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**Dosimetry with solid  
thermoluminescence detectors for  
photon and electron radiations in  
radiotherapy**

*Dosimétrie avec détecteurs de thermoluminescence solides pour le  
photon et rayonnements d'électron en radiothérapie*



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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. [www.iso.org/directives](http://www.iso.org/directives)

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. [www.iso.org/patents](http://www.iso.org/patents)

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The committee responsible for this document is ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [http://www.iso.org/iso/home/standards\\_development/resources-for-technical-work/foreword.htm](http://www.iso.org/iso/home/standards_development/resources-for-technical-work/foreword.htm)

## Introduction

The thermoluminescence dosimetry (TLD) with lithium fluoride (LiF) detectors has several advantages, in particular:

- small volumes of the detectors;
- applicability to continuous and pulsed radiation;
- fair water equivalency of the detector material;
- few correction factors needed for absorbed dose determinations.

The main disadvantage of thermoluminescence (TL) detectors is, however, that they have to be regenerated by a pre-irradiation annealing procedure. Unfortunately, it is not possible to restore the former response of the detectors perfectly by this annealing. Provided, however, that all detectors of a production batch always undergo the same thermal treatment, one can at least determine the mean alteration of the response of these detectors, with sufficiently small fluctuations of the individual values. From this mean alteration, a correction factor can be derived.

The essential aim of this International Standard is to specify the procedures and to carry out corrections which allow one to achieve (1) a repeatability of the indicated value within a fraction of a percent<sup>[17]</sup> and thus, (2) a total uncertainty of measurement (including the calibration steps tracing to the primary standards) of a few percent, as in ionization chamber dosimetry.<sup>[18][31][25][61][62]</sup>

The specifications in this International Standard comprise special terms used in TLD, rules for the measurement technique, and requirements for the measurement system. The defined requirements and the testing techniques can, in whole or in part, serve as a basis for stability checks and acceptance tests. The TLD procedures described in this International Standard can be used for photon radiation within the energy range from 20 keV to 50 MeV, including photon brachytherapy, and for electron radiation within the energy range from 4 MeV to 25 MeV, excluding beta radiation brachytherapy. In order to achieve the repeatability and total uncertainty stated above, this International Standard is applicable in the dose range above 1 mGy. The upper limit of the minimum measuring range is in the order of magnitude of 10 Gy to 100 Gy. In clinical dosimetry, TL detectors are applied taking into account the requirements of high spatial resolution, i.e. in the study of the dose distributions with high gradients occurring in small stereotactic radiation fields and around brachytherapy sources. The other common application is the measurement of dose distributions in large absorbers, e.g. geometrical or tissue equivalent phantoms, either within the radiation field or in its periphery. A further usage is the quality assurance of clinical dosimetry by postal dose intercomparison.<sup>[1][2][10][12][20][22][26][27][55]</sup>

The role of this International Standard is not to anticipate national or international codes of practice in clinical dosimetry, neither for external beam therapy, brachytherapy, whole-body irradiation, mammography, nor dose measurements outside the treatment field or radiation protection of the staff. The authors of this International Standard are well aware of the wide spectrum of the methods of clinical dosimetry, in which TL dosimetry is merely occupying a small sector. But within this framework, this International Standard provides reliable concepts and rules for good practice for the application of TLD methods. The items covered include the terms and definitions, the rules for TLD measurement procedures, and the requirements for the TLD system; this International Standard also addresses medical physicists and instrument producers. Notably, the numerical examples given are valid for the TL detector materials and products stated in the publications referred to, and tests may be necessary to check whether they apply to TLD materials of other producers. The practical examples given, e.g. for the TL probe calibration conditions and for the numerical values of correction factor,  $k_Q$ , accounting for the dependence of the detector response on radiation quality,  $Q$ , are not conceived to be preemptive in relation to more general standards of the methods of clinical dosimetry or of dose intercomparisons. Rather, this International Standard provides access to the reliable application of TLD methods based upon the published results of worldwide development. The long-standing experience in the clinical usage of TLD, expressed in a set of valuable textbooks, protocols, and recommendations,<sup>[6][13][25][28][29][42][43][61][62][54]</sup> has been accounted for.



# Dosimetry with solid thermoluminescence detectors for photon and electron radiations in radiotherapy

## 1 Scope

This International Standard describes rules for the procedures, applications, and systems of thermoluminescence dosimetry (TLD) for dose measurements according to the probe method. It is particularly applicable to solid “TL detectors”, i.e. rods, chips, and microcubes, made from LiF:Mg,Ti or LiF:Mg,Cu,P in crystalline or polycrystalline form. It is not applicable to LiF powders because their use requires special procedures. The probe method encompasses the arrangement, particularly in a water phantom or in a tissue-equivalent phantom, of single TL detectors or of “TL probes”, i.e. sets of TL detectors arranged in thin-walled polymethyl methacrylate (PMMA) casings.

The purpose of these rules is to guarantee the reliability and the accuracy indispensable in clinical dosimetry when applied on or in the patient or phantom. This International Standard applies to dosimetry in teletherapy with both photon radiation from 20 keV to 50 MeV and electron radiation from 4 MeV to 25 MeV, as well as in brachytherapy with photon-emitting radionuclides. These applications are complementary to the use of ionization chambers.

## 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.

ICRU 60, *Fundamental Quantities and Units for Ionizing Radiation* (1998)

ICRU 62, *Prescribing, recording and reporting photon beam therapy. International Commission on Radiation Units and Measurements* (1999)

IEC 60050-88, *IEV: International Electrotechnical Vocabulary. Radiology and radiological physics*.

IEC 60601-1, *Electromedical equipment — Part 1: General instructions pertaining to safety*

IEC 61000-4-2, *Electromagnetic compatibility (EMV) — Part 4-2: Test and measurement procedure; Test of immunity against static electric discharges*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) — Part 4-5: Testing and measurement techniques - Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) — Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) — Testing and measurement techniques - Power frequency magnetic field immunity test*

IEC 61000-4-11, *Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests*