International Standard

ISO/CIE 28077

Photocarcinogenesis action spectrum (non-melanoma skin cancers)

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

Third edition
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Foreword

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This document was prepared by the International Commission on Illumination (CIE) Technical Committee 6-32, *Action Spectrum for Photocarcinogenesis*, in cooperation with Technical Committee ISO/TC 274, *Light and lighting*.

This third edition cancels and replaces the second edition (ISO/CIE 28077:2016), which has been technically revised.

The main changes are as follows:

— text giving historical background shifted to Annex A;

— Normative reference updated;

— Bibliography updated;

— minor editorial changes.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

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

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

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 S 017/E, ILV: International Lighting Vocabulary

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions given in CIE S 017 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

CIE maintains a terminology database for use in standardization at the following address:

— ILV: International Lighting Vocabulary: available at http://cie.co.at/e-ilv

3.1.1
ultraviolet radiation
UV radiation
UVR
optical 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:2020, entry 17-21-008, modified — Notes 2 to 5 have been omitted.]

3.2 Symbols and abbreviations

SCUP	Skin Cancer Utrecht-Philadelphia (an action spectrum proposed in Reference [1])
SCUP-m	original SCUP action spectrum, based entirely on mouse data
SCUP-h	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 Action spectrum for photocarcinogenesis of non-melanoma skin cancers

The action spectrum for photocarcinogenesis is based principally on experimental data from mice because comparable data are 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.

Some historic background information on the development of the photocarcinogenesis action spectrum is given in Annex A.

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
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

Table 1 *(continued)*

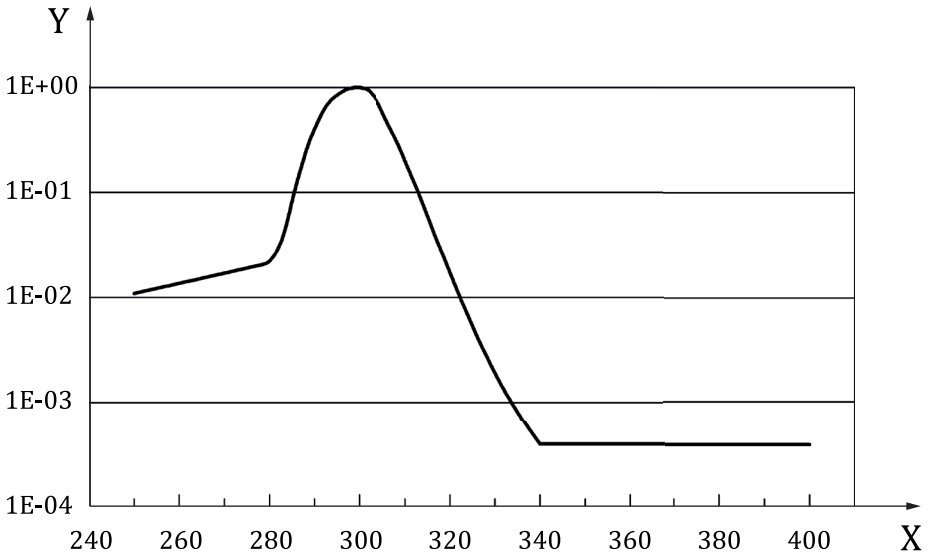
Wavelength λ/nm	**Effectiveness (decimal)**	**Effectiveness (exponential)**
281	0,025 368	2,536 80E-02
282	0,030 166	3,016 60E-02
283	0,035 871	3,587 10E-02
284	0,057 388	5,738 80E-02
285	0,088 044	8,804 40E-02
286	0,129 670	1,296 70E-01
287	0,183 618	1,836 18E-01
288	0,250 586	2,505 86E-01
289	0,330 048	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
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

Table 1 *(continued)*

Wavelength λ/nm	**Effectiveness (decimal)**	**Effectiveness (exponential)**
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
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

Table 1 *(continued)*

Wavelength λ/nm	**Effectiveness (decimal)**	**Effectiveness (exponential)**
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



Key

X wavelength/nm

Y relative effectiveness

Figure 1 — Action spectrum for photocarcinogenesis: non-melanoma skin cancer

Annex A
(informative)

Historical background

The effectiveness of ultraviolet radiation in causing photocarcinogenesis of non-melanoma skin cancers has been studied for many years[1-16]. The biology of UV-induced squamous cell carcinomas is highly analogous in mouse and human, as proven in decades of extensive studies showing the parallels between mouse and man ('cross species similarities'), for a review see Forbes.[17] Experiments substantiated the premise that the basal cell in the epidermis are the primary target cells of UV radiation in causing squamous cell carcinomas.[18] Consequently, the human action spectrum in this document was derived from the mouse action spectrum after adjustment for epidermal transmission differences between mouse and human. It 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 the original action spectrum for mice (SCUP-m) and then for human (SCUP-h):

> "The UV-A1 part (340 nm–400 nm) of the SCUP 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 (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 a small 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 seven 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 fit program. Based on SCUP-m, a SCUP-h ("-h" for human) was estimated by correcting for differences in UV transmissions between human and murine epidermis[19].

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