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

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

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Contents

	Page
Foreword.....	iv
Introduction.....	v
1 Scope.....	1
2 Normative references.....	1
3 Terms, definitions, symbols and abbreviations.....	1
3.1 Terms and definitions.....	1
3.2 Symbols and abbreviations.....	1
4 The action spectrum for photocarcinogenesis of non-melanoma skin cancers.....	1
5 Tabulated and graphic values.....	2
Bibliography.....	7

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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 (see 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 (see www.iso.org/patents).

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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 World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

ISO/CIE 28077 was prepared by CIE Technical Committee 6-32, *Action Spectrum for Photocarcinogenesis*, as CIE S 019. The committee responsible for this document is ISO/TC 274, *Light and lighting*.

This second edition cancels and replaces the first edition (ISO 28077:2006), of which it constitutes a minor revision.

Introduction

Solar ultraviolet radiation (UVR) is recognized as a major cause of non-melanoma skin cancer in human beings. 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 document proposes the adoption of an action spectrum (weighting function) derived from experimental laboratory data and modified to estimate the non-melanoma tumour 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.

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Photocarcinogenesis action spectrum (non-melanoma skin cancers)

1 Scope

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

2 Normative references

There are no normative references in this document.

3 Terms, definitions, symbols and abbreviations

For the purposes of this document, the terms and definitions given in CIE S 017/E:2011 and the following terms and definitions, symbols and abbreviations apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Terms and definitions

3.1.1

ultraviolet radiation

UVR

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

Note 1 to entry: The range between 100 nm and 400 nm is commonly subdivided into: UV-A: 315 nm to 400 nm; UV-B: 280 nm to 315 nm; UV-C: 100 nm to 280 nm.

[SOURCE: CIE S 017/E:2011, Term 17-1367, modified — Notes 2 and 3 have been omitted.]

3.2 Symbols and abbreviations

SCUP Skin Cancer Utrecht-Philadelphia (an action spectrum proposed in Reference [1])

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 wavelength range from 340 nm to 400 nm

UV-A2 wavelength range from 315 nm to 340 nm

4 The action spectrum for photocarcinogenesis of non-melanoma skin cancers

The effectiveness of ultraviolet radiation in causing photocarcinogenesis of non-melanoma skin cancers has been studied for many years^[1-16]. The action spectrum defined in this document was first published by the CIE as the product of research by CIE Technical Committee 6-32, as CIE 138/2.^[16] The document stated the following recognized limitations to this action spectrum:

“The UV-A1 part (340 nm–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).”^[16]

NOTE 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.^[17]

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 [Figure 1](#).

5 Tabulated and graphic values

Table 1 — Action spectrum for photocarcinogenesis (non-melanoma skin cancer)

Wavelength λ / nm	Effectiveness (decimal)	Effectiveness (exponential)
250	0,010 900	1,090 00E-02
251	0,011 139	1,113 90E-02
252	0,011 383	1,138 30E-02
253	0,011 633	1,163 30E-02
254	0,011 888	1,188 80E-02
255	0,012 158	1,215 80E-02
256	0,012 435	1,243 50E-02
257	0,012 718	1,271 80E-02
258	0,013 007	1,300 70E-02
259	0,013 303	1,330 30E-02
260	0,013 605	1,360 50E-02
261	0,013 915	1,391 50E-02
262	0,014 231	1,423 10E-02
263	0,014 555	1,455 50E-02
264	0,014 886	1,488 60E-02
265	0,015 225	1,522 50E-02
266	0,015 571	1,557 10E-02
267	0,015 925	1,592 50E-02
268	0,016 287	1,628 70E-02
269	0,016 658	1,665 80E-02
270	0,017 037	1,703 70E-02
271	0,017 424	1,742 40E-02

Table 1 (continued)

Wavelength λ / nm	Effectiveness (decimal)	Effectiveness (exponential)
272	0,017 821	1,782 10E-02
273	0,018 226	1,822 60E-02
274	0,018 641	1,864 10E-02
275	0,019 065	1,906 50E-02
276	0,019 498	1,949 80E-02
277	0,019 942	1,994 20E-02
278	0,020 395	2,039 50E-02
279	0,020 859	2,085 90E-02
280	0,021 334	2,133 40E-02
281	0,025 368	2,536 80E-02
282	0,030 166	3,016 60E-02
283	0,035 871	3,587 10E-02
284	0,057 388	5,738 80E-02
285	0,088 044	8,804 40E-02
286	0,129 670	1,296 70E-01
287	0,183 618	1,836 18E-01
288	0,250 586	2,505 86E-01
289	0,330 048	3,300 48E-01
290	0,420 338	4,203 38E-01
291	0,514 138	5,141 38E-01
292	0,609 954	6,099 54E-01
293	0,703 140	7,031 40E-01
294	0,788 659	7,886 59E-01
295	0,861 948	8,619 48E-01
296	0,919 650	9,196 50E-01
297	0,958 965	9,589 65E-01
298	0,988 917	9,889 17E-01
299	1,000 000	1,000 00E+00
300	0,991 996	9,919 96E-01
301	0,967 660	9,676 60E-01
302	0,929 095	9,290 95E-01
303	0,798 410	7,984 10E-01
304	0,677 339	6,773 39E-01
305	0,567 466	5,674 66E-01
306	0,470 257	4,702 57E-01
307	0,385 911	3,859 11E-01
308	0,313 889	3,138 89E-01
309	0,253 391	2,533 91E-01
310	0,203 182	2,031 82E-01
311	0,162 032	1,620 32E-01
312	0,128 671	1,286 71E-01
313	0,101 794	1,017 94E-01
314	0,079 247	7,924 70E-02

Table 1 (continued)

Wavelength λ / nm	Effectiveness (decimal)	Effectiveness (exponential)
315	0,061 659	6,165 90E-02
316	0,047 902	4,790 20E-02
317	0,037 223	3,722 30E-02
318	0,028 934	2,893 40E-02
319	0,022 529	2,252 90E-02
320	0,017 584	1,758 40E-02
321	0,013 758	1,375 80E-02
322	0,010 804	1,080 40E-02
323	0,008 525	8,525 00E-03
324	0,006 756	6,756 00E-03
325	0,005 385	5,385 00E-03
326	0,004 316	4,316 00E-03
327	0,003 483	3,483 00E-03
328	0,002 830	2,830 00E-03
329	0,002 316	2,316 00E-03
330	0,001 911	1,911 00E-03
331	0,001 590	1,590 00E-03
332	0,001 333	1,333 00E-03
333	0,001 129	1,129 00E-03
334	0,000 964	9,640 00E-04
335	0,000 810	8,100 00E-04
336	0,000 688	6,880 00E-04
337	0,000 589	5,890 00E-04
338	0,000 510	5,100 00E-04
339	0,000 446	4,460 00E-04
340	0,000 394	3,940 00E-04
341	0,000 394	3,940 00E-04
342	0,000 394	3,940 00E-04
343	0,000 394	3,940 00E-04
344	0,000 394	3,940 00E-04
345	0,000 394	3,940 00E-04
346	0,000 394	3,940 00E-04
347	0,000 394	3,940 00E-04
348	0,000 394	3,940 00E-04
349	0,000 394	3,940 00E-04
350	0,000 394	3,940 00E-04
351	0,000 394	3,940 00E-04
352	0,000 394	3,940 00E-04
353	0,000 394	3,940 00E-04
354	0,000 394	3,940 00E-04
355	0,000 394	3,940 00E-04
356	0,000 394	3,940 00E-04
357	0,000 394	3,940 00E-04

Table 1 (continued)

Wavelength λ / nm	Effectiveness (decimal)	Effectiveness (exponential)
358	0,000 394	3,940 00E-04
359	0,000 394	3,940 00E-04
360	0,000 394	3,940 00E-04
361	0,000 394	3,940 00E-04
362	0,000 394	3,940 00E-04
363	0,000 394	3,940 00E-04
364	0,000 394	3,940 00E-04
365	0,000 394	3,940 00E-04
366	0,000 394	3,940 00E-04
367	0,000 394	3,940 00E-04
368	0,000 394	3,940 00E-04
369	0,000 394	3,940 00E-04
370	0,000 394	3,940 00E-04
371	0,000 394	3,940 00E-04
372	0,000 394	3,940 00E-04
373	0,000 394	3,940 00E-04
374	0,000 394	3,940 00E-04
375	0,000 394	3,940 00E-04
376	0,000 394	3,940 00E-04
377	0,000 394	3,940 00E-04
378	0,000 394	3,940 00E-04
379	0,000 394	3,940 00E-04
380	0,000 394	3,940 00E-04
381	0,000 394	3,940 00E-04
382	0,000 394	3,940 00E-04
383	0,000 394	3,940 00E-04
384	0,000 394	3,940 00E-04
385	0,000 394	3,940 00E-04
386	0,000 394	3,940 00E-04
387	0,000 394	3,940 00E-04
388	0,000 394	3,940 00E-04
389	0,000 394	3,940 00E-04
390	0,000 394	3,940 00E-04
391	0,000 394	3,940 00E-04
392	0,000 394	3,940 00E-04
393	0,000 394	3,940 00E-04
394	0,000 394	3,940 00E-04
395	0,000 394	3,940 00E-04
396	0,000 394	3,940 00E-04
397	0,000 394	3,940 00E-04
398	0,000 394	3,940 00E-04
399	0,000 394	3,940 00E-04
400	0,000 394	3,940 00E-04