Every year in Australia there are 270,000 new cases of skin cancer diagnosed. Over 1200 Australians die of skin cancer each year. The occurrence of skin cancers is related to UVR exposure. Australia has the highest incidence of skin cancers in the world so accurate information about the levels of solar UVR is very important.

In the mid 1980s ARPANSA, then known as the Australian Radiation Laboratory (ARL) set up a network of detectors to measure UVR levels around Australia and in Antarctica. Evidence of depletion of stratospheric ozone, which has a direct effect on UVR levels, over the Antarctic region has encouraged the monitoring of solar UVR in the region.

How does ARPANSA measure solar UVR?

ARPANSA has measured solar UVR levels using a network of detectors in Australian capital cities and at other sites since 1986. These UVR monitoring devices cover a wide range of latitudes and different climates and record data for the study and reporting of variations and magnitude of UVR changes. However, care must be taken in assuming that a specific site in one city represents all locations within a region, as there can be significant localized differences due to cloud cover and air pollution.

There are currently 12 sites in Australia and Antarctica that have broadband UVR detectors installed. Broadband detectors measure the total energy received over a range of wavelengths in the UVR region. The detectors measure both direct and diffuse radiation. The information is analysed by computer then distributed daily to news services and other interested organisations.

What are skin types?

Skin is classified by sensitivity to UV radiation. If you are very fair skinned (white skin) and tend to burn easily in the summer sun and find it difficult to achieve a tan you have skin type 1. People with skin type 1 have the highest risk of premature skin aging and greatest risk of developing some form of skin cancer. If you are of this type then you should limit your exposure to the sun and always dress to minimise sun exposure, wear a hat and use sunscreen.

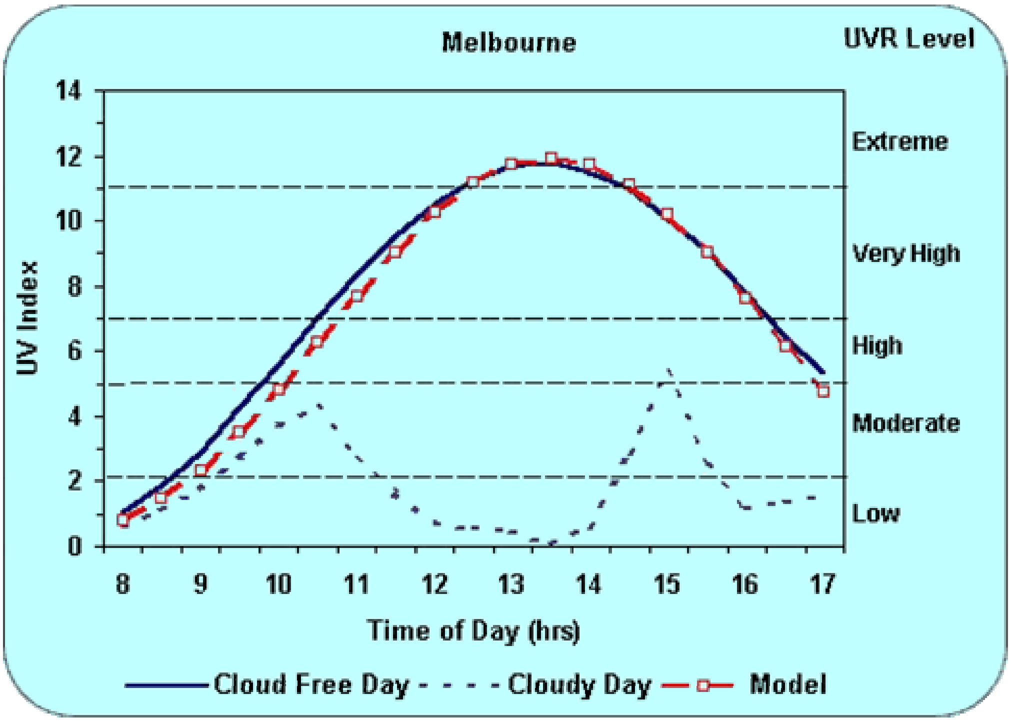
People with skin type 2 (white skin) usually burn and only rarely tan so they need to take the same precautions as skin type 1.

People with skin types 3 and 4 (white and light brown skin respectively) usually tan and occasionally burn so they still require protection from the higher levels of UVR in summer.

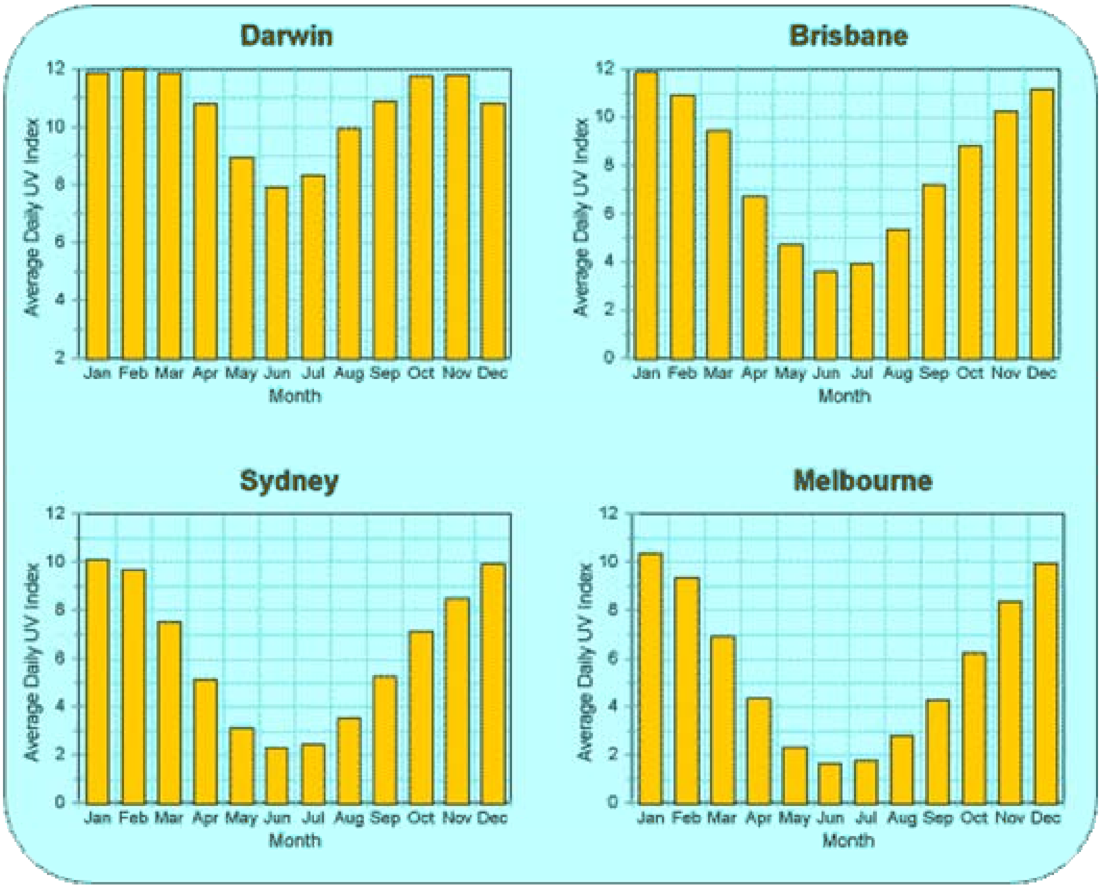
People with skin types 5 and 6 (moderate brown and dark brown-black respectively) have sufficient levels of melanin pigment in their skin to provide protection from solar UVR so they rarely burn and easily tan. However, even though darker skin offers natural protection against UVR those people are still not immune to developing skin cancers.

How does UVR intensity vary during the day?

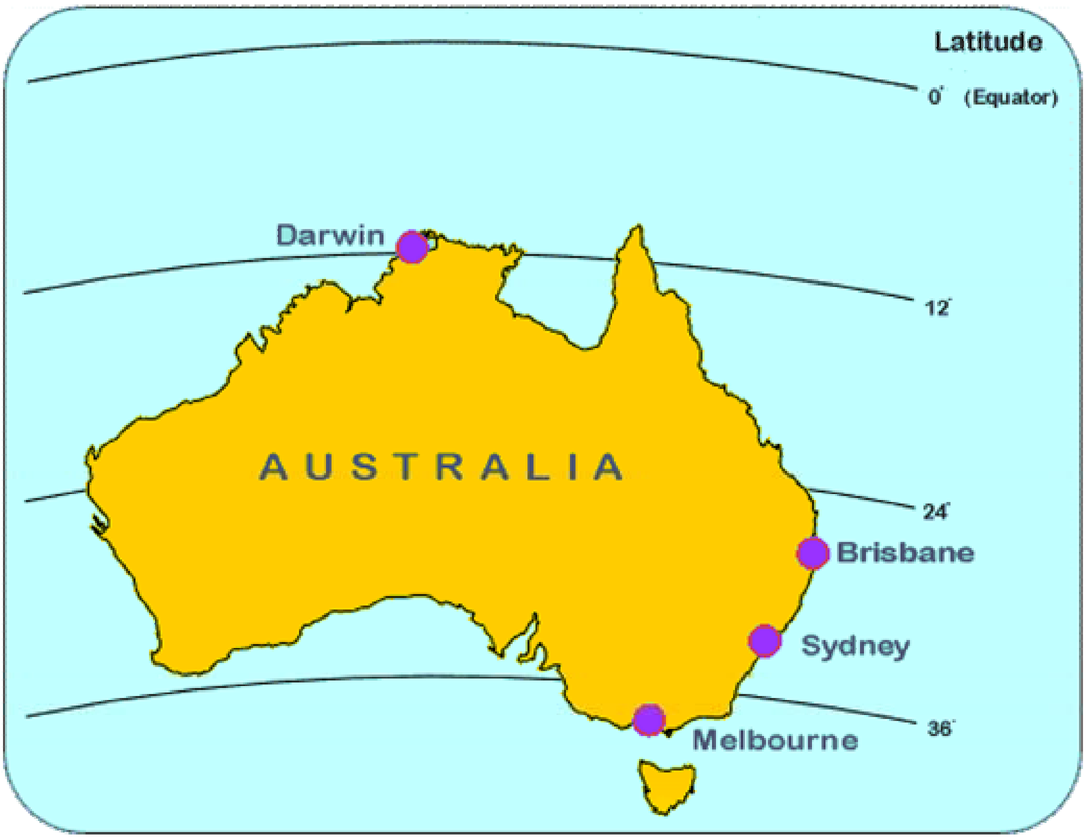
This graph shows the UV Index for Melbourne on a cloud free day (solid line) and a day when there was heavy cloud and rain, which reduced the UVR (dotted line). There is also a computer model, which is a prediction of the UV levels for a clear sky day (dashed line). The model is calculated using a measured ozone value for the day. Unusual cloud conditions and variation in ozone levels may occasionally cause the measured UV-Index to exceed the model prediction.



These graphs of average monthly UV-Indexes for some widely separated Australian capital cities show that regions closer to the equator (further north) have significantly higher levels of solar UVR especially during the winter months.



This map shows the latitudes of some widely separated Australian capital cities.



What are the risks from UVR exposure?

Over-exposure to UVR can cause sunburn, skin damage and skin cancer. UVR exposure also places our eyes at risk of photokeratitis, photoconjunctivitus and cataracts. The most obvious short-term effect of over-exposure to UVR is sunburn, also known as erythema. The more UVR exposure, the worse the sunburn becomes. A person's cumulative exposure to UVR along with the number of severe sunburns they have received, especially during childhood, increases their risk of developing skin cancer. Skin cancers affect people of all skin types.

Sun exposure causes the outer layers of the skin to thicken. Long-term exposure can cause skin to wrinkle, sag and become leathery. Due to the high levels of UVR and an outdoors lifestyle, Australians also suffer from high rates of skin cancers.

Melanoma, the least common of the skin cancers but the most dangerous, may be related to severe exposure to solar UVR at an early age. Malignant melanomas may appear without warning as a dark mole or other dark spot on the skin. Any concerns regarding moles or skin spots should be referred to a doctor or skin clinic. Further information about skin cancers can be obtained from the Cancer Councils.

Prolonged exposure to solar UVR can have serious consequences for the eyes. Cataract is one of the most common types of eye damage in Australia. Cataract is the clouding of the lens of the eye, which is responsible for focusing light and producing sharp images. Without intervention cataract can lead to blindness. Wearing wrap around sunglasses and a broad brimmed hat can prevent most of the UVR from reaching the eyes.

The sensitivity to sunburn can vary between different parts of the body. The neck, face, ears and trunk tend to be more sensitive than the limbs. These parts of the body are at more risk from UVR exposure.

Our lips have thinner layers of skin than the rest of the body. They have no sweat or oil glands so they can dry and crack easily in the sun. There are lip balms available that contain sunscreens.

What are the sources of solar UVR exposure?

Solar UVR can reach you on the ground from three sources:

- Directly from the sun.
- Scattered from the open sky.
- Reflected from the environment.

This means that even if you are shaded from the direct sun you can still receive substantial UVR exposure from the open sky and reflective ground surfaces. Reflective surfaces can reduce the effect of protective measures. For example a person in a boat wearing a hat may still receive expose to their face from UVR reflected off the water. Also some ground and building surfaces are quite reflective to UVR including white paint, light coloured concrete and metallic surfaces. These surfaces can reflect UVR onto the skin and eyes.

What factors affect solar UVR levels?

- **Sun Angle:** The most important factor affecting the level of solar UVR at the earth's surface is the height of the sun in the sky. The higher the sun is in the sky, the shorter path the UVR has to travel through the atmosphere, so less is absorbed resulting in higher levels of UVR at the surface. When the sun is low in the sky the radiation has a longer path to travel so more radiation is absorbed and scattered by the atmosphere resulting in lower levels of UVR at the surface.
- **Geographical Position:** Australia generally has high levels of solar UVR in comparison with Europe and many parts of North America, due mainly to its geographical position close to the equator.
- **Seasonal Effects:** There is significantly less UVR in winter as the sun is lower in the sky. In Melbourne the levels of UVR are approximately three times higher in midsummer than in midwinter. The highest risk months are November to February and this period is generally longer at latitudes closer to the equator.
- **Cloud Cover:** Solar UVR can penetrate through light cloud cover, and on lightly overcast days the UVR level can be similar to that of a cloud-free day. Heavy cloud can reduce the intensity of UVR. Scattered cloud has a variable effect on UVR levels, which rise and fall as clouds pass in front of the sun. UVR levels can be high enough to cause sunburn on cloudy days.
- **Ozone:** This is a form of oxygen that occurs naturally in the upper atmosphere and has the ability to absorb UVC and UVB radiation. Atmospheric absorption prevents all UVC and most of the UVB from reaching ground level.

  Ozone levels rise and fall naturally from day to day and seasonally. Ozone over Australia is generally lowest in March. The ozone "hole" is the significant springtime (September-October) reduction in the total ozone over Antarctica. Publicity about the discovery of an ozone hole over Antarctica has increased general awareness and caused concern about possible increases in UVR levels in southern Australia.

  The ozone hole does not extend as far north as Australia but stratospheric winds can occasionally carry ozone-depleted air towards Australia causing a short-term decrease in ozone and a corresponding rise in UVR levels.

  Ozone depletion and the associated increase in solar UVR reaching the earth's surface is a major environmental issue. Other factors such as sun height and variations in cloud cover may have more local influence on the intensity of UVR reaching the ground.
- **Scattering:** Due to scattering of solar UVR by molecules and particles in the atmosphere there is often about as much UVR received from the open sky as there is directly from the sun. If you are in the shade but can see a lot of blue sky you are still exposed to UVR scattered from the sky. At times, the amount of scattered solar UVR that reaches your skin may even exceed that from the direct sun.
- **Environment:** A highly reflective environment can also increase UVR levels. Some ground and building surfaces are quite reflective to UVR. White paint, light coloured concrete, snow, water and to a lesser extent soil can reflect UVR onto the skin.
- **Altitude:** The intensity of UVR increases by about 12% for every 1000 metres increase in altitude. At higher altitudes there is less atmosphere for the UVR to pass through before it reaches the ground so less is absorbed.

Consequently, people at higher altitudes can be exposed to more UVR than those at sea level. In the Australian ski fields, at an altitude of around 2000 metres, the UVR levels on clear days can be substantially higher than at sea level. The fact that snow is extremely reflective to UVR is an additional hazard.

How can you reduce your UVR exposure?

Many forms of protection are available to reduce your exposure to solar UVR. The best protection is to avoid going outdoors during the middle of the day. When outdoors, wear clothing with good body coverage, a hat, sunglasses and a sunscreen. The following strategies can reduce your UVR exposure:

- Avoid going outdoors when the sun is at its highest. UVR peaks between 10am and 2pm (11am to 3pm during daylight-saving time). This practice can dramatically reduce your UVR exposure;
- Wear clothing that covers the arms and legs as well as the body;
- Wear a broad-brimmed or legionnaires style hat to shade the eyes, face, ears and back of the neck;
- Apply at least SPF 15 and preferably SPF 30+ sunscreen to all areas of your body not covered by clothing. Reapply sunscreen every two hours, even on cloudy days. Reapply sunscreen after swimming or perspiring as it does wear off. The greatest problem with sunscreen as UVR protection is that most people apply it too thinly and do not receive the full protection;
- Wear sunglasses when outside. Choose a style of glasses such as wrap around, that prevent the UVR reaching your eyes from the sides;
- Choose shaded areas where you cannot directly see the open sky. Even if you are out of the direct sun, UVR can still reach you from the open sky. UVR can also reflect from some surfaces such as beach sand, white paint, light coloured concrete, snow and water, increasing your UVR exposure;
- Remember that if the temperature drops it does not mean that the UVR level has also decreased; and
- Protect children from excessive sun exposure with shade, suitable clothing, hats, sunglasses and sunscreens. Use pram covers and shades for babies. Young children are unaware of the dangers. Apply sunscreen liberally and often to children following the directions on the container. The greatest problem with sunscreen as UVR protection is that most people apply it too thinly and unevenly and do not receive the full protection.

Does clothing offer good UVR protection?

Most sun protective garments rely on the fabric's natural ability to block UVR. Sun protective garments are not usually specially treated, although chemical treatments are available. Laboratory testing determines how effective a material is at blocking UVR and this is often stated on the garment label as a UPF rating. The UPF rating of a material can be determined by placing it under a UVR lamp and measuring the amount of UVR that passes through the fabric. From this UVR transmission data the UPF rating can be calculated.

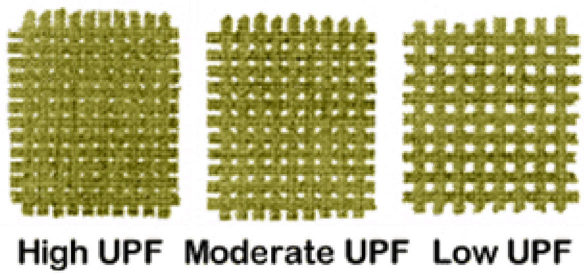
The UPF rating indicates how much the material reduces UVR exposure. For example, a material with a UPF rating of 20 would only allow 1/20th of the hazardous UVR falling on its surface to pass through it. A garment made from this material would reduce UVR exposure on the areas of skin it covered by a factor of 20.

The UVR protection offered by different types of fabrics varies considerably and depends on the factors listed below.

What makes a good sun protective garment?

Several factors determine how effective garments are at reducing UVR:

- **Composition of the fabric:** Different materials such as cotton, polyester and nylon have different natural UVR-absorbing properties.
- **Weave density:** Less UVR passes through tightly woven or knitted fabrics. As shown below the smaller the spacing between the individual fibre strands the higher the protection.



- **Colour:** Many dyes absorb UVR. In darker colours of the same fabric type (black, navy, dark red) will absorb UVR more strongly than light pastel shades (white, sky blue, light green) and consequently will have a higher UPF rating.
- **Tension:** Stretching a fabric may cause a decrease in the UPF rating. This is common in knitted or elasticised fabrics and care should be taken to select the correct size for the wearer.
- **Weight:** Heavier weight materials generally have a higher UPF ratings than lighter materials of the same type.
- **Moisture content:** Many fabrics have lower UPF ratings when wet. The drop in UPF rating depends on the type of fabric and the amount of moisture it absorbs when wet.
- **Design:** As well as considerations of fashion and comfort, selecting garments that are sensibly designed for sun protection can make a large difference to your overall UVR exposure. A shirt with long sleeves and a high collar offers more protection than a short-sleeve shirt without a collar. Loose fitting garments give better protection than garments that are worn close to the skin and also may be more comfortable to wear on hot days. A legionnaire style cap with a flap protects the ears and back of the neck. A broad-brimmed hat shades the face and neck.
- **Condition:** Unless otherwise stated, UPF ratings are made on fabrics that are in new condition. The UPF rating of many cotton based fabrics can improve over the "new" rating after they have been washed at least once. Shrinkage in these fabrics closes small gaps between the fibres and allows less UVR to pass through. However, old, threadbare or faded garments may have a lower UPF rating.
- **UVR absorbers:** Some fabrics are treated to improve the UPF rating. This is usually done if the base fabric has a low natural resistance to UVR. Treatment with a UVR absorber, generally during manufacture,

can result in a fabric with a higher UPF rating that still retains the comfort properties of the original fabric. Many dyes absorb UVR and therefore increase the UPF rating of the fabric. Some UVR absorbers behave like colourless dyes. They bond to the fabric in a similar way, and have a comparable permanency to coloured dyes. Recently there has been interest in adding UVR absorbers to commercial washing powders.

How effective are sunscreens?

In Australia two out of three people will develop some form of skin cancer during their lifetime. Often the best ways to protect skin from the sun are by use of clothing and shade. However, any remaining exposed skin should be protected by use of a sunscreen of at least SPF 15 and preferable SPF 30+. Remember that the purpose of using sunscreens is to reduce UVR exposure, not to extend the time spent outside in the sun.

Sunscreen is used on the skin to stop harmful UVR from reaching the skin. There are two main types of sunscreens, chemical absorbers and physical blockers.

A sunscreen that absorbs UVR is a chemical barrier and is the most common type of sunscreen available. Additionally, these sunscreens may be waterproof, non-greasy and contain a variety of water-soluble or oil soluble chemicals. Chemical sunscreens are usually easy to apply to the skin.

A sunscreen that scatters or reflects UVR from the skin is called a physical blocker. Zinc cream, which contains zinc oxide, is this type of blocker but is generally only used on small areas of skin as it also prevents heat loss and perspiration from the skin. Titanium dioxide is also used in sunscreens due to its reflective properties. The physical blockers tend to mainly reflect UVR, however, they can also absorb UVR at specific wavelengths.

The individual chemicals in sunscreens absorb UVR at specific wavelengths. Broad spectrum sunscreens contain several ingredients that each absorb at different wavelengths and so are effective over more of the UVR spectrum.

The effectiveness of sunscreens is dependent upon many factors including how thickly the sunscreen is applied to the exposed skin. When considering how much sunscreen is adequate, it is internationally accepted that the application should be about two milligrams per square centimetre. This translates to about thirty millilitres (ml), which is approximately six teaspoons, of sunscreen lotion to protect the entire exposed skin of an adult male. Therefore a 120ml tube of sunscreen should only last four applications if used on the entire body of an average adult.

The sun protection factor (SPF) rating indicates the level of protection provided by a sunscreen against UVR. Sunscreens sold in Australia must be labeled with an SPF rating of at least 4, up to a maximum of 30+. Sunscreens of less than SPF 15 offer only moderate to low protection.

A sunscreen with a rating of SPF 15+ would provide a fair-skinned person with 15 times more protection for their exposed skin than if they didn't use a sunscreen. For example, if a fair skinned person reddens after 10 minutes of sun exposure, then correctly applying SPF 15 sunscreen will provide protection for up to 10 x 15 = 150 minutes. It is important to remember that after 150 minutes in the sun while wearing sunscreen this person would still have received the same UVR exposure as they would have received in 10 minutes if they had not been wearing sunscreen. In both cases their skin has received the same amount of UVR exposure.

Factors that may alter the effectiveness of sunscreen are the time of year, time of day, amount of surface reflection, cloud cover, water resistance and the person's skin type. Use of sunscreens with a higher SPF rating than SPF 30+ is not generally recommended as they may not provide much greater protection but require an increased amount of active chemicals which may irritate some sensitive skins.

The following table shows that a broad spectrum sunscreen of SPF 15 blocks approximately 93% of the UVR and one of SPF 30 blocks approximately 96% of the UVR. Simply looking at the ratio of the SPF value one can compare the amount of protection offered by SPF 15 and SPF 30 sunscreens. For any exposure time an SPF 30 sunscreen has double the protection of an SPF 15 sunscreen. In practice the amount of sunscreen applied and the evenness of the coverage can have a significant affect on the duration of protection offered by the sunscreen.

SPF rating	% UVR blocked
4	75
8	87
15	93
30	96

The values shown in the above table are approximate

Sunscreen is best applied to clean, dry skin. Sunscreen must be applied at least 15 minutes before going outside to all exposed areas of skin and reapplied every two hours to maintain the stated protection. Reapplication does not give additional protection but ensures that the stated protection is achieved. Application of sunscreen ineffectively or too sparingly may considerably reduce the level of protection for the wearer.

Remember that sunscreens do not block out all of the UVR so a person is not completely protected by sunscreen and may still sunburn.

The current Australian sunscreen standard *(AS/NZS 2604:1998 'Sunscreen products - Evaluation and classification')* limits the maximum protection claimed on labelling of sunscreen products to SPF 30+.

Australian clothing standard

In July 1996 Australia became the first country to introduce a standard for evaluating and classifying sun protective clothing *(AS/NZS 4399:1996 'Sun Protective Clothing-Evaluation and Classification')*. The standard uses the term ultraviolet protection factor (UPF) to designate the amount of protection provided by personal clothing and also classify clothing into broad protection categories as shown in the following table.

Protection category	UPF ratings	% UVR blocked
Excellent protection	40, 45, 50, 50+	More than 97.5
Very good protection	25, 30, 35	95.9 to 97.4
Good protection	15, 20	93.3 to 95.8

In Australia garments with UPF ratings less than 15 cannot be labelled as sun protective. Garments with UPF ratings higher than 50 are labelled as UPF 50+. ARPANSA offers a UPF testing service for rating sun protective materials.

Companies can have their materials tested for UPF rating then make UPF labels follow the directions for in AS/NZS 4399. ARPANSA can supply ready made UPF swing tags that are made according to this standard.

How can you test sun protective materials?

Over-exposure to ultraviolet radiation (UVR) can cause sunburn, skin damage and an increased risk of developing skin cancer. Clothing provides one of the most convenient forms of protection against UVR but not all garments offer adequate sun protection.

Laboratory testing can determine how effective different fabrics are at blocking UVR. ARPANSA has operated a UPF Testing Service since 1990. The UPF Testing Service can test fabrics and other materials to determine the Ultraviolet Protection Factor (UPF) rating. UPF testing is performed according to Australian/New Zealand standard AS/NZS4399.

UPF testing involves exposing a fabric to ultraviolet radiation (UVR) and measuring how much is transmitted through the sample. Different wavelengths of radiation in the UVR spectrum have different effects on human skin and this is taken into consideration when calculating the UPF rating. The higher the UPF rating, the more effective the material is at blocking UVR and the better sun protection it can give the wearer.

The ARPANSA UPF Testing Service can be contacted by phone +61 3 9433 2211, fax +61 3 9432 1835 or e-mail UPF Testing Service. Information is also available from the ARPANSA UPF Testing Service web page.

How can you label products with a UPF rating?

Labeling of sun protective clothing is done according to Australian/New Zealand Standard AS/NZS4399, **Sun protective clothing - Evaluation and classification**. Companies can have their fabrics tested to determine the UPF ratings then follow the directions in this standard and make their own UPF labels. ARPANSA can provide ready-made UPF rating swing tags made according to AS/NZS4399. The ARPANSA UPF tags are available in packs of 500 tags with UPF ratings of 15, 20, 25, 30, 35, 40, 45, 50 and 50+ depending on the rating of the products to be labeled.

The ARPANSA tags feature one of ARPANSA's trademarks, known as the **UPF Certification Trade Mark**, and companies that wish to use the ARPANSA UPF tags must first licence use of this trademark. The UPF Certification Trade Mark is widely used to label sun protective products. When this trademark is applied to a product it indicates that ARPANSA has been satisfied that the materials used to construct that product will provide the amount of sun protection stated on the rating label. Refer to the UPF Certification Trade Mark page for further information.