET.

d) To correct the effect of reflections from cables, test equipment, or any other reflective object in SAR measurements, as well as to avoid harmful RF interference, the The measurement system must be housed within a Faraday cage using materials absorbents, the referred Faraday cage must comply with the requirements established in Then, additionally, ferrite cores can be used in the cables

i. Shielding loss greater than or equal to 100 dB in the 30 MHz to 6 GHz range.

ii. The access of signal, control and power supply cables from the outside to the inside of the cage Faraday, it must be with RF filters with an insertion loss greater than or equal to 100 dB to maintain the effect of shielding.

iii. The effect of reflections from cables, test equipment, or any other object reflector should be determined by the SAR for the head, contained in D.2 of **Annex D** of this Technical Provision. The This determination must be made with and without the reflecting objects present. Must meet the requirements of the following subsections e) and f).

and) EBP SAR measurements should be performed only when the effects of the reflections and secondary RF transmitters, among others, result in a peak spatial average SAR less than 0.012 W / kg (for 1 g or 10 g of mass, whatever applicable to the test). The above when measuring the spatial average peak of SAR at 0.04 W / kg.

When the effect of cables and reflectors is greater than 0.012 W / kg, cores should be applied ferrite, RF absorbing materials and other mitigation techniques to reduce SAR error. Yes the above limit cannot be achieved, a value greater than 3% of 0.012 W / kg should be considered in the Uncertainty budget in the "RF environmental conditions - reflections" row of the **Table A.1** in **Annex A** of this Technical Provision; in such a way that it can be demonstrated that the SAR contribution due to the reflections determined by the review procedure system is less than 10% of the SAR measured for EBP.

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F) The effect of the reflections should be verified at least annually or when the system review (**Annex D** of this Technical Provision) shows unexpected results.

g) During testing, the EBP must not be connected to any wireless network except a base station simulator.

h) The validation of the system according to the protocol defined in **Annex D** of this Provision Technique, it should be done at least once a year or when a new system is put into operation. operation and when modifications have been made to it (example: a new version of software, different type or version of the measurement electronics or use of a different probe).

i) The measurement system must be validated as a complete system; however, the calibration of the probe separately from the system, providing that the interface characteristics between the probe and the measurement electronics, are specified and implemented during the measures. The probe (s) must be calibrated at the same time with amplifiers, devices measurement and data acquisition systems. The probe must be calibrated on the LET at appropriate operating frequency and temperature range, according to the methodology described in **Annex E** of this Technical Provision **.**

j) The lower limit of detection must be less than or equal to 0.01 W / kg, and the upper limit of detection must be older

k) A larger probe diameter can be used, if it is shown that the electric field of Any potential distribution can be measured with an uncertainty less than ± 15% (k = 2) in the surface of the MAC, considering the distances shown in **Table 2,** or the distances recommended by the manufacturer of the dosimetry system (whichever is less).

l) Where performance characteristics are explicitly specified for the measurement system or For part of the measurement system, compliance with the aforementioned Specifications.

5.1.2. MAC HEAD ANTHROPOMORPHIC MODEL SPECIFICATIONS (HOUSING AND LIQUID EQUIVALENT TO FABRIC).

I. For the typical configuration of a sagittally sectioned MAC, each half of the model The anthropomorphic head must be placed on one of its sides, and the EBP is placed below the referred model.

II. The MAC must be filled with the LET considering the required dielectric properties.

III. To minimize reflections from the upper surface of the LET, the depth of the liquid should be at least 150mm, which is the approximate distance between the ears of a human head; liquid depths less than 150 mm can also be used, if demonstrates (for example, using numerical simulations) that the effect on the average peak SAR space is less than 1% under worst-case conditions. If it is more than 1% but less than 3%, the Uncertainty for the worst case value from the demonstration is due add to the budget of Uncertainty of **Table A.1** of **Annex A** of this Provision Technique.

IV. Dielectric parameters should be evaluated and compared with the values given in **Table 4** using linear interpolation. This measurement can be performed using the equipment and procedures described in **Annex F** of this Technical Provision **.**

V. For SAR calculations, the measured dielectric properties should be used, not the values of the **Table 4** of this Technical Provision.

Note. See section **5.1.7.1** . subsection IV of this technical provision, for the permissible variation of the dielectric parameters measured and those in **Table 4** of this Technical Provision.

SAW. The MAC manufacturer must define at least three benchmarks on said model, the above for the alignment of the scanning system with the referred model. These points should be visible, covering at least 80% of the upper surface of the model and there must be at least 200 mm of separation between each point.

5.1.2.1. MAC HEAD AND HOUSING ANTHROPOMORPHIC MODEL SPECIFICATIONS.

The MAC dimensions are listed in **Table 3** and are shown in **Figure 1** . The **Table 4** shows other relevant dimensions for comparison. In the Ear Reference Point (PRO), a 6 mm thickness including the 2 mm shell to model the outer ear (pinna), this slim ear spacer also simulates wearers with small ears, and gives a rendering conservative SAR.

A system of reference lines and points should be used to correlate the positioning of the Handset with the model (**Figures 2 and 3**). Point "M" is the reference point of the mouth, "OI" is the point of reference of the left ear (PRO), and "OD" is the right PRO. PROs are 15mm after ear canal entrance (ECA) together with the BM (Posterior-Mouth) line.

Figure 1. Illustration of the dimensions in Table 3 and Table 4.

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Table 2. Dimensions used in obtaining the anthropomorphic model of the information head of the head of the 90th percentile of army men.

Ref.	Anatomy	Gordon's report [mm]	MAC	Deviation

		Value average	Deviation standard	90th percentile	[mm]	[%]
fifteen	Zygion-Pogonio-Zygion Bow	325.8	13.4	343.1	329.3	-4.0
16	Zygion-Vertex-Zygion Bow	353.3	12.9	369.7	367.3	-0.6
18	Zygion-Glabela-Zygion Bow	304.3	10.6	318.2	314.1	-1.3
19	Zygion-Submandible-Zyigion Arch	304.2	14.5	323.2	333.5	3.2
twenty	Zygion-Nasospinal-Zygion Arch	292	11.1	306.3	305.3	-0.3
H60	Head width	151.7	5.4	158.6	158.4	-0.1
61	Head circumference	567.7	15.4	587.3	594.8	1.3
62	Head length	197.1	7.1	206	206.0	0.0
77	Chin-Nasion Length	121.9	6.5	130.4	125.0	-4.1
80	Neck circumference	379.6	19.7	405.3	395.4	-2.5

Table 3. Additional dimensions of the Anthropomorphic Model of the head compared to Select dimensions of head information from the 90th percentile of army men. Section of head measurements for specialists.

Ref.	Anatomy	Gordon's report [mm]			MAC [mm]	Deviation [%]
		Value average	Deviation standard	90th percentile		
H3	Bigoniáca width	118.9	7.9	129.2	130.0	0.6
H6	Bzygomatic diameter	144.8	6	152.3	152.7	0.2
H10	Pogonio-Back of Head	194.2	10.3	207.3	206.5	-0.4
H11	Pogonio-Top of head	216.8	8.9	228.3	220.4	-3.5
H18	Glabella-Back of head	199.7	7.2	208.5	209.2	0.3
H19	Glabella-Top of head	96.2	7.3	105.6	104.4	-1.1
H30	Chin-Top of head	232.0	8.8	243.3	246.7	1.4
H36	Nasion-Back of head	197	7.1	205.9	205.3	-0.3
H37	Nasion-Top of head	112	6.9	120.9	121.7	0.7
H38	Prostion-Back of Head	199.4	9.6	211.9	211.4	-0.2
H39	Prostion-Top of head	186.3	7.8	196.3	196.3	0.0
H40	Nasospinal-Posterior part of the head	203.5	8.3	213.6	213.0	-0.3
H42	Nasospinal-Upper part of the head	161.9	7.7	171.8	177.6	3.4
H43	Zygion-Back of head	98.9	8.5	106.4	106.4	0.0
H44	Zygion-Top of head	131	5.7	138.2	138.2	0.0

Figure 2. Close-up lateral view of the model showing the region of the right ear.

Figure 3. Side view of a model showing the relevant marks.

The plane that passes through the two PRO and M is defined as the reference plane. The NF line (neck-forehead), also called the pivoting reference line, is along the truncated front edge of the ear. The two lines NF and BM should be marked on the outer casing of the model to facilitate Handset positioning. Subsequent to the NF line, the shell of the model in the shape of an ear is a 6 mm thick flat surface on PROs. Anterior to the NF line, the ear is truncated as illustrated in **Figure 2** . Truncation of the ear is introduced to prevent unstable positioning of the ear. EBP on the cheek.

The projection of the BM reference line and the NF reference line should be marked on the model. I know they can choose additional lines for convenience. Optional markings in **Figure 3** can be etched on the external surface of the model without affecting the specifications.

The MAC shell with an integral ear spacer, must be constructed of a material chemically resistant, low permittivity and low losses, with relative permittivity between 2 and 5.

The loss tangent of the MAC casing must be less than or equal to 0.05. It has been shown that higher frequencies, particularly above 3 GHz, the permittivity of the model case has an increasing impact on the Uncertainty of SAR measurements, therefore, the evaluation of the Uncertainty above 3 GHz should be carried out in accordance with **P.2.4.** of **Annex P** of the present Technical Provision **.**

The MAC case shape should be within ± 0.2mm tolerance of digital design (*Computer-aided Design* , *CAD*) from MAC. In any area within the Handset projection, the thickness of shell should be 2mm ± 0.2mm, except ear and extended perimeter walls (see **Figure 4**). The MAC housing must be made of materials resistant to the compounds used for preparation of the LET (for example, those listed in **Annex G** of this Technical Provision), to avoid damage and maintain tolerances of ± 0.2 mm. For non-critical areas, i.e. the central zone containing the nose, as shown in **Figure 5,** the tolerance is allowed to be within ± 1 mm.

Figure 4. Sagittally bisected model with extended perimeter (shown resting on its cost as used for SAR testing).

Figure 5. Image of the model showing the central area.

5.1.2.2. LIQUID EQUIVALENT TO THE TISSUE (LET) OF THE HEAD.

I. The nominal dielectric values of the MSH liquid are specified in **Table 4** , for discrete frequencies in the range of 300 MHz and 6 GHz.

II. For other frequencies in the 300 MHz to 6 GHz range, the dielectric values Nominals must be obtained by linear interpolation between the largest and smallest tabulated figures.

III. In **Annex G** of this Technical Provision, examples of recipes are provided for prepare tissue-equivalent liquids, which are designed to produce the properties dielectrics in the frequency range 30 MHz to 6 GHz.

IV. Measurements of the dielectric properties of the LET should be made with the equipment and procedures described in **Annex F** of this Technical Provision. The measurements of the

LET should correspond to the target values in **Table 4** , for the measured values of the Relative permittivity and conductivity, taking into account the tolerances established in the **fraction IV** of numeral **5.1.7.1** . For SAR calculations, the properties must be used dielectric measurements and not those in **Table 4** .

Table 4. Dielectric properties of LET for head.

Frequency MHz	**Relative permittivity**	**Conductivity (σ) S / m**
300	45.3	0.87
450	43.5	0.87
750	*41.9*	*0.89*
835	41.5	0.90
900	41.5	0.97
1,450	40.5	1.20
1,500	*40.4*	*1.23*
1 640	*40.2*	*1.31*
1 750	*40.1*	1.37
1 800	40.0	1.40
1 900	40.0	1.40
2,000	40.0	1.40
2 100	*39.8*	*1.49*
2 300	*39.5*	*1.67*
2 450	39.2	1.80
2,600	*39.0*	*1.96*
3,000	38.5	2.40
3 500	*37.9*	*2.91*
4,000	*37.4*	*3.43*
4 500	*36.8*	*3.94*
5000	*36.2*	*4.45*
5 200	*36.0*	*4.66*
5 400	*35.8*	*4.86*
5 600	*35.5*	*5.07*
5 800	*35.3*	*5.27*
6,000	*35.1*	*5.48*

Note. The values shown in italics were linearly interpolated between the values in this table that are immediately above and below these values, except for the 6,000 MHz values that were linearly extrapolated from the values at 3 000 MHz and 5 800 MHz.

5.1.3. HAND CONSIDERATIONS.

During normal operation of an ICD, the head and hand are in the near field of the EBP when it is worn close to the ear and therefore both absorb energy. For limbs such as the hand, a upper limit of SAR, for example 4 W / kg averaged over 10 g of tissue. Numerical studies and Experiments (1) have shown that the SAR measured on the hand is not expected to exceed those limits at the power levels used by the Handsets. Therefore, the SAR measurement on the hand is not mandatory in this Technical Provision.

5.1.4. SCANNING SYSTEM REQUIREMENTS.

I. The scanning system with probes to measure SAR must have the ability to scan the necessary MAC measurement regions, which are within the projections of the EBP, the above with the objective of evaluating the SAR distribution in three dimensions.

II. The tolerance of the probe tip positioning at the measuring point should be ≤0.2 mm.

III. The resolution of the probe positioning should be ≤1mm.

IV. The accuracy of the scanning system probe positioning will require that the model reference, defined by the manufacturer of the model, are verified.

5.1.5. HOLDING DEVICE CONSIDERATIONS AND SPECIFICATIONS.

I. The clamping device must allow the EBP to be positioned according to the definitions given in numeral **5.1.7.4** . of this Technical Provision.

II. It should be made of materials with low losses and low permittivity, the loss tangent it must be ≤ 0.05 and the Relative Permitivity must be ≤ 5 F / m.

III. Upon coupling the EBP to the model, the clamping device must provide the minimum quantity contact with the EBP to ensure a secure hold and maintain the required position during measurement.

IV. The clamping device should help to position the EBP repeatedly in the same position.

V. In cases where a predetermined relative positioning cannot be achieved, for example, due to the interaction of the clamping device with the buttons and controls of the EBP, then must apply minimal differences in positioning in a predefined direction to achieve EBP test position required.

SAW. Positioning uncertainties must be estimated following the procedures described in numeral **P.2.5.** of **Annex P** of this Technical Provision.

VII. To verify that the restraint device does not disturb the SAR, a replacement, which consists of supporting the test Handset against the flat MAC with blocks of foam with low relative permittivity and low losses (according to paragraph **P.2.5.2** of the **Annex P** of this Technical Provision).

5.1.6 CHARACTERISTICS OF THE MEASURING ELECTRONICS.

The probe output is processed by the associated measurement and instrumentation electronics that combines the voltages from the probe sensors to provide an output that is proportional to the square of the amplitude of the electric field incident on the sensors. Diodes are used detectors at the dipole feed point to rectify sensor voltages, signals rectified are transmitted through resistive lines (transparent to RF) to the electronics system of measurement.

For a Continuous Wave (OC) signal at low levels of field strength, the probe output is proportional to the square of the amplitude of the incident electric field; at higher signal levels (for above the compression point of the diode), the output is not linearly proportional to , but it becomes proportional to . This compression of the signal will lead to an underestimation of the actual SAR under higher field strength if not compensated correctly by probe calibration.
In addition, the amplifiers in the measurement electronics can deviate from an ideal linear response and introduce additional uncertainty.

To calculate the uncertainties associated with the measurement electronics of the probes, one must observe the numeral **P.2.2.6.** of **Annex P** of this Technical Provision **.**

5.1.7. PROTOCOL FOR SAR MEASUREMENTS.

5.1.7.1. PREPARATION OF THE LET AND REVIEW OF THE SYSTEM.

I. The dielectric properties of the LET must be measured within 24 hours prior to the SAR measurements and every other day in case of continuous use.

II. Dielectric measurements less frequently are acceptable if the compliance with **Table 4** of this Technical Provision and the requirements of section **5.1.2.** of this Technical Provision, using measurement intervals of up to one week, but not greater than her.

III. If the Handset test series takes more than 48 hours, the LET parameters must also be measured at the end of the handset test series.

IV. LETs should yield measured values of Relative Permitivity and Conductivity within ± 10% of the target values in the frequencies in which the SAR is measured, in the cases where it is applied the method described in numeral **P.2.7.2.** of **Annex P** of this Technical Provision, to correct the measured SAR when deviations in permittivity and conductivity occur; of what Otherwise, the relative permittivity and conductivity should be within ± 5%.

V. If applying uncertainty correction formulas for the dielectric parameters of the LET, the measured permittivity and conductivity values must be within ± 10%.

SAW. A check of the measurement system should be performed within 24 hours prior to performing the SAR measurements for an EBP, in accordance with the procedures described in **Annex D** of this Technical Provision.

VII. The purpose of the system check is to verify that it operates within its specifications in the test frequencies. The system check is a repeatability test with a source calibrated to ensure that the system works correctly during the Accordance.

VIII. The system review must be carried out in order to detect possible drifts in shorts time periods and other uncertainties in the system, such as:

to) Unacceptable changes in liquid parameters, for example due to evaporation of the water or changes in temperature;

b) Component failure;

c) Drift in instruments;

d) Operator errors in the preparation or in the software parameters;

and) Adverse environmental conditions for the system, for example RF interference.

IX. The system overhaul procedure must be performed on the same measurement system as the SAR, with the same probe (s) and LET that will be used in the Conformity Assessment of the EBP in each frequency band tested.

5.1.7.2. EQUIPMENT UNDER TEST PREPARATION (EBP).

I. The antenna (s), battery and Accessories must be those specified by the manufacturer, and documented in the Test Report and in **Annex A** of this Technical Provision.

II. The battery must be fully charged before each measurement, without external connections or cables.

III. For 3G / 4G technologies, the RF output power and frequency (channel) must be controlled over a wireless link with a base station or network simulator.

IV. The EBP must be configured to transmit at the maximum output power level to conditions of use at the ear.

V. Tests should be performed at the highest power level consistent with the manufacturing specifications.

SAW. The measured SAR should be scaled to the maximum allowable output power level for the EBP, said Escalation must be documented in **Annex A** of this Technical Provision.

VII. The maximum output power levels of the EBP should be verified by testing radiated power, performed with a fully charged battery, to support the scaling.

For certain signals with digital modulation similar to noise (see **5.1.7.3.4.,** Of the present Technical Provision) the maximum output power of the EBP may vary in the different operating modes depending on the bandwidth of the signal, the modulation scheme, the ratio between peak and average and data rate. These conditions require careful selection of the configuration of the device for SAR measurements. When using the Duplexing by Division scheme

Time *division duplexing* (*TDD*), uplink and downlink signals they are transmitted on the same frequency; typically in random order with non-periodic Work Factors. It is important that these factors are considered for such wireless technologies to ensure that the SAR is measured correctly. For example, for devices with the IEEE 802.11 (WiFi / WLAN) standard the Output power during SAR measurements should typically be set by the test software of the measurement system at the maximum level for the corresponding modulation and data rate. Software testing also configures the device to transmit with a given Periodic Duty Factor what allows to correctly measure SAR.

The measured SAR may need to be scaled to a higher Duty Factor corresponding to the maximum expected exposure during actual use. For Handsets with WiFi functionality, it is typically expected that the lowest order modulation has the lowest ratio between peak powers and average power, and the highest average output power; therefore, where appropriate, modulation should be tested lower order, to ensure conservative measurements and avoid errors in SAR measurement due to high ratios between peak and average powers.

5.1.7.3. MODES OF OPERATION.

5.1.7.3.1 GENERAL.

I. The wireless technologies used by the EBP will determine the mode of operation and the type of signals (frequency, modulation scheme, power output, etc.) used in the tests of the

HE.

II. All applicable modes of operation intended for Wearing the device at the ear must be considered for testing.

III. The numeral **5.1.11.** , of this Technical Provision, establishes a reduction procedure of tests for operating modes in the same technology and frequency band.

The signal characteristics of each operating mode are described in paragraphs **5.1.7.3.2.,** And **5.1.7.3.4.,** Of this Technical Provision.

For devices that do not operate with Periodic Duty Factors, software will generally be required or special equipment, to make the EBP transmit with a maximum Periodic Work Factor before the SAR measurement is carried out.

5.1.7.3.2. CONSTANT ENVELOPE MODES OF OPERATION (MODULATIONS ANALOGUE).

An EBP operating in mode where the envelope of the signal in the time domain is constant, for For example, Frequency Division Multiple Access (FDMA) mode should be tested with an OP signal (carrier wave) -Equivalent using test codes or a base station simulator.

5.1.7.3.3. MODE OF OPERATION TDMA (PULSE ENVELOPE).

An EBP operating in TDMA mode can transmit voice and data using different numbers of slots of time. Depending on the data rate, the mode of operation for sending data using modulations high order can operate with reduced power output to accommodate the ratio between the powers peak and average; for example, EDGE.

If the operating modes for sending data are working during voice calls, as is the case In certain configurations of the GSM / GPRS / EDGE dual transfer mode of operation, the number of time intervals and the highest output power, for voice and data should be considered in the settings for simulcast conditions for at-the-ear SAR tests.

If it is not feasible to configure the EBP to operate at its maximum power output under slotted conditions multiples for voice and data due to EBP limitations, the test must be performed in a single slot operation so that the results are scaled to the maximum number of slots in that can be transmitted.

Any difference in maximum power output between single and multiple slot conditions slots must also be taken into account in scaling.

The SAR scaling must be shown to be linear or slightly less than linear with respect to the output power and that the SAR distribution is independent of the output power, both reasoning must be contained in **Annex A** of this Technical Provision, as well as the relationship between the SAR and the output power in accordance with the power scaling procedure described in the numeral **5.1.7.3.5** ., of the present Technical Provision.

5.1.7.3.4. DIGITAL MODES OF OPERATION WITH RANDOM AMPLITUDE MODULATION AND PHASE.

For an EBP in modes of operation employing spread spectrum CDMA, Multiplexing by Orthogonal Frequency Division (OFDM) or other modulation scheme where the envelope of the signal vary randomly over time, the output power usually varies due to the change in the ratio between peak and average powers due to data rate and other conditions and parameters of specific operation of that technology. In these cases, the tests must be carried out with the highest level of output power supported by the EBP and, where applicable, with a fixed Duty Factor.

It must be ensured that the transmitter is configured to operate at an output power level acceptable and supported by the EBP and to scale the measured SAR to the required output power level.

5.1.7.3.5. PROCEDURE FOR SCALING THE SAR FOR SIGNAL VARIATIONS OR POWER.

SAR scaling is the extrapolation or interpolation of the SAR of a given EBP with a test signal (mod $_x$) to a SAR of the same EBP at the same test exposure position and the same frequency channel with a different signal (mod $_y$).

The difference can be in power level, modulation, or both. RF output power of mod $_x$ and mod $_y$ should be determined by measuring the average power for both or by numerical integration of the power envelope if the signals are sufficiently known.

SAR escalation is possible if the following are met:

I. The same stage RF amplifier is used to mod $_X$ mod $_Y$.

II. The same antenna is used for mod $_X$ and mod $_Y$ and there is no MIMO (multiple inputs multiple outputs) or the application of other antenna diversity techniques.

III. The uncertainty of the probe response to modulation has been evaluated for the signal modulated mod $_X$ (see paragraph **P.2.2.4** of **Annex P** of this Technical Provision) and it has SAR determined mod $_X$.

IV. The ratio of the time-averaged RF output power (R $_p$) of mod $_X$ and mod $_Y$ after the RF amplifier stage is known according to the following equation:

5.1.7.4. POSITIONING OF THE EBP REGARDING THE MAC .

5.1.7.4.1. GENERAL.

This Technical Provision specifies two test positions for the Handset against the MAC, the

" **cheek** " position and " **bowed** " position , these two test positions are defined in the numerals **5.1.7.4.2** and **5.1.7.4.3** , respectively.

The EBP should be tested in these two positions on both the left side and the right side of the MAC. In some cases (for example, Asymmetric Handsets) the EBP positioning procedures representing the conditions of intended Use cannot be used (observe the numerals **5.1.7.4.2** and **5.1.7.4.3**). In this case, an alternative alignment procedure must be adapted with all the details settled in the corresponding RP. These alternative procedures must replicate the Conditions of Use provided as much as possible, in accordance with the purpose of the procedures described in **5.1.7.4.2** and **5.1.7.4.3** .

For other shapes associated with head-mounted devices (worn on the ear but not inserted into the ear canal), the positions and orientations used for the assessment should be aligned as closely possible with those defined for Handsets in **5.1.7.4.2** and **5.1.7.4.3** . Consideration should also be given to guidance for the intended use, observe numeral **5.1.7.4.6.** of this Technical Provision.

When the EBP contains an acoustic input and an acoustic output, then it should be aligned with the points reference PRO and M, respectively.

All details of the actual position must be clearly documented in the relevant PR.

5.1.7.4.2. DEFINITION OF THE CHEEK POSITION.

The cheek position is established from items **a)** to **i)** as follows:

to) Configure EBP to operate in talk mode. For example, for EBP with a hinged lid, rotating or sliding, open the lid if this is consistent with talk mode operation. If the EBP can also be used with the lid closed, they must be tested with both settings.

b) For the EBP to be in vertical orientation as shown in **Figure 6** , define two lines imaginary in said EBP, the vertical center line and the horizontal line. The vertical center line becomes through two points on the front side of the EBP: the center point of the width w_t of the EBP at the height of the acoustic output (point A in **Figure 6**), and the center point of the width w_b at the bottom of the Handset (point B). The horizontal line must be perpendicular to the vertical center line and must pass through the center of the acoustic outlet (see **Figure 6**). The two lines intersect at the point A. In some cases for various handsets, point A coincides with the center of the output acoustics. However, the acoustic output may be located elsewhere on the line. horizontal. At the same time note that the center line is not necessarily parallel to the front face of EBP, especially for Handsets with clamshell, flip-top and other irregularly shaped covers.

c) Position the EBP close to the surface of the MAC so that point A is on the extension (virtual) of the line passing through the OD (right ear) and LE (left ear) points in the model (see **Figure 7-a** and **Figure 7-b**). The plane defined by the vertical center line and the line horizontal of the EBP should be parallel to the sagittal plane of the MAC.

d) Transfer the EBP towards the MAC along the line that passes through OD and OI until the Handset touch the ear (see **Figure 7-c**).

and) Rotate the EBP around the OI-OD (virtual) line until the vertical center line of the EBP is at the reference plane (see **Figure 7-d**).

F) Rotate the EBP around its vertical center line until the plane defined by the center line vertical line and horizontal line are parallel to the NF line, and then transfer the EBP towards the MAC to along the OI-OD line until point A of the EBP touches the ear at the PRO (reference point ear) (see **Figure 7-e**).

g) While keeping point A on the line passing through OD and OI, and keeping the EBP at contact with the pinna, rotate the Handset around the NF line until any point of the EBP is in contact with a point on the MAC under the pinna (cheek) (see **Figure 7-f**) The physical angles of rotation must be documented on the RP.

h) While keeping point A of the EBP in contact with the PRO, rotate the Handset around a line perpendicular to the plane defined by the vertical center line and the horizontal line and passing through the point A of the EBP, until the vertical center line of the EBP coincides with the reference plane (see **Figure 7-g**).

i) Verify that the cheek position is correct, as follows:

- The NF line is in the plane defined by the vertical center line and the horizontal line of the EBP;
- Point A of the EBP must be in contact with the PRO's ear;
- The vertical center line of the EBP coincides with the reference plane.

NOTE: **Annex N** of this Technical Provision defines reference coordinate systems Optional options that can be used to provide an unambiguous description of the position of the EBP with respect to MAC.

Figure 6. Vertical and horizontal reference lines and reference points A and B in two examples of device types: a smartphone with a full touch screen (top) and a Handset with keyboard (bottom).

Figure 7-a. Phone position 1 - cheek position.

Figure 7-b. One possible position of the EBP against the head after Step c).

Figure 7-c. Handset position of Figure 7-b after applying Step d).

Figure 7-d. Handset position of Figure 7-c after applying Step e).

Figure 7-e. Handset position of Figure 7-d after applying Step f).

Figure 7-f. Handset position of Figure 7-e after applying Step g).

Figure 7-g. Handset position of Figure 7-f after applying Step h).

5.1.7.4.3. DEFINITION OF THE INCLINED POSITION.

The inclined position is established from items **a)** to **d)** as follows:

to) Repeat from Step **a)** to Step **i)** of numeral **5.1.7.4.2,** to place the EBP in the position of cheek (see **Figure 7**).

b) While maintaining the orientation of the EBP, move the EBP away from the pinna along the line passing through OD and RO just enough to allow rotation of the Handset away from the cheek 15 °.

c) Rotate the EBP 15 ° around the horizontal line (see **Figure 8**).

d) While maintaining the orientation of the EBP, move the EBP towards the MAC on a line that passes by OD and LE until some part of the EBP touches the ear. The inclined position is obtained when contact is made with the pinna. If the contact is anywhere other than the pinna, for example, the extended antenna touching the back of the MAC, the angle of the EBP should be reduced. In this case, the inclined position is obtained if any part of the EBP is in contact with the auditory pavilion and a second part of the EBP is in contact with the MAC.

Figure 8. Tilted position of the wireless device on the left side of the MAC.

5.1.7.4.4. ANTENNA.

For DCIs employing one or more external antennas with variable position (for example, extended antenna, retracted, rotated), they must be positioned in accordance with the Instructions for Intended Use provided by the manufacturer in the user manual. If an antenna position is not specified, the tests should be carried out with the antennas oriented in such a way that the exposure condition is obtained higher while keeping the EBP in the cheek or leaning position according to the numerals

5.1.7.4.2 ., And **5.1.7.4.3.** For antennas that can be extended, tests should be performed with the antenna fully extended and fully retracted. The antenna settings should be document in the RP of **Annex A** of this Technical Provision.

5.1.7.4.5. OPTIONS AND ACCESSORIES SUPPLIED BY THE EBP MANUFACTURER.

Accessories included in the EBP packaging that may affect the power output should be tested RF signal or the distribution of RF currents in the EBP when used in close proximity to the ear, according to with the conditions of Intended Use specified by the manufacturer. For example, (a) optional antennas, (b) additional battery packs that may change the performance of the Handset or SAR, etc., and (c) cables connected during Intended Use.

5.1.7.4.6. EBP WITH ALTERNATIVE FORM FACTOR.

For the purpose of this Technical Provision, specifically section **5.1.** , it is considered that the EBP It has a conventional bar-like shape (rectangular, cuboid). However, the basic principles defined and specified herein may be applied to other forms of other INN within the scope of the present Technical Provision.

One such device is a Wireless Headset (for example, connected via Bluetooth), which can be evaluated in the same way as any other EBP by using similar geometry and the Coordinate mapping of this device to the definition of EBP given in **Figure 9** .

Figure 9. An EBP with alternative form factor and with the coordinates and reference points applied standards.

The basic characteristics of any DCI that allow easy mapping to the geometry system and coordinates used in this Technical Provision includes the identification of an acoustic exit point which will be defined as point A when it is at the midpoint of the DCI width and point B which will be at the bottom of the DCI where the primary microphone location is at the end closest to the mouth.

Likewise, the modes of operation available in the referred device and the levels maximum operating power that apply.

All details related to alternate form factor DCI must be documented completely in the RP, including diagrams or photographs that help in the description, additionally it is must apply sound engineering tests to implement mapping of a device with factor of alternative way.

5.1.7.5. TEST FREQUENCIES FOR THE EBP.

The EBP must comply with the exposure limits in all frequency bands in which transmit and for all those in which the EBP will operate in the United Mexican States. Nevertheless, testing each transmission channel is impractical and unnecessary.

For each mode of operation of EBP wireless technologies, tests must be performed in the channel closest to the center of each transmission band. If the width of the transmission band

exceeds 1% of the central frequency (f_c), then it should also be tested with the channels in the highest and lowest frequency of the band. Also, if the transmission bandwidth is greater than 10% of the center frequency, the following equation should be used to determine the number of channels (N_c) to be tested.

Equation (4)

Where:

f_c It is the center frequency of the center channel in the transmit band in Hz.

f_{high} It is the highest frequency of the last channel in the transmit band in Hz.

f_{low} It is the lowest frequency of the first channel in the transmit band in Hz.

N_c It is the number of channels in the transmission band.

And the " *round [x]* " function rounds its argument *x* to the next highest integer. Therefore, the number Channels N_c will always be an odd number.

The channels tested should be equally spaced in frequency (as much as possible) and they should include channels of the highest and lowest frequencies. The calibration of the probes must be valid for all frequencies and LET parameters at those frequencies. Very large frequency bands may require multiple probe calibration points and different LET recipes to cover all the band.

5.1.8. TESTS TO BE PERFORMED.

In order to determine the average spatial peak value of the highest SAR of a Handset, you must test in each frequency band, in which the EBP will operate in the United Mexican States, all device positions, settings and modes of operation required, the foregoing according to with Steps **1** through **3** shown below.

For devices with simultaneous transmission capability, the procedure described in the numeral **5.1.9.2.** ; **A** flow chart of the testing process is shown in **Figure 10** for further reference.

one: The measurement procedure described in section **5.1.9** of this Technical Provision is must perform on the channel that is closest to the center of the transmit frequency band (f_c) for each transmitting antenna used:

to) In all test positions of the device (cheek and tilted, for the left side and the right side of the MAC, as described in **5.1.7.4**);

b) In all configurations of use for each position of the device indicated in subsection **a)** , for example, a device with the cover open and closed or the antenna extended and retracted;

c) In all modes of operation, for example analog and digital modulation at each position of the device indicated in item **a)** and configuration indicated in item **b)** on each band of frequency.

2: For the condition that provides the highest peak of the SAR space average determined in the **number 1** for each configuration described in sections **a)** , **b)** and **c)** , all the tests described in **5.1.9.,** on all other test frequency channels, for For example, on the highest and lowest channel.

Additionally, for each position, configuration and operating mode of the EBP where the peak value spatial average of the SAR determined in **numeral 1, subsections a), b) and c)** is greater than or equal to half the applicable SAR limit, testing will be required on all other required test channels; otherwise it will not be necessary.

3: Examine all data for the largest peak value of the SAR spatial average measured in the fractions **1** and **2** of this paragraph and, determine the requirements that must be documented in the RP.

Figure 10. Flow diagram of the tests to be carried out.

5.1.9. MEASUREMENT PROCEDURE.

5.1.9.1. GENERAL PROCEDURE.

The following procedure must be performed for each of the test conditions described in the numeral **5.1.8** (see **Figure 10**).

The **Table 5** provides the measurement parameters used in scanning area (*area scan*) and **Table 6** the used in the *zoom scan* .

to) Measure the local SAR at a test point 10 mm or less from the inner surface of the MAC where the measured local SAR exceeds the lower detection limit of the measurement system. Preferably, the test point should be above the location of the expected SAR peak within the distance mentioned above. As explained in **Step f)** , a Comparative measurement by the system at the same point after completing the measurements of the HE.

b) The area over which the SAR measurement is made should cover an area larger than the projection of the Handset and its antenna. For some Handsets, the projected area on the MAC may be such that the probe may not reach all points. In this case, MAC can be used rotated and the area can be assessed by multiple overlapping area scans. Measure the two-dimensional SAR distribution within the MAC (area scan procedure). The Measurement area limits should be with respect to MAC requirements. The resolution of the measurement and spatial resolution for interpolation should be chosen such that allow identification of the location of local peaks within the middle of the linear dimension which corresponds to the volume side of the zoom scan. The maximum spacing of the grid should be 20 mm for frequencies equal to or less than 3 GHz and (60 / *f* GHz) mm for frequencies above 3 GHz. Measurement SAR resolution uncertainty may be estimated using the functions described in paragraph **P.2.10.** of **Annex P** of this Technical provision **.**

The maximum distance between the geometric center of the detector probes and the inner surface of the MAC must be less than or equal to 5 mm for frequencies equal to or less than 3 GHz and mm for frequencies above 3 GHz, where is the penetration depth in the skin of the plane wave and *ln* (x) is the natural logarithm. The maximum variation in the distance between the sensor and the internal surface of the MAC should be ± 1 mm for frequencies equal to or below 3 GHz and ± 0.5 mm for frequencies above 3 GHz. At all measurement points, the angle of the probe with respect to the line normal to the surface must be less than 30 ° for frequencies equal or less than 3 GHz and 20 ° for frequencies above 3 GHz (see **Figure 11**). The **Table 5** provides the measurement parameters required for the area scan.

c) From the scanned distribution of the SAR, the position of the Primary Maximum Value of the SAR, in addition, the positions of the local SAR secondary peak values must be identified. within 2 dB of the maximum value that will not be in the zoom scan of other peaks. Should be measure additional peaks only when the primary peak SAR value is within 2 dB of the limit compliance with the SAR of **Table 1** of this Technical Provision.

d) Measure the SAR distribution in three dimensions at the locations of the primary and peak values secondary identified in **Step c)** (zoom scan process). The division The horizontal grid must be (24 / *f* GHz) mm or less but not more than 8 mm. The size Minimum volumetric zoom scan is 30mm by 30mm by 30mm for equal frequencies or less than 3 GHz.

For higher frequencies, the minimum volumetric size of the zoom scan can be reduced to 22mm by 22mm by 22mm. Smaller zoom scan volume with less spacing between measurement points is allowed, due to a more pronounced decay electric field, which can reduce the measurement time. For frequencies greater than 3 GHz, the division of the grid in the vertical direction should not exceed (8 - *f* GHz) mm, and for frequencies equal to or less than 3 GHz if uniform spacing is used the grid division should not exceed 5 mm. If variable spacing is used in the vertical direction (non-uniform gratings or

graduated grids), the maximum spacing between the two measurement points closest to the Model housing should not exceed (12 / *f* GHz) mm for frequencies above 3 GHz, and not greater than 4 mm for frequencies equal to or less than 3 GHz. In addition, the spacing between the farthest adjacent points shall be increased by a factor not exceeding 1.5, when use graduated grids, extrapolation routines should be used according to the numeral **P.2.10.3.2** of **Annex P** of this Technical Provision, with the same spacing used in the measures. The maximum distance between the geometric center of the detector probes and the interior surface of the MAC must be 5 mm for frequencies equal to or less than 3 GHz and

mm for frequencies greater than 3 GHz, where δ is the penetration depth of the plane wave and *ln* (x) is the natural logarithm. Separate grids should be centered on each of the the peak values found in **Step c)** . At all measurement points, the angle of the probe with respect to the line normal to the surface must be less than 30 ° for frequencies equal or less than 3 GHz and 20 ° for frequencies greater than 3 GHz.

and) The spatial average peak values of the SAR must be determined by post-processing, that is say the interpolation and extrapolation procedures defined in paragraph **5.1.10** of the present Technical Provision.

F) The local SAR should be measured at exactly the same location as the **Step Step** test point. **subsection a)** . The EBP SAR Drift can be estimated by the difference between the measured values at the same point in **Step a)** and this subsection. The EBP SAR Drift must stay within ± 5%; otherwise, the numeral **P.2.8** of **Annex P** of the This Technical Provision, for more information about the Drift of the SAR measurement.

Commercial Handsets must have a Power Output Drift of ± 5%. Some INNs may have significant fluctuations in output power that are not classifiable as a Drift undesirable power but as a characteristic of the normal operating behavior of the DCI. In In this case, other methods can be used, such as potential scaling, in order to ensure an accurate and conservative SAR.

Uncertainty due to distortion of the fields between the boundary of the medium and the dielectric shell of the probe should be minimized, which is achieved if the distance between the MAC surface and the physical tip of the probe is larger than the diameter of the probe tip.

Table 5. Area scan parameters.

Parameter	**Frequency of EBP being tested**	
	***f* ≤ 3 GHz**	**3 GHz < *f* ≤ 6 GHz**
Maximum distance between measured points (center sensors) and the internal surface MAC (z M 1 in **Figure 11** in mm)	5 ± 1	
Maximum distance between measurement points adjacent (see **P.2.10.3.1** of **Annex P** of the present Technical Provision, in mm) b	20 or half of the corresponding length area scan reduced, whatever less	60 / *f* or half the corresponding length area scan reduced, whatever less
Maximum angle between probe axis and normal of the MAC surface (α in **Figure 11**)	30 °	20 °
Probe angle tolerance	1st	1st

[to] is the depth of penetration of the plane wave incident in a normal flat half-space.

[b] See numeral **P.2.10** of **Annex P** of this Technical Provision, on how Δ *x* and Δ *y* can be selected for individual area scanning needs.

[c] The angle of the probe with respect to the normal of the model surface is restricted due to the degradation in measurement accuracy in fields with rapidly changing spatial gradients. Measurement accuracy decreases with increasing probe angle and frequency. This is the reason why the probe angle restriction is stricter at frequencies greater than 3 GHz.

Table 6. Zoom scan parameters

Parameter	**Frequency of EBP being tested**

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	$f \leq$ 3 GHz	**3 GHz < $f \leq$ 6 GHz**
Maximum distance between the closest measured point and the MAC surface (z_M 1 in **Figure 11** and **Table 5** , in mm)	5	
Maximum angle between the probe axis and the normal of the MAC surface (α in **Figure 11**)	30 °	20 °
Maximum spacing between the points measured on the x- and y- directions (numeral **P.2.10.3.2** of this Technical Provision, in mm)	8	
For uniform grids:		
Maximum spacing between the points measured on the address of the normal casing MAC (Δz1 in **Figure 11** , in mm)	5	
For graded grids:		
Maximum spacing between the two measured points plus close in the direction of the normal MAC casing (Δz1 in **Figure 11** , in mm)	4	12 / *f*
For graded grids:		
Maximum incremental increase in spacing between points measured in the direction of the MAC casing normal (R_z = Δz2 / Δz1 in **Figure 11**)	1.5	1.5
Minimum side length of zoom scan volume in the x- and y- directions (L_z in numeral **P.2.10.3.2** of the present Technical Provision, in mm)	30	22
Minimum side length of zoom scan volume in the address of the normal MAC casing (L_h in the numeral **P.2.10.3.2** of **Annex P** of this Provision Technique, in mm)	30	22
Probe angle tolerance	1st	1st

[to] is the depth of penetration for a plane wave incident in a flat half-space normal.

[b] This is the maximum separation allowed, which may not work in all circumstances.

Figure 11. Orientation of the probe with respect to the line normal to the MAC surface, shown in two different locations.

5.1.9.2. SAR MEASUREMENTS OF HANDSETS WITH MULTIPLE ANTENNAS OR TRANSMITTERS.

Handsets with multiple antennas or multiple transmitters transmitting simultaneously require special testing considerations. The methods for combining the fields, in order to determine the The combined SAR distribution differs depending on whether the corresponding RF transmitters emit waveforms that are correlated or not in time. The method of adding the fields and the Associated measurement instrumentation required for correlated signal waveforms are different from those for uncorrelated signals.

5.1.9.2.1. MEASUREMENT OF SAR FOR UNCORRELATED SIGNALS.

The following procedures are applicable to DCIs that incorporate multiple modes of operation and that are intended to operate simultaneously through:

to) Multiple frequencies (*f1, f2* , etc.), which have a separation greater than the frequency range valid for probe calibration or LET, whichever is smaller (i.e. when the SAR does not it can usually be evaluated simultaneously using the same probe and liquid);

The valid frequency range of the probe calibration is typically narrow (for example, ± 50 MHz to ± 100 MHz) for electric field probes in most systems today In use. Furthermore, since the electric field probes used in current systems typically have a DC voltage at the output, the probe cannot distinguish between signals at different frequencies. The valid frequency range of the LET refers to the frequency range above which the dielectric parameters are within the tolerance of the target values (see the **Table 4**). Due to these limitations, the SAR values must first be evaluated separately and then arithmetically combined.

b) Multiple antennas transmitting using different modulations (for example, a call from voice using CDMA and data using WiFi) in the same valid frequency range for the probe and LET calibration.

In the case of multiple antennas transmitting different modulations in the same frequency range frequencies, measurements should be made with both signals transmitting simultaneously. Without However, this is not necessary if the spatial average peak values are summed as described in the **Alternative 1** (since this method provides a conservative overestimate of the combined SAR). For the case of multiple antennas transmitting correlated signals (for example, certain MIMO configurations), see **5.1.9.2.2.** of this Technical Provision **.**

In numeral **5.1.9.2,** of this Technical Provision, a test combination is defined as a particular combination of the EBP position (left cheek, right tilt, etc.), the settings (for example, antenna position) and Accessory (s) (for example, battery).

There are other alternative evaluation procedures for simulcasts in different frequency bands. An example of them can be found below, however, to be in possibility of applying them, at least the following prerequisites must be met:

- Area scan, zoom scan, and SAR spatial average peak should be evaluated separately on each frequency (according to numeral **5.1.9.1** of this Technical Provision) with transmission on at that frequency and off at other frequencies.
- SAR data from different frequencies or antennas are combined only when the The test combination is the same for those frequency bands or antennas, and if that test combination is a test combination intended for simultaneous operation.

Some alternatives of evaluation procedures for simultaneous transmissions in different frequency bands are summarized below:

- **Alternative 1** : Sum of the values of the spatial average peak of the SAR - it is the simplest method and conservative to find an upper limit; always applicable. The procedure applies to determine the upper limit of the combined SAR in a conservative manner, when the maximum Output power is used in each transmitter or antenna is used for simple transmission and simultaneous. If values of the spatial average peak of the SAR are used, these will be different in different spatial locations, so this procedure will overestimate the combined value of the SAR in this case.

  a) For a combination of tests in which simultaneous operation is required, add the values of the spatial average peak of the SAR in each antenna and frequency band where use simultaneous operation.

  b) Verify that the maximum value of the SAR sum is within 3 dB of the applicable limit of the SAR. If so, ensure that all frequency channels required in **5.1.7.4.7** have been measured for all frequency bands and all DCI antennas on which use simultaneous operation (repeat step a) if necessary).

  c) The sum of the SAR values obtained in steps a) and b) is the combined SAR.

- **Alternative 2** : Selection of the highest evaluated value of the spatial average peak of the SAR - method simple; applicable under certain circumstances. This procedure gives an estimate of the multiband SAR when separately measured zoom scan distributions have little or no overlap. The maxima are separated so that the maximum of the average peak value spatial SAR of each distribution shall not increase more than 5% when the SAR distributions in other simultaneous ways they are added. This Alternative 2 is only applicable if the peak value Highest SAR spatial average is less than 70% of the compliance limit, according to calculated on the zoom scans at each frequency.

  a) Measure the spatial average peak value of the SAR at each frequency according to **5.1.7.4.7** . The Area scanning must be performed in the same plane at each frequency. Distance for all area scans it must be less than or equal to the smallest value of in **Table 6** for all frequencies to be measured.

b) Area scans performed separately must be interpolated so that the overlap area has the same measurement grid. The resolution of the interpolated grid it should be 1mm or better. Locate the peak value in each of the area scans. The areas Overlapping will contain all of the SAR peaks.

c) Using all the area scans performed, create a new SAR distribution by adding spatially interpolated area scans (point-to-point).

d) IF the peak value in the new SAR distribution created in step c) does not exceed the highest value high of the maximum SAR values, located in step b), by more than 5%, the value of the Multiband SAR is selected as the maximum value of the spatial average peak of the SAR calculated from the zoom scan in step a).

- **Alternative 3** : Calculation of combined volumetric SAR from area scans / area scans existing zoom - exact and fast method; always applicable. This procedure uses scans of existing area and zoom in combination with interpolation and extrapolation to generate a volumetric distribution of SAR.

a) For a combination where simultaneous operation is used, calculate the distribution volumetric SAR over the region corresponding to the area scan of each band of frequency at which simultaneous operation is required. The uncertainty calculation must be documented and included in the RP.

b) Perform the summation of all SAR distributions for all bands in a spatial, using interpolation according to the **provisions** of paragraph **5.1.10.1** of the present Technical Provision. For each frequency band in which operation is required Simultaneously, this step must be performed on each channel tested according to what is established in numeral **5.1.7.4.7** . and the procedure established in **5.1.8.**

c) Use post-processing techniques defined in paragraph **5.1.10** and Annex H of this Technical provision to determine the spatial average peak value of the SAR of the distributions obtained in step b).

d) Verify that the maximum spatial average peak value of the SAR is within 3 dB of the value SAR limit. If so, ensure that all frequency channels have been tested (**5.1.7.4.7**) on all bands where simultaneous operation and repeat steps are required a) to c).

- **Alternative 4:** Volumetric scan - the most accurate method; always applicable. SAR values they are combined for each test condition where simultaneous transmission is required.

a) For a combination of tests where simultaneous operation is required, ensure that the zoom scan has been measured in accordance with the **provisions** of **5.1.7.4.7** and **5.1.8** of this Technical Provision in all bands in which operation is required simultaneous.

b) For each frequency band in step a), select the channel with the maximum peak value SAR spatial average.

c) Determine a volumetric grid that includes the zoom scans at the frequencies determined in step b) in all frequency bands in which it is required simultaneous operation. Yes, the zoom scans on the frequencies , etc. they are very separated so that the volumetric grid is very large, an acceptable variation of this step is to identify the zoom scan locations for each frequency in step b) and apply the alternate procedure in step d).

d) At each frequency determined in step b), measure the volumetric grid determined in the step c). If it was decided to use zoom scan locations instead of the volumetric grid in step c), then, on each frequency channel determined in step b), measure the zoom scan for the other frequencies in exactly the same places as for each zoom scan performed in step a). Measurement ends with operating mode on at that frequency and the modes of operation on other frequencies off.

e) Carry out the summation of the SAR distributions obtained in step d). Calculate the maximum of the combined SAR of the summative distribution using post-processing techniques to determine the spatial average peak value of the SAR. When volumetric scans are performed at each frequency, these must be added to determine the maximum using the total distribution. In case zoom scans are used in step d), they should be combined and the largest will be identified to calculate the spatial average peak value of the SAR.

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- It is considered that the EBP measurement fully complies with the requirements of this Technical Provision, referring to uncorrelated signals, if it satisfies the requirements of at least one of these alternative assessment procedures.

The **Alternative 1** is the most conservative and computationally simple also it does not require measurements additional SAR. The **Alternatives 2 and 3** successively reduce the degree of overestimation, but require further calculation and analysis of evidence. The **Alternative 4** provides the minor overestimation and requires the greatest effort.

5.1.9.2.2. SAR MEASUREMENT FOR CORRELATED SIGNALS.

In general, two types of signals can be found in most transmitters with multiple antennas of the latest generation.

The first **type 1** call , are signals with relative phases unchanged for a relatively long time. long compared to symbol duration. This type of signals can be found in systems with antennas in phase arrangement, where the relative phases of the signals fed to the antennas are controlled to form the radiation pattern of the antenna array towards a given direction. In different environments of operation, the relative phases may change to obtain a different desired radiation pattern. By Therefore, when the transmission direction is determined and the pattern is formed, the relative phases are set to a certain duration, and will only change when the radiation pattern is configured in a different. In fact, the time in which the relative phases remain unchanged is relatively long compared to symbol duration in normal communication.

On the other hand, the second type of signals, called **Type 2,** are signals with relative phases that vary quickly in a relatively short period of time. These signals can be found in systems that employ MIMO techniques. The relative phases of the signals change from symbol to symbol due to the function of Space-Time Block Coding (STBC) of MIMO schemes. The relative phases of signals change from symbol to symbol according to the STBC encoding, and the beamforming is not used during normal communication.

There are two methods for combining the SAR of individual measurements using scalar probes of conventional electric field.

I. The first method combines the magnitudes of the individual electric field values, and

II. The second is based on the magnitudes of the individual components of the electric field.

These two methods (**I** and **II**) can be implemented using conventional SAR measurement systems and they require only a limited number of scans equal to the number of transmitters.

The measurement procedure for different types of correlated signals is described in **Figure 12** .

For **Type 1** signals in the aforementioned classification, or signals without specification, the second approximation based on a combination of the individual electric fields should be used, This leads to a lower probability of overestimating the SAR and many SAR systems provide quickly the input data required for post-processing.

For **Type 2** signals , the use of the approximation of the time-averaged SAR measurements requires only the measurement procedure defined in section **5.1.9.** of this Technical Provision, with the use of conventional scalar probes.

Figure 12. Measurement procedure for different correlated signals.

5.1.10. POST-PROCESSING OF SAR MEASUREMENT DATA.

5.1.10.1. INTERPOLATION.

If the resolution of the measurement grid is not fine enough to meet the requirements of interpolation of the area scan and the zoom scan to calculate the spatial average peak of the SAR, must apply interpolation procedures at the measurement points, according to **Annex H** of the present Technical Provision.

5.1.10.2. EXTRAPOLATION.

Electric field probes used to measure SAR generally contain three dipoles orthogonal in proximity and integrated into a protective housing / cover. The measuring point is located a few millimeters from the tip of the probe, this distance must be taken into account when Identify the position of the measured SAR. Due to errors caused by border effects and the "offset" of the probe sensor, SAR is not measured on the surface of the MAC. The measured points closest to the surface should be extrapolated to estimate the highest SAR on the model surface, from in accordance with the provisions of **Annex H** of this Technical Provision.

5.1.10.3. DEFINITION OF THE VOLUME IN WHICH THE AVERAGE IS MADE.

The volume that is averaged should be in the shape of a cube, the sides of which should have the dimensions necessary to contain 1 g or 10 g of mass. A density of 1 000 kg / m3 should be used To represent the density of the head tissue, the length of the side of the 1-g cube must be 10 mm, and the length of the side of the 10g cube should be 21.5mm, as far as the orientation of the cubic volume is concerned **Annex H** of this Technical Provision must be observed .

5.1.10.4. SEARCH FOR THE MAXIMUM LEVEL.

The cubic volume that is averaged must pass through the interpolated zoom scan and extrapolated on the internal surface of the MAC in the vicinity of the local maximum of the SAR, taking considerations such as those given in **Annex H** of this Technical Provision. The cube with the maximum spatial average peak of the SAR should not be on the edge / perimeter of the zoom scan volume, in if it is, the zoom scan volume must be shifted and measurements must be repeated.

5.1.11. REDUCTION OF SAR TESTS.

5.1.11.1. GENERAL REQUIREMENTS.

The number of SAR measurements required to identify the configuration that gives the maximum peak spatial average of the SAR for an EBP capable of transmitting on several frequencies and with different usage configurations can be great. This is the case when the EBP can be used with different Accessories. The total time required to perform measurements and Assess Conformity of an INN is it can be decreased by directly reducing the number of tests to be performed.

SAR test reduction methods applied during testing must be recorded clearly in the corresponding RP. And these methods can be:

A. Reduction of tests for different modes of operation in the same frequency band using the same wireless technology;

B. Reduction of tests based on the characteristics of the EBP design;

C. Test reduction based on analysis of peak SAR level;

D. Test reduction based on multi-band simulcast considerations **.**

NOTE 1 For example, GSM, GPRS and EDGE (all using GMSK modulation) are considered to be the same wireless technology, however, GSM and UMTS are not considered the same technology wireless.

NOTE 2 The SAR test reduction procedures described in **5.1.11.** of the present Technical Provision, save time for tests. These test alternatives are not mandatory, the Test Laboratory is free to apply them or follow the measurement procedure described in paragraphs **5.1.7** to **5.1.10.** of this Technical Provision.

5.1.11.2. TEST REDUCTION FOR DIFFERENT OPERATION MODES IN THE SAME FREQUENCY BAND USING THE SAME WIRELESS TECHNOLOGY.

In case multiple modes (mod_x , mod_y , etc.) operate on the same frequency band, you can employ procedures to reduce the number of measurements for low power modes (mod_y , etc.). These procedures can be applied if the following conditions are met:

a) The same RF amplification stage is used for mod_x and mod_y .

b) The same antenna is used for mod_x and mod_y .

c) MIMO techniques are not applied for mod_x and mod_y .

d) The mod_x and mod_y modes use the same wireless technology.

e) The modulation of the signal is the same and this modulation has constant amplitude, or the power of mod time averaged output $_y$ is at least 2 dB lower than mod_x output power .

f) The probe calibration is valid for mod_x and mod_y . The probe calibration certificate defines the validity and uncertainty of calibration are applicable to mod_x and mod_y).

g) The same measurement system (probe, MAC, LET, measurement electronics) is used for all modes of operation.

h) The carrier frequency of mod_x is the same for mod_y .

i) The ratio between the channel bandwidth of mod_x and mod_y meets the following equation:

Equation (5)

To reduce the number of tests required, the following procedure can be applied if all tests above conditions are met:

Step 1. Test all modes of operation (mod $_x$, mod $_y$, etc.) in any of the settings test (for example, cheek position).

Step 2. Perform full test on all test configurations for mode of operation with the highest SAR value found in Step 1.

Step 3. Perform full test on all test configurations all other modes operation evaluated in Step 1 that meet the following conditions:

to. The SAR measured in Step 1 is within 15% of the highest SAR value (identified in Step 2), and;

b. The highest SAR value identified in step 2 is within 15% of the limit value of the HE.

5.1.11.3. TEST REDUCTION BASED ON EBP DESIGN CHARACTERISTICS.

The following procedure can be applied to DCI with internal antennas and operating frequencies between 800 MHz and 2 GHz.

For a DCI with internal antenna on the bottom of the device, maximum 2.5 cm from the bottom of the itself, and the spatial average peak value of the SAR measured in the cheek position, for a given band of frequency and mode of operation, is at least 3 dB or better of the SAR limit value, not required test in the tilted position.

For other antenna positions, when the SAR value measured in the inclined position and the frequency channel with the highest measured SAR value is 3 dB or better than the SAR limit value, no requires testing in the same inclined position for the other channels.

The following conditions must be met in order to apply this reduction procedure tests:

to) The DCI uses the same elements in the RF stage (transmitters, amplifiers, connectors, etc.)

b) Use the same antenna and ground connection.

c) MIMO techniques are not applied.

d) The same measurement system (probe, MAC, LET, measurement electronics) is used.

In order to apply test reduction to DCI with internal antenna at the bottom and using the same lower antenna for multiple communication modes with the same wireless technology and radio bands frequencies, select the communication system with the highest time-averaged output power and perform a complete SAR measurement, including all settings and test positions. Successive tests in the inclined position, for other communication modes in the same frequency band, not required if the following conditions are met:

one) The cheek position has the highest value of the spatial average peak value of the SAR for the band of frequency.

2) The spatial average peak SAR values for the inclined position are below 30% of the value SAR limit.

The Test Report must include photos or diagrams, showing the position and location of the antennas in the DCI, and, describe the wireless operating modes applicable to each antenna to justify the reduction of tests. If the DCI related test reduction with internal antenna at the bottom is used and that uses the same bottom antenna for multiple communication modes with the same wireless technology and frequency bands, the antenna and the coupling circuits for each DCI communication system.

5.1.11.4. REDUCTION OF TESTS BASED ON THE ANALYSIS OF THE PEAK LEVEL OF THE SAR.

The purpose of this procedure is to eliminate performing the zoom scan when the measured value of the SAR in the area scan is below a certain threshold, ensuring that the average peak value SAR space is:

• measured correctly and is not overestimated, especially when it could be close to the value SAR limit;

• correctly identified, even if the zoom scan is not performed.

Note: This test reduction procedure is different from the " *Fast SAR* " measurement procedure. because the decision to apply the full SAR measurement procedure is made after analyze the values obtained in the area scan. In addition, it requires a threshold value since the objective is to avoid performing the zoom scan for certain particular measurement setups and does not depend of a " *Fast SAR* " algorithm to estimate the spatial average peak value of the SAR.

The procedure described below is only applicable to Handsets operating in the UMTS bands GSM900 / DCS1800 and their respective modes of operation (does not apply to modes of operation in GSM850, PCS1900, GPRS, etc.) and does not apply to simultaneous transmissions. To apply the procedure, it is necessary:

one) adjust the area scan parameters specified in **Table 5** to use a no larger grid at 10 mm;

2) perform area scans at a fixed distance of 4 mm maximum between the measured points (center probe geometry) and the internal surface of the MAC.

The test reduction for a single frequency band consists of:

to) Measure SAR as described in section **5.1.9.1** , step a).

b) Perform the area scan for one of the positions defined in **5.1.9** at the center frequency of the band considered, as indicated in the complete procedure indicated in section **5.1.9.1** .

c) Determine the peak SAR of the area scan; this is defined as the first absolute peak of the SAR (PABS).

d) Carry out the zoom scan, as indicated in section **5.1.9.1** . Evaluate Drift as indicated in section **5.1.9.1** step f).

and) For the other frequency positions and channels to be measured, repeat the following steps:

Step 1. Measure the local SAR as described in **5.1.9.1** step a).

Step 2. Perform the area scan as indicated in paragraph **5.1.9.1** step b).

Step 3. Evaluate the SAR peak value of the area scan; if the value is greater than the first peak absolute SAR (part c), then the PABS will be assigned as the peak value of the SAR of the area scan determined in this step, after completing step 4.

Step 4. Perform the zoom scan required by **5.1.9.1** . If the peak SAR value of the area scan is not less than 1.6 W / kg (80% of 2.0 W / kg) or if the peak SAR value is equal to or greater than , where the threshold *U (f)* is defined in **Table 7** and *PABS* is the absolute peak value of the SAR. If it is required to measure multiple peak values (such as indicates numeral **5.1.9.1** step c) of this Technical Provision), apply this step to all peak values.

Step 5. Calculate the measurement drift as indicated in paragraph **5.1.9.1** step f) of this Technical provision.

Steps e.1 to e.5 must be applied sequentially to all applicable bands. The Threshold values used in step e.4 are shown in **Table 7 below** .

Table 7. Threshold values *U (f)* used in the test reduction procedure.

Operation mode	***U (f)***
GSM900	0.75
UMTS VI	0.75
DCS1800	0.60
UMTS IX	0.60
UMTS I	0.60

When following this test reduction procedure:

• The diagram on the left in **Figure 10** should be followed .

• The diagram on the right in **Figure 10 will** apply only to the first SAR measurement.

Successive SAR measurements must be performed according to **Figure 13** , which is a modification of the procedure described in **Figure 10** .

Figure 13. Modified Figure 10 diagram.

5.1.11.5. TEST REDUCTION BASED ON SIMULTANEOUS TRANSMISSION IN MULTIPLE BANDS

Simultaneous multi-band transmission means that the EBP can operate in multiple modes of transmission at the same time, therefore, if the secondary transmitter operates at lower or lower power levels equal to 20 mW, such a transmitter can be excluded from SAR measurement tests.

5.1.12. ESTIMATION OF UNCERTAINTY.

The estimation of the measurement uncertainty of the SAR values produced by an EBP of the This Technical Provision must be made in accordance with **Annex P** of this Technical Provision, **Table A.1** of **Annex A** of this Technical Provision must be included in the corresponding PR .

Likewise, it should be noted that it is not enough to provide only the aforementioned **Table A.1** without the availability of detailed documentation on estimating the influence of uncertainty on each quantity, including its methodology and the evaluation of the data for each component, as well as the way in which the uncertainty was derived from the data set.

5.1.13. TEST REPORT (RP).

All the results of the tests corresponding to numeral **5.1** must be recorded in the format contained in **Annex A** of this Technical Provision. Said report must include all the information necessary for the interpretation of the evaluated EBP test combinations, the calibration performed and all the information required by the method and instrumentation used.

Additionally, the RP must contain at least the following elements;

to) All information necessary to perform tests, calculations or measurements should be recorded repeatable, giving the results within the required uncertainty limits.

b) General introduction

1) Identification of the Test Laboratory.

2) Identification of the EBP including hardware and software versions, serial number, and in where applicable, IMEI (International Mobile Terminal Equipment Identifier).

3) Compliance requirements, e.g. test standards, guidelines, recommendations, etc.

4) Applicable exposure limits, **Table 1** of this Technical Provision, etc.

c) Measuring system

1) Description of the main components of the measuring system, including positioner, liquid, measuring electronics, holding device, model and any other item relevant.

For the probe (s) used, include:

- dimensions,
- isotropy,
- spatial resolutions,
- dynamic range,
- linearity.

2) Information on the calibration of relevant components, for example, certificates of probe calibration.

3) A description of the interpolation and extrapolation algorithms used in the scans of area and / or zoom scans.

4) Characteristics of the dielectric liquids and the materials used.

Including:

- dielectric properties for each frequency band,
- deviation from the target value,
- liquid temperature,
- summary of the composition of LETs.

5) Results of the system review

- Measurement results for each frequency band.

- Deviation from the SAR target value.
- Description of the radiant source.

d) Estimation of Uncertainty (revision of the system for the measurement of SAR and validation of same).

1) Include measurement uncertainty values in **Table A.1** of **Annex A** of this Technical provision.

2) Any other relevant information.

and) EBP and testing details

1) Description of the EBP form factor in a brief description of its Intended Use.

2) Description of the positions and orientations to be tested, including photos and justification for any test reduction.

3) Description of the antennas and Accessories, including batteries, available and tested.

4) Description of the operating modes, power levels and available frequency bands and proven, as well as the justification for any reduction in evidence.

5) Environmental test conditions, eg temperature.

6) Results of all tests performed (value of the spatial average peak of the SAR for each test, and a graphical representation of the broad scans with respect to the EBP for the maximum SAR value of each operating mode) and details of the results of the scaling.

F) Information regarding the validation of the SAR measurement method.

1) Description of the validation process (s).

2) Results of calculations, measurements and / or other evaluations made of the method of SAR measurement.

3) Description of the radiant source and SAR distribution for each frequency band.

4) Range of operating frequencies, modulations, EBP operating settings, exposure conditions and SAR distributions for each specific frequency band at the method.

5) SAR uncertainty.

g) SAR test reduction report

When the test reduction procedures are applied, described in section **5.1.11.** from this Technical Provision, during the SAR measurements of an EBP, the PR must include Additional information on the following test reduction alternatives.

1) Reduction of tests for different modes of operation in the same frequency band (see paragraph **5.1.11.2** of this Technical Provision). The PR must provide a detailed description of how the conditions of numeral **5.1.11.2,** of the present Technical provision.

2) Reduction of tests based on the characteristics of the EBP design (observe the numeral **5.1.11.3** of this Technical Provision). The PR must include drawings or photographs illustrating the arrangement and location of the antennas on the Handset and a description of the applicable to each antenna to support the reduction and exclusion of tests

considered.

3) Reduction of tests based on the analysis of the peak level of the SAR (see paragraph **5.1.11.4** of this Technical Provision). The PR should include a systematic description of how applied the test reduction protocol described in the paragraph in comment.

4) Test reduction based on simulcast considerations in multiples bands (observe section **5.1.11.5** of this Technical Provision). The PR must include the measurement of time-averaged output power and how it meets the level of the available power threshold.

h) Report summary

1) Test combinations and frequency bands.

i) List of all frequency bands and modulations tested.

ii) List of all tested test combinations.

2) Tabulated SAR values plus test positions, bands, modes of operation and device settings.

3) Results of the SAR tests performed as a result of paragraphs **5.1.9** and **5.1.10** of this Technical Provision, which include the value of the spatial average peak of the SAR for each required test and a graphical representation of the scans against the EBP.

5.2. TEST METHOD FOR COMPLIANCE WITH THE MAXIMUM LIMITS OF NON-IONIZING RADIO FREQUENCY ELECTROMAGNETIC RADIATION. INDEX OF

SPECIFIC ABSORPTION (SAR) IN DCI USED AT A DISTANCE LESS THAN OR EQUAL 200 MM FROM THE HUMAN BODY.

5.2.1. MEASUREMENT SYSTEM SPECIFICATIONS.

5.2.1.1. GENERAL REQUIREMENTS.

I. The SAR measurement system must consist of a human silhouette model (MSH), electronic measuring instruments, a scanning system and a clamping device.

II. The test should be performed using a miniature probe, which should be positioned automatically to measure the internal distribution of the electric field in the MSH representing a human body exposed to electromagnetic fields produced by EBP. From the measured electric field values, the SAR distribution and peak value must be calculated spatial average of it.

III. The test must be performed under the following environmental conditions:

to) Ambient and LET temperatures must be in the range of 18 ° C to 25 ° C; for To determine the Uncertainty derived from the temperature of the LET, the numeral must be observed **O.2.4.4** of **Annex O** of this Technical Provision;

b) The EBP, measuring equipment, LET and MSH must be kept static long enough so that their temperatures stabilize;

c) The variation of the LET temperature during the test must not exceed the temperature obtained during the measurement of dielectric properties by more than ± 2 ° C, or that which results in a SAR deviation of ± 5%, whichever is less; you must observe the numeral **O.2.4.4** of **Annex O** of this Technical Provision, to determine the Uncertainty caused by the LET temperature;

d) Environmental noise (for example, noise from measuring equipment, noise from movements of the robot, noise from other RF transmitters, etc.) should not induce a SAR greater than 0.012 W / kg in 1 g (3% of the minimum value of 0.4 W / kg, which must be determined with the Uncertainties of the **Table B.1** of **Annex B**), measured according to numeral **O.2.4.5** of **Annex O** of this Technical Provision, with the RF transmitter of the EBP off;

and) The EBP must not be connected to any wireless network, during the test; Nevertheless, can be connected to a simulated base station;

F) The effects of dispersers (for example, the floor, the robot, other devices, etc.), other than the transmitter and MSH must be less than 3% of the SAR measured according to the numeral **O.2.4.5** of **Annex O** of this Technical Provision, with the RF transmitter of the EBP switched on. If the effect of the dispersers is greater than 3%, a Additional uncertainty according to numeral **O.2.4.5** of **Annex O** of this Technical provision.

g) The system must be validated according to the protocol defined in **Annex I** of this Technical provision, at least once a year, when a new system is put into operation and each time modifications are made to the system. The standard means of used to validate the system (for example, a half wave dipole, antenna patch, open waveguide) should be designed and validated according to the protocol described in **Annex I** of this Technical Provision **.**

5.2.2. SPECIFICATIONS OF THE MODEL OF HUMAN SILHOUETTE (MSH).

I. A model of the human silhouette constructed in the form of a container opened by the top with a flat bottom (flat MSH).

II. The MSH must be filled with the liquid equivalent to the human body tissue with the required dielectric properties and must have the following dimensions:

to) For frequencies less than or equal to 300 MHz the figure of the silhouette model must be a ellipse with a length of 600 mm ± 5 mm (see **Figure 13**) and a width of 400 mm ± 5 mm.

SAW. The bottom wall thickness of the flat MSH should be 2.0 mm with a tolerance of ± 0.2 mm.

VII. If the above requirements are met, the effect of the shape and thickness of the MSH should be less than 1% in the repeatability of the results of SAR measurements.

VIII. MSH material must be resistant to damage or reaction with LET chemicals.

5.2.3. MATERIAL PROPERTIES OF LIQUID EQUIVALENT TO TISSUE (LET).

I. The nominal dielectric values of the MSH liquid are specified in **Table 8** , for discrete frequencies in the 30 MHz and 6 GHz range.

II. For other frequencies in the 30 MHz to 6 GHz range, the dielectric values Nominals must be obtained by linear interpolation between the largest and smallest tabulated figures.

III. In **Annex T** of this Technical Provision, examples of recipes are provided for prepare tissue-equivalent liquids, which are designed to produce the properties dielectrics in the frequency range 30 MHz to 6 GHz.

Table 8. Dielectric properties of LET for the body.

Frequency MHz	**Real part of the permittivity complex relative,** ′	**Conductivity (σ) Ye**
30	55.0	0.75
150	52.3	0.76
300	45.3	0.87

450	43.5	0.87
750	41.9	0.89
835	41.5	0.90
900	41.5	0.97
1,450	40.5	1.20
1 800	40.0	1.40
1 900	40.0	1.40
1 950	40.0	1.40
2,000	40.0	1.40
2 100	39.8	1.49
2 450	39.2	1.80
2,600	39.0	1.96
3,000	38.5	2.40
3 500	37.9	2.91
4,000	37.4	3.43
4 500	36.8	3.94
5,000	36.2	4.45
5 200	36.0	4.66
5 400	35.8	4.86
5 600	35.5	5.07
5 800	35.8	5.27
6,000	35.1	5.48

For SAR evaluations, the LET should be assumed to have a density of 1000 kg / m3.

5.2.4. SPECIFICATIONS OF MEASURING INSTRUMENTS.

5.2.4.1. GENERAL REQUIREMENTS.

The general requirements of the scanning system and probes are given in **sections 5.2.4.2** and **5.2.4.3** respectively. Probe calibration and EBP clamp requirements are defined in numbers **5.2.4.4** and **5.2.4.5** both in this Technical Provision.

5.2.4.2. SCANNING SYSTEM.

The minimum requirements of the scanning system are:

I. Position accuracy: less than or equal to ± 0.2mm;

II. Minimum resolution (size of the increment): less than or equal to 1 mm;

III. Scan interval: greater than or equal to 90% of the dimensions of the MSH in all directions.

5.2.4.3. PROBES.

For accurate measurements it is required that the probe tip be small enough to be able to effectively distinguish the distribution of induced fields in MSH. The probe should cause only minimal distortion in the field distribution, which can be achieved if the probe diameter is less than a third of the wavelength in the LET. Furthermore, exact measurements are needed as closely as possible possible of the MSH surface to keep the extrapolation error to a minimum.

V. If the maximum value of Work factor used is not well identified and it is difficult to generate a Fixed and controlled duty factor, then an available mode of operation should be used and you must choose an appropriate escalation, both must be documented in the RP.

SAW. Exposure tests should be based on characteristics of the EBP, for example, modes of operation, operating bands, antenna configurations, etc. When they exist and are Multiple modes of operation are available, all of these must be measured, unless in some In these ways, the use of a lower output power of RF, the above with respect to other modes on the same frequencies. For example, if an EBP has multiple transmission slots, the mode with the largest number of transmission slots should be used. transmission and modes using fewer slots at the same frequencies should not be measured (assuming the RF output power during a slot is the same for all modes).

VII. In general, the EBP should be evaluated using all operating settings for the frequencies authorized to operate in the United Mexican States.

VIII. There should be no cables connected to the EBP, unless the cables are necessary for your operation in the chosen operational configuration, in which case the cable position must be documented in the RP.

IX. If an operational mode is capable of being used in simultaneous multiple transmissions mode, eg GSM and Bluetooth transmitter together, this operational mode also needs to be measured in accordance with the **provisions** of section **5.2.9.2** of this Technical Provision.

X. When an EBP is intended to be operated only with an external power source, it must be connected to a battery, which must be 100% charged before measurements and SAR values must be corrected according to **5.2.6.1** on multiple measurements SAR using a battery charge.

5.2.6.1. MULTIPLE SAR MEASUREMENTS USING A SINGLE BATTERY CHARGE.

5.2.6.1.1. GENERAL REQUIREMENTS.

There are three conditions that must be met when making multiple measurements using one single battery charge:

to) The measured SAR values must be corrected by a factor greater than or equal to the magnitude of the Drift;

b) the accumulated Drift (the magnitude of the Drift after the second, third, fourth, etc., measurement in sequence of the SAR) must be less than or equal to ± 1.0 dB;

c) the results of the measurement in which the accumulated drift is greater than ± 1.0 dB, must be discarded (measurement must be repeated).

The magnitude of the accumulated Drift can be determined in three different ways, as described below continuation.

5.2.6.1.2. METHOD 1 - DETERMINATION OF THE DRIFT THROUGH THE CHARACTERIZATION OF THE BATTERY DISCHARGE.

This method of determining the accumulated drift uses the measurement of the characteristics of the battery discharge for the DCI operating at the same frequency and mode of operation to be measured in the SAR test. Battery discharge can be characterized using a test conducted by means of from a connection to the RF output of the DCI (if available) or by SAR measurement using a Flat MSH. For both cases, the transmit power of the DCI must be monitored (configured to transmit on the frequency and mode required by the SAR test) until the magnitude of the Drift exceed 1.0 dB (26%).

Note: To avoid performing numerous repetitions of the DCI battery discharge characterization, a single measurement can be made using the frequency and mode of operation with the highest power of temporal average transmission. This will give a conservative value to the correction of the Drift.

For conducted characterization, an output power measurement is performed. These measurements are performed on the DCI antenna port using appropriate equipment prior to testing the DCI of the SAR. IF this type of characterization is carried out, the output power must be measured before and after of the SAR test.

To measure the transmit power radiated by the DCI, the SAR value at a fixed distance within the LET and a flat MSH will be monitored. The reference point must be selected so that the SAR value exceeds the lower limit of detection of the SAR measurement system. A measurement secondary can be performed by the system at the reference point after the completion of the HE.

The resulting power curve or SAR reduction versus time should be used to determine correct Drift in multiple measurements. The correction must be recorded in the RP, denoting the duration of time from the start of the multiple measurement sequence and the end of each test, plus of the values of the corresponding drop in SAR or power for that period of time, derived from the curve.

5.2.6.1.3. METHOD 2 - DETERMINATION OF THE DRIFT THROUGH THE CALCULATION OF THE DRIFT ACCUMULATED.

In this method, the Drift recorded in each individual SAR measurement is added to the Drift accumulated for all SAR measurements in the sequence. For example, if in a sequence of 3 measurements are obtained Drifts of 0.4 dB, 0.25 dB and 0.31 dB; the accumulated drift will be:

- for the initial test: 0.4 dB
- for the second test: 0.65 dB (i.e. 0.4 dB + 0.25 dB)
- for the third test: 0.96 dB (i.e. 0.4 dB + 0.25 dB + 0.31 dB)

The magnitude of the Drift for each individual SAR measurement must be obtained by means of the measurement of the intensity of the radiated electric field (or SAR at a single point) at a fixed reference value in the LET, as described in section **5.2.6.1.2** of this Technical Provision, before and after each individual SAR measurement. If the radiated method is not possible, it can be used as an alternative the method conducted by measuring the DCI output power before and after each SAR measurement. The The interval between successive SAR measurements should not exceed 5 minutes.

When the accumulated SAR Drift exceeds 1.0 dB, the last SAR measurement in the sequence must if discarded and the values of the other measurements will be adjusted with the magnitude of the Drift.

5.2.6.1.4. METHOD 3 - DETERMINATION OF THE DRIFT THROUGH THE CALCULATION OF THE DRIFT ACCUMULATED.

This method is only applicable if the DCI is not moved during the test sequence. This method is similar to that described in paragraph **5.2.6.1.3** , however, the accumulated drift is calculated after each test with the DCI reconfigured to operate on the frequency and transmission mode used in the test initial and recording the conducted power or radiated electric field (or SAR value) relative to the previous level registered before the first test.

When the accumulated SAR Drift exceeds 1.0 dB, the last SAR measurement in the sequence must if discarded and the values of the other measurements will be adjusted with the magnitude of the Drift.

5.2.7. POSITIONS OF EBP IN RELATION TO THE MSH.

This numeral describes the positioning procedures for the following types of ICDs.

to. Desktop Wireless Communication Device (DCE).

b. Wireless communication devices with articulated or rotating antennas (DAG).

c. Generic Wireless Communication Device (DG).

d. Wireless communication device for use in front of the face (DFR).

and. Wireless communication device for body use (DUC).

F. Wireless communication device used in extremities (DEX).

g. Body-supported wireless communication device (DSC).

If the manufacturer specifies in the user manual various positions and orientations due to the use **The measurements should be limited to each of these positions and orientations** , as required by the DCI. Otherwise, the positions and orientations established for DGs should be used.

In all cases the EBP must be evaluated against the flat MSH, the EBP must be positioned below the MSH so that the spatial average peak of the SAR can be measured. For large INNs or in case of If the maximum value is recorded at the edge of the scan area, an MSH at least 20% more will be required larger than the EBP projection (including cables), or a displacement of the EBP and reassess it, the above in order to fully capture the maximum SAR value within the scan area.

The EBP must be oriented according to the Intended Use specified by the manufacturer, otherwise it will you should follow the following procedure:

P1, P2, P3, and P4 are defined as the midpoints of each edge of the surface as shown in **Figure 15** . Line P1-P2 and line P3-P4 must be parallel to the surface of the MSH, so that the Separation distance between P1 and the surface of the MSH is equal to the Separation distance between P2 and the surface of the MSH. Similarly, the separation distance between point P3 and the surface of the MSH It must be equal to the Separation Distance between P4 and the surface of the MSH. The closest point on the The practice can then be P1 and P2, P3 and P4 or the point defined by the separation distance between the MSH housing and the point closest to the EBP when positioned as described in the following **Figure 15** .

Figure 15. Definition of reference points.

5.2.7.1. POSITION OF AN INN THAT IS RELATIVELY LARGER IN THE AREA OF THE MSH SURFACE.

If the EBP is larger than the minimum elliptical MSH defined in **Figure 14** , the EBP must be shifted in such a way that multiple scans of the area can cover the EBP completely. When the MSH is displaced on the considered surface of the EBP, the coupling between the EBP and the MSH can change and will be different from that seen with a larger MSH covering a full EBP.

To limit differences in measured SAR caused by coupling variations, there must be an overlap between the scanned areas of the EBP of two consecutive tests of at least one third in the direction of travel as shown in **Figure 16** .

Figure 16. Measurement by device displacement in the MSH.

It should be verified that the maximum SAR deviation at individual points between two overlapping areas is less than the expanded Uncertainty for repetitions according to **Table O.6** of this Provision Technique. Otherwise, the resulting uncertainty must be valued and documented according to the procedures and techniques presented in section **5.2.11** of this Technical Provision. There is not need for displacement if the radiating structures are small compared to both, the EBP and MSH and / or the first scanned area shows that the SAR distribution was fully captured within that area. The reasons for omitting the displacement must be clearly specified in the RP.

5.2.7.2. GENERIC WIRELESS COMMUNICATION DEVICE (DG).

Any device that cannot be categorized as any of the device types specified in this Technical Provision, it is considered a DG.

The SAR assessment must be performed for all surfaces of the EBP that are accessible during the Intended use, as indicated in **Figure 17** . The separation distance in the test must correspond to the Distance of Intended Use as specified in the user manual provided by the manufacturer. If he The manufacturer does not specify the Intended Use, all EBP surfaces must be tested directly against the MSH.

The surface of a DG (or the surface of the Fixture that holds the EBP) pointing to the surface MSH Flat should be placed parallel to the surface of the MSH.

When the transmitter is attached to the device and operates as one, it should be treated according to the Numerals **5.2.7.3.,** to **5.2.7.9.,** as applicable. In the case where the antenna or RF transmitter is external the EBP and the position of the antenna or the RF transmitter are independent of the position of the same, for For example, if the transmitter is connected via a cable, the evaluation should be performed using the procedures of a DG.

For EBP with multiple antennas, the same principles apply, and all relevant combinations of antenna position.

Figure 17. Test positions for a generic DG Device

5.2.7.3. CORPORAL USE WIRELESS COMMUNICATION DEVICE (DUC).

A typical example of a DUC is a mobile phone, a PDA with wireless connectivity or any other Wirelessly connected device powered by a battery with the ability to transmit while mounted on a person's body using an Accessory approved by the manufacturer of the device and included, together with the DCI, in its packaging.

If the instructions for use provided by the manufacturer specify the Intended Use with an Accessory portability (belt clip, bra, case or similar), the device must be placed as it was provided on the Accessory and the Accessory must be positioned in the intended orientation against the MSH.

In the event that different Accessories built with non-conductive materials hold the EBP to different minimum MSH distances, the Accessory that offers the shortest separation produces the highest SAR, therefore it is not necessary to test Accessories that hold the EBP at a greater distance. For Accessories that do not contain conductive materials (e.g. metal), it is acceptable to be replaced by empty space (with air) or a separator that keeps the EBP at a distance from the surface of the MSH no greater than the distance given by the manufacturer of the Accessory. The spacer must be made from a low loss, low permittivity material with a loss tangent less than or equal to 0.005 and a relative permittivity ≤ 1.1 F / m.

Accessories that do not contain RF transmitters and have been shown to produce an increase in The SAR peak of less than 5%, as hands-free devices, are not susceptible to being subjected to SAR tests separately.

If the user manual provided by the manufacturer specifies the Intended Use with an Accessory appropriate at a given Body Separation Distance, the device must be placed at that Distance of the outer surface of the MSH

Figure 18. Test positions for DUC.

When evaluating SAR without the specified Accessory, the separation should not exceed 25mm. The The surface of the EBP pointing to the surface of the flat MSH must be parallel to the latter. However, no all devices have a flat surface, therefore the details of device placement, for For example, the definition of the Separation Distance and the physical relationship between the EBP and the MSH must be document in the corresponding RP according to the instructions.

A Separation Distance of 15mm is commonly used for body-worn mobile phones to represent the space produced by the Accessories.

If the Intended Use is not specified in the user manual, the EBP must be tested with all its surfaces directly against the flat surface of the MSH. The details of the position of the EBP, especially the contact points with the MSH surface must be documented on the RP correspondent. If tests are omitted for one or more surfaces, the proof must be specified and substantiated. reason in the RP.

5.2.7.4. WIRELESS COMMUNICATION DEVICES WITH ARTICULATED ANTENNAS OR ROTARY (DAG).

For DCIs that make use of one or more external antennas that can be placed in different positions (for example, an antenna extended, retracted, rotated), and according to its Intended Use they are used at less than 200 mm from the body, the external antenna (s) must be placed according to the user provided by the manufacturer.

For devices with a single antenna, if there is no position of use specified in the manual, the tests should be performed, as applicable, in both positions, horizontal and vertical with respect to the MSH and with the antenna pointed away from the body of the EBP (**Figure 19**) and / or with the antenna extended and retracted depending on the highest exposure obtained. For antennas with rotation in one or two planes, the tests to find the scenario with the highest exposure and measure only under these conditions, such scenario must be documented in the RP. For DCI with multiple detachable antennas See the provisions in numeral **5.2.8.2** . of this Technical Provision.

Figure 19. Device with rotating antenna (example of desktop device)

5.2.7.5. BODY SUPPORTED WIRELESS COMMUNICATION DEVICES (DSC).

A typical example of a body-supported device is a laptop with connectivity wireless that can be placed on the thighs of a seated user. To represent this orientation, the EBP should be placed with the base against the surface of the flat MSH. The manufacturer may specify these Guidance in the user manual. If the Intended Use is not specified, the EBP must be tested directly against the flat surface of the MSH in all possible orientations.

The portion of the EBP with the screen should be in an open position with a 90 ° angle as shown. shown in **Figure 20-a** (left side), or at the angle of operation specified by the manufacturer on the user manual. In the case of EBPs that require a full screen for normal operation, the The side of the screen does not need to be tested if the screen remains 200mm away from the body. If If there is an antenna mounted on the screen, repeat the position with the screen against the surface of the flat MSH as shown in **Figure 20-b** (right side), as long as this is consistent with the Intended Use described by the manufacturer.

Other devices that are grouped in this category are tablet-type laptops and terminals. authorization of credit card transactions, points of sale and / or inventory terminals. Some of these EBPs can be placed on the torso or attached to a member of the body, in this case, they must be apply the same principles as an EBP placed on the body.

The example in **Figure 20-b** shows a tablet-shaped laptop for which the SAR must be evaluated separately with:

a) Each surface and;

b) Separation distances.

They should be positioned against the flat MSH surface corresponding to the Intended Use indicated by the maker. If the Intended Use is not specified in the user manual, the device must be tested directly against the flat MSH surface in all possible orientations.

Some body-supported devices can be tested with an external power source (e.g. example, an AC adapter) in addition to the battery, however, it must be verified and documented in the RP that the registered SAR is conservative. For DCIs using an external antenna with variable positions (for example, a rotating antenna) see **5.2.7.4,** and **Figure 19** .

Figure 20-a. Laptop with external *plug-in-radio-card* antenna (left side) or with internal antenna attached to the display section (right side).

Figure 20-b. Tablet form factor laptop

Figure 20-c. Point of sale terminal

5.2.7.6. DESKTOP WIRELESS COMMUNICATION DEVICE (DCE).

A typical example of a desktop device is a computer with wireless connectivity placed on a table or desk at the time of use as long as, due to the Intended Use, it is used 200 mm or less from the human body.

In this case, the EBP should be positioned at a distance of 25mm and oriented towards the MSH, as It corresponds to the Intended Use specified by the manufacturer in the user manual. For devices that use an external antenna with variable positions, tests should be performed for all possible antenna positions. The **Figures 19** and **21** show positions of the SAR measurement devices desk. If the Intended Use is not specified by the manufacturer, the device must be tested directly against the flat surface of the MSH.

Due to the physical design, some surfaces may not be subjected to testing, for example, the base of a device that is placed on a desk.

Figure 21. Test positions for DE.

5.2.7.7. WIRELESS COMMUNICATION DEVICE FOR FACE-FRONT USE (DFR).

A typical example of Face-to-Face Devices is a two-way radio or transceiver, which is held at a certain distance from the user's face when transmitting, in these cases the EBP must be positioned at a distance from the surface of the MSH that corresponds to the distance of Intended Use indicated by the manufacturer in the user manual (**Figure 22-a**). If the manufacturer does not specify an Intended Use, a Separation distance of 25 mm (2) between the surface of the MSH and the EBP.

Other devices that can also be considered within this category include cameras wirelessly connected video and photographic images, which can send data to a network or other device (**Figure 22-b**). In the case of any device whose intended use requires a separation distance from the user (for example, devices with a display screen), this should be placed at a distance of the surface of the MSH that corresponds to the Intended Use indicated by the manufacturer in the user manual (**Figure 22-b** , left side). If the manufacturer does not specify an Intended Use, a Distance of 25mm MSH surface spacing.

For a device where the Intended Use requires the user's face to have contact with the device (for example, a device with an optical viewfinder), it should be placed directly against the surface of the MSH (**Figure 22-b,** right side).

5.2.7.8 WIRELESS COMMUNICATION DEVICES USED IN EXTREMITIES (DEX).

A device worn on a limb is an ICD intended to be strapped to the user's arm or leg while transmitting (except in idle mode). It is similar to a DUC. Therefore, test positions from **5.2.7.3.** also apply to you. In case the Intended Use of the DEX considers the use facing the Face, the test positions of **5.2.7.7** will also apply . The strap should be open in such a way that it is divided into two parts as shown in **Figure 23** . The EBP must be placed directly against the surface of the MSH with the strap as tight as possible and the part rear of the device facing the MSH.

Figure 23. Test position for DEX.

If it is not possible to open the strap to allow placing the EBP in direct contact with the surface of the MSH, it may be necessary to break the strap, as long as you make sure not to damage the antenna.

5.2.8. TESTS TO BE PERFORMED.

5.2.8.1. GENERAL REQUIREMENTS.

To determine the spatial average peak value of the highest SAR of an EBP according to the device positions, configurations and operational modes, each frequency band should be tested in which the EBP will operate in the United Mexican States as follows:

to) All possible EBP test combinations are identified (frequency and bands of frequency in accordance with the **provisions** of section **5.1.7.5** of this Technical Provision, operating modes, Accessories specified by the manufacturer, EBP positions, etc.)

b) The test combinations to be measured are selected by applying the reduction methods of tests (see section **5.2.8.2** , optional)

- **i.** Exclude unnecessary test conditions based on physical reasoning (see numeral **5.2.8.2.2.**) or in the analysis of the SAR data. (numeral **5.2.8.2.3**);

ii. Carry out a search (see paragraph **5.2.8.2.4** .) To choose the test conditions to carry out.

c) The selected test conditions are evaluated, according to what is established in paragraph **5.2.8.3** .

5.2.8.2. TEST REDUCTION.

5.2.8.2.1. GENERAL REQUIREMENTS.

In all cases where the reduction of evidence has been exercised, it must be clearly documented in the RP, the relevant combination of Accessories or EBP guidance to be excluded and the support for apply the aforementioned reduction.

5.2.8.2.2. TEST REDUCTION BASED ON PHYSICAL REASONING.

SAR testing may be excluded for certain device-accessory combinations if, through From a solid engineering justification, it is shown that there is no increase in SAR with respect to a reference configuration. Two common cases where physical conditions are argued and, these are considered acceptable are:

I. The Accessories of a Body-worn Device (DC) do not contain conductive materials (for example, metal), and

II. Accessories that are similar (with identical metal content), except for color, which is not has an impact on the SAR.

5.2.8.2.3. TEST REDUCTION BASED ON ANALYSIS OF SAR DATA.

They may be used to develop engineering justifications for reducing certain tests of the SAR, the analysis of SAR data, e.g. statistical analysis based on design of experiments focused. For example, if the devices are available with optional faceplates painted with coating by varying the metallic content of the same, an analysis of the data can be used SAR statistics to justify excluding faceplate tests with less than a certain amount metallic content.

5.2.8.2.4 . **SEARCH FOR TEST CONDITIONS OF THE HIGHEST VALUE OF THE SAR.**

An EBP can operate in different transmission modes and can be used with various positions of the antenna, battery options and other accessories, and the number of possible combinations can be very large, therefore, methods are required to delimit the measurement process, so that the test conditions for the highest SAR value can be quickly identified. For example, EBP with two antenna configurations (extended and retractable), four types of batteries, four types of Accessories Carrier and four kinds of Audio Accessories. The fact of trying all the possible combinations can result in at least tests by frequency band and by position of the EBP. Would be unnecessary to try all possible combinations; so statistical techniques can be used that show trends from a smaller group of data and determine which device combination-Accessory results in higher SAR values.

5.2.8.3 . **GENERAL TESTING PROCEDURE.**

In order to determine the highest peak value of the spatial average SAR of an EBP, the Applicable test conditions determined, where appropriate by numeral **5.2.8.2** , must be performed to each frequency band in which the EBP will operate in the United Mexican States, the foregoing of according to the following:

one. The tests must be carried out in the positions of the EBP that correspond to them according to the type of device and on the usable channel that is closest to the center of the frequency band of transmission in which the EBP and its corresponding antenna operate.

2. For the test condition that provides the highest peak of the SAR space average determined in section **1** , the tests described in section **5.2.9** must be performed for all the other frequencies in which the EBP will operate in the United Mexican States. further for all other conditions (EBP positions, setup and operation modes), where the spatial average peak value of the SAR determined in **paragraph 1** is within 3 dB of the limit established in **Table 1** of this Technical Provision.

3. Examine all data to determine the highest peak value of the SAR spatial average found in **numbers 1** and **2.**

Four. For EBP with separate multiple antenna simultaneous transmission capabilities, you must apply the procedure described in section **5.2.9.2.** of this Technical Provision.

Figure 25. Block diagram of tests to be carried out.

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Figure 26. General Procedure.

h) For all measurement points, the angle of the test probe relative to the normal line
to the flat surface of the MSH must be less than 5 °. If the above cannot be achieved, it should be done
an Uncertainty evaluation in accordance with numeral **O.2.2.6** of this Provision
Technique **.**

i) At least the procedures defined in section **5.2.5.6** hereof must be used.

Technical Provision, to determine the local SAR values in the necessary spatial resolution for mass averaging.

j) The local SAR must be measured at the same location as **Step a)** . The SAR Drift is must evaluate and report in the Uncertainty balance of **Table B.1** of **Annex B** of this Technical Provision, as described in numeral **O.2.2.10** of this Technical Provision.

In the event that the SAR Drift measurement exceeds 5% of the tolerance, the measurements according to the above steps.

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3) Multiband SAR calculation of an existing area and zoom scan. This method uses scans of area and zoom in combination with interpolations and extrapolations to generate SAR data volumetric and is a quick way to obtain multiband SAR.

i. At each frequency, calculate the volumetric distribution of the SAR in the region projected by the area scan. There are different methods and its uncertainty must be documented in the corresponding RP.

ii. Sum the volumetric distributions of the SAR at all frequencies, using interpolation if necessary.

iii. Use post-processing procedures to determine the average peak SAR value in the distribution obtained in the previous paragraph.

4) Volumetric scan. This method is the most accurate way to determine multiband SAR and is always applicable. The SAR information is combined for each test condition where two or more transmission modes operate together.

i. Determine the volumetric mesh spanning the zoom scans at all frequencies previously measured.

ii. At each frequency, perform the volumetric zoom scan determined in the previous step. This zoom scan must satisfy all the requirements established in the numeral **5.2.9** with the exception of the minimum size of the volumetric scan. The measurement is due to drive with the transmission mode operating on the selected frequency and the others frequencies off.

iii. Add the SAR distributions obtained in the previous step to obtain the distribution sum. Calculate the maximum multiband SAR using the sum distribution.

In order to carry out the SAR measurement using these alternatives, the following requirements:

to) The scan area, zoom scan area and spatial average peak of the SAR should be evaluate separately at each operating frequency with the transmission mode turned on at that frequency and modes of other frequencies turned off.

b) When two or more modes of operation are intended to operate simultaneously, the SAR measurement conditions must be combined (EBP position, channel, configuration and Accessories).

Whatever the alternative to the **TESTING PROCEDURE FOR EBP WITH SIMULTANEOUS MULTI-BAND TRANSMISSIONS** chosen, it must be documented and duly justified in the corresponding RP.

5.2.10. POST-PROCESSING.

5.2.10.1. INTERPOLATION.

If the measurement grid is not as fine as required to calculate the average SAR over a mass given, interpolation between the measured points must be carried out; For the purposes of the above, observe the provisions of **Annex H** of this Technical Provision, and the Uncertainty must be evaluated according to numeral **5.1.12** of this Technical Provision.

5.2.10.2. EXTRAPOLATION OF THE DISPLACEMENT OF THE TEST PROBE.

The electric field probes used generally contain three orthogonal dipoles in proximity and these dipoles are integrated into a protective tube. Measurement points located a few millimeters from the probe tip and its displacement should be considered when identifying the measured position of the SAR, according to **Annex H** of this Technical Provision and its Uncertainty must be also evaluated according to numeral **5.1.12** of this Technical Provision.

5.2.10.3. DEFINITION OF AVERAGE VOLUME.

The average volume must have the shape of a cube and the lateral dimension of 1 g or 10 g of mass, is should use a density of 1 000 kg / m3 to represent the density of the body tissue, the above to be consistent with the definition of the LET properties, that is, the cube side length of 1 g should be 10mm, the side length of the 10g cube is 21.5mm.

5.2.10.4. SEARCH FOR THE MAXIMUM LEVEL.

Cubic volumes must move on the interior surface of the MSH, in the vicinity of the maximum value local SAR considering the provisions of **Annex H** of this Technical Provision **.** The cube with the Local maximum SAR value should not be at the edge of the volume, if this is the case, the volume of scan should be shifted and measurements should be repeated.

5.2.11. ESTIMATION OF UNCERTAINTY.

The estimation of the uncertainty of the measurements of the SAR values of this Provision Technique produced by an EBP must be carried out according to **Annex O** of this Technical Provision, **Table B.1** of **Annex B** of this Technical Provision must be included in the corresponding PR .

5.2.12. TEST REPORT (RP).

All the results of the tests corresponding to numeral **5.2** must be recorded in the format contained in **Annex B** of this Technical Provision. Said report must include all the results obtained, the information necessary for the interpretation of the tests performed, the calibration of the probes and the information that is required according to the method and procedure used to evaluate a EBP.

Additionally, the RP must contain at least the following elements:

to) Introduction

- **i.** Identification of the Test Laboratory.
- **ii.** Identification of the EBP, including software and hardware, serial number, and, where appropriate, IMEI.
- **iii.** Compliance technical specifications (**Table 1** of this Technical Provision).

b) Measurement system.

- **i.** Description of the main components of the measurement system, for example, positioner, probe, LET, etc.
- **ii.** Current calibration certificates for the relevant elements of the system, if applicable.
- **iii.** Description of the interpolation / extrapolation scheme used.
- **iv.** LET used and its characteristics.
- **v.** Results of the system review.

c) Estimation of Uncertainty.

- **i.** Include **Table B.1** of the **Annex B** .
- **ii.** Any other relevant element in the estimation of uncertainty.

d) Details of the EBP and the tests.

- **i.** Description of the EBP form factor and a brief description of the Intended Use.
- **ii.** Description of the position and orientation to be tested (according to what is established in the numeral **5.2.7** of this Technical Provision) and the reasoning for including any reduction, when appropriate; according to number **5.2.8.2** of this Provision Technique, justification of the definition of the distance based on a physical relationship between the EBP and the MSH.

iii. Description of the available and tested antennas, as well as the Accessories, including batteries.

iv. Description of all available and tested modes of operation, power levels and frequency bands and, where appropriate, the reasoning for test reductions.

v. Environmental conditions.

saw. Results of all tests performed (the spatial average peak value of the SAR for each test, and its graphical representation in the total of the scans with respect to the EBP for the maximum SAR value in each operating mode) and details of the scaling of the results.

and) Test report summary

i. Table of SAR values against tested positions, bands, modes, and settings.

ii. Reference to the limits established in **Table 1** of this Technical Provision.

5.3 INHERENTLY CONFORMING INN.

It will be verified visually that the INNs inherently compliant in accordance with the provisions of the numeral **4.3** . are in the database provided for this purpose by the Concessions Unit and Institute services.

6. COMPLIANCE WITH INTERNATIONAL STANDARDS.

This Technical Provision basically coincides with:

I. IEC 62209-1: *Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted Wireless communication devices- Part1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz).* Ed.2. August of 2016.

II. IEC 62209-2: *Human exposure to radio frequency fields from hand-held and body-mounted Wireless communication devices-Human models, instrumentation, and procedures- Part. 2: Procedure to determine the specific absorption ratio (SAR) for Wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz).* Ed. 1. March 2010.

III. *International Commission on Non-Ionizing Radiation Protection* , " *Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)* . " *HEALTH PHYSICS* 74 (4): 494-522. 1998.

It differs in the frequency range considered for the maximum radiation limits electromagnetic radio frequency products, equipment, devices or apparatus in the field of telecommunications used by ICNIRP.

7. BIBLIOGRAPHY.

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6) IEC / CISPR 16-1-4: 2010. Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-4: Radio disturbance and immunity measuring apparatus - Ancillary equipment - Radiated disturbances

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9) IEC 62209-2: *Human exposure to radio frequency fields from hand-held and body-mounted Wireless communication devices-Human models, instrumentation, and procedures- Part 2: Procedure to determine the specific absorption ratio (SAR) for Wireless communication devices used in close proximity to the human body (frequency range of 30 MHZ to 6 GHz).* Ed 1. March 2010.

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12) IEEE Std 1528, *Recommended Practice for Determining the Peak Spatial-Average Specific Absorption 5936 Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques* , New 5937 York: Institute Electrical and Electronics Engineers, Sep.

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8. EVALUATION OF CONFORMITY.

The Evaluation of the Conformity of this Technical Provision will be carried out in the terms of the LFTR, as well as what is applicable to the Conformity Assessment Procedure regarding telecommunications and broadcasting in force, in accordance with the following:

I. The Conformity Assessment will be carried out by Test Laboratories and Bodies of Accredited and authorized certification.

The documentation, formats, user manuals and requirements necessary to carry out the Conformity Assessment procedures referred to in this ordinance They must be presented in Spanish. The other required technical documentation, such as the block or electrical diagrams, can be presented in Spanish or English.

II. For the purpose of submitting a DCI to the Conformity Assessment Procedure to demonstrate that it complies with the specifications provided in this Technical Provision, the interested party must request the certification services of a Certification Body and the services of tests from a Testing Laboratory, in order to obtain the aforementioned Certificate of Compliance, which must indicate the maximum value of the average spatial SAR obtained for each frequency band in which the DCI operates in Mexico, according to the objective and field of application of this DT.

III. If an INN, according to the use intended by the manufacturer, or in a common way, is used by the final user:

to) close to the head (particularly close to the ear), and

b) less than or equal to 200 mm from the human body,

must be evaluated only by the test method described in section **5.1** of this Technical provision.

IV. Once the certificate of conformity has been issued, the Certification Body must send it in electronically to the interested party and to the Institute's Concessions and Services Unit. Unit Concessions and Services of the Institute must register the certificate of conformity in the system that it administers for this purpose. The Certification Body must send the certificate in accordance in the electronic format (s) determined by the Concessions Unit and Institute services.

V. The holder of the Certificate of Conformity corresponding to the DCI must request the Homologation to the Concessions and Services Unit of the Institute; For this purpose, the holder of the Certificate of Compliance must follow what is established in the inventory of procedures for Homologation, or in its case, the guidelines issued by the institute for this purpose.

The Homologation Certificate issued by the Institute will contain the following legend:

"Each of the Wireless Communication Devices covered by the This Homologation Certificate complies with the basic limits of the SAR in accordance with the provisions of Technical Provision IFT-012-2019 ".

The Homologation Certificate must indicate the value of the average spatial SAR obtained for each frequency band in which the DCI operates, according to the objective and field of application of this Technical Provision.

SAW. If the conducted power of the DCI, on any radio frequency channel for all frequency bands operating frequencies in Mexico, has a maximum value of 20 mW and also the DCI manual indicates that it is commonly used near the head (particularly near the ear) or a distance less than 200 mm from the human body; then DCI referrals are not required To demonstrate compliance with this Technical Provision, the Interested Party must make disposition of the Concessions and Services Unit of the Institute, **Format 003** "Registry of Inherently Compliant Wireless Communication Devices ", contained in **Annex C** of this Technical Provision, signed by the interested party where it is recorded that the DCI operates with a transmission power less than or equal to 20 mW and that this is used commonly close to the head (particularly close to the ear) or at a distance less than 200 mm of the human body. The Institute may carry out verification actions on said products, equipment, devices or apparatus registered as inherently compliant.

The General Coordination of User Policy of the Institute will publish and keep updated in its Internet portal the list of INNs registered as inherently compliant and of approved telecommunications products, equipment, devices or apparatus, indicating the spatial SAR value per frequency band of said DCIs. This list should be published twelve months after the entry into force of this Technical Provision and be updated at least every 6 months.

VII. The interpretation, updating or modification of this procedure, as well as the attention and Resolution of the cases not foreseen in the same, will correspond to the Institute.

8.1. MONITORING OF CERTIFICATION COMPLIANCE.

EBPs that have a Certificate of Conformity in accordance with this Technical Provision will be subject to surveillance of compliance with the certification, by the Certification Body that issued said certificate, through sampling, measurement, laboratory tests, ocular verification or examination of documents; The referred monitoring visits of compliance with the certification must be carried out in the wineries or points of sale of the holder of the Certificate of Conformity that are in national territory, and they will be carried out by the Certification Bodies assisted by Test Laboratories authorized by the Institute.

The annual number of surveillance visits of compliance with the certification will be carried out on a portion of between five to fifteen percent of the total Certificates of Conformity issued by Each Certification Body regarding Technical Provision IFT-012-2019, the previous year in which the carry out the Monitoring of compliance with the certification, selected these at random.

The Monitoring of compliance with the certification of this Technical Provision will be carried out in the applicable terms of the Conformity Assessment Procedure for telecommunications and current broadcasting, and the provisions issued to that effect by the Institute.

9. VERIFICATION AND MONITORING OF COMPLIANCE.

Corresponds to the Institute within the scope of its competence, the verification and monitoring of compliance with the This Technical Provision, in accordance with the applicable legal provisions.

10. PRODUCT PASSWORD.

Wireless communication Devices covered by the Homologation Certificate must display the corresponding approval certificate number, as well as the brand and model with which said certificate is issued in each product unit by marking or label that makes it conspicuous, clear, visible, legible, non-transferable and indelible with normal use. If it is not possible to display said number in the product itself, must be done in its container, packaging, label, wrapper, travel sheet, electronic record internal or user manual.

The marking or label referred to in the previous paragraph must comply with the elements and characteristics that indicates the provision issued by the Institute for this purpose.

11. TRANSIENT.

FIRST. - This Technical Provision will come into force three hundred and sixty-five calendar days counted from the day following its publication in the Official Gazette of the Federation, in the case of products, equipment, devices or apparatus intended for telecommunications that can be connected to a telecommunications network and / or make use of the radioelectric spectrum and that:

to) Used close to the head, particularly close to the ear in the 300 frequency range MHz to 6 GHz.

b) They are used at a distance less than or equal to 200 mm from the human body in the frequency range 30 MHz to 6 GHz.

The foregoing without prejudice to the provisions of the following transitory ones.

SECOND. - The Testing Laboratories and Certification Bodies may carry out the Evaluation of Conformity, as long as they are in a position to carry it out in accordance with provided in this Technical Provision, requiring an accreditation by an Accreditation Body authorized by the Institute and an authorization by the same.

THIRD. - Wireless communication Devices may be certified with respect to this Technical Provision once the Institute authorizes the first Testing Laboratory and Testing Agency Certification, the above once this Technical Provision enters into force.

FOURTH . - The Testing Laboratories and the Product Certification Bodies may initiate the Accreditation and Authorization procedures in this Technical Provision from the day following its publication in the Official Gazette of the Federation.

FIFTH. - This Technical Provision will be reviewed by the Institute at least after five years counted from its entry into force. The foregoing in no way limits the powers of the Institute to carry out said review at any time, within the established period.

ANNEX A

TEST REPORT OF THE APPLICATION OF THE METHODS OF NUMERAL 5.1 TO THE SUBJECT EBP UPON COMPLIANCE WITH THE DT IFT-012-2019.

Test Report Number:

I. DATA OF THE REQUESTOR OF THE TESTS.

1. Name or company name:

2. Federal Taxpayers Registry:

3. Address. Street:

Outdoor Number: Interior number:

Suburb: Municipality or Mayor's Office:

Postal Code: Federal entity:

Telephone and extension:

Email:

(IF ANY) APPLICANT'S LEGAL REPRESENTATIVE

4. Name of the legal representative:

5. Address. Street:

Outdoor Number: Interior number:

Suburb: Municipality or Mayor's Office:

Postal Code: Federal entity:

Telephone and extension:

Email:

NOTICE : "In terms of the provisions of articles 68, last paragraph and 120 of the General Law of Transparency and Access to Public Information; 16 and 117 of the Federal Law of Transparency and Access to Public Information; 1 and 20 of the General Law on Protection of Personal Data in Possession of Obliged Subjects, I give my express consent to the Test Laboratory: "___________________" for the disclosure of my personal data contained in this format, without prejudice to the treatment of the same in accordance with the indicated legislation and other applicable legal provisions ".

II. TEST LABORATORY DATA.

1. Name or company name:

2. Federal Taxpayers Registry:

3. Address. Street:

Outdoor Number: Interior number:

Suburb: Municipality or Mayor's Office:

Postal Code: Federal entity:

Telephone and extension:

Email:

4. About the tests:

to. Start date:

b. End date:

5. Tests prepared by:

Firm:

Name:

6. Supervised and approved report by:

Firm:

Name:

III. GENERAL DATA OF THE EQUIPMENT UNDER TEST.

1. Manufacturer's Name:

2. Country of origin

3. Brand:

4. Model:

5. Description:

6. If applicable, IMEI:

7. Bands and frequencies in which EBT operates:	to)	Band 1 () MHz to () MHz,
	b)	Band 2 () MHz to () MHz,
	c)	Band 3 () MHz to () MHz.
	Add as many lines as necessary.	

8. Modes of operation:

9. Hardware version:

10. Software version:

11. Device category:

12. Type of antenna: External [] Internal []

13. Antenna gain:

14. Type of modulation:

15. Accessories included and description of the same (including battery).

16. Date of receipt

IV. COMPLIANCE REQUIREMENTS.

1. For products, equipment, devices or appliances that have a transmitter or transceiver of radio frequency, make use of the radioelectric spectrum or connect to a telecommunications network in the 30 MHz to 6 GHz frequency range and are used close to the head, particularly near of the ear, in the frequency range from 300 MHz to 6 GHz, should be evaluated with the method of test 5.1. of TECHNICAL PROVISION IFT-012-2019: TECHNICAL SPECIFICATIONS FOR THE COMPLIANCE WITH THE MAXIMUM LIMITS OF ELECTROMAGNETIC RADIATION OF NON-IONIZING RADIO FREQUENCY OF PRODUCTS, EQUIPMENT, DEVICES OR DEVICES INTENDED FOR TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A NETWORK OF TELECOMMUNICATIONS AND / OR MAKING USE OF THE RADIOELECTRIC SPECTRUM. INDEX OF SPECIFIC ABSORPTION (SAR).

2. Considering the basic maximum exposure limits established in Table 1 of the PROVISION TECHNICAL IFT-012-2019: TECHNICAL SPECIFICATIONS FOR COMPLIANCE WITH THE LIMITS NON-IONIZING RADIO FREQUENCY ELECTROMAGNETIC RADIATION MAXIMUM OF THE PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS DESTINED TO TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A NETWORK OF TELECOMMUNICATIONS AND / OR MAKING USE OF THE RADIOELECTRIC SPECTRUM. INDEX OF SPECIFIC ABSORPTION (SAR).

Table 7.- Basic maximum exposure limits.

Kind of exposition	Interval of frequencies	Density of current in the head and the trunk [mA / m2] (effective value)	HE average in all the body [W / kg]	HE Located in the head and the trunk [W / kg]	Localized SAR in the extremities [W / kg]	Density of wave power equivalent flat [W / m2]
Public in general	30 MHz-6 GHz	-	0.08	2	4	-

V. ENVIRONMENTAL CONDITIONS OF THE LABORATORY DURING THE TEST.

	Required	Registered
Temperature (° C):	18–25	
RH):	30-70	

SAW. ABOUT THE MEASUREMENT SYSTEM.

1. Description and block diagram of the main components of the measurement system, p. eg, positioner, probe, robot, etc. For probes, include:

to. Dimensions;

b. isotropy;

c. spatial resolution;

d. dynamic range;

and. linearity.

2. Current calibration certificates for all relevant elements of the system.

3. Description of the interpolation / extrapolation scheme used for area and / or zoom scanning.

VII. USED LET AND ITS CHARACTERISTICS.

1. For each LET recipe used, include:
   - **to.** Dielectric properties for each frequency band.
   - **b.** Deviation from the target value.
   - **c.** Temperature.
   - **d.** Summary of LET composition.

VIII. RESULTS OF THE VALIDATION OF THE SYSTEM.

Include:
- **to.** Measurement results for each frequency band
- **b.** Deviation from the SAR target value.
- **c.** Description of the radiant source.

IX. ESTIMATION OF UNCERTAINTY.

1. Table A.1 . Uncertainty budget for SAR measurement and system validation.

TO	b	c	d	e = f (d, k)	F	g	h = c × f / e	i = c × g / e	K
Source of Uncertainty	**Description**	**Uncertainty ±%**	**Distribution of probability**	**Divider**	**c_i (1 g)**	**c_i (10 g)**	**Uncertainty standard ±%, (1 g)**	**Uncertainty standard ±%, (10 g)**	**v_i or v_{eff}**
			Measuring system						
Calibration of the probe	Annex E		N	one	one	one			∞
Axial isotropy	P.2.2.2		R	√3	√0.5	√0.5			∞
Hemispheric isotropy	P.2.2.2		R	√3	√0.5	√0.5			
Border effect	P.2.2.5		R	√3	one	one			∞
Linearity	P.2.2.3		R	√3	one	one			∞
Detection limits	P.2.2.3		R	√3	one	one			∞
Response to modulation	P.2.2.4		R	√3	one	one			∞
Electronics measurement	P.2.2.6		N	one	one	one			∞

Response time	P.2.2.7	R	√3	one	one	∞
Integration time	P.2.2.8	R	√3	one	one	∞
Terms RF environmental - noise	P.2.9	R	√3	one	one	∞
Terms RF environmental - reflections	P.2.9	R	√3	one	one	∞
Positioning mechanical probe. Restrictions	P.2.3.1	R	√3	one	one	∞
Probe position relative to the housing from MAC	P.2.3.2	R	√3	one	one	∞
Post-processing	P.2.10	R	√3	one	one	∞
		Related to EBP				
Positioning of the EBP	P.2.5.3	N	one	one	one	
Uncertainty of EBP bra	P.2.5.2	N	one	one	one	
Drift Measurement SAR	P.2.8	R	√3	one	one	∞
SAR escalation	P.2.11	R	√3	one	one	∞
		MAC and test fix				
Uncertainty of MAC (Uncertainty shape and thickness)	P.2.4	R	√3	one	one	∞

Uncertainty in SAR correction for deviations in conductivity and permittivity	P.2.7.2	N	one	one	0.84	∞
Conductivity of liquid (Uncertainty temperature)	P.2.6.6, P.2.6.5	R	√3	0.78	0.71	∞
Conductivity of liquid (measure)	P.2.6.3, P.2.6.5	N	one	0.78	0.71	∞
Permittivity of liquid (Uncertainty temperature)	P.2.6.6, P.2.6.5	R	√3	0.23	0.26	∞
Permittivity of liquid (measure)	P.2.6.4, P.2.6.5	N	one	0.23	0.26	
Uncertainty combined standard		RSS				
Uncertainty expanded (interval 95% confidence)		k = 2				

2. Any other relevant element for estimating Uncertainty.

X. DETAILS OF THE EBP AND OF THE TESTS.

1. Description of the EBP form factor and a brief description of the Intended Use.

2. Description of the positions and orientations to be tested, including the justification for applying any reduction of tests, when appropriate, according to section **5.1.7.4.** of the present Technical provision.

3. Description of available antennas and measurements, as well as Accessories including battery (s) and her CARACTERISTICS.

4. Description of all available and measured modes of operation, power levels and bands of frequency and, where appropriate, the justification for the applied test reductions.

5. Results of all tests performed (the average spatial SAR peak value for each test, and its graphical representation in the total of the scans with respect to the EBP for the maximum value of SAR in each operating mode) and the details of the scaling of the results

XI. INFORMATION ON THE VALIDATION OF THE SAR MEASUREMENT METHOD.

1. Description of the validation procedure (s).

2. Results of calculations, measurements and / or other evaluations carried out by the developer of the method.

3. Additional analysis or conditions imposed by the developer of the method and applied by the user (if it is applicable).

4. Description of the radiant source or SAR distribution for each frequency band.

5. Range of operating frequencies, modulations, EBP operating settings, exposure conditions and SAR distributions for each frequency band of the method.

6. SAR uncertainty

XII. REPORT OF THE REDUCTION OF SAR TESTS.

When test reduction procedures are applied during SAR measurements of a EBP, include additional information on the following trial reduction alternatives.

1. For test reduction for different modes of operation on the same frequency, include detailed description of how the conditions established in section **5.1.11.2 are met.**

2. In case of applying the test reduction based on the application of the conditions of the numeral **5.1.11.3.** , include diagrams or photographs illustrating the arrangement and location of the antennas in the Handset and a description of the modes of operation applicable to each antenna to support reduction and exclusion of evidence.

3. In case of applying the test reduction based on the analysis of the peak level of the SAR according to the established in section **5.1.11.4.** , include a systematic description of how the reduction protocol of tests was applied for the measurements of the EBP

4. In case of applying the test reduction based on considerations of simultaneous transmission in multiple bands (paragraph **5.1.11.5.**), include the measurement of the output power averaged over time and how it meets the threshold of the available power level.

XIII. SUMMARY.

1. Summary of measured frequency bands and settings.

Tested frequency bands

Tested test configurations

2. Table of SAR values against measured positions, frequency bands, modes and configurations (add as many configurations as necessary).

Configuration 1:

Mode	Distance [mm] Position	Band	Frequency	Power [dBm]	10-g SAR [W / kg]

Configuration 2:

Mode	Distance [mm] Position	Band	Frequency	Power [dBm]	10-g SAR [W / kg]

Setting #:

Mode	Distance [mm] Position	Band	Frequency	Power [dBm]	10-g SAR [W / kg]

3. Results of all SAR tests performed (after post-processing of the data).

Position	Band of	Mode of	Setting	Space SAR value

frequency operation average

Graphical representation of the scans with respect to the EBP

XIV. REMARKS AND ANNEXES

ANNEX B

TEST REPORT OF THE APPLICATION OF THE METHODS OF NUMERAL 5.2 TO THE SUBJECT EBP UPON COMPLIANCE WITH THE DT IFT-012-2019.

Report Number
Test:

I. DATA OF THE REQUESTOR OF THE TESTS.

1. Name or company name:

2. Federal Taxpayers Registry:

3. Address. Street:

Outdoor Number: Interior number:

Suburb: Municipality or Mayor's Office:

Postal Code: Federal entity:

Telephone and extension:

Email:

(IF ANY) APPLICANT'S LEGAL REPRESENTATIVE

4. Name of the legal representative:

5. Address. Street:

Outdoor Number: Interior number:

Suburb: Municipality or Mayor's Office:

Postal Code: Federal entity:

Telephone and extension:

Email:

NOTICE : "In terms of the provisions of articles 68, last paragraph and 120 of the General Law of Transparency and Access to Public Information; 16 and 117 of the Federal Law of Transparency and Access to Public Information; 1 and 20 of the General Law on Protection of Personal Data in Possession of Obliged Subjects, I give my express consent to the Test Laboratory: "___________________" for the disclosure of my personal data contained in this format, without prejudice to the treatment of the same in accordance with the indicated legislation and other applicable legal provisions ".

II. TEST LABORATORY DATA.

1. Name or company name:

2. Federal Taxpayers Registry:

3. Address. Street:

Outdoor Number: Interior number:

Suburb: Municipality or Mayor's Office:

Postal Code: Federal entity:

Telephone and extension:

Email:

4. About the tests:

to. Start date:

b. End date:

5. Tests prepared by:

Firm:

Name:

6. Supervised report and approved by:

Firm:

Name:

III. GENERAL DATA OF THE EQUIPMENT UNDER TEST.

1. Manufacturer's Name:

2. Country of origin

3. Brand:

4. Model:

5. Description:

6. IMEI, if applicable:

7. Bands and frequencies in which EBT operates:

d) Band 1 () MHz to () MHz,
e) Band 2 () MHz to () MHz,
f) Band 3 () MHz to () MHz.

Add as many lines as necessary.

8. Modes of operation:

9. Hardware version:

10. Software version:

eleven. Category of the device:

12. Type of antenna: External [] Internal []

13. Gain from antenna:

14. Type of modulation:

15. Accessories included and description from the themselves (included the battery).

16. Date of receipt

IV. COMPLIANCE REQUIREMENTS.

1. For products, equipment, devices or appliances that have a transmitter or transceiver of radio frequency, make use of the radioelectric spectrum or connect to a telecommunications network in the 30 MHz to 6 GHz frequency range and are used close to the head, particularly near of the ear, in the frequency range from 300 MHz to 6 GHz, should be evaluated with the method of test 5.2. of TECHNICAL PROVISION IFT-012-2019: TECHNICAL SPECIFICATIONS FOR THE COMPLIANCE WITH THE MAXIMUM LIMITS OF ELECTROMAGNETIC RADIATION OF NON-IONIZING RADIO FREQUENCY OF PRODUCTS, EQUIPMENT, DEVICES OR DEVICES INTENDED FOR TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A NETWORK OF TELECOMMUNICATIONS AND / OR MAKING USE OF THE RADIOELECTRIC SPECTRUM. INDEX OF SPECIFIC ABSORPTION (SAR).

2. Considering the basic maximum exposure limits established in Table 1 of the PROVISION TECHNICAL IFT-012-2019: TECHNICAL SPECIFICATIONS FOR COMPLIANCE WITH THE LIMITS NON-IONIZING RADIO FREQUENCY ELECTROMAGNETIC RADIATION MAXIMUM OF THE PRODUCTS, EQUIPMENT, DEVICES OR APPARATUS DESTINED TO TELECOMMUNICATIONS THAT CAN BE CONNECTED TO A NETWORK OF TELECOMMUNICATIONS AND / OR MAKING USE OF THE RADIOELECTRIC SPECTRUM. INDEX OF SPECIFIC ABSORPTION (SAR).

Table 8.- Basic maximum exposure limits.

Kind of exposition	Interval of frequencies	Current density in the head and the trunk [mA / m2] (value effective)	Average SAR in all the body [W / kg]	Localized SAR in the head and the trunk [W / kg]	Localized SAR in the extremities [W / kg]	Density of wave power equivalent flat [W / m2]
Public in general	30 MHz-6 GHz	-	0.08	2	4	-

V. ENVIRONMENTAL CONDITIONS OF THE LABORATORY DURING THE TEST.

	Required	Registered
Temperature (° C):	18–25	
RH):	30-70	

SAW. ABOUT THE MEASUREMENT SYSTEM.

1. Description and block diagram of the main components of the measurement system, p. eg, positioner, probe, robot, etc. For probes, include:

F. Dimensions;

g. isotropy;

h. spatial resolution;

i. dynamic range;

j. linearity.

2. Current calibration certificates for all relevant elements of the system.

3. Description of the interpolation / extrapolation scheme used for area and / or zoom scanning.

*** VII. USED LET AND ITS CHARACTERISTICS.**

1. For each LET recipe used, include:

and. Dielectric properties for each frequency band.

F. Deviation from the target value.

g. Temperature.

h. Summary of LET composition.

VIII. RESULTS OF THE VALIDATION OF THE SYSTEM.

Include:

d. Measurement results for each frequency band

and. Deviation from the SAR target value.

F. Description of the radiant source.

IX. ESTIMATION OF UNCERTAINTY.

1. Uncertainty budget for SAR measurement and system validation.

Table B.1. SAR measurement uncertainty evaluation template.

TO	b	c	D	e = f(d, k)	F	g	h = c × f / e	i = c × g / e	K
Source of uncertainty	**Description**	**Tolerance / value of the Uncertainty ±%**	**Distribution from probability**	**Divider**	**c_i (1 g)**	**c_i (10 g)**	**Uncertainty standard ±%, (1 g)**	**Uncertainty standard ±%, (10 g)**	**v_i o v_{effec}**
				Measuring system					
Calibration of the probe	O.2.2.1		N	one	one	one			∞
Isotropy	O.2.2.2		R	√3	one	one			∞
Linearity	O.2.2.3		R	√3	one	one			∞
Response from the probe to modulation	O.2.2.4		R	√3	one	one			∞

Limits of detection	O.2.2.5		R	√3	one	one			∞
Border effect	O.2.2.6		R	√3	one	one			∞
Electronics measurement	O.2.2.7		N	one	one	one			∞
Time of answer	O.2.2.8		R	√3	one	one			∞
Time of integration	O.2.2.9		R	√3	one	one			∞
Conditions of Environmental RF - noise	O.2.4.5		R	√3	one	one			∞
Conditions of Environmental RF - reflections	O.2.4.5		R	√3	one	one			∞
Restrictions mechanical positioner the probe	O.2.3.1		R	√3	one	one			∞

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Positioning of the probe according to the MSH housing	O.2.3.3		R	√3	one	one			∞
Post-processing	O.2.5		R	√3	one	one			∞
			Related to EBP						
Uncertainty of EBP bra	O.2.3.4.2		N	one	one	one			*M* -1
Positioning of EBP	O.2.3.4.3		N	one	one	one			*M* -1
Scaling of power	L.3		R	√3	one	one			∞
It derives from the output power (Measured drift SAR)	O.2.2.10		R	√3	one	one			∞
			MSH and test fix						
Uncertainty of MSH (tolerances of form and thickness)	O.2.3.2		R	√3	one	one			∞
Algorithm for correct the SAR because deviations in the permittivity and conductivity	O.2.4.3	1.9	N	one	one	0.84	1.9	1.6	∞
Conductivity of LET (measure)	O.2.4.3		N	one	0.78	0.71			*M* -1
Permittivity of LET (measure)	O.2.4.3		N	one	0.23	0.26			*M*
Permittivity of LET - uncertainty of temperature	O.2.4.4		R	√3	0.78	0.71			∞
Conductivity of LET - uncertainty of temperature	O.2.4.4		R	√3	0.23	0.26			∞
Uncertainty standard combined	O.3.1		RSS						

Uncertainty expanded (interval of 95 confidence %)	O.3.2

2. Any other relevant element for estimating Uncertainty.

X. DETAILS OF THE EBP AND OF THE TESTS.

1. Description of the EBP form factor and a brief description of the Intended Use.

2. Description of the positions and orientations to be tested, including the justification for applying any reduction of tests, when appropriate, according to section **5.2.7.** of the present Technical provision.

3. Description of available antennas and measurements, as well as Accessories including battery (s) and her CARACTERISTICS.

4. Description of all available and measured modes of operation, power levels and bands of frequency and, where appropriate, the justification for the applied test reductions.

5. Results of all tests performed (the average spatial SAR peak value for each test, and its graphical representation in the total of the scans with respect to the EBP for the maximum value of SAR in each operating mode) and the details of the scaling of the results

XI. SUMMARY

1. Summary of measured frequency bands and settings.

Tested frequency bands

Tested test configurations

2. Table of SAR values against measured positions, frequency bands, modes and configurations (add as many configurations as necessary).

Configuration 1:

Mode	Distance [mm] Position	Band	Frequency	Power [dBm]	10-g SAR [W / kg]

Configuration 2:

Mode	Distance [mm] Position	Band	Frequency	Power [dBm]	10-g SAR [W / kg]

Setting #:

Mode	Distance [mm] Position	Band	Frequency	Power [dBm]	10-g SAR [W / kg]

3. Results of all SAR tests performed (after post-processing of the data).

Position	Band of frequency	Mode of operation	Setting	Space SAR value average

Graphical representation of the scans with respect to the EBP

XII. REMARKS AND ANNEXES

ANNEX C

FORMAT 003

INHERENTLY WIRELESS COMMUNICATION DEVICE REGISTRATION IN ACCORDANCE WITH THE TECHNICAL PROVISION IFT-012-2019.

Before filling out the form, read the attached instructions completely and carefully **.**

I. Data of the Holder and / or legal representative

1. Name or company name:

2. (If applicable) Name of the legal representative:

3. Federal Taxpayers Registry (RFC):

4. Legal address.

Street:

Outdoor Number: Interior number: Suburb:

Municipality or territorial demarcation: CP:

Federal entity:

5. Telephone (s):

6. Email:

I give my consent to be notified via email: [] Yes [] No

II. Wireless Communication Device Data.

1. Manufacturer and country of origin:

2. DCI brand:

3. Model of the DCI:

4. Firmware version:

5. Description of the DCI:

6. Intended use by the manufacturer:

7. DCI operating frequency bands:

a) Band 1: () MHz to () MHz,

b) Band 2: () MHz to () MHz,

c) Band 3: () MHz to () MHz,

d) ...

Add as many lines as necessary.

8. Maximum power conducted in each frequency band of the DCI operation in Mexico:

a) Band 1: W

b) Band 2: W

c) Band 3: W

d) ...

Is the Driven Power adjustable? [ ]If not. Indicate the interval in each frequency band DCI operation in Mexico:

a) Band 1: W to W

b) Band 2: W to W

c) Band 3: W to W

d) ...

Add as many lines as necessary.

9. Separation Distance for Intended Use. mm.

10. Gain of the Antenna (s) in each DCI operating frequency band in Mexico.

a) Band 1: dBi

b) Band 2: dBi

c) Band 3: dBi

d) ...

Add as many lines as necessary.

I declare, under oath to tell the truth, that:

i) The data recorded in this application are true;

ii) Be the person responsible for responding to inquiries related to this application, and;

iii) The DCI described operates in or below the level of transmission power expressed in **all** the operating frequency bands of the same, in accordance with the provisions of section 4.3 of the Technical Provision IFT-012-2019, and is commonly used at a distance less than 200mm from the body human.

____

Name and signature of the Holder or legal representative

Filling date:

Format 003 DT-IFT-012-2019

Instructions for filling out the form.

General indications.

I. Before filling out the forms, read this instruction manual completely and carefully;

II. Erasures, strikes or amendments are not allowed in the formats;

III. As long as there are no means to implement the electronic signature, the signature must be autograph with blue ink pen;

IV. The filling must be by hand with legible letters, with a typewriter or computer. In case of use a computer use a *sans-serif typeface* (for example: Arial, Liberation Sans, etc), with a size of 11 points;

V. In the selection boxes, mark your choice with an **X** ;

SAW. Record the information with capital letters and Arabic numbers;

VII. Cancel unused lines with a line;

VIII. To send the forms by electronic means, the Holder, Legal Representative or applicant You must print the format you want to present, initial it, scan all the sheets that form and send it, in PDF format, to the email address that the Institute determine for this purpose;

IX. In case it is necessary to attach additional files, the Holder, Legal Representative or Applicant must consolidate all files to be submitted, including the format to be submitted present, in a compressed folder, preferably in ZIP, RAR or 7z format. further this folder must not exceed 25 MB.

Section I. Data of the Holder and / or legal representative.

one	Name or Social reason	Indicate the name and surname or business name of the applicant.
2	(In his case) Name of the legal representative	In the event that this format is submitted through a legal representative, you must indicate in the box your name full.
3	Federal taxpayer registration (RFC)	Indicate the Federal Taxpayers Registry, with Owner's homoclave. Optional for individuals.
4	Legal address	Indicate the address where the applicant wishes to receive notifications.
5	Phones)	Enter one or more phone numbers (10 digits) for contact.
6	Email	If applicable, indicate an email to receive notifications.

• Indicate if you wish to receive notifications from the Institute via email.

- or If yes, select: "YES"
- or If not, select "NO" and cancel the space for the email with a horizontal line.

Section II. Wireless Communication Device Data

one	Manufacturer and country of origin	Provide the name of the INN manufacturer and the country of manufacture.

2	DCI brand	Indicate the Brand of the Wireless Communication Device.
3	DCI model	Indicate the Model of the Wireless Communication Device.
4	Firmware version	Indicate the DCI firmware version.
5	Description of the DCI	Describe the INN: its main functions, ways of using the DCI radio spectrum, etc.
6	Manufacturer's intended use	Indicate the intended use of the ICD according to the user manual provided by the manufacturer.
7	Bands and frequencies operation	Indicate the DCI operating bands and frequencies. Add as many lines as necessary. For example: a) GSM 900: 880 MHz to 915 MHz
8	Maximum Conducted Power Is the conducted power adjustable? [ ]If not. Indicate the interval: W.	Indicate the maximum conducted power of the DCI. This value must to be the one established in numeral 4.3 of the DT IFT-012-2019. **Fill in the fields** .
9	Separation distance for Expected use	Indicate the operating distance of the DCI according to specified in the Intended Use. This distance must be equal or less than 200 mm.
10	Antenna (s) Gain	Indicate the gain of the DCI Antenna (s) [in dBi]. Add how many lines are necessary.

ANNEX D

VALIDATION OF THE SAR MEASUREMENT SYSTEM FOR THE HEAD.

D.1 GENERAL DESCRIPTION.

This annex provides the procedures for the following two levels of validation systems SAR measurement:

to) System review;

b) System validation.

The system review provides a fast and reliable test method that can be applied in a routine to verify the accuracy of the SAR measurement system. The goal here is to make sure that the SAR system and tissue equivalent media are suitable for testing at the frequencies of Handset operation. This test requires a flat MSH and a radiant source, for example, a dipole of half wave.

System validation provides a means of validating at the system level the specifications of the measurement of SAR and its components. The test setup consists of a flat MSH and a source validation of the system (see **Annex Q** of this Technical Provision). This test is performed annually (for example, after probe calibration), prior to comparisons of measurements between laboratories (see **Annex T** of this Technical Provision), and each time they are made modifications to the system, such as new probes or changes in the software, or different additions measurement electronics or test probes.

Since a flat MSH is used, both the system review and system validation do not address the Uncertainty of the measurements related to the MAC or the variability of the EBP positioning.

NOTE Interlaboratory comparisons allow the reproducibility of SAR measurements be quantized using a Reference Handset and the MAC. The measurements address both the dispersion of data due to MAC such as Positioning Uncertainty, which are not included in the review of the system or system validation. The tests can also be used to establish the accuracy and expected uncertainty of measurement across various laboratories.

D.2 REVIEW OF THE SYSTEM.

D.2.1 PURPOSE.

The purpose of the system review is to verify that the system operates within its specifications by the DCI test frequencies. The system review corroborates the repeatability of the measurements of a SAR system prior to conformance testing and is not a validation of all specifications of the system. The latter is not required to test a DCI, but is required before the system is used. The system review detects possible drifts in the short term and unacceptable measurement errors o Uncertainties in the system, such as:

i. Incorrect LET parameters (for example, due to incorrect dielectric measurement);

ii. Failures in the components of the test system;

iii. Drift in test system components;

iv. Operator errors in the preparation of the measurement and in the adjustment of the parameters of the measurement;

v. Any other possible adverse conditions that may introduce measurement errors, for example, Harmful RF interference.

The system review is a complete measurement of the spatial average peak of the SAR in 1 g or 10 g in a simplified configuration with a system revision source (see **D.2.3**). The instrumentation and procedures in the system review should be the same as those used in the Compliance. The system check should be performed using the same LET and frequency point probe calibration than that used in the Conformity Assessment tests and within the range of frequency valid for probe calibration, LET dielectric parameters, and losses due to return required for SAR measurements. The frequencies at which the system check is performed must be within 10% of the center frequency of the test DCI band when below 1 000 MHz or within 100 MHz of the center frequencies of the test device band when it is above 1,000 MHz. The environmental requirements for system overhaul testing are specified in **5.1.1** .

The system review must be performed before the Conformity Assessment tests or within 24 hours prior to the SAR assessment and in the same SAR measurement system that is used for Handset evaluation. The SAR target values of the system check may deviate from the target numerical values in **Tables D.1** and **D.2** due to design variations, uncertainties electrical and mechanical sources for system review, particularly at high frequencies as explained in **Table D.1** . Therefore, the target values of the system review must be determined for an individual source of the system review using experimental and numerical validations. The Objective values of the spatial average peak of the SAR in 1 g and 10 g from **Table D.1** have been validated experimentally for this Technical Provision using the test arrangement for review of the the **Figure D.1** and dielectric parameters of the LET of **Table 4** of this layout technique.

D.2.2 SETTLEMENT OF THE MSH.

A flat MSH with LET should be used for system review and validation. The specifications of the Plan MSH are given in section **5.2.2** of this Technical Provision.

For dipole sources the feed point must be centered below the flat MSH, and the arms of the dipole must be aligned with the longest axis of the flat MSH (see **numeral Q.1** of this Technical Provision, for the dipole specifications). The relative permittivity of the shell material MSH must be between 2 and 5; however, less than 2 may be acceptable only below 3 GHz.

The bottom thickness of the flat MSH should be 2mm. The thickness should be uniform with a tolerance of ± 0.2 mm. The loss tangent of the MSH shell material must be less than or equal to 0.05. The material it must be resistant to damage or reaction with LET chemicals. When the MSH is filled with LET, the sinking at the interface of the liquid and the inner surface of the silhouette directly above the source (for example, a dipole) must be less than 1% of the wavelength in free space in the range of frequencies from 800 MHz to 6 000 MHz, and less than 0.5% of the wavelength in free space in frequencies below 800 MHz. To minimize reflections from the surface of the LET, its depth should be at least 150 mm. Depths less than 150 mm can be used if demonstrated (for For example, through numerical simulations) that the effect on the spatial average peak of the SAR is less than 1

% of SAR measured under worst-case conditions. If it is more than 1% but less than 3%, the Worst case values should be added to the Uncertainty budget.

D.2.3 SOURCE FOR THE REVIEW OF THE SYSTEM.

The flat MSH must be irradiated using a radiant source for the required frequency (for example, a half-wave dipole, a patch antenna, or waveguide). The sources used for the validation of the system (see **Annex Q** of this Technical Provision) are typically, but not necessarily, used for system review. The source for the system review should have good repeatability of positioning, mechanical stability and impedance matching. From this point on, a dipole of half wave is used as an example to illustrate the source positioning requirements for the system review. Similar instructions should apply for other sources.

A half-wave dipole must be positioned below the bottom of the flat MSH and centered with its axis. parallel to the greatest dimension of the MSH, within ± 2 °. The distance between the inner surface of the filled MSH with LET and the dipole feed point, *s* , is specified in **Table R.1** of this Provision Technique, for each test frequency. A separator with low losses (loss tangent <0.05) and low dielectric constant (relative permittivity <5) should be used to establish the correct distance between the upper surface of the dipole and the lower surface of the MSH. Below 3 GHz, the separator must not change the spatial average peak of the measured SAR by 1 g and 10 g more than 1%, compared to the condition without separator. Above 3 GHz, the separator can affect the target SAR value of a dipole and must be taken into account by additional experimental validation (see the first paragraph at the foot of **Table D.1**). The dipole must have return losses greater than 20 dB at the test frequency of the system revision, which must be measured annually during the validation of the system using a network analyzer, to ensure that the uncertainty of the SAR measurement due to power reflections is kept low. To meet this requirement, it may be necessary to tune the dipoles using low loss dielectric or metal tuning elements at the ends of the dipole. Acceptable Uncertainty for Distance separation between the dipole and the LET, *s* , for the test configuration of **Figure D.1** must be within ± 0.2 mm.

D.2.4 MEASUREMENT OF THE SOURCE INPUT POWER FOR THE REVIEW OF THE SYSTEM.

The uncertainty of the power to the source should be as low as possible. This requires the use of a test setup with directional couplers and power meters during system. The recommended configuration is shown in **Figure D.1** (a half wave dipole is used as source example for system review).

Figure D.1.- Test arrangement for the system revision.

First, the PM1 power meter (including Att1 attenuator) is connected to the cable to measure the power to load at connector location (X) to source for system check. Generator signal is adjusted to the desired power towards the load in the connector (taking into account the attenuation of Att1) as measured by the PM1 power meter and even as coupled through Att2 to PM2. After connecting the cable to the source and positioning it under the MSH, the signal generator is adjusted again to achieve the same measurement initially recorded on the PM2 power meter. Yes the signal generator does not allow adjustments in 0.01 dB steps, the remaining difference in PM2 must be taken into consideration (for example, by scaling the measured SAR values against the difference in power in PM2).

The source coupling for the system review should be checked using a power analyzer. networks (for example, during annual performance characterization intervals) to ensure that the reflected power is at least 20 dB less than the power to the load. If a different font is used where higher decoupling is inherent in the font design (for example, a font composed of a waveguide described in **numeral Q.2** of this Technical Provision), lower losses due to return are acceptable only if it has been characterized that it will be stable and that the reflected power is taken in account to determine the net power transmitted by the source for the inspection of the system for normalize the spatial average peak of the SAR. The specified return loss must be determined in the frequency at which the system check is performed.

The components and instrumentation required are the following:

to) The output of the signal generator and amplifier should be stable within 2% (after heating up). The power supplied to the dipole should produce a spatial average peak of the SAR of at least 0.4 W / g. The range of the SAR peaks for 1 g or 10 g is 0.4 W / kg to 10 W / kg. Yes the signal generator can deliver 15 dBm or more, generally an amplifier is not

necessary if the generator is connected to the dipole with a low loss cable. Some High power amplifiers should not be operated at powers far below their rated power. maximum output, for example a 100 W power amplifier operated at 250 mW of power Exit can be very noisy. An attenuator is recommended between the signal generator and the amplifier to protect the amplifier input.

b) The low-pass filter inserted after the amplifier reduces the effect of harmonics and noise coming from the amplifier. For most amplifiers in its operating range normal, the filter is not necessary.

c) Attenuator after amplifier improves source coupling and sensor accuracy power meter (see power meter manual).

d) The directional coupler (with a recommended coupling coefficient of -20 dB) is used to monitor the power to the load in order to make adjustments to the generator output signals to maintain constant power towards the load in PM2. The coupler must have return losses greater than 25 dB at the input and output ports. A directional coupler Dual is necessary when the powers towards the load and reflected are to be measured, for example, when using wave guides.

and) The PM2 power meter should have high stability and a resolution of 0.01 dBm; otherwise, the Absolute accuracy has a negligible effect on the power adjustment towards the dipole.

F) The PM1 power meter and Att1 dimmer must be high quality components. These must

be calibrated, preferably together. The attenuator (-10 dB) improves the accuracy of the power (some high power heads have a calibrated attenuator built in). The
The exact attenuator attenuation at the test frequency must be known. For some attenuators this may vary by more than ± 0.2 dB from the specified value across the operating frequency.

g) A fixed power level setting should be used for PM1 and PM2 in order to avoid Uncertainties in linearity and interval switching in power measurements. If the level power is set, the same power level setting should be used for PM1 and PM2.

h) The source for the inspection of the system must be connected directly to the cable at location X. If the power meter has a different type of connector, high-quality adapters should be used.

i) The insertion losses of the cables, especially the cable connecting the coupler directional with the antenna, should be periodically reviewed to ensure that losses due to insertion are stable in the frequency range. It should be considered that a cable that works properly at a frequency (for example, 900 MHz) will not perform equivalent to a different frequency (for example, 5 GHz). During the review measurements of the system, all movements of the cables should be avoided as it may cause changes on the loss characteristics of the cables and introduce SAR errors.

D.2.5 PROCEDURE FOR THE REVIEW OF THE SYSTEM.

The system check is a complete measurement of the spatial average peak of the SAR at 1 g and / or 10 g. The SAR spatial average peak measured in 1 g or 10 g is normalized to 1 W by input power from the source for system review (power to the load for dipoles and net power for wave) and compared with the target value of the spatial average peak of the SAR for 1 g and / or 10 g validated numerically and experimentally established by the source for the revision of the system.

The target values of the system check should not deviate by more than ± 10% of the numerical value objective in **Tables D.1** or **D.2** . If this cannot be maintained for the reasons described in **D.2.1** to higher frequency sources, the spatial average SAR value measured in 1 g (or 10 g) should not deviate from the SAR target value validated for the source for the system review (described in **D.2.3**) by more than the expanded Uncertainty for reproducibility (**Table P.9** of this Technical Provision), or ± 5%, whichever is less.

The spatial average peak value of SAR measured in 1 g (or 10 g) should not deviate more than ± 10% from the target numerical values (**Table D.1** or **Table D.2**). If this cannot be maintained for the reasons described in **D.2.1** , the spatial average peak value of the SAR measured in 1 g (or 10 g) should not deviate from the SAR target value for the source for the system review (described in **D.2.3**) rather than the Uncertainty expanded for reproducibility (**Table P.9** of this Technical Provision), or ± 5%, whichever is less. The Target value of the validated SAR for the system review is evaluated at least once a year, as explained in section **D.1** .

D.3 VALIDATION OF THE SYSTEM.

D.3.1 PURPOSE.

The system validation procedure tests the SAR system using standard dipoles and test guides. waveforms defined by this Technical Provision to verify the accuracy of the measurements and the performance of probes, measurement electronics and system software. It is a validation of the system with respect to all performance specifications. This procedure uses a flat MSH and source for the validation of the system defined in **Annex Q** of this Technical Provision. Consequently, this Validation process does not include data dispersion or DCI positioning uncertainty due to MAC. System validation should be done at least once a year, when a new system is put into operation, or when modifications have been made to the system, such as updates to software, use of different measurement electronics or probes and after calibrating the probes. Validation must be done with the calibrated probe.

The objective of **numeral D.3** is to provide a methodology for the validation of the measurement system of the HE. Since SAR measurement equipment, calibration techniques, MSH, and LET can vary between LP, a validation methodology is necessary to ensure that uniform results can be obtained in accordance with defined measurement procedures and uncertainty requirements. Values SAR targets calculated numerically for the system validation sources defined in the **Annex Q** of this Technical Provision, are listed in **Table D.1** and **Table D.2** . Environmental requirements for the validation tests of the system are specified in section **5.1.1** of this Provision Technique.

D.3.2 SETTLEMENT OF THE MSH.

The flat MSH preparation described for the system review (see **D.2.2** and **Figure D.1**) is used also for system validation tests. System validation must be done using LET having the dielectric properties defined in **Table 4** of this Technical Provision.

D.3.3 SOURCES FOR THE VALIDATION OF THE SYSTEM.

Two types of sources are defined for system validation: standard dipoles and a standard source of waveguide (both described in **Annex Q** of this Technical Provision).

When using dipoles, the MSH must be irradiated using a standard dipole specified in the **Numeral Q.1** of this Technical Provision, for the required frequency. The dipole must be positioned below the MSH flat and centered with its axis parallel to the longest side of the MSH. A casualty separator losses and low dielectric constant should be used to establish the correct distance between the surface top of the reference dipole and the bottom surface of the MSH. Below 3 GHz, the separator must not

change the values of the spatial average peak of the SAR measured by 1 g and 10 g by more than 1%, if Compare with the condition without separator. Above 3 GHz, the splitter can affect the measured SAR and introduce deviations from the target numerical values in **Table D.1** ; therefore, target values of the Experimentally validated SARs with specific separators should be used (see the first paragraph in the footer of **Table D.1**). The distance between the surface of the LET and the center of the reference dipole (designated *s* in **Figure D.1**) must be within ± 0.2 mm of the required distance for each test frequency.
The reference dipole must have return losses greater than 20 dB (measured in the configuration of conditions for system validation) at the test frequency to reduce power reflection and

SAR measurement uncertainty. To meet this requirement it may be necessary to tune the dipoles standard by using low-loss dielectrics or metal tuning elements in the ends of the dipole.

For the standard dipoles described in **numeral Q.1** of this Technical Provision, the Distance of separation *s* is given by:

s = 15 mm ± 0.2 mm for 300 MHz $\leq f \leq$ 1000 MHz;

s = 10 mm ± 0.2 mm for 1 000 MHz $\leq f \leq$ 6 000 MHz;

The arms of the dipole must be parallel to the flat surface of the MSH with a tolerance of ± 2 ° or minus (see **Figure D.1**) this can be guaranteed with careful horizontal positioning of the dipole standard against the LET-filled MSH and comparing the separation at the ends of the dipole.

The target numerical values in **Table D.1** for frequencies above 5000 MHz require specific considerations due to the high sensitivity of those values for construction details of small dipoles. The target values in **Table D.1** may deviate from the actual target values of the dipole validated by the dipole manufacturer. The dielectric separator used for the dipole must be modeled also since it can affect the SAR value determined numerically.

Waveguide sources are suitable alternatives to dipole antennas at higher frequencies where the target values of dipole antennas may be sensitive to manufacturing uncertainties and construction details. Examples of waveguide sources are described in **D.2** for 5.2. GHz and 5.8 GHz, and the target numerical values of the SAR are provided in **Table D.2** for the specific measurement settings. The waveguide source is positioned with the window coupler in direct contact with the MSH. Net power must be measured correctly to scale the HE.

D.3.4 MEASUREMENT OF THE INPUT POWER OF THE REFERENCE DIPOLE.

The input power measurement described by the system review (see **D.2.4**) is also used in system validation tests.

D.3.5 SYSTEM VALIDATION PROCEDURE.

System validation is used to verify the accuracy of the measurements of a SAR system. complete, including software algorithms. Uncertainties of device positioning and MAC form are not considered during system validation. The validation procedure of the system consists of up to six steps, from **a)** to **f)** . El **Paso a)** is the most important part of the process system validation and must be performed for each combination of probe, measurement electronics and version of the measurement and post-processing system that is used to evaluate each time the validation system is required. Then the applicable selections from **Step b)** to **Step f)** must be made. These additional tests should be performed each time the system components have been modified (e.g. a new software version, new measurement electronics, new probes or calibrations). The **Step f)** is optional if the information is included in the equivalent certificate probe calibration and is easily accessible to the user, which must be confirmed by the user. The system validation procedure is as follows.

to) SAR Assessment: A complete measurement of the SAR spatial average peak is performed. The input power of the system validation source is adjusted to produce 1 g and / or 10 g a spatial average peak value of SAR within the range of 0.4 W / kg to 10 W / kg. Peak spatial average SAR in 1 g and / or 10 g is measured at the frequencies in **Table D.1** or **Table D.2** within the range of the parameters supported by the SAR system. For dipole sources, the Results should be normalized to 1 W of power to the load and compared with the values SAR numbers in **Table D.1** (columns 3 or 4). For waveguide sources the results should be normalized to a net power of 1 W, and compared with the target values of the SAR standardized in **Table D.2** . Differences between measured values and numerical values target should be less than the expanded uncertainty for the validation of the system using the procedures in **Table P.8** , but not more than 10%.

b) Routine extrapolation: Local SAR values are measured along the vertical axis directly above the center of the source for system validation (i.e. the point of dipole feed or the center line of the waveguide) using the same spacing between points on the test grid than used for the zoom scan in SAR assessments of Handsets. The measured values are extrapolated to the surface of the MSH and compared with the Appropriate target values given in **Table D.1** or **Table D.2** . If the dipole source is used, this measurement is repeated along another vertical axis with a transverse displacement of 20 mm (*y*- direction of **Figure D.1**) of the standard dipole feed point. SAR values are extrapolated to the MSH surface and compared to the normalized numerical values given in Column 6 of **Table D.1** . The difference between extrapolated values and numerical values target given in **Table D.1** (or specific values for the specific source used) should be less than the expanded uncertainty for system validation using the **Table P.8,** the present arrangement technique, or 15%, whichever is less. Note that **Step b)** can be performed at the same time as **Step a)** if a zoom scan is used in it expanded to provide extrapolated SAR values. Probe linearity for signals equivalent to Continuous Wave: Measurements from **Step a)** are repeated using different input power levels of the reference dipole. Power levels for each frequency are selected to produce in 1 g or 10 g values of the spatial average peak of the SAR of about 10 W / kg, 2 W / kg, 0.4 W / kg and 0.12 W / kg. The measured SAR values are normalized to 1 W of power to the load for dipole sources (or 1 W of net power for waveguide sources) and compared to the normalized values from **Step a)** . The difference between these values must be less than the expanded uncertainty for the linearity component using the procedure in **Table P.8** and **P.2.2.3** , of this Technical Provision, or 10%, the make it less.

c) Probe linearity for periodic signals with pulse modulation: This step should be carried out once the requirements of **Step c)** have been met. The measurements of the **Step a)** are repeated with pulse modulation signals having a duty factor of 0.1 and a pulse repetition rate of 10 Hz. Power is adjusted to produce 1 g or 10 g a spatial average SAR peak of approximately 8 W / kg with the periodic signal with pulsed modulation or a SAR peak of approximately 80 W / kg. The measured SAR values are normalized to 1 W of power towards the load and duty factor of 1, and compared with the normalized values to 1 W from **Step a)** . The difference between these values must be less than the expanded uncertainty for system validation using the procedures in **Table P.8** , of this Technical Provision, or 10%, whichever is less.

d) Probe linearity for digital modulations with random amplitude and phase characteristics (for example, CDMA and OFDM signals): Measurements from **Step a)** are repeated with the Specific modulations that will be evaluated by the LP. This test can be performed at a alone by modulation. These modulations have a high ratio between peak and average. The power is adjusted to produce a 1 g spatial average peak SAR of 8 W / kg. If the ratio between the peak and average powers of a particular modulation is what high enough for the local SAR peak to exceed the dynamic range of the system, the power input should be reduced to produce a spatial average SAR peak of less than 8 by 1 g W / kg, but the closest to this. The measured SAR values are normalized to 1 W power input to the load for a dipole source (or 1 W of net power for guide sources of wave) and to a duty factor of 1, then compared to the normalized value from **Step a)** . The The difference between these values must be less than the expanded uncertainty for the validation of the system using the procedures in **Table P.8** of this Technical Provision or 10%, the make it less.

and) Probe axial isotropy: The geometric center of the probe sensors is located directly above the center of the system validation source a distance of measurement of approximately 1 times the probe diameter of the inner surface of the MSH. The The probe is rotated on its axis ± 180 ° in intervals no greater than 15 °. The maximum and minimum reading of the SAR are registered. The difference between these values must be less than the Expanded Uncertainty for the axial isotropy component using the procedures of **Table P.8** and of **numeral P.2.2.2** of this Technical Provision, or 5%, whichever is less.

NOTE The system validation procedure is not an alternative to probe calibration or estimation of the uncertainty in **Annex P** of this Technical Provision. Probe and electronics measurement to take readings should be calibrated regularly according to the procedures given in the **Annex E** of this layout technique. The hemispherical isotropy of the probe is not considered in the protocol for system validation.

D.3.6 TARGET NUMERICAL VALUES OF THE SAR.

The **Table D.1** shows the target values of the SAR validated numerically for validation of the system (see **D.3.5**), using the standard dipoles described in **numeral Q.1** of this Provision Technique. The target numerical values of SAR in **Table D.1** were calculated using the method of finite differences in time domain using the MSH requirements of **Annex R** and **Table R.1** of the present Technical Provision, and also validated against equivalent results measured in configurations from 300 MHz to 5 800 MHz. Local SAR values in Columns 5 and 6 of **Table D.1** were verified experimentally for each test frequency using polynomial extrapolation of fourth order. Values above 3 GHz are dependent on the dipole spacer used and the construction details of the dipole; therefore, target values for individual dipoles may vary with respect to the values in **Table D.1** up to ± 10%. The reason is that the dimensions of the dipole are small compared to the diameter of the arms and the dimensions of the spacer, that is, the values

Target numbers are not generic and need to be determined for a particular configuration.

Table D.1.- Target numerical values of SAR (W / kg) for a standard dipole and a flat MSH.

Frequency	**Thickness of the casing of MSH**	**SAR in 1 g**	**SAR in 10 g**	**Local SAR at surface (by on top of the Point of feeding)**	**Local SAR at surface (y = 20mm distance from Point of feeding) to**
MHz	mm	W / kg	W / kg	W / kg	W / kg
300	6.3	3.02	2.04	4.40	2.10
300	2.0	2.85	1.94	4.14	2.00
450	6.3	4.92	3.28	7.20	3.20
450	2.0	4.58	3.06	6.75	2.98
750	2.0	8.49	5.55	12.6	4.59
835	2.0	9.56	6.22	14.1	4.90
900	2.0	10.9	6.99	16.4	5.40
1,450	2.0	29.0	16.0	50.2	6.50
1,500	2.0	30.5	16.8	52.8	6.53
1 640	2.0	34.2	18.4	60.4	6.69
1 750	2.0	36.4	19.3	64.9	6.53
1 800	2.0	38.4	20.1	69.5	6.80
1 900	2.0	39.7	20.5	72.1	6.60
1 950	2.0	40.5	20.9	72.7	6.60
2,000	2.0	41.1	21.1	74.6	6.50
2 100	2.0	43.6	21.9	79.9	6.58
2 300	2.0	48.7	23.3	92.8	7.18
2 450	2.0	52.4	24.0	104	7.70
2,600	2.0	55.3	24.6	113	8.29
3,000	2.0	63.4	25.6	142	9.50
3 500	2.0	67.1	25.0	169	12.1
3 700	2.0	67.4	24.2	178	12.7
5,000	2.0	77.9	22.1	305	15.1
5 200	2.0	76.5	21.6	310	15.9
5 500	2.0	83.3	23.4	349	18.1
5 800	2.0	78.0	21.9	341	20.3

Values above 3 GHz are dependent on the dipole spacer and the construction details of the dipole can vary up to ± 10%. The reasons are that the dimensions of the dipole are small compared with respect to the diameter of the arms and the dimensions of the spacer, that is, the values Target numerics are not generic and need to be determined for a test setup in particular. Also, the results may be sensitive to the permittivity of the MSH shell. By For these reasons, the LP should determine the target SAR values for the test configuration in particular using numerical and experimental methods.

Power to the dipole must be limited so that the measured SAR values are within the range dynamic probe and thus avoid damage to the probe.

NOTE 1 All SAR values are normalized to 1 W of power to the load.

NOTE 2 SAR target values of 1 g and 10 g are only valid for defined system validation in **numeral D.3** , using dipoles that have the dimensions defined in **numeral Q.1** of the present Technical Provision.

[a] Non-monotonous behavior of local SAR values at 20 mm distance in the direction transverse to the feed point from 1 640 MHz to 2 100 MHz is due to the conductivity values of the LETs selected for these frequencies (see **Table 4** of this Technical Provision).

The **Table D.2** shows the values of the SAR for target validation system using sources guides waveforms described in **numeral Q.1** of this Technical Provision. The SAR target values numerically validated are dependent on the relative permittivity of the MSH shell; therefore, the Target values are given for relative permittivities of the shell of 3, 4 and 5. Linear interpolation should be applied when the permittivity of the MSH shell is between these values. Numerical values SAR targets in **Table D.2** are for 1 W of net power measured inside the waveguide, were calculated using the finite difference method in the time domain with the requirements of the volume for average and verified with measurements. The power delivered to the MSH is equal to the power towards the load within the waveguide source minus reflected power and transmission losses in the waveguide (including losses in the adapter and waveguide walls). The losses per transmission of the adapter can be determined by measuring *S* 11 on its coaxial port with three different known standard waveguides connected to the waveguide port, for example a short circuit over two transmission lines of different lengths terminated in a short circuit. Transmission losses of the waveguide should be measured at least once a year using a calibrated network analyzer.

The waveguide used in the simulations was modeled as a perfect conductor with a window dielectric coupling with the dimensions specified in **numeral Q.2** of this Provision Technique. The MSH used in the simulations is 216 mm long, 152 mm wide and 80 mm wide. depth, the shell thickness is 2mm. The dielectric parameters of the liquid are defined in the

Table 4 of this Technical Provision.

Table D.2.- SAR target numerical values for waveguides specified in numeral Q.2 placed in contact with the flat MSH

Frequency MHz	**Relative permittivity silhouette MSH flat**	**SAR in 1 g** W / kg	**SAR in 10 g** W / kg	**Local SAR as a function of distance *d* [mm] within MSH along its center line**
	3	165	53.7	667 exp (-2 *dl* 6.2)
5 200	4	180	56.5	733 exp (-2 *dl* 6.2)
	5	194	59.1	796 exp (-2 *dl* 6.2)
	3	165	49.3	804 exp (-2 *dl* 5.5)
5 800	4	184	52.5	907 exp (-2 *dl* 5.5)
	5	200	55.2	982 exp (-2 *dl* 5.5)

In case the net power produces measured SAR values that are above the range dynamic probe, lower powers should be used so that uncertainty is not introduced additional to the measurement and not to damage the probe.

NOTE 1 All SAR values are normalized to a net power of 1 W (i.e. the power delivered to MSH)

NOTE 2 The 1 g and 10 g SAR reference values are only valid for system validation defined in **numeral D.3** , using waveguides with the construction and dimensions defined in the **numeral Q.2** of this Technical Provision.

E.3.2.2 SENSITIVITY IN AIR (FIRST STEP).

The most accurate setting used for generating well-defined fields to simulate conditions free space to use for probe calibration are the waveguides. The reasons are as follows:

- Waveguide setups require moderate power and less space than waveguide setups.
  far field calibration settings;
- The generation of more accurate fields traceable to power readings is possible;
- The uncertainty produced by the disturbances produced in the field due to the fact that the insertion of the
  probe is negligible for small near-field probes when guide dimensions waveforms are considerably longer than the dimensions of the probe;
- Settings allow easy access to orient the probe's axis normal or parallel to the
  field polarization within the configuration;
- In addition, cross-validation of general field strengths is possible using a
  set of waveguides with overlapping frequency ranges.

At lower frequencies (e.g. below 750 MHz), TEM cells can be used in their place. However, the field within a TEM cell is not well defined, that is, there is a deviation quite large of the homogeneous prediction of the field distribution.

The probe is generally inserted through small holes in the walls of the TEM cell and is positioned in the center (above or below the septum) where the field is mostly homogeneous over the probe dimensions. Each sensor is evaluated with respect to the component of the field parallel to the sensor.

As long as the resistive line does not load the dipole diode sensor and the probe is small Compared to wavelength, free-space sensitivity is independent of frequency. This provides additional validation to the calibration settings, and checks for possible field penetrations due to the probe. Effects due to probe insertion are typically negligible, if high quality waveguide couplers and coupled sources are used. A fountain Additional uncertainty in the waveguide configuration is due to reflections from the load terminated, which can result in a standing wave pattern within the setup. Reflections they can be kept below 1% if high quality waveguide loads are used. Besides, the

Uncertainty can be compensated for by making supplementary measurements with a displacement load and averaging two readings.

E.3.2.3 SENSITIVITY IN THE MIDDLE (SECOND STEP).

E.3.2.3.1 GENERAL.

Sensitivity in the LET is determined by generating locally known field values within the medium. Two methods can be used:

a) Transfer calibration with the temperature probe;

b) Calibration with analytical fields.

E.3.2.3.2 TRANSFER CALIBRATION WITH TEMPERATURE PROBES.

In liquids with losses the SAR is related to the electric field (E) and the rate of increase of temperature in liquid (dT / dt) that has specific heat capacity c_h. Therefore, based on the relationship

Equation (E.4)

The electric field in a leaking liquid can be indirectly measured by measuring the rate of temperature increase in the liquid. Probes that do not disturb the temperature are available (probes optical or thermistor probes with resistive lines) with small sensors (<2 mm) and time of fast response (<1 s) and can be easily calibrated with high precision. The configuration and source excitation have no influence on the calibration; only the uncertainties of relative positioning of the temperature and electric field probes to be calibrated. Nevertheless, many problems limit the available accuracy of probe calibrations with temperature probes.

- The rate of temperature rise is not directly measurable, but must be evaluated from the temperature measurements carried out over a short period of time. Caution is needed special to avoid uncertainty in measurements caused by temperature gradients due to for the purposes of energy equalization or convection currents in the liquid. These effects do not they can be completely avoided. With careful configuration these uncertainties can be keep small.
- The volume measured around the temperature probe is not well defined. It is difficult to calculate transfer of energy into the probe from a surrounding gradient temperature field in the probe (typically, temperature probes are calibrated in liquids with temperatures homogeneous). There is no traceable standard for measurements of temperature rise.
- The calibration depends on the evaluation of the density of the mass, the thermal capacity specific and the electrical conductivity of the medium. As long as the mass density and capacity specific temperature can be measured accurately with standardized procedures (~ ± 2% for c_h; much better for), there is no standard for measuring electrical conductivity. Depending on the method and the liquid, the uncertainty can be ± 5%.
- Sufficient rise in temperature is required to produce measurable increases in temperature; by Therefore, calibration is commonly performed at a higher power level than the methods of the electric field. Non-linearities in the system (e.g. power measurements, different field components, etc.) must be compensated.

Considering these problems, the accuracy of the calibration of electric field probes using the temperature rise technique in a carefully designed configuration is around ± 10 % (Combined standard uncertainty). The estimated combined standard uncertainty of this configuration is ± 5% when the same liquid is used for both calibration and actual measurements, and the ± 7% to 9% when not, which is in agreement with its estimates. When performing an analysis of the uncertainty of the transfer calibration using the temperature rise technique, at least The parameters included in **Table E.1** must be considered .

Table E.9.- Analysis of the uncertainty for transfer calibration using temperature

Source of uncertainty	**Value of uncertainty ±%**	**Distribution from probability**	**Divisor**	**c_i**	**Uncertainty standard u_i ±%**	**v_i o v_{effec}**
Positioning of the electric field probe		R	√3	one		∞
Positioning of the temperature probe		R	√3	one		∞
Linearity probe electric field		R	√3	one		∞
Probe drift temperature and noise		R	√3	one		∞
Liquid conductivity		R	√3	one		∞
Specific heat of liquid		R	√3	one		∞
Liquid density		R	√3	one		∞
Probe Accuracy temperature		R	√3	one		∞
Standard uncertainty combined		RSS				

NOTE c_i is the sensitivity coefficient.

The components of **Table E.1** must be determined as follows:

a) The positioning tolerances of the temperature and electric field probes are evaluated in accordance with **numeral P.2.3.1** of this Technical Provision, using the depth of actual penetration determined from the dielectric parameters of the tissue, measured in the calibration frequency. Since small variations of the SAR are expected at the peak value for addresses parallel to the MAC surface, the procedures of **numeral P.2.3.1** of the present Technical Provision, are applicable when both the movements of the temperature probes as the movements of the electric field probe can be limited to only transverse directions, without the need for movement in the normal direction of the surface or in the z-axis direction.

b) The uncertainty of the linearity of the field probe is evaluated according to the **numeral P.2.2.3** of this Technical Provision, and for calibration it must not exceed 0.1 dB in the calibration field strength.

c) The drift of the temperature probe and noise are evaluated by temperature measurements in 1-second intervals for 1 hour, with an integration time less than 0.5 seconds in a constant temperature condition. Temperature tolerance is calculated as:

Equation (E.5)

where is the minimum temperature rise for different power levels used for calibration.

d) The tolerance of the linearity of the temperature probe must be determined using the following procedures. The accuracy and linearity of the temperature probe readings are compared against a traceable temperature reference in 10 temperature jumps in a interval greater than or equal to that used during calibration. Tolerance is calculated as shown in equation **E.5** .

e) The tolerance in the measurements of the conductivity of the liquid during the calibration, is determined using the same procedures as in **numeral P.2.6.3** of this Technical Provision.

f) The tolerance of the specific heat of the LET must be determined using procedures calorimetric.

g) The tolerance of the liquid density measurements must be calculated according to the RSS of tolerances obtained for volume and weight using standard measurement methods for the volume and weight.

h) The temperature probe must have a skip response time of 1 second or less, which It is determined from the time required by the measuring equipment, the temperature probe and the measurement electronics to reach 90% of the expected final temperature value after a jump variation of 5 ° C or more has been applied to the temperature probe.

E.3.2.3.3 CALIBRATION WITH ANALYTICAL FIELDS (WAVE GUIDES).

In this method a test of the configuration is used in which the field can be calculated analytically from measurements of other physical quantities (eg input power). This corresponds to the standard field method for probe calibration in air; however, there is no defined standard for fields in leaky liquids.

When using fields calculated in leaky liquids for probe calibration, they must be considered many points in estimating uncertainty.

- The net RF dissipated power in the waveguide must be accurately measured. East requirement involves precise measurements of two of the following three quantities: power incident, reflected power, and reflection coefficient at the waveguide input port.
- The accuracy of the field strength calculation will depend on the evaluation of the parameters dielectrics of the liquid.
- Due to the small wavelength in liquids with high permittivity, modes can be excited. of higher order. The field distribution in the setup should be carefully checked in accordance with the theoretical field distribution.

Figure E.1. Experimental arrangement for the evaluation of sensitivity (conversion factor) using a vertically oriented rectangular waveguide

Table E.2.- Guidelines for the design of waveguide calibration

Frequency	Weaving simulator head		Dimension of waveguide	Depth penetration	Dielectric separator	
MHz	ε_r '	σ	to	δ	ε_r '	Thickness
		Ye	mm	mm		mm
300	Four. Five	0.87	584.2	45.78	5.5	106.0
450	44	0.87	457.2	42.94	6.0	66.1
835 to 900	42	0.97	247.6	36.16	5.6	34.8
1,450	41	1.20	129.5	28.55	4.7	24.8
1800 to 2000	40	1.40	109.2	24.15	4.8	19.4
2 450	39	1.80	109.2	18.59	5.7	12.6
3,000	39	2.40	86.4	13.97	5.7	10.3
3 500	38.0	2.92	58.2	11.42	4.9	9.76
5 400	35.8	4.86	47.5	6.69	5.6	5.73
6,000	35.1	5.48	40.4	5.89	5.4	5.25

Permitivity and thickness of the dielectric separator may vary from the values shown for accommodate commercially available materials. If the permittivity of the dielectric separator varies from value indicated by more than 2%, it is recommended to optimize the spacer thickness again for the best adaptation (return losses typically greater than 10 dB).

Note 1 By convention, the length of the short edge of the cross section is half the long edge, that is, b = a / 2.

Note 2 Waveguide dimensions are consistent with ECIA RS-261 (3)

Note 3 These dimensions are also dependent on the frequencies of the bandwidths of interest.

Table E.3.- Uncertainty analysis of the probe calibration in the waveguide

Component of uncertainty	to Uncertainty ±%	Distribution of probability	b Divider	c c_i	$u_i = (a / b) \times c$ Uncertainty standard ±%	v_i
Incident power or towards the load		R	√3	one		∞
Reflected power		R	√3	one		∞
Measurement of liquid conductivity		R	√3	one		∞
Measurement of						

permittivity of the liquid	R	√3	one	∞
Deviation from liquid conductivity	R	√3	one	∞
Deviation from permittivity of the liquid	R	√3	one	∞
Deviation from frequency	R	√3	one	∞
Homogeneity of countryside	R	√3	one	∞
Positioning of the field probe	R	√3	one	∞
Probe linearity field	R	√3	one	∞
Uncertainty combined standard	RSS			

Note Column headings *a, b, c* are for reference.

Table E.4.- Uncertainty model for the evaluation of the antenna gain

Source of uncertainty	**Values of the uncertainty ±%**	**Distribution from probability**	**Divider**	c_i	**Uncertainty standard u_i ±%**	v_i o v_{effec}
Incident power		R	√3	one		∞
Coefficients of reflection		R	√3	one		∞
Distance		R	√3	one		∞
LET conductivity		R	√3	one		∞
LET permittivity		R	√3	one		∞
Standard uncertainty combined		RSS				

When performing a calibration uncertainty analysis with reference antennas, will consider at least the parameters included in **Table E.5** .

Table E.5.- Uncertainty template for calibration using a reference antenna

Source of uncertainty	Value of uncertainty ±%	Distribution from probability	Divisor c_i		Uncertainty standard u_i ±%	v_i o v_{effec}
Incident power		R	√3	one		∞
Reflection coefficients		R	√3	one		∞
Antenna gain		N	1 or *k*	one		∞
LET conductivity		R	√3	one		∞
LET permittivity		R	√3	one		∞
Positioning of the						

probe	R	√3	one	∞
Standard uncertainty combined	RSS			

E.3.3.2 EXTENDED EQUATIONS FOR ANTENNA GAIN IN MEASURING NEAR FIELD.

The antenna gain *G* , as in equation **E.9** , and the theoretical electric field E_{th} are based on the far field measurement in tissue equivalent liquid. However, it is difficult to measure *S21* in the region of far field due to large field attenuation in liquid. In this case, you can enter a extension of the Friis transmission formula, in the liquid with losses to define the field gain near the reference antenna $G_{near}(d)$, therefore it is possible to estimate the E_{th} in the field region near.

The near field gain $G_{near}(d)$ is a function of the distance from the antenna *d* , and can be expressed by the power series of the inverse of *d* .

The SAR probe is used to measure the electric field in the liquid, at a reference point for 1 W input power approx. Then, a temperature probe is used to measure the increase the rate of this, in the liquid in the same position, using approximately 30 W. For the accuracy, it is important that the actual temperature rise is limited to 1 ° C, since the conductivity of liquids change between three and five percent per degree Celsius. The ratio of power to measurement of the SAR probe and the temperature rise measurement shall be measured using a sensor directional power, or a directional coupler and power sensor, although absolute power does not is required. Calibration is achieved by comparing the output linear voltages of the probe sensors of the SAR with the electric field in the liquid that is calculated using the following equation:

This system provides accurate calibrations in the 30 MHz to 450 MHz frequency range, with a standard uncertainty of about ± 5%. When calibrating using this method, the will consider at least the parameters included in **Table E.6** .

Table E.6 - Uncertainty template for calibration using a reference antenna

Component of uncertainty	*to* Uncertainty ±%	Distribution of probability	*b* Divisor	*c* Coefficient of sensitivity c_i	$u_i = (a / b) \times (c)$ Uncertainty standard ±%	v_i o v_{effec}
Coefficients of LET temperature		R	√3	one		∞
Heat capacity of the LET		R	√3	one		∞
LET density		N	1 or *k*	one		∞
Conductivity of LET		R	√3	one		∞
Linearity and Drift sensor power		R	√3	one		∞
Linearity of probe temperature		R	√3	one		∞
Thermal effects that originate a non-linear increment in temperature		R	√3	one		∞
Errors of positioning		N	one	one		∞
Uncertainty combined standard		RSS				

E.4 ISOTROPY.

E.4.1 AXIAL ISOTROPY.

The probe must be exposed to a wave with incident polarization normal to the probe axis. The Axial isotropy is determined by rotating the probe along its major axis from 0 ° to 360 ° with a size interval less than or equal to 15 °.

E.4.2 HEMISPHERIC ISOTROPY.

E.4.2.1 GENERAL.

The probe must be exposed to a reference wave with varying angles of incidence with respect to to the plane normal to the probe axis. The evaluation of spherical isotropy shall be carried out in a place where the SAR gradients are less than 3% per millimeter. The hemispheric isotropy shall be determined by tilting the probe or by changing the polarization of the reference wave. Incidence angles will vary from 90 ° (axial) at 0 ° (normal) with an interval size less than or equal to 30 °. For each angle of incidence, the probe must rotate through a full 360 ° interval and with movements in intervals less than or equal to 15 °.

The following four methods can be used for hemispherical isotropy, each producing similar results:

a) Flat MAC with dipole on the side;

b) flat MAC with dipole below;

c) spherical MAC with dipole;

d) Antenna reference method, (see **numeral E.4.2.5**).

E.4.2.2 ISOTROPY WITH FLAT MAC AND DIPOLE ON ONE SIDE.

The setup consists of a thin-walled plastic box filled with LET exposed to a dipole half-wave resonant operating at a test frequency. The following protocol will be used to evaluate the spherical isotropy of the probe.

- Mount the dipole antenna horizontally on a mounting fixture and position it parallel to the plane of the MAC (see **Figure E.4**). The antenna will be placed at a maximum distance of *e* = / 10 from the wall adjacent to the liquid container.
- Insert the probe vertically into the LET so that the center of the three probe sensors are place in front of the dipole feed point at the height of the dipole axis.
- The horizontal position of the probe should be, whenever possible, at the maximum of the wave stationary near the back side of the case, at a distance *c* from the MAC / LET interface, where the electric field is partially homogeneous and the magnetic field is minimal.
- The dipole must rotate around the axis of its mounting device at least 0 ° to 180 ° with in intervals of less than or equal to 30 °.
- In each step the probe is rotated around its axis between 0 ° to 360 ° by the probe positioner and the measurement data is recorded in intervals less than or equal to 15 °.
- The deviation of the spherical isotropy is then expressed as a component of Uncertainty with a rectangular probability distribution limited by the measured response peaks.

Figure E.4. Fix for evaluating spherical isotropy deviation in LET.

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As with the flat MAC isotropy test, an Uncertainty distribution is assumed rectangular. However, Uncertainty can be substantially reduced when calibrating of the probe under a specific polarization and direction of the incident wave and remain the same conditions during SAR measurements.

E.4.2.5 ISOTROPY WITH REFERENCE ANTENNAS.

The following protocol will be used to evaluate the isotropy of the probe using the configuration of the reference antenna in **Figure E.8** .

a) Place an antenna on the LET. The antenna must be at least 10 cm away from the walls of the liquid container and have dimensions such that it can be placed in the position indicated in **Figure E.8** .

b) Place the probe in the LET so that the geometric center of the sensors is at a distance *d*

antenna: $d \geq$, where *D* is the largest dimension of the reference antenna, and

is the length of the wave in the liquid. It is recommended that the SAR value be established between 0.5 W / kg and 1 W / kg in this position.

c) Orient the axis of the probe so that its main axis is orthogonal to the direction of propagation antenna (see **Figure E.8**).

d) Rotate the probe along its main axis from 0 ° to 360 ° with intervals less than or equal to 15 °. Record the SAR values. Axial isotropy is expressed as an uncertainty component with a rectangular probability distribution based on the measured response peaks.

e) Vary the incidence of the reference field by tilting the reference antenna or the probe axis (see **Figure E.8**) 0 ° to 90 ° in 15 ° or 30 ° steps.

f) For each angle of incidence, rotate the probe along its main axis from 0 ° to 360 ° in steps less than or equal to 15 °. Record the SAR values.

g) The hemispheric isotropy is expressed as an uncertainty component with a distribution of probability of rectangular shape limited by the measured response peaks.

Figure E.8 - Hemispheric isotropy measurement with reference antenna

E.5 LOWER LIMIT OF DETECTION.

The lower limit of detection is the minimum measurable SAR within the general system of uncertainty. Is related to the noise level and displacement of the measurement system and can be evaluated by varying the output power in the same configuration as described in **paragraph P.2.2** . of the present Technical provision.

Under actual operating conditions of the measurement system, the electromagnetic environment can affect the detection limit environment. Therefore, revision of the lower limit of detection is recommended, through the configuration of the flat MAC described in **Annex R** of this Technical Provision, or with a calibration waveguide. The required lower detection limit is 10 mW / kg.

E.6 BORDER EFFECTS.

In the closest proximity to the inner surface of the MAC cover, the sensitivity of the probe is deviates from that established under typical calibration conditions. Boundary effects are evaluated with a open, liquid-filled waveguide configuration used for probe calibration. Peak value SAR spatial average is measured using all system components and compensation routines.

The uncertainty due to border effects is the deviation of the analytical value on the surface, the which is estimated by extrapolating the trend of the samples measured at the interface of the liquid and the plate dielectric. This measurement will be made for each frequency band and for each volume average. For frequencies below 800 MHz, where the calibration waveguides may not be available due to the relatively large size, a composite experimental setup can be used by a half wave dipole below a flat MAC. In this case, extrapolation to the surface is not based on known analytical behavior of the waveguide mode, but rather on an extrapolation of the measured samples. The effect of the boundary error is defined as the deviation between the SAR data measured and the actual value in the liquid. When the probe is oriented normal to the MAC surface, the Border effect can be largely offset. The uncertainty of the boundary effect will be evaluated from in accordance with **P.2.2.5.** of this Technical Provision.

E.7 RESPONSE TIME.

The uncertainty of the response time of the field probe signal is evaluated by exposing the probe to a stepped electric field response producing at least 100 W / kg. The time of Signal response is determined as the time required by the probe and its measurement electronics to reach 90% of the expected final value produced by a step response when connecting and turn off the RF power. The probe must remain stationary in each measurement position for at least three times the evaluation response time to ensure negligible uncertainty of the response time of the probe signal. Under these measurement conditions, a value can be entered Uncertainty of zero in **Table P.7** , **Table P.8** and **Table P.9** of this Technical Provision. Of what Otherwise, the SAR uncertainty due to the signal response time uncertainty, will be evaluated using the signal characteristics of the EBP. In this case, the Uncertainty of the response time of the Step signal is equal to the percentage difference of the measured SAR with the measurement time selected from the measured SAR, using a measurement time of at least three times the evaluation response. A rectangular probability distribution will be assumed.

ANNEX F

MEASUREMENT OF THE DIELECTRIC PROPERTIES OF THE LET AND ESTIMATION OF UNCERTAINTY.

F.1 PRELIMINARY OBSERVATIONS.

The **numeral F.2** of this Annex describes measurements of the dielectric properties of the LET required for SAR measurement procedures, it also provides sufficient detail to select a method based on convenience and performance. The dielectric properties of some Reference liquids are provided in **numeral F.6** of this Annex to evaluate the performance of measurement procedures. General Procedures for Evaluating Measurements of uncertainty of the dielectric parameters are provided in **numeral P.2.6** of this Provision Technique **.**

F.2 MEASUREMENT TECHNIQUES.

F.2.1 GENERAL.

The dielectric parameters required are the complex relative permittivity

Equation (F.1)

LET at specific test frequencies and temperatures. Several techniques can be used well established to carry out measurements of the dielectric properties of the LET.

F.2.2 INSTRUMENTATION.

The following instrumentation or its equivalent is required:

- Vector network analyzer and S parameter testing equipment.
- The liquid sample container for use with the dielectric coaxial probe, or the scored line and the TEM line containing the sample of the liquid to be tested.
- Software to calculate the dielectric properties of the samples from the measurements of the parameters S.

Three measurement techniques and the corresponding test methodologies are described in **paragraphs F.3** to **F.5** of this Annex. The achievable accuracy of measurements for the different methods can to vary. The dimensions of the transmission line or the coaxial probe are a function of the intervals of measurement frequency. The accuracy of the measurement is validated by measuring the parameters dielectrics of the reference **LETs** in **numeral F.6** of this Annex.

F.2.3 GENERAL PRINCIPLES.

The following general principles should be applied to all procedures.

- The sample holder must be completely clean.
- All cells, probes, cables, and connectors must be in optimal condition.
- The procedure for filling the sample holder with the liquid sample completely filled volume without trapping air bubbles.
- The temperature of the sample must be recorded and it must be reported that these properties Dielectrics are applicable only at that temperature.
- Personnel performing measurements should be familiar with the nature of measurements and with what to expect at each stage of the procedure.
- After calibration, a measurement should be performed in a reference liquid to validate the system prior to sample measurement. In **F.6 numeral** of this annex is provided information on various recommended reference materials.
- Data reduction methods to relate the complex reflection coefficient and the Complex permittivity must be precise and appropriate for the used fastener geometry shows.

F.3 SLOTTED COAXIAL TRANSMISSION LINE.

F.3.1 GENERAL.

A grooved coaxial line terminated with a moving probe can be used as a support for shows. A network analyzer provides an RF signal at the input of the slotted line and enables the magnitude and phase of the transmitted signal in the sample to be determined, as a function of the position along of the line by means of the mobile probe.

The test procedure should specify the calibration of the network analyzer and the settings for the required frequency range, the initial measurement position, the size of the increment along the slot, and the total number of subsequent measurement positions. The software must interpret the information measured to obtain the dielectric properties of the sample. In **numeral F.3.3** of this Annex, provides an example of the procedure.

F.3.2 EQUIPMENT ARRANGEMENT.

The test set consists of a slotted coaxial transmission line with a probe connected to the vector network analyzer, as shown in **Figure F.1** . The probe sensor is the center conductor extended cable / coaxial connector. The logarithmic magnitude and phase of S21 should be displayed simultaneously. The power supply must be set at a high enough level to provide a good signal to noise ratio. Since the measured quantities are magnitudes and phase changes against the distance, the accuracy of the scale is very critical.

Figure F.1. Grooved line arrangement.

The network analyzer introduces a signal into one of the ends of the coaxial transmission line grooved.

The probe inserted through the slot inside the LET detects from each measured position, the amplitude of RF and phase along the length of the line. Full calibration of the two ports of the analyzer nets should be carried out before filling the line with liquid, and the following should be considered precautions.

a) Fill the slotted line carefully to avoid trapping air bubbles. This operation must be performed while the slotted line is horizontal.

b) The probe should be inserted at the end closest to the slotted line input connector, so that the LET is flush with the inner surface of the line, and aligned with a position well defined on the distance scale of the slotted line.

c) The probe should be inserted perpendicular to the longitudinal axis of the grooved line until it is achieve a stable and adequate amplitude response. The probe should not be inserted too deep into the coaxial line, this may excessively disturb the distribution of the countryside.

F.3.3 MEASUREMENT PROCEDURE.

a) Configure and calibrate the network analyzer.

b) Measure the logarithmic magnitude and phase from 10 to 20 positions along the scored line corresponding to a change in magnitude of approximately 30 dB.

c) Plot the logarithmic magnitude and phase of S21 against the measurement distance.

d) Determine whether the plotted points closely follow a linear approximation, based on the correlation coefficient or a similar statistical measure. The data should produce a good fit linear regression (expected correlation coefficient for materials with losses r2> 0.99). Of what Otherwise, the LET should be measured again by increasing the number of measurement points to extend the change in magnitude from 30 dB to 40 dB.

For materials with low losses, it must be ensured that the grooved line is sufficiently long to avoid reflections from the load terminated end.

Figure F.2. Open-ended coaxial probe with inner radius and outer radius.

A non-metallic container should be used that is long enough compared to the size of the probe immersed in it for the liquid sample. A probe with an inner diameter of the outer conductor of 2 mm to 4 mm is suitable for LET measurements in the 300 MHz to 6 GHz range. This size of probe requires sample volumes of 50 cm3 or more. Larger sample volumes are required for probes with external diameter b up to 7 mm.

The coaxial probe must be connected to a network analyzer and must be calibrated with terminations short and open and also in a known dielectric medium, such as deionized water. There are probes commercially available, which are supplied with high precision short circuit plugs for calibration of the probe. Calibration procedures are highly automated by the software provided with commercially available probes. To ensure accurate measurements, the end of the probe it must be clean and free of oxidation.

Measurement errors can occur due to "edge resonances" when the edge diameter is approximately equal to half the wavelength of the dielectric medium. Such effects are more pronounced for liquids with high permittivity that have a loss tangent less than approximately 0.25 (at mobile phone frequencies these include water, methanol, and dimethyl sulfoxide). Therefore, calibration with a liquid with a high loss tangent, for example, the ethanol, is strongly recommended for larger sensors. There could be calibration problems coaxial sensors with watery edges at some frequencies. The LET has a loss tangent of around 0.5 which is high enough to ensure that the resonance effects are practically non-existent regardless of the sensor used.

The network analyzer must be configured to measure the magnitude and phase of the admittance under the control of the software. A one-port reflection calibration is performed in the probe measurement plane placing it in a liquid with a known reflection coefficient, with the probe in direct contact with the liquid. Three standards are needed for calibration, typically a short circuit, air (open circuit) and deionized water at a well-defined temperature (other reference liquids such as methanol and ethanol for calibration). Calibration is a key part of the measurement procedure, and therefore therefore it is important to ensure that it has been carried out correctly. It can be checked by measurement of the reference liquids indicated in **numeral F.6** and measuring the short circuit again to ensure that the reflection coefficient of = -1.0 (linear units) is consistently obtained.

F.4.3 MEASUREMENT PROCEDURE.

a) Configure and calibrate the network analyzer and probe system as required by the software.

b) Place the sample in a non-metallic container and immerse the probe in the liquid. It is recommended a fixture or clamp to allow mounting of the probe with the face oriented at an angle to the surface of the liquid, to minimize air bubbles trapped under the edge during insertion into the liquid and thus stabilize it.

c) Activate the software to measure complex admittance with respect to the opening of the probe.

d) The complex relative permittivity (equation **F.1**), is calculated automatically by the software; for example, according to the following formula:

This formula can be computed numerically, or expanded and simplified into a series. The formula is Solve first for the sample wave number k and then the complex Permitivity sample, using the Newton-Rapson method or other iterative approaches. Other may be used approximations, for example, the software can be thoroughly tested and verified through measurements of reference liquids.

F.5 TRANSMISSION LINE TEM.

F.5.1 GENERAL.

This method is based on measurements of the complex transmission coefficient of a line of coaxial transmission TEM mode filled with test liquid. Measuring transmission with an analyzer The vector of networks is used to determine the magnitude and phase of the spread coefficient S21, at from which the complex permittivity can be calculated. The network analyzer must be calibrated and the Test procedures should specify the equipment settings for the frequency range to be measured. The software should use the information to calculate the dielectric properties of the liquid sample as a function of frequency.

F.5.2 EQUIPMENT ARRANGEMENT.

The arrangement for the measurement is shown in **Figure F.3** . The liquid sample is contained in the TEM line open wall consisting of a central conductor with a circular cross section, two conductors of vertical (lateral) planar ground, an optically transparent plastic bottom wall, an open lid and a temperature sensor. The length *d* of the TEM line is chosen for a given frequency interval, from so that the effect of multiple reflections within the TEM line is small, and the total attenuation due to liquid inside the line do not exceed the dynamic range of the network analyzer. For example, can use two TEM lines with different lengths to cover the frequency range from 800 MHz to 2 000 MHZ. The liquid sample must be carefully injected or poured into the TEM line through the lid open to avoid any air bubbles.

F.5.3 MEASUREMENT PROCEDURE.

a) Configure and calibrate the network analyzer.

b) Record the magnitude and phase of the empty cell at the desired frequencies.

F.6 DIELECTRIC PROPERTIES OF THE REFERENCE LIQUIDS.

The procedures indicated in **numeral F.2** of this Annex require liquid measurements. reference that have well established dielectric properties in order to validate the system of dielectric measurements. It is recommended to use a reference liquid from those indicated in **Table F.1** to validate the dielectric measurement system. The difference between measurement results and properties calculated dielectrics (normalized frequency and temperature) must be within the uncertainty used in the dielectric measurement system. Two reference fluids are required, one for the calibration, and the other to check the calibration. The following is a general formula for calculating the frequency dependent dielectric properties:

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Table F.2.- Dielectric properties of the reference LETs at 20 ° C

300	33.41	0.048	47.07	0.027	80.19	0.022	39.01	0.14
450	33.05	0.11	46.99	0.060	80.16	0.049	36.49	0.30
750	31.95	0.29	46.73	0.17	80.07	0.14	30.73	0.66
835	31.57	0.35	46.64	0.20	80.03	0.17	29.16	0.76
900	31.25	0.40	46.56	0.24	80.00	0.20	28.00	0.83
1450	28.10	0.92	45.68	0.60	79.67	0.51	20.38	1.34
1500	27.79	0.97	45.68	0.64	79.63	0.55	19.87	1.38
1640	26.91	1.12	45.30	0.76	79.52	0.65	18.54	1.48
1750	26.21	1.23	45.06	0.86	79.43	0.74	17.62	1.55

1800	25.89	1.29	44.94	0.91	79.38	0.78	17.23	1.58
1900	25.62	1.39	44.71	1.01	79.29	0.87	16.51	1.63
2000	24.63	1.49	44.46	1.11	79.19	0.96	15.85	1.69
2100	24.02	1.59	44.21	1.22	79.09	1.06	15.24	1.74
2300	22.81	1.79	43.68	1.44	78.87	1.27	14.18	1.83
2450	21.94	1.94	43.26	1.61	78.69	1.44	13.49	1.89
2600	21.11	2.07	42.82	1.79	78.51	1.61	12.88	1.94
3000	19.05	2.41	41.59	2.31	77.96	2.13	11.56	2.07
3500	16.84	2.77	39.95	2.99	77.18	2.87	10.34	2.20
4000	15.02	3.07	38.24	3.70	76.30	3.70	9.44	2.31
4500	13.52	3.32	36.51	4.42	75.33	4.62	8.75	2.40
5000	12.29	3.52	34.78	5.14	74.27	5.62	8.21	2.48
5200	11.87	3.59	34.10	5.42	73.83	6.04	8.03	2.51
5400	11.47	3.66	33.43	5.70	73.37	6.47	7.86	2.54
5600	11.11	3.72	32.77	5.98	72.91	6.91	7.70	2.57
5800	10.77	3.77	32.12	6.25	72.43	7.36	7.55	2.60
6000	10.45	3.83	31.48 to	6.52 to	71.95	7.81	7.42	2.62

a Parameters were derived from measurements at 5 GHz only; the accuracy of these parameters above 5 GHz has not been evaluated.

ANNEX G

EXAMPLE OF RECIPES FOR MAC HUMAN TISSUE EQUIVALENT (LET) LIQUID.

G.1 GENERAL PERSPECTIVE.

The dielectric properties of the liquids for MAC must be those indicated in **Table 4** of the present Technical Provision. For frequencies not stated, the dielectric properties must be calculated from starting from tabulated values using linear interpolation. The **Tables G.1** , **G.2** and **G.3** suggest examples recipes for liquids with parameters defined in **Table 5** of this Technical Provision (4).

G.2 INGREDIENTS.

The following ingredients can be used in the formulas to produce the LET:

- Sucrose (sugar) (purity greater than 98%).
- Sodium chloride (salt) (purity greater than 99%).
- Deionized water (minimum resistivity of 16 MΩ).
- Hydroxyethylcellulose (HEC).
- Bactericidal.
- Diethylene glycol butyl ether (DGBE) (purity greater than 99%).
- Polyethylene glycol mono [4- (1,1,3,3-tetramethylbutyl] phenyl ether]. This is available as Triton ™ X-100. The quality of the Triton X-100 must be ultra pure to match the composition of the salt. After making Triton X-100 based liquids, dielectric parameters are difficult to adjust in order to keep them close to the target. Therefore, it is recommended to use alternatives when are available.
- Diacetin.
- 1,2-Propanediol.
- Polysorbate 20.
- Diethylene glycol monohexyl ether.

Considerations:

1. The viscosity of the HEC-based LET must be low enough not to affect the movement of the electric field probe.
2. Salt must first be added to the water to make a saline solution and then the Triton X-100 must be added.
3. Actual results and mixing percentages vary depending on the degree and type of components used.
4. Tolerance of in **Tables G.1** , **G.2** and **G.3** are the tolerances of the temperature of the liquid described in **numeral P.2.6.6** of this Technical Provision, based on the measurements of the applicable liquid formulas.

G.3 FORMULAS FOR THE LET (ALLOWANCE / CONDUCTIVITY).

The formulas for the LET are found in **Tables G.1** , **G.2** and **G.3** .

Table G.10.- Suggested recipes to obtain dielectric parameters from 300 MHz to 900 MHz

Frequency MHz	**300**	**450**	**450**	**450**	**835**	**835**	**900**	**900**	**900**	**900**
					Ingredients (% by weight)					
1,2-Propanediol								64.81		

Bactericide	0.19	0.19	0.50		0.10		0.10		0.50	
Diacetin			48.90						49.20	
DGBE										
CET	0.98	0.98			1.00		1.00			
NaCl	5.95	3.95	1.70	1.96	1.45	1.25	1.48	0.79	1.10	1.35
Saccharose	55.32	56.32			57.00		56.50			
Triton X-100										
Polysorbate 20				49.51		48.39				48.34
Water	37.56	38.56	48.90	48.53	40.45	50.36	40.92	34.40	49.20	50.31

Dielectric parameters measured

Table G.2.- Suggested recipes to obtain dielectric parameters from 1450 MHz to 2000 MHz

Frequency MHz	**1450**	**1800**	**1800**	**1800**	**1800**	**1800**	**1900**	**1900**	**1950**	**2000**
Ingredients (% by weight)										
1,2-Propanediol										
Bactericide					0.50					
Diacetin					49.43					
DGBE	45.51	47.00	13.84	44.92			44.92	13.84	45.00	50.00
CET										
NaCl	0.67	0.36	0.35	0.18	0.64	0.50	0.18	0.35		
Saccharose										
Triton X-100			30.45					30.45		
Polysorbate 20										
Water	53.82	52.64	55.36	54.90	49.43	54.23	54.90	55.36	55.00	50.00

ANNEX H

POST-PROCESSING TECHNIQUES.

H.1 EXTRAPOLATION AND INTERPOLATION SCHEMES.

H.1.1 PRELIMINARY OBSERVATIONS.

Local SAR within the MAC should be measured using small dipoles (sensors) embedded in a protective housing / cover on the probe. The probe calibration (which involves measuring the field electrical) can be carried out with respect to the geometric center of the set of internal dipoles, in in which case the fact that these are a few millimeters from the physical tip of the probe must be taken into counts when defining measurement positions.

In order to minimize the uncertainty derived from the boundary effect of the probe, the tip of the probe should not be in contact with the MAC surface, although higher local SAR values they generally occur on this surface. Assessment of these elevated local SAR values is essential to determine the spatial average peak of the SAR and therefore must be obtained by extrapolation from measurements made over a range of distances from the MAC surface.

Exact evaluation of the SAR average spatial peak requires a very fine resolution according to the **Table 6** , the present arrangement technique, within a volume scanning three - dimensional and Measurements should be made with a fully charged battery. The measurements obtained must be extrapolate and interpolate to generate an information matrix with sufficient resolution to calculate with accuracy the spatial average peak value of the SAR. The measurement uncertainty resulting from these interpolations, extrapolations and other numerical procedures (integration, average, etc.) must be decide. The uncertainty of the location of the measurement points should be determined as a Separate uncertainty component.

H.1.2 INTERPOLATION SCHEMES.

Interpolation can be performed using various mathematical techniques, such as: statistics, curve fitting base functions, Fourier analysis, small wave transformations, polynomials or polynomial curve fitting. Several numerical analysis textbooks describe how to implement some of these methods.

H.1.3 EXTRAPOLATION SCHEMES.

Extrapolation can be done by: curves, biarmonic curves, wave transformations small, polynomials or rational functions. Several computational math books describe how implement some of these methods, since the accuracy of the extrapolation depends on the distance between the measurement points and the field distribution being extrapolated, the associated uncertainty with this it must be carefully estimated.

H.2 SCHEME FOR OBTAINING THE AVERAGE AND MAXIMUM RESULTS.

H.2.1 AVERAGE SCHEME BY VOLUME.

The cubic volumes evaluated to obtain the mean value of the measured SAR values after extrapolation and interpolation, they must be spread over the MAC surface to include the values Highest SAR premises. In post-processing, the cube where the averaging is performed must match one of its sides parallel to the surface of the MAC.

H.2.2 EXTRUSION METHOD TO AVERAGE.

The method for averaging is inherently simple since the cube is essentially adapted to the measurement grid, or at least fits the extrapolated and interpolated data grid. Peak value SAR spatial average is found by moving the cube to average over a selected region.

The **Figure H.1** illustrates the extrusion method. The extraction method for averaging can be done parallel to the surface of the MAC providing that the four lateral sides are parallel to the line normal of this, in the center of the side of the cube next to the surface of the MAC. This ensures that the volume The extrudate is close to a cubic shape, and approximates the surface.

Figure H.1 - Extrusion method for averaging.

H.2.3 ESTIMATION OF THE MAXIMUM LEVEL OF SAR AND ESTIMATION OF UNCERTAINTY.

The local peak value of the SAR will occur on the interior surface MAC, so the spatial average peak value SAR must occur in a cubic tissue volume on the surface of the MAC. Therefore, then the The zoom scan should focus on the position of the SAR peak determined from the area near the MAC surface. The zoom scan volume must extend in all directions at least 1.5 times the linear dimension of the cube to average, used for the determination of the average peak value SAR space. Computationally controlled algorithms should be used to determine the peak value spatial average of maximum SAR, according to interpolated and extrapolated local SAR gradients on the zoom scan volume. The contribution of the scheme uncertainty to averaging and the Maximum value estimation is included in the evaluation methods of numeral **P.2.10** of the present Technical provision, since it not only serves as a reference point for interpolation and extrapolation, but also also for the schemes to average and find the maximum value.

H.3 EXAMPLE OF IMPLEMENTATION OF PARAMETERS FOR SCANNING AND EVALUATION OF DATA.

H.3.1 GENERAL.

Here are some examples of the parameters to implement procedures for SAR scanning and information (data) evaluation procedures, it is possible to implement procedures other than described.

H.3.2 REQUIREMENTS FOR AREA SCAN MEASUREMENT.

For Handsets that operate above 300 MHz and are evaluated with a homogeneous MAC, the The SAR distribution is measured on a two-dimensional grid with a greater separation between points and at a Fixed separation distance from the MAC deck surface, as defined in **Table 5** of the present Technical Provision. The area scan should cover all areas covered by the projection of the Handset. In order to maintain a fixed distance ± 1 mm from the surface, as required by the measurement, the exact shape and dimensions of the interior surface of the MAC must be known, calibrated or preferably be detected during SAR measurement with a mechanical mechanism or surface detection optical that meets the positioning requirements of the probe. This technique of evaluation determines the maximum spacing between grid points as indicated in **Table 5** , to achieve the accuracy required to locate the position of the maximum SAR value.

H.3.3 ZOOM SCANS.

The spatial average peak value of the SAR is evaluated on an interpolated grating with a resolution of 1 mm after the zoom scan. Zoom scan volume is positioned at peak location (s) SAR of the area scan and measured in accordance with the requirements of **Table 5** . The resolution of scanning parallel to the surface and those normal to the MAC surface should be carefully selected according to **Table 6** to achieve the required extrapolation accuracy.

H.3.4 EXTRAPOLATION.

Because the actual position of the field probe measurement corresponds to the geometric center of the set of sensors (dipoles) which travels from the tip of the probe, the SAR values between the MAC surface and the closest measurable points required to calculate the average peak values 10-g SAR space, should be calculated by extrapolation.

While a basic exponential fit may not be adequate for extrapolating many of the typical SAR distributions that occur in Handset evaluations, a polynomial fit of fourth order least squares of the readings obtained, usually gives n results satisfactory. The triangle shaped points shown in **Figure H.2** represent the SAR values extrapolated, at 1 mm intervals for points close to the MAC surface where they cannot be measured.

Figure H.2 - Extrapolation of SAR data to the inner surface of the MAC based on a fit fourth-order least squares polynomial of the measured data (square markers).

H.3.5 INTERPOLATION.

The SAR values measured and extrapolated within the zoom scan volume must be interpolated to a 1 mm grid to determine the spatial average peak value of the SAR in 10 g.

H.3.6 INTEGRATION.

One way to integrate the SAR over a 10 g cube is by using the basic trapezoidal algorithm. The spatial average peak value of SAR is determined by search algorithms that apply integration numerical to all possible 10 g cubes within the zoom scan volume or by applying more complex procedures. If the tallest 10g cube is touching the border of the scan volume zoom, the entire zoom scan must be repeated from a new center, located at the maximum peak value SAR spatial average, indicated by the previous zoom scan measurement.

ANNEX I

VALIDATION OF THE SAR MEASUREMENT SYSTEM FOR THE BODY.

I.1 GENERAL DESCRIPTION.

This annex provides the procedures for the following two levels of validation systems SAR measurement:

a) System review;

b) System validation.

The objectives and applications of these different validation procedures are as follows.

The System Review provides a fast and reliable test method that can be applied in routinely to verify the accuracy of the SAR measurement system. The goal here is to make sure that the SAR system is within calibration parameters. This test requires a flat MSH and a radiant source, for example a half wave dipole or open waveguide

System validation provides a means of validating at the system level the specifications of the measurement of SAR and its components. Test preparation consists of a flat silhouette model and a reference dipole (see **Annex S** of this Technical Provision) or a waveguide source open. Therefore, the system validation does not include Uncertainty due to the use of an MSH; nor due to the variability of the DCI positioning. This test is performed annually (for example, after calibration of probes), prior to comparisons of measurements between laboratories (see **Annex T** of this Technical Provision), and each time modifications are made to the system, such as new probes and software changes, which add different electronic sensors for output readings or probes.

NOTE Comparisons between LPs allow the reproducibility of SAR measurements to be quantified using a Reference Handset and the MSH. The measurements address both the dispersion of the data due to MSH such as positioning uncertainty, which are not included in the system or system validation. The tests can also be used to establish the accuracy and expected uncertainty of measurement across various LPs.

I.2 REVIEW OF THE SYSTEM.

I.2.1 PURPOSE.

The purpose of the system check is to verify that the system operates to its specifications at the DCI test frequencies. The System Review verifies the repeatability of the measurements of a SAR system prior to Conformity Assessment tests. System Check detects possible deviations in the short term and unacceptable measurement errors or uncertainties in the system, such as:

a) incorrect liquid parameters (eg due to incorrect dielectric measurement);

b) failures in the test system components;

c) Drift in the components of the test system;

d) operator errors in the preparation of the measurement and in the adjustment of the parameters of the measurement;

e) any other possible adverse conditions that may introduce measurement errors, for example, RF interference.

The system review is a complete measurement of the spatial average peak of the SAR in 1 g or 10 g in a simplified arrangement with one source for system review (see **I.2.3**). The instrumentation and Procedures in the system review should be the same as those used in conformance testing. System check should be performed using the same probe calibration LET and frequency point than that used in the Conformity Assessment tests and within the valid frequency range for the probe calibration, the dielectric parameters of the liquid and the return losses necessary to SAR measurements. The frequencies at which the system check is performed must be within the ± 10% or within ± 100 MHz of the center frequencies of the EBP band.

The system review must be performed before the Conformity Assessment tests or within 24 hours prior to the SAR assessment and in the same SAR measurement system that is used for Handset evaluation and must always be within the tolerances specified in **I.2.5** . The sought values will be the average SAR over 1 g or 10 g in systems with the current validation system and using the check and calibration shown in **Figure I.1** . These values must be determined using a standard font.

Figure I.1.- Test arrangement for the system revision.

I.2.2 SETTLEMENT OF THE MSH.

A flat MSH with LET should be used for system review and validation. The specifications of These are given in section **5.2.2** of this Technical Provision.

For dipole sources, the feed point should be centered under the flat MSH, and the arms of the dipole must be aligned with the longest axis of the silhouette (see **Annex S** of this Provision Technique, for dipole specifications). For waveguide sources, the longest part of the waveguide it should be aligned with the major axis. The material must be resistant to damage or reaction with LET.

I.2.3 STANDARD SOURCE.

The flat MSH must be irradiated using a radiant source for the required frequency (for example, a half-wave dipole, a patch antenna, or waveguide). The sources used for the validation of the system (see **Annex S** of this Technical Provision) are typically, but not necessarily, used for system review. The source for system review should have good repeatability of positioning, mechanical stability and impedance matching. From this point on, a dipole of half wave is used as an example to illustrate the source positioning requirements for the system review. Similar instructions should apply for other sources.

A half-wave dipole must be positioned below the bottom of the flat MSH and centered with its axis. parallel to the greater dimension of the MSH. The distance between the inner surface of the MSH containing the LET and the dipole feed point, *s* , (see **Figure I.1** and **Table S.1** of **Annex S** of this Technical Provision) must be specified for each test frequency. A low loss separator (loss tangent <0.05) and low dielectric constant (relative permittivity <5) should be used for set the correct distance between the top surface of the dipole and the bottom surface of the MSH. The dipole must have return losses of less than 20 dB at the resonant frequency (measured at the setting system), to ensure that the SAR measurement uncertainty due to power reflections is keep low. The acceptable uncertainty for the separation distance between the dipole and the LET, *s* , for the Test setting of **Figure I.1** should be within ± 0.2mm.

I.2.4 MEASUREMENT OF STANDARD SOURCE INPUT POWER.

The uncertainty of the power to the source should be as low as possible. This requires the use of a test setup with directional couplers and power meters during system. The recommended arrangement is shown in **Figure I.1** (a half wave dipole is used as an example source for system review).

First, the PM1 power meter (including Att1 attenuator) is connected to the cable to measure the power to load at connector location (X) to source for system check. Generator signal is adjusted to the desired power towards the load in the connector (taking into account the attenuation of Att1) as measured by the PM1 power meter and even as coupled through Att2 to

PM2. After connecting the cable to the source and positioning it under the silhouette, the signal generator is adjusted again to achieve the same measurement initially recorded on the PM2 power meter. Yes the signal generator does not allow adjustments in 0.01 dB increments, the remaining difference in PM2 must be taken into consideration (for example, by scaling the measured SAR values against the difference in power in PM2).

The source link for the system review should be checked using a network analyzer (for example, during the annual performance characterization intervals) to ensure that the power reflected is at least 20 dB lower than the power to the load.

The components and instrumentation required are the following:

to) The output of the signal generator and amplifier must be stable within 2% (after warming up). The power supplied to the dipole should produce a spatial average peak of the SAR greater than the lower limit of detection of the sensor system (see **numeral E.5** of the present Technical Provision). If the signal generator can deliver 15 dBm or more, it is not need an amplifier. Some high-power amplifiers should not be operated at powers well below their maximum output power, for example a power amplifier 100 W operated at 250 mW power output can be very noisy. A recommended attenuator between the signal generator and the amplifier to protect the amplifier input.

b) The low-pass filter inserted after the amplifier reduces the effect of harmonics and noise coming from the amplifier. For most amplifiers in its operating range normal, the filter is not necessary.

c) Attenuator after amplifier improves source coupling and sensor accuracy power meter (see power meter manual).

d) The directional coupler (with a recommended coupling coefficient of -20 dB) is used to monitor the power to the load in order to make adjustments to the generator output signals to maintain constant power towards the load in PM2. A dual directional coupler It is necessary when the powers towards the load and reflected are to be measured, for example, when using wave guides.

and) PM2 and PM3 power meters should have high stability and a resolution of 0.01 dBm. By On the other hand, absolute accuracy has a negligible effect on the power adjustment towards the dipole. (absolute calibration is not required).

F) The PM1 power meter and Att1 dimmer must be high quality components. These must be calibrated, preferably together. The attenuator (-10 dB) improves the accuracy of the power (some high power heads have a calibrated attenuator built in). The The exact attenuator attenuation at the test frequency must be a known value. For some attenuators this may vary by more than ± 0.2 dB from the specified value throughout the operating frequency band.

g) The same power level should be used for the PM1 test and in actual measurements, to Avoid linearity and range uncertainty in PM2 and PM3 power meters. If the level of power is altered, the power setting procedure must be repeated.

h) The source of the system dipole must be connected directly to the cable at location X. If the power meter has a different type of connector, high-quality adapters must be used.

i) The insertion losses of the cables, especially the cable connecting the coupler directional with the antenna, should be periodically reviewed to ensure that losses due to insertion are stable in the frequency range used. Insertion losses should be minimum (less than 1 dB, depending on cable length and frequency) and stable throughout the frequency range. Do not assume that a cable that performs well at low frequencies (for example 900 MHz), it will work the same at high frequencies (for example 5 GHz). High cables quality will be needed in high frequency operations. During the review measurements of the system, all movements of the cables should be avoided as it may cause changes on the loss characteristics of the cables and introduce SAR errors.

I.2.5 PROCEDURE FOR REVIEW OF THE SYSTEM.

The system check is a complete measurement of the spatial average peak of the SAR at 1 g and / or 10 g. The spatial average peak of the SAR measured in 1 g and / or 10 g is normalized to 1 W by the power of source input for system review (power to load for dipoles and net power for waveguides) and compared to the target value of the spatial average peak of the SAR for 1 g and / or 10 g numerically validated and experimentally established by the source for the System Review.

System Check target values should not deviate by more than ± 10%. If another is used different standard source, the target value and its uncertainty must be measured and documented.

I.3 VALIDATION OF THE SYSTEM.

I.3.1 PURPOSE.

The system validation procedure tests the SAR system using standard dipoles and test guides.

waveforms defined by this Technical Provision to verify the accuracy of the measurements and the performance of probes, measurement electronics and system software. It is a validation of the system with respect to all performance specifications. Consequently, this validation process does not include the DCI positioning uncertainty due to MSH.

System validation must be done at least once a year, when a new system is put in place. in operation, or when modifications have been made to the system, such as software updates, using different measurement electronics or probes and after calibrating the probes. System validation should be done with the calibrated probe.

The objective of this clause is to provide a methodology for the validation of the measurement system of the SAR. Since SAR measurement equipment, calibration techniques, models, and LET can vary widely across multiple LPs, a validation methodology is needed to ensure that obtain consistent results within reasonable measurement uncertainties. Reference values of Numerically calculated SARs to be used in the validation of the system are listed in **Table I.1** .

I.3.2 PLANO MSH ARRANGEMENT.

The flat MSH preparation described for the system review (see **Figure I.1**) is also used to system validation tests. System validation must be performed using LETs that have the Dielectric properties defined in **Table 8** of this Technical Provision.

I.3.3 SOURCES FOR VALIDATION OF THE SYSTEM.

I.3.3.1 DIPOLE TYPE REFERENCE SOURCE.

The flat MSH must be irradiated using a standard dipole, specified in **Annex S** of this Technical Provision, for the required frequency. The dipole must be positioned below the flat MSH and centered with its axis parallel to the longest side of the model. A low loss, constant low separator dielectric must be used to establish the correct distance between the top surface of the dipole reference and the lower surface of the MSH. The distance between the surface of the liquid and the center of the dipole reference (designated *s* in **Figure I.1**) must be within ± 0.2 mm of the required distance for each test frequency. The reference dipole must have return losses greater than -20 dB (measured in setting conditions for system validation) on the test frequency to reduce the Power reflection and SAR measurement uncertainty.

For the standard dipoles described in **Annex S** of this Technical Provision, the Distance of separation *s* is given by:

a) s = 15 mm ± 0.2 mm for 300 MHz ≤ f ≤ 1,000 MHz;

b) s = 10 mm ± 0.2 mm for 1 000 MHz ≤ f ≤6 000 MHz;

The arms of the dipole must be parallel to the flat surface of the MSH with a tolerance of ± 2 ° or less (see **Figure I.1**).

Calculation of reference values for frequencies greater than 5 GHz requires consideration specific to the construction and structure (both internal and external) of the dipole. In such a way that the values Numericals can be specific to dipoles of a particular manufacturer.

It is also necessary to model the dielectric separator used for the dipole since it can affect the numerical value of the SAR.

I.3.3.2 REFERENCE WAVE GUIDE SOURCE.

Waveguide sources are suitable alternatives to dipole antennas at higher frequencies where the target values of dipole antennas may be sensitive to manufacturing uncertainties and construction details. The target numerical values of the SAR are provided in **Table I.2** for the specific measurement settings. The waveguide source is positioned with the window coupler in direct contact with the MSH. Net power must be measured correctly to scale the HE.

I.3.3.3 REFERENCE FOR OPEN WAVE GUIDE TYPE SOURCE.

The purpose of this numeral is to provide a procedure for using a rectangular waveguide as source for validation and review of the system. The procedure is applicable for frequencies above 5 GHz, where the use of dipoles requires detailed consideration of the use of spacers and internal structure, to allow exact calculation of reference values. Waveguide sources allow for geometry more accessible to modeling, so that reference values are less dependent of the processes and details of its manufacture.

Different waveguide sources have been studied, highlighting the cases of grooved guide spaced away from flat MSH and for resonant window guides positioned directly on MSH. In In each case, different dimensions were used for the waveguides, so the reference values (**Table I.2**) are different for each case. The choice of method will depend on the availability of the equipment. A window-coupled waveguide is required for the SAR sensor calibration, and the use of this This procedure makes it easier to position the source and requires fewer components. The procedure with Grooved guide has the advantage of not requiring a docked window and the ability to adjust the guide to minimize reflected power.

In this Technical Provision the process is described using a resonant window from which the reference values listed in **Table I.2** .

The attached guide source uses a rectangular guide (WR137, also known as WG13) with 40mm x 20mm internal dimensions. A 4.3mm thick resonant window was used in the form of a coupler, containing low loss ceramic material with relative permittivity, K = 6. Dimensions The coupler length is 81mm by 62mm.

The reference values for the geometry of this source have been calculated, at frequencies of 5 200 MHz and 5,800 MHz, by different groups using different codes of the finite difference method in the time domain (*FDTD*) and the values are found in **Table I.2** .

Reference values for validation include data from the decrease of the center line in the box of the silhouette, when the procedures mentioned above are performed. The equations in the **Table I.2** have been adjusted from the data derived from the *FDTD* computation and can be used to represent the reference values of the center line.

Centerline scans (above the center of the resonant window) should be performed at 0.2 mm intervals, starting with the sensor in direct contact with the bottom of the MSH. SAR values should be normalized to the input power of 0.25 W and post-processed to apply border, so that they can be compared with the reference profiles. It should also be considered, separately, the magnitude and shape of the measured data relative to the reference values. It must of demonstrate that the profile figure corresponds to the reference profiles, to confirm the absence of interference and the applicability of any boundary correction that has been applied.

With the waveguide input source positioned as in **Figure I.1** (but with waveguide in place of the dipole), and with the data of the 3-dimensional scan collected according to the provisions of the **numeral 5.2** of this Technical Provision, the SAR values obtained and normalized to the power 0.25 W input should be compared with the reference values shown in **Table I.2** .

Rectangular waveguides can be used as well characterized radiators for the SAR system validation for frequencies above 3 GHz.

I.3.4 MEASUREMENT OF THE INPUT POWER OF THE REFERENCE DIPOLE.

The input power measurement described by the system review (see **I.2.4**) is also used in system validation tests.

I.3.5 SYSTEM VALIDATION PROCEDURE.

System validation is used to verify the accuracy of the measurements of a SAR system. complete, including software algorithms. The uncertainties of the DCI positioning and the shape of the MSH are not considered during the validation of the system. The system validation procedure It consists of up to six steps, from **Step a)** to **Step f)** . El **Paso a)** is the most important part of the process validation of the system and must be performed for each combination of probe, measurement electronics and version of the post-processing system that is used to evaluate each time the validation of the system it is necessary. Then the applicable selections from **Step b)** to **Step e)** must be made. These tests Additional must be performed each time the system components have been modified (for example, a new version of software, new measurement electronics, new probes or calibrations). The system validation procedure is as follows.

to) SAR Assessment: A complete measurement of the spatial average peak of the SAR at 1 g and / or 10 g it must be done. The input power of the system validation source is adjusted to produce, in 10 g, a spatial average peak value of SAR within the range of 0.4 W / kg to 10 W / kg. The spatial average peak of the SAR in 10 g is measured at the frequencies in **Table I.1** within of the range of parameters supported by the SAR system. The results should be normalized to 1 W of power to the load and compared with the numerical values of the SAR in the **Table I.1** (column 3 or 4). Differences between measured values and numerical values The objective of **Table I.1** or **Table I.2** must be less than the Expanded Uncertainty for the system validation using the procedures in **Table O.5** of this Provision Technique.

b) Routine extrapolation: Local SAR values are measured along the vertical axis directly above the center of the system validation source (that is, the point of dipole feed or the center line of the waveguide) using the same spacing between test grid points than that used for area scanning in SAR assessments of Handsets. The measured values are extrapolated to the surface of the MSH and compared with the Appropriate target values given in **Table I.1** (column 5) or **Table I.2** (column 4 with d = 0). Yes dipole source is used, this measurement is repeated along another vertical axis with a 20 mm transverse difference (*y*- direction from **Figure I.1**) of the dipole feed point standard. The SAR values are extrapolated to the surface of the MSH and compared with the Normalized numerical values given in Column 6 of **Table I.1** . The difference between the values extrapolated and the target numerical values given in **Table I.1** must be less than the Expanded uncertainty for system validation using the procedures in **Table O.5** of this Technical Provision.

c) Probe linearity: Measurements from **Step a)** are repeated using different levels of input power of the reference dipole. The power levels for each frequency are selected to produce in 10 g values of the spatial average peak of the SAR of about 10 W / kg, 2 W / kg, 0.4 W / kg and 0.08 W / kg and 0.01 W / kg. The measured SAR values are normalized to 1 W of power to the load for dipole sources and compared to normalized values from **Step a)** . The difference between these values must be less than Expanded uncertainty for the linearity component using the procedure in **Table O.5** and **O.2.2.3** of this Technical Provision.

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d) Response to Modulation: Measurements from **Step a)** are repeated with signals with pulse modulation having a duty factor of 0.1 and a pulse repetition rate of 10 Hz. Power is adjusted to produce a 10 g spatial average peak SAR of approximately 8 W / kg with the pulse modulated periodic signal or a SAR peak of about 80 W / kg. The measured SAR values are normalized to 1 W power to the load and duty factor of 1, and compared with the values normalized to 1 W from **Step a)** . The The difference between these values must be less than the expanded uncertainty for the validation of the system using the procedures in **Table O.5** of this Technical Provision.

and) Probe axial isotropy: The geometric center of the probe sensors is located directly above the center of the system validation source a distance of measuring 5 mm to 10 mm from the internal surface of the model. The probe is rotated on its axis ± 180 ° in intervals no greater than 15 °. The two SAR readings, maximum and minimum, are recorded. The difference between these values must be less than the expanded uncertainty for the component of axial isotropy using the procedures of **Table O.5** and **O.2.2.2** of this Provision Technique.

I.3.6 TARGET NUMERIC VALUES OF THE SAR.

In the system validation test, the reference dipole constructed for the frequency (described in the **Annex S** of this arrangement Technique) should produce the reference number for the peak values SAR spatial average, shown in columns 3 and 4 of **Table I.1** , considering Uncertainty system validation. Columns 5 and 6 are used to validate the extrapolation routine, which described in **I.3.5** . SAR reference values were calculated using the numerical method for *FDTD* with the flat MSH parameters in **Table S.2** of this Technical Provision. The values for Frequencies between 300 MHz and 6 000 MHz were experimentally verified. Values above 3 GHz they are dependent on the dipole spacer and the construction details of the dipole can vary up to ± 10%. The reasons are that the dimensions of the dipole are small compared to the diameter of the arms and spacer dimensions, that is, the target numeric values are not generic and need be determined for a particular test setup. The dielectric properties used in the liquid are defined in **Table 8** and the reference dimensions for the dipoles are shown in the **Table S.1** . Different reference values can be presented for dipoles whose dimensions mechanics differ from those provided in **Annex S** of this Technical Provision.

Table I.1.- Target numerical values of the SAR (W / kg) for a standard dipole and silhouette model flat.

Frequency	Thickness of the casing of model	SAR in 1 g	SAR at 10 g	Local SAR at the surface (by on top of the Point of feeding)	Local SAR at surface (y = 20mm distance from Point of

					feeding)
MHz	Mm	W / kg	W / kg	W / kg	W / kg
300	6.3	3.02	2.04	4.40	2.10
300	2.0	2.85	1.94	4.14	2.00
450	6.3	4.92	3.28	7.20	3.20
450	2.0	4.58	3.06	6.75	2.98
750	2.0	8.49	5.55	12.6	4.59
835	2.0	9.56	6.22	14.1	4.90
900	2.0	10.9	6.99	16.4	5.40
1,450	2.0	29.0	16.0	50.2	6.50
1 800	2.0	38.4	20.1	69.5	6.80

1 900	2.0	39.7	20.5	72.1	6.60
1 950	2.0	40.5	20.9	72.7	6.60
2,000	2.0	41.1	21.1	74.6	6.50
2 450	2.0	52.4	24.0	104	7.70
2 585	2.0	55.9	24.4	119	7.90
2,600	2.0	55.3	24.6	113	8.29
3,000	2.0	63.8	25.7	140	9.50
3 500	2.0	67.1	25.0	169	12.1
3 700	2.0	67.4	24.2	178	12.7
5,000	2.0	77.9	22.1	305	15.1
5 200	2.0	76.5	21.6	310	15.9
5 500	2.0	83.3	23.4	349	18.1
5 800	2.0	78.0	21.9	341	20.3

NOTE 1 The mechanical dimensions of the reference dipoles indicated in the **Annex must be used. S** of this Technical Provision. Values above 3 GHz are dependent on the separator of the Dipole and dipole construction details can vary up to ± 10%. The reasons are that dimensions of the dipole are small compared to the diameter of the arms and the dimensions of the separator, that is, the target numeric values are not generic and need to be determined for a particular test setup.

NOTE 2 The dimensions of the silhouette must be those indicated in section **5.2.2** of this Technical provision. Values above 3 GHz are dependent on the dipole spacer and details dipole construction can vary up to ± 10%.

NOTE 3 The power to the dipole must be limited so that the measured SAR values are within dynamic range of the probe to avoid damage to the probe.

The **Table I.2** shows the values of the SAR for target validation system using sources guides waveforms described in **Annex S** of this Technical Provision. The target numerical values of the SAR of **Table I.2** were calculated using the finite difference method in the time domain.

The waveguide used in the simulations was modeled as a perfect conductor with a window Resonance dielectric with the dimensions specified in **Annex S** of this Provision Technique. The model used in the simulations is 216 mm long, 152 mm wide and 80 mm wide. depth, the shell thickness is 2mm and the relative permittivity is 2.56. Dielectric parameters of the LET are defined in **Table 8** of this Technical Provision.

Table I.2.- Target numerical values of SAR for waveguides placed in contact with the model flat silhouette

Frequency MHz	SAR in 1 g W / kg	SAR in 10 g W / kg	Local SAR as a function of distance *d* [mm] within of the model along its center line
5 200	159.0	56.9	548.4 exp (-2 *dl6.25*)
5 800	181.2	61.5	682.0 exp (-2 *dl* 5.57)

NOTE 1 All SAR values are normalized to a net power of 1 W.

NOTE 2 The 1 g and 10 g SAR reference values are only valid for system validation using waveguides with the construction and dimensions defined in **Annex S** of this Technical provision.

Note 3 In case the net power produces measured SAR values that are above the range dynamic probe, lower powers should be used so that uncertainty is not introduced additional to the measurement and not to damage the probe.

ANNEX J

CORRECTION OF THE SAR IN CASE OF DEVIATION FROM THE COMPLEX ALLOWANCE OF THE TARGET VALUES.

J.1 GENERAL QUESTIONS.

In this Technical Provision, the dielectric parameters of the equivalent liquid used for the SAR measurements are selected in such a way as to obtain a conservative SAR value with respect to exposure in a person. Deviations from these parameters can cause uncertainty in the measurement. One way to reduce measurement uncertainty is to maintain the dielectric parameters of the liquid within a close tolerance of the target value (for example, within ± 5%). However, you can It will be difficult to find suitable and stable liquid recipes, whose dielectric parameters are close to the target; especially for frequencies above 2 GHz. There are three solutions to this problem:

a) Change the reference values of the dielectric parameters to match the values of the LETs available.

b) Increase tolerance (without correcting SAR for deviation in dielectric parameters)

c) Allow greater tolerance and correct SAR for deviation in dielectric parameters

The third solution is the best, because changing the reference values would have the consequence of restrict this Technical Provision to certain LET recipes. Just increasing tolerance increases measurement uncertainty.

The methodology used to determine the correction of the SAR is described in previous studies. Is methodology was conducted in a range of frequencies from 30 MHz to 6 GHz, and was studied for ranges of permittivity and conductivity of ± 20% of the reference values in **Table 8** of this Provision Technique; however, ranges of ± 10% have been chosen for this Technical Provision. Considering that the change in dielectric parameters influences the conversion factor of the sensor, the influence will be minimum if a range of ± 10% is used.

J.2 CORRECTION OF THE SAR FORMULA.

ANNEX K

MEASUREMENT OF THE DIELECTRIC PROPERTIES OF THE LET AND ESTIMATION OF UNCERTAINTY (MSH).

The **Annex F** of this arrangement applies technique for measuring the dielectric properties of the LETs and the estimation of uncertainty. For the frequency range 30 MHz to 6 GHz, **Table K.1** and **Table K.2** should be used instead of **Table F.1** and **Table F.2** .

Table K.1.- Parameters to calculate the dielectric properties of various reference liquids.

Deionized water	twenty	Debye	80.21	5.6	9.36	one

Deionized water	25	Debye	78.36	5.2	8.27	one
DMSO [to]	twenty	Debye	47.13 7.13		21.27	one
DMSO [to]	25	Debye	46.48 6.63		19.18	one
DMSO	25	Cole-Davidson	47.0	3.9	21.1	0.878
Ethylene glycol [b]	twenty	Cole-Davidson	41.5	3.8	157.18	0.82
Ethylene glycol [c]	twenty	Cole-Davidson	41.9	5.02	161.4	0.88
Methanol	twenty	Debye	33.90 4.70		53.20	one
Methanol	twenty	Debye	33.7	4.8	53.8	one
Methanol [a]	twenty	Debye	33.64 5.68		56.6	one
Methanol [a]	25	Debye	32.67 5.58		50.8	one

DMSO = Dimethylsulfoxide; Ethylene Glycol also known as Ethanediol.

[a] Data derived from measurements at 5 GHz only.

[b] Prescription valid from 130 MHz to 20 GHz

[c] Recipe valid from 30 MHz to 5 GHz

Table K.2.- Dielectric properties of reference liquids at 20 ° C

30	33.64	0.0005	47.13	0.00027	80.20	0.00022	41.87	0.0016
150	33.56	0.012	47.11	0.0067	80.20	0.0055	40.89	0.038
300	33.33	0.049	47.07	0.027	80.19	0.02	39.21	0.14
450	32.94	0.11	46.99	0.06	80.16	0.05	36.78	0.29
750	31.95	0.29	46.73	0.17	80.07	0.14	30.73	0.66
835	31.37	0.35	46.64	0.20	80.03	0.17	29.53	0.76
900	31.04	0.41	46.56	0.24	80.00	0.20	28.38	0.83
1,450	27.77	0.92	45.68	0.60	79.67	0.51	20.63	1.36
1 800	25.51	1.27	44.94	0.91	79.38	0.78	17.38	1.61
1 900	24.88	1.37	44.71	1.01	79.29	0.87	16.64	1.66
2,000	24.25	1.47	44.46	1.11	79.19	0.96	15.96	1.72
2 450	21.57	1.89	43.25	1.61	78.69	1.44	13.53	1.92
2,600	21.11	2.07	42.82	1.79	78.51	1.61	12.88	1.94
3,000	18.76	2.33	41.59	2.31	77.96	2.13	11.53	2.11
4,000	15.17	3.12	38.24	3.70	76.30	3.70	9.36	2.34
5,000	12.40	3.58	34.78	5.14	74.27	5.62	8.12	2.51
6,000	10.51	3.89	31.48 [to]	6.52 [to]	71.95	7.81	7.33	2.64

[a] Data derived from measurements at 5 GHz only.

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ANNEX L

POWER ADJUSTMENT PROCEDURE.

L.1 PROCEDURE.

Power scaling is the extrapolation of the SAR of a given EBP with a test signal (mod_X) to a SAR of the same EBP with a modulation (mod_Y). Power scaling based on Numerical or experimental methods for different modulation signals is possible if:

- Used the same stage of RF amplifier for mod_X mod_Y.
- The same antenna is used for mod_X and mod_Y and MIMO techniques are not used.
- The SAR probe has been calibrated for mod_X signal modulation and the SAR has been determined for mod_X.
- The ratio of the time-averaged RF output power (R_p) of mod_X and mod_Y after the modulations of the RF amplifier stage is known as:

ANNEX M

JUSTIFICATION OF THE TEST PROBE PARAMETERS.

M.1 DIMENSIONS OF THE OUTER TIP OF THE PROBE.

300	45.3	0.87	148.6	46.1	8.0	16.0	5.0
450	43.5	0.87	101.1	42.9	8.0	14.9	5.0
750	41.9	0.89	61.8	39.8	8.0	13.8	5.0
835	41.5	0.9	55.8	38.9	8.0	13.5	5.0
900	41.5	0.97	51.7	36.1	8.0	12.5	5.0
1,450	40.5	1.20	32.5	28.6	8.0	9.9	5.0
1 800	40.0	1.40	26.4	24.3	8.0	8.4	5.0
2,000	40.0	1.40	23.7	24.2	8.0	8.4	5.0
2 450	39.2	1.80	19.6	18.7	6.5	6.5	5.0
2,600	39.0	1.96	18.5	17.2	6.2	5.9	5.0
3,000	38.5	2.40	16.1	13.9	5.4	4.8	5.0
4,000	37.4	3.43	12.3	9.6	4.1	3.3	3.3
5000	36.2	4.45	10.0	7.3	3.3	2.5	2.5
5 200	36.0	4.66	9.6	7.0	3.2	2.4	2.4
5 400	35.8	4.86	9.3	6.7	3.1	2.3	2.3
5 600	35.5	5.07	9.0	6.4	3.0	2.2	2.2
5 800	35.3	5.27	8.7	6.1	2.9	2.1	2.1
6,000	35.1	5.48	8.4	5.9	2.8	2.0	2.0

* z50 % = In (2) / 2

M.2 MOVING THE PROBE SENSOR.

The distribution of the induced field is a function of the depth of penetration and the distribution incident of the magnetic field H, that is, the field can attenuate even faster than the depth of penetration with respect to the normal distance from the border of the MSH. Due to this strong attenuation, the extrapolation becomes very sensitive to uncertainty at measured points, for example distortions field premises, border effects, noise, etc. In order to keep the uncertainty within limits reasonable, the nearest measuring point M1 should be measured at a distance $z50_{\%}$ = In (2) / 2 within of which the SAR is more than 50% of the SAR at the surface. These distances are provided in column 7 of **Table M.1** assuming plane wave attenuation. Attenuation is typically stronger for antennas near the surface of the MSH than for flat waves, especially at low frequencies so that the minimum distance up to 3 GHz is defined as $z_{M}1$ = 5 mm. However, at frequencies above 3 GHz, $z_{M}1$ can be set to $z50_{\%}$, since the penetration depth is similar to that of a plane wave at higher frequencies. Since exact results cannot be measured when the probe is in contact direct with the surface of the MSH, the distance corresponds to the displacement of the sensor plus the distance minimum from the probe tip to the surface of the MSH.

M.3 INCLINATION OF THE PROBE WITH RESPECT TO THE SURFACE.

At high frequencies, the probe tends to be larger than the wavelength used and it is important take measurements very close to the surface. To achieve results with acceptable uncertainty, the probe must be in a position normal to the surface, for example, for deviations greater than 20 °, require special precautions and considerations to ensure acceptable uncertainty. The Deviations of less than 5 ° are technically preferable.

M.4 UNCERTAINTY OF EXTRAPOLATION AND INTEGRATION.

The gradient normal to the surface grows sharply at high frequencies. The number of measurements within zoom scan volume, which is above the sonar noise level, decreases and may significantly affect extrapolation and integration. One strategy to overcome this problem is to use graduated grids. However, the uncertainty can increase considerably when the probe is not sensitive enough. In **Table M.2** , the error is determined by adding white noise to the functions $f1$, $f2$ and $f3$, whose amplitude is defined in dB of the values on the surface. The **Table M.2** allows determination of the evaluation error with respect to system noise level. Values are standard deviation after than 4,000 iterations.

For example, the evaluation with a noise (N_{rms}) of 25 mW / kg will result in an uncertainty of 5% for graduated grids (nearest measuring point 1.5 mm, graduated 1.5, 7 x 7 x 5) and 30% for grids homogeneous (nearest measurement point 4 mm, grid 11 x11 x 7).

Table M.2.- Extrapolation and integration of the uncertainty of the spatial average peak of the SAR (k = 2) in 10 g of mass for homogeneous and graduated grates

	Homogeneous grid					Graduated grid				
S / N	$f11_{peak}$	$f12_{peak,}$	$f12_{peak, sec}$	f2	f3	$f11_{peak}$	$f12_{peak,}$	$f12_{peak, sec}$	f2	f3

	prim			prim			
30 dB 0.1%	0.0%	0.1%	0.1% 17% 0.0%	0.1%	0.0%	0.0% 1.3%	
20 dB 0.1%	0.1%	0.1%	0.2% 18% 0.1%	0.1%	0.1%	0.0% 1.9%	
13 dB 0.6%	0.6%	0.6%	0.4% 27% 0.5%	0.5%	0.5%	0.3% 8.7%	

10 dB 2.8%	2.7%	2.7%	1.8% 69% 2.3%	2.4%	2.2%	1.4%	39%

ANNEX N

DEFINITION OF A COORDINATE SYSTEM FOR MAC AND EBP.

The offset and rotation between these optional reference coordinate systems can be used to provide an unambiguous description of the position of the EBP relative to the MAC. The **Figure N.1** shows a definition of the MAC coordinate system for the ear reference point left (LE).

Figure N.1 - Example of reference coordinates for the Reference Point of the left Ear of the MAC.

The *x, y, z* axes must form a right-hand coordinate system. To the landmark Left axes are defined as follows:

a) The z axis is defined by a line connecting the left and right reference points and It points from the right to the left, from the point of view of the MAC. The origin $z = 0$ is at left of the left reference point.

b) The *y*- axis is located in the reference plane along the line BM (numeral **5.1.2.1** of the present Technical Provision) and is perpendicular to the z axis.

c) The *x*- axis is perpendicular to the reference plane along the NF line (numeral **5.1.2.1** of the present Technical Layout) and cuts the reference plane at the reference point of the left ear.

For the reference point of the right ear, the reference coordinate system can be defined as analogously where the *x* , *y* axes are the same as in the setting for the ear reference point left, with the *z*- axis pointing left to right. In **Figure N.2** definition shown a coordinate system of the EBP.

Figure N.2 - Example of coordinate system in the Equipment Under Test

ANNEX O

ESTIMATION OF UNCERTAINTY FOR THE TESTS INDICATED IN NUMERAL 5.2.

O.1 GENERAL CONSIDERATIONS.

O.1.1 CONCEPT OF ESTIMATION OF UNCERTAINTY.

To facilitate the estimation of the Uncertainty in the SAR measurement, this Annex provides guidelines and approximation formulas that allow the estimation of each individual component of the Total uncertainty. The Uncertainty templates in **Table O.4** , **Table O.5** , and **Table O.6** are intended to address generic system uncertainty covering the entire frequency range from 30 MHz to 6 GHz and for any DCI under test. However, the quantities and values of the components of Uncertainty will generally not be the same throughout the entire frequency range from 30 MHz to 6 GHz, and consequently the uncertainties for the partial frequency ranges should be adjusted necessarily. The use of templates and standard values of the components of Uncertainty have the disadvantage that Uncertainty may be overestimated in some cases, but the advantages include the use of approximations and formulas as provided in this Annex.

Manufacturers of SAR measurement systems must specify the operating frequencies of coverage in which the measurement system has been designed. This makes it easier to determine the variables at quantities used in **Table O.5** that must be updated with respect to values determined for specific frequencies, eg, probe isotropy, boundary effect, probe positioner, etc.
In case the measurements are extended beyond the frequency range specified by the manufacturer the user must determine the quantities and influence associated with the uncertainty, and update the table accordingly. Where a series of values has been used to cover a wide range frequencies (3 GHz to 6 GHz), additional documentation may be required, detailing the estimate of each quantity, its influence and the methodology. When a system uses a value of zero for a quantity determined in the Uncertainty table, a strong technical justification must be provided, since either by the system manufacturer or by the user.

O.1.2 TYPE A AND TYPE B EVALUATIONS.

The uncertainty posed by the deviation of the isotropy can be quite high and depends on the manufacturing details, that is, it must be evaluated individually for each probe.

In **Table O.4** , a rectangular probability distribution has been assumed for the Uncertainty of the isotropy of the probe.

O.2.2.3 UNCERTAINTY OF THE LINEARITY OF THE PROBE.

Generally the response of diode detectors is non-linear with respect to field strength and modulation. The Uncertainty with respect to the true average power detector needs to be determined by the procedure described below:

Since the effects are only functions of the sensing element (diode, sensor, line) and not functions of the environment in the surroundings, the deviation of the response from the average power can be determined in any medium including air.

An Uncertainty factor must be evaluated for Continuous Wave signals. Uncertainty too must be evaluated for pulsating signals with a duty factor of 10% and a pulse repetition rate 11 Hz, and with a duty factor of 4% with a repetition rate of 1 000 Hz at the frequencies applicable highest and lowest used in TDMA systems.

For modulations other than Continuous Wave (including CDMA) and TDMA, the deviation of the linearity must be evaluated separately.

For each probe it is necessary to determine individually the uncertainty posed by the response non-linear. If the Uncertainty has not been established for a particular probe, a 200% uncertainty.

O.2.2.4 UNCERTAINTY OF THE PROBE RESPONSE TO MODULATION.

The response to modulated signals from diode detector-based probes can be complex given that diodes are largely non-linear elements. The linearization parameters for a modulation in particular can be determined by two methods: 1) numerically based on the modulation envelope and electrical characteristics of the diode and other sensor elements (must be determined experimentally) or 2) by relative experimental calibration, that is, making a power sweep at a particular modulation. These parameters must be determined for each sensor separately. For pulsating signals with constant surround (GSM, GMSK, Bluetooth, DECT), the parameters of the compensation function are reduced to one parameter for some probes, namely the factor crest.

Uncertainty can be determined using any source (eg waveguide or dipole) with an arrangement similar or equivalent to the arrangement described in **Figure E.1** of this Technical Provision. The The configuration of the signal generation must simulate the modulation for which the Uncertainty according to the specification of the communication system standard. The power must be increased to obtain a range of voltages in the probe sensor from the equivalent of less than 100 mW / kg to the equivalent of more than 10 W / kg for the investigated sensor, in steps of 5 dB. In Each power level, the SAR must be measured with the modulated signal and with Continuous Wave at the same average power (it is required to verify that the power meter is a true average power detector and that the amplifier is linear enough for the full dynamics of the signal). This procedure must be repeated for each field sensor.

The equation below can be used to derive the modulation uncertainty for the *X* modulation in particular.

Equation (O.5)

Where

SAR $_{\text{mod}\,Xi}$	is the Uncertainty for the particular modulation X in percentage;
SAR (P_i) $_{\text{modXi}}$	is the SAR measured with the signal modulated at an average power;
SAR (P_i) $_{\text{OCi}}$	is the SAR measured with Continuous Wave at the same average power.

The SAR Uncertainty is determined as the maximum of all SAR $_{\text{mod}\,Xi}$ in each of the steps for all three sensors. In **Table O.4** a rectangular probability distribution has been assumed for the Uncertainty of the probe response to modulation.

O.2.2.5 SENSITIVITY AND LIMITS OF DETECTION OF THE PROBE.

Uncertainties in the sensitivity of the field probe and the limit of detection of the system can arise when the intensity of the measured field is close to the detection limit of the probe and the instrumentation associated with the system. This Uncertainty must be evaluated with a Continuous Wave signal and a pulsating signal corresponding to the minimum duty factor allowed or specified by the control system SAR test. For this evaluation, the Continuous Wave and pulsating signals must produce about 0.1 W / kg, 2.0 W / kg, and 10 W / kg of the time-averaged SAR. For example, at 10% of the duty factor, 10 W / kg of the time averaged SAR would correspond to the maximum peak of 100 W / kg specified by the protocols in this standard. The SAR level of 0.1 W / kg is chosen to provide a sufficient signal-to-noise ratio for this assessment, corresponding to 1 W / kg at a duty factor from 10 %. Another reason for choosing this level is because SAR levels less than 0.1 W / kg typically they have a negligible contribution to the average space SAR peak. This range of SAR levels should cover the peak-to-average power ratio and signaling requirements of typical EBPs operating in FDMA, TDMA, and CDMA modes. For DCI operating at work factors less than 10%, the evaluation should be modified accordingly to cover that operating interval. Uncertainty due to detection limits should be evaluated assuming it has a rectangular distribution of probability.

O.2.2.6 UNCERTAINTY OF THE BORDER EFFECT.

In some cases, it may be necessary to take measurements with the probe at a distance less than the radius r_p of the probe tip, in order to reduce interpolation and extrapolation uncertainties. So, the Boundary effect uncertainty should preferably be evaluated using the waveguide system described in **Annex E** of this Technical Provision. Alternatively, the method of temperature. The method described below is valid assuming that the angle between the probe axis and the line normal to the surface is less than 5 °. Since the boundary effect is a characteristic of a specific probe, it must be determined during the calibration process (i.e. according to the value of r_p of the probe). If algorithms are applied to compensate for the boundary effect, then the Uncertainty of the SAR must be determined with the same hardware and software evaluation used to carry out of SAR measurements. The uncertainty of the border effect can be estimated according to the following formula for approximation of uncertainty based on linear and exponential extrapolations between the surface and $d_{EF} + d_{\text{pass}}$ along lines that are approximately normal to the surface:

Equation (O.6)

for ($d_{EF} + d_{\text{step}}$) <10 mm and f ≤ 3 GHz

Equation (O.7)

for $d_{\text{EF}} < \delta$ and f> 3 GHz

Where:

SAR $_{\text{incert}}$	is the Uncertainty, in percentage, of the boundary effect of the probe;
d_{EF}	is the distance, in millimeters, between the surface and the closest measurement point used in the averaging process;

d_{step} is the separation distance, in millimeters, between the first and second point of measurement from the surface provided that the boundary effect uncertainties in the second measurement point are negligible;

is the minimum penetration depth, in millimeters, of the LET (see **Table 8**), that is, δ = 6 mm at 6 GHz;

ΔSAR_{EF} is the deviation between the SAR value measured at the distance d_{EF} from the border and the analytical value of the waveguide or the value evaluated by the temperature probe SAR_{ref} .

If the diameter of the wave exceeds one third of the wavelength (in the middle), the boundary effect is large (>> 1 dB) and it is difficult to obtain exact measurements. The condition that the boundary effect is negligible at the second measurement point can be breached as well. In these cases, a 50% predetermined uncertainty for the border effect (**Annex M**).

In case the angle between the probe axis and the normal vector to the surface is greater than 5 °, must be evaluated by the following procedure using the arrangement defined in **E.3** for the test frequency:

Step 1: Perform an area scan and go to maximum interpolation (all measurements in steps 2 to 8 are taken on a line normal to the surface that includes this interpolated maximum).

Step 2: Perform a *z*- axis scan in which all points correspond to the points on the grid in the *z* direction of the volume scan. These values will represent the values of reference. The reference values should be compared with the numerical values and must be documented and not deviate more than the Uncertainty for the validation of the system.

Step 3: Rotate the probe angle tilt to 10 ° (the maximum angle 5 ° plus 5 °).

Step 4: Rotate the axial rotation to 0 °.

Step 5: Perform a scan along the z-axis and evaluate the deviation by comparing it to the values of reference for the first measurement point.

Step 6: Rotate the probe on the axis in 15 ° steps until the rotation is less than 360 ° and repeat from **Step 4)** to **Step 6)** .

Step 7: Rotate the probe angle tilt by 5 ° until the rotation is less than the maximum inclination achieved during measurements and repeat **Step 4)** to **Step 7)** .

Step 8: Report all values. The maximum deviation recorded in Step 5 is the maximum Boundary uncertainty that will be used in the equations of this numeral.

For the uncertainty due to the border effect, a rectangular probability distribution has been assumed in the **Table O.4** .

O.2.2.7 UNCERTAINTY OF MEASURING ELECTRONICS.

The components of the field probe measurement electronics uncertainty include amplification, linearity, probe loading and evaluation algorithm uncertainties, etc. The expected ranges of these components of uncertainty can generally be evaluated using simulated terminations instead of field probes and using the specifications of the manufacturer for electronic components. The square root of the sum of the components of the Uncertainty squared must then be used to obtain the overall uncertainty of the measurement electronics. For the Uncertainty of the measurement electronics a distribution has been assumed normal probability in **Table O.4** .

O.2.2.8 RESPONSE TIME.

The probe must be exposed to a well-defined electric field producing at least 2 W / kg near the surface area of MSH and LET. The response time of the signal is evaluated as the time required by the measuring equipment (probe and measuring electronics) to reach 90% of the expected final value after of a one-step variation or power source off / on. The Uncertainty of SAR resulting from this response time can be neglected if the probe remains spatially stationary, for a period of time greater than twice the response time, before a SAR value be measured. In this case, put a zero in column *c* of **Table O.4** . If the probe is not spatially stationary for a period of at least twice the response time, enter the actual value

of the Uncertainty caused by the response time in column *c* of **Table O.4** . For the
Uncertainty due to response time, a rectangular probability distribution has been assumed in the **Table O.4** .

O.2.2.9 INTEGRATION TIME.

Probe integration time uncertainties may increase when EBPs do not emit a continuous signal, such as the digital modulations used in some EBPs. When the time of integration and discrete sampling intervals used in probe electronics are not synchronized with the modulation characteristics of the measured signal, the RF energy at each measurement point it may not be captured correctly or completely. This uncertainty must be evaluated according to the characteristics of the EBP signal before performing the SAR measurement.

For signals with amplitude modulation or pulse modulation components and with periodicity greater than 1% of probe integration time, additional SAR uncertainties should be considered when the integration time of the probe is not an exact multiple of the maximum periodicity T . The Uncertainty must be evaluated according to the maximum uncertainty expected for a time of unsynchronized probe integration assuming a rectangular probability distribution. For one signal with an envelope $s(t)$, the average signal detected by the probe during the integration time t_{int} that begins at time t_0 is given by $s_{int}(t_0, t_{int})$ in:

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O.2.2.10 MEASUREMENT OF THE SAR DRIFT.

If the SAR drift measurement is within 5%, then it can be treated as a Uncertainty (that is, random error) or as a bias. If treated as an Uncertainty, the drift it must be recorded in the Uncertainty table. If treated as a bias, a correction should be applied to the measured value of SAR; in this case, it is not necessary to record the drift in the Uncertainty budget (that is, $u_i = 0\%$).

The measured SAR drift is dynamic at the EBP during the SAR evaluation and derived as a method. to ensure stable power is applied to the EBP throughout the measurement process. This means that Uncertainty must be established. In **Table O.4** to cover the measured drift of the SAR, the including a value of 5% for the standard uncertainty. The 5% tolerance can be updated to reflect a different value using one of the two methods.

a) As a preferred method, dynamic SAR (single point) measurements should be made with the system SAR measurement within the LET at a user-defined point prior to scanning of area. A secondary measurement must be made with the system at the user defined point after completing the SAR value. The difference between the measured SAR values can be applied dynamically to **Table O.4** for **Measurement** Uncertainty.

b) Alternatively and if the preferred method of a) is not sensitive enough, you can perform measurements to the EBP at the antenna port using equipment capable of measuring the power of RF before the EBP is placed for the SAR test. The user must repeat the measurement of RF power performed after completion of the SAR test. The difference between measurements RF power ratings performed, can be evaluated and used as an update to tolerance in **Table O.4** .

In **Table O.4** , a rectangular probability distribution has been assumed for the Uncertainty of the drift from measured SAR (labeled Power Output Drift).

O.2.3 CONTRIBUTION OF MECHANICAL RESTRICTIONS.

O.2.3.1 SCANNING SYSTEM.

Mechanical restrictions of the field probe positioner can introduce drift in the accuracy and repeatability of probe positioning which increases the SAR uncertainty measured. Uncertainty can be estimated relative to probe positioner specifications relative to the position required by the actual location of the measurement point defined by the geometric center of the field sensors of the probe and is expressed as the maximum deviation d_{ss} . Assuming a rectangular probability distribution, the contributions to the uncertainty of the spatial average peak of the SAR due to probe positioner mechanical constraints, d_{ss} , can be calculated using a first order uncertainty approximation:

If the positioner manufacturer does not specify the mechanical restriction of the probe positioner, this must be evaluated to determine the contribution to the uncertainty of the SAR measurement. This could be easily evaluated by evaluating the relative accuracy of movement in the area of the scatter scanning and converting the differences between the positions specified by the software and those actually achieved in an Uncertainty. The SAR Uncertainty should be entered in column *c* of the **Table O.4** assuming a rectangular probability distribution.

O.2.3.2 UNCERTAINTY OF THE MSH HOUSING.

Uncertainty as a function of the tolerance of the MSH housing is evaluated according to a strongly conservative dependence on distance, that is, dependence on the square of the distance and assuming a distance of a = 5 mm between the LET and the location of the filament equivalent to the density of current (the equivalent current density does not correspond to the closest current source but to the current density approximating the local distributions of the H-field).

O.2.3.4 UNCERTAINTIES OF THE POSITIONER AND THE SUBSCRIBERS OF THE EBP.

O.2.3.4.1 GENERAL.

Because the fastener can influence the characteristics of the EBP, the Uncertainty of the SAR due to the fastener shall be estimated using the procedures in **O.2.3.4.2** . The procedures for SAR uncertainties caused by variations in positioning resulting from mechanical tolerances bra are discussed in **O.2.3.4.3** . Both numerals include procedures for Uncertainties applicable to specific EBP or to predetermined uncertainties. If Uncertainties are used default, in most cases multiple retests can be done for an EBP specifically to further reduce the default standard deviations.

O.2.3.4.2 UNCERTAINTY OF THE DISTURBANCE CAUSED BY THE SUBMISSION HOLDER.

O.2.3.4.2.1 GENERAL.

The EBP holder should be made of low loss dielectric material with a permittivity relative less than 5 and a loss tangent less than 0.05 (these material parameters can be determined, for example, using the coaxial contact probe method). However, some fasteners can still affect the source, so the resulting uncertainty of the fastener (i.e., the deviation compared to an arrangement without the bra) should be estimated. The Uncertainty for an EBP in Specific must be estimated according to the method described in **O.2.3.4.2.2** , which is a Type B method. The method described in **O.2.3.4.2.3** provides a Type A method for evaluating Uncertainty for a group of EBP that have similar SAR characteristics and are tested with the same EBP clip.

The SAR Uncertainty to be used in **Table O.4** is:

Equation (O.15)

Where

SAR_{incert} is the Uncertainty in percentage;

$SAR_{with\ bra}$ is the SAR with the bra of the EBP in W / kg;

$SAR_{without\ bra}$ is the SAR without the EBP clip in W / kg.

O.2.3.4.2.2 UNCERTAINTY OF DISTURBANCE CAUSED BY THE SUBMISSION HOLDER FOR A SPECIFIC EBP: TYPE B.

The Uncertainty for a specific EBP operating with a specific configuration must be estimated by performing the following two tests using an MSH:

a) Evaluate the space-averaged SAR peak ($SAR_{with\ bra}$) by placing the EBP in the bra in the same way it would be held when tested against the body, then position the EBP in direct contact with at MSH (the horizontal and vertical center lines of the EBP should be parallel to the bottom of the MSH);

b) Evaluate the spatial average peak of the SAR ($SAR_{without\ bra}$) by placing the EBP in the same position, but holding it in position using expanded polystyrene or an equivalent material will not reflective and with few losses (permittivity not greater than 1.2 and loss tangent not greater than 10^{-5}).

This uncertainty has been assumed to have a rectangular probability distribution and degrees of freedom.

O.2.3.4.2.3 UNCERTAINTY OF THE DISTURBANCE CAUSED BY THE SUBMISSION HOLDER FOR A SPECIFIC EBP: TYPE A.

A Type A Uncertainty analysis can be applied to a group of EBP that have shapes and similar SAR distributions. The Uncertainty resulting from this analysis can be applied to other EBPs that have similar SAR characteristics and are tested with the same EBP fastener, such that that the specific tests described in **O.2.3.4.2.2** can be avoided. The effect of EBP bra for *N* different EBP models in the different configurations should be estimated by performing the **O.2.3.4.2.2** for each model (*N* must be at least 6), and for each configuration.

The corresponding uncertainty, for **Table O.4** , must be estimated using the quadratic value mean of the individual uncertainties, with degrees of freedom of $v_i = N - 1$.

O.2.3.4.3 EVALUATION OF THE UNCERTAINTY OF THE POSITIONING OF THE EBP REGARDING THE MSH.

O.2.3.4.3.1 GENERAL.

The EBP test positions established by a single test operator using a clamp of EBP may deviate from the exact positions described in **paragraph 5.2.7** of this Provision Technique. SAR Uncertainties due to deviations in EBP positioning may vary by depending on the design of the EBP and the procedures used for a specific bra or by a operator of the test, and these effects are generally inseparable. The procedures of **O.2.3.4.3.2** they can be used to evaluate the individual design of an EBP. The **numeral O.2.3.4.3.3** describes the procedure

applicable for the evaluation of a specific series or group of EBP designs that have the same shape and have substantially equivalent dimensions and were tested using the same EBP fastener. Unless these requirements are met, the procedures in **O.2.3.4.2.3** shall be used to evaluate each device individually. If a predetermined standard deviation for an EBP bra in specific, derived from tests to a specific group of EBP, is applicable, an individual EBP may not require that the test indicated in **O.2.3.4.3.2 be repeated** .

O.2.3.4.3.2 UNCERTAINTY OF THE POSITIONING OF A SPECIFIC EBP IN A EBP FASTENER IN PARTICULAR.

The Uncertainty of positioning a specific EBP in a particular EBP fastener is evaluated by repeating SAR measurements at 1 g and 10 g. This positioning uncertainty should be evaluated using the antenna position, frequency channel, and device position for the mode operational (see **5.2.8**) that produced the highest SAR among all frequency bands. In addition to the original SAR measurement, the EBP must be repositioned and the tests repeated upon minus four times. If it is suspected that the Positioning Uncertainty value is large for a Individual EBP, further testing may be required to reduce the impact on Uncertainty total measurement. Increasing the number of tests will increase the effective degrees of freedom ($v_{efc.}$) And the coverage factor will decrease. The average SAR of the total number of measurements (N) is used to determine the SAR uncertainty according to the standard deviation and the degrees of freedom ($v_i = N - 1$) of the number of tests performed.

O.2.3.4.3.3 UNCERTAINTY OF THE POSITIONING OF SPECIFIC TYPES OF EBP IN A EBP FASTENER IN PARTICULAR.

The positioning uncertainty for a specific group of EBP with the same predominant form and with substantially equivalent dimensions tested with a particular EBP fastener can be evaluated using the following procedures. Tests must include at least six devices, each one evaluated according to the procedures of **O.2.3.4.3.2** (5 tests each). When an EBP has the same substantially equivalent shape, dimensions and characteristics of the SAR, as to satisfy the requirements of the specific EBP group tested using a specific EBP fastener, the Uncertainty of the EBP positioning for this selected group of EBP may be used instead to perform the tests described in **O.2.3.4.3.2** for that particular EBP (default). The SAR uncertainty is reported in the corresponding row and column of **Table O.4** according to power mean of the uncertainties determined for each EBP obtained from the procedures established in **O.2.3.4.3.2** . The degrees of freedom (v_i) are determined according to the number of tests (N) performed on the M devices included in the specific group of EBP, with $v_i = (N \times M) -1$.

Table O.1 - Example of Uncertainty template and example numerical values for the measurement of the relative permittivity () and the conductivity (σ); separate tables may be needed for each and σ.

	to		b	c	d $u_i = (a / b) \times c$	AND
Component Uncertainty	**from Tolerance (±%)**	**Distribution of probability**	**Divisor c_i**		**Uncertainty standard (±%)**	**v_i or $v_{effec.}$**
1 Repeatability of (N repetitions)	5.2	N	one	one	5.20	4
2 Deviation of the value of target reference of ε_r or σ for the LET	3.0	R		one	1.73	4
3 Drift, linearity, etc., network analyzer	0.5	R		one	0.29	∞
4 Cable variations from the test port	0.5	OR		one	0.35	∞
5 Standard uncertainty combined					5.50	5

NOTE The headings in rows 1 through 5 and the headings in columns a through d are for reference.

O.2.4 CONTRIBUTION OF THE PHYSICAL PARAMETERS.

O.2.4.1 GENERAL.

Details of the test methods for dielectric parameters are given in **Annex F** , and the Methods for estimating Uncertainty are given in the referred Annex. The **Appendix K** provides parameters for the 30 MHz to 6 GHz frequency band.

O.2.4.2 LET DENSITY.

LETs are assumed to have a density of 1 000 kg / m3. This density value should be used for SAR evaluations without any associated uncertainty.

O.2.4.3 PERMITABILITY AND CONDUCTIVITY OF THE LET.

The uncertainty due to the conductivity and permittivity of the LET arises from two different sources. The The first source of uncertainty arises from the use of the SAR correction for the dielectric parameters that are within the allowable variation of ± 10% of the target value of **Table 8** (and **Annex J** of this Technical Provision). The second source of uncertainty arises from measurement procedures used to evaluate permittivity and conductivity, this second source of uncertainty is described in this section.

Dielectric properties measurement procedures use vector network analyzers. Network analyzers need calibration in order to account for and remove losses and reflections inherent. The Uncertainty budget for a dielectric measurement derives from inaccuracies in the calibration data, analyzer drift, and random errors. Other possible sources of errors are tolerances on specimen fastener hardware and deviations from optimal dimensions for specified frequencies. This applies regardless of the type of bra in the sample and the nature of the spreading parameters being measured.

Uncertainties due to straight-line fit in the grooved line method can be evaluated using a least squares analysis.

An example of the Uncertainty template is shown in **Table O.1** . All quantities that influence may or may not apply to a test setup or procedure, and other components that are not listed may be relevant in some test arrangements. It may be necessary to consider other possible amounts that influence and are not included in **Table O.1** , such as bubbles or air gaps between probe and sample, frequency interpolations, sensor positioning / dimensional considerations, numerical analysis / data extraction, finite flange effects on the coaxial probe, etc.

The **Table O.1** also includes examples of numerical values. Depending on the test arrangement, Actual estimates of Uncertainty can and should be different from the values shown. Measuring Well characterized reference materials can be used to estimate the uncertainty of the measurement of dielectric property as described in the following procedure.

a) Set up and calibrate the network analyzer in a sufficiently large frequency range around the center frequency of interest, for example 835 MHz ± 100 MHz at five or more frequencies within the DCI transmission band.

b) Measure a reference material at least *n* times to obtain the average and standard deviation of the relative permittivity and conductivity in the center of each DCI band and at frequencies close.

c) For each of the tests performed in **Step b),** perform **Step d)** to **Step h)** .

d) Calculate the repeatability as the standard deviation of the sample divided by the average value. For the permittivity, it is given by:

Equation (O.16)

Where the average value is

Equation (O.17)

Do the same for conductivity.

These equations can be used to derive the temperature uncertainty for the LET in particular. The uncertainty of $_{low}T$ and $_{high}T$ must be less than 0.1 ° C.

O.2.4.5 DISTURBANCE OF THE ENVIRONMENT.

Measurement uncertainties can occur when unwanted environmental RF signals are present during the SAR test. Environmental RF levels are evaluated by making measurements of the SAR using the same arrangement of the equipment used for the EBP test, but with the RF power off. It is possible to avoid checking the RF ambient noise before each SAR test if the Test Lab can demonstrate that any RF source that can influence the peak measurement SAR at 1 g does not exceed 0.012 W / kg.

The **5.2.1** requires the uncertainty due to ambient noise signals RF and Uncertainty due to the effects of RF spreaders is, for each, less than 3% of the limit of lowest detection system. The testing arrangements described in **Annex I** of this Provision Technique, they are used to evaluate the effects of reflections from nearby objects at the site of test. Additionally, environmental RF noise must be determined by performing SAR measurements with all local RF sources turned off. The effects of RF reflections and environmental fields should result in a SAR peak of 1 g less than 0.012 W / kg, which corresponds to 3% of 0.4 W / kg, for provide a sufficient signal-to-noise ratio to meet the low dynamic range of 100 mW / kg specified in this Technical Provision. The SAR Uncertainty must be entered in the row of **Table O.4** for environmental field effects and a distribution can be assumed rectangular probability.

When SAR measurements are made in a controlled environment, such as an anechoic chamber, the effects of environmental RF should be evaluated at least once a year. When SAR measurements are not performed in controlled environments, the effects of environmental RF must be periodically evaluated, at least every 4 months, or when ambient RF conditions change ensuring that any source non-periodic high emission, for example two-way radios, is present in the uncontrolled environment during SAR measurements. In the case of the uncontrolled environment, the Test Laboratory must declare in the Test Report the conformity of the environmental RF and the date of noise verification environmental.

The rationale for evaluating the environmental RF check in uncontrolled environments is that there is no reason to evaluate this Uncertainty contribution prior to any SAR measurement if RF sources can be shown to be far enough away from the location of the monitoring system SAR measurement, even if the measurement system is located in an uncontrolled environment, given the near-field nature of the SAR measurement. Justification on the intervals of calibration described in the standard -NMX-CC-10012-IMNC-2004 "MANAGEMENT SYSTEMS OF MEASUREMENTS-REQUIREMENTS FOR MEASURING PROCESSES AND MEASURING EQUIPMENT "(5) to evaluate the periodicity of the evaluation of the effects of environmental RF on SAR measurements.

O.2.5 POST-PROCESSING CONTRIBUTION.

O.2.5.1 GENERAL.

This numeral describes the estimation of the Uncertainty resulting from the post-processing of the discrete information measured to determine the spatial average peak of the SAR at 1 g and 10 g, that is, the Combined uncertainty of the algorithms for interpolation, extrapolation, averaging, and for finding the maximum. These algorithms can add uncertainty due to general assumptions about the behavior of the fields, and therefore may not perfectly predict the field distribution in the LET for a specific EBP. The uncertainty of the algorithm is a function of the resolution chosen for the measurement and post-processing methods used in scans and area and zoom.

The actual SAR distribution at the peak location is strongly dependent on the frequency of operation and design of the EBP, test position, and proximity to the LET. SAR distributions can have a fairly flat gradient when a low frequency source is at a great distance, or it can have a fairly steep gradient when a small high-frequency source such as an antenna helical is located on one side of the tissue. In some cases, the maximum SAR is not at the surface of the MSH due to the cancellation of the magnetic fields on the surface of this.

The analytical distribution functions of the SAR presented below are intended to simulate these conditions and have been developed for the purpose of this uncertainty estimate. These functions

Reference benchmarks are used to create artificial or "fictitious" SAR data sets to test the system software post-processing subroutines. Calculated values of the reference function with large and small separations between the points of the grid, the same that are used in the measurements are inputs for the SAR system software. The SAR values at the grid points that correspond to the area scan and zoom scan measurement grids are calculated from according to the three SAR distributions given in **O.2.5.2** and processed by interpolation, extrapolation and system integration algorithms as if they were actually being measured. The values The resulting SAR at 1 g and 10 g are compared with the SAR reference values listed in **O.2.5.2** . The procedures for evaluating the SAR uncertainty of the post-processing algorithms in the area and zoom scans are described in **O.2.5.3** . The test functions assume an interface LET-MSH flat. This concept of Uncertainty assumes that there are no errors in the placement of the points of the grid calculated with the analytical distribution functions, and the positioning uncertainties of the probe and measurement are not included.

Post-processing uncertainty should be estimated using a probability function rectangular.

O.2.5.2 EVALUATION OF TEST FUNCTIONS.

Three analytical functions, $f1$, $f2$ and $f3$, are used to represent the possible interval of distributions of the SAR of an EBP tested in accordance with the procedures of this Technical Provision. For the interval frequencies 30 MHz - 3 000 MHz, the function $f1$ is based on the evaluation of SAR levels obtained of actual DCIs. Sets of two parameters are given for $f1$ such that the SAR distributions with one or two maxima they can be evaluated. The function $f2$ is used to consider the conditions of exposure with cancellation of the magnetic field on the surface MSH / LET. For the frequency range above 3 GHz, $f3$ is added to account for the higher attenuations. Since noise can have effects on extrapolation at these frequencies, a noise term is included. The functions of distribution are defined on the surface of the MSH where $z = 0$, and the half-space LET is defined for all z> 0.

a = 20 mm;

A = 1 W / kg;

N_{rms} is the amplitude of the system noise in W / kg at the LET in the absence of an RF signal. East The parameter is system dependent and corresponds to the noise measured within the LET at absence of an RF signal according to **O.2.4.5** . For the evaluation of the function of reference f 3, a value of 0.1 W / kg should be used for N_{rms} .

A value of d = 2.5 mm, for example, provides a lateral shift in the SAR distribution of so that the location of the peak is not aligned with the measurement grid having an increment of 5 mm. This deviation is used to test the subroutines and Uncertainty of the peak search software.

The SAR reference values of the distribution functions f 1, f 2, and f 3 for 1 g and 10 g cubes aligned with the coordinate axes (x, y, z) are given in **Table O.3** . When the function f 1 is considered, the maximum deviation of the reference values obtained considering the cases of a peak or two peaks should be used for post-processing uncertainty calculations. The values of reference are used in the following numerals to test other data processing functions.

Table O.3.- Reference SAR values in Watts per kilogram used to estimate the Post-processing uncertainties

Function	SAR reference value W / kg		Peak case
	1 g cube	10 g bucket	
$f1$	0.791	0.494	A peak
$f1$	0.796	0.503	Two peaks, cube centered on primary peak
$f1$	0.686	0.438	Two peaks, hub centered on secondary peak
$f2$	1,796	1,375	
$f3$	0.157	0.026 8	

O.2.5.3 ASSESSMENTS OF THE UNCERTAINTY OF ALGORITHMS FOR THE DATA PROCESSING.

O.2.5.3.1 AREA SCAN EVALUATION WITH WIDE SEPARATION.

A precondition for the evaluation of the spatial average peak of the SAR with a given Uncertainty is that the location of the maximum exposure can be determined from the scan data area with such precision that the spatial average peak of the SAR is completely contained in the volume zoom scan. In other words, the area scan interpolation algorithms must be capable of locating the locations of SAR peaks with an accuracy equal to or greater than ± L_z / 2 mm, where L_z is the side length of the zoom scan volume. If this precondition is met, which is test with the procedures in this numeral, then the *area scan* evaluation does not contribute to the Uncertainty budget.

The values of the reference functions calculated at the usual points of the area are inputs for the system software. The interpolation algorithm treats this point data

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as if they had been measured to complete the area scan and determine the location of the SAR peak (x_{eval} , y_{eval}). This is compared to the actual location of the peak defined by the analytical functions at (x_{ref} , y_{ref}) = (-2.5, -2.5) mm, when d = 2.5 mm. The subscripts "eval" and "ref" refer to evaluated and reference, respectively. In other words, the following inequalities must be satisfied:

This displacement is considered in the reference functions $f\,1$, $f\,2$ and $f\,3$, defined **O.2.5.2** by incorporating distance d . Since this displacement will vary in practice, the value of d must vary within the range:

Equation (O.26)

where L_c is the length of the side of the cube (10 mm for 1 g, 21.5 mm for 10 g). For each distance d , the Largest uncertainty produced by any of the three functions is recorded. The quadratic value mean of the largest Uncertainty values for various distances d is entered as the Uncertainty due to extrapolation, interpolation and integration.

NOTE Although the requirement for area scanning is that the local SAR peak be located within $| d | \leq L_z / 2$, a smaller interval than that established in equation **O.26.** is used here to ensure that the 1 g and 10 g cube can be calculated on the first try. For values of $(L_z - L_c) / 2 < | d | \leq L_z / 2$, the software of The measurement should note that the 1g or 10g cube is not captured and that the measurement should be retried.

This will not affect the Uncertainty, so it is not necessary to consider this case here.

a) Choose a displacement d for the evaluation of the functions $f1$, $f2$ and $f3$. d must vary from - (L_z - L_c) / 2 to + (L_z - L_c) / 2 in small increments (for example, in 1 mm steps). Must also be varied separately in the x and y *directions* .

b) The SAR values are calculated according to the functions $f1$, $f2$ and $f3$, at the points of the evaluation grid that corresponds to the volume points measured in the zoom scan. The The center of the zoom scan volume should be placed at

where

L_h is the volume height of the zoom scan, and

z_d is the closest measurement point to the inner surface.

c) The calculated SAR values are extrapolated to the surface of the MSH at $z = 0$ by the software of the system to get additional points in zoom scan volume that cannot be measured due to probe restrictions. Both, the calculated and extrapolated data points are then interpolated to a finer resolution with the system software, which subsequently applies the integration algorithms, as well as the search algorithm for find the spatial average peak of the SAR within the zoom scan volume to Determine the highest SAR at 1g or 10g. Other procedures are possible. If the system does not allows the import of SAR values to perform the evaluation, the same algorithm must be implemented independently by other methods to evaluate the algorithms of extrapolation, interpolation and integration.

d) SAR values in 1 g and 10 g determined by the system or by the processing software (SAR_{eval}) are compared with the SAR reference values given in **O.2.5.2** . Deviation standard caused by random noise ($SAR_{desvest}$ (N_{rms})) is determined by evaluating $f3$ at least 100 times, and with each of 100 or more evaluations using different noise parameters random. The SAR uncertainty for the distribution functions $f1$ and $f2$ is calculated using The equation:

Equation (O.27)

The uncertainty for the distribution function $f3$ is calculated using the equation:

Equation (O.28)

e) The highest SAR uncertainty estimated by any of the three functions of distribution.

f) Repeat **Step b)** through **Step d)** for other displacement values d .

g) Calculate the mean square value of the Uncertainties calculated in **Step d)** for each displacement d from above. This value should be entered as the Uncertainty due to the extrapolation, interpolation and integration in the corresponding row and column of **Table O.4** assuming a rectangular probability distribution.

h) Record the following parameters used to estimate the Uncertainty of the zoom scan.

- the dimension of the grid used to sample the reference functions both in terms of the number of sampling points and steps in the three dimensions;
- the number of interpolation points included between the two test points, or the resolution of interpolation in the three directions, for the reference functions;
- the dimension d_{be} of the extrapolation region, that is the distance between the sensor position the probe at the first measurement point and the surface of the MSH (the measurement point is behind the probe tip);
- the interpolation, extrapolation and averaging algorithms used.

The computational conditions (such as the number of grid points, the grid increments, and the number of interpolation points in the three directions) must be the same for all three functions.

O.2.6 TOLERANCE AND DISPLACEMENT OF THE STANDARD SOURCE.

For system validation, the mechanical and electrical tolerances of the standard source affect the resulting SAR spatial peak values. The actual physical construction also deviates from the model numeric on which the target values are based. The resulting deviation and uncertainty can be determined by Type A or Type B evaluations. Type A would involve evaluations with different LETs, probes and MSH. For Type B evaluations, it is necessary to evaluate all experimental parameters or numerically.

O.3 ESTIMATION OF UNCERTAINTY.

O.3.1 COMBINED AND EXPANDED UNCERTAINTIES.

The contributions of each component to the Uncertainty should be recorded with a description, distribution probability, sensitivity coefficient and uncertainty value. A recommended tabular form is shown in **Table O.4** . The combined standard uncertainty u_c should be estimated according to the following formula:

Equation (O.29)

Where:

c_i is the sensitivity coefficient;

u_c is the combined standard uncertainty;

u_i is the standard uncertainty.

The expanded uncertainty U must be estimated using a 95% confidence interval.

O.3.2 MAXIMUM EXPANDED UNCERTAINTY.

The expanded uncertainty with a 95% interval must not exceed 30% for the peak values Average spatial SAR in the range of 0.4 W / kg to 10 W / kg. If the Uncertainty is greater than 30%, the reported data must consider the difference in percentage between the actual uncertainty and 30% of the value target.

Table O.4.- Measurement uncertainty evaluation template for a SAR test of a EBP.

Table O.5.- Measurement uncertainty evaluation template for system validation.

Table O.6.- Measurement uncertainty evaluation template for system repeatability.

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Notes for Tables O.4 to O.6:

NOTE 1 : Column headings *a* - *k* are given for reference.

NOTE 2 : The abbreviations used in **Table O.4** :

N, R, U - normal, rectangular, u-shaped probability distribution functions.

Div.- divisor used to obtain the standard uncertainty.

NOTE 3 : The Uncertainty components indicated in this table are based on procedures and test protocols developed for this document. When protocols and procedures vary, different components of uncertainty can be applied, for example defined parameters to test other MSH arrangements and DCI positions.

NOTE 4 : The divisor is a function of the probability distribution and the degrees of freedom (v_i and v_{effec})

NOTE 5 : c_i is the sensitivity coefficient to be applied to convert the variability of the Uncertainty component in a SAR variability.

NOTE 6 : See **numeral O.1.3,** for discussions on degrees of freedom (v_i) for Uncertainty standard and effective degrees of freedom (v_{effec}) for the expanded uncertainty.

NOTE 7 : *M* in the column of v_i is the number of trials.

NOTE 8 : Some quantities that influence Uncertainty can be estimated from the specification the performance provided by the equipment manufacturer; the uncertainty of certain other components that may vary from test to test may require estimation for each measurement.

NOTE 9: All influencing quantities in this template are applicable for testing of validation of the system except the three items in the group Related to Test Samples where they are replaced by a Dipole group containing two quantities with influence described as: distance between the axis of the dipole and the LET, derives from the input power and the SAR.

NOTE 10 : The measurement repeatability condition is here defined as "measurement condition, obtained from a set of conditions that include the same measurement procedure, the same operators, the same measurement system, the same operating conditions and the same location, and replicated measurements on the same or similar objects in a short period of time "therefore, implicitly emphasizing that a key aspect is that repeatability must include the conditions and components for testing ONLY within a specific Test Laboratory. In this context, The dipole used for system repeatability tests is not part of the measurement system.

ANNEX P

ESTIMATE OF UNCERTAINTY FOR THE TESTS INDICATED IN NUMERAL 5.1.

P.1 GENERAL CONSIDERATIONS.

P.1.1 CONCEPT OF ESTIMATION OF UNCERTAINTY.

Estimating Uncertainty for complex measurements remains a difficult task and requires specialized and high-level engineering knowledge. In order to facilitate this task, this annex provide guidelines and approximation equations, allowing estimation of each component individual of Uncertainty. The concept is designed to provide the system uncertainty for the entire frequency range from 300 MHz to 6 GHz and for any EBP within the range of the numeral **5.1** of this Technical Provision. The Uncertainty Assessment described herein The annex is also designed to be broadly applicable to SAR measurement systems that comply with the requirements of this Technical Provision. However, some measurement systems may require additional analysis of uncertainty. Since Uncertainties take into account a wide DCI range within range, Uncertainty may be overestimated for some components in order not to underestimate the uncertainty of the measurement, but allows approximations, as explained in this annex.

It should be noted that it is insufficient just to provide **Table P.7** without the availability of detailed documentation on the estimation of each influential quantity including its methodology, evaluation of the data for each component, as well as the way in which the uncertainty was derived from the data set.

P.1.2 TYPE A AND TYPE B EVALUATION.

Both Type A and Type B evaluations of standard uncertainty should be employed. The evaluation of uncertainty through statistical analysis of a series of observations is called Evaluation of Type A Uncertainty. The evaluation of Uncertainty by means other than analysis The statistical analysis of a series of observations is called the Type B Uncertainty evaluation. Component of Uncertainty, regardless of how it was evaluated, is represented by a estimated standard deviation, called the standard uncertainty, which is determined by the root positive square of the estimated variance.

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P.1.3 DEGREES OF FREEDOM AND COVERAGE FACTOR.

When the degrees of freedom are less than 30, a coverage factor of 2 is not the multiplier appropriate to achieve 95% confidence level. A simple but only approximate method is to use the Student's *t* probability distribution with *t* instead of coverage factor *k* . The standard deviations of *t* probability distributions are narrower than normal probability distributions (Gaussian), but they approximate a Gaussian distribution when there are a large number of degrees of freedom. The degrees of freedom can be assumed to be infinite for most uncertainties based on Type B evaluations. Then, the effective number of degrees of freedom of the Combined standard uncertainty, u_c , will mostly depend on the degrees of freedom of the Type A contributions and their magnitudes with respect to those of Type B contributions. coverage k_p for a small population must be determined with the following equation:

Equation (P.1)

Where:

k_p	is the coverage factor for a given probability *p* ;
$t_p(v_{effec})$	is the *t* distribution ;
v_{effec}	is the effective number of degrees of freedom estimated using Welch's equation-Satterthwaite:

Equation (P.2)

c_i is the sensitivity coefficient of each component of Uncertainty u_i;

v_i is the number of degrees of freedom for each component of the Uncertainty u_i.

The subscript *p* refers to the approximate level of confidence, for example 95%.

NOTE As an example, the standard uncertainty combined using the equation of Welch-Satterthwaite from all the influencing quantities indicated in **Table P.7** (Column *h*) is u_c = 13.9% assuming 6.0% and 5.0% tolerances for positioning and fastener. From the equation above and **Table P.7** , Columns *f* , *h* and *k* , the effective degrees of freedom for the standard uncertainty combined v_{effec} = 136 so k = 2 applies in this case, and the expanded uncertainty is U = 2 × 13.9% = 27.8 %. To illustrate the effect of variations in specific components, an extreme example is with Uncertainties of 22% and 15% for variations in positioning and fastener, respectively, with degrees of freedom equal to 5 for each (v_i = 5). Then, u_c = 25, k = k_p = K95 = t = t95≈$t95_{,}$ 45 = 2.11, and the Expanded uncertainty U = 2.11 × 29.0% = 61.2%.

P.2 COMPONENTS THAT CONTRIBUTE TO UNCERTAINTY.

P.2.1 GENERAL.

Each frequency dependent component of uncertainty must be evaluated in the frequencies in which the SAR evaluation will be carried out. For modes of operation with an interval of determined frequency, the Uncertainty contribution is the highest value found in that interval frequencies.

P.2.2 CALIBRATION OF THE PROBES FOR SAR.

P.2.2.1 GENERAL.

In **Annex E** of this Technical Provision, a protocol is established for the evaluation of the calibration coefficients of the probes for SAR and for estimating Uncertainty. The

Uncertainty of probe sensitivity should be estimated assuming a probability distribution normal.

P.2.2.2 ISOTROPY OF THE PROBE.

The isotropy of the electric field probe is a measure of the deviation in the probe's response to an arbitrary polarization of the field. In general, the fields emitted by a Handset are polarized according to arbitrary shape. However, induced fields in LET have a predominant component of polarization that is parallel to the surface of the MAC, due to the physics of the absorption mechanism. The Uncertainty hemispherical isotropy (or $_{isotropía\_hemisférica}$) is related to the arbitrary polarization field (includes the Uncertainty of the axial isotropy), and the Uncertainty of the axial isotropy is related to fields normal to the probe axis.

The isotropy of the probe must be measured according to the protocol defined in **Annex E** of this Technical provision. The uncertainty a due to isotropy (or $_{isotropy}$) must be estimated with a distribution of rectangular probability given by the following equation:

The reference power level P_{ref} should be chosen in such a way that the signal-to-noise ratio (determined at the time of measurement) is 6 dB. This should be verified using the data from the power sweep. In **Table P.7** , **Table P.8** and **Table P.9** a probability distribution must be assumed Rectangular for the Uncertainty of the probe's detection limit.

P.2.2.4 RESPONSE OF THE PROBE TO MODULATION.

The responses of the probe's sensors, based on detector diodes, to modulated signals can be complex since detector diodes are primarily non-linear elements. The parameters of linearization for a particular modulation should be determined by an experimental calibration relative, that is, power sweep with a particular modulation, as described in **E.2** . The linearization parameters must be determined separately for each sensor.

The following uncertainty can be determined using any source (for example, a waveguide or a dipole) with an arrangement equivalent to that described in **Figure D.1** . The arrangement for the generation of signal must simulate the modulation for which the uncertainty is determined according to the specification of the communication system standard. The power must be increased until the sensor of the probe an equivalent voltage from less than P 0 = 0.1 W / kg to the equivalent of greater than 10 W / kg for the investigated sensor, in steps of 5 dB. At each power level, the SAR should be measured with the modulated signal and with OC at the same RMS power (verification is required that the power meter use a true RMS detector and that the amplifier is linear enough for all the dynamics of the signal). This procedure must be repeated for each field sensor.

P.2.2.5 BORDER EFFECT.

The boundary effect of the probe introduces uncertainty in the measurement. For the purposes of this standard, this uncertainty is negligible if the minimum distance between the probe tip and the surface The interior of the MAC is always greater than the diameter of the probe tip.

In some cases, the probe may be required to measure at distances less than one diameter of the probe tip, in order to reduce the uncertainty of interpolation and extrapolation. So, The uncertainty of the border effect of numeral E.6 should preferably be evaluated using the system of waveguide described in **E.3.2.3.3** . Alternatively, the temperature method described in **E.3.2.3.2** can be used at frequencies below 800 MHz. The method described below is valid assuming the The angle between the probe axis and the line normal to the surface is within the requirements of **Table 5** and the **Table 6** . Since the boundary effect is a specific characteristic of the probe, it must be determined during probe calibration (i.e. influence of probe tip diameter). If they apply algorithms to compensate for the boundary effect, then the SAR uncertainty must be determined with the same hardware and software evaluation used for the development of SAR measurements. The Uncertainty of the border effect can be estimated according to the approximation equation of the Uncertainty shown below, which is based on linear and exponential extrapolations between the surface and $d_{be} + d_{step}$ along lines that are approximately normal to the surface:

If waveguide systems are not available for certain frequency ranges, temperature probes should be used to evaluate the reference values SAR_{ref} on placements d_{be} y ($d_{be} + d_{step}$), and the Uncertainty of the SAR of the temperature probe must be taken into account. Yes temperature methods are used, then SAR_{ref} is the value at that location determined using the temperature probe. Note that the calibration itself must be performed at distances greater than a diameter of the probe between the probe tip and the boundary, where the boundary effect is negligible. Enter the Uncertainty of the probe boundary effect in the appropriate row and column in **Table P.7** , **Table P.8** , and **Table P.9** using a rectangular probability distribution.

P.2.2.6 UNCERTAINTY OF THE FIELD PROBE MEASUREMENT ELECTRONICS.

All uncertainties related to the measurement electronics of the probes, including the gain and linearity of the instrumentation amplifier, its loading effect on the probe, and the accuracy of the signal converter algorithm, must be evaluated to estimate the maximum SAR uncertainty. A method to determine these components of uncertainty is to replace the probe with an equivalent source that has the same source impedance as the probe under consideration, according to the specification of the probe manufacturer. This is usually done by the system manufacturer. Each Uncertainty must converted to a standard uncertainty using a rectangular probability distribution. Thus, the root value of the sum of squares of these uncertainties should be used to determine the Total uncertainty of the measurement electronics.

P.2.2.7 UNCERTAINTY OF THE RESPONSE TIME TO A STEP SIGNAL.

The uncertainty of the response time to a signal from the field probe is evaluated by exposing the probe to an electric field step producing at least 100 W / kg SAR near the surface of the MAC. The response time to the signal is evaluated as the time that the probe and its electronics of measurement to reach 90% of the expected final value produced by the step response through the RF power on and off. During the SAR measurement, the probe must remain stationary at each measurement location for at least twice the time resulting from the evaluation of the response time, the above so that the uncertainty of the response time of the probe to a signal be despicable. Under these measurement conditions, a zero tolerance value can be entered into the Appropriate uncertainty table. Otherwise, the SAR uncertainty due to response time to a signal must be evaluated, using the signal characteristics of the EBP. In this case, the Uncertainty of the response time to a step signal is equal to the percentage difference between the SAR measured in a chosen measurement point in time and the SAR measured at twice the time of the chosen measurement point previously. A rectangular probability distribution must be assumed.

P.2.2.8 UNCERTAINTY OF THE PROBE INTEGRATION TIME.

P.2.2.8.1 GENERAL.

Probe integration time uncertainties can arise when EBPs do not emit a continuous signal. When the integration time and discrete sampling intervals used in the probe electronics are not synchronized with the pulsating characteristics of the measured signal, the RF energy at each measurement location may not be captured correctly. This uncertainty It must be evaluated according to the characteristics of the EBP signal before performing the SAR measurement.

P.2.2.8.2 UNCERTAINTY OF THE INTEGRATION TIME OF THE SIGNAL PROBE NEWSPAPERS.

For signals with pulsed periodic modulation and with a pulse period greater than 1% of the probe integration, additional SAR uncertainties should be considered when the Probe integration is not an exact multiple of the maximum periodicity. Uncertainty must be evaluated according to the maximum expected uncertainty for an unsynchronized probe integration time assuming a rectangular probability distribution. For a signal with an envelope $s(t)$, the signal average measured by the probe during the integration time t_{int} starting at time t0 is given by $s_{int}(t0, t_{int})$ in the following equation:

The above equation is an approximation that typically overestimates the Uncertainty; where, $_{idle}\,slot$ is the number of idle slots in a frame with $_{total}\,slot$ being the total number of slots. t_{frame} is the duration of the frame, with $t_{frame} < t_{int}$. The total uncertainty of the probe integration time is the sum of the errors for all subframes in the frame structure that has idle slots. By For example, the basic frame for a GSM system has a frame duration of t_{frame} = 4.6 ms, with 7 slots idle in an 8-slot frame, and the duration of a multiframe is $t_{multiframe}$ = 120 ms, 1 idle slot in a frame with 26 slots. For an integration time of 0.2 s, the Uncertainty is estimated to be 0.0201 + 0.0231 = 0.0432 or 4.32% for GSM using the alternative equation, compared to 3.84% using the other two equations. In the case of GPRS, it is considered the same as GSM, except that the number of idle slots can be 6, 5, ..., where 7 idle frames is the worst case.

For the uncertainty of the probe integration time, a distribution of rectangular probability. For continuous or OC equivalent signals, a value of Zero uncertainty.

P.2.2.8.3 UNCERTAINTY OF THE PROBE INTEGRATION TIME FOR SIGNALS NO NEWSPAPERS.

For signals other than the periodic pulsating, the probe integration time must determined from SAR measurements using a stable source with the same signal characteristics and the same type of probe that is used for EBP measurements. Measurements must be made consecutive at a single point (where the SAR is at least 1 W / kg) using the chosen integration time and progressively longer integration times. For the probe integration time, you must assume a rectangular probability distribution. Uncertainty is the difference in percentage between the Average SAR at a given integration time and the average SAR at maximum integration time.

P.2.3 CONTRIBUTION OF MECHANICAL RESTRICTIONS.

P.2.3.1 MECHANICAL TOLERANCES OF THE PROBE POSITIONERS (DIRECTIONS PARALLELS TO THE SURFACE OF THE MAC).

Mechanical tolerances of the field probe positioner can introduce deviations in the accuracy and repeatability of probe positioning which adds uncertainty to the measured SAR. The Uncertainty can be estimated with respect to the specifications of the probe positioner relative to the position required by the actual measurement location defined by the geometric center of the sensors of the field probe and is expressed as the maximum deviation d_{ss} . Assuming a probability distribution rectangular, the Uncertainty contributions to the spatial average peak of the SAR due to the tolerances Probe positioner mechanics can be calculated using d_{ss} according to an approximation of the first order error:

Where *d* is the maximum tolerance of the shell thickness and the shape of the MAC. The term

is defined as the absolute value of the real permittivity of the shell minus 4 multiplied with the 5% uncertainty evaluated when the permittivity deviates by 1.

The SAR Uncertainty for MAC Production Uncertainty should be entered in the row corresponding to **Table P.7** , **Table P.8** , and **Table P.9** , likewise a distribution of rectangular probability.

P.2.5 UNCERTAINTIES OF THE BRA AND THE POSITIONING OF THE EBP.

P.2.5.1 GENERAL.

A device holder is used to maintain the test position of the Handset against the MAC during SAR measurement. Because the EBP fastener can influence the characteristics of the Handset under test, SAR uncertainty due to fastener disturbances must be estimated using the procedures indicated in **P.2.5.2** . Procedures for SAR Uncertainties due to Variations in positioning resulting from mechanical uncertainties of the clamping device are explained in **P.2.5.3** . The aforementioned parts of **Annex P** include procedures for INN in particular and predetermined uncertainties. If the predetermined uncertainties are used, in the In most cases, multiple retests are necessary for a specific DCI in order to further reduce the default standard deviation.

P.2.5.2 UNCERTAINTY OF THE DISTURBANCE OF THE EBP FASTENER.

P.2.5.2.1 GENERAL.

The device holder should be made of low loss dielectric material with a tangent of losses ≤0.05 and Relative permittivity ≤5 (these parameters of the materials can be determined, by example, using the coaxial contact probe method). However, some bras still can affect the source, so the resulting uncertainty of the fastener (i.e. the deviation regarding an arrangement without the bra) should be estimated. The Uncertainty of the fastener of the device for Evaluating a specific EBP must be estimated according to the Type B method described below.

Alternatively, the Type A method described below can also be used to assess the Uncertainty for a group of Handsets that have similar SAR characteristics and that are evaluated with the same EBP bra.

P.2.5.2.2 UNCERTAINTY OF THE DISTURBANCE OF THE EBP FASTENER FOR AN EBP IN SPECIFIC: TYPE B.

The Uncertainty for a specific Handset operating in a particular EBP clamp must be estimated by performing the following two tests using an MSH:

a) Evaluation of the spatial average peak of the $SAR_{w\,/\,fastener}$ of 1 g and 10 g of mass by placing the EBP in the bra in the bra in the same way it would be held when it was evaluated next to the head, then place the Handset in direct contact with the MSH (the horizontal and vertical line center of the Handset must be parallel to the bottom of the MSH);

b) Evaluation of the spatial average peak of the $SAR_{w\,/}$ 10 g mass $_{fastener}$ by placing the EBP in the same position as in **a)** but held in position using foam polystyrene or a material with low losses and equivalent non-reflective (the permittivity must not be greater than 1.2 and the Loss tangent should not be greater than 10 - 5).

The SAR Uncertainty to be used in **Table P.7** is:

Equation (P.16)

where

SAR_{incert}	is the Uncertainty in percentage;
$SAR_{w\,/\,bra}$	is the SAR with the bra of the EBP in W / kg;
$SAR\ without_{bra}$	is the SAR without the EBP clip in W / kg.

This uncertainty has assumed a rectangular probability distribution and $v_i = \infty$ degrees of freedom.

P.2.5.2.3 UNCERTAINTY OF THE DISTURBANCE OF THE EBP FASTENER FOR AN EBP IN SPECIFIC: TYPE A.

The Uncertainty data of the disturbance of a specific EBP fastener evaluated from according to the Type B method described above for a group of Handsets with the same shape and with Substantially equivalent SAR distribution characteristics should be compiled statistically and applied to selected groups of ICDs evaluated in the same EBP bra and with the same settings. Statistical procedures must include at least 6 INNs, each of them evaluated according to the Type B method described above. The more Handsets they have similar SAR characteristics, are evaluated with the same EBP clip, the disturbance error can be included in a Type A Uncertainty analysis and applied to future SAR assessments with DCI configurations and similar fasteners. Increasing the number of test DCIs will increase the degrees of freedom (v_i) and the coverage factor (k_p) will decrease . The coverage factor (k_p) for such conditions must be determined as $k_p = t_p\,(v_{effec})$ where t_p (v_{effec}) is the coverage factor of a distribution of probability t , and v_{effec} is the effective number of degrees of freedom estimated using the equation Welch-Satterthwaite (equation **P.2**)

The effect of the EBP fastener for N different models of Handsets in the different configurations must be estimated by performing the tests according to the Type B method described above for each model (N must be at least 6).

P.2.5.3 UNCERTAINTY OF HANDSET POSITIONING WITH AN EBP FASTENER IN SPECIFIC: TYPE A.

P.2.5.3.1 GENERAL.

The deviation of the actual position of the Handset from the positions described in section **5.1.7.4** of the present Technical Provision, depend on the precision of the Handset positioner as well as the interpretation and management of the person conducting the evaluation. Additionally, the magnitude of this deviation in the values of the spatial average peak of the SAR depends on the design of the Handset. Given the These parameters cannot be separated, the following Type A tests, described below, must be done.

P.2.5.3.2 UNCERTAINTY OF THE POSITIONING OF A SPECIFIC HANDSET IN A EBP FASTENER IN SPECIFIC.

The Uncertainty of the positioning of a specific Handset evaluated in an EBP holder in Specific is evaluated by repeating the measurements of the spatial average peak of the SAR in 1 g or 10 g of mass. This positioning uncertainty should be evaluated using the position of the antenna, channel of frequency, and DCI position for the mode of operation that produces the highest SAR of all frequency bands. In addition to the original SAR measurement, the Handset must be repositioned and the test must be repeated at least 4 times. This minimum of five tests is sufficient to establish a value reasonable for degrees of freedom. If it is suspected that the positioning uncertainty for a DCI in particular will be large, further testing may be necessary to reduce the impact on the Total measurement uncertainty. Increasing the number of tests will increase the degrees of freedom effective (v_{effec}) and the coverage factor will decrease. The average SAR for the total number of measurements (N) is used to determine the SAR Uncertainty according to the standard deviation and degrees of freedom ($v_i = N\text{-}1$) of the number of tests performed.

P.2.5.3.3 UNCERTAINTY OF THE POSITIONING OF SPECIFIC TYPES OF HANDSETS IN A FASTENER OF THE EBP IN SPECIFIC.

A Type A Uncertainty analysis can be applied to a group of Handsets with predominantly the same shape and distributions of the SAR and substantially equivalent dimensions. The tests must include at least six INNs, each evaluated according to the procedures for a Handset in specific in a specific EBP bra described above. The number of tests *n* must be at minus 5, and each of the *n* tests must be performed for all *M* ICDs. Half of the *n* tests must

be in the cheek position and the other half in the bow position. The corresponding uncertainty must It is estimated using the root mean square of the deviations from the standard DCI M . The value to be entered in the Uncertainty table should be the standard Uncertainty with $k = 1$. The degrees of freedom are determined according to the total number of tests $N = n \times M$. For M INNs included in the specific group of Handsets, $v_i = N\text{-}1$. If this procedure is applied to determine Uncertainty, it may be unnecessary apply the procedures for a specific Handset to a specific EBP bra described above for individual Handsets. The database must be updated annually in order to Consider changes to the Handset design.

P.2.6 UNCERTAINTY OF THE LET PARAMETERS.

P.2.6.1 GENERAL.

The details of the test methods for the dielectric parameters are indicated in **Annex F** of the

This Technical Provision, and the methods for estimating its Uncertainty are indicated in **P.2.6.5** .

In accordance with usual metrological practices, it is required that the measurement uncertainty to each of the measured dielectric parameters is less than or equal to the allowable variations (see numeral **5.1.7.1**) with respect to the target values of dielectric parameters.

P.2.6.2 LET DENSITY.

The electromagnetic parameters of LETs are assumed to have a density of 1 000 kg / m3. Is density should be used for SAR evaluations. To calculate the SAR from the distribution of the electric field measured by the dosimetric probe, the density of the LET is merely a parameter numerical which is not related to the real density of the LET. Therefore, it is not necessary to associate a Uncertainty.

P.2.6.3 UNCERTAINTY OF THE CONDUCTIVITY OF THE LET.

The uncertainty due to the conductivity of the LET comes from two different sources. The first source Uncertainty is the allowable tolerance with respect to the target value in **Table 4** and the second source of Uncertainty comes from the measurement procedures used to evaluate conductivity. The Uncertainty a normal probability distribution must be estimated. See **5.1.7.1** for the applicable tolerances and corrections of the dielectric properties of the LET. The following should be used Equation to correct for deviations in conductivity in SAR measurements:

P.2.6.4 UNCERTAINTY OF THE LET'S PERMIT.

The Uncertainty due to the relative permittivity of the LET comes from two different sources. The first Source of Uncertainty is the allowable tolerance with respect to the target value from **Table 4** and the second source Uncertainty comes from the measurement procedures used to evaluate relative permittivity. Uncertainty must be estimated from a normal probability distribution. See **5.1.7.1** for the applicable tolerances and corrections of the dielectric properties of the LET. The equation should be used **P.17** to correct for deviations in permittivity in SAR measurements:

P.2.6.5 UNCERTAINTIES OF THE EVALUATION OF THE DIELECTRIC PARAMETERS OF THE LET.

The measurement procedures described in **Annex F** of this Technical Provision use vector network analyzers for measurements of dielectric properties. Analyzers Networks require calibration in order to consider and remove inherent losses and reflections. The Uncertainty budget for dielectric measurements derives from inaccuracies in the

calibration, analyzer drift, and random errors. Other sources of errors are the uncertainties of the EBP fastener hardware, and deviations from optimal dimensions for frequencies specified, and the properties of the sample. This applies regardless of the type of bra EBP and the nature of the dispersion parameters analyzed. The uncertainties due to the Straight-line fit on the scored line can be evaluated using least squares analysis.

An example Uncertainty template is shown in **Table P.1** . All the quantities they have influence may or may not apply to a particular test procedure or arrangement, and other components not listed may be relevant in some test arrays. Reference LET measurement ok characterized can be used to estimate the uncertainty of the measurement of dielectric properties, as described in the procedure below.

a) Configure and calibrate the network analyzer in a frequency range (*span*) sufficiently large around the center frequency of interest, of the LET used in the SAR measurement.

b) Measure a reference material.

c) Repeat **Step a)** and **Step b)** at least *n* times (where *n* is at least 3 and it is enough of such so that the measurements have stabilized). *n* must be large enough to hold the repeatability in **Step d)** within the applicable tolerances as specified in the numeral **5.1.7.1** of this Technical Provision in all frequencies of interest. Perform the measurements at the same LET temperature at which the target dielectric properties of reference are known. At each frequency, perform **Step d)** through **Step g)** .

d) Calculate the repeatability as the standard deviation of the sample divided by the value of the mean. For permittivity, this is given by the following equation:

f) Enter the deviation in Row 2, Column *a* , of **Table P.1** . The number of degrees of freedom $v_i = n-1$ is entered in Column *e* . Do the same for conductivity.

g) Estimate the Type B Uncertainties for the other components of **Table P.1** (and other components relevant if necessary) in the frequency range under consideration.

h) Determine the combined standard uncertainty as the *root of the sum of squares* of the Uncertainty components of **Step d)** , **Step e)** and **Step f)** . Enter this value in Row 5, Column *d* of **Table P.1** .

i) For Relative Permitivity, choose the frequency that gives the largest value for Uncertainty combined standard from **Step g)** . Record this uncertainty and the degrees of freedom corresponding v_i in the appropriate Row of **Table P.7** , **Table P.8** , and **Table P.9** . Do the same for conductivity.

Using this approximation, the measurement uncertainty is lower, because this correction eliminates the need for elements of uncertainty that take into account the deviation of the parameters dielectric to targets. Instead, there is an Uncertainty item that takes into account the correction equation error. The value of this Uncertainty item is given in **Table P.2** . To ± 10% deviation in permittivity and conductivity, enter 1.9% and 1.6% in the Uncertainty budget for the spatial average peak of the SAR at 10 g. These Uncertainty values must be entered in the rows appropriate from **Table P.7** , **Table P.8** and **Table P.9** , where a normal probability distribution is assumed.

P.2.8 DRIFT OF MEASURED SAR.

The drift of the EBP SAR measurement is taken into account with the first and last step of the process defined in section **5.1.9.1** by using the following two methods:

a) As a preferred method, the SAR measurement system performs SAR measurements in a single point before performing the area scan. A secondary measurement is performed by the system at the same point after completing the SAR measurement. The measurement is performed within the LET at the reference point where the primary and secondary SAR measurement values exceed the lower limit of detection of the measurement system. The distance from the reference point to the inner surface of the MAC, in the direction normal to the inner surface of the MAC, must be less than or equal to 10 mm.

b) Alternatively, and if the preferred method **a)** is not sensitive enough, measurements of Conducted power can be performed on the DCI at the antenna port using equipment capable of measure RF power before placing the DCI in position for SAR testing. It Must be done a secondary RF power measurement after SAR testing has been completed.

In any case, the Drift is recorded as the difference in percentage of the secondary measurement of reference $Ref_{secondary}$ (SAR or power driven), and primary reference measurement, $Ref_{primary}$:

Equation (P.23)

Commercial handsets should have SAR Drifts within ± 5%. Some devices may have significant fluctuations in output power that are not classifiable as Undesirable Drift in power if not they are a characteristic of the normal operating behavior of the DCI. In this case, other methods such as SAR escalation should be considered to ensure that a SAR is obtained accurate and conservative.

If the SAR Drift cannot meet the 5% threshold while the SAR tests are being performed as stated in **5.1.9.1** , then a Drift measurement should be performed for the longest run time. Assessment measurement provided without recharging the battery. This is achieved by performing a measurement according to to method **a)** or **b)** above, continuously during the evaluation time (at least once every 5 s). This time-swept measurement must be made in each frequency band for the operation that has maximum time-averaged output power. If the difference between the maximum and the minimum in the time sweep is less than 5% of the average value, or if the difference is less than 10% and SAR primarily decreases during the time sweep (does not increase by more than 2% in any instant during time sweep), it is sufficient to perform reference measurements at the beginning of the scan area and at the end of the last zoom scan, as described in **Step d)** and **Step e)** of numeral **5.1.9.1** . Otherwise, additional reference measurements must be taken during the zoom scan, and Zoom scan measurements should be corrected prior to extrapolation, integration, and average. Before correction, a linear interpolation is performed between the reference measurements. The SAR values measured during the zoom scan should be corrected by the difference between the interpolated values and the first reference value measured before the area scan. The time between Reference measurements during the zoom scan should be small enough such that the time sweep curve correction described above is conservative for all points.

If the SAR Drift is within 5%, then it can be treated as either an Uncertainty (it is i.e. a random error) or as a systematic shift. If the Drift is greater than 5%, the Drift of the Measurement should be viewed more as a systematic shift than as an Uncertainty.

If it is treated as an Uncertainty, record the absolute value of the Drift in the Uncertainty table. No

Add the Drift to the value of the evaluated SAR. The value of Uncertainty reported in the budget of Uncertainty should correspond to the maximum reported SAR measurement drift, or the maximum allowed (5%).

If it is treated as a systematic displacement, apply compensation to the measured SAR, that is, add the absolute difference to the SAR value determined if the Drift is positive or negative.

Equation (P.24)

In this case, it is not necessary to record the Drift in the Uncertainty budget. .
To maintain a conservative value of the resulting SAR, Drifts should not be subtracted from the evaluated SAR. Yes Different DCI operating modes evaluated exhibit different Drift ratios, all Corresponding measured SAR values should be compensated with the same ratio, provided that the proportion of the drift applied is the maximum detected during the SAR assessment in all modes operation of the DCI. Uncertainty must be estimated assuming a probability distribution rectangular.

P.2.9 RF ENVIRONMENTAL CONDITIONS.

The effects of environmental RF on measurement uncertainties should be evaluated. The environmental level The RF signal is evaluated by performing SAR measurements using the same equipment arrangement as that used to test the EBP, but with the RF power turned off. For the average 10-g mass, the SAR due to of the ambient RF should be less than or equal to 0.012 W / kg (i.e. 3% of 0.4 W / kg).

It is not necessary to check the RF ambient noise before each SAR test as long as the LP can demonstrate that there are no new RF sources.

The test configurations described in numeral **D.2** of this Technical Provision are used to evaluate the effects of reflections from nearby objects at the test site. The total amount of reflections must meet the requirements of paragraph **5.1.1** . Additionally, the noise Environmental RF should be determined by performing a SAR measurement with all local RF sources. turned off. The allowable variation must be within ± 3% of 0.4 W / kg and the Uncertainty must be estimated assuming a rectangular probability distribution.

When SAR measurements are made in a controlled environment, such as an anechoic chamber, the effects of environmental RF should be evaluated at least once a year. Otherwise, the effects of Environmental RF should be evaluated before any SAR measurements are made to the DCI, and the conditions Environmental conditions should be monitored during measurement in such a way that any significant source of RF, for example, a two-way radio, do not affect SAR measurements. The rationale for evaluating the verification of uncontrolled environmental RF is that there is no reason to evaluate this contribution of Uncertainty prior to any SAR measurement whether it can be shown that RF sources are as far enough away from the location of the SAR measurement system, even if the measurement system It is located in an uncontrolled environment, given the near-field nature of the SAR measurement.

P.2.10 POST-PROCESSING CONTRIBUTION.

P.2.10.1 GENERAL.

Numeral **P.2.10** describes the estimation of the uncertainty resulting from the post-processing of the data discretes measured to determine the spatial average peak of the SAR at 1g or 10g, that is, the Uncertainty Combined interpolation, extrapolation, average and maximum algorithms. These algorithms can add uncertainty due to general field behavior assumptions, and therefore therefore they may not perfectly predict the distribution of the SAR in the LET for a Handset in specific. The uncertainty of the algorithm is a function of the resolution chosen for the measurement and the post-processing methods used in area scan and zoom scan.

The actual SAR distribution at the peak location is strongly dependent on the frequency of Handset design and operation, test position, and proximity to the LET. The SAR distributions can have both a flat gradient when a low frequency source is far away as a steep gradient when a small high frequency source such as a propeller antenna is placed near the LET. In some cases, the maximum SAR is not on the surface of the MAC due to the cancellation of magnetic fields on the surface.

The SAR analytical distribution functions shown below are intended to simulate these conditions and were developed for the purpose of this uncertainty estimate. These functions empirically derived benchmarks are used to create auxiliary SAR data sets for test the subroutines of the system post-processing software. Values calculated with the function of reference with small and large gaps at the points of the grid, the same as those used in the measurements are entered into the SAR system software. SAR values are calculated at points on the grids that correspond to the area scan and zoom scan measurement grids according to the three SAR distribution functions given in **P.2.10.2** and processed by the interpolation algorithms, extrapolation, and integration as if they were actually measured. The resulting values of the average peak spatial SAR at 1 g or 10 g are compared to the SAR reference values listed in **P.2.10.2** . The procedures for evaluating the SAR uncertainty of the post-processing algorithms of the area and zoom scans are indicated on **P.2.10.3** . The test functions assume a LET and interface of the Flat MAC. The applicability of these functions for curved interfaces is discussed in **P.2.10.4** . This concept Uncertainty assumes that there are no errors in the location of the grid points calculated with the analytical distribution functions, and does not include the uncertainties of probe positioning or the measurement.

P.2.10.2 REVIEW OF TEST FUNCTIONS.

Three analytical functions *f1, f2* and *f3 are used* to represent the possible range of distributions of the Expected SAR for Handsets tested according to the procedures of this Technical Provision. A distribution, *f* 1, is based on the evaluation of actual DCI SAR fingerprints and is applicable for frequencies up to 2 GHz. Since *f* 1 takes into account DCIs placed in close proximity of the MAC to frequencies above 900 MHz, *f* 1 is also used to model very steep SAR gradients. Two sets of parameters are given for *f* 1 such that the SAR distributions with one or two maximums can be evaluated. The *f2* function is used at frequencies up to 3 GHz to consider the

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exposure conditions with the cancellation of the magnetic field on the MAC-LET surface. A third reference function *f3* is defined to test in the frequency range 3 GHz to 6 GHz. Given Since noise can affect extrapolation at these frequencies, a term for noise is included. The distribution functions are defined for the surface of the MAC at $z = 0$ and for the half space of the middle of LET for all z> 0 in the equation below:

In the equations for *f1, f2,* and *f3* , the parameters are set as follows:

$$x' = x + d$$

$$y' = y + d$$

Where is the offset parameter,

a = 20 mm;

A = 1 W / kg.

The above parameters *A* and *a* only apply to the equations of *f1, f2* and *f3* . These parameters do not have another meaning in particular rather than for the generation of appropriate SAR distributions. A value of d = 2.5 mm, for example, provides a lateral offset of the SAR such that the location of the peak it is not aligned with a measurement grid that has a 5mm increment. This offset is used to test the Uncertainty and subroutines of the peak search software. N_{rms} represents the variance system noise (in W / kg) at the LET in the absence of an RF signal. However, for purposes analytical, a fixed value of N_{rms} should be used . For the evaluation of the reference function *f3* , one must use N_{rms} = 0.1 W / kg, corresponding to a signal-to-noise ratio of $10 \log10 (A / N_{rms})$ = 10 dB in the location of the spatial average peak of the SAR. rnd () is a function that returns random numbers

normally distributed at each point on the measurement grid. rnd () has a mean of zero and a standard deviation of 1. Appropriate functions are available in typical mathematical applications. The variable is an arbitrary seed.

The SAR reference values obtained from the distribution functions *f1, f2,* and *f3* for 10-g cubes aligned with the coordinate axes (*x, y, z*) are indicated in **a)** through **e)** below. These SAR values they were calculated with an accuracy of 0.01%.

a) SAR_{ref} = (f1) 1_g = 0.791 W / kg, SAR_{ref} = (f1) 10_g = 0.494 W / kg; for the case of a single peak;

b) SAR_{ref} = (f1) 1_g = 0.796 W / kg, SAR_{ref} = (f1) 10_g = 0.503 W / kg; for the case of two peaks, centered cube in the primary peak;

c) SAR_{ref} = (f1) 1_g = 0.686 W / kg, SAR_{ref} = (f1) 10_g = 0.438 W / kg; for the case of two peaks; centered cube in the secondary peak;

d) SAR $_{ref}$ = (f2) 1 $_g$ = 1.796 W / kg, SAR $_{ref}$ = (f2) 10 $_g$ = .375 W / kg;

e) SAR $_{ref}$ = (f3) 1 $_g$ = 0.157 W / kg, SAR $_{ref}$ = (f3) 10 $_g$ = 0.0268 W / kg.

When the function *f1* is considered, the maximum deviation obtained with respect to the reference values considering the cases of one and two peaks, it should be used for calculations of the uncertainty of the post-processing.

These reference values are used in the following paragraphs to test the algorithms of post-processing used by area and zoom scans.

P.2.10.3 EVALUATIONS OF THE UNCERTAINTY OF THE PROCESSING ALGORITHM OF DATA.

P.2.10.3.1 AREA SCAN EVALUATION WITH WIDE SEPARATION.

Area scan interpolation algorithms must be able to locate the coordinates of the SAR spatial average peak with an accuracy of ± L $_z$ / 2 mm or better, where L $_z$ is the length of the side of the zoom scan volume. If this precondition is met, which is evaluated with the procedures of **P.2.10.3.1** , the area scan evaluation does not contribute to the Uncertainty budget.

The reference functions calculated at the usual points of the area scan grid are data input for the system software. The interpolation algorithm treats this point data as if were measured to complete the area scan and determine the location of the spatial average peak of the SAR (x $_{eval}$, y $_{eval}$). This is compared to the actual location of the peak defined by the analytical functions at (x $_{ref}$, and $_{ref}$), with a displacement parameter *d* , as defined in **P.2.10.2** for *x '* and *y'* for the equations of *f1, f2* and *f3* . The subscripts "eval" and "ref" refer to evaluated and reference, respectively. In others In words, the following inequalities must be satisfied:

Equations (P.26)

The following procedure should be used to evaluate the uncertainty of the interpolation algorithms used in area scanning to determine the location of the SAR peak.

a) Choose the measurement resolution ( ), and the number of evaluation points (N_x , N_y) (corresponding to the measurement points). The center of the area scan should be set to (*x0, y0*) = (0, 0)

b) SAR values are calculated using the functions *f1, f2* and *f3* at the evaluation points of the area scan grid within the following ranges:

Equations (P.27)

Where N_x *and* N_y are odd integers. A value of $z = 0$ is assumed since the location of the peak is independent of *z* for these three functions.

The SAR values calculated by these three distribution functions are interpolated by the system of SAR measurement with a spatial resolution of ( ) according to the interpolation functions $g_i(x)$ and $g_i(y)$ used by the system to determine the location of the spatial average peak of the SAR (x_{eval} , *and* $_{eval}$). If the measurement system does not allow the import of SAR values to perform the assessment, the same algorithm must be implemented independently by other means to determine the Uncertainties interpolation and peak search.

The location of the spatial average peak of the SAR determined by the interpolation algorithms must satisfy the requirement of the aforementioned inequalities. Otherwise, the measurement and Data processing should use a finer grating resolution and / or a higher number of points of interpolation to repeat the evaluation starting at **Step b)** .

The center of the area scan (*x0, y0*) must be moved in 1 mm steps within the range of

0 <x0≤ / 2 y 0 <y0≤ / 2 to repeat the evaluation starting at **Step b)** for each of the (*x0, y0*) displaced within these intervals.

P.2.10.3.2 ZOOM SCAN EVALUATION.

The zoom scan is evaluated by comparing the highest SAR values in 1 g and 10 g with the values SAR reference in **P.2.10.3.2** . Starting from the area scan procedure of **P.2.10.3.1** , the true location of the peak (x_{ref} , y_{ref}) will be offset from the estimated location of the peak (x_{eval} , y_{eval}) by a quantity given by the inequalities shown in equations **P.26** . This displacement is taken in It counts in the reference functions *f1, f2* and *f3* of **P.2.10.2** when incorporating the distance *d* . Since this displacement can vary in practice, the value of *d* must vary in the interval:

Equation (P.28)

Where L_c is the length of the side of the cube (10 mm for 1 g and 21.5 mm for 10 g). For each distance *d* , records the maximum uncertainty produced by any of the three functions. The root mean square of the Larger values of Uncertainty for various distances *d* are entered as the Uncertainty due to the extrapolation, interpolation and integration.

Although the requirement for the area scan in which the local SAR spatial average peak must be located within $| d | \leq L_z / 2$, the smaller interval of equation **P.28** is used here to ensure that the 1 g or 10 g cubes can be calculated on the first try. For values of $(L_z - L_c) / 2$ and $| d | \leq L_z / 2$, the software of The measurement should alert that the 1g or 10g cube is not captured and that the measurement should be retried. This will not affect the Uncertainty, so it is not necessary to consider it in this case.

The procedure is the next.

a) Choose a displacement *d* for the evaluation of the functions *f1, f2* and *f3* . *d* must vary from - $(L_z - L_c) / 2$ to + $(L_z - L_c) / 2$ in small increments (for example, in 1 mm increments). The displacement must also vary separately in the *x* and *y directions* .

b) The SAR values are calculated according to the functions *f1, f2* and *f3* , at the evaluation points of the grid that correspond to the points measured in the zoom scan volume. The volume zoom scan should focus on

Equation (P.29)

Where

L_h is the volume height of the zoom scan;

d_{be} is the distance to the closest measurement point from the inner surface of the MAC.

c) The calculated SAR values are extrapolated to the MAC surface at $z = 0$ by the software of the system to get the extra points in zoom scan volume that cannot be measure due to probe restrictions. Then the data for the calculated points and the Extrapolated point data is interpolated to a finer resolution by the software of the system, which subsequently applies the integration algorithms, as well as the algorithm of search for the spatial average peak of the SAR within the zoom scan volume to determine the maximum spatial average peak of the SAR in 1 g or 10 g. Other procedures are possible. If the system does not allow the SAR values to be imported to perform the evaluation, the same algorithm must be implemented independently by other means to test the extrapolation, interpolation and integration algorithms.

d) The values of the spatial average peak of the SAR in 1 g or 10 g determined by the system or by the data processing software (SAR_{eval}) are compared to the SAR reference values given in **P.2.10.2** . The standard deviation caused by the random noise ($SAR_{std\_dev}(N_{rms})$) is determined by evaluating *f3* at least 4,000 times, and with each of the 4,000 or more evaluations using different random noise parameters. The SAR uncertainty for the functions of distribution *f1* and *f2* is calculated using the following equation:

Equation (P.30)

The SAR uncertainty for the distribution function *f3* is calculated with the following equation:

Equation (P.31)

e) The highest uncertainty estimated by the three distribution functions is recorded.

f) Repeat **Step b)** through **Step e)** for other displacement values *d* .

g) Calculate the root mean square value of the Uncertainties calculated in **Step d)** for each displacement *d* mentioned in the previous step. This value must be entered as the Uncertainty because of the extrapolation, interpolation and integration in the corresponding row and column of the **Table P.7** , **Table P.8** , and **Table P.9** , and a rectangular probability distribution should be used.

h) Record the following parameters used to estimate the Uncertainty of the zoom scan:

- The dimension of the grid used to sample the reference functions, both in terms of the number of points and sampling intervals in the three dimensions;
- The number of interpolation points included between two test points, or the resolution of interpolation in the three directions, for the reference functions;
- The dimension of the extrapolation region, that is, the distance between the sensor location probe at the first measurement point and the surface of the MAC (the measurement point is behind the tip of the probe;
- The interpolation, extrapolation and averaging algorithms used.

The computational conditions (such as the number of grid points, the increments of the grid, and the number of interpolation points in the three directions) should be the same for all three functions.

P.2.10.4 EVALUATION OF CURVED SURFACES.

The procedures in **P.2.10.3** assume that the boundary between the LET and the MAC is flat. However, the Estimated uncertainty with these functions for flat boundaries between the LET and the MAC is also valid for smooth curved surfaces, provided that the four lateral faces are parallel to the line normal to the MAC in the center of the cube face that is next to the MAC surface. The fact that the function is based on a flat surface does not imply a restriction on the applicability of the test provided that the procedure is based on equivalent distances from the grid to the surfaces. This produces the volumes for averaging illustrated in **Figure P.1** . However, the uncertainty estimated with these functions for flat borders between the LET and the MAC is also valid for smooth curved surfaces. The **Figure P.1** illustrates an acceptable method for shaping the cube during SAR post-processing. Face The front of the volume facing the MAC / LET interface forms the curved border, to ensure that all SAR peaks are captured. The back face must be equally distorted to keep the mass for correct average.

Figure P.1. Orientation and volume area for averaging relative to MAC area

P.2.11 UNCERTAINTY OF SAR SCALING

Uncertainties of SAR scaling (see **5.1.7.3.5**) as a function of the level of the SAR SAR are associated with non-linearities of the RF signal and amplification stages, the bandwidth of the signal modulation and the impedance of the antenna.

For the Uncertainty of the SAR scaling, a probability distribution must be assumed rectangular. Uncertainty is calculated by determining the SAR of mod $_Y$ at the location of the average peak spatial (x_p , y_p , z_p) using the following procedure:

a) Perform an area scan with mod $_X$ modulation according to **5.1.9.1** .

b) Move the probe to the location of the area scan peak.

c) Take the reading of the SAR at the location of the peak with mod $_X$.

d) Change the device to mod $_Y$ (without moving the DCI).

e) Take the reading of the SAR with mod $_Y$.

f) Calculate the ratio between the measured and scaled $_{modY}$ SAR using the following equation:

Equation (P.32)

With R $_p$ as the ratio of the time-averaged output power of mod $_X$ and mod $_Y$ according to **5.1.7.3.5** .

If SAR $_{incert\_escalamiento}$ > 5% do not use scaling, perform a full evaluation of the SAR for mod $_Y$.

P.2.12 DEVIATION OF EXPERIMENTAL SOURCES.

Sources for validation system in **Annex Q** of this arrangement technique **,** are well defined and were simulated to obtain numerical reference values using numerical codes validated. However, specific source electrical and mechanical uncertainties affect the values resulting from the spatial average peak of the SAR, for example, different impedances at the point of power supply and current distribution as a function of distance, MAC housing, LET, etc. In other words, the target numeric values are valid for specific font requirements and arrangement configuration. Deviation from target values should be determined with Type A evaluations o Type B. Type A evaluations should use statistical evaluations of various measurements using different LETs, probes and MAC For Type B evaluations, all parameters must be evaluated experimentally. The target numerical values have been established using numerical simulations and have been validated with laboratory calibration.

For the waveguide source, **Table P.4** provides the contributions of the deviations from the waveguide source with respect to the theoretical one.

Table P.4. Uncertainties related to the deviations of the guidance source parameters from standard wave

Symbol	**Source of Uncertainty**	**Value** (±%)	**Distribution of probability**	**Divider**	**c** i 1 g / 10 g	**u** i ±%	**saw**
	Mode variation waveguide theoretical in the LET	5.0	Rectangular		one	2.9	∞
L, W	Dimensions of the waveguide	1.0	Normal	one	one	1.0	∞
u_c	Uncertainty combined		Root of the sum squares			3.1	∞

For the dipole source, the contributions to the deviation of the experimental dipole from the theoretical They include variations in the physical parameters described in **Annex Q** .

The combined uncertainty of the deviations in the experimental sources from the theoretical ones is enter **Table P.8** and **Table P.9** assuming a normal probability distribution.

P.2.13 OTHER SOURCES OF UNCERTAINTY WHEN SOURCES ARE USED TO SYSTEM VALIDATION.

In addition to the source uncertainty terms for system validation discussed elsewhere of this Technical Provision, there are additional terms that must be added to the budget of Uncertainty. These terms depend on the type of source used for the validation of the system. For one dipole source, a term can be the distance from the axis of the dipole to the LET, and for a guide source of wave, one term may be the decoupling error. The **Table P.5** and **Table P.6** show the terms Uncertainty for the dipole source and the waveguide source, respectively. The Uncertainty of The expanded measurement for **Table P.6** must be within ± 10% for k = 2. These additional terms of Uncertainties are entered in the row for "Other contributions from the source" of **Table P.8** and **Table P.9** .

NOTE 1 The numerical values in **Table P.5** and **Table P.6** are only examples and it should not be assumed that represent the values for specific fonts.

NOTE 2 The waveguide is placed directly against the MAC, as described in **Annex G** . For the Therefore, an Uncertainty term that takes into account the distance to the MAC is not required, as with the dipole antenna.

Table P.5. Other contributions to uncertainty related to the dipole sources described in Annex Q.

Source of Uncertainty	**Value** (±%)	**Distribution of probability**	**Divider**	**c** i	u i ±%	v i
Axis distance from dipole to LET	2.0	Rectangular		one	1.2	∞

Table P.6. Other Contributions to Uncertainty Related to Waveguide Sources

standard described in Annex Q.

Source of Uncertainty	**Value** (±%)	**Distribution of probability**	**Divider**	**c_i**	u_i ±%	v_i
Decoupling error for the system [a]	5.0	U shape		one	3.5	∞
Uncertainty in measuring the transmission power loss adapter and waveguide	1.0	Normal	2	one	0.5	∞
Combined uncertainty		Root of the sum squares		±	**3.5**	∞

[a] This is calculated for an 8 dB return loss to the waveguide, a return loss of 30 dB for the power sensor, and a return loss of 25 dB for the output port of the coupler.

P.3 CALCULATION OF THE UNCERTAINTY BUDGET.

P.3.1 COMBINED UNCERTAINTY AND EXPANDED UNCERTAINTY.

The contributions of each component of Uncertainty must be recorded with a description, distribution probability, sensitivity coefficient and uncertainty value. A recommended tabular form is shown in **Table P.7** . The combined standard uncertainty u_c should be estimated according to the following equation:

Equation (P.33)

where c_i is the sensitivity coefficient and is the standard uncertainty. The expanded uncertainty U it must be estimated using a 95% confidence interval.

P.3.2 MAXIMUM EXPANDED UNCERTAINTY.

The expanded uncertainty with a 95% confidence interval should not exceed 30% for the SAR spatial average peak values in the range of 0.4 W / kg to 10 W / kg.

If the Uncertainty of the actual measurement ($unc_{measured}$) is not within ± 30%, the reported *psSAR* ($_{corrected}psSAR$) may have to take into account the difference in percentage between the actual Uncertainty and the ± 30% of target value per

Equation (P.34)

Where $_{measured}psSAR$ is the measured value of the spatial average peak of the SAR. Note that linearity and level noise levels have to be verified beyond the aforementioned values due to the signal to noise ratio The largest peak-to-average ratio is already necessary for some communication signals.

For spatial average peak SAR values in 1 g outside the range of 0.4 W / kg to 10 W / kg, they can Additional procedures and considerations, not included here, may be needed to achieve a non-Uncertainty. greater than 30%, as recommended for values measured in that range. In all cases the Measurement uncertainty should accompany the SAR results measured at the RP. Uncertainty The expanded measurement for **Table P.9** must be within ± 10% for $k = 2$.

The **Table P.9** shows the reproducibility for a review of the system (see paragraph **D.2**). The System revision reproducibility takes into account the variation in the system revision measurements.

system over time in the same measuring system or in several systems of the same type and maker. Provides an indication that the system is operating within its specifications. System failure High drift and operator errors can be easily detected if the deviation from the target value of the dipole during system review is greater than the reproducibility uncertainty of the system review system.

Table P.7. Example of a measurement uncertainty evaluation template for a test of the SAR to a Handset

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The component values in this table are only examples and are not intended to represent the Measurement uncertainty in a specific SAR test system. The Uncertainty of Measurement for a specific Handset tested with a specific SAR test system must be evaluated individually.

NOTE 1 Headings *a* through *k* are given for reference.

NOTE 2 Abbreviations used in this table:

a) Root Sum of Squares (*Root Sum Square*);

b) N, R, U - normal, rectangular and U-shaped probability distributions;

c) Divisor - amount used to obtain the standard uncertainty.

NOTE 3 The Uncertainty components indicated in this table are based on test procedures and protocols developed for this Technical Provision.

NOTE 4 The divisor is a function of the probability distribution.

NOTE 5 c_i is the sensitivity coefficient applied to convert the variability component of Uncertainty in a SAR variability.

NOTE 6 See P.1.3 for a discussion of the degrees of freedom (v_i) for the Standard Uncertainty and the effective degrees of freedom (v_{effec}) for the expanded uncertainty.

NOTE 7 The numbers in the Column correspond to the number of tests (M or N in the respective sections).

NOTE 8 Use the rectangular probability distribution and $v_i = \infty$ when the Uncertainty of the EBP bra comes from a single test to a DCI

NOTE 9 Some of the quantities that influence Uncertainty can be estimated from the performance specifications provided by equipment manufacturers; it can be necessary
estimate the uncertainty of certain other components that vary from test to test for each measurement

Table P.8. Example template for the evaluation of measurement uncertainty for validation of the system.

The component values in this table are only examples and are not intended to represent the Measurement uncertainty in a specific SAR test system. The Uncertainty of Measurement for a specific Handset tested with a specific SAR test system must be evaluated individually.

See NOTES 1 through 9 of **Table P.7** .

NOTE 10 All sources of uncertainty in **Table P.8** and **Table P.9** are applicable in the tests for system validation and system review. Here, the three entries in the group "Related to EBP" are replaced by a group labeled "Source for system validation" or "Source for review of the system "which contains the three quantities of influence described as:" Deviation between experimental dipoles "," Measurement of input power and SAR drift "and" Other contributions from the source".

NOTE 11 The Source Uncertainty examples in **Table P.8** and **Table P.9** are specific to dipole antenna sources. If another source is used, the Uncertainty values will be different, as shown explained in **P.2.13.**

Table P.9. Example template for evaluation of measurement uncertainty for review system (applicable for one system).

[a] The probe calibration drift is the repeatability of the probe calibration within a specific calibration laboratory (see **Annex E**). The calibration laboratory must provide this value on the calibration certificate. If the calibration drift uncertainty is not available, in instead the Full Calibration Uncertainty (**Annex E**) should be used.

See NOTES 1 through 9 of **Table P.7** and NOTES 10 through 12 of **Table P.8** .

ANNEX Q

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SOURCES FOR THE VALIDATION OF THE SAR SYSTEM USED IN NUMERAL 5.1.

Q.1 STANDARD DIPOL AS SOURCE.

The standard dipole antennas in **Figure Q.1** with the mechanical dimensions indicated in **Table Q.1 will** produce the SAR values listed in **Table D.1** when the validation test of the **D.3.5** system . If dipole antennas are used that have dimensions other than those indicated in the **Table Q.1** , or if the dipole antennas are used at frequencies other than those indicated in **Table Q.1** , the values of the Reference SARs for those sources should be independently documented and verified using procedures that are consistent with the methodologies described in this Technical Provision.

Table Q.1.- Mechanical dimensions of the reference dipoles.

Frequency	**MAC shell thickness**	***L***	***h***	***d1***
MHz	mm	mm	mm	mm
300	6.3	396	250	6.35
300	2	420	250	6.35
450	6.3	270	166.7	6.35
450	2	290	166.7	6.35
750	2	176	100	6.35
835	2	161	89.8	3.6
900	2	149	83.3	3.6
1,450	2	89.1	51.7	3.6
1,500	2	80.5	fifty	3.6
1 640	2	79	45.7	3.6
1 750	2	75.2	42.9	3.6
1 800	2	72	41.7	3.6
1 900	2	68	39.5	3.6
1 950	2	66.3	38.5	3.6
2,000	2	64.5	37.5	3.6
2 100	2	61	35.7	3.6
2 300	2	55.5	32.6	3.6
2 450	2	51.5	30.4	3.6
2,600	2	48.5	28.8	3.6
3,000	2	41.5	25	3.6
3 500	2	37	26.4	3.6

3 700	2	34.7	26.4	3.6
5,000 to 6,000	2	20.6 [a]	40.3 [a]	3.6

Dimensions *L, h* and *d1* must be within a tolerance of ± 1%

[a] These dimensions are applicable for a coaxial diameter in the balun of d2 = 2.1 mm (see **Figure Q.1**).

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The reference dipole arms must be parallel to the flat surface of the MAC within a tolerance of ± 2 ° or less (see **Figure D.1**). This can be ensured by carefully placing the Empty MAC and reference dipole on a horizontal level using a spirit level.

Numerical target values above 3 GHz cannot be given universally as for which are below 3 GHz due to increased spacer effect, MAC housing and uncertainties mechanical. Therefore, the numerical target values can be different from one dipole to another. It is important that for each dipole used for system validation an analysis is provided fully documented based on numerical simulations and experimental validation.

Figure Q.1.- Mechanical characteristics of the standard dipole.

Q.2 Standard waveguide as source

The standard waveguide source of **Figure Q.2** with mechanical dimensions given in **Table Q.2** (corresponding to WR159 or UK WG-13 with an IEC-UDR58 flange) will produce the stated SAR values in **Table D.2** when the system validation test of **D.3.5** is followed . Feeding guide wave must be placed at least one wavelength from the coupling layer to ensure that higher order modes have vanished. The transmission loss of the waveguide is characterized by measurement with a network analyzer. If waveguides that have parameters are used different from those listed in **Table Q.2** , or if waveguides are used at frequencies other than listed in **Table Q.2** , the reference SAR values for those sources should be documented and independently verified (for example, by comparing numerical simulations with measurements).

Figure Q.2.- Standard waveguide as source (dimensions are according to table Q.2)

Table Q.2.- Mechanical dimensions of the standard waveguide.

Frequency MHz	**Thickness of the casing of MAC** mm	***L*** mm	***W*** mm	***L*** mm	***Wf*** mm	***t*** mm	mm
5 200	2	40.39	20.19	81.03	61.98	5.3	6
5 800	2	40.39	20.19	81.03	61.98	4.3	6

NOTE *L* and *W* are the internal length and width of the waveguide, L_f and W_f are the length and width of the waveguide flange, and *t* y are the thickness and relative permittivity of the matching layer. The tolerance for *L* and *W* is ± 0.13 mm. The coupling layer is a lossless dielectric slab that fills the L × W cross-sectional area of the waveguide. The waveguide and layer coupling are in direct contact with the MAC housing. The minimum height of the waveguide (from feed to flange) is a free space wavelength. This arrangement provides an input return loss of at least 8 dB. The uncertainty of the permittivity and the thickness of the Dielectric slab are included in the return loss. Therefore, these need not be specified independently.

ANNEX R

MSH PLANO.

The influence of the dimensions of the flat MSH (see **Figure R.1**) on the energy absorbed in a cube of 10 g into the LET-filled MSH (without shell) was evaluated numerically using a commercial code FDTD. The MSH was illuminated with a dipole antenna coupled at a distance of 15 mm (0.042 to 840 MHz). The dimensions of the MSH (*W* and *L*) were varied between 0.4 and 3. The power absorbed in the cube is alternately normalized to a feed point current of 1 A or a point power of 1W power supply. Although there are deviations in the power absorbed in the hub when normalizes to power point power or power point current, they were determined the minimum dimensions necessary to keep the Uncertainty below 1% for both methods standardization. At 800 MHz, the above conditions are met for the dimensions of the flat MSH greater than 0.6 in both length and width, as shown in **Figure R.2** . The influence of width MSH is not very big. However, the length must be at least 0.6 and 0.4 wavelengths, in the air, along the largest and smallest dimensions, respectively, to ensure that the effect of the MSH dimensions over SAR is less than 1%. The dimensions of the MSH configuration can be scalar in terms of the wavelength of free space. The dependency of LET properties does not it is very critical as long as it is relatively lossless.

Due to its larger size, a cube averaging 10 g will be more sensitive to changes in dimension, that is, the uncertainty associated with the average of 1 g will be less than that of the cube for average in 10 g. The effects that produce differences depend on the disturbances of the magnitude of the dipole current and spatial distribution. Since the dimensions of the dipole are large in Compared to the volumes for average SAR, the disturbances will increase with the size of the volume. Although the depth used in this study was 10 cm, instead of the 15 cm required for the flat MSH in **5.2.2** is 2.57 times the penetration depth at 840 MHz, and therefore the Power reflection on the LET surface is negligible (less than 1%).

The numerical target SAR values in **Table D.1** were calculated using the FDTD method. The parameters for the lossless MSH housing used in the simulations (dimensions, thickness of the shell and permittivity) and the distance *s* between the reference dipole and the LET are shown in **Table R.1** . The MSH dimensions used in this table produce the same SAR values as an MSH that meets the requirements of section **5.2.2** , within the Uncertainty of the SAR test system. Dimensions of the MSH recommended in **5.2.2** should be used for system inspection and validation. of the system. The dielectric properties used for the LET are defined in **Table 8** and the dimensions of the reference dipoles are shown in **Table Q.1** .

Figure R.1.- Dimensions of the flat MSH arrangement used to obtain the minimum dimensions MSH for W and L for MSH depth D

Figure R.2. The FDTD code predicted the Uncertainty in the spatial average peak of the SAR at 10 g

as a function of the dimensions of the flat MSH compared to an infinite flat MSH, at 800 MHz

Table R.1. Parameters used to calculate the SAR reference values in Table D.1.

Frequency MHz	**Thickness of casing of MSH** mm	**Permittivity of the casing of the MSH**	**MSH Dimensions Used for FDTD models** mm *x; Y; z*	**Distance *s* from LET up to the dipole reference** mm
300	6.3	3.7	1,000; 800; 170	fifteen
300	2	3.7	1,000; 800; 170	fifteen
450	6.3	3.7	700; 600; 170	fifteen
450	2	3.7	700; 600; 170	fifteen
750	2	3.7	700; 600; 170	fifteen
835	2	3.7	360; 300; 150	fifteen
900	2	3.7	360; 300; 150	fifteen
1,450	2	3.7	240; 200; 150	10
1,500	2	3.7	220; 160; 150	10
1 640	2	3.7	220; 160; 150	10
1 750	2	3.7	220; 160; 150	10
1 800	2	3.7	220; 160; 150	10
1 900	2	3.7	220; 160; 150	10
1 950	2	3.7	220; 160; 150	10
2,000	2	3.7	160; 140; 150	10
2 100	2	3.7	160; 140; 150	10
2 300	2	3.7	160; 140; 150	10
2 450	2	3.7	180; 120; 150	10
2,600	2	3.7	180; 120; 150	10
3,000	2	3.7	220; 160; 150	10
3 500	2	3.7	174; 110; 150	10
3 700	2	3.7	174; 110; 150	10
5,000	2	3.7	90; 80; 35	10
5 200	2	3.7	90; 80; 35	10
5 500	2	3.7	90; 80; 35	10
5 800	2	3.7	90; 80; 35	10

NOTE The SAR values in **Table D.1** at frequencies above 3 GHz depend on the separator of the dipole and the detailed construction of the dipoles, and can vary up to ± 10%. The reasons are that the dimensions of the dipole are short with respect to the diameter of the arm and the dimensions of the spacer, that is, the numerical reference values are not generic and must be determined for an array of particular test. Additionally, the results may be sensitive to the permittivity of the MSH shell.

ANNEX S

SOURCES FOR THE VALIDATION OF THE SAR SYSTEM USED IN NUMERAL 5.2.

S.1. DIPOLS.

A flat MSH must be irradiated using a reference dipole for the required frequency. Dipoles Reference benchmarks are defined for the dielectric parameters and specific shell thickness of the MSH of the **Table S.1** .

The reference dipole must be placed at the bottom of the housing and with its axis centered in the dimension major of the MSH. A low loss, low permittivity spacer can be used to establish the correct distance between the top surface of the reference dipole and the bottom surface of the MSH. The The spacer should not change the measured SAR values averaged over 1 g and 10 g of tissue more than 1%.

The distance between the bottom of the LET-filled MSH and the center of the reference dipole (designated *s*) must be 0.2mm for each frequency test. The reference dipole must have a return loss better than -20 dB (measured in the test system) at the frequency to be measured, to reduce the uncertainty in power measurement. It is acceptable to fit the reference dipoles with elements of low loss dielectric material or metal at the end of the dipole elements. The **Table S.1** and **Figure S.1** indicate the mechanical dimensions of the dipole.

For frequencies above 3 GHz, the influence of the spacer on the impedance of the dipole can be significant. Therefore, the dipole must be used together with the spacer optimized for itself. The effect The change in position with respect to the feeding point of the same must be considered in the dipole uncertainty budget (see numeral **O.2.6** of this Technical Provision).

S.2. TARGET VALUES OF SAR.

S.2.1. TARGET VALUES OF SAR BELOW 3 GHz.

The mechanical dimensions of the dipoles must have a tolerance better than ± 2%. Objective values they are indicated in **Table I.1** . It is important to demonstrate, by means of numerical methods, that the spacer does not change the SAR value averaged over 1 g and 10 g of tissue in amounts greater than 1%.

S.2.2. TARGET VALUES OF SAR ABOVE 3 GHz.

Target values above 3 GHz cannot be universally determined, unlike values below 3 GHz, due to the influence of the spacer, the thickness of the bottom of the MSH and the tolerances dipole mechanics. Therefore, the target values may differ from dipole to dipole.

A detailed analysis must be provided for each dipole used in the validation of the system and documented of the numerical simulations of said dipole. This should include a sensitivity analysis to mechanical tolerances, feed point modeling and MSH properties.

Table S.1.- Mechanical dimensions of the reference dipoles.

Frequency MHz	**Shell thickness MSH** mm	***L*** mm	***h*** mm	***d1*** mm	***d2*** mm
300	6.3	396.0	250.0	6.35	
300	2.0	420.0	250.0	6.35	
450	6.3	270.0	166.7	6.35	
450	2.0	290.0	166.7	6.35	
750	2.0	176.0	100.0	6.35	
835	2.0	161.0	89.8	3.6	
900	2.0	149.0	83.3	3.6	
1450	2.0	89.1	51.7	3.6	
1800	2.0	72.0	41.7	3.6	
1900	2.0	68.0	39.5	3.6	
1950	2.0	66.3	38.5	3.6	
2000	2.0	64.5	37.5	3.6	
2450	2.0	51.5	30.4	3.6	
2585	2.0	49.1	29.0	3.6	
2600	2.0	48.5	28.8	3.6	
3000	2.0	41.5	25.0	3.6	
3500	2.0	37.0	26.4	3.6	
3700	2.0	34.7	26.4	3.6	

5000	2.0	20.6 [a]	40.3 [a]	3.6	2.1
6000	2.0	20.6	40.3	3.6	2.1

Note 1: Dimensions *L, h* and *d1* should have a tolerance of 2%

Note 2: The values for 5,000 MHz and 6,000 MHz are valid for a thickness of 2 mm. Losses of return should be better at -20 dB.

For the reference dipoles provided in this Annex, the spacer distance is calculated from the Following way:

a) s = 15 mm ± 0.2 mm for 300 MHz ≤ *f* <1000 MHz;

b) s = 10 mm ± 0.2 mm for 1000 MHz≤ *f* ≤6000 MHz.

The reference dipole arms must be parallel to the surface of the flat MSH, with a tolerance of ± 2 ° or less (see **Figure S.2**).

Figure S.1. Mechanical details of the reference dipole.

S.3. MSH PLANO.

The influence of the dimensions of the flat MSH (see **Figure S.2**) on the absorbed energy in a cube of 10 g of LET has been determined numerically using FDTD methods (see **Table S.2** for the parameters used). The dimensions of the MSH must be greater than 0.6 in length and 0.4 in width, this with the aim of keeping the uncertainty below 1%. MSH dimensions can be scaled in terms of the free space wavelength of the frequency to be measured.

Figure S.2. Flat MSH dimensions with 10g cube shown in center of cube.

Table S.2. Parameters used for the calculation of the reference SAR values in Table I.1

Frequency MHz	**Thickness of the MSH housing** mm	**Permittivity of MSH housing**	**Dimensions of the MSH used in FDTD models** mm *X and Z*	**Distance s from dipole of reference to LET** mm
300	6.3	3.7	1000, 800, 170	fifteen
450	6.3	3.7	700, 600, 170	fifteen
750	2.0	3.7	700, 600, 170	fifteen
835	2.0	3.7	360, 300, 150	fifteen
900	2.0	3.7	360, 300, 150	fifteen
1450	2.0	3.7	240, 200, 150	10
1800	2.0	3.7	220, 160, 150	10
1900	2.0	3.7	220, 160, 150	10
1950	2.0	3.7	220, 160, 150	10
2000	2.0	3.7	160, 140, 150	10
2450	2.0	3.7	180, 120, 150	10
2585	2.0	3.7	180, 120, 150	10
2600	2.0	3.7	180, 120, 150	10
3000	2.0	3.7	220, 160, 150	10
3500	2.0	3.7	174, 110, 150	10
3700	2.0	3.7	174, 110, 150	10

5000	2.0	3.7	90, 80, 35	10

6000	2.0	3.7	90, 80, 35	10

This Table represents the values used in the FDTD simulation.

S.4. MECHANICAL DIMENSIONS OF THE STANDARD WAVE GUIDE.

The standard waveguide source in **Figure S.3** , with the mechanical dimensions stated in the **Table S.3** (corresponding to WR159 or UK WG-13 with an IEC-UDR58 flange) will produce the SAR values indicated in **Table I.2** of this Technical Provision when the validation test of the system established in numeral **I.3** of this Technical Provision. If waveguides are used with parameters other than those listed in **Table S.3** , or if waveguides are used at frequencies other than those listed in **Table S.3** , the reference SAR values for those sources should be independently document and verify (e.g. comparison of numerical simulations with measurements).

Figure S.3. Waveguide as a source.

Table S.3. Standard waveguide mechanical dimensions

Frequency MHz	**Thickness of MSH** mm	**L** mm	**W** mm	**Lf** mm	**Wf** mm	**T** Mm	mm
5200	2	40.39	20.19	81.03	61.98	5.3	6
5800	2	40.39	20.19	81.03	61.98	4.3	6

Note: *L* and *W* are the internal dimensions of the waveguide (length and width, respectively); *t* and are the thickness and relative permittivity of the coupling layer. L_f and W_f are the outer length and width of the flange. The coupling layer is a lossless dielectric slab that fills the sectional area *L x W* cross section of the waveguide. Waveguide and coupling layer are in contact direct with the MAC housing.

ANNEX T

SAMPLE RECIPES FOR MSH HUMAN TISSUE EQUIVALENT (LET) LIQUID.

T.1 GENERAL PERSPECTIVE.

The dielectric properties of liquids for MSH must be those indicated in **Table 8** of the present Technical Provision. For frequencies not stated, the dielectric properties must be calculated from

starting from tabulated values using linear interpolation. The **Table T.1** suggests examples of recipes for liquids with parameters defined in **Table 8** of this Technical Provision (6).

T.2 INGREDIENTS.

The following ingredients can be used in the formulas to produce the LET:

• Sucrose (sugar) (purity greater than 98%).

• Sodium chloride (salt) (purity greater than 99%).

• Deionized water (minimum resistivity of 16 MΩ).

• Hydroxyethylcellulose (HEC).

• Bactericidal.

• Diethylene glycol butyl ether (DGBE) (purity greater than 99%).

• Diethylene glycol monohexyl ether (DGME).

• Polyethylene glycol mono [4- (1,1,3,3-tetramethylbutyl] phenyl ether]. This is available as Triton ™ X-100. (7) The quality of the Triton X-100 must be ultra pure to match the composition of the Salt.

• Diacetin.

• 1,2-Propanediol.

• Polysorbate 20.

• Emulsifiers

• Mineral oil

Considerations:

5. The viscosity of the HEC-based LET should be low enough not to affect the movement of the electric field probe.

6. Salt must first be added to the water to make a saline solution and then the Triton X-100 must be added.

7. Actual results and mixing percentages vary depending on the degree and type of components used.

T.3 FORMULAS OF THE LET (ALLOWANCE / CONDUCTIVITY).

Suggested LET formulas are shown in **Table T.1** .

Table T.1. Suggested recipes to obtain the target values of dielectric parameters.

Frequency (MHz)	**30**	**fifty**	**144**	**450**	**835**	**900**
			Ingredients (% by weight)			
Deionized water	48.30 48.30 53.53 55.12 48.30 48.53			56	50.36 50.31	56
Polysorbate 20		44.70 43.31		49.51	48.39 48.34	
Mineral oil				44		44

DGME										
Triton X-100										
Diacetin	fifty	fifty			fifty					
DGBE										
NaCl	1.60	1.60	1.77	1.57	1.60	1.96		1.25	1.35	
Additives and salt	0.10	0.10			0.10					
				Dielectric parameters measured						
	54.2	53.1 54.54 52.81 51.0 43.29 42.3 41.6							41.0	40.6
[Ye]	0.75	0.75	0.76	0.76	0.77	0.88 0.84 0.90			0.98	0.98
Temperature [° C]			twenty-one twenty-one			twenty-onetwenty		twenty-one twenty-one twenty		
temp_liquido Incert [%]	0.8	0.1			0.1	0.1		0.04	0.04	
temp_liquido Incert [%]	2.8	2.8			2.6	4.2		1.6	1.6	

Target values

	55	54.5	52.4	43.5	41.5	41.5
[Ye]	0.75	0.75	0.76	0.87	0.90	0.97

Table T.1 (Continuation)

Frequency (MHz)	**1800**		**2450**	**4000**	**5000**	**5200**	**5800**	**6000**
			Ingredients (% by weight)					
Deionized water	54.23	56	56	56	56	65.53	65.53	56
Polysorbate 20	45.27							
Mineral oil		44	44	44	44			44
DGME						17.24	17.24	

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The Presiding Commissioner, **Gabriel Oswaldo Contreras Saldívar** .- Signature.- The Commissioner, **Mario Germán Fromow Rangel** .- The Commissioner, **Adolfo Cuevas Teja** .- Signature.- The Commissioner, **Javier Juárez Mojica** .- Signature.- The Commissioner, **Arturo Robles Rovalo** .- Signature.- The Commissioner, **Sóstenes Díaz González** .- Signature.- The Commissioner, **Ramiro Camacho Castillo** .- Signature .

This Agreement was approved by the Plenary of the Federal Institute of Telecommunications in its XXIX Ordinary Session held on November 13, 2019, by unanimous vote of the Commissioners Gabriel Oswaldo Contreras Saldívar, Mario Germán Fromow Rangel, Adolfo Cuevas Teja, Javier Juárez Mojica, Arturo Robles Rovalo, Sóstenes Díaz González and Ramiro Camacho Castillo; based on the Articles 28, fifteenth, sixteenth and twentieth paragraphs, section I of the Political Constitution of the United States of Mexico; 7, 16, 23, section I and 45 of the Federal Telecommunications Law and Broadcasting, and 1, 7, 8 and 12 of the Organic Statute of the Federal Institute of Telecommunications, through Agreement P / IFT / 131119/649.

Commissioner Mario Germán Fromow Rangel attended, participated and cast his reasoned vote in the Session, through remote electronic communication, in terms of articles 45, fourth paragraph of the Law Federal Telecommunications and Broadcasting, and 8, third paragraph of the Organic Statute of the Federal Institute of Telecommunications.

(R.- 492379)

one ICNIRP RF Exposure Guidelines. IEEE C95.1-2005 standard.

2 This distance corresponds to the 95th percentile of the height of the nose obtained in the anthropomorphic survey of Gordon et al. .

3 ECIA RS-261, Rectangular Waveguides (WR3 to WR2300), 2018

4 To ensure the safety of personnel, the appropriate treatment must be followed for each material of compliance with applicable regulation.

5 Published in the DOF on July 27, 2004. http://dof.gob.mx/nota_detalle.php?codigo=678919&fecha=27/07/2004

6 To ensure the safety of personnel, the appropriate treatment must be followed for each material of compliance with applicable regulation.

7 Triton is the brand name for a product supplied by The Dow Chemical Company or a company affiliated with Dow. This information is provided for reference and does not constitute an endorsement or endorsement of such product. They may be Equivalent products are used if they are shown to lead to the same results.