



Sun protective clothing — Evaluation and classification



AS 4399:2020

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- Australian Radiation Protection and Nuclear Safety Agency
- Cancer Council Australia
- Consumers' Federation of Australia
- National Retail Association
- Queensland University of Technology
- University of New South Wales
- University of Southern Queensland

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Preface

This Standard was prepared by the Australian members of the joint Standards Australia/Standards New Zealand Committee TX-021, Sun Protective Clothing, to supersede AS/NZS 4399:2017.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

This Standard is intended to provide guidance regarding the information communicated to the consumer on UPF labels and/or swing tags about the relative sun-protective capability of material and items of clothing based on an objective, reproducible *in vitro* test method. This information is intended to assist the consumer in the selection of those items which best suit their need for sun protection. This Standard also specifies the minimum level of body coverage that an item of clothing needs to achieve in order to legitimately display or claim a UPF rating.

This Standard is applicable to all materials and clothing claiming a UPF rating.

Sun protection offered by synthetic shade cloth, sunscreens, sunglasses and eye protectors is not covered in this Standard.

The major changes in this edition are as follows:

- (a) Introduction of a minimum level of body coverage required for clothing to display or claim a UPF rating.
- (b) Revision of the UPF classification scheme.
- (c) Introduction of minimum requirements for specified items of clothing, including hats and gloves.

The term “normative” is used in Standards to define the application of the appendices to which it applies. A “normative” appendix is an integral part of a Standard.

Contents

Preface	ii
Introduction	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Body coverage	3
4.1 General.....	3
4.2 Clothing.....	4
4.2.1 General.....	4
4.2.2 UPF ratings for multi-component and multiple-material clothing.....	5
4.2.3 Upper body clothing.....	6
4.2.4 Lower body clothing.....	6
4.2.5 All-in-one clothing.....	6
4.2.6 Clothing exclusions.....	6
4.3 Sun protective hats.....	6
4.3.1 General.....	6
4.3.2 Hat styles.....	6
4.3.3 Hats made from multiple materials.....	7
4.3.4 Hat exclusions.....	7
4.4 Gloves.....	7
4.5 Wraps, blankets and other non-fitted items.....	8
4.6 Accessories.....	8
4.7 Exceptions for all-in-one clothing.....	8
5 Classification for labelling	8
6 Marking and labelling	9
6.1 General.....	9
6.2 Labels and packaging.....	9
6.2.1 Permanent labels.....	9
6.2.2 Non-permanent labels and packaging.....	9
6.2.3 Additional labelling required for items not meeting the minimum body coverage requirements.....	10
6.3 Additional information.....	10
6.4 Optional claims.....	12
Appendix A (normative) Method for the determination of the UPF rating of a dry fabric	13
Appendix B (normative) Combined solar spectral irradiance (E_{λ}) and erythral spectral effectiveness function tables (S_{λ})	19
Bibliography	21

Introduction

Australia experiences one of the highest rates of skin cancer in the world. As a result, substantial effort has been invested in ensuring sun protective measures are readily available for, and easily adopted by, the Australian public.

There is scientific evidence to indicate that skin cancer risk can be meaningfully reduced by ensuring that a greater proportion of the body is routinely covered by clothing, particularly during childhood (Harrison et al., 2005, Harrison et al., 2010 and Smith et al., 2013).

Therefore, this revision adds a new requirement by specifying the minimum amount of body coverage required in order to permit a UPF claim to be made. It explicitly excludes the manufacturers of brief clothing items, such as bikini swimwear, from making any sun protection claims regardless of the UPF rating of the material that the bikini is made from.

This Standard does not seek to prescribe the ideal level of body coverage to ensure 100 % sun protection. Furthermore, it does not address the issue of ultraviolet radiation (UVR) exposure that achieves an ideal balance between skin cancer prevention and vitamin D production as this issue is outside the scope of this Standard.

It is not the intention of this Standard to inhibit innovation. However, clothing which does not cover significant areas of exposed skin, should not be considered as sun protective clothing in the general sense, although the material itself may block UVR.

To designate clothing which provides inadequate skin coverage as sun protective is misleading. Clothing of such design is therefore excluded from the scope of this Standard.

In determining the test method and thus the rating system given in this Standard, the Committee considered the relative merits of *in vivo* (direct testing in humans) and *in vitro* (laboratory-based) test methods, and the relationship between sunglasses and sun protective materials (which are inert products) and sunscreens (where there may be an interaction such as bioactivation, or a variability in the sunscreen film thickness because of the uneven application onto the skin surface). Many consumers will be familiar with the term “sun protection factor” (SPF) which is used to rate sunscreens. The test method used to determine an SPF value is an *in vivo* one, using the start of a sunburn on human skin as an end point, and the procedure is given in AS/NZS 2604. However, the term “ultraviolet protection factor” (UPF) is used in this Standard to rate sun protective materials and clothing, and it is based on an *in vitro* test method (Gies et al., 1994). The UPF measurement is a relative ranking of the sun protective capabilities of a material. The UPF is not related to the development of redness in human skin due to excessive sun exposure.

dry material. It is expected that some materials will have a lower UPF rating when wet, and that the amount of protection offered by materials is likely to vary according to how much they are stretched. Research to identify these variables is currently underway, but the relevant variables for a wet test procedure and a stretched test procedure are not yet known.

It is also noted that loose clothing provides better protection from solar UVR than tight fitting clothing (tight enough to stretch material) and that dark colours generally offer better sun protection than light colours. The sun protection afforded by clothing is also influenced by the weave or knit structure of the material, with denser construction blocking more UVR. It is recommended that a high SPF sunscreen product be applied to any exposed areas of the skin not protected by clothing.

Australian Standard[®]

Sun protective clothing — Evaluation and classification

1 Scope

This Standard sets out procedures for determining the performance of materials and items of clothing that are worn in close proximity to the skin to provide protection against solar ultraviolet radiation (UVR). The sun protective capability of materials and clothing is described in terms of their ultraviolet protection factor (UPF), which is based on an objective, reproducible test conducted on the material. This information is provided to the consumer in the form of a labelling scheme.

This Standard applies to all materials and items of clothing seeking to claim a UPF rating. All such clothing needs to be designed in a manner that supports the concept of minimal skin exposure. This Standard specifies the minimum amount of body coverage by an item of clothing in order to be allowed to make a UPF claim.

This Standard excludes the following:

- (a) Sunglasses.
- (b) Sunscreen products for topical application to human skin.
- (c) Materials for architectural or horticultural use such as shade cloth.
- (d) Items which offer protection at a distance from the skin such as shade structures.
- (e) Protection from UVR from sources other than the sun.

In this Standard, any reference made to UVR refers exclusively to solar UVR.

NOTE 1 For sunscreen requirements, refer to AS/NZS 2604.

NOTE 2 For sunglasses requirements, refer to AS/NZS 1067.1 and AS 1067.2.

NOTE 3 For shade fabric requirements, refer to AS 4174.

NOTE 4 Products such as umbrellas and shade structures which are not in close proximity to the skin will provide a lesser degree of protection than would be indicated by the rating of the material from which the product is made because of the amount of scattered radiation that could enter from around the edges of the product. The amount of this radiation will vary with the area of the product and the distance of the product from the body. This Standard is therefore not appropriate for evaluating such items (refer to AS 4174).

2 Normative references

There are no normative references in this document.

NOTE Documents for informative purposes are listed in the Bibliography.

3 Terms and definitions

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

3.1

elbow

joint situated between the upper arm (humerus) and the forearm (primarily connected to the ulna)

Note 1 to entry: See [Figure 1](#).

3.2

erythema

start of a sunburn for people with the most sun-sensitive skin type

3.3**hip line**

line formed by measuring the hips at the fullest part, i.e. where the girth of the body is greatest between the abdomen and the crotch

Note 1 to entry: See [Figure 1](#).

3.4**knee**

corresponds with a horizontal line drawn through the uppermost point of the knee cap (patella) just below where it meets the femur

Note 1 to entry: See [Figure 1](#).

3.5**lower body**

incorporates the buttocks and legs, from the hip line to halfway between the crotch and the knee

Note 1 to entry: See [Figure 1](#).

3.6**may**

indicates the existence of an option

3.7**meagre**

deficient in quantity

Note 1 to entry: For the purpose of this Standard, meagre is used to describe clothing which only covers a small percentage of the total body surface area, e.g. bikini swimwear.

3.8**neck point**

point at the base of the neck where a collar would sit on a business shirt

Note 1 to entry: See [Figure 1](#).

3.9**shall**

indicates that a statement is mandatory

3.10**should**

indicates a recommendation

3.11**shoulder point**

outermost extent of the shoulder joint and generally aligned with the seam joining a “set-in” sleeve to the body of clothing

Note 1 to entry: It can be defined anatomically as the outermost extent of the acromio-clavicular joint (commonly known as the A-C joint), which is derived from the junction of the collar bone (clavicle) and the shoulder blade (scapula). The exact point of measurement (see [Figure 1](#)) coincides with the hollow between the shoulder (acromion) and above the long bone of the upper arm (the humerus).

3.12**sun protective clothing**

item of clothing that is designed or made to be used in a way that reduces or minimizes skin exposure and is manufactured from material which meets the requirements for the minimum UPF rating in accordance with this Standard

EXAMPLE Personal clothing and clothing accessories such as hats, gloves, sleeves, leggings, wrist protectors, body wraps and blankets, brim and neck protectors such as gaiters or balaclavas for use with helmets or hats.

3.13

torso

front and back of the body from neck point to hip line and from shoulder point to shoulder point

Note 1 to entry: See [Figure 1](#).

3.14

ultraviolet protection factor

UPF

ratio of the average effective *UVR* ([3.15](#)) irradiance calculated for unprotected skin to the average effective *UVR* irradiance calculated for skin protected by the test material

Note 1 to entry: See tables in [Appendix B](#).

3.15

ultraviolet radiation

UVR

optical radiation that is part of the electromagnetic radiation spectrum in the range 100 nm to 400 nm

Note 1 to entry: Solar *UVR* consists of only *UVA* and *UVB* in the range 280 nm to 400 nm.

Note 2 to entry: Solar *UVR* at the earth's surface only covers the range 290 nm to 400 nm as 280 nm to 290 nm is absorbed by the atmosphere and is not present.

Note 3 to entry: See [Tables B.1](#) and [B.2](#).

3.15.1

ultraviolet radiation A

UVA

solar *ultraviolet radiation* ([3.15](#)) in the range 315 nm to 400 nm

3.15.2

ultraviolet radiation B

UVB

solar *ultraviolet radiation* ([3.15](#)) in the range 280 nm to 315 nm

Note 1 to entry: This classification is based on the ranges given by the International Commission on Non-Ionizing Radiation Protection in 2004 and apply to all *UVA*, *UVB* and *UVR*.

3.16

upper body

incorporates the torso and shoulders and 3/4 of the upper arm

Note 1 to entry: See [Figure 1](#).

4 Body coverage

4.1 General

The design of clothing for sun protection is an important component in lowering exposure of the body to *UVR*. Minimal skin coverage afforded by scant clothing design does not provide the required protection for conformance to this Standard. Correct sizing of clothing or loose fitting clothing is also necessary to avoid stretching and afford maximum protection.

The following specifications shall be required for clothing to carry a sun protection UPF rating.

4.2 Clothing

4.2.1 General

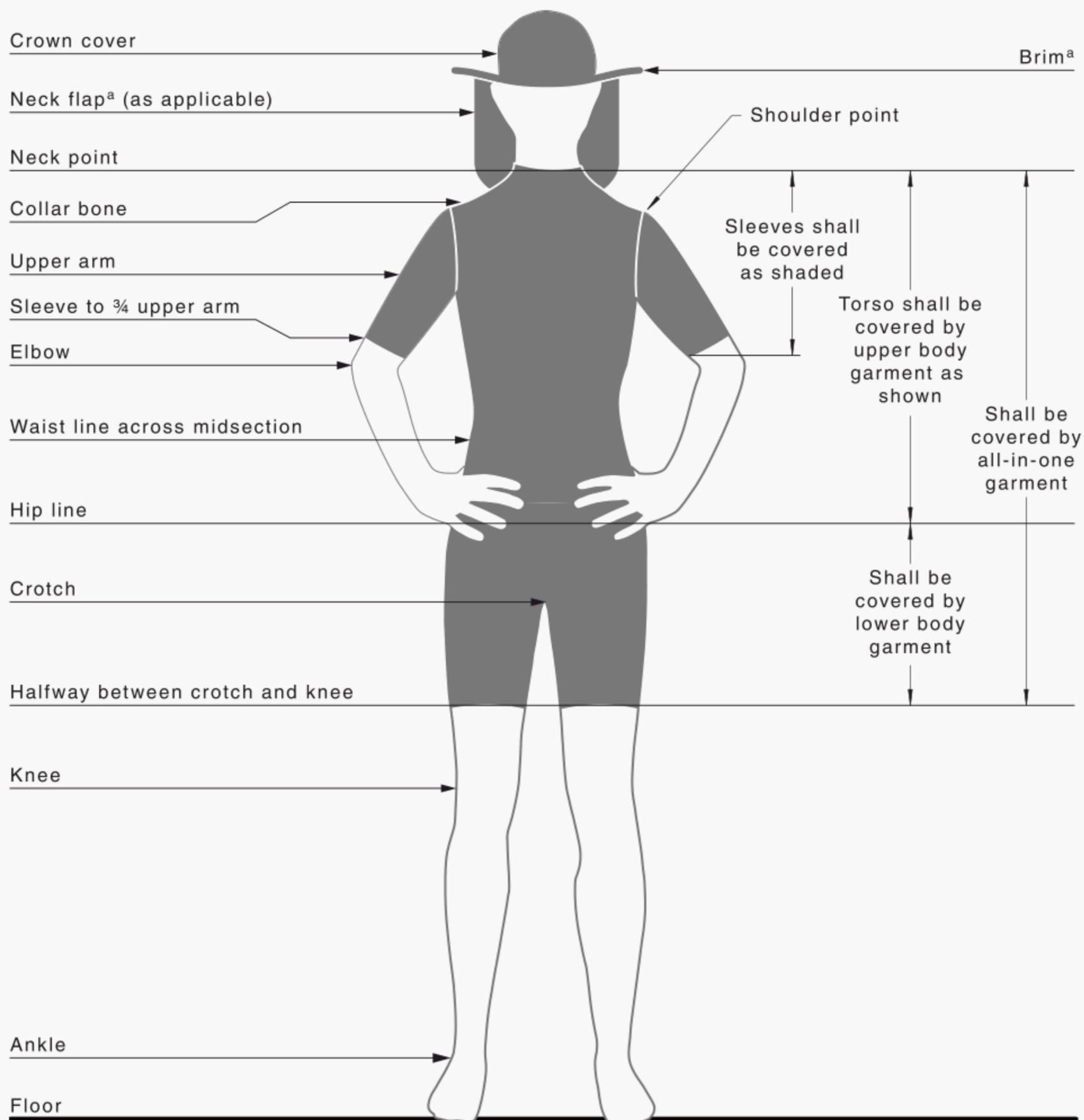
Maximum coverage of the skin is recommended to reduce exposure to solar UVR. Therefore, the more skin covered by material, the better the protection provided. Clothing designs incorporating full length sleeves, collars, crew necklines, long skirt or long trouser legs cover more body surface area, thereby providing a more extensive physical barrier to solar UVR than sleeveless dresses and vests, low necklines, mini-skirts, shorts, bikini tops and briefs.

To claim a UPF rating, clothing shall cover a minimum of —

- (a) upper body including the torso and 3/4 of the upper arms; or
- (b) the lower body; or
- (c) both (a) and (b).

The design for clothing which offers optimal protection from solar UVR includes full coverage of both the upper and lower body and hats that cover the crown and shade the face, ears and neck.

NOTE All-in-one clothing (see [Clause 4.2.5](#)) should not be considered the only design able to make a sun protection claim.



^a As per Figure 2 design

Figure 1 — Minimum body coverage specifications

4.2.2 UPF ratings for multi-component and multiple-material clothing

There are circumstances where a range of materials are used in combination to make up clothing. This Standard provides for such combinations, e.g. use of mesh in underarm of outdoor work shirts. However, parts of the clothing covering body parts usually exposed to the sun while outdoors shall meet testing requirements (see [Clause A.8](#)) to claim a UPF rating.

The lowest rated UPF achieved in testing multi-component clothing, excluding those areas not exposed to sunlight (i.e. armpits), shall be the rating used for those clothing items. The armpit area not exposed to sunlight is a maximum of 100 mm wide under each arm and extends not more than 100 mm below the underarm point (refer to AS/NZS 4602.1). The lowest rated UPF achieved in testing of clothing made from multiple materials shall be the rating used for that clothing.

4.2.3 Upper body clothing

To claim a UPF rating, the clothing shall fully cover the torso and 3/4 of the upper arm from the shoulder down to the hip line as shown in [Figure 1](#).

4.2.4 Lower body clothing

To claim a UPF rating, the clothing shall fully cover the body from the hip line to at least halfway between the crotch and the knee (based on inner thigh measurement) as shown in [Figure 1](#).

4.2.5 All-in-one clothing

All-in-one clothing seeks to provide UV protection through a combination of the clothing given in [Clauses 4.2.3](#) and [4.2.4](#), see [Figure 1](#).

4.2.6 Clothing exclusions

The following articles of clothing shall not claim a UPF rating:

- (a) Singlets.
- (b) Crop and halter tops.
- (c) Bikini tops.
- (d) Briefs.
- (e) G-strings.

NOTE Such articles of clothing do not provide sufficient body coverage to offer adequate UVR protection.

4.3 Sun protective hats

4.3.1 General

Caps and sun visors do not provide adequate protection from UVR as they do not cover the ears or shade the lower face. Designs affording better protection of the crown, face, ears and neck include bucket hats, broad brimmed hats and legionnaire hats.

NOTE See hat examples in [Figure 2](#).

4.3.2 Hat styles

To claim or display a UPF rating, hat designs shall protect the face, head, ears and neck as follows:

- (a) Bucket hats — a minimum 6 cm brim width.

NOTE 1 See [Figure 2\(a\)](#).

NOTE 2 Brim widths measurement points are shown in [Figure 2](#).

- (b) Broad brimmed hats —

- (i) a minimum 6 cm brim width for hats with a circumference less than or equal to 56 cm; and

- (ii) a minimum 7.5 cm brim width for hats with a circumference greater than 56 cm.

NOTE 3 See [Figure 2\(b\)](#).

NOTE 4 Brim width measurement points are shown in [Figure 2](#).

NOTE 5 Circumferences are measured in a relaxed state.

- (c) Legionnaire hats —
- (i) a minimum 6 cm brim width for hats with a circumference less than or equal to 56 cm; and
 - (ii) a minimum 7.5 cm brim width for hats with a circumference greater than 56 cm.

Legionnaire hats shall have a neck flap providing coverage for the ears and back of the neck to the collarbone/shoulder.

NOTE 6 See [Figure 2\(c\)](#).

NOTE 7 Brim width measurement points are shown in [Figure 2](#).

- (d) Alternative hats —
- (i) a minimum 6 cm brim width for hats with a circumference less than or equal to 56 cm; and
 - (ii) a minimum 7.5 cm brim width for hats with a circumference greater than 56 cm.

Hat designs providing protection and shading at the crown, face, ears and neck are also acceptable.

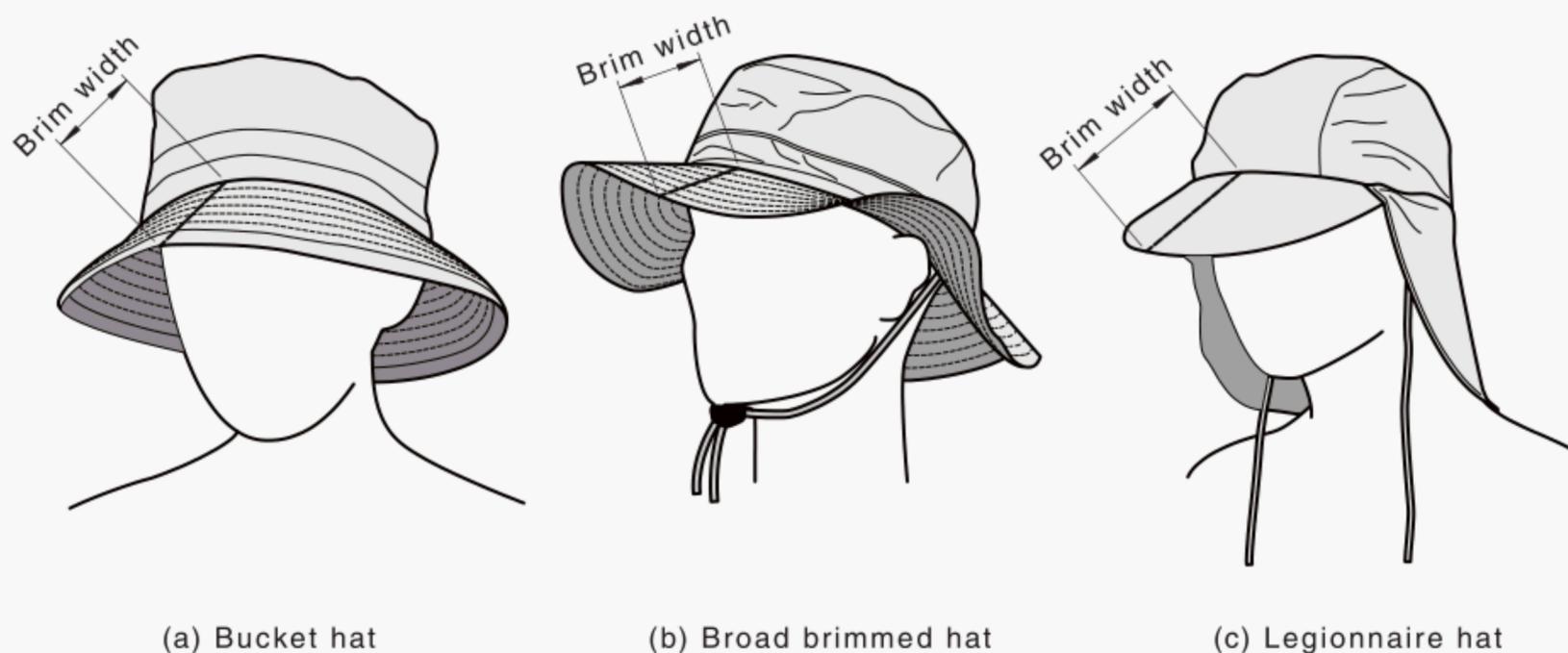


Figure 2 — Examples of sun-protective hats

4.3.3 Hats made from multiple materials

The UPF rating for hats made from multiple materials shall be the lowest rated UPF achieved during testing.

4.3.4 Hat exclusions

Caps and sun-visors shall not claim or display a UPF rating. These designs do not provide adequate coverage.

4.4 Gloves

To claim or display a UPF rating, the design of the glove shall cover the entire back of the hand to the wrist.

4.5 Wraps, blankets and other non-fitted items

The following products may be used to provide coverage to specific body parts but are not classified as clothing for the purpose of this Standard:

- (a) Sarongs.
- (b) Wraps.
- (c) Blankets.

The UPF of these items cannot be determined by any specific body-coverage metrics. However, these items should be able to make UPF claims and be labelled in accordance with [Clause 6](#) if the material used is in accordance with [Clause 5](#) of this Standard.

4.6 Accessories

Accessories are permitted to have UPF ratings when designed to provide additional protection. Accessories may include:

- (a) Sleeves and leggings, including gaiters.
- (b) Wrist protectors.
- (c) Brim and neck flaps for protective hats and helmets.
- (d) Head and neck protection including scarves and bandanas.
- (e) Balaclavas for use with helmets or hats.

Accessories shall be classified in accordance with [Clause 5](#) and maybe labelled in accordance with [Clause 6](#).

4.7 Exceptions for all-in-one clothing

UPF ratings shall be allowed for items of clothing that do not specifically meet the body coverage requirements for all-in-one clothing (see [Clause 4.2.5](#)) such as:

- (a) All-in-one items that cover all of the upper body, see [Clause 4.2.3](#).
- (b) All-in-one items that cover all of the lower body, see [Clause 4.2.4](#).

[Clause 5](#) and labelling

requirements in accordance with [Clause 6](#).

5 Classification for labelling

For the purposes of labelling, sun protective clothing shall be classified according to the following:

- (a) The rated UPF shall be determined in accordance with [Appendix A](#). The UPF classification of the protection provided by the fabric used in the construction of the clothing shall be determined in [Table 1](#).
- (b) Terms “50+” or “50 plus” shall only be claimed for products with a rated UPF of 55 or greater.
- (c) UPF ratings other than 15, 30, 50 or 50+ (50 plus) shall not be claimed or implied for the product.
- (d) The UPF rating for clothing made from multiple materials shall be the lowest rated UPF achieved during testing. Materials used in areas not exposed to sunlight (i.e. armpits, see [Clause 4.2.2](#)) shall be excluded.

Table 1 — UPF classification system

Rated UPF	UPF classification
15	Minimum protection
30	Good protection
50, 50+	Excellent protection

6 Marking and labelling

6.1 General

Where a length of material or item of clothing is eligible to claim a rated UPF and UPF classification, it shall be accompanied by the information stipulated in [Clause 6.2](#). The information shall be presented in a clear and legible manner by means of a permanent or removable label securely attached to the item at point of sale.

NOTE Manufacturers making a statement of conformance to this Standard on product, packaging, or promotional material related to that product should ensure that such conformance is able to be verified.

6.2 Labels and packaging

6.2.1 Permanent labels

Permanent labels shall contain the following minimum marking requirements:

- (a) Manufacturer's or supplier's name, trade name or identification mark.
- (b) Rated UPF and UPF classification in accordance with [Table 1](#), which shall be provided as follows:
 - (i) Numerical rating used for the product shall be preceded by either "Ultraviolet Protection Factor" or "UPF".
 - (ii) Same font and type size shall be used for the rating and the protection category.
 - (iii) Terms "50+" or "50 plus" shall only be claimed for products with a rated UPF of 55 or greater.
 - (iv) UPF ratings other than 15, 30, 50 or 50+ (50 plus) shall not be claimed or implied for the product.
- (c) Reference to this Standard, e.g. AS 4399:2020.

NOTE 1 The information in Item(a) may appear on a separate label.

NOTE 2 Permanent labels may also include the following marking: Maximum skin coverage helps to prevent skin damage.

6.2.2 Non-permanent labels and packaging

Non-permanent labelling and packaging (e.g. swing tags) shall include the information stipulated in [Clause 6.2.1](#) and the following wording:

"The UPF rating applies only to the area of skin covered. Protection may be reduced if the material is wet, stretched or from the effects of normal wear or exposure to chemicals. For best sun protection use hats, clothing that provides maximum skin coverage, sunglasses, sunscreen and shade."

6.2.3 Additional labelling required for items not meeting the minimum body coverage requirements

6.2.3.1 Sun protective hats

For sun-protective hats identified in [Clause 4.3](#), these products shall include the information in [Clause 6.2.1](#) and [6.2.2](#) and the following wording:

“Hats that shade the face, head, ears and neck provide optimal protection.”

6.2.3.2 All-in-one clothing and non-fitted items and accessories

UPF ratings for items that do not meet the body coverage requirements of [Clauses 4.2](#) or [4.3](#) shall relate only to the fabric and not the design of the clothing. This specifically applies to:

- (a) [Clause 4.4](#).
- (b) [Clause 4.5](#).
- (c) [Clause 4.6](#).
- (d) [Clause 4.7](#). Exceptions for all-in-one clothing that do not meet the requirements of [Clause 4.2.5](#) but do meet the requirements of:
 - (i) [Clause 4.2.3](#) covering all of the upper body.
 - (ii) [Clause 4.2.4](#) covering all of the lower body.

Where such items carry a UPF rating, the items shall include the information stipulated in [Clauses 6.2.1](#) and [6.2.2](#) on labels and packaging (e.g. swing tags) and the following wording:

“The UPF rating does not consider the design of this item in relation to recommended body coverage. Wear in combination with other sun protective clothing that has a UPF rating.”

6.2.3.3 Retail purchases of rolls or lengths of material intended to provide coverage

These products shall use the following wording:

“Stretching and sewing during clothing manufacture may lower the UPF of the material. To claim a UPF rating, the design of the product needs to meet the body coverage requirements of AS 4399.”

6.2.3.4 Items of clothing that are convertible or for use in combination or able to be broken into parts of lesser body coverage and intended to meet the minimum body coverage requirements

These products shall use the following wording:

“The UPF rating of this clothing applies only when worn in its entirety.”

6.3 Additional information

Attached labels and other accompanying information or packaging or both shall contain all the minimum markings in accordance with [Clauses 6.2.1](#) and [6.2.2](#) or [Clause 6.2.3](#).

The label or other accompanying information (e.g. websites, digital figures, and pre-packaged items) or the packaging or both should also contain the following clothing-specific information:

- (a) *Clothing intended to cover the upper body* — the minimum coverage of the clothing should include the shoulders, torso and at least 3/4 of the upper-arms.

NOTE 1: See [Figure 3](#), label (a).

- (b) *Clothing intended to cover the lower body* — the minimum coverage of the clothing should extend from the hip line to at least halfway down the thighs.

NOTE 2 See Figure 3, label (a).

- (c) *Clothing intended to provide all-in-one coverage* — the recommended minimum coverage of the clothing includes the shoulders, at least 3/4 of the upper-arms, and the torso to at least halfway down the thighs.

NOTE 3 See Figure 3, label (b).

- (d) *Hats intended to provide coverage* should use the following wording:

“This hat does not provide protection against reflected or scattered solar ultraviolet radiation. Brim widths 6 cm or greater are recommended to shade the face, head, ears and neck.”

- (e) *Retail purchases of rolls or lengths of material intended to provide coverage* should use the following wording:

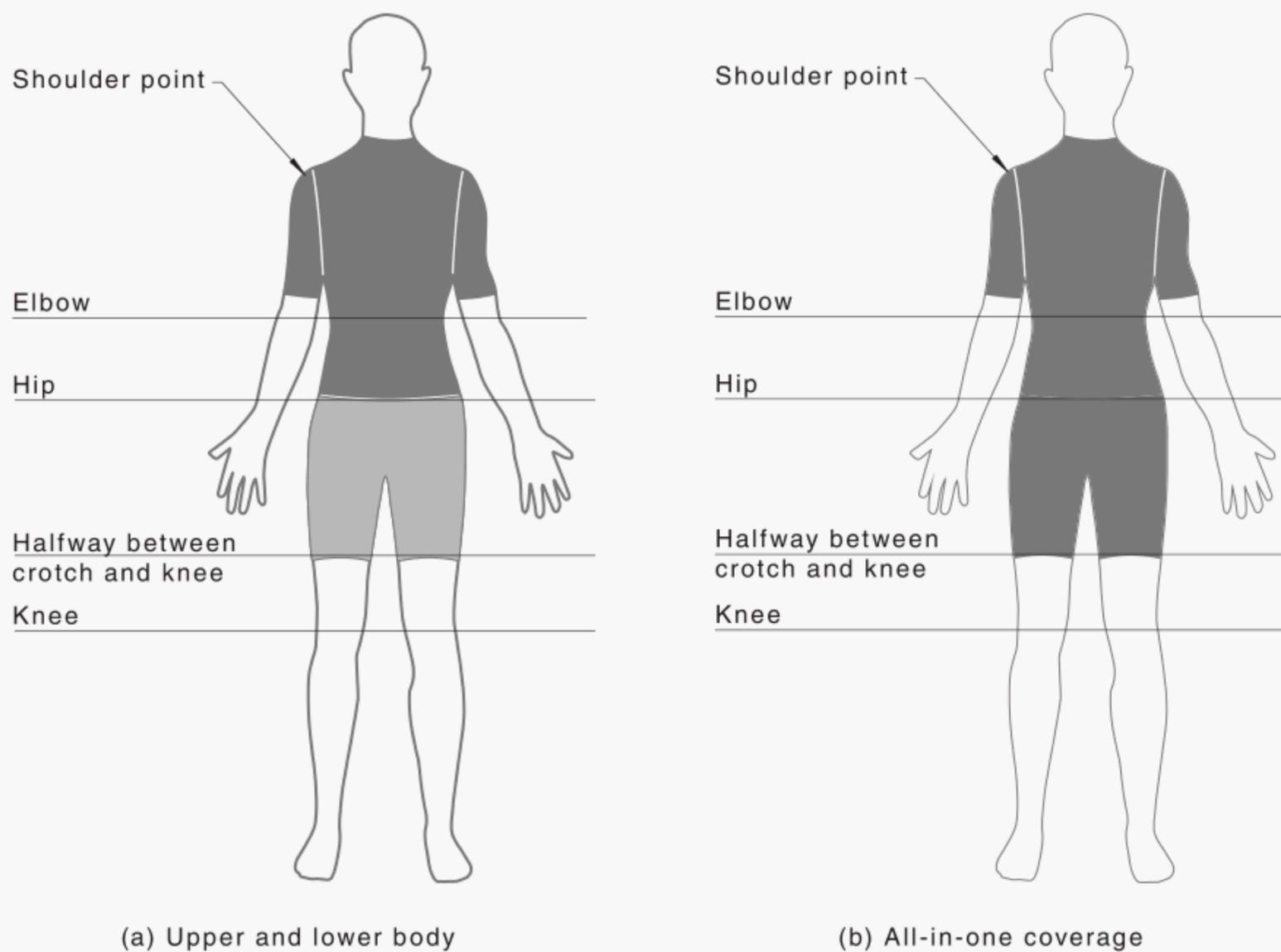
“Stretching and sewing during clothing manufacture may lower the UPF of the material.”

- (f) *Gloves, wraps, blankets, non-fitted items and other accessories intended to provide coverage*, should use the following wording:

“This UPF rating only relates to the areas of skin that this accessory covers. Accessories not in direct contact with skin do not provide protection against reflected or scattered solar ultraviolet radiation. Manipulations involved in manufacturing such as stretching or sewing may lower the UPF rating. For optimal sun protection this accessory should be used in combination with other sun protective clothing that carries a UPF rating and classification in accordance with AS 4399.”

- (g) *Items of clothing that are convertible or to be used in combination or can be broken into parts of lesser body coverage and intended to meet the minimum body coverage requirements*, should use the following wording:

“The UPF rating of this clothing relates only when worn in its entirety.”



Key:

- Upper body
- Lower body

Figure 3 — Body coverage of clothing

6.4 Optional claims

In addition, the following optional claims may be used:

- (a) The mean UVA transmittance of the material, as specified in accordance with [Appendix A](#).
- (b) The mean UVB transmittance of the material, as specified in accordance with [Appendix A](#).

Appendix A (normative)

Method for the determination of the UPF rating of a dry fabric

A.1 Scope

This Appendix sets out a spectrophotometric or spectroradiometric method for determining the UPF rating by measuring the UVR transmittance of a dry fabric.

NOTE Other test methods may be used provided they are shown to be equivalent.

A.2 Principle

The UVR (290 nm to 400 nm) transmitted through a specimen is measured using a spectrophotometer or spectroradiometer with integrating sphere. An integrating sphere is used to ensure that the total (i.e. both the direct and diffuse) spectral transmittance of the material is measured.

A.3 General

The average effective UVR irradiance for unprotected skin (E_{eff}) is calculated by convolving the incident solar spectral irradiance with the relative spectral effectiveness summed over the wavelength range 290 nm to 400 nm. To obtain the average effective UVR irradiance for the skin when it is protected (E'), the calculation is repeated with the spectral transmittance of the fabric as an additional weighting. The ratio of E_{eff} to E' is expressed as the ultraviolet protection factor (UPF).

A.4 Apparatus

A.4.1 General

The following apparatus is required:

- (a) A spectrophotometer or spectroradiometer, with a beam of radiation of angular divergence of less than $\pm 5^\circ$ about the beam axis.

The measurement shall be made using a spectral half bandwidth of 5 nm or less in the range 290 nm to 400 nm. Stray radiation in the beam, including from fluorescence, shall produce an error of less than 0.01 in the value of spectral transmittance being measured.

The spectrophotometer or spectroradiometer shall be fitted with an integrating sphere attachment.

The measurement entrance port shall be of dimensions that encompass size variations in the fabric construction.

NOTE 1 Alternatively, a spectroradiometer with a diffuser may be used if data from the instrument has been shown to match the data recorded from a spectroradiometer with an integrating sphere.

NOTE 2 Methods for determining fluorescence are specified in [Clauses A.5.2](#) and [A.5.3](#). These methods are suitable for determining the amount of stray radiation in the beam if the measurement is done without a sample in place.

- (b) An integrating sphere having total openings representing no more than 10 % of the internal spherical surface area. The internal surface of the sphere shall be lined with a highly reflective

matt surface, for example, barium sulfate paint. The internal surface shall be recoated when the reflectance becomes less than 75 %.

- (c) In order to minimize any measurement error that may be caused by fluorescent properties of the test material, a suitable filter [see [Clauses A.5.2\(b\)](#) and [A.5.3\(b\)](#)] shall be placed after the sample.
- (d) Templates with measurement apertures of a suitable size for the entrance port of the integrating sphere in Item (b).

A.4.2 Wavelength scale calibration of spectrophotometer or spectroradiometer

Spectrophotometer or spectroradiometer wavelength scales shall be calibrated by one of the following methods:

- (a) Spectral emission lines of an electrical discharge in mercury vapour, supplemented by the spectral emission lines of other elements.
- (b) A filter with absorption bands appropriate to the range being calibrated.

NOTE Commonly used filters are —

- (a) a glass filter containing holmium oxide for the ultraviolet range; or
- (b) a glass filter containing rare earth elements known as didymium.

A.4.3 Response checking of spectrophotometer or spectroradiometer

Spectrophotometer or spectroradiometer linearity of response shall be checked at regular intervals (e.g. every six months) by one of the following methods:

- (a) Calibrated neutral density glass filters of optical quality and spectral transmittance of the limits appropriate to the protection categories 6.7 %, 3.3 % and 2.0 %.
- (b) Calibrated meshes with transmittances of 6.7 %, 3.3 % and 2.0 %.

A.5 Assessment of the contribution of fluorescence to the spectral transmittance measurement

A.5.1 General

sample, some dyes or whitening agents used in fabric manufacturing may be fluorescent, resulting in an underestimation of the UPF of the sample. In order to determine that the measurement system, including any filters, minimizes the effect of such fluorescence, the contribution of fluorescence to the spectral transmittance measurement shall be determined, unless the fabric has previously been shown not to be fluorescent.

A.5.2 Fluorescence in the 290 nm to 350 nm range

Fluorescence in the 290 nm to 350 nm range shall be determined as follows:

- (a) Measure the spectral transmittance of a specimen of the sample under test, including any means used to minimize the influence of fluorescence, in accordance with the procedure specified in [Clause A.7](#).
- (b) Place a filter, which has spectral transmittance 0.001 at wavelengths 350 nm or less and spectral transmittance 0.80 at wavelengths in the range 410 nm to 600 nm, immediately in front of the integrating sphere input port and after the sample and any other means used to control the effects of fluorescence.

- (c) Measure the spectral transmittance in the range 280 nm to 350 nm using the procedure given in [Clause A.7](#). Any measurable value is due to fluorescence.
- (d) Where the indicated spectral transmittance is greater than 0.01 in the range 280 nm to 350 nm when measured according to [Clause A.7](#) —
 - (i) an alternative means of reducing the effect of fluorescence shall be found; and
 - (ii) this procedure shall be repeated commencing from Item (a) above.

A.5.3 Fluorescence in the 350 nm to 400 nm range

Fluorescence in the 350 nm to 400 nm range shall be determined as follows:

- (a) Measure the spectral transmittance of a specimen of the sample under test, including any means used to minimize the influence of fluorescence in accordance with the procedure specified in [Clause A.7](#).
- (b) Place a filter, which has spectral transmittance 0.001 at wavelengths 400 nm and less and spectral transmittance 0.80 at wavelengths in the range 460 nm to 600 nm, immediately in front of the integrating sphere input port and after the sample and any other means used to control the effects of fluorescence.
- (c) Measure spectral transmittance in the range 350 nm to 400 nm using the procedure given in [Clause A.7](#). Any measurable value is due to fluorescence.
- (d) Where the indicated spectral transmittance is greater than 0.01 in the range 350 nm to 400 nm when measured in this way, an alternative means of reducing the effect of fluorescence shall be found, and this procedure shall be repeated from [Clause A.7](#).

A.6 Sample preparation

A minimum of four specimens shall be taken from each sample submitted for test. A minimum of two measurements shall be made from the machine direction and a minimum of two from the cross-machine direction. These specimens shall be spaced across the width of the sample to ensure that sampling is representative. The first 5 cm from each selvedge shall be discarded. More specimens may be needed from that sample if the material is non-uniform, e.g. if there are areas of different colour, printing or fibre content.

When selecting areas of material for testing, the following requirements shall be met:

- (a) Where the clothing or material has areas of different colour, a representative range of colours within the area of test shall be tested and the lowest rating colour reported.
- (b) Where the clothing or material has areas of different texture, the area with the most open structural area shall be used as a sample.
- (c) Where the clothing is fully lined, the lining and outer fabric shall be tested together.

The cloth structure shall not be distorted during the preparation of test specimens. Where the sample is to be cut, lay the material sample out in a flat, tensionless state to minimize distortion.

A.7 Procedure

Preconditioning of the test specimen is not required.

Testing shall be carried out under nominally ambient conditions (i.e. $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ and a relative humidity of $50\% \pm 20\%$).

The measurement shall be made on an area of dimensions not less than 10 times the dimensions of holes in the test material.

The procedure shall be as follows:

- (a) Calibrate the spectrophotometer or spectroradiometer according to the manufacturer's instructions.
- (b) Check (and recalibrate, where necessary) the wavelength scale of the spectrophotometer or spectroradiometer using a suitable wavelength standard.
- (c) Place the specimen at the port of the integrating sphere in the plane of the sphere wall.
- (d) Record the UVR transmittance of the specimen from 290 nm to 400 nm, logging the transmittance data at least every 5 nm.

NOTE Although the definitions of UVR and UVB given in this Standard start at 280 nm, the wavelengths below 290 nm are not used for the calculations in this Appendix. These wavelengths are unlikely to reach the surface of the Earth, and requiring their inclusion in the calculations would prevent the use of some otherwise acceptable spectrophotometers and spectroradiometers.

- (e) Repeat Steps (c) and (d) for each of the remaining test specimens.

A.8 Calculation

The results shall be calculated and expressed as follows:

- (a) The arithmetic mean of the UVA transmittance (UVA_{AV}) shall be given by the following equation:

$$UVA_{AV} = \frac{T_{315} + T_{320} + T_{325} + \dots + T_{395} + T_{400}}{18} \quad A.8(1)$$

- (b) The arithmetic mean of the UVB transmittance (UVB_{AV}) shall be given by the following equation:

$$UVB_{AV} = \frac{T_{290} + T_{295} + T_{300} + T_{305} + T_{310} + T_{315}}{6} \quad A.8(2)$$

where

T = spectral transmittance at wavelength

- (c) The UPF of the specimen shall be calculated by the following equation:

$$UPF = \frac{E_{eff}}{E'} = \frac{\sum_{290}^{400} E_{\lambda} \times S_{\lambda} \times \Delta\lambda}{\sum_{290}^{400} E_{\lambda} \times S_{\lambda} \times T_{\lambda} \times \Delta\lambda} \quad A.8(3)$$

where

$E_{\lambda} \times S_{\lambda}$ = combined solar UVR spectral irradiance (E_{λ}) (Note 1) and relative erythema spectral effectiveness (S_{λ}) (Note 2) function in $W.m^{-2}.nm^{-1}$ (see [Tables B.1](#) and [B.2](#))

T_{λ} = spectral transmittance of the item

$\Delta\lambda$ = wavelength step in nm

λ = wavelength in nm

NOTE 1 The Solar UVR spectral irradiance (E_λ) measured in Summer at Solar Noon on 17 January 1990 in Melbourne (38 °S) (Gies et. al., 1997).

NOTE 2 The CIE Erythral Effectiveness function is found in Webb et al. (2011). The CIE erythral effectiveness function (S_λ) is included in the equation to ensure that sufficient weighting is given to the biologically effective wavelengths below 315 nm.

(d) The mean UPF of the sample shall be as given in the following equation:

$$\text{Mean UPF} = \frac{\text{UPF}_1 + \text{UPF}_2 + \dots + \text{UPF}_N}{N} \quad \text{A.8(4)}$$

where

N = number of specimens

(e) The standard deviation (SD) of the mean UPF shall be as follows in the following equation:

$$SD = \sqrt{\frac{\sum_{i=1}^N (\text{UPF}_i - \text{mean UPF})^2}{N - 1}} \quad \text{A.8(5)}$$

(f) The standard error (E) in the mean UPF, calculated for a 99 % confidence level, shall be as given in the following equation:

$$E = t_{k,\alpha} \times SD / \sqrt{N} \quad \text{A.8(6)}$$

where

$t_{k,\alpha}$ = t variate ($\alpha = 0.005$)

k = $N - 1$

SD = standard deviation

N = number of specimens

NOTE: Where there are more than 10 specimens, use $E = SD \times 1.00$.

The calculation will vary with the number of specimens tested, according to [Table A.8](#).

Table A.8 — T-distribution according to v values

N (number of specimens)	v (degrees of freedom)	$T_{v,0.005}$ (t-variate)	$T_{v,0.005}/\sqrt{N}$
4	3	5.84	2.92
5	4	4.60	2.06
6	5	4.03	1.65
7	6	3.71	1.40
8	7	3.50	1.24
9	8	3.36	1.12
10	9	3.25	1.03
11+	10+	N/A	1.00

(g) The rated UPF shall be as follows:

Rated UPF = mean UPF – E , rounded down to the nearest UPF rating of 15, 30, 50 or 50+ (if the value is 55 or greater).

Where the rated UPF, determined using the above calculation, is less than the lowest individual UPF measurement for that sample, the rated UPF shall be determined as follows:

Rated UPF = lowest UPF measured in Item (c) above, rounded down to the nearest UPF rating of 15, 30, 50 or 50+ (if the value is greater than 55).

A.9 Test report

The test report shall contain the following:

- (a) Sample identification details, including material type and colour.
- (b) Reference to the solar spectrum used.
- (c) The mean UPF of the sample.
- (d) The standard deviation of the samples tested to indicate the variability of the material.
- (e) The number of specimens tested.
- (f) The rated UPF.
- (g) Reference to this Standard, i.e. AS 4399:2020.
- (h) Any deviations from the standard method.

In addition, where the optional labelling claims of UVA and UVB transmittance are to be made, the test report shall contain the following:

- (i) Arithmetic mean UVA transmittance of the sample (UVA_{AV}).
- (ii) Arithmetic mean UVB transmittance of the sample (UVB_{AV}).

Appendix B (normative)

Combined solar spectral irradiance (E_λ) and erythemal spectral effectiveness function tables (S_λ)

Table B.1 — Combined solar spectral irradiance (E_λ) and erythemal spectral effectiveness function tables (S_λ) at 5 nm intervals

Wavelength nm	Spectral function ($E_\lambda \times S_\lambda$) W.m ⁻² .nm ⁻¹
290	7.57E-05
295	1.34E-03
300	8.83E-03
305	1.69E-02
310	1.28E-02
315	7.11E-03
320	3.23E-03
325	1.43E-03
330	8.55E-04
335	6.92E-04
340	6.55E-04
345	5.27E-04
350	4.71E-04
355	4.31E-04
360	3.24E-04
365	3.48E-04
370	2.98E-04
375	2.26E-04
380	2.19E-04
385	1.41E-04
390	1.54E-04
395	1.00E-04
400	1.44E-04

Table B.2 — Combined solar spectral irradiance (E_λ) and erythral spectral effectiveness function tables (S_λ) at 1 nm intervals

λ nm	Spectral function ($E_\lambda \times S_\lambda$) W.m ⁻² .nm ⁻¹	λ nm	Spectral function ($E_\lambda \times S_\lambda$) W.m ⁻² .nm ⁻¹	λ nm	Spectral function ($E_\lambda \times S_\lambda$) W.m ⁻² .nm ⁻¹
290	5.78E-05	327	1.16E-03	364	3.53E-04
291	8.83E-05	328	8.57E-04	365	3.23E-04
292	1.87E-04	329	9.20E-04	366	3.94E-04
293	2.70E-04	330	1.00E-03	367	3.59E-04
294	4.65E-04	331	8.35E-04	368	3.27E-04
295	9.28E-04	332	8.33E-04	369	3.20E-04
296	1.98E-03	333	8.02E-04	370	3.46E-04
297	3.04E-03	334	7.39E-04	371	2.93E-04
298	4.85E-03	335	7.93E-04	372	2.70E-04
299	7.17E-03	336	6.60E-04	373	2.52E-04
300	7.20E-03	337	6.38E-04	374	2.18E-04
301	1.02E-02	338	6.61E-04	375	2.04E-04
302	9.89E-03	339	6.83E-04	376	2.44E-04
303	1.74E-02	340	7.65E-04	377	2.44E-04
304	1.57E-02	341	6.28E-04	378	2.96E-04
305	1.77E-02	342	6.35E-04	379	2.38E-04
306	1.44E-02	343	6.48E-04	380	2.11E-04
307	1.61E-02	344	4.96E-04	381	2.32E-04
308	1.55E-02	345	5.38E-04	382	1.62E-04
309	1.17E-02	346	5.22E-04	383	1.23E-04
310	1.09E-02	347	5.34E-04	384	1.28E-04
311	1.41E-02	348	4.84E-04	385	1.76E-04
312	1.04E-02	349	4.69E-04	386	1.48E-04
313	9.57E-03	350	5.13E-04	387	1.53E-04
314	8.43E-03	351	5.08E-04	388	1.46E-04
315	7.14E-03	352	4.74E-04	389	1.46E-04
316	4.94E-03	353	4.44E-04	390	1.69E-04
317	6.07E-03	354	5.11E-04	391	1.77E-04
318	4.17E-03	355	4.96E-04	392	1.57E-04
319	3.75E-03	356	4.36E-04	393	7.92E-05
320	3.43E-03	357	3.35E-04	394	9.43E-05
321	2.75E-03	358	3.13E-04	395	1.48E-04
322	2.25E-03	359	3.08E-04	396	1.25E-04
323	1.60E-03	360	4.28E-04	397	7.12E-05
324	1.60E-03	361	3.24E-04	398	1.38E-04
325	1.30E-03	362	3.14E-04	399	1.63E-04
326	1.40E-03	363	3.59E-04	400	1.60E-04

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