

INTERNATIONAL  
STANDARD

ISO  
28077

CIE S 019/E

First edition  
2006-12-15

---

---

**Photocarcinogenesis action spectrum  
(non-melanoma skin cancers)**

*Spectre d'action de la photocarcérogenèse (cancers de la peau hors  
mélanome)*

STANDARDSISO.COM : Click to view the full PDF of ISO 28077:2006



Reference number  
ISO 28077:2006(E)  
CIE S 019/E:2006

© ISO 2006

**PDF disclaimer**

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

STANDARDSISO.COM : Click to view the full PDF of ISO 28077:2006

© ISO 2006

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
Case postale 56 • CH-1211 Geneva 20  
Tel. + 41 22 749 01 11  
Fax + 41 22 749 09 47  
E-mail [copyright@iso.org](mailto:copyright@iso.org)  
Web [www.iso.org](http://www.iso.org)

Published in Switzerland

## 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.

ISO 28077 was prepared as Standard CIE S 019/E by the International Commission on Illumination, which has been recognized by the ISO Council as an international standardizing body. It was adopted by ISO under a special procedure which requires approval by at least 75 % of the member bodies casting a vote, and is published as a joint ISO/CIE edition.

The International Commission on Illumination (abbreviated as CIE from its French title) is an organization devoted to international cooperation and exchange of information among its member countries on all matters relating to the science and art of lighting.

ISO 28077 was prepared by CIE Technical Committee TC 6-32.

STANDARDSISO.COM : Click to view the full PDF of ISO 28077:2006

[STANDARDSISO.COM](https://standardsiso.com) : Click to view the full PDF of ISO 28077:2006



Standard

COMMISSION INTERNATIONALE DE L'ECLAIRAGE  
INTERNATIONAL COMMISSION ON ILLUMINATION  
INTERNATIONALE BELEUCHTUNGSKOMMISSION

---

**CIE S 019/E:2006**

# **Photocarcinogenesis Action Spectrum (Non-Melanoma Skin Cancers)**

Spectre d'action de la photocarcérogénèse (cancers de la peau hors mélanome)

Aktionsspektrum für Photokarzinogenese (epitheliale Hautkrebse)

CIE Standards are copyrighted and shall not be reproduced in any form, entirely or partly, without the explicit agreement of the CIE.

CIE Central Bureau, Vienna  
Kegelgasse 27, A-1030 Vienna, Austria

CIE S 019/E:2006

---

UDC: 612.014.481-06

Descriptor: Optical radiation effects on humans

© CIE 2006

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from CIE Central Bureau at the address below.

CIE Central Bureau  
Kegelgasse 27  
A-1030 Vienna  
Austria  
Tel.: +43 1 714 3187 0  
Fax: +43 1 714 3187 18  
e-mail: [ciecb@ping.at](mailto:ciecb@ping.at)  
Web: [www.cie.co.at](http://www.cie.co.at)

## FOREWORD

Standards produced by the Commission Internationale de l'Eclairage (CIE) are a concise documentation of data defining aspects of light and lighting, for which international harmony requires such unique definition. CIE Standards are therefore a primary source of internationally accepted and agreed data, which can be taken, essentially unaltered, into universal standard systems.

This CIE Standard has been prepared by CIE Technical Committee TC 6-32\*, which proposed an action spectrum describing the effectiveness of ultraviolet radiation at causing photocarcinogenesis of non-melanoma skin cancers, and was approved by the National Committees of the CIE.

## TABLE OF CONTENTS

FOREWORD .....	vii
1. INTRODUCTION .....	1
2. SCOPE .....	1
3. NORMATIVE REFERENCES.....	1
4. DEFINITIONS, SYMBOLS AND ABBREVIATIONS.....	1
4.1 Definition .....	1
4.2 Symbols and abbreviations.....	2
5. THE ACTION SPECTRUM FOR PHOTOCARCINOGENESIS OF NON-MELANOMA SKIN CANCERS .....	2
6. ANNEX A (INFORMATIVE): BIBLIOGRAPHY.....	7

© CIE 2006

---

\* The chairperson of this TC was Paul Donald Forbes (US); members were: Janusz Beer (US), Homer Black (US), Jean-Pierre Césarini (FR), Curtis Cole (US), Frank DeGruijl (NL), John Epstein (US), Anny Fourtanier (FR), Adèle Green (AU), Ronald Ley (US), Romano Mascotto (FR), Warwick Morison (US), Robert Osterberg (US), Frederick Urbach (US) †, Jan van der Leun (NL), and Antony Young (GB), with the following committee advisors: Ronald Davies (CA), John Davitt (US), Thomas Koval (US) and David Sliney (US).

[STANDARDSISO.COM](https://standardsiso.com) : Click to view the full PDF of ISO 28077:2006

## PHOTOCARCINOGENESIS ACTION SPECTRUM (NON-MELANOMA SKIN CANCERS)

### 1. INTRODUCTION

Solar ultraviolet radiation (UVR) is recognized as a major cause of non-melanoma skin cancer in man. Skin cancer occurs most frequently in the most heavily exposed areas and correlates with degree of outdoor exposure. Describing the relationship of exposure (dose) to risk (skin cancer) requires the availability of a biological hazard function or *action spectrum* for photocarcinogenesis. This standard proposes the adoption of an action spectrum (weighting function) derived from experimental laboratory data and modified to estimate the non-melanoma tumor response in human skin. The experimental data are sufficient for estimating effectiveness down to about 250 nm, but experimental data are not sufficient for specifying effectiveness above 400 nm.

### 2. SCOPE

This International Standard specifies the action spectrum for photocarcinogenesis of non-melanoma skin cancers.

### 3. NORMATIVE REFERENCES

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

CIE 17.4-1987. *International Lighting Vocabulary*, ILV (joint IEC/CIE publication).

CIE 90-1991. *Sunscreen testing (UVB)*.

CIE 98-1992. *Personal dosimetry of UV radiation*.

CIE 103/3-1993. *Reference action spectra for ultraviolet induced erythema and pigmentation of different human skin (CIE Collection in Photobiology and Photochemistry)*.

ISO 17166:1999/CIE S 007/E-1998. *Erythema reference action spectrum and standard erythema dose*.

### 4. DEFINITIONS, SYMBOLS AND ABBREVIATIONS

For the purposes of this standard, the following definition, symbols and abbreviations apply. This definition is taken from CIE 17.4-1987, where other relevant terms will also be found.

#### 4.1 Definition

**ultraviolet radiation (UVR)** (see ILV 845-01-05)

optical radiation for which the wavelengths are shorter than those for visible radiation

Note - For ultraviolet radiation, the range between 100 nm and 400 nm is commonly subdivided into:

UV-A 315 .... 400 nm

UV-B 280 .... 315 nm

UV-C 100 .... 280 nm

## 4.2 Symbols and abbreviations

### SCUP

Skin Cancer Utrecht-Philadelphia (an action spectrum proposed in de Gruijl, F.R. and van der Leun, J.C., 1994)

### SCUP-m

designates the original SCUP action spectrum, based entirely on mouse data

### SCUP-h

designates a proposed action spectrum estimated by correcting for differences in UV transmissions between human and murine epidermis

**UV-A1** 340 .... 400 nm

**UV-A2** 315 .... 340 nm

## 5. THE ACTION SPECTRUM FOR PHOTOCARCINOGENESIS OF NON-MELANOMA SKIN CANCERS

The effectiveness of UVR at causing photocarcinogenesis of non-melanoma skin cancers has been studied for many years (Roffo, 1933; Blum 1959; Freeman, 1978; Forbes et al., 1981, 1982; Cole et al., 1983; Rundell, 1983; Epstein, 1985; Cole et al., 1986; Freeman et al., 1989; Berg et al., 1993; de Gruijl et al., 1993; de Gruijl and van der Leun, 1994; Anders et al., 1995; de Gruijl and Forbes, 1995; CIE, 2000). The action spectrum defined in this standard was first published by the CIE as the product of research by CIE Technical Committee 6-32. The document stated the following recognized limitations to this action spectrum (CIE, 2000):

"The UV-A1 part (340-400 nm) of the SCUP action spectra has large margins of uncertainty (from 10-20% at 340 nm to an order of magnitude at 390 nm); the minimum at 350 nm and especially the secondary maximum at 380 nm are not well defined. Recent biochemical data do, however, indicate that action spectra for some types of DNA damage from reactive oxygen species, such as released by UV-A, show a minimum around 350 nm.

Exploiting this as yet ill-defined *fine structure* in the UV-A1 region of the SCUP-h action spectrum (e.g., for optimizing commercial *tanning* lamps) would be unjustified. Because the Committee report should provide a standard for risk assessment in regulatory applications, its recommendation eliminates the uncertainty associated with the fine structure of the SCUP-h action spectrum. Committee consensus involved flattening the plateau at the 340 nm level. Mathematically, this results in the least available deterioration of the curve fit to the actual experimental data (the Chi-square of the fit goes up from 13,7 to 18,2 with 7 degrees of freedom)."<sup>1</sup>

The action spectrum for photocarcinogenesis is based principally on experimental data from mice; comparable data are obviously not available from humans. The limits of this extrapolation are yet to be determined. Based on all these considerations, a standard action spectrum for photocarcinogenesis is provided in Table 1 and shown in Fig. 1.

---

<sup>1</sup> An action spectrum based on the Utrecht-Philadelphia collaboration bears the acronym "SCUP" (for Skin Cancer Utrecht Philadelphia). "SCUP-m" is the best fit to the mouse data, using a computer polynomial program. Based on SCUP-m, a SCUP-h action spectrum ("-h" for human) was estimated by correcting for differences in UV transmissions between human and murine epidermis (de Gruijl, 1999).

**TABULATED AND GRAPHIC VALUES**

**Table 1.** Action spectrum for photocarcinogenesis (Non-Melanoma skin cancer).

Wavelength $\lambda$ [nm]	Effectiveness (decimal)	Effectiveness (exponential)
250	0,010900	1,09000E-02
251	0,011139	1,11390E-02
252	0,011383	1,13830E-02
253	0,011633	1,16330E-02
254	0,011888	1,18880E-02
255	0,012158	1,21580E-02
256	0,012435	1,24350E-02
257	0,012718	1,27180E-02
258	0,013007	1,30070E-02
259	0,013303	1,33030E-02
260	0,013605	1,36050E-02
261	0,013915	1,39150E-02
262	0,014231	1,42310E-02
263	0,014555	1,45550E-02
264	0,014886	1,48860E-02
265	0,015225	1,52250E-02
266	0,015571	1,55710E-02
267	0,015925	1,59250E-02
268	0,016287	1,62870E-02
269	0,016658	1,66580E-02
270	0,017037	1,70370E-02
271	0,017424	1,74240E-02
272	0,017821	1,78210E-02
273	0,018226	1,82260E-02
274	0,018641	1,86410E-02
275	0,019065	1,90650E-02
276	0,019498	1,94980E-02
277	0,019942	1,99420E-02
278	0,020395	2,03950E-02
279	0,020859	2,08590E-02
280	0,021334	2,13340E-02
281	0,025368	2,53680E-02
282	0,030166	3,01660E-02
283	0,035871	3,58710E-02
284	0,057388	5,73880E-02
285	0,088044	8,80440E-02
286	0,129670	1,29670E-01
287	0,183618	1,83618E-01
288	0,250586	2,50586E-01
289	0,330048	3,30048E-01
290	0,420338	4,20338E-01
291	0,514138	5,14138E-01
292	0,609954	6,09954E-01
293	0,703140	7,03140E-01

Wavelength $\lambda$ [nm]	Effectiveness (decimal)	Effectiveness (exponential)
294	0,788659	7,88659E-01
295	0,861948	8,61948E-01
296	0,919650	9,19650E-01
297	0,958965	9,58965E-01
298	0,988917	9,88917E-01
299	1,000000	1,00000E+00
300	0,991996	9,91996E-01
301	0,967660	9,67660E-01
302	0,929095	9,29095E-01
303	0,798410	7,98410E-01
304	0,677339	6,77339E-01
305	0,567466	5,67466E-01
306	0,470257	4,70257E-01
307	0,385911	3,85911E-01
308	0,313889	3,13889E-01
309	0,253391	2,53391E-01
310	0,203182	2,03182E-01
311	0,162032	1,62032E-01
312	0,128671	1,28671E-01
313	0,101794	1,01794E-01
314	0,079247	7,92470E-02
315	0,061659	6,16590E-02
316	0,047902	4,79020E-02
317	0,037223	3,72230E-02
318	0,028934	2,89340E-02
319	0,022529	2,25290E-02
320	0,017584	1,75840E-02
321	0,013758	1,37580E-02
322	0,010804	1,08040E-02
323	0,008525	8,52500E-03
324	0,006756	6,75600E-03
325	0,005385	5,38500E-03
326	0,004316	4,31600E-03
327	0,003483	3,48300E-03
328	0,002830	2,83000E-03
329	0,002316	2,31600E-03
330	0,001911	1,91100E-03
331	0,001590	1,59000E-03
332	0,001333	1,33300E-03
333	0,001129	1,12900E-03
334	0,000964	9,64000E-04
335	0,000810	8,10000E-04
336	0,000688	6,88000E-04
337	0,000589	5,89000E-04
338	0,000510	5,10000E-04
339	0,000446	4,46000E-04
340	0,000394	3,94000E-04

STANDARDSISO.COM: Get the full PDF of ISO 28077:2006

Wavelength $\lambda$ [nm]	Effectiveness (decimal)	Effectiveness (exponential)
341	0,000394	3,94000E-04
342	0,000394	3,94000E-04
343	0,000394	3,94000E-04
344	0,000394	3,94000E-04
345	0,000394	3,94000E-04
346	0,000394	3,94000E-04
347	0,000394	3,94000E-04
348	0,000394	3,94000E-04
349	0,000394	3,94000E-04
350	0,000394	3,94000E-04
351	0,000394	3,94000E-04
352	0,000394	3,94000E-04
353	0,000394	3,94000E-04
354	0,000394	3,94000E-04
355	0,000394	3,94000E-04
356	0,000394	3,94000E-04
357	0,000394	3,94000E-04
358	0,000394	3,94000E-04
359	0,000394	3,94000E-04
360	0,000394	3,94000E-04
361	0,000394	3,94000E-04
362	0,000394	3,94000E-04
363	0,000394	3,94000E-04
364	0,000394	3,94000E-04
365	0,000394	3,94000E-04
366	0,000394	3,94000E-04
367	0,000394	3,94000E-04
368	0,000394	3,94000E-04
369	0,000394	3,94000E-04
370	0,000394	3,94000E-04
371	0,000394	3,94000E-04
372	0,000394	3,94000E-04
373	0,000394	3,94000E-04
374	0,000394	3,94000E-04
375	0,000394	3,94000E-04
376	0,000394	3,94000E-04
377	0,000394	3,94000E-04
378	0,000394	3,94000E-04
379	0,000394	3,94000E-04
380	0,000394	3,94000E-04
381	0,000394	3,94000E-04
382	0,000394	3,94000E-04
383	0,000394	3,94000E-04
384	0,000394	3,94000E-04
385	0,000394	3,94000E-04
386	0,000394	3,94000E-04
387	0,000394	3,94000E-04

Wavelength $\lambda$ [nm]	Effectiveness (decimal)	Effectiveness (exponential)
388	0,000394	3,94000E-04
389	0,000394	3,94000E-04
390	0,000394	3,94000E-04
391	0,000394	3,94000E-04
392	0,000394	3,94000E-04
393	0,000394	3,94000E-04
394	0,000394	3,94000E-04
395	0,000394	3,94000E-04
396	0,000394	3,94000E-04
397	0,000394	3,94000E-04
398	0,000394	3,94000E-04
399	0,000394	3,94000E-04
400	0,000394	3,94000E-04

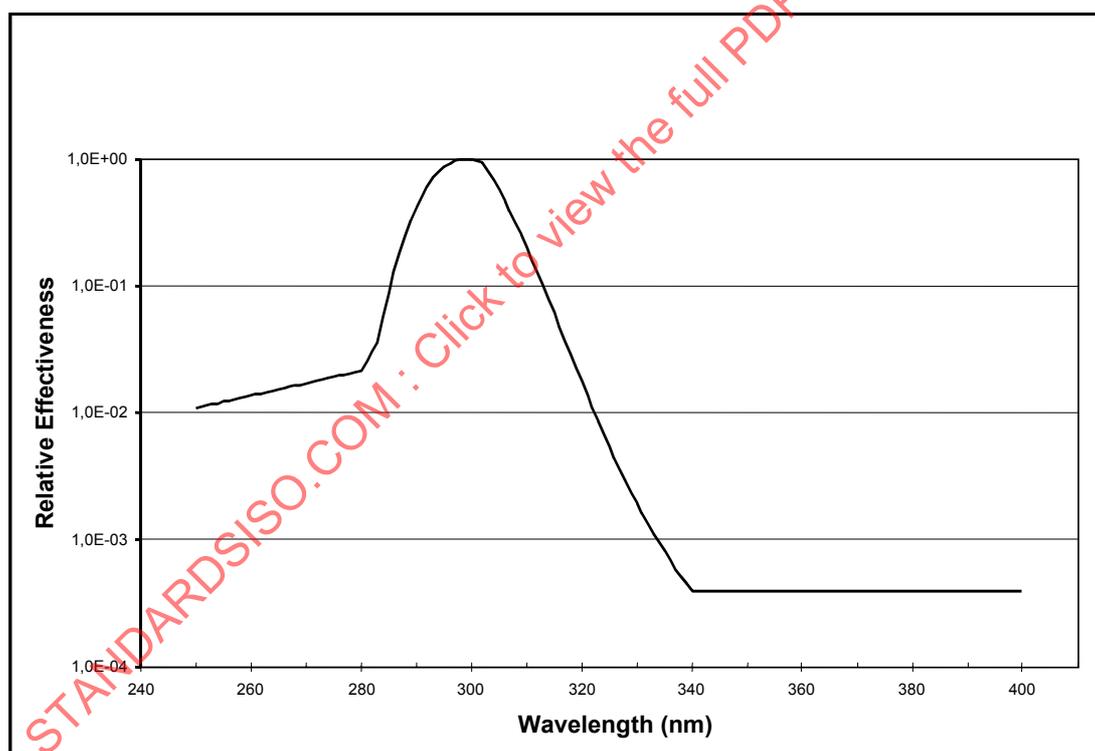


Fig. 1. Action spectrum for photocarcinogenesis. Non-Melanoma skin cancer.