IEC 61161

Edition 3.0 2013-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Ultrasonics – Power measurement – Radiation force balances and performance requirements

Ultrasons – Mesurage de puissance – Balances de forces de rayonnement et exigences de fonctionnement

IEC 61161:2013

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,…).
It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,…).
Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 61161

Edition 3.0 2013-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Ultrasonics – Power measurement – Radiation force balances and performance requirements

Ultrasons – Mesurage de puissance – Balances de forces de rayonnement et exigences de fonctionnement

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX X

ICS 17.140.50

ISBN 978-2-83220-617-1

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ULTRASONICS – POWER MEASUREMENT – RADIATION FORCE BALANCES AND PERFORMANCE REQUIREMENTS

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61161 has been prepared by IEC technical committee 87: Ultrasonics.

This third edition cancels and replaces the second edition published in 2006. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– whereas the second edition tacitly dealt with circular transducers only, the present edition as far as possible deals with both circular and rectangular transducers, including a number of symbols for rectangular transducers;
– attention is paid to focused cases and the influence of scanning has been added;
– the method of calibrating the radiation force balance now depends on whether the set-up is used as a primary or as secondary measurement tool;
– Annex B (basic formulae) has been updated and in Annex C the buoyancy change method is mentioned (see also future IEC 62555).

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

FDIS	Report on voting
87/520/FDIS	87/528/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

NOTE The following print types are used:

- Requirements: in Arial 10 point
- Notes: in Arial 8 point
- Words in **bold** in the text are defined in Clause 3
- Symbols and formulae: *Times New Roman + Italic*.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

A number of measuring methods exist for the determination of the total emitted power of ultrasonic transducers ([1], [2], [3][1], see also Annex C). The purpose of this International Standard is to establish standard methods of measurement of ultrasonic power in liquids in the lower megahertz frequency range based on the measurement of the radiation force using a gravimetric balance. The great advantage of radiation force measurements is that a value for the total radiated power is obtained without the need to integrate field data over the cross-section of the radiated sound beam. This standard identifies the sources of errors and describes a systematic step-by-step procedure to assess overall measurement uncertainty as well as the precautions that should be undertaken and uncertainties that should be taken into account while performing power measurements.

Basic safety requirements for ultrasonic physiotherapy devices are identified in IEC 60601-2-5 and make reference to IEC 61689, which specifies the need for acoustic power measurements with an uncertainty better than ± 15 % at a level of confidence of 95 %. Considering the usual degradation of accuracy in the practical application of this standard, reference measurement methods need to be established with uncertainties better than ± 7 %. Ultrasonic diagnostic device declaration requirements including acoustic power are specified in other IEC standards, as for example in IEC 61157.

The measurement of acoustic power accurately and repeatably using a radiation force balance as defined in this standard is influenced by a number of practical problems. As a guide to the user, additional information is provided in Annex A using the same section and clause numbering as the main body.

---

1 Numbers in square brackets refer to the Bibliography.

ULTRASONICS – POWER MEASUREMENT – RADIATION FORCE BALANCES AND PERFORMANCE REQUIREMENTS

1 Scope

This International Standard

- specifies a method of determining the total emitted acoustic power of ultrasonic transducers based on the use of a radiation force balance;
- establishes general principles for the use of radiation force balances in which an obstacle (target) intercepts the sound field to be measured;
- establishes limitations of the radiation force method related to cavitation and temperature rise;
- establishes quantitative limitations of the radiation force method in relation to diverging and focused beams;
- provides information on estimating the acoustic power for diverging and focused beams using the radiation force method;
- provides information on assessment of overall measurement uncertainties.

This International Standard is applicable to:

- the measurement of ultrasonic power up to 1 W based on the use of a radiation force balance in the frequency range from 0,5 MHz to 25 MHz;
- the measurement of ultrasonic power up to 20 W based on the use of a radiation force balance in the frequency range 0,75 MHz to 5 MHz;
- the measurement of total ultrasonic power in well-collimated, diverging and focused ultrasonic fields;
- the use of radiation force balances of the gravimetric type or force feedback type.

(See also Clause A.1)

NOTE 1 A focused beam is converging in the pre-focal range and diverging beyond focus.

NOTE 2 Ultrasonic power measurement in the high intensity therapeutic ultrasound (HITU) range, i.e. beyond 1 W or 20 W, respectively, is dealt with in the future IEC 62555.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61689, *Ultrasonics – Physiotherapy systems – Field specifications and methods of measurement in the frequency range 0,5 MHz to 5 MHz*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
acoustic streaming
bulk fluid motion initiated by a sound field

3.2
free field
sound field in a homogeneous isotropic medium whose boundaries exert a negligible effect on the sound waves

[SOURCE: IEC 60050-801:1994, definition 801-23-28, modified – the term no longer contains "sound"]

3.3
output power
P
time-average ultrasonic power emitted by an **ultrasonic transducer** into an approximately **free field** under specified conditions in a specified medium, preferably water

Note 1 to entry: **Output power** is expressed in watt (W).

3.4
radiation force
acoustic radiation force
F
time-average force acting on a body in a sound field and caused by the sound field, excluding the component due to **acoustic streaming**; or, more generally: time-average force (excluding the component due to **acoustic streaming**) in a sound field, appearing at the boundary surface between two media of different acoustic properties, or within a single attenuating medium

Note 1 to entry: **Radiation force, acoustic radiation force**, is expressed in newton (N).

3.5
radiation pressure
acoustic radiation pressure
radiation force per unit area

Note 1 to entry: This term is widely used in the literature. However, strictly speaking, the **radiation force** per unit area is a tensor quantity [4] and it should be referred to as the acoustic radiation stress tensor when a strict scientific terminology is to be used. The integral quantity "**acoustic radiation force**" is generally preferred in this International Standard. Whenever at some places, the term "**acoustic radiation pressure**" appears it is to be understood as the negative value of the normal radiation stress in the direction of the field axis.

Note 2 to entry: **Radiation pressure, acoustic radiation pressure,** is expressed in pascal (Pa).

3.6
target
device specially designed to intercept substantially all of the ultrasonic field and to serve as the object which is acted upon by the **radiation force**

3.7
ultrasonic transducer
device capable of converting electrical energy to mechanical energy within the ultrasonic frequency range and/or reciprocally of converting mechanical energy to electrical energy

3.8
radiation conductance
G
ratio of the acoustic **output power** and the squared RMS transducer input voltage

Note 1 to entry: It is used to characterize the electrical to acoustical transfer of **ultrasonic transducers**.

Note 2 to entry: **Radiation conductance** is expressed in siemens (S).

4 List of symbols

a	radius of a circular ultrasonic source transducer
b_x and b_y	half-dimensions of a rectangular ultrasonic source transducer in x and y direction, respectively (so that 2 b_x and 2 b_y are the transducer's side lengths)
c	speed of sound (usually in water)
d_x and d_y	geometrical focal lengths of a focusing **ultrasonic transducer** in the x-z and the y-z plane, respectively
d	geometrical focal length of a focusing **ultrasonic transducer** in the case of $d_x = d_y = d$
F	**radiation force** on a **target** in the direction of the incident ultrasonic wave
g	acceleration due to gravity
G	**radiation conductance**
h_d	half the diagonal of a rectangular transducer, $h_d = (b_x^2 + b_y^2)^{1/2}$
h_h	harmonic mean of b_x and b_y, $h_h = 2 / (1/b_x + 1/b_y)$
k	circular wavenumber, $k = 2\pi / \lambda$
P	**output power** of an **ultrasonic transducer**
s	normalized distance from a circular **ultrasonic transducer**, $s = z \lambda / a^2$
z	distance between an **ultrasonic transducer** and a **target**
α	amplitude attenuation coefficient of plane waves in a medium (usually water)
β_x and β_y	focus (half-)angles of a rectangular focusing **ultrasonic transducer** in the x-z and the y-z plane, respectively; $\beta_x = \arctan(b_x/d_x)$, $\beta_y = \arctan(b_y/d_y)$ if the transducer is planar and the focal lengths are counted from the planar transducer surface
γ	focus (half-)angle of a circular focusing **ultrasonic transducer**; $\gamma = \arcsin(a / d)$ if the transducer is spherically curved and the focal length is counted from the "bottom" of the "bowl"; $\gamma = \arctan(a / d)$ if the focal length is counted from the plane defined by the rim of the active part of the "bowl" or if the transducer is planar
θ	angle between the direction of the incident ultrasonic wave and the normal to a reflecting surface of a **target**
λ	ultrasonic wavelength in the sound-propagating medium (usually water)
ρ	(mass) density of the sound-propagating medium (usually water)

NOTE 1 The direction of the incident wave mentioned above under F and θ is understood to be the direction of the field axis, i.e., it is understood in a global sense rather than in a local sense.

NOTE 2 Strictly speaking, in the case of a focusing transducer, the focusing details and the transducer shape are independent of each other, i.e. a circular transducer, too, can have two different focus (half-)angles. With regard to ultrasound practice, however, this standard restricts to the two cases of a circular transducer with one focus (half-) angle and of a rectangular transducer with two focus (half-)angles (which can, of course, be equal to each other).

5 Requirements for radiation force balances

5.1 General

The **radiation force** balance shall consist of a **target** which is connected to a balance. The ultrasonic beam shall be directed vertically upwards or downwards or horizontally on the **target** and the **radiation force** exerted by the ultrasonic beam shall be measured by the balance. The ultrasonic power shall be determined from the difference between the force measured with and without ultrasonic radiation. Guidance is contained in Annex B. Calibration can be carried out by means of small precision weights of known mass.

NOTE Different possible **radiation force** measurement set-ups are presented in Figures F.1 to F.7. Each measurement set-up has its own merits, which are also summarized in Annex F.

5.2 Target type

5.2.1 General

The **target** shall have known acoustic properties, these being relevant to the details of the relation between ultrasonic power and **radiation force.** (See also A.5.2.1)

If the **target** is chosen so as to closely approach one of the two extreme cases, i.e. perfect absorber or perfect reflector, the appropriate formula of Annex B shall be used depending on the field structure and the following requirements apply:

5.2.2 Absorbing target

An absorbing **target** (see Figures 1, F.1a, F.3, F.4, F.5a and F.7) shall have

- an amplitude reflection factor of less than 3,5 %;
- an acoustic energy absorption within the **target** of at least 99 %.

(See also A.5.2.2)

5.2.3 Reflecting target

A reflecting **target** (see Figures F.1b, F.2, F.5b and F.6) shall have

- an amplitude reflection factor of greater than 99 %.

A conical reflecting **target** should not be used for power measurements of non-focusing transducers where < 30. A convex-conical reflector with a cone half-angle of 45° shall not be used for power measurements of transducers where $ka < 17,4$, which follows from theoretical consideration of the effects of beam divergence. (See also A.5.3)

NOTE The exact meaning of the quantity *a* depends on circumstances. For practical transducers, this is the effective transducer radius in accordance with the particular definition in the field of application. In model calculations using a piston approach, it is the geometrical piston radius.

In addition, a convex-conical reflector with a cone half-angle of 45° should not be used for power measurements of focusing transducers where $d < 32a$. If the geometrical focal length d is not known then a convex-conical reflector with a cone half-angle of 45° should not be used when the distance z_f of the pressure maximum from the transducer is

$$z_f < 1 / [(1/32a) + (\lambda / a^2)]$$

This condition recommends restricting the use of convex-conical reflectors to the unfocused case or the case of weak focusing. If, nevertheless, a convex-conical reflector is used in strongly focused fields and Formula (B.6) is applied, additional uncertainties that are not covered by Clause 7 need to be taken into account. In case of an oblique beam (scanning) conical reflectors should not be used.

The above statements apply to circular transducers. In case of a rectangular transducer, consider all the above conditions twice, replacing a with b_x as well as with b_y, and use the reflecting **target** only if all conditions are fulfilled in a positive sense for b_x as well as for b_y.

(See also A.5.2.3 and Clause B.6)

5.3 Target diameter

The lateral size of the **target** shall be large enough to intercept all significant parts of the field, in the sense that the **radiation force** is at least 98 % of the reference **radiation force**, i.e. that experienced by a **target** of infinite lateral size.

As the reference **radiation force** is often unknown in practice, an alternative requirement for unfocused fields is as follows. The **target** dimension in any lateral direction shall in no case be lower than 1,5 times the corresponding dimension (e.g. the diameter) of the **ultrasonic transducer**.

Whether or not the **target** dimensions should be more than 1,5 times the transducer dimensions, depends on the dimensions of the field cross-section at the particular location of the **target**. The beam dimensions shall be measured or calculated from theoretical estimation as given, for example in A.5.3.

In case of an oblique beam (scanning), i.e. when the beam axis is tilted by a certain angle from the axis of the **radiation force** balance, a larger **target** size is required. In this case, the field cross-section at the particular location of the **target** is not centred to the **target** centre but is shifted from it by a certain amount depending on the tilt angle and the **target** distance, and the required **target** size needs to be increased by this amount.

5.4 Balance/force measuring system

The **radiation force** balance may be a gravimetric balance with, therefore, the beam orientation vertical. Alternatively the balance may be of a force feed-back design, allowing the beam to be horizontal. If the balance has been calibrated against mass units, a correct conversion of the balance readings to force values shall be ensured by the manufacturer of the **radiation force** device or by the user.

NOTE Vertical beam orientation allows traceability to national mass standards (calibrated weights). Set-ups with horizontal beam orientation exist in practice using either a reflecting **target** [5, 6] or an absorbing **target** [7]. Calibration may be carried out using an appropriate balance arm attachment or by calibration against sources of known acoustic power.

The balance used shall have sufficient resolution for the magnitude of the ultrasonic power to be measured. (See A.5.4)

5.5 System tank

If a reflecting **target** is used, an absorbing lining of the measuring vessel shall be used so that returning reflections do not contribute to more than 1 % of the overall measured power. (See also A.5.5)

5.6 Target support structures

In static-force balances, the structural members supporting the **target** and carrying the **radiation force** across the air-water interface shall be designed to limit the effect of surface tension to less than 1 % of the overall measured power. (See also A.5.6)

5.7 Transducer positioning

The **ultrasonic transducer** mount shall allow stable and reproducible positioning of the **ultrasonic transducer** with respect to the **target** in a way that related changes in overall measured power do not exceed 1 %.

5.8 Anti-streaming foils

If an anti-streaming foil is used it shall be positioned close to the **target** and shall not be oriented parallel to the surface of the **ultrasonic transducer** [8]. Its transmission coefficient shall be known from measurement and a correction shall be applied if its influence is more than 1 % of the overall measured power. (See also A.5.8)

NOTE In practice a tilt angle of 5° to 10° has been found to be adequate.

5.9 Transducer coupling

The **ultrasonic transducer** shall be coupled to the measurement device such that the impact on the overall measured power is less than 1 %, otherwise a correction shall be applied. (See also A.5.9)

5.10 Calibration

The force-measuring part of the **radiation force** balance shall be calibrated by the use of small weights of known mass.

Further, in case of a non-primary measurement set-up, the **radiation force** balance shall be calibrated by use of an ultrasonic source or sources of known **output power** traceable to a primary measurement standard. The calibration shall be carried out at multiple **acoustic working frequencies** and **output power** levels representative of the range over which the balance is to be used. In this case, the calibration shall be undertaken once every two years or more frequently if there is any indication that the balance sensitivity to ultrasonic power has changed. (See also A.5.10)

NOTE In this standard, "a primary measurement set-up" means a measurement set-up that has taken part in an international key comparison or another international comparison, organized by the CIPM/BIPM.

Depending on the set-up used, corrections for diffraction, focusing angles, energy missing the **target** or not-absorbed/not-reflected by the **target**, absorption in the water path between transducer and **target**, streaming, etc. should be applied as necessary to meet accuracy goals.

6 Requirements for measuring conditions

6.1 Lateral target position

The lateral position of the **target** during measurement shall be constant and reproducible to an extent that related changes in overall measured power do not exceed 1 %. (See also A.6.1)

6.2 Transducer/target separation

The distance between the **ultrasonic transducer** surface and the **target**, or foil (if used) and **target**, should be as small as possible in view of the fact that **acoustic streaming** may occur due to the ultrasonic absorption along the sound path. (See also A.6.2)

The distance between the **ultrasonic transducer** surface and the **target**, or foil (if used) and **target**, shall be known and reproducible to an extent that possible changes in overall measured power do not exceed 1 %. (See also A.6.2)

6.3 Water

When using a **radiation force** balance, the liquid used for the measurements shall be water.

For determining **output powers** above 1 W, only degassed water shall be used.

Degassing of water shall be accomplished in a well-defined process such as described in IEC/TR 62781, referred to in Annex D. Where degassed water is required, the amount of dissolved oxygen in the water shall be < 4 mg/l during all measurements and shall, in addition, be low enough to prevent the occurrence of cavitation. The measurements shall be discarded if any cavitation bubbles are observed. (See also A.6.3)

6.4 Water contact

Before starting the measurements, it shall be ensured that all air bubbles are removed from the active faces. After measurements are completed, the active faces shall again be inspected, and the measurements shall be discarded if any air bubbles are found. (See also A.6.4)

6.5 Environmental conditions

For measurements in the milliwatt and microwatt region, the measuring device shall be either provided with thermal isolation or the measurement process, including data acquisition, shall be performed in such a way that thermal drift and other disturbances during the measurement cause no more than a 1 % effect on the overall measured power.

The measuring device shall be protected against environmental vibrations and air flow. (See also A.6.5)

6.6 Thermal drifts

When using an absorbing **target**, an estimate of the thermal effects due to the absorbed sound energy (expansion and buoyancy change) shall be made by recording the measured signal before and after the switch-on and switch-off of the **ultrasonic transducer.** (See also A.6.6)

7 Measurement uncertainty

7.1 General

An estimation of the overall measurement uncertainty or accuracy assessment shall be determined individually for each set-up used. This assessment should include the following elements.

The uncertainty shall be assessed using the BIPM JCGM 100:2008 [9].

7.2 Balance system including target suspension

The balance system shall be checked or calibrated using small weights of known mass with the whole system prepared for **radiation force** measurements, including with the **target** suspended in water.

This procedure shall be repeated several times with each weight to obtain an indication of the random scatter of results. An uncertainty estimate for the balance calibration factor shall be derived from the results of this calibration and from the mass uncertainty of the weights used.

The results of these checks should be filed in order to enable a judgment of the long-term stability of the balance calibration factor. (See also A.7.2)

7.3 Linearity and resolution of the balance system

The linearity of the balance system shall be checked at least every six months as follows.

The measurements described in 7.2 shall be made with at least three weights of different masses within the balance output range of interest. The balance readout as a function of input mass can be represented as a graph in accordance with Figure 2. The resulting points of this graph should ideally be on a straight line starting at the origin of the coordinates. If deviations from this line occur, an additional uncertainty contribution shall be derived from them.