1. SCOPE

Free TV Australia Operational Practice 31 is a guideline for the minimum lighting requirements for television coverage of night time sporting events staged under artificial light. Typical sports are the various codes of football - Rugby League, Rugby Union, AFL, Soccer etc., Cricket, Aquatic competition, Basketball, Netball, Hockey etc. OP31 is a summary of international TV field lighting system specifications intended as a guideline for planning of installations to meet international standards and for upgrade of existing installations to cater for the stringent lighting demands for Digital and HDTV (High Definition TV) live production.

This Operational Practice is based on international practice and the experience of Australian Commercial Television Stations, and ABC television. Adherence to this Practice will result in optimum lighting conditions for colour television broadcasting of sports events whilst providing good lighting for both competitors and the audience. The values given in this Operational Practice are intended to cover a wide range of sports at both national and international level.

This Operational Practice has been developed by the Free TV Australia Project Group - Outside Broadcasts in the interests of maximising TV and Radio production potential and productivity at sports venues and avoidance of costly omissions at planning and construction stages.

This Operational Practice recognises the introduction and wide usage of Super Slow Motion cameras, ("Super Slo-Mo" or SSM) High Definition (HD) cameras and a wide range of special effects cameras in general service in sports and entertainment telecasts.

The previous concept of MAIN and SECONDARY camera positions has been abandoned with all camera positions now deemed main and requiring full lighting level.

Rugby football codes depend heavily for cameras placed in the dead ball corners for SSM replays and video referee deliberations.

Large arena sports such as cricket and AFL employ camera positions around the 360 degree field. All cameras require full lighting level and even illumination. This is also a necessary requirement for players.

The wide general usage of SSM cameras and increasing use of HD cameras has led to revision of the minimum illumination for TV to the professional level of 1000 lux Ev. The International level remains at 1400 lux.

2. TECHNICAL CONSIDERATIONS

In order to enable a television cameraman to follow an object when high apparent speeds are involved, higher light levels are required. Where the action moves rapidly along the direction of view, the camera lens system must have a sufficiently large depth of field (i.e. range of distance within which objects stay in focus). This will necessitate a small lens aperture and consequently higher light levels are again needed to compensate.

The apparent size of an object is dependent upon the distance from the object to the camera (pick-up distance) and the actual size of the object. If a telephoto (zoom) lens is used to increase the apparent size, then a higher light level is needed because the longer the focal length of the zoom lens (i.e. the greater the magnifications the smaller the aperture generally has to be (e.g. the "ramp function" of a typical telephoto lens gives f/2 for wide angle pictures, decreasing to f/8 for narrow angle telephoto pictures).- extender lenses (in combination with zoom lenses) are also used with the same effect; smaller apertures at smaller picture angles or longer focal lengths.

For installations handling multi-purpose events it may be desirable to have a degree of flexibility of operation.

1. Choice of lighting levels available, say low level for normal use and high level for television use.

2. By switching, lighting of selected areas e.g. a tennis competition commencing with two or more courts, reducing to one court for the final.

Whilst developments in television camera design have lead to a dramatic increase in camera sensitivity, this has been offset by the production of zoom lenses having a much wider range of focal lengths and the introduction of the new super slow motion camera. Consequently, high levels of illuminance are still required to produce the quality images that we have come to expect from a television broadcast.

Whilst there have been significant gains in camera sensitivity over the past decade (particularly with CCD cameras) this has not greatly influenced sports lighting criteria for a number of reasons.

2.1 Lens design

The focal range of broadcast zoom lenses has also been extended over the decade. The best available circa 1980 was 30 x Zoom with maximum focal length of 700mm (equivalent) for a 2/3 inch CCD.

General lenses in current use are 70 x Zoom with focal length of 1200 mm equivalent. Special lenses with 100 x Zoom with focal length of 1800mm are also now in service The trade off with these more powerful zooms is F stop, and therefore overall camera system sensitivity, with the status quo being virtually maintained.

2.2 Signal-to-Noise

Picture quality standards have also progressed. Overall system signal-to-noise ratio acceptability has risen over the decade from a nominal 40dB circa 1980 to around 50dB as at present. This also offsets camera sensitivity gains.

2.3 Super Slo Mo Cameras

Super Slo Mo (SSM) cameras operate at a field rate of 150/sec compared with 50 fields per second for standard PAL cameras. As a result, sensitivity of the SSM cameras is lower by 2 F stops compared to standard cameras. At least 1400 lux V illumination toward SSM camera positions is essential for satisfactory performance.

3. ILLUMINATION

3.1 Vertical Illuminance

Illuminance on a vertical plane, commonly called vertical illuminance (E_v), is essential for viewing vertical objects. The side of a player visible to an observer can be approximated by a vertical plane at right angles to the observer's line of view.

The scene illuminance, and more particularly the vertical illuminance, has a major influence on the quality of the final television picture. To guarantee an optimal view and identification of players from all directions, specified illuminances on vertical planes at a height of 1.5 metres above the playing area are required.

The orientation of the vertical plane at a grid point depends partly on the camera positions and partly on the layout of the competitive area. For example, where the camera has an undefined position somewhere in an area bordering one of the side-lines of say, a football pitch, the illuminance on vertical planes facing that side-line should fulfil the following requirements.

Recommended E_v toward cameras: 1400 lux Av.

Low End Useable Level 1000 lux Av.

Uniformity of E_v toward cameras

$E_{v\ min}$: $E_{v\ max} > 0.5$

Ratio of E_v towards cameras to E_v to other planes (i.e. E_v toward far side-line and towards N and S dead ball lines)

$E_{v\ min}$: E_v (to cameras) > 0.5

3.2 Horizontal Illumination (E_h)

Establishes the overall look, of the arena and is a major contribution to a satisfactory spectator environment.

For colour TV the ratio of horizontal to vertical illumination should be in the range:

E_h:E_v = 0.5 to 2.0

Uniformity of horizontal illumination is important in avoiding dark spots in the overall viewing.

Recommended maximum variation of E_h: $E_{h\ min}$: $E_{h\ max}$ = 0.5

3.3 Ratio between Horizontal and Vertical Illuminance

As the illuminated field forms a major part of the field of view of the camera, an adequate horizontal illuminance is important. A sufficiently good balance between the horizontal and vertical lighting levels is obtained when the average horizontal to the average vertical illuminance (relative to each of the main camera areas or main camera positions):

$E_{h\ av.}$: $E_{v\ av.}$ is between 0.5 and 2.0

3.4 Uniformity of Horizontal Illuminance

Good illuminance uniformity in both the horizontal and vertical planes is important in order to avoid, on the one hand, adaptation problems for players and spectators, and, on the other hand, adjustment problems for cameras for different directions of view. If the uniformity is not good enough, there is a risk (especially with television cameras) that the ball and/or a player will not be clearly seen at certain positions on the field.

The uniformity of the horizontal illuminance on the playing field must be better than: $E_{h\ min}$: $E_{h\ max}$ > 0, 5

It is important also that there is not too great a change in horizontal illuminance over a given distance. For example on large playing fields such as soccer pitches a maximum gradient of horizontal illuminance of 20% change per 4 metres is recommended.

3.5 Reduction of Flicker

When using discharge lamps, light flicker should be minimised by distribution to the three phases of the mains so that, when shooting with film or TV cameras whose field frequency differs from the mains frequency, interference will be as low as possible.

Therefore, when choosing and aligning the luminaires, it has to be ensured that each point on the playing surface is supplied with approximately equal partial horizontal illuminances produced over the three phases.

This is extremely important in cases where the mains frequency and the TV-field frequency are different (e.g. 50 Hz, 60 Hz).

Any high intensity discharge (HID) lamp, operating on an alternating voltage will exhibit a fluctuating light output, because of the extinguishing and re-striking of the lamp every half cycle of the supply. When this effect is visible one speaks of the stroboscopic effect or “flicker”.

This light flicker can be minimised by dividing the floodlights equally over the three phases of the mains and/or the (temporary) generator set, as well as having them equally distributed over the playing area, so that interfere be as low as possible.

3.6 Colour Temperature

In the case of outdoor installation or indoor installations with a significant daylight contribution, the colour temperature of the artificial lighting must be between 4000 K and 6500 K where floodlighting is used during the day and into dusk. This is to minimize apparent colour changes in the scene when daylight is replaced progressively by artificial lighting.

Within an installation the colour-temperature must not deviate from the average value by more than ±500 K while the tolerance values have to be within the stated limits as well.

3.7 Colour Rendering

The colour rendering properties of a light source can be indicated by the general colour rendering index (R_a). The maximum value of the colour rendering index is 100, which indicates that there is no difference in colour reproduction between the source under test and a given reference illuminant having the same colour temperature.

Lighting installations intended for use with colour television should have a colour rendering index R_a in the order of 90 and not less than 65 to ensure that visual differences between direct viewing and viewing on television are minimised.

3.8 Light Level on Surrounding Spectators' Areas

For television broadcasts it is desirable that the areas bordering the playing field should be illuminated to an average vertical illuminance level of 0.25 times the average vertical illuminance level on the playing area. This will ensure adequate contrast between the sporting action and its background. This level may be produced by existing stray light. Other stray or spill light should be avoided in the design of the installation.

3.9 Glare

It is essential that the lighting does not produce an unacceptable degree of glare to players/competitors, spectators or officials. In addition the photographic equivalent of glare, termed lens flare, must be minimal at all the camera positions.

The glare rating GR is given by:

$$GR = 27 + 24 \log (L_{vl}/L_{ve}, ^{0,9})$$

where L_{vl} is the veiling luminance produced by the luminaires and the L_{ve}, is the veiling luminance produced by the environment. A GR value of 50 is termed "Just admissible". It is necessary to calculate GR over all the relevant areas in the installation and with the observer looking in the appropriate directions.

For football pitch lighting installations, the GR is relevant, and should be in accordance with the GR values as given in CIE Publication Number 83 [(1)]. The calculated GR value is also dependent upon the reflectance of the pitch. For pitches, a diffuse reflected value between 0.15 and 0.25 is usually a realistic value.

The maximum value of GR = 50, judged on a scale of 0 to 100, is termed "just admissible" and should be based on the given standard observer positions, at a height of 1.5 metres above the playing area, in the direction of the goal and touch-lines at ground level.

The effect of stray light outside the venue has to be indicated for the centre of the playing area, at a level of 1.5 metres above the playing area, by means of calculating the veiling luminance or this centre, as seen from the five positions.

4. SPECIAL REQUIREMENTS FOR INDOOR INSTALLATIONS

Cameras unavoidably positioned facing windows may encounter high levels of daylight from those windows. On such occasions excessive contrast may be reduced by covering the offending windows with blinds, curtains or filter material either neutral or colour correcting. Good colour matching between artificial illumination and daylight can be achieved by using suitable lighting sources and luminaires and, where necessary, the combination of:

- translucent roofing material
- unsaturated wall and ceiling colours
- avoiding adjacent surfaces with high contrast
- colour correction filters

Direct viewing by cameras of light sources and reflections from polished floors, water, or ice may create disturbing overexposures in cameras and flare effects in lenses.

5. REFERENCES

(1) Commission Internationale de 1'Eclairage, "Guide for the lighting of sports events for colour television and film systems". CIE Publication No. 83, 1989

(2) Commission Internationale de 1'Eclairage, "Guide for the photometric specification and measurement of sports lighting installations". CIE Publication No. 67, 1986

6. SUMMARY

A brief summary of lighting standards is as follows:-

6.1 International Standard for Colour TV Venues

Lighting level (EV) toward main cameras:	1400 lux
Lighting level toward other directions:	1000 lux
Colour temperature (TK):	4000 K to 6500 K, but within 500K at individual venues.
Colouring rendering index R_a:	$\geq$ 90

6.2 Professional Standard

E_V toward main cameras:	1000 lux
E_V toward other directions:	700 lux
Colour temperature:	4000 K to 6500 K, but within 500K at individual venues.
Colour rendering index /R_a	Minimum requirement is Ra 65, Ra > 90 preferred

Note: Whilst satisfactory picture quality can be achieved at the minimum lighting levels stated, restrictions are placed on full usage of telezoom lenses and focusing becomes quite difficult for camera operators on BCU (big close up) camera angles. Super Slo-mo cameras cannot perform satisfactorily below Professional standard lighting.

6.3 Spectator Only

For non TV night matches, the minimum standard is

E_V toward spectator areas:	500 lux.
Horizontal illumination (E_H):	300 lux.
Colour temperature/R_a:	> 65